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Editors

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EDITORIAL

Journal of Plantation Crops, Volume 18 (Supplement) is the *Proceedings of the Eighth Plantation Crops Symposium (PLACROSYM VIII)*, held at Kochi during 28-30 December, 1988. PLACROSYMS are held at periodical intervals under the auspices of the Indian Society for Plantation Crops in collaboration with Central Plantation Crops Research Institute, Central Coffee Research Institute, Indian Cardamom Research Institute, Rubber Research Institute of India, Tocklai Experimental Station and UPASI Tea Research Institute. These symposia are helpful for the scientists to have fruitful and effective interaction to keep themselves abreast with the latest trends in plantation crops research, development and marketing and to reorient the strategies relevant to the present needs of the various plantation crops.

This proceedings contains the full text of 78 papers (62 as oral presentation and 16 as poster presentation) arranged in 8 sessions *viz.*, Genetic Resources and Crop Improvement., Biotechnology, Crop Physiology and Biochemistry., Crop Management., Crop Protection (Disease Management)., Crop Protection (Pest Management)., Harvest and Post Harvest Technology., Marketing, Economics and Statistics and Developmental Strategies. During the deliberations the important points wherever discussed are given at the end of the concerned session. The reports of the individual sessions with recommendations are given under the Plenary Session. The author index is given at the end.

We thank Dr. R. Naidu, General Chairman, members of Standing and Working Committees of PLACROSYM VIII for their wholehearted co-operation. We gratefully acknowledge the guidance and encouragement received from Dr. M. K. Nair, President, Indian Society for Plantation Crops. Thanks are also due to Mr. S. M. Chettiar, National Research Centre for Spices, Kozhikkode for typing the manuscripts. We place on record our deep appreciation to M/s. St. Joseph's Press, Thiruvananthapuram for the utmost cooperation in bringing out this volume.

Thiruvananthapuram
1-3-1991

Editors



R. NAIDU
General Chairman
PLACROSYM VIII

FOREWORD

This issue of proceedings of PLACROSYM VIII is intended to present a true image of our hopes in Plantation Crops Research. The eighth symposium on plantation crops organised by various research institutes working on plantation crops, which was hosted by Spices Board at Kochi in 1988, covered a wide range of crops viz., Cardamom, Coffee, Tea, Coconut, Arecanut, Oil palm, Rubber, Pepper, Cashew etc. In all 78 research papers were presented and discussed in the following 8 technical sessions.

1. Genetic Resources and Crop Improvement
2. Biotechnology, Crop Physiology and Biochemistry
3. Crop Management
4. Crop Protection (Disease Management)
5. Crop Protection (Pest Management)
6. Harvest and Post Harvest Technology
7. Marketing, Economics and Statistics
8. Developmental Strategies

Unlike the annual crops, the plantation crops play a very significant role in the earning of foreign exchange to the nation and the research approaches for increasing the productivity have also been very much different because of their perennial nature. In the past, the main thrust of activity has been directed towards the increase in yield but attention in future will lie in the improvement of quality and the reduction of production cost through efficient management techniques.

Encouraged by our research activities in 1987-88, we can thus look to the future with the experiences gained in the common forum i.e., PLACROSYM VIII will help us better address the problem of crop production in the plantation crops.

A stylized handwritten signature in dark ink, appearing to read 'R. Naidu'.

R. Naidu
Director (Research)
Indian Cardamom Research Institute
(Spices Board)

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PLANTATION CROPS IN INDIA — THEIR IMPORTANCE, PRESENT STATUS, PROBLEMS, SCOPE AND FUTURE NEEDS*

C. K. GEORGE

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The plantation crops are important agricultural commodities for our country as they contribute substantially to the national economy. Though raised only in about 2% of the total cultivated area almost 75% of the export earnings from agricultural commodities come from them. In physical terms this industry annually produces goods worth Rs. 40,000 million, earn foreign exchange to the tune of Rs. 15000 million and employ 2 million people that too in the rural and backward areas. A Symposium on research and development of these crops at this juncture is conspicuous as the commodity analysts believe that all these crops are now undergoing a productivity improvement period. Research on plantation crops in India dates back to eight decades in tea, coconut and coffee, three decades in rubber and cardamom and less than that for others. But it has contributed enormously to the growing technologies and development of improved strains. We are infact ahead of our plan targets in production in important plantation crops like tea, coffee and rubber. Even in cardamom the present years estimated crop is an impressive recovery considering the severe droughts faced consecutively in the last four seasons. In coconut some of the improved varieties have recorded more than 40% yield increase over the conventional West Coast Tall types. The research for improved types in oil palm, the richest source for our future edible oil is also picking up fast.

Present status

Due to the significant breakthrough over the years by our scientists in the production front important plantation crops performed well. The tea production has been increasing at a rate of 100 million kgs annually though consumption in the country has not been growing above 60 million kgs. The Indian export share of tea in the world market has improved from 20.7% in 1986-87 to 21.1% in the last crop season. The coffee consumption in the country has been growing at a rate of only 1.2% per annum as against the production growth of 1.5%. In the global quota also India's share increased from 1.4% in last crop season to 1.66% during this season. In both these

* Presidential address delivered during the inaugural session of Placrosym VIII

crops as well as in cardamom the domestic market is to be strengthened to accommodate the surplus. In rubber, the productivity of 300-500 kg/ha is a long forgotten figure, it has now improved to the level of 900 kg/ha in small holdings and about 1000 kg/ha in large estates. More than double this yield is reported from some of the latest varieties. Our production has gone upto 2.35 lakh tonnes last season from 2.20 lakh tonnes a year ago. By raising per hectare yield by 150 kgs, the supply demand gap of 37,500 tonnes can be bridged. In this crop we have done well in increasing the production, but the consumption has done even better and the gap remains. The production and productivity of coconut in Kerala is still hit hard by the dreadful root (wilt) disease. However, the area of cultivation has been extended, successfully to many other states. The quick as well as slow wilt diseases in pepper are also to be managed. The frequently occurring drought in the plantation area is the major set back to the cardamom industry.

Problems

The industry is facing a number of problems both in production and marketing fronts even though tea, coffee and rubber are poised for an all time record output. The easy availability of elite planting materials to planters is not assured in most of these crops. Of late, we are now giving increased thrust to bio-technological research and micro-propagation of plantation crops which I hope may be able to correct this lapse. The pepper, cardamom, cashew, cocoa etc. have to be improved by broadening its genetic base, replanting senile plantations and by the control of major pests and diseases. Agriculture in India is still continuing as a gambling with nature and that is more so with the plantation crops. This can be minimized by adopting modern irrigation techniques and also by developing stress tolerant lines. In our developmental programmes conservation of water resources and soil, afforestation and above all agriculture in harmony with nature should receive prime importance. We are facing stiff competitions from Brazil in coffee, from Kenya and Ceylon in tea, from South-East Asian countries in pepper, from Guatemala in cardamom and from some African countries in cashew. This results in unhealthy decline in price factor. To site an example, in cardamom since the emergence of Guatemala in late seventies as a major producer and exporter the price situation in the international market has declined sharply from Rs. 203/kg in 1978-79 to Rs. 142 in 1981-82 and in 86-87 it was only Rs. 128/- far below our estimated production cost. There is a surplus of coffee and tea in the world market as population is not on the increasing trend in the importing countries. This results in the context of increased production a decline in the price of commodities and on the otherhand investment is always showing an upward trend. Coupled with this, the plantation tax hike by different State Governments act as a counter-productive step. In fact, a rationalisation of the tax on the central pattern by the State Governments may pave way for higher revenue to them.

Scope for development

The projections on production and productivity by 2000 AD has already been worked out in most of the crops. In rubber by doubling the present day production it is estimated that we will become self-sufficient by that time. In tea the target is for 1000 millions kgs, in pepper it is for one lakh tonnes, and in cardamom it accounts for 9,000 tonnes. In all these crops stability of supply, competitive cost and acceptable quality are also to be assured. Special attention by scientists for augmenting productivity and developing improved post harvest technologies is warranted.

The high density multiple species system successfully demonstrated by CPCRI for coconut based farming, the low cost technology developed in coffee, the high production technology of cardamom and such other innovations are to be popularised. The agricultural extension programme has to get its due share of importance from our research institutes as well in our contest because plantation crops such as cardamom, pepper, coffee, coconut, cashew, cocoa and rubber are all cultivated more by small and marginal farmers having less scientific knowhow on modern technologies and development.

Conclusion

A Symposium of this type will definitely help the scientists to interact with each other and a particular finding in one crop may be successfully applied in others too. The plenary session, I hope will give a fair picture of long term future of our plantation crops *vis a vis* production, consumption and exports. I have little doubt that the deliberations to be followed for the three days will bring in a lot of new ideas for the long term betterment of crop production, plant protection, marketing and development. I sincerely hope that the delegates will find the Symposium informative and useful and for the planners it will serve as a future guideline.

Thank you.

GENETIC RESOURCES AND CROP IMPROVEMENT

Chairman : M. K. NAIR

Rapporteurs : M. A. NAZEER
A. G. S. REDDY

PERFORMANCE OF A FEW RR II CLONES OF *HEVEA BRASILIENSIS* (WILLD. EX. A. JUSS) MUELL. ARG. IN A LARGE SCALE TRIAL

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ABSTRACT

Performance of nine clones of *Hevea brasiliensis* evolved by the Rubber Research Institute of India (RR II), Kottayam in a large scale trial over a period of 13 years is presented in this paper. The clones tested are RR II 101, RR II 103, RR II 105, RR II 106, RR II 107, RR II 114, RR II 116, RR II 151 and RR II 153. Wide variation was exhibited by the clones in yield and associated characters. The popular clone RR II 105 out-yielded all other clones. Only four clones showed better performance than the control (Tjir 1) as far as yield was concerned.

INTRODUCTION

Breeding of improved clones by hybridization is being practised in the RR II since 1954. From the early hybrids of 1954 and 1955, 39 lines were selected for large scale evaluation (Bhaskaran Nair, 1963; Bhaskaran Nair and Panikkar 1966; Bhaskaran Nair and George, 1968; Bhaskaran Nair and Jacob, 1968; Bhaskaran Nair, George and Saraswathy Amma, 1975). Out of these, nine clones, seven belonging to the 1954 progeny and two belonging to the 1955 progeny were evaluated in a large scale trial at the Central Experiment Station of the RR II. Performance of these clones during 13 years are presented in this paper.

MATERIALS AND METHODS

The details of the experimental material and their parentage are given in Table I. The experiment was laid out in an RBD with three replications and 49 plants per plot, planted adopting the square method as 4.87m spacing (Anonymous 1980). Plants were observed for eight years before commencement of tapping and five years thereafter.

Important characteristics recorded were growth vigour during pre yielding period, girth increment after opening the trees, thickness of virgin bark and renewed bark, yield during the first five years of tapping, yield depression during summer, incidence of wind damage and susceptibility to common diseases under normal prophylactic conditions. Growth vigour was recorded by measuring the girth of the trunk at a height of 150 cm above the bud union. System of tapping adopted was 1/2 S d/2. Yield was estimated by cup coagulation method once in a month. Yield depression was assessed by computing the yield during the period February to May as the percentage of the annual yield (Bhaskaran Nair and Joseph 1975). Thickness of bark was measured using a Schleiper's guage (Bhaskaran Nair and Joseph 1981) at a height of 150 cm above bud union when the trees were 13 years old. Incidence of wind damage, pink disease and brown bast was estimated by counting the affected trees. Intensity of diseases of a general nature such as abnormal leaf fall and powdery mildew was assessed by visual observation of the extent of damage caused by them. Data on mean

Table I. *Clones used in the trial*

Clones	HP series	Parentage
RRII 101	1954	Tjir 1 X AV 255
RRII 103	1954	Tjir 1 X Gl 1
RRII 105	1954	Tjir 1 X Gl 1
RRII 106	1954	Tjir 1 X Mil 3/2
RRII 107	1954	Tjir 1 X Mil 3/2
RRII 114	1954	Mil 3/2 X Hil 28
RRII 116	1954	Mil 3/2 X Hil 28
RRII 151	1955	Tjir 1 X PB 5/60
RRII 153	1955	Tjir 1 X PB 5/139
Tjir 1 (control)	Exotic	Primary clone

girth at opening, mean girth increment over five years of tapping, mean annual yield and yield depression during the first five years of tapping, mean thickness of virgin bark and renewed bark were subjected to statistical analysis.

RESULTS AND DISCUSSION

The observations are summarised and presented in Tables II and III.

Mean yield/tree/tap over five years was highest (62.17 g) in RRII 105. This clone was significantly superior to the control as well as other clones. Clone RRII 151 (30.51g) was the poorest yielder. Analysis of mean angles relating to yield depression during wintering period has shown that all RRII clones were significantly superior to the control. Among the RRII clones, depression was minimum (23.67%) in RRII 116 and maximum (51.67%) in RRII 151. Vigour during the pre-tapping period as indicated by girth of the trunk was found to be not significantly better in RRII clones compared to the control (47.89 cm). However clones like RRII 116 (52.65 cm), RRII 105 (51.08

cm) and RRII 114 (50.88 cm) were numerically superior while the girth of RRII 151 (44.20 cm), RRII 101 (44.22 cm) etc were found to be the minimum. Increase in the girth of the trees after commencement of tapping also showed very wide variation among the different clones. Annual girth increment was above 5 cm in RRII 101, 114 and 116 while in the case of RRII 105 (3.47 cm) and RRII 103 (3.95 cm) it was very low. RRII 101 and RRII 114 were found to be significantly superior to Tjir 1 in this character. Thickness of virgin bark did not show much variation among the clones observed. Similarly bark renewal was also found to be more or less comparable in the different clones.

Incidence of brown bast was comparatively high in RRII 153 (3.85%), RRII 105 (2.94%) and RRII 114 (2.38%) while it was completely absent in four clones RRII 107, RRII 116, RRII 151 and Tjir 1.

Pink infection was more in five clones compared to the control clone. Largest number of trees were affected (6.86%) in RRII 105 followed by RRII 151 (4.17%).

Table II. *Performance of clones in the trial*

Clones	Mean yield over 5 years (g/tree/tap)	Mean yield depression during wintering as percentage of mean yield	Mean girth at opening (cm/tree)	Mean annual girth increment after opening (cm/tree)	Mean thickness of virgin bark (mm/tree)	Mean thickness of 5 years renewed bark (mm/tree)
RR11 101	40.58	43.67 (41.35)*	44.22	5.93	11.21	8.04
RR11 103	42.53	32.33 (34.45)	45.08	3.95	11.45	8.66
RR11 105	62.17	33.33 (35.24)	51.08	3.47	11.78	8.71
RR11 106	32.50	26.00 (30.52)	47.17	4.68	10.93	8.16
RR11 107	33.97	42.67 (40.77)	48.02	4.18	10.49	7.50
RR11 114	33.60	31.67 (34.22)	50.88	5.47	11.02	7.95
RR11 116	42.95	23.67 (29.03)	52.65	5.18	10.54	7.24
RR11 151	30.51	51.67 (45.95)	44.20	4.74	11.18	7.80
RR11 153	37.37	47.33 (43.47)	44.51	4.28	10.68	8.09
Tjir 1	35.32	62.33 (52.14)	47.89	4.30	10.61	7.69
S.E.	2.71	1.88	1.97	0.39	0.38	0.35
C.D.	8.05	5.58	5.85	1.16	—	—

* Figures in parenthesis indicate the corresponding transformed figures (angles).
S.E. and C.D. are for these figures only.

Table III. *Performance of clones in the trial*

Clones	Pink disease percentage incidence	Brown bast percentage incidence	Uprooting percentage incidence	Branch snap percentage incidence	Trunk snap percentage incidence	Total wind damage percentage incidence	Abnormal leaf fall	Powdery mildew
RR11 101	2.99	1.49	Nil	1.49	10.45	11.94	moderate	moderate
RR11 103	0.97	0.97	2.91	3.88	20.38	27.12	severe	light
RR11 105	6.86	2.94	Nil	5.88	12.75	18.63	light	light
RR11 106	0.79	0.79	0.79	Nil	0.79	11.58	severe	moderate
RR11 107	0.93	Nil	0.95	0.93	7.62	9.50	light	severe
RR11 114	2.38	2.38	1.19	Nil	3.57	4.76	light	light
RR11 116	1.75	Nil	Nil	Nil	1.75	1.75	light	moderate
RR11 151	4.17	Nil	Nil	6.25	38.54	44.75	light	light
RR11 153	1.92	3.85	1.92	Nil	10.58	12.50	light	severe
Tjir 1	1.85	Nil	Nil	2.78	11.11	13.89	moderate	severe

All clones were affected by damages caused by wind. RRII 151 was found highly prone to this malady affecting 44.75% of the trees. It was also high in RRII 103 (27.12%). In the case of RRII 151 only two types of wind damage namely trunk break and branch snap were noted while in the case of 103 uprooting also occurred. Except three, all RRII clones exhibited more resistance to this damage compared with the control. The clones exhibited very wide variability with regard to their susceptibility to powdery mildew and abnormal leaf fall diseases.

Among the clones evaluated RRII 105 remained outstanding in yield, initial girth, thickness of virgin bark and bark renewal. Some serious defects exhibited by this clone were high incidence of brown bast and pink disease. RRII 116 which was the second highest yielder also possessed certain good secondary characters like high initial vigour, good girth increment on tapping, low wintering depression and resistance to brown bast and wind damage.

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EFFECT OF TIME AND SEVERITY OF PRUNING IN CASHEW (*ANACARDIUM OCCIDENTALE* L.)

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ABSTRACT

An experiment on pruning in cashew (*Anacardium occidentale* L.) was conducted during 1984 - 1985 at National Research Centre for Cashew, Shanthigodu, Karnataka, to adjudge its effect on growth, flowering, fruiting and yield. The leader-shoot pruning (secondary branches) and lateral-shoot pruning (tertiary branches) were done for four months (May to August) in an experiment involving nine treatments. The experimental material was M 76/2 (VTH-539) cultivar.

Leader-shoot pruning during August increased the yield more than twice (9.36 kg/tree) over the control (4.32 kg/tree), closely followed by leader-shoot pruning in July (9.22 kg/tree). These two treatments also recorded the highest bisexual flowers/panicle and produced the highest number of lateral shoots; whereas leader-shoot pruning in May had an adverse effect and thus gave the lowest yield (3.26 kg/tree). Further more, lateral shoot pruning in August also proved beneficial and gave around 8.0 kg nuts/tree.

INTRODUCTION

Generally cashew trees are grown without even removing the deadwood, criss-cross branches and water shoots which may reduce the yield potential of the trees. To keep good sanitary conditions of the plant, all the undesirable branches are to be removed.

In several other crops, pruning was found to be beneficial in increasing per tree yield, as in the case of mango (Rao and Shanmugavelu, 1975) citrus (Moore 1959) and guava (Sundararajan and Muthuswamy 1964). In cashew, Mohan (1983) observed that pruning of shoots in June increased the yield per tree substantially.

To adjudge the effect of severity of pruning and its time on the yield and other growth parameters in cashew, the leader-shoot and lateral-shoots were pruned by heading back, starting from May to August.

MATERIALS AND METHODS

The investigation was carried out at National Research Centre for Cashew, Shanthigodu, Dakshina Kannada. The annual rainfall of the area is about 3500 mm, which is spread over a period of 6 to 7 months from May to November. The temperature ranges from 15°C (min.) to 39°C (max.). The relative humidity fluctuates between 40 and 93 per cent. Such an agro-climate is best suited for cashew.

The seedling progeny of M 76/2 (9 year old) grown on a slopy land of red laterite soil were made use of for this study. The pruning treatments viz., leader-shoot pruning and lateral-shoot pruning were carried out for four months starting from May to August in 1984 and 1985, during which period the cashew tree remains dormant. One control plot was also maintained without pruning

and thus total nine treatments were replicated thrice in the Randomised Block Design.

The leader and lateral-shoot pruning was done during the second week of the month by heading back 2/3 length of the shoots, and thereby 60 per cent of the shoots were pruned from all sides of each tree.

The observations recorded include, number of laterals produced, per cent of productive laterals, length of shoot, number of leaves and leaf area per shoot, total flowers and bisexual flowers per panicle and nut yield (in kg) per tree.

The observations were recorded from 10 tagged shoots per tree on complete emergence of the panicle and before the first flower opened. The leaf area was calculated by using the formula suggested by Murthy et al (1979), which is as follows:-

$$\text{Leaf area in seedling trees} \\ = 0.74 + 0.668 X;$$

where X = length $\times$ breadth.

The opened male and bisexual flowers were counted separately at weekly intervals from the tagged panicles and then removed each time. The nut yield per tree was obtained by weekly harvest of mature nuts, sun dried for two days and weight recorded. The data thus collected on different parameters were statistically analysed.

RESULTS AND DISCUSSION

Bud activation

The cashew tree enters dormancy soon after the last picking is over (April to May) and continues to remain dormant during the rainy season till middle of September under the coastal climate of Karnataka. It was noticed that the buds just below the cut-end became active between 22 and 28 days after the pruning.

It was observed that even though the buds of May-pruned shoots were opened, there was no active growth. In case of June and July pruning, the activated buds showed growth at a slower rate whereas on the August pruned shoots, the activated bud showed normal growth. At the end of September, the flushing in case of June-pruned trees was about 80 per cent and it varied between 55 to 60 per cent for other treatments; however the unpruned trees in the control plot remained dormant without flushing.

Vegetative growth characters

The effect of pruning on vegetative characters, flowering and yield are given in Table I.

(a) *Number of laterals per shoot*: The leader-shoot pruning increased the number of laterals produced per shoot significantly. Number of laterals (4.83 per shoot) recorded was highest in July, followed by August (4.07) and June (3.79). The lateral-shoot pruned in June also produced significantly more number of laterals per shoot (3.01) over the control (2.05).

The mechanism of response to pruning is hormonal in nature. The downward flow of auxin from growing tip of shoots control the bud development. When the top is pruned by heading back, the downward flow of auxin is arrested, which enables to increase the number of lateral buds to sprout just below the cut-end and subsequently induce branching. Perhaps this would be the reason for significantly higher number of laterals produced on the pruned cashew shoots. The higher number of laterals produced on the pruned shoots in the present study, has also been observed by earlier workers, in cashew (Mohan, 1983) in guava (Aravindakshan, 1963) and in fig (Sundararaj et al, 1969).

Table I. *Effect of time and severity of pruning in cashew (Av. for two years, 1984 & 1985)*

Treatments		Lateral produced (No.)	Length of lateral (cm)	Leaf area/lateral (cm ²)	Total flowers/panicle	Bisexual flowers/panicle (No.)	Yield/tree (kg)
Month	Shoot pruning						
May	Lateral	2.61	14.5	750	247	53.9	5.14
	Leader	2.39	17.6	958	272	66.6	3.26
June	Lateral	3.01	16.6	883	300	59.7	4.91
	Leader	3.79	20.6	1019	323	72.9	6.07
July	Lateral	2.24	15.9	996	403	109.4	4.24
	Leader	4.83	20.8	1152	384	111.4	9.22
Aug	Lateral	2.74	17.4	740	340	77.3	7.98
	Leader	4.07	24.6	1310	342	97.7	9.36
Control		2.05	14.1	666	256	58.2	4.32
CD (P=0.05)		1.55	5.31	254	81	25.5	2.90

(b) *Length of laterals*: The leader-shoot pruning done in the months of August, July and June were the effective treatments producing significantly the longest laterals 24.6 cm, 20.8 cm and 20.6 cm, respectively; while the shoot length in respect of control was only 14.1 cm. Similar reports have been made in guava by Bajpai, Shukla and Chaturvedi, (1973) and in sweet orange by Alexander and Maggs (1971).

(c) *Number of leaves and leaf area per shoot*: Higher number of leaves ranging from 8.8 to 11.6 per shoot was recorded almost in all treatments, whereas in unpruned control, it was only 7.0. Leader-shoot pruning during August recorded the highest leaf area of 1310 sq. cm per shoot, followed by July (1152 sq.cm), June (1019 sq.cm) and May (958 sq.cm). Lateral-shoot pruning done in July also recorded higher leaf area of 996 sq.cm. per shoot while the unpruned control registered only 666 sq.cm per shoot.

The increased number of leaf and leaf area in the case of the laterals emerged on pruned shoots, may be due to early emergence of lateral shoots. This is in confir-

mity with earlier findings. Grigorov (1975) reported that pruning increased the leaf surface area in apple by 30 to 40 per cent.

Reproductive characters

Flowering has been found to be induced by pruning in many fruit crops. Sen, Maiti and Maiti, (1972) succeeded in inducing axillary flowering in Mango cv. 'Langra' and 'Gulabkhas' by decapitation of shoot with or without ringing treatment. Mohan (1983) observed increased rate of productive laterals in cashew by pruning in June.

(a) *Number of flowers per panicle*: Pruning of shoots in July and August produced significantly higher number of total flowers and bisexual flowers. Leader-shoot pruning in July was the best treatment producing 384 flowers/panicle of which 111.3 were bisexual flowers; while lateral-shoot pruning in July was the second best treatment producing 109.3 bisexual flowers. Though the leader-shoot pruning in August produced the second highest (342 flowers per panicle), the bisexual flowers was less (97.7/ panicle).

Pruning of shoots in woody perennials was successfully employed to obtain higher

number of flowers. Aravindakshan (1963), Sundararajan and Muthuswamy (1964) and Bajpai et al. (1973) observed that pruning increased the number of flowers per shoot in guava. Mohan (1983) observed the highest magnitude of bisexual flowers per shoot in June-pruned cashew trees under Dharwar conditions.

The increased number of flower production may be attributed to the availability of more nutrients and water on the pruned shoots.

(b) *Yield per tree*: Leader-shoot pruning during August was the best treatment in producing the highest yield (9.3 kg) per tree, which was 116% more than the yield of unpruned trees in the control plot. July leader-shoot pruning and August lateral-shoot pruning also recorded significantly higher yields of 9.2 kg and 7.9 kg/tree, respectively; compared to 4.3 kg per tree in the control plot (Table I).

The increased yield in the present study may be attributed to the higher number of bisexual flowers, per cent determinate laterals and higher leaf surface area per shoot in respect of the August leader-shoot and lateral-shoot pruning and also leader-shoot pruning in July. The source-sink activity increase also might have contributed to the higher yields.

Pruning of leader shoots in July and August increased the productive laterals, bisexual flowers and thereby increased the yield in cashew.

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EVALUATION OF CERTAIN PRIMARY AND SECONDARY HEVEA CLONES IN LARGE SCALE TRIAL

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ABSTRACT

Nine clones of *Hevea brasiliensis* (Willd ex. Adr. de. Juss.) Muell. Arg. evolved at the Rubber Research Institute of India, (RRII) Kottayam (five primary and four secondary clones) were evaluated in a statistically laid out large scale trial in central Kerala. Clone Tjir 1 was included as the control. Yield performance of the clones over a period of ten years, yield depression due to wintering, vigour during immaturity period, girth increment on tapping, thickness of virgin and renewed bark, number of latex vessel rings in both virgin and renewed bark, incidence of major diseases like pink disease, abnormal leaf fall, brown bast etc. and damage caused by wind were recorded. The performance over ten years showed that all the clones were on par with respect to yield of dry rubber and girth increment on tapping. Yield depression due to wintering was highest (40.25%) for RRII 108 and lowest (8.75%) for RRII 1. The differences among the clones with respect to bark thickness and number of latex vessel rings in the virgin bark were statistically significant. Clone to clone variation was observed for other characters studied and the results are discussed.

INTRODUCTION

The Rubber Research Institute of India initiated tree improvement programmes in 1954, for which the techniques adopted have been ortet selection and hybridization (Nair and Panikkar, 1966; Nair and Jacob, 1968; Nair and George, 1968; Nair, George and Saraswathy Amma, 1975; Joseph, Panikkar and Saraswathy Amma 1986; Nazeer et al, 1986). The clones evolved through these methods are evaluated and the promising ones finally released for commercial cultivation. In the present paper the performance of nine RRII clones along with one clone as control in a large scale trial over a period of ten years is presented.

MATERIALS AND METHODS

The trial was laid out with nine RRII clones and Tjir 1 as control, at the Central Experiment Station of RRII during 1968

(Anonymous, 1980). Randomised block design with three replications, having 36 trees per plot was adopted. The clones, were RRII 1, RRII 2, RRII 19, RRII 20, RRII 21, RRII 108, RRII 112, RRII 115 and RRII 119, the origins of which are given in Table I. The trees were opened for tapping at the eighth year (1976). Yield recording was done by cup coagulation method on two normal tapping days per month. The tapping system followed was 1/2 S d/2. The trees were given tapping rest during the month of February till 1979. Since then no annual rest was given. The trees were rain-guarded during rainy months from 1979. Annual recording of tree girth at a height of 150 cm from the bud union was made and girth increment was calculated. Other important secondary characters such as incidence of wind damage, brown bast and other major diseases under normal prophylactic

Table I. *Performance of clones in the trial*

Clone	Parentage	Mean yield in gram/tree/tap				Mean girth in cm		
		Yield for the first 5 years (1976-81)	Yield for 6th to 10th years (1981-85)	Yield over 10 years (1976-85)	Yield depression due to wintering as percentage of mean yield	Girth at opening (1976)	Girth at 10th year of tapping (1985)	Mean annual girth increment
RRII 1	Primary clone	41.05	42.53	41.81	8.75	54.99	89.56	3.46
RRII 2	Primary clone	36.28	41.21	38.75	21.05	40.40	84.46	4.41
RRII 19	Primary clone	39.19	55.76	47.48	20.81	53.02	85.79	3.28
RRII 20	Primary clone	43.81	43.92	43.87	20.33	48.26	84.03	3.58
RRII 21	Primary clone	40.78	48.62	44.71	15.59	44.75	81.81	3.71
RRII 108	Tjir 1 X Mil 3/2	40.78	56.80	48.79	40.25	50.06	84.18	3.41
RRII 112	Mil 3/2 X Hil 28	44.20	52.97	48.59	17.62	52.51	89.55	3.70
RRII 115	Mil 3/2 X Hil 28	35.37	51.61	43.49	21.18	50.22	84.49	3.43
RRII 119	Mil 3/2 X Hil 28	39.61	56.96	48.29	16.82	47.74	82.19	3.45
Tjir 1 (Control)	Primary clone	37.78	49.50	43.64	25.76	46.36	88.71	4.24
General Mean		39.89	49.99	44.94	20.82	48.83	85.48	3.67
S. E.		3.84	4.32	3.65	—	3.82	2.87	0.40

conditions were observed periodically. Bark thickness and number of latex vessel rings were recorded from the virgin bark as well as from renewed bark of five years growth. For this one sample each of virgin bark from 150 cm from the bud union and the renewed bark of five years growth were employed. The samples were sectioned in the radial plane, stained with Sudan III and the number of latex vessel rings were counted using a light microscope. Bark thickness was also measured. Data on mean yield per tree per tap for the first five years of tapping, subsequent five years and the mean over ten years, girth at opening and at the tenth year of tapping, annual girth increment on tapping, and the anatomical parameters were statistically analysed. Yield depression due to wintering (Feb–May) as percentage of mean yield over ten years was calculated.

RESULTS AND DISCUSSION

Table I shows the mean yield in gram per tree per tap for the first five years, sixth to tenth year, and mean over ten years of tapping. Analysis of variance showed that all

the clones were on par with respect to yield figures (Table II).

When the mean yield over ten years was considered RR11 108 (48.79 g), RR11 112 (48.59 g) and RR11 119 (48.29 g) were the top yielders, of which the first and third clones were the top yielders over the period of 6th to 10th year also. RR11 20 and RR11 115 were comparable to the control clone and two clones RR11 1, and RR11 2, recorded lesser yield (Table I). RR11 2 continued to be the lowest yielder as was the case during 6th to 10th years.

Yield depression due to wintering was highest in clone RR11 108 (40.25%). The control clone showed a depression of 25.76 per cent. RR11 1 is noteworthy for its very low depression in yield (8.75%) during summer. Other clones showed varying degrees of depression ranging from 15 to 21 per cent (Table I).

It is evident from the foregoing observations that the clones evaluated showed an increasing trend of yield only upto the sixth

Table II. *Variance ratio for the characters studied*

Yield gram/tree/tap	First five years (1976–1980)	Sixth to 10th year (1981–1985)	Mean over 10 years (1976–1985)
	<1	1.85	<1
Girth (cm)	At opening (1976)	At 10th year of tapping (1985)	Mean annual girth increment over 10 years
	1.28	<1	<1
Bark anatomical characters	Bark thickness (mm)		No. of latex vessel rings
	Virgin	Renewed	Virgin
	2.77	1.16	2.75
		Renewed	
			<1
CD	1.32	—	6.68
F _{9, 18} = 2.47			

year of tapping. The secondary clones evaluated in the present trial are preliminary selections from the 1954 hand pollination progeny. Present high yielders in the large scale trial (RRII 108, RRII 112 and RRII 119) showed a rising trend in yield during the first four years of tapping in small scale trial also (Nair and George, 1968).

Secondary characters

Table III depicts some of the important secondary characters of the clones evaluated.

(a) *Girth:* Girth at opening, girth at 10th year of tapping and annual girth increment are given in Table I. Analysis of data on the above characters did not reveal any significant differences between clones (Table II). The rate of annual girth increment on tapping (over 10 years of tapping) was highest for RRII 2 (4.41 cm) followed by the control clone (4.24 cm). The better yielding clones, RRII 108, RRII 112 and RRII 119 in the present study did not show high initial girth or girth increment on tapping. This is in agreement with the report that high yield need not necessarily be associated with high girth increment (Nazeer et al., 1986).

(b) *Bark anatomical characters:* Table IV shows bark characters such as bark thickness and the number of latex vessel rings in virgin bark and renewed bark. Analysis of the data showed that the differences among clones were significant for thickness of bark and the number of latex vessel rows in the virgin bark (Table II). Virgin bark thickness was highest for the control (8.59 mm) followed by RRII 21 (7.85 mm), RRII 1 (7.48 mm) and RRII 119 (7.07 mm). RRII 19 and RRII 112 recorded very low bark thickness 5.71 mm and 5.21 mm respectively. In the case of renewed bark also control clone had the highest thickness of 6.38 mm, while RRII 115 showed the lowest (4.25 mm).

The number of latex vessel rings in the virgin bark was highest for RRII 1 (41) followed by RRII 20 (36) and RRII 2 (34). In the control, the number was 26 and the lowest number of latex vessel rings in the virgin bark (21) was found in RRII 115. In the renewed bark, highest number of latex vessel rings (27) was found in RRII 21 and the lowest (18) in RRII 115. Other clones did not show much variation (Table IV).

(c) *Diseases and wind damage:* Observations on disease incidence and wind damage under normal field conditions were made and the data are recorded in Table III. On visual observations, most of the clones were found to be susceptible to abnormal leaf fall disease caused by *Phytophthora* spp, while four clones showed comparatively low incidence under normal prophylactic conditions. Powdery mildew caused by *Oidium* was also found to infect all clones at varying degrees of intensity (Table III). Incidence of powdery mildew was very severe in RRII 112 and RRII 108 and it was comparatively low in the control clone.

Incidence of pink disease was noticed in all the clones evaluated. RRII 1 was the most susceptible clone which recorded 30.72% incidence followed by RRII 19 (27.60%). The control clone Tjir 1 was the least susceptible (1.04%). All the clones studied showed proneness to brown bast. RRII 19 was the most susceptible clone to this disease (18.52%), while RRII 115 was least susceptible (4.63%).

Almost all the clones were found to be affected by wind and the incidence of wind damage was highest in RRII 19 (15.27%) and lowest in RRII 2 (1.85%). Major types of wind damages affecting the trees were trunk snap, branch snap and uprooting.

From the above results it is evident that clonal variation with respect to yield

Table III. Some important secondary characters of RRII clones

Clone	Trunk	Branching	Canopy	Wind damage percentage incidence	Pink disease percentage incidence	Brown bast percentage	Powdery mildew incidence	Abnormal leaf fall incidence
RRII 1	Straight and tall, slightly fluted, surface smooth	Top branching 2-3 heavy branches, fork narrow, union strong.	Light and compact leaves small and pale green.	2.19	30.72	12.96	Moderate	Moderate
RRII 2	Slightly leaning and fluted, surface smooth	Low branching, 2-4 heavy branches, fork wide and union strong.	Dense and spreading pale green leaves	1.85	13.02	5.56	Severe	Severe
RRII 19	Slightly leaning and cylindrical, surface smooth.	High branching 2-3 heavy branches, fork wide and union strong.	Dense and compact green leaves	15.27	27.60	18.52	Moderate	Moderate
RRII 20	Slightly leaning and fluted, surface rough.	Medium branching, 2-3 heavy branches, fork wide and union strong. Branchlets numerous.	Dense and nearly spreading pale green leaves.	3.57	16.15	10.19	Moderate	Severe
RRII 21	Straight and cylindrical surface smooth.	High branching, 2-4 heavy branches, fork wide and strong union, branchlets tall.	Dense and spreading pale green leaves.	3.54	19.79	10.19	Severe	Severe
RRII 108	Straight and tall slightly fluted, surface rough.	Medium branching, 2-3 heavy branches, fork narrow, union strong, branchlets tall	Sparse and compact pale green leaves	4.11	17.70	12.96	Very severe	Severe
RRII 112	Straight and fluted, slight twisting, surface smooth.	Medium branching, 2-4 heavy branches, fork narrow, union strong.	Sparse and spreading pale green leaves with wavy margin.	10.21	15.10	7.41	Very severe	Moderate
RRII 115	Slightly leaning and twisted surface smooth	Medium branching, 3-4 heavy branches, fork wide, union strong.	Dense and spreading narrow leaves with green colour	7.58	8.85	4.63	Very low	Moderate
RRII 119	Leaning and slightly fluted, surface smooth	Medium branching, 2-4 heavy branches, fork wide and union strong. Branchlets many.	Dense and spreading large and thick green leaves	12.86	19.79	8.33	Moderate	Severe
Tjir 1	Slightly leaning and twisted, smooth surface.	Low branching, 3-4 heavy branches, fork wide, union strong, branchlets many.	Dense and spreading	5.67	1.04	6.48	Low	Severe

Table IV. *Bark anatomical characters of the clones studied*

Clone	Mean bark thickness (mm)		Mean no. of latex vessel rings	
	Virgin	Renewed	Virgin	Renewed
RRII 1	7.48 $\pm$ 1.16	5.02 $\pm$ 0.85	41 $\pm$ 3.89	25 $\pm$ 8.24
RRII 2	6.84 $\pm$ 0.74	4.67 $\pm$ 0.98	34 $\pm$ 10.17	24 $\pm$ 4.02
RRII 19	5.71 $\pm$ 0.64	5.15 $\pm$ 1.09	29 $\pm$ 4.56	25 $\pm$ 7.99
RRII 20	6.25 $\pm$ 0.83	5.14 $\pm$ 1.52	36 $\pm$ 5.55	25 $\pm$ 7.20
RRII 21	7.85 $\pm$ 0.79	5.92 $\pm$ 1.60*	31 $\pm$ 4.15	27 $\pm$ 5.79*
RRII 108	6.36 $\pm$ 1.01	4.72 $\pm$ 0.70	28 $\pm$ 6.87	23 $\pm$ 4.90
RRII 112	5.21 $\pm$ 0.59	4.47 $\pm$ 1.00	27 $\pm$ 5.43	19 $\pm$ 3.60
RRII 115	5.98 $\pm$ 1.83	4.25 $\pm$ 1.16	21 $\pm$ 4.49	18 $\pm$ 6.37
RRII 119	7.07 $\pm$ 1.09	5.15 $\pm$ 0.63	31 $\pm$ 4.14	24 $\pm$ 2.35
Tjir 1 (control)	8.59 $\pm$ 2.16	6.38 $\pm$ 1.14	26 $\pm$ 6.51	24 $\pm$ 6.75
General Mean	6.73	5.09	30	23

* S.E. Average of 5 samples only.

performance did not show significant differences. Yield depression due to wintering was highest for RRII 108, while RRII 2 showed the highest girth increment on tapping. Clonal differences for bark anatomical characters were statistically significant.

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COMPARATIVE BARK ANATOMY OF THREE INDUCED POLYPLOIDS OF *HEVEA BRASILIENSIS* (WILLD. EX. A. JUSS) MUELL. ARG. AND THEIR DIPLOIDS

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ABSTRACT

Comparative bark anatomy of the mature trees of three induced polyploids of *Hevea brasiliensis* and their respective diploids (GT 1, Tjir 1 and RRII 105) was studied to explore the feasibility of polyploidization as a tool for crop improvement in *Hevea*.

Two of the clones studied, GT 1 and Tjir 1 showed considerable reduction in bark thickness, number of latex vessel rows and the density of laticifer rows along with highly increased height and width of the phloem rays. The difference between the tetraploids and the diploids was not pronounced for RRII 105 with respect to bark thickness and number of latex vessel rows. The diameter of laticifers and the extent of anastomosing were also high for the polyploids of GT 1 and Tjir 1 compared to their diploids while this difference also was negligible in the case of RRII 105. However, a tendency for higher size and reduced number of cells for the polyploids was indicated that the response was clone-specific. The possible effect of these characteristics are discussed.

INTRODUCTION

Hevea brasiliensis has a chromosome complement of $2n = 36$. In earlier years several workers (Markose, 1975; Mendes, 1969; Shepherd, 1969) attempted to produce induced polyploids in this species. In India autotetraploids were evolved both from seeds and vegetative buds using aqueous solution of colchicine. Quantitative studies on certain leaf characters like leaf thickness, leaf weight, lateral vein divergence, stomatal characters and the stem and foliar indices of the induced tetraploids have also been made at the immature age (Markose, 1975).

Hevea being a commercial crop and its economic product being obtained from the latex produced in laticiferous tissue of the bark, the variability induced in the bark characters is very important. Reports on the characters of mature trees of *Hevea* at higher ploidy level, especially on the bark

anatomical characters are scanty. Quantitative estimations of certain bark anatomical traits of three induced tetraploids in comparison to their respective diploids of *Hevea brasiliensis* were made. The results and their implications are discussed.

MATERIALS AND METHODS

An induced seedling tetraploid of Tjir 1, obtained by treating seeds with 0.75% aqueous solution of colchicine and cloned later, a tetraploid of GT 1 and another of RRII 105, both obtained by treating the vegetative buds of the respective clones, were taken for this study along with their diploids at comparable ages. Tjir 1 and GT 1 were available from a trial laid out in 1971 and RRII 105 from an observational trial planted in 1977 at the Central Experiment Station of RRII at Chethackal.

Three trees at random per clone of the

tetraploids and the respective diploids were selected. Samples of virgin bark at a height of 150 cm from the bud union were collected and fixed in formalin acetic alcohol. Radial longitudinal sections of 120 μm thickness and tangential longitudinal sections 80 μm thickness were cut using a sledge microtome. The sections were stained with Sudan III and observed under the microscope. The following characters were recorded from three sections per bark sample.

- (1) Thickness of soft bast and hard bast;
- (2) Number of laticifer rows;
- (3) Height and width of phloic rays in the laticifer layer;
- (4) Laticifer density (number of laticifers per unit circumference of the tree);
- (5) Diameter of laticifers;
- (6) Number of connections within 0.5 mm height of the laticifers.

For characters 3–6, five observations per section have been taken.

RESULTS

The thickness of bark and number of latex vessel rows are shown in Tables I and II respectively. At the tenth year of planting GT 1 tetraploid had a mean thickness of only 1.77 millimetre. At the same age the respective diploid had attained 7.63 mm thickness of bark. A similar trend was noticed for Tjir 1 also in which the mean bark thickness of the tetraploid and its diploid were 4.04 mm and 6.93 mm respectively. In the case of RRII 105, four year old tetraploid was comparable to the diploid for bark thickness, the mean values being 4.11 and 4.44.

The retarded growth of polyploids was evident with regard to the girth also. At the ninth year of planting the average girth of GT 1 tetraploid in the field was only 16 cm and that of Tjir 1 tetraploid was 52.5 cm, when the respective diploids had attained 80 cms and 79 cms respectively (personal communication from late V. C. Markose). The mature trees of these two polyploid clones

also showed comparatively lesser tree height on visual observation.

The tetraploids of GT 1 and Tjir 1 recorded very low number of latex vessel rows (Table II) the mean values being 3.89 and 6.89 respectively against the corresponding values 16.22 and 19.00 recorded for the respective diploids. RRII 105 did not show such a wide difference between the two ploidy levels with respect to this character.

On the contrary the laticifer diameter was higher for the tetraploids of GT 1 and Tjir 1 (Table IV), the mean values being 24.24 μm and 25.16 μm respectively against 21.51 μm and 21.87 μm for their respective diploids. Practically there was no difference between the two ploidy levels in the case of RRII 105 in which the tetraploid recorded a mean laticifer diameter of 22.93 μm against 22.60 μm for the diploid.

The density of laticifers/row and the density of connection between latex vessels are also shown in Table IV. In all the three clones, laticifer density was low and density of connections between laticifers was high for the tetraploids than their respective diploids. The mean laticifer density recorded for the tetraploids of GT 1, Tjir 1 and RRII 105 were 20.83, 21.39 and 22.19 against the corresponding values for the respective diploids 26.33, 25.83 and 26.13. With respect to the density of connection between laticifers, the mean values recorded for the tetraploids of the three clones in the order mentioned above were 11.44, 11.51 and 9.07, the corresponding values for the respective diploids being 10.80, 10.44 and 8.87.

Very wide phloic rays was a characteristic feature of the tetraploids in all the three clones under study. The mean values recorded for the tetraploids of GT 1, Tjir 1 and RRII 105, regarding this trait, were 74.80 μm , 70.93 μm and 62.03 μm respectively

Bark anatomy of polyploids in *Hevea*

Table I. Bark thickness of the tetraploids and their diploids (Mean $\pm$ S.D.)

Clone	Soft bast (mm)		Hard bast (mm)		Total (mm)	
	Tetraploid	Diploid	Tetraploid	Diploid	Tetraploid	Diploid
GT 1 (10 years)	0.63 $\pm$ 0.40	1.56 $\pm$ 0.21	1.14 $\pm$ 0.48	5.24 $\pm$ 0.60	1.77 $\pm$ 0.46	7.63 $\pm$ 0.97
Tjir 1 (10 years)	1.73 $\pm$ 0.28	2.12 $\pm$ 0.57	2.30 $\pm$ 0.69	4.75 $\pm$ 1.54	4.04 $\pm$ 0.64	6.93 $\pm$ 1.23
RRII 105 (4 years)	1.55 $\pm$ 0.19	1.45 $\pm$ 0.23	2.55 $\pm$ 0.55	3.08 $\pm$ 0.38	4.11 $\pm$ 0.48	4.44 $\pm$ 0.48

Figures in parenthesis indicate age of trees.

Table II. Number of latex vessel rows in the tetraploids and the diploids (Mean $\pm$ S.D.)

Clone	Soft bast		Hard bast		Total	
	Tetraploid	Diploid	Tetraploid	Diploid	Tetraploid	Diploid
GT 1 (10 years)	3.89 $\pm$ 0.35	11.44 $\pm$ 3.24	—	4.78 $\pm$ 1.99	3.89 $\pm$ 0.35	16.22 $\pm$ 3.03
Tjir 1 (10 years)	5.67 $\pm$ 1.5	12.22 $\pm$ 1.20	1.11 $\pm$ 0.33	6.78 $\pm$ 3.31	6.89 $\pm$ 1.27	19.00 $\pm$ 3.00
RRII 105 (4 years)	3.78 $\pm$ 0.67	3.11 $\pm$ 0.60	1.22 $\pm$ 0.44	2.33 $\pm$ 1.12	5.00 $\pm$ 0.50	5.44 $\pm$ 1.50

Figures in parenthesis indicate age of trees.

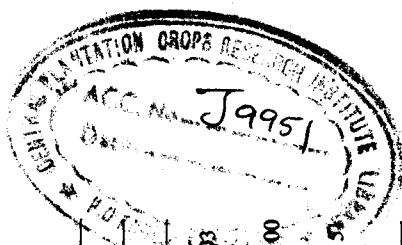


Table III. *Phloic rays in the tetraploids and their diploids (mean $\pm$ S.D.)*

Clone	Mean height μm		Mean width μm	
	Tetraploid	Diploid	Tetraploid	Diploid
GT 1 (10 years)	736.67 $\pm$ 130.15	472.6 $\pm$ 67.91	74.80 $\pm$ 3.39	52.51 $\pm$ 3.00
Tjir 1 (10 years)	548.53 $\pm$ 66.3	392.5 $\pm$ 47.23	70.93 $\pm$ 5.13	52.89 $\pm$ 8.69
RRII 105 (4 years)	445.13 $\pm$ 68.14	462.4 $\pm$ 73.32	62.03 $\pm$ 5.06	50.58 $\pm$ 2.84

Figures in parenthesis indicate age of trees.

Table IV. *Density, diameter and the intensity of anastomosing of laticifers in tetraploids and their diploids (Mean $\pm$ S.D.)*

Clone	Vessel density per 1 mm		Vessel diameter (μm)		No. of connection per 0.5 mm height	
	Tetraploid	Diploid	Tetraploid	Diploid	Tetraploid	Diploid
GT 1 (10 years)	20.83 $\pm$ 1.44	26.33 $\pm$ 3.67	24.24 $\pm$ 1.22	21.51 $\pm$ 1.23	11.44 $\pm$ 0.53	10.80 $\pm$ 0.82
Tjir 1 (10 years)	21.39 $\pm$ 2.20	25.83 $\pm$ 2.50	25.16 $\pm$ 1.69	21.87 $\pm$ 1.55	11.51 $\pm$ 0.11	10.44 $\pm$ 0.76
RRII 105 (4 years)	22.19 $\pm$ 1.60	26.13 $\pm$ 1.81	22.93 $\pm$ 0.63	22.60 $\pm$ 0.71	9.07 $\pm$ 0.15	8.87 $\pm$ 0.43

Figures in parenthesis indicate age of trees.

against the corresponding values for their diploids 52.51 μm , 52.89 μm and 50.58 μm . Ray height also showed the same trend with respect to GT 1 and Tjir 1 while the data of RR11 105 did not show such a difference between the two ploidy levels (Table III).

DISCUSSION

One of the effects of polyploidy is an increase in cell size. This need not increase the size of the plant as a whole because polyploidy often leads to reduction in the number of cell division during development (Stebbins, 1971; Indira and Abraham Susan, 1977). Retarded initial growth of buds after colchicine treatment has been reported in many plants and also in *Hevea* (Shepherd, 1969). Earlier reports on reduced number and larger size of stomata, associated with tetraploidy in *Hevea* (Mendes, 1969; Mendes and Mendes, 1963) already indicated a tendency for reduction in cell numbers and increase in cell size at higher ploidy level. An increase in leaf blade thickness and leaf weight can be attributed to the increased size of mesophyll tissue. However, *Hevea* is reported to be a tetraploid adapted to the environment while most other species in the family are diploids having chromosome complement of $2n = 18$ (Majumdar, 1964 and Shepherd, 1969).

In the present study, reduction in stem girth, bark thickness, number of laticifer rows, laticifer density and tree height was noticed in the mature trees of GT 1 and Tjir 1. There was no improvement of any of these traits due to high ploidy level in RR11 105 also although the differences between the tetraploid and the diploid were not so pronounced as in the case of the other two clones. An increase in diameter of laticifers as well as broader and longer phloic rays were the characters of tetraploids. Although this effect was only less pronounced in the case of RR11 105.

In this context it is relevant to say that RR11 105, available for this study had attained only four years growth *i.e.*, just covered the stage of canopy closure. The growth retardation effect due to higher cell size is generally affected at a stage when the plants face competition for space, food or interference of the environment. Earlier reports on increased vigour of RR11 105 (Saraswathy Amma *et al.*, 1984) and IAN 45, 873 (Mendes, 1969) associated with autotetraploidy were based on the observations of young plants, *i.e.*, after two years of growth in the case of RR11 105 and only after nine months growth in the case of IAN 45,873. There was no further report on the latter. Markose (1975) observed higher stem index for young plants of GT 1 tetraploids. However, the clone showed reduced growth in the field as observed in the present study.

Anatomical traits like bark thickness and number of laticifer rows are clonal characteristics (Gomez and Chen, 1967; Gomez, Narayanan and Chen, 1973; Narayanan, Ho and Chen, 1974), influencing the yield of *Hevea* clones (Narayanan, Gomez and Chen, 1973; Ho, Narayanan and Chen, 1973). Positive linear relationship between the number of laticifer rows and initial rate of flow has also been advocated (Sethuraj, Sulochana and George, 1974).

Significant clonal variations of the height and width of phloic rays and the effect of these traits on the orientation of laticifers in *Hevea* clones have been reported (Premakumari, Panikkar and Joseph, 1985). Further studies have indicated the bearing of laticifer orientation and laticifer quantity, in terms of cross sectional area, on the yield of *Hevea* clones (Premakumari, Panikkar and Joseph, 1988). Considerable reductions in the number of laticifer rows and laticifer density along with low girthing in the tetraploids assure a steep fall in the total cross

sectional area of laticifers in the tetraploids. A slight increase in laticifer diameter cannot be the least adequate compensation for this effect.

Width of phloic rays have significant negative association with the density of laticifers at genotypic and phenotypic levels (Premakumari et al, 1984). Waviness of laticifers due to broad rays may affect the rate of latex flow also. Hence the broad phloic rays of tetraploids is not an appreciable trait as far as the yield is concerned.

The technique of polyploidy is usually employed to induce genetic variability and exploit the useful traits directly or by further breeding and selection. As far as *Hevea* is concerned, the anatomical traits and the general tendency discussed above do not promise improvement of yield or growth by this technique although the possibility of inducing other desirable traits cannot be ruled out.

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ISOLATION BARRIERS OF DIPLOID SPECIES (*COFFEA RACEMOSA* LOUR AND *C. CANEPHORA* PIERRE) AS REFLECTED IN THEIR HYBRIDS

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ABSTRACT

Hybrids between the two cross-fertile and distant diploid species ($2n = 22$), *Coffea racemosa* Lour and *C. canephora* var. *laurantii* sub var. 'robusta' were studied and found that high sterility barriers are in operation as reflected in the diploid F_1 hybrids. Under open pollination there was some fruit set which gave rise to F_2 population with varied chromosome numbers. This fertility was not determined by the chromosome affinity shown in certain per cent of cells in F_1 and F_2 hybrids.

Reproductive isolation of the parent species delimiting the gene exchange has been pointed out in relation to the cytomorphology of these hybrids.

INTRODUCTION

Interspecific hybridization not only between the tetraploid ($4n = 44$) *C. arabica* L. and the diploid species, but also between the diploid ($2n = 22$) species of different sub-sections of the section *Eucoffea* of the genus *Coffea* L. have been well documented from Brazil (Sybenga, 1960), India (Ramanathan, Ball and Thomas 1951, Narasimhaswamy and Vishweshwara 1961, 1967) and Indonesia (Cramer 1957).

In the process to obtain drought hardy hybrids with less caffeine content and early ripening quality, the exotic diploid species viz., *C. racemosa* Lour of the sub-section *Mozambicoffea* was crossed with the diploid *C. canephora* cv. *robusta*, S. 2597 in Central Coffee Research Institute, Coffee Research Station, Chikmagalur, Karnataka (Anonymous 1971, 1978 and 1979). The observations made on the parental crossability and

as to the hybrid behaviour during the period from 1985 to 1987 are reported here.

MATERIALS AND METHODS

C. racemosa ($2n = 22$) from C.I.F.C. Portugal established in 1958 and maintained at the Central Coffee Research Institute under Culture No. S. 2004 was utilized as the female parent (10/9). The male parent (14/29), a *Robusta* ($2n = 22$) under Culture No. S. 2597 with parentage of S. 26 ($2n = 44$) and *Robusta* ($2n = 22$) was established during 1963. The F_1 ($2n = 22$) between the two was established in March 1971 under culture No. S. 3678. These F_1 hybrids like parents were self-sterile and did not yield any seed for three consecutive years even on Sibmatings. Under open pollination alone the plants yielded a few seeds from which F_2 (S. 4088-4099) were raised in 1977 and they consisted of both diploids ($2n = 22$) and tetraploids ($2n = 44$).

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Ten plants each of the parents and the existing 16 F₁ and 19 F₂ plants were taken for studies. Means ($\bar{X}$) and coefficients of variation (CV) were calculated for plant, leaf, flower and fruit characters of the parents and progeny, taking minimum of 20 leaves, 9 minimum fruiting nodes and 25 floral nodes. The leaf colour was compared with Munsell colour charts (Wilde and Voigt 1952).

PMC meiosis in the flower buds was induced, and the anthers were fixed at suitable stage and smears made as described elsewhere (Reddy, 1976; Reddy and Narayan, 1981). Chromosome associations and chiasma frequency in 10 plants each of the parents and F₁ and in five of the diploids and four tetraploids of the F₂ were recorded at diakinesis and metaphase I. Means, standard deviations and co-efficients of variation were calculated and presented in Tables I, II and III.

Frequency of abnormalities in the PMCs from diakinesis to telophase II and in pollen were recorded (Table IV). Functional pollen was estimated by using Alexander's (1969) stain.

RESULTS

Morphology

The parent species showed marked differences in plant growth, leaf, floral and fruit characters (Tables V and VI).

The F₁ hybrids are less vigorous and mostly of an intermediary group with respect to morphological features such as leaf dimensions, base angle, petiole length and leaf-tip length into consideration (Tables V and VI). These characters, save leaf tip length fell within the parental mean. The flowers and fruits per node in F₁ were far below the parental mean but similar to the female parent *i.e.*, *C. racemosa*. While the qualitative character like young leaf colour

Table I. *Distribution of chiasmata in bivalents and per cent of pairing at diakinesis in two diploid species of Coffea and their progeny*

Species/Hybrid	Bivalents with						Univalents			Pair- ing	Total No. cells
	I-Chiasma			2-Chiasmata			$\bar{X}$	SD	CV		
	$\bar{X}$	SD	CV	$\bar{X}$	SD	CV					
<i>Coffea racemosa</i>	5.47 (4-7)	0.92	16.85	5.2 (4-7)	1.04	20.10	0.67 (0-2)	0.94	141.4	93.33	60
<i>Coffea</i> 'robusta'+ (S. 2597)	5.86 (4-7)	1.06	18.06	4.98 (4-6)	0.81	16.30	0.32 (0-2)	0.73	229.0	84.07	50
F ₁ (C. 3678)	7.48 (1-10)	1.84	24.50	1.98 (0-9)	1.83	92.30	2.88 (0-10)	2.26	78.45	18.00	50
F ₂ * diploids from open polli- nated F ₁ (C. 4088-4099)	5.50 (3-8)	1.15	20.90	4.72 (2-7)	1.10	23.22	2.44 (0-6)	1.13	46.40	46.00	50

+ Secondary association of bivalents in 76.67% of p.m. cs observed.

* Bivalents with 3-chiasmata at mean frequency of 0.12 (0-1) SD, 0.32 and CV, 270% also were observed.

Table II. *Distribution of chiasmata in bivalents and per cent pairing at metaphase I in two diploid species of Coffea and their progeny*

Species/Hybrid	Bivalents						Univalents			Pairing	Total Cells
	1-Chiasma			2-Chiasmata			$\bar{X}$	SD	CV		
	$\bar{X}$	SD	CV	$\bar{X}$	SD	CV					
<i>C. racemosa</i>	8.75 (7-11)	0.94	10.80	2.11 (0-4)	0.93	44.0	0.27 (0-4)	0.77	289	83.33	60
<i>C. 'robusta'</i> (S. 2597)*	8.72 (7-11)	1.17	13.40	1.62 (0-4)	1.07	66.4	1.32 (0-6)	1.77	134	54.00	50
F ₁ (C. 3678)	7.98 (5-11)	1.12	14.06	0.72 (0-3)	0.94	130.0	4.6 (0-8)	1.76	38.2	6.00	50
F ₂ diploids from open-pollinated F ₁ (C. 4088-4099)	8.2 (7-10)	1.05	12.75	1.2 (0-3)	1.10	92.3	3.2 (0-4)	1.22	38.2	6.67	60

* Secondary association of bivalents in 22.73% of p.m. cs observed.

Table III. *Chromosomal associations at meiotic stages in F₂ tetraploids from the open-pollinated F₁ (C. 3678)*

Chromosomal associations	Diakinesis			Metaphase I		
	$\bar{X}$	SD	CV	$\bar{X}$	SD	CV
Univalents	3.63 (0-7)	1.74	48.0	6.07 (3-10)	2.36	38.8
Bivalents	7.17 (2-10)	1.97	27.5	6.18 (3-10)	2.43	39.3
Trivalents	2.5 (0-4)	1.40	55.9	3.39 (0-4)	1.39	41.2
Tetralents	2.97 (1-4)	0.93	31.4	2.68 (2-4)	0.60	22.7
Multivalents	1.13 (0-2)	0.75	66.5	0.88 (0-2)	0.71	81.57
	1.125	0.7479	66.48	—	—	—
No. of PMC observed	40			40		

Figures in parenthesis indicate the range.

had red to red-yellow-red hue as of *racemosa* in 62.5% and yellow hue in 37.5% of F₁ population as in the *canephora* parent.

The F₂ population was more vigorous and a few of the characters crossed the parental mean (Table VI).

The meiotic genome behaviour in the two diploid parents (2n = 22) viz., *C. racemosa* and *C. robusta* Cv S. 2597 and the pairing behaviour in their F₁ (C. 3678) progeny are given in Tables I and II. The female parent had perfect pairing in 88-93 % of

Table IV. Average percentages of abnormalities at PMC meiosis and abnormal pollen in two diploid species of *Coffea* and their progeny

Species/Hybrid	Abnormalities* at		Total No. of cells scored	Stainable pollen	Total No. of Pollen scored	Abnormal* pollen	Total pollen scored
	Meiosis I	Meiosis II					
<i>Coffea racemosa</i>	1.25	1.25	1600	92.0	500	2.49	402
<i>Coffea robusta</i> (S. 2597)	2.40	3.00	1000	89.2	650	11.50	600
F ₁ C. 3678	96.8	98.00	777	9.19	5683	55.3	550
F ₂ diploids from open-pollinated F ₁ (C. 4088-4099)	89.0	96.00	784	22.5	5000	47.5	600
F ₂ Tetraploid from open pollinated F ₁ (C. 4088-4099)	91.1	66.70	1107	92.0	1000	59.1	1546

* Univalents at diakinesis and metaphase I. Division of Univalents (in hybrids), precocious movement of univalents and bivalents, irregular distribution at anaphase I and II, irregular grouping at metaphase II and persisting laggards at telephase I and II resulting diads, triads and polyads.

p.m. cs in the heterotic meiosis with occasional univalents which lead to the incidence of stray irregularities in meiosis I and II in 2.50% of cells and in pollen formation.

In the male parent *C. robusta* C. 2597, 84% of cells had 11 bivalents at diakinesis; at metaphase I pairing was noticed only in 54% PMCS I. The univalents from the initial 0-1 rose to 0-3 in metaphase I. Secondary association of bivalents in 22.73 to 76.67% of cells was noticed. In late stages 3% of cells had meiotic abnormalities and consequent abnormal pollen formation in 11.50% of cells.

The F₁ hybrids being diploid (2n = 22) were akin to the parents sans fertility. Pairing observed in only 18% cells at diakinesis and 6% at Metaphase I. Univalents ranged from 0-5. Thus meiosis was totally impaired leading to pollen abnormalities and sterility.

The F₂ population of 19 plants were vigorous consisted both of diploids (15) as

well as tetraploids (4). The F₂ diploids of unknown male parent had similar meiosis and sterile pollen production as in F₁. Tetraploids exhibited univalents and multivalents in 95% of cells at diakinesis and resulted in abnormal meiosis in 66 to 91% of cells which however did not make them totally sterile.

DISCUSSION

While assessing the genetic relationship of a few of the species of the section *Eucoffea* of the genus *Coffea* L. Carvalho and Monaco (1967) found that most including the diploid species under report viz., *C. canephora* and *C. racemosa* are allopatric in their distribution, the former habiting Congo river basin while the latter confined to the far south eastern Mozambique. As a result of this spatial isolation hybrids between the diploid species in their natural habitat has been very low, observed by Singh Daliwal, Melandez-Gonzales and Torres Sepulveda 1969.

Although several of these diploid species as well as the tetraploid *C. arabica* are

Table V. Mean, standard deviation and coefficient of variation of different plant characters of the diploid species and their hybrids

Species/Hybrid	Plant character	$\bar{X}$	SD	CV (%)
<i>C. racemosa</i>	Stem girth (cm)	28.45	4.5741	16.07
<i>C. 'robusta'</i> <i>C. 2597</i>	"	131.9	23.308	17.67
<i>F₁ 3678</i>	"	20.125	3.586	17.82
<i>F₂ 4088-4099</i>	"	14.9	4.1851	28.10
<i>C. racemosa</i>	Plant height (cm)	126.0	40.38	32.05
<i>C. 'robusta'</i> <i>C. 2597</i>	"	131.9	23.308	17.67
<i>F₁ 3678</i>	"	107.31	19.937	18.58
<i>F₂ C. 4088-4099</i>	"	93.26	14.24	15.27
<i>C. racemosa</i>	Bush radius (cm)	179.9	58.91	32.75
<i>C. 'robusta'</i> <i>C. 2597</i>	"	182.4	17.6985	9.70
<i>F₁ 3678</i>	"	147.00	23.417	15.93
<i>F₂ C. 4088-4099</i>	"	111.31	34.7815	31.25
<i>C. racemosa</i>	Flowers/node	4.707	0.3969	21.24
<i>C. 'robusta'</i> <i>C. 2597</i>	"	22.496	9.957	44.862
<i>F₁ 3678</i>	"	110.66	4.1356	40.00
<i>F₂ C. 4088-4099</i>	"	12.1847	4.9889	42.13
<i>C. racemosa</i>	Fruits/node	1.5274	0.6374	40.648
<i>C. 'robusta'</i> <i>C. 2597</i>	"	8.579	4.9925	57.52
<i>F₁ 3678</i>	"	1.4668	0.7708	51.43
<i>F₂ C. 4088-4099</i>	"	1.6349	0.8443	36.26

spatially isolated in their natural habitat are nevertheless crossable but showed varied degree of vigour and fertility (Carvalho and Monaco 1967, Narasimhaswamy and Vishweshwara 1961, 1967, Reddy and Narayan 1981). On the other hand there were strong incompatibility barriers

between members of the sub-section Mozambicoffea viz., *C. racemosa*, *C. kapakata*, *C. salvatrix* and members of the Pachycoffea (*C. liberica*, *C. dewevrei*) and of Melanocoffea (*C. stenophylla*) as these crosses were not successful. Further the self sterility in *C. racemosa* is reported

Table VI. Mean, standard deviation and co-efficient of variation of different leaf characters of the diploid species and their hybrids

Species/Hybrid	Leaf character	$\bar{X}$	SD	CV%
<i>C. racemosa</i>	Leaf length (cm)	6.3143	0.7742	12.34
<i>C. 'robusta'</i> <i>C. 2597</i>	"	20.109	3.5749	17.82
<i>F</i> ₁ 3678	"	11.2279	1.5484	13.9054
<i>F</i> ₂ <i>C. 4088-4099</i>	"	11.2632	1.7981	16.0672
<i>C. racemosa</i>	Leaf breadth (cm)	2.7406	0.3859	14.2467
<i>C. 'robusta'</i> <i>C. 2597</i>	"	9.032	1.7926	19.7762
<i>F</i> ₁ 3678	"	4.4724	0.5994	13.4056
<i>F</i> ₂ <i>C. 4088-4099</i>	"	5.4821	0.9541	17.3574
<i>C. racemosa</i>	Base angle (°)	24.6469	3.2695	13.2947
<i>C. 'robusta'</i> <i>C. 2597</i>	"	41.492	7.0015	16.833
<i>F</i> ₁ 3678	"	31.1023	3.8395	12.3095
<i>F</i> ₂ <i>C. 4088-4099</i>	"	39.8674	4.7319	11.9289
<i>C. racemosa</i>	Petiole length (cm)	2.981	0.711	26.2327
<i>C. 'robusta'</i> <i>C. 2597</i>	"	12.486	3.1042	25.161
<i>F</i> ₁ 3678	"	5.1765	0.8439	16.097
<i>F</i> ₂ <i>C. 4088-4099</i>	"	6.38	1.1368	18.54
<i>C. racemosa</i>	Leaf tip length (cm)	2.0625	1.051	84.081
<i>C. 'robusta'</i> <i>C. 2597</i>	"	11.55	3.7094	40.614
<i>F</i> ₁ 3678	"	6.9606	1.6281	23.0306
<i>F</i> ₂ <i>C. 4088-4099</i>	"	8.1216	2.3425	32.98

to be controlled by 5 S-alleles of gametic sterility according to Santa Ram and Sreenivasan (1984). The species is cross-fertile as in *C. canephora* noted by Devreux et al (1959). Despite the fact, crossability of *C. racemosa* with members of the subsection *Erythrocoffea* viz. *C. arabica* and *C. canephora* and *C. congensis* was 0.9%, 1.3% and 1.9% respectively in

Brazil as observed by Carvalho and Monaco (1967).

In India, besides the poor crossability of *C. canephora* and *C. racemosa* there was hybrid inviability to the tune of 90.3% as only 16 seedlings survived out of 125 seeds obtained from the total pollinated flowers. Further there was total hybrid

sterility in F_1 . The sterility was reflected in the low pairing of parental genomes, followed by total break-down of meiotic process and pollen sterility in the F_1 hybrids. Louarn (1976) was of the opinion that F_1 between diploid species viz, *C. canephora* x *C. eugenioides* were almost excluded from any fertility and the F_2 could be exploited for improvement.

The F_2 from the open-pollinated F_1 studied were vigorous and consisted of both diploids ($2n = 22$) and tetraploids ($4n = 44$). Improved pairing in F_2 (open pollinated) diploids was observed. Among the tetraploids, although there was irregular pairing and frequent meiotic abnormalities, were having high per cent of functional pollen. The gametes even with unequal number of chromosomes appeared to be functional. Similar instances were reported by Sybenga (1960) and Reddy and Narayan 1981 with F_2 progenies of 'excelsa' x *eugenioides*.

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MODEL SYSTEMS FOR HYBRID SEED PRODUCTION IN ARABICA COFFEE

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ABSTRACT

Two model systems for the production of hybrid seed of *Coffea arabica* were presented. The first system stems from the concept of selective male sterilization of plants by chemicals. The study indicated the efficacy of CEPA and MH as selective male sterilents for coffee. The second system exploits the concept of competitive differences among the pollen from different inbred genotypes leading to unilateral fertilizations and consequent hybrid production when appropriate combinations were made. Present study indicated that the combinations (Hibrido-di-Timor and Agaro), (Hibrido-di-Timor and Geisha) and (Hibrido-di-Timor and Cioccie) are good for hybrid production; on the basis of the pollen of Hibrido-di-Timor being least competitive in the styles of Agaro, Geisha and Cioccie as well as the self style. Implications of these studies on the evolution of a field procedure for the production of hybrid seed of Arabica coffee was discussed.

INTRODUCTION

With the advent of 'Hybrid Corn' in the arena of practical agriculture more than a half century ago (Shull, 1909; Jones et al. 1917) the potential of hybrids for crop production is widely appreciated. This is reflected in the rapid succession of methods devised for hybrid seed production in crops such as onion (Jones and Clarke, 1943), tomato (Lapushner and Frankel, 1967) and vegetables (Gabelman, 1974). Hybrid seed of coffee was very much sought after; and a possible scheme to obtain hybrid seed was projected by van der Vossen and Walyaro (1981). Present paper attempts to present two potential models that can be exploited for hybrid seed production of Arabica coffee. Conceptual basis of these models is derived from the earlier studies on fertility manipulation (Rowell and Miller, 1971; Bennet and Hughes, 1972; Peretz et al., 1973; Frankel and Galun, 1977) and differential

competitive capabilities of pollen from different genotypes (Pfahler, 1983; Currah, 1983; McKenna and Mulcahy, 1983; Ottaviano, Sari Gorla and Arenari, 1983)

MATERIALS AND METHODS

Two separate experiments were conducted to elucidate the use of induced male-sterility and pollen competitive differences among coffee genotypes in hybrid seed production of *Coffea arabica* L.

1. Induced male-sterility experiment

Two gametocidal chemicals, 2-Chloroethyl phosphonic acid (CEPA) at 210 ppm and Maleic hydrazide (MH) at 100 ppm were used in this experiment (Rehm, 1952; Rowell and Miller, 1971). About 500 ml of the solutions of each chemical was applied to the experimental plants as a fine spray with the help of a backpack on the second day after watering. Each chemical was applied on 5 replicates and

5 untreated plants were considered as control. On the day of anthesis, controlled crosses were effected as follows:

- (i) CEPA treated x Normal
- (ii) CEPA treated self
- (iii) MH treated x Normal
- (iv) MH treated self
- (v) Normal self (Control)

Pollinated styles were harvested at 2 hourly intervals upto 8 hrs after pollination to assess the germination and elongation of pollen tube and the data are presented in Fig. 1.

2. Pollen competition experiment

Blossom was induced by irrigation, in the original collections of the four inbred genotypes of coffee; Agaro, Geisha, Cioccie

and Hibrido-di-Timor (HDT). Controlled crosses were effected as follows:

- (i) HDT x Agaro
 - (ii) HDT x Geisha
 - (iii) HDT x Cioccie
 - (iv) HDT self
 - (v) Agaro self
 - (vi) Geisha self
 - (vii) Cioccie self
- } and reciprocals

Pollinated styles were collected as in the previous experiment and the data are presented in the Fig. 2

Pollinated styles were spread on microscopic slides by the styler squash method (Sreenivasan, Vishweshwara and Ramachandran, 1975) and Alexander's stain (Alexander, 1969) was used to render the pollen

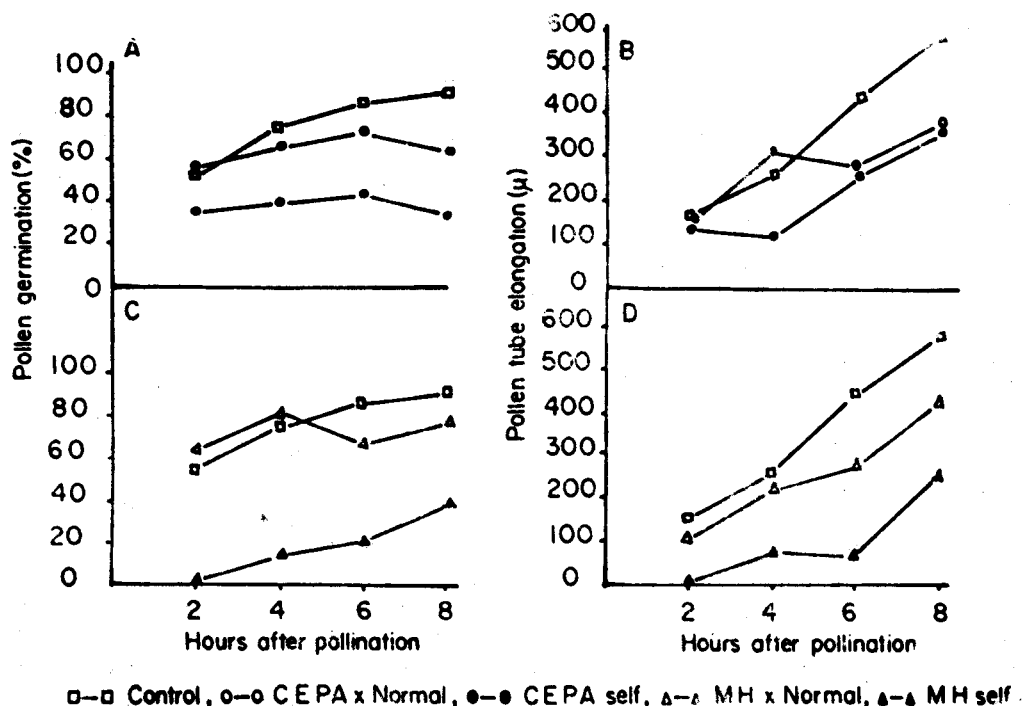


Fig. 1 Competitive capability of coffee pollen treated with CEPA and MH.

A. Germination of pollen in CEPA self, CEPA x Normal and Control. B. Pollen tube elongation in CEPA self, CEPA x Normal and Control. C. Germination of pollen in MH self, MH x Normal and Control. D. Pollen tube elongation in MH self, MH x Normal and Control.

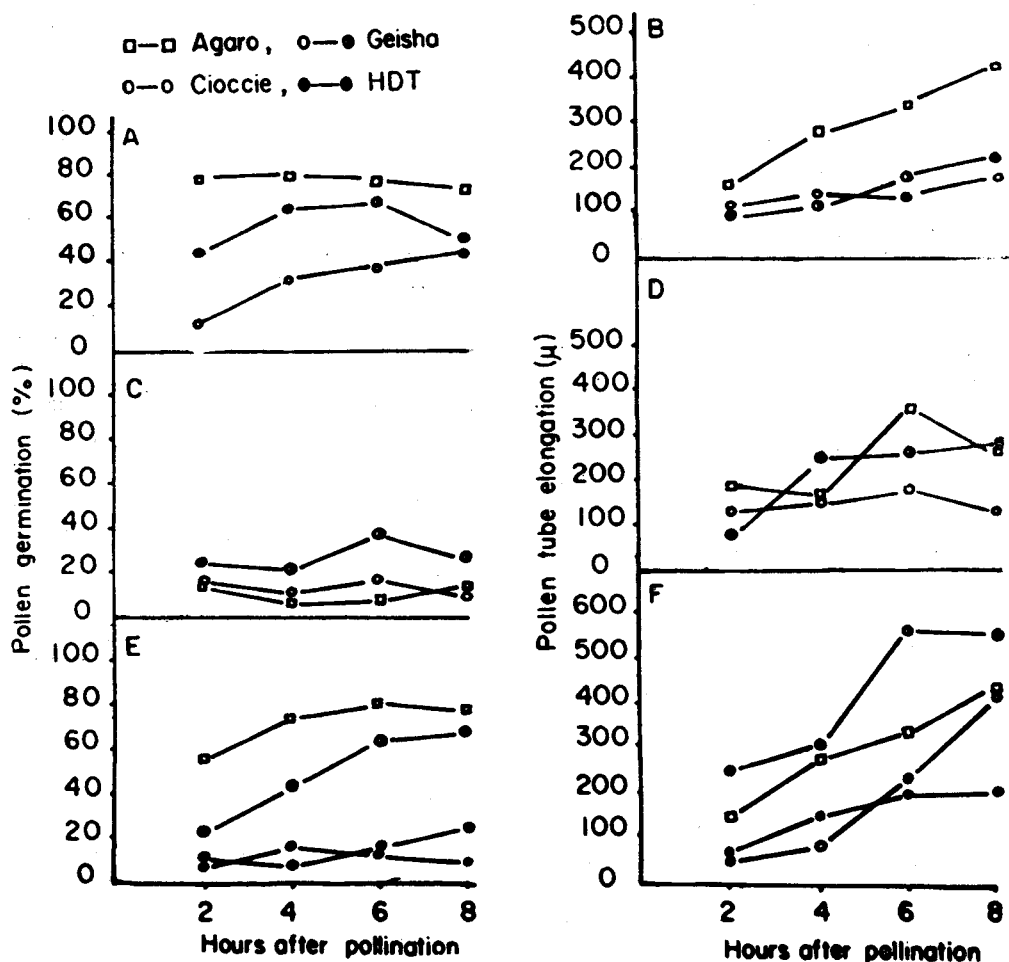


Fig. 2. Pollen competition patterns in coffee

A. Germination of pollen of Agaro, Geisha and Cioccie in HDT style. B. Elongation of pollen tubes of Agaro, Geisha and Cioccie in HDT style. C. Germination of HDT pollen in the styles of Agaro, Geisha and Cioccie. D. Elongation of pollen tubes of HDT in the styles of Agaro, Geisha and Cioccie. E. Germination of pollen in selfs of Agaro, Geisha, Cioccie and HDT. F. Pollen tube elongation in the selfs.

grains and pollen tubes observable. Germinated pollen grains were scored by observing the stigma in the microscope. Pollen tube length was measured by the use of an ocular micrometer. Pollen germination on the stigma and pollen tube elongation were considered the indices to measure the superiority of the source genotype as pollinator.

RESULTS AND DISCUSSION

Spontaneous male sterility exists in the genus *Coffea* (Ram, Jyothi and Sreenivasan, 1986), but its use in the breeding programmes is limited on account of the restorer sources being not known besides the long gestation periods required to arrive at a practical fertility manipulation

strategy. The following experiments were intended to circumvent these limitations and arrive at a field procedure for the production of coffee hybrid seed. van der Vossen and Walyaro (1981) outlined a scheme for the mass production of hybrid seed of coffee in Kenya. This scheme involves mass emasculation of all plants in the seed gardens and then artificially pollinating them with pollen from plants grown in a pollen supply garden. This is a labour intensive scheme and requires skilled labour. Present experiments depend more on the natural processes and circumvent the necessity of labour also.

1. Induced male sterility experiment:

In coffee, the micro- and mega- sporogenesis differ in time taken after the breakage of dormancy through rain/irrigation (Sybenga, 1961; Chinnappa, 1969). On this basis, the present experiment was devised to render the plants male-sterile by treating with selective male gametocides (Frankel and Galun, 1977).

In the two treatment selfs, germination of pollen grains on the stigma was hindered (Fig. 1A, C) (MH- O and CEPA- 36.65% at 2 hrs after pollination). However, there was a gradual increase of germination to a maximum extent of 38.75% (MH at 8 hrs) and 44.19% (CEPA at 6 hrs), while in control 90.60% pollen germination was recorded at 8 hrs after pollination. Germination of normal pollen on the treated stigmas was not hindered (MH-63.90% and CEPA- 57.17% at 2 hrs) and this has also shown a gradual increase (to 76.32% and 64.63% in MH and CEPA respectively at 8 hrs). A similar trend could be observed in the elongation of pollen tubes also (Fig. 1B, D). Thus, the pollen tubes produced by CEPA treated pollen have grown to a length of 374.08μ in 8 hrs time after pollination, while those from MH treated pollen

have grown to 260.52μ in such time. Normal pollen tubes in the CEPA and MH treated styles have elongated to 394.12μ and 420.84μ respectively in the same length of time. In the untreated styles of control, the pollen tubes extended to 591.18μ .

From the foregoing account it can be concluded that the two chemicals, CEPA and MH reduces pollen germinability significantly or make them competitively disadvantageous by reducing the pollen tube growth in the presence of normal pollen. Hence the two chemicals can be used as selective male sterility in coffee hybrid seed programmes. But the extent of recovery of hybrids may not be very high because the sterility induced is not complete.

2. Pollen competition experiment:

Differential competitive capabilities of the male gametophytes of different inbred genotypes and its application in gametophytic selection has become a major area of study in plant breeding (Pfahler, 1983). Present experiment aims at evaluating the competitive capabilities of the pollen of four different inbred genotypes of *C. arabica*: Hibrido-di-Timor (HDT), Agaro, Geisha and Cioccie.

Germination of HDT pollen was hindered in the stigmas of Agaro, Geisha and Cioccie (Fig. 2A, C), wherein a maximum germination of 15.03% (at 2 hrs), 38.65% (at 6 hrs) and 17.60% (at 2hrs) was observed respectively. Pollen tube elongation has also presented a similar trend (Fig. 2B, D). Thus HDT pollen tubes elongated to a maximum length of 367.40μ (in 6 hrs) in the styles of Agaro, while in the style of Geisha average maximum length of the pollen tubes recorded was 287.24μ and in the style of Cioccie it was 171.77μ (in 6 hrs).

Styles from the reciprocal crosses of the above combinations presented an interesting pattern of pollen germination and pollen tube growth. Thus the pollen of Agaro reached the maximum point of germination (79.13%) within 4 hrs after pollination on the stigma of HDT. It was 77.39% at 2 hrs after pollination. Geisha pollen was also favourably recognized in this stigma and germination at 2 hrs after pollination was 44.34% and it reached a maximum of 63.98% by 6 hrs. Cioccie pollen germinated more slowly on this stigma (13.81% at 2 hrs) and reached the maximum of 44.57% by 8 hrs after pollination. Pollen tube elongation has been found to follow a similar trend. Thus Agaro pollen tubes extended to a maximum average length of 422.51μ in 8 hrs, Geisha pollen tubes to 223.78μ in 8 hrs and Cioccie pollen tubes to a length of 176.39μ in 4 hrs after pollination.

From the foregoing account it can be concluded that the style of HDT can be a good receiver of pollen from the genotypes Agaro, Geisha and Cioccie in that order on the basis of their germination advantage. This data can be used in formulating the composites for hybrid seed gardens. However, before the formulation of composites for seed orchards, the possible interference/contamination due to self pollinations has to be evaluated and this was done by including the selfs of the four genotypes also in the study.

Germination of pollen in the selfed styles has also presented an interesting picture that can support the conclusion from the study of crossed styles. Thus, pollen germination on the self style of HDT reached a maximum of 17.92% at 2 hrs after pollination and the pollen tubes attained a maximum length of 206.06μ in 8 hrs. Agaro self pollen manifested the highest germination of 80.91% at 6 hrs and the pollen tubes reached the maximum length of 414.16μ in 8 hrs. Geisha pollen germination on the self style

reached the maximum point (69.20%) in 8 hrs and the pollen tubes extended to 561.12μ in the same period of time. Cioccie pollen germination in the self style was relatively poor (23.27% in 8 hrs) but the pollen tube elongation of 414.16μ was recorded at 8 hrs after pollination (Fig. 2 E, F).

From the above account of pollen-pistil interactions it can be concluded that the pollen of Agaro, Geisha and Cioccie are competitively superior to that of HDT in the self styles as well as the style of HDT. This study indicates that the competitive differences of pollen between inbred genotypes can be used for hybrid seed production in coffee.

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PHYSICAL CHARACTERISTICS OF COFFEE BEANS AS SELECTION INDICES

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ABSTRACT

Indian coffee is known world over for its quality. The planter is paid based on the visual assessment of his produce. Further, extra remuneration is based on the cup quality. The produce is graded into peaberry and A, B, C and T grades based on the physical standards of measurement and appearance.

At Central Coffee Research Institute, breeding is in progress since its inception. In the breeding programme importance is given for maximising the production of 'A' grade beans by eliminating the triage components. So far 12 arabica and three robusta genotypes have been released for commercial cultivation. In this article, procedures adopted to obtain the superior bean characteristics for commercial acceptance are discussed.

INTRODUCTION

There can be no question that the most efficient and economical means of improving the productive capacity of an agricultural crop lies in the long run, by planting the best possible plants produced through breeding. In coffee improvement programme, importance has been given for incorporating resistance to leaf rust (*Hemileia vastatrix* B & Br.). Due consideration was also given for quality, productivity and adaptability while evolving genotypes. To accomplish the target of producing suitable strains of coffee a massive germplasm bank has been established (Sreenivasan, 1986a). Standard methods of plant breeding such as introduction of germplasm, their assessment for leaf rust resistance and other characteristics, followed by hybridization and selection have been adopted. In most of the cases F_2 generation and onwards are given for commercial cultivation. So far, 12 arabica genotypes and three genotypes of robusta have been distributed for commercial cultivation. In the present paper, strategies adopted to produce

superior quality bean characteristics are presented.

MATERIALS AND METHODS

In the course of plant improvement programme, progenies evolved by different breeding techniques are constantly monitored for bean characteristics. The individual plants are assessed over a period of 3-4 years to determine the percentage of ovules yielding complete seeds. A maximum of 100 fruits are collected at maturity (Oct.-Nov.) and are cut transversely to determine the formation of peaberries, flat beans, multiovular, multilocular seeds and empty locules. Plants having maximum number of flat beans with least pea berries and empty locules coupled with other desirable characters such as leaf rust resistance and productivity are usually utilised in the breeding programme as mother plants. In addition, the final produce is also subjected to grading to the commercial standards (Table I).

Table I. *Bean characteristics in advanced generations (released for commercial cultivation) of station selections*

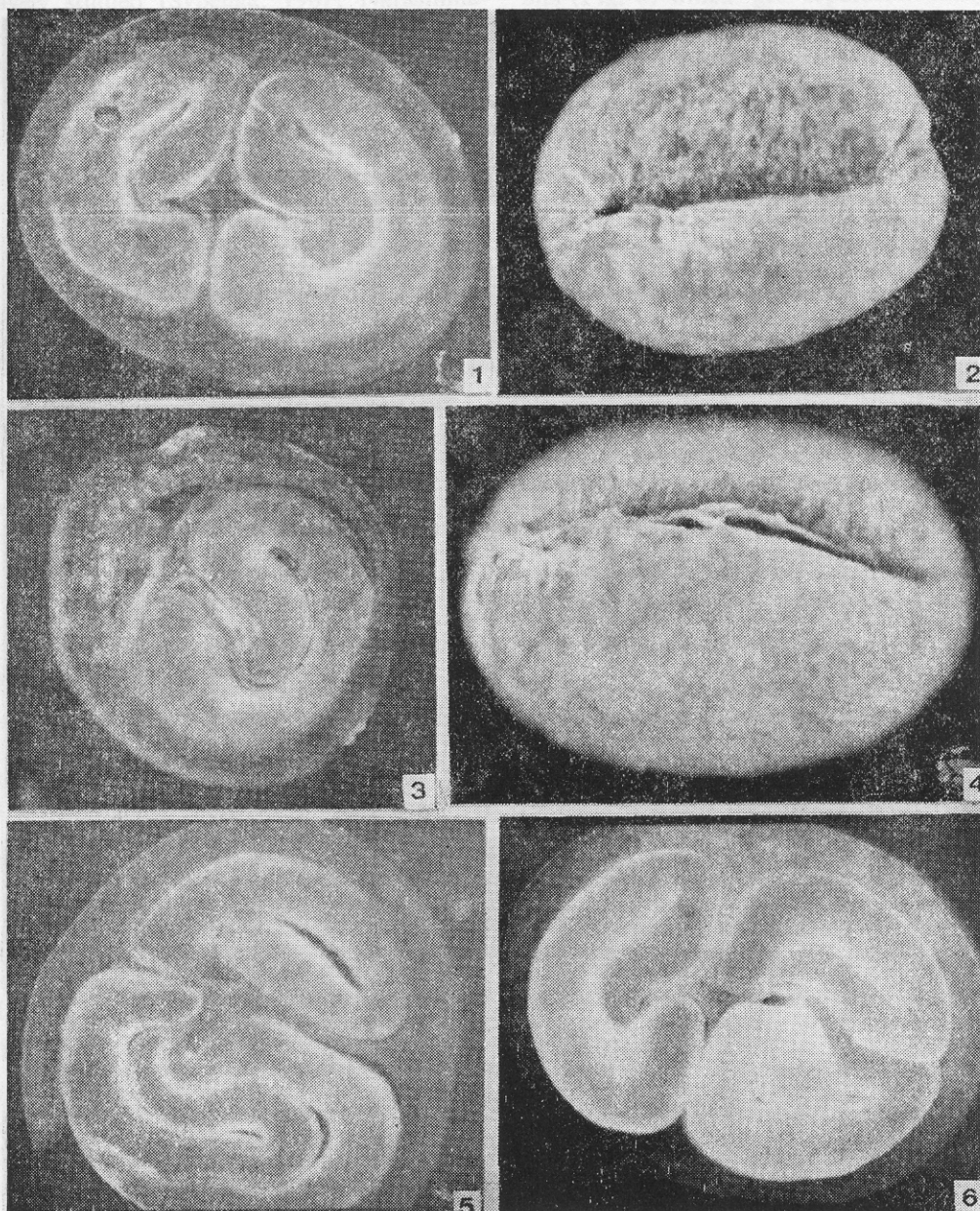
Sl. No.	Selection	Flats (%)				Pea berry (%)	Triage (%)
		A	B	C	Total		
Arabica							
1	Sln. 1	38.40	10.90	00.60	49.90	40.10	10.00
2	Sln. 3	65.00	10.00	05.60	80.60	10.15	09.25
3	Sln. 3.4	65.32	05.67	02.11	73.10	24.00	02.00
4	Sln. 4						
	Tafarikela	41.70	25.70	00.00	67.40	17.90	14.70
	Cioccie/Agaro	65.22	05.67	02.00	72.89	24.09	02.99
5	Sln. 5						
	A	30.00	50.00	04.00	84.00	10.00	06.00
	B	70.19	07.84	02.74	80.77	18.03	01.17
6	Sln. 6	69.32	09.83	00.27	79.42	13.17	07.41
7	Sln. 7.3	62.15	11.34	03.25	76.74	20.41	02.75
8	Sln. 8	59.70	26.90	00.00	86.60	08.75	04.65
9	Sln. 9	64.34	11.32	01.82	77.48	11.89	03.73
10	Sln. 10	63.23	11.38	00.45	75.06	13.55	09.49
11	Sln. 11	09.84	36.06	22.95	68.85	21.31	09.84
12	Cauvery	68.70	10.10	10.80	89.60	10.10	00.03
Robusta							
1	Sln. 1R	43.40	22.60	10.30	76.00	23.50	00.00
2	Sln. 2R	50.40	21.00	08.00	79.40	18.50	02.10
3	Sln. 3R	54.24	10.36	02.17	66.77	28.86	04.37

RESULTS AND DISCUSSION

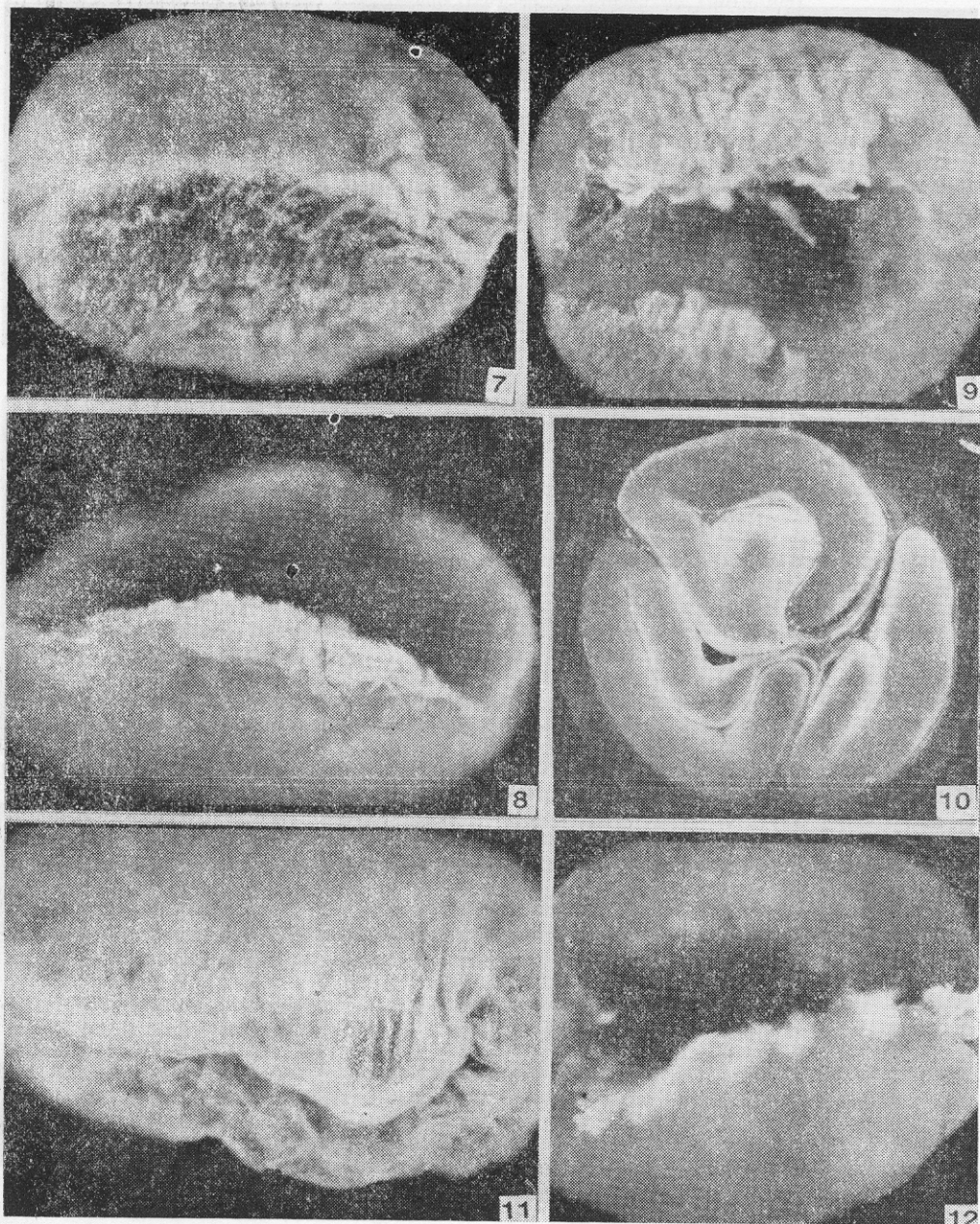
Production of defective beans in coffee could be attributed to the following three major factors *viz.*, constitutional (genetic), environmental and mechanical/processing (Narasimhaswamy et al., 1961). In this paper, defects arising from constitutional factors are discussed since they can only be controlled through breeding techniques.

Constitutional

Normal: In the genus *Coffea* ovary is inferior and made out of two carpels (locules) and each locule will have one ovule on the axile placenta. These ovules ultimately give rise to two flat beans (Figs. 1 and 2). However, the constitutional abnormalities in production of ovules and seeds is also common in the genus *Coffea* which has been exten-



Figs. 1. T. S. of normal coffee fruit 2. Normal flat bean 3. T. S. of fruit showing one of the locules aborted resulting in peaberry development. 4. Peaberry 5. T. S. of fruit showing multiovular condition as interlocked ovules in one of the locule. 6. T. S. of fruit showing multiovular condition as gestopposed ovules in one of the locules.



Figs. 7. Bit component of an elephant bean. 8. Hollow component of an elephant bean. 9. Pocket bean showing depression of the aborted ovule. 10. T. S. of a fruit showing multilocular condition (trilocular). 11. Flat bean with shifted central groove. 12. Gaping central groove owing to incomplete development of endosperm.

sively studied (Sybenga, 1961; Narasimhaswamy and Vishveshwara, 1962; Chinnappa and Vishveshwara, 1964; Vishveshwara and Chinnappa, 1965; Sreenivasan, 1986b).

Peaberry: During the course of berry development one of the ovules may fail to develop either due to genetic defect or due to mechanical hindrance to the fertilized ovule with the result that the other developing ovule in the ovary takes a round shape. This is commercially termed as 'Peaberry' (Figs. 3 and 4).

Multilocular ovary: Often, in some lines of coffee selections, the locules in the fruit will be more than two (frequently three) with a single ovule in each locule, which will give rise to triangular beans (Fig. 10).

Shift in the central groove: During the course of post-fertilization changes, if one of the ovules fails to develop in a trilocular fruit, the resulting two flat beans will have the central groove shifted to a side (Fig. 11) giving lopsided appearance to the bean as the axile placenta moves to a parietal position on the longitudinal axis of the fruit.

Multiovular condition

Quite often, instead of one ovule in a locule of the fruit, initiation of more than one ovule takes place resulting in the development of the following types of defective beans;

(i) **Elephant beans:** If the two ovules produced in a locule grow in the form of an interlocked structure (Fig. 5), this results in the production of a composite type of bean composed of a hollow and a bit interlocked (Figs. 7 and 8). These beans are termed as elephant beans. Occasionally three ovules take part in the formation of elephant bean.

(ii) **Bits:** If the ovules in a multiovular ovary develop side by side, they give rise to

bits (Fig. 6) which get separated easily in hulling.

(iii) **Pocket beans:** If one of the ovules abort in the developmental stages of a multilocular locule, the reminiscents of the aborted ovule cause a depression on the developed seed in the form of a pocket (Fig. 9). The position of the pocket on the developed bean may vary depending upon the orientation of the developing ovules. They are termed as pocket beans.

(iv) **Gaping central groove:** Endosperm development may not be complete owing to genetic defects or environmental factors resulting in the production of a bean with a gaping central groove (Fig. 12).

During early 1950's there was an apprehension from the planting community that there was an increase in the triage content of estate pooled coffee owing to expansion with station selections. Since then in the breeding programme due importance has been given to rectify the occurrence of triage components influenced by constitutional factors. Here it may be pointed out that higher triage components of Sln. 1 and Sln. 3 (Narasimhaswamy et al., 1961) has been brought down from 32.1% to 10.0% and 32.0% to 9.25% respectively in further generations by adopting straight line selection. Likewise all the newer genotypes issued for commercial cultivation have been monitored for this aspect and the triage components in commercial produce of different selections is presented in Table I.

Production of triage in different genotypes is also governed by environmental factors which alter the quantum of superior grade percentages from year to year. In this context, due importance has been given for the production of flat beans, reduction in pea berry content and triage and elimination of empty locules. During a high cropping year

occurrence of B and C grade flat beans would be higher than on a normal cropping year. As seen from the table, triage components owing to the production of multiovular and multilocular conditions has been contained in most of the station released selections within the reasonable limits. In the case of peaberry production, which is controlled by both constitutional and environmental factors, the occurrence has been contained within 10–20%. It is also evident from the table, that the 'Cauvery' genotype, which has been released recently from CCRI, has got good commercial value in its produce *i. e.*, 89.6% of flat beans, 10.0% Pb and less than 1.0% of triage.

Similar results are also evident in the case of robusta. The higher 'Pb' content noted in these lines could be attributed to its cross pollinating nature.

In conclusion, it may be noted that the breeding techniques adopted to improve the commercial qualities of the produce in station selections have been successful.

ACKNOWLEDGEMENT

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CHARACTERISATION OF *PISIFERA* PARENTS AND ITS RELEVANCE TO OIL PALM IMPROVEMENT

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ABSTRACT

Twenty eight *Pisifera* palms were identified from *tenera* x *tenera* population. These palms were critically studied for morphological features and individual fruit characters. The percentage of fruits containing kernel and embryo (fertile), those with kernel or mesocarp alone and fruits with half filled kernel or having cavity alone varied highly from palm to palm. Fertility status of *Pisifera* is known to influence the yield potential of *Tenera* hybrids (*dura* x *pisifera*) which is the only planting material used for commercial cultivation of oil palm. The significance of characterising *Pisifera* palms for selection as pollen parent for the production of good quality oil palm hybrids is discussed.

INTRODUCTION

In oil palm, three distinct fruit forms are observed viz., the thick shelled *dura*, the shell-less *pisifera* and thin shelled *tenera*. *Tenera* is a hybrid between *dura* and *pisifera* and by virtue of its higher oil yield it is the only variety commercially cultivated. Non-availability of *tenera* hybrid seeds has been the major constraint in the large scale cultivation of oil palm in India. Attempts made during 1980-81 to isolate the parent lines resulted in the identification of 43 *dura* and 28 *pisifera* palms which were not reported in the country earlier (Pillai and Nampoothiri, 1981). Since then, *dura* and *pisifera* palms were being critically studied for various characters to identify individual palms for generating the best *tenera* hybrid combinations for commercial cultivation.

Selection of *dura* mother palms for breeding is made based on bunch yield, mesocarp percentage and oil content. But such direct selection methods cannot be applied for selection of the male parent - *pisifera* since they are usually female sterile. Hence the

potential of *pisifera* is harder to gauge than that of the *dura*. It appears likely that the range of sterility is associated with genes modifying shell thickness thus regulating the quality of *teneras* obtained from *dura* x *pisifera* crosses. Although the influence of *pisifera* parents on the performance of the hybrid is evident, this aspect has not been thoroughly investigated. An attempt is made in this paper to classify the *pisifera* palms critically for identifying sterile palms for direct use, suggesting breeding for fertile *pisiferas* using those palms showing less sterility and to design a proper trial to test the influence of the range of fertility of the *pisifera* palms on the shell-thickness in *dura* x *pisifera* crosses of oil palm.

MATERIALS AND METHODS

A population of 226 *tenera* x *tenera* palms (Malaysian origin) available at the Oil Palm Station, Thodupuzha, Kerala was used for the isolation of *pisifera* palms. From the segregating population 28 *pisifera* palms were identified during 1981 and since then these palms were critically studied for

various morphological and yield characters. For studying the bunch characters, mature bunches were harvested and fresh weight of individual bunches was recorded. Individual spikelets were separated from these bunches to extract the fruit and longitudinal section of fruits were examined for different fruit characters. The fruits were then classified into the following seven categories.

1. Fruits with endosperm and embryo;
2. Fruits with endosperm and no embryo;
3. fruits with half-filled endosperm and no embryo;
4. Fruits with empty endosperm cavity and no endosperm;
5. Fruits with endosperm cavity, endosperm liquid and no endosperm;
6. Fruits with a linear shell-streak and no endosperm and
7. Fruits with only mesocarp and no endosperm.

A total of 24 bunches were analysed from the 18 palms and the actual values were converted to percentage for comparison. The study was confined to 18 palms since the rest of the palms did not yield any mature bunches during the period.

RESULTS

Proportion of different fruit types along with the mean weight of FFB for individual palms are presented in Table I. All the palms showed a wide variability with respect to the mean bunch weight and all other characters. Bunch weight varied from 5 kg to 23 kg which is lower than that of *dura* and *tenera* of comparable age. Among 18 palms, one palm (Palm No. 5) was totally sterile while palm nos. 98 and 113 showed very low fertility percentage varying from 1.9 to 3.2% and the rest of the palms were fertile to varying degrees. Among the categories of fruits within the sterile group the ones with endosperm (without embryo) were more. But there were no definite relationships between the various categories; neither was there any relationship between the yield (bunch weight) and the extent of sterility.

DISCUSSION

Pisifera is the pollen parent used in the production of high yielding *tenera* hybrid. Vander Weyen (1952) observed that in majority of *pisifera* palms all the fruits get aborted. Hartley (1977) also reported that the yield of *pisifera* is more or less strongly associated with abortion of female inflorescences. It is believed that the quality of the *tenera* obtained from *dura* x *pisifera* crosses can be influenced by the type of the pollen parent used. Several attempts have been made to classify *pisifera*. Based on fertility Gascon, (1956) has classified them to 1. fertile palms producing large number of shell less fruits; 2. partially sterile producing only a few fertile fruits per bunch and; 3. sterile palms producing only few fruits occasionally. In such sterile fruits there is either no development of the ovule or the outer shell development is retarded (Hartley 1977). Arasu (1970) observed that many apparently well developed *pisifera* palms lacked embryos and those fruits which appear to be well formed show very low percentage of germination (3 to 28%). Obasola (1973) reviewed the classification on the basis of the mature fruit development and grouped the *pisifera* palms into four categories viz., fertile, blind, sterile and super sterile palms. Obasola and Okwuagwu (1978) later classified *pisifera* into eight groups considering the degree and nature of fruit development as well as the pattern of yield simultaneously. Pillai and Nampoothiri (1981) identified 22 *pisifera* palms from a *tenera* x *tenera* population and classified these into two major categories viz., 1. fertile palms which bear fruits with kernel and embryo and; 2. sterile palms producing bunches with few fruits. They stressed the need for a wider choice of *pisifera* palms for a successful oil palm breeding programme. In the present study spread over a period of eight years, *pisifera* palms are classified

Table I. *Classification of Pisifera palms – Proportion of different fruit types*

Sl. No.	Palm No.	Mean weight of FFB (Kg)	Fertile				Sterile		
			Fruits with endosperm and embryo %	Fruits with endosperm and no embryo %	Fruits with half-filled endosperm and no embryo %	Fruits with empty endosperm cavity and no endosperm %	Fruits with endosperm cavity, endosperm liquid and no endosperm %	Fruits with linear shell-streak and no endosperm %	Fruits with only mesocarp and no endosperm %
1	5	6.00	Nil	46.40	5.90	7.30	4.60	3.70	31.80
2	13	5.25	16.05	47.93	Nil	1.45	5.00	29.51	Nil
3	51	9.75	8.45	30.85	0.38	0.85	7.80	24.30	27.35
4	98	10.00	1.90	40.90	6.10	5.90	1.91	Nil	43.00
5	100	7.00	14.70	32.90	Nil	Nil	Nil	6.12	46.10
6	111	13.20	12.90	58.00	0.38	3.56	2.73	4.64	14.76
7	113	13.00	3.20	65.30	12.1	8.90	Nil	7.21	2.42
8	120	23.40	10.90	37.60	Nil	4.21	Nil	19.50	28.50
9	152	14.00	19.50	32.20	Nil	2.91	2.52	Nil	43.30
10	214	12.70	9.80	73.60	Nil	5.12	Nil	0.73	10.60
11	223	22.25	8.75	41.81	1.75	8.85	4.85	2.52	34.12
12	242	5.50	12.20	36.32	Nil	Nil	5.91	Nil	45.41
13	245	15.30	34.75	34.55	3.65	3.20	1.61	19.00	2.10
14	266	8.00	11.80	63.10	3.60	14.41	1.30	1.30	5.20
15	283	12.50	19.90	34.12	6.41	7.40	6.90	7.71	17.20
16	310	9.00	12.60	31.62	0.78	4.10	1.81	11.00	38.00
17	313	18.50	10.30	51.71	2.71	4.11	0.71	9.60	20.20
18	458	12.00	14.30	32.90	Nil	Nil	Nil	26.30	26.50

into two major categories viz., sterile and fertile with five sub-classes of the sterile fruits. Such a detailed classification is very important since sterile *pisifera* palms are assumed to be the best category for the production of superior *tenera*. Obasola (1973) presumed that sterility is linked with shell thickness in the resultant *tenera* progeny. This theory however remains to be proved through field trials. It is therefore essential to elucidate the influence of the

degree of sterility of individual palms on the shell thickness of the hybrid.

Results obtained in the present study revealed the presence of one palm which is fully sterile producing fruits without embryos. Two other palms were more or less sterile (96.8 to 98.1%). Sterile *pisifera*s produce extremely thin shelled *tenera* fruits when crossed with *dura*, and hence these palms could be employed in the large scale hybrid seed production.

Out of the 28 *pisifera* palms identified so far, only 18 were classified, as the rest of the palms did not produce bunches with developed fruits for analytical purpose. There are a good number of palms which have high proportion of fertile fruits (upto 34%) and good bunches (upto 23 Kg) which is generally uncommon (Gascon, 1956, Anonymous, 1986). Fertile *pisiferas* classified by high bunch numbers, good fruit set, high mesocarp to fruit content and good oil to mesocarp content could form the base population for breeding fertile *pisiferas*. Malaysian plant breeders have evinced optimism in using fertile *pisiferas* to complement the conventional D x P hybrids.

Oil palm breeders have been so far concentrating on the association of sterility with the quality of the resultant hybrids. Owing to the fact that there are sub-classes of fruits other than completely fertile or sterile ones it is necessary to study the relationship of all the fruit forms with shell thickness of the hybrid combinations on a field scale. Hybrid progenies involving 43 selected *duras* and 11 *pisiferas* of different classes have been planted at the Chithara estate of Oil Palm India Ltd. in 1988.

The strategy for *pisifera* in oil palm breeding as envisaged now can be summarised as follows:

1. Use of only sterile *pisifera* for *tenera* production for immediate commercial cultivation;
2. Testing the relationship of various categories of *pisiferas* with shell thickness in the *dura* x *pisifera* combinations;
3. Classification of all the *pisifera* palms in the available population;
4. Production of more *pisiferas* for a wider choice of male parents from *tenera* x *tenera* and *tenera* x *pisifera* populations belonging to different countries of origin;
5. Using the already identified *pisifera* palms

as a base population for breeding fertile *pisiferas* on a larger scale.

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YIELDING BEHAVIOUR OF 'MANGALA' ARECANUT IN COMPARISON WITH LOCAL SOUTH KANARA TYPES *

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ABSTRACT

Yield performance of individual areca palms of 'Mangala' arecanut plantation in comparison with local South Kanara types was studied at the Central Plantation Crops Research Institute, Regional Station, Vittal for continuous period of six years beginning from 1981. The study revealed that the 'Mangala' variety of arecanut gives a mean yield of 12.67 kg of ripe nuts per palm as compared to South Kanara local which gives 8.59 kg per palm. About 50 per cent of the palms yielded more than 12 kg of ripe nuts/palm which was accounted to 70.17 per cent to the total garden yield while 29 per cent gave less than 10 kg of ripe nuts/palm with a contribution of 9.13 per cent of yield to that of total. Studies on the yielding behaviour of palms also revealed that 43.13 per cent of palms are regular bearers and the rest were found to be having alternate bearing habit and 7.5 per cent of palms had given less than 3.0 kg of yield of fresh nuts per palm while 1.6 per cent of palms yielded more than 30.0 kg/palm.

INTRODUCTION

'Mangala' is a high yielding variety of arecanut released from the Central Plantation Crops Research Institute, Regional Station, Vittal during 1972. It has a number of desirable characters such as earliness in bearing, more number of female flowers per inflorescence, higher percentage of nut set, initial and cumulative higher yields, quicker stabilisation of production and lower height, in comparison with the local South Kanara cultivar (Bavappa, 1977). A unique feature of this type is the short stature (semi dwarf) and the smaller internodal distance, partially drooping crown and well spread leaves that accommodate more number of leaflets. (Murthy and Mohan 1982).

Due to the above characters Mangala has become popular among the areca growers. However, the performance of

individual trees in a plantation was not studied while the yield pattern of individual trees in a yield stabilised garden of local variety of arecanut was carried out and reported by ShamaBhat (1968). It was reported that, maximum yield in terms of no. of nuts ranges between 201 to 400 per palm in South Kanara local type and 33.1 per cent of the palms yield only 11.9 per cent of the total crop, whereas 59.1 per cent of the trees give 71.1 per cent of the produce and 7.8 per cent of the population share 17.0 per cent of the total yield. It is further seen that 16.1 per cent of the palms produce less than 100 fruits per year. Further 2.0 per cent of the trees were non-yielding throughout and 4.0 per cent bore fruits only once during the period of three years.

MATERIALS AND METHODS

The observations were recorded from a garden planted during 1967 at CPCRI,

* Contribution No. 678. Central Plantation Crops Research Institute, Kasaragod, Kerala

Regional Station, Vittal. The progenies of open pollinated 'Mangala' palms were used for planting. The seedlings of 1½ years old were planted with a recommended spacing of 2.7 x 2.7 m in pits of 90 cm. cube, filled with top soil to a height of 60 cms from the base during the month of September. The palms received all the recommended package of practices.

There were 320 palms in the garden. Fully ripe nuts were harvested at regular intervals from 320 experimental palms and the data on yield were recorded for a continuous period of six years beginning from 1981-82 to 1986-87. Yield both in terms of weight and number of ripe nuts were recorded from all the 320 palms and pooled into different yield groups. The percentage of palms as well as the percentage of yield to the total garden yield under each group were compiled and compared to the yields of local South Kanara palms of same

age raised with recommended package of practices. The results are presented in this paper.

RESULTS AND DISCUSSION

The data on yield of nuts are presented in Figure 1. The results on weight of nuts revealed that the mean yield of nuts per palm in Mangala was 12.67 kg as against 8.59 kg ripe nuts in South Kanara Local and 30.58 per cent of palms gave an yield of less than 12.01 kg of nuts (less than average yield). The number of palms observed under the yield group of 12.01 to 15.00 kg were 18.40 per cent (Table I). It can also be seen from the tables that 29.0 per cent of the palms yielded only 12.07 per cent of the total produce and 11.30 per cent of the population had resulted in 21.85 per cent of the total yield.

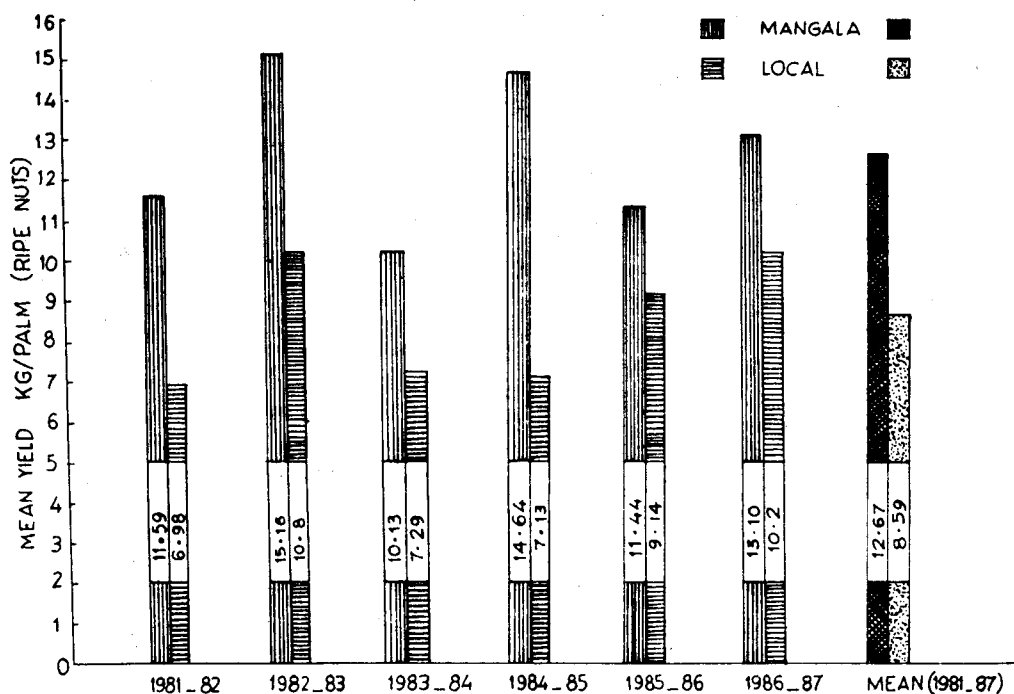


Fig. 1. Year-wise mean yield of individual palms (from 1981-82 to 1986-87)

Table I. *Yield pattern of individual areca palms in 'Mangala' (weight of ripe nuts)*

Sl. No.	Wet wt. of nuts (kg/palm)	No. of palms in the group	Per cent of palms	Total Yield (kg)	Per cent yield to the total garden yield
1.	0-3	24	7.5	32.2	0.75
2.	3-6	26	8.1	122.83	3.05
3.	6-9	43	13.4	333.26	8.27
4.	9-12	68	21.3	715.57	17.76
5.	12-15	56	17.5	741.19	18.40
6.	15-18	43	13.4	731.97	18.17
7.	18-21	24	7.5	473.24	11.75
8.	21-24	23	7.2	512.46	12.72
9.	24-27	6	1.9	152.70	3.79
10.	27-30	2	0.6	57.81	1.43
11.	> 30	5	1.6	157.66	3.91
Total		320	100.0	4028.9	

The yield figures on number of nuts showed that 6.88 per cent of palms gave less than 100 nuts per palm. The highest percentage of palms (17.19%) comes under the yield group of 301-400 nuts per palm (Table II). But in the case of South Kanara (local) highest percentage of palms (24.3%) comes under the yield group of 201-300 nuts per palm (ShamaBhat, 1968) (Table III). It was also seen that more than 900 nuts per palm in local type was 0.2% (Shama Bhat, 1968) whereas in the case of Mangala it was 3.12% and also 1.56% of palms gave more than 1000 nuts per palm (Table II).

Alternate bearing habit

The yield data showed alternate bearing nature in 'Mangala' (Fig. 1). During 1981-82 season viz., after 14 years of planting the mean yield per palm obtained was 11.59 kg and during the next year it has increased to a mean yield of 15.16 kg per palm and in subsequent years the above figure has

again fallen to 10.13 kg. The same trend was maintained throughout on all the six years to which this study is related (1981-82 to 1986-87).

It was further seen that out of 320 palms 138 (43.13%) were regular bearers and the remaining 181 palms (56.87%) were alternate bearers.

The above observations though they do not appear very significant but if we consider vis-a-vis the economics of raising arecanut plantation the importance could well be realised. The cost of maintaining one hectare of Mangala arecanut garden works out to Rs. 24,140/- per annum. Thus the cost of maintaining each tree of the garden with 1300 trees per hectare works out to be Rs. 18.57 per annum. To meet this expenditure the palms has to yield at least more than 3 kg of ripe nuts under the present market price. In the present study 7.5 per cent of the palms gave less than 3 kg of nuts per palm which

Table II. *Yield pattern of individual areca palms of 'Mangala'*

SL.No.	No. of nuts per palm	No. of palms in the group	Per-cent of palms to the total No. of palms in the group
1	0-100	22	6.88
2	101-200	22	6.88
3	201-300	35	10.94
4	301-400	55	17.19
5	401-500	47	14.69
6	501-600	41	12.81
7	601-700	43	13.44
8	701-800	26	8.12
9	801-900	14	4.37
10	901-1000	10	3.12
11	> 1000	5	1.56
Total		320	

Table III. *Yield pattern of individual trees in South Kanara local (Mean of 3 years)*

Yield groups (No. of fruits)	No. of palms in the yield group	Percentage of palms to total	Percentage of yield to total
100 & Less	92	16.1	2.6
101 to 200	97	17.0	9.3
201 to 300	139	24.3	22.2
301 to 400	127	22.2	28.3
401 to 500	72	12.6	20.6
501 to 600	27	4.7	9.5
601 to 700	10	1.8	4.1
701 to 800	6	1.1	2.8
801 to 900	—	—	—
901 & above	1	0.2	0.6
Total	571		

means Rs. 1810.57 invested on every hectare of the garden runs on loss as the yield obtained per tree was less than 3.00 kg of ripe nuts. The present practice of areca growers is to maintain all the palms in a garden irrespective of their individual performance. Therefore, in the case of 'Mangala' it will be advantageous to replace the palms yielding less than 3 kg of ripe nuts with fresh stocks. Shama Bhat (1968) also recommended for the replanting of palms yielding less than 100 nuts in the case of local varieties. This investigation revealed that in Mangala decline in yield was not noticed as the palms grow older.

ACKNOWLEDGEMENT

This paper is dedicated to late Dr. K. Shama Bhat who was the Joint Director of

Central Plantation Crops Research Institute, Regional Station, Vittal.

The authors wish to thank Dr. K. V. Ahamed Bavappa former Director and Dr. M. K. Nair, Director, CPCRI, Kasaragod for providing necessary facilities to undertake these studies.

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A KEY TO THE IDENTIFICATION OF TYPES IN CARDAMOM *

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ABSTRACT

Small cardamom (*Elettaria cardamomum* Maton) shows a wide range of variability in nature owing to the cross pollinated nature of the crop. At Indian Cardamom Research Institute, a total of 276 accessions are being maintained in the germplasm collection. A classification at the level of type accession has been proposed in the report based on the evaluation of the available cardamom accessions. Based on this classification, 29 types have been recognised under three cultivars. A key has been prepared for the identification of these types. Importance of this classification in the germplasm collection and conservation has been discussed.

INTRODUCTION

Elettaria cardamomum Maton, is a monotypic genus of the family Zingiberaceae. The tropical evergreen forests of south India and Sri Lanka are considered to be its primary centre of origin. Cardamom accessions show a wide range of variability due to normally cross-pollinated nature. Very few attempts have been made so far to classify the genetic variants into types and sub-types. Generally, 2-3 types are recognised in cardamom (Molegode, 1938; Abraham and Tulasidas, 1958). Classification of sub-types under these types has been once attempted (Anonymous, 1972). During the evaluation and cataloguing of cardamom germplasm at ICRI, Myladumpara the earlier classification was found to be inadequate. Therefore, an attempt has been made here to classify the types based on the morphological characteristics.

MATERIALS AND METHODS

Cardamom accessions were collected from cardamom growing tracts through extensive surveys of cardamom plantations as well as the evergreen forests of Western Ghats. All the accessions were maintained under identical conditions at ICRI, Myladumpara, Idukki Dist., Kerala. In each accession 6 entries were evaluated and pooled data has been used. A total of 276 cardamom accessions including accessions obtained from Regional Research Station, Mudigere; CRS, Pampadumpara; NRCS, Appangala and exotic collections were utilised for the classification. Characters were recorded based on the cardamom descriptor prepared by Dandin and Madhusoodanan (1981). For evaluation the identity of each individual introduction was maintained as a separate accession. Following characters

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were taken into account for the classification of types and sub-types:

1. Height of the plant:
 - a) Mysore/Vazhukka:
 - i) Tall — above 3.5 m.
 - ii) Short — below 3.5 m.
 - b) Malabar:
 - i) Tall — above 2.5 m.
 - ii) Short — below 2.5 m.
2. Colour of the rhizome/tiller:
 - a) Pink pigmented (PT)
 - b) Green pigmented (GT)
3. Leaves:
 - i) a. Broad — lamina width above 5 cm. (LB)
 - b. Narrow — lamina width below 5 cm. (LN)
 - ii) a. Pubescent — in mature plants. (P)
 - b. Non pubescent — in mature plants. (NP)
4. Panicle:
 - i) Erect (I)
 - ii) Semi erect (II)
 - iii) Prostrate (III)
 - iv) Brached — a — basal branching (BR) — b — terminal branching — c — uniform branching

- v) Unbranched (UB)

5. Capsule:

- i) Pedicel:
 - a. Long pedicelled — above 1 cm. (LP)
 - b. Short pedicelled — below 1 cm. (SP)
- ii) Size - visual observation.
 - a. Bold (B)
 - b. Medium (M)
 - c. Small (S)
- iii) Shape:

$$\text{a. Round (r) - } \frac{\text{Length}}{\text{Diameter}} = 1.$$

$$\text{b. Oval (o) - } \frac{L}{D} = 1 \text{ to } 1.9$$

$$\text{c. Oblong (l) - } \frac{L}{D} = 2 \text{ and above}$$

RESULTS AND DISCUSSION

Based on the general characters of the plant and principally on the nature of panicle, three cultivars have been recognised in cardamom viz., cv. Mysore, cv. Vazhukka and cv. Malabar (Table I).

Table I. *Difference between cardamom cultivars*

Parameters	cv. Malabar	cv. Mysore	cv. Vazhukka
1. Adaptability	Lower elevation (600–1000 m MSL)	Higher elevation (900–1200 m MSL)	Higher elevation (900–1200 m MSL)
2. Tolerance to drought	Withstand long dry spell (4–6 months)	Prefer well distributed rain	Prefer well distributed rain
3. Plant stature	Dwarf (2–3m)	Tall (3–5 m)	Tall (3–5 m)
4. Leaf	Short petiole	Long petiole	Long petiole
5. Panicle	Prostrate	Erect	Semi-erect
6. Bearing nature	Early, short span of flowering	Late, long flowering span	Late, long flowering span
7. Capsule colour	Pale/golden yellow	Green	Green

In the present classification, eleven types each have been recognised under cv. Mysore and cv. Malabar and seven types in cv. Vazhukka.

The dichotomous key has been prepared for identification of different types, giving ample provision for addition of genetic variants, if any. It encompasses all the genetic variants observed in cardamom. Numbers were given for some important characters followed by other salient characters being represented by some letters as shown in the materials and methods (parenthesis).

KEY TO THE TYPES OF CARDAMOM

A. Plants tall statured:

a) Panicle erect:

I – Mysore type

b) Panicle semi-erect:

II – Vazhukka type

A. Plants medium statured:

III – Malabar type

I. cv. MYSORE

A. Plants tall 1:1

b) Leaves broad 1:1

c) Panicle branched 1:1:BR

a) (i) Pedicel short, capsule medium long 1:1:BR:SP:ml.

a) (ii) Pedicel long, capsule medium oval 1:1:BR:LP:mo

c) Panicle unbranched 1:1:UB

b) Panicle only basal 1:1:BR

i. Bold long capsule 1:1:UB:B1

ii. Small round capsule 1:1:UB:Sr.

b) Panicle basal + terminal.

i. Oval bold capsule. 1:1:TP: be

B. Leaves narrow 1:1:NL

i. Leaves pubescent 1:1:NL: P:Sr.

small round capsule

ii. Leaves non-pubescent 1:1: NL:NP:Sr.

small round capsule

A. Plants short 1:2

c. Leaves pubescent 1:2:P.

i. Small oval capsule 1:2:P:SQ.

ii. Medium long capsule 1:2:P: Ml.

c. Leaves non-pubescent 1:2:NP

i. Small round capsule 1:2: NP:Sr

ii. Medium oblong capsule 1:2:NP:mo

II. cv. VAZHUKKA

A. Plants tall (all non-pubescent) II:i

B. Panicle branched II:i:BR.

i. Basal, medium oval capsule II:i:BR:bmo.

ii. Terminal, medium oval capsule II:i:BR:tmo.

iii. Uniform, small round capsule II:i:BR:usr.

B. Panicle unbranched II:i:UB.

i. Medium oval capsule II:i: UB:mo.

ii. Bold long capsule II:i:UB: bl.

A. Plants short II:2.

i. Leaves pubescent II:2:p. small oval capsule II:2:P: so.

ii. Leaves non pubescent II:2: NP. Medium oval capsule II: 2:NP:mo

III. cv. MALABAR

A. Plants tall III:i.

b. Leaves pubescent III:i:p.

- i. Bold oval capsule III:i:p:bo.
- ii. Medium long capsule III:i:p:ml.

B. Leaves non-pubescent III:i:NP.

B. Panicle unbranched.

- i. Small round capsule III: i: NP: Sr.
- ii. Bold long capsule III:i:NP:bl.
- iii. Bold round capsule III:i:NP:br.
- iv. Medium long capsule III:i: NP:ml.

a. Panicle branched.

- i. Small round capsule III:i: NP:BR: Sr.

A. Plants short. III:2.

a. Leaves pubescent III:2:P.

- i. Medium round capsule III: 2:P:mr.
- ii. Medium oval capsule III:2: P:mo.

a. Leaves non-pubescent III:2:NP.

- i. Tiller pink
Medium oval capsule III:2: ND:PT:mo.
- ii. Tiller green III:2:ND:GT: mr. medium round capsule.

In the present classification, characters like branching of panicle and pubescence on leaves are recorded in all the three cultivars of cardamom for the first time. Earlier,

Abraham and Tulasidas (1958) reported the occurrence of pubescence in flexuous and erect panicle types from Mysore region and considered that these could be hybrids. Compared to cv. Malabar, the pubescence of leaves observed in Mysore and Vazhukka cultivars in the present study formed only a low percent of the type of accessions.

At present, the germplasm of cardamom are collected and maintained individually as separate accessions at ICRI and elsewhere due to the lack of uniform classification criteria. Hence many collection which are duplicates are wrongly maintained as separate accessions leading to increase in number and resulting in problem for conservation and evaluation. The lack of classification criteria also complicated the process of germplasm collections. The present classification thus, helps in grouping collections, avoiding duplications and provides a basis for making more objective germplasm collection in future.

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VARIABILITY IN CASHEW GERMPLASM COLLECTION AND EFFORTS TO CHARACTERISE THEM

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ABSTRACT

Cashew (*Anacardium occidentale* L.), originated in Brazil, was introduced into the west coast of India during 16th century and is now under cultivation in different agroclimatic regions which has generated a wide genetic diversity. The inherent genetic variability of cross pollinated crop like cashew has to be retained and properly conserved. Keeping this in view, an attempt has been made by the newly established National Research Centre for Cashew, to promote a national network of cashew genetic resources, by establishing "Clonal Gene Bank". A total collection of 292 accessions obtained from different Cashew Research Stations in the country, in addition to primary collections made from Southern region were systematically evaluated and characterized using IBPGR germplasm descriptor list. Considerable variation was noticed among the collections for some economic characters, viz., the season of flowering and its duration; apple colour, shape and weight; nut weight (2.4 – 18.0 g); kernel to whole nut ratio (19.0 – 32.0%) etc. In addition, different ideotypes like dwarf and bushy habit, erect/tall types; compact/loose canopy etc. have been classified.

INTRODUCTION

Cashew (*Anacardium occidentale* L.) is commercially grown for its kernels, although cashew nut shell liquid (CNSL) and apples are valuable by-products. It is considered to be the most important edible nut in the world trade (Ascenso, 1986a). It is a cross-fertilized species and therefore highly heterozygous, exhibiting a wide variation for a number of characters such as growth, yield and quality (Ascenso, 1986 b). The objective of any germplasm collection programme is to increase the range of genetic variation available for use by breeders. The value of the germplasm resources will increase as they become more adequately described, evaluated and catalogued (Sprague, 1980).

In the present paper, an attempt has been made to report the variability present in cashew for some of the economic

characters in the existing germplasm holding at National Research Centre for Cashew (NRCC), Puttur and the efforts made towards characterization and cataloguing them.

MATERIALS AND METHODS

For exploiting the genetic variability present in cashew, germplasm collection was carried out by the Central Plantation Crops Research Institute, Regional Station, Vittal, since 1972. A total of 292 accessions which were maintained both at Vittal (161 Nos.) and NRCC Experimental Farm, Shantigodu (131 Nos.), were evaluated. Most of these are secondary collections obtained from different Cashew Research Stations in the country (Table I). Initially seednuts were collected and planted. In order to characterize and catalogue these accessions, the IBPGR germplasm descriptor list was suitably modified and used for

Table I. *Cashew germplasm holding (seedling progenies) at NRCC*

Source of collection	Indigenous	Exotic	Total
Cashew Research Station Vengurla, Maharashtra	25	1	26
Cashew Research Station, Anakkayam, Kerala	19	—	19
Cashew Research Station, Vridhachalam, Tamil Nadu	34	—	34
Cashew Research Station, Bapatla, Andhra Pradesh	129	6	135
Cashew Research Station, Ullal, Karnataka	1	—	1
Primary collections (Survey and introductions)	75	2	77
Total	283	9	292

recording observations. The data collected are being computerized.

Currently, programme is underway to establish clonal germplasm conservation block at NRCC, Puttur, both with fresh survey collections as well as with elite and genetically diverse material available in the existing germplasm holding in order to preserve the genetic variability present in cashew. So far 153 clonal accessions have been planted in the germplasm conservation block (Table II) at the rate of 6 plants/accession providing a spacing of 6m x 6m.

RESULTS AND DISCUSSION

The germplasm accessions evaluated exhibited a considerable amount of diversity for some of the economic characters (Table III). The data obtained revealed that the flowering season of almost all the accessions ranged from October-January. Early flowering genotypes are desirable as they escape from major pests like tea mosquito and there will be abundance of pollinators and the produce gets premium price in the market (Ohler, 1979).

The flowering period ranged from 40–127 days. Genotypes with short flowering period are desirable. Protracted flowering period contributes to high yields but the harvesting period will be long, resulting in more harvesting costs. Therefore, genotypes that complete flowering in one flush are good (Ohler 1979).

The harvesting period was ranged from 30 to 105 days. However, the genotypes with short harvesting period are desirable (Ohler 1979), which will reduce the collection costs considerably.

The number of fruits borne on the panicles contributes to the yield. High yielding trees will have 5 to 10 fruits/panicle (Ohler 1979). The range was 1 to 8 fruits/panicle in most of the germplasm collections.

The range of variability for apple weight was 30 to 150 g. Where apple is utilized for juice exploitation, increased weight of apple is important.

The nut weight ranged from 2.4 to 18.0 g. Bold nuts yield big size kernels and hence

Table II. *Clonal accessions planted in the germplasm conservation block at NRCC*

Source of collection	No. of accessions
NRCC Experimental Farm, Shanthigodu	72
CPCRI, Regional Station, Vittal	14
Goa	38
Andhra Pradesh	12
Tamil Nadu	3
Maharashtra	1
Karnataka	13
Total	153

Table III. *Range of variability recorded for some of the economic characters in the cashew germplasm accessions at NRCC*

Character	Range
Flowering period	October-January
Flowering duration	40-127 days
Harvesting duration	30-105 days
No. of fruits/panicle	1-8
Apple weight	30-150 g.
Nut weight	2.4 - 18.0 g.
Apple: nut ratio	4:1 - 12:1
Kernel weight	0.5 - 4.5 g
Kernel count	100 - 900/lb.
Kernel: wholenut ratio	
(shelling %)	19.0 - 32.0%
Shell thickness	1.5 - 5.0 mm
Mean yield/plant/year	
(Mean of 10 years)	0.50 - 11.75 kg.
Plant habit	Erect/bushy/spreading
Canopy shape	Compact/medium/sparse
Apple colour	Yellow/pink/red
Apple shape	Round/pear/long
Coherence of nut with apple	Loose/tight.

ideal for export purpose. However, those having shell thickness more, the shelling per cent will be low.

Apple to nut ratio ranged from 4:1 to 12:1. Where nut yield is important, using a genotype with a lower ratio and where apple yield is important selection of a genotype with higher ratio is desirable.

The kernel weight, kernel count, shelling percentage and shell thickness are all

interrelated. Kernel weight ranged from 0.5 to 4.5 g and kernel count from 100-900/lb. For export purposes, a kernel weight of more than 2g (Nair et al., 1979) with a kernel count of less than 210 wholes/lb is preferred. The shelling percentage ranged from 19.0 to 32.0 per cent and shell thickness from 1.5 to 5.0 mm. Genotypes with thin shell and high shelling percentage are desirable. A genotype which is completely free from cashew nut shell liquid

(CNSL) with a very thin shell is available in the germplasm collection. The production of such nuts might cause great changes in the processing industry, considerably reducing the costs. There would be no danger of CNSL contamination of the kernel and the kernel-to-whole nut ratio would be much higher (Ohler, 1979).

In the present germplasm collection ideal genotypes with an yield potential of 8kg and more/tree/year with a mean nut weight of more than 7 g per nut are available in the collection which are ideal. Therefore, crop improvement through selection on the basis of individual tree yield appears to be promising (Ohler 1979).

The plant habit varied from erect to bushy (dwarf) to spreading types. The dwarf genotypes exhibit two major advantages *viz.*, smaller tree size and earliness of bearing. Individual tree yields may be lower than those of common varieties. However, high density orchards of selected high yielding dwarf clones are considered to have the potential nut yield several times more than the common standard sized cashew trees (Ascenso, 1986 b). An erect genotype with upright growing branches suitable for the high density orchards and genotype which produces purple leaves are available in the present collection.

The collections also include three related species *viz.*, *A. microcarpum* (slow growing tree, 5–6g nut weight), *A. pumilum* (dwarf

and slow growing tree, 1.0 g nut weight) and *A. orthonianum* (slow growing and erect tree, 2.0–2.5 g nut weight), which are graft compatible with *A. occidentale*. Ascenso (1986 b) reported that seedlings from *A. microcarpum* can be used as root-stocks which exert a dwarfing effect and induce earlier bearing upon the grafted trees. No symptoms of stock-scion incompatibility have been observed.

The variability observed in the accessions for some of the economic characters reveals its utilisation in the future crop improvement programme.

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The authors express their sincere thanks to the Director, Central Plantation Crops Research Institute, Kasaragod and the Senior Scientist-in-charge, National Research Centre for Cashew, Puttur for providing the facilities.

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DISCUSSIONS

S. BHAGAVAN: Have you observed any biennial bearing trend in the rubber yield? If it exists is it not better to consider averaging for even number of years data rather than considering 5 years ?

JOSEPH G. MARATTUKALAM: *Hevea* is not a biennial bearing crop.

R. C. MANDAL: Since bark thickness, number of latex vessel rows and density of laticifer rows are the major criteria for selection of superior clones like RRII 105 and 108, they should be released describing their superiority over TJIR I alongwith package of practices to create an awareness among the rubber planters.

JOSEPH G. MARATTUKALAM: Latex vessel rows (number and density) is only one of the factors influencing the yield. RRII 105 is already included under category 1 for commercial planting. The planting community is aware of this cultivar and the clone has been well accepted.

M. JAYARAMA: Is there any relationship between annual girth increment of the tree and yield ?

JOSEPH G. MARATTUKALAM : Yield is a complex character where several components are involved. Girth increment is a desirable attribute.

K. U. K. NAMPOOTHIRI: Supremacy of clones as expected varies for different characters. Will it not be better to develop an index giving due weightage to the characters?

JOSEPH G. MARATTUKALAM: This will be an useful approach when specific

planting materials are developed for different agroclimatic regions. So far stress is given only for yield.

T. S. GOVINDARAJAN: Whether the plants taken for screening are of the same age? RRII 105 has been found susceptible for brownbast and pink disease. Is there any attempt to screen the different material for comparative resistance?

JOSEPH G. MARATTUKALAM : All the plants were of the same age. Screening for secondary characters is also being attempted.

M. V. PUSHPADAS: It is seen that the highest incidence of brownbast is in RRII 153 clone even though it is not a high yielding clone like RRII 105. Could you attribute any particular reason for this?

JOSEPH G. MARATTUKALAM : Although high yielding clones are generally prone to brownbast this disease is not new to high yielding cultivars alone.

SAMRESH DWIVEDI: Is the factor over time and variation over years not accounted over years in the case of large scale trials? Why RRII 105 is recommended inspite of its susceptibility to diseases?

JOSEPH G. MARATTUKALAM : Large scale trial is the second stage of experimentation for selection. Usually the mean yield over a period of 5 years is taken as index for selection. The diseases in rubber can be contained with appropriate treatments. Clone RRII 105 is outstanding for its yield potential. In addition it has got desirable secondary attributes.

A. RAMADASAN: Generally in di-cots (like cashew) more foliage is produced than the actual requirement. When the vegetative growth is suppressed by pruning productivity increases. Hence expressing pruning in cashew should be based on canopy area and not on weight basis.

M. V. PUSHPADAS: It is seen that pruning in cashew carried out in May results in severe depression in yield. Can you explain why this is happening?

E. MOHAN : Pruning in the case of cashew was done in May just after the last picking. Moreover the shoots developed early were affected by leaf miner during peak monsoon which could not be contained as it was not feasible to take up plant protection. This might be the reason for depression in yield.

P. P. BALASUBRAMANIAN: What is the plot size adopted in the pruning trial?

E. MOHAN: A total of 27 trees @ 3 trees per treatment were used.

P. P. BALASUBRAMANIAN: Whether the physiological and cultural conditions were uniform?

E. MOHAN: Uniform age group of trees *i.e.*, 8 years old with yield ranging from 4.5 – 5 kg/tree were used for the trial.

JACOB MATHEW: It is seen that the yield of rubber has been presented in terms of grams/tree/tap. Is it not better to present the actual yield?

A. O. N. PANIKKAR: The annual production potential can be worked out from the mean yield/tree/tap. The mean annual yield is given in the case of blockwise commercial trials.

SAMRESH DWIVEDI: Large scale trial only refers to bigger plot size. Time is an important factor and when the data is available it would be better if this factor component analysis is carried for the identification of more stable clone.

M.A.NAZEER: Large scale trial means statistically designed field trials with optimum number of replications and number of trees/plot.

Rather than analysing annual yields separately for 1 or 2 years it is always advantageous to take into consideration the performance over the period of 5 years.

M. V. PUSHPADAS: Have you studied the correlation between the number of latex vessel rings and yield. I find that one poor yielder in the trial had the highest number of latex vessel rings.

M. A. NAZEER: The correlation was not studied in this trial.

N. K. JAIN : Rubber shows wide variation in tree to tree performance even in clonal plantation. A strong interaction with statistician is required to eliminate inter-tree variation and improve the efficiency of treatment comparison.

T. S. GOVINDARAJAN: In the data presented on bark thickness it is observed that TJIR 1 and GT 1 were indicated as 10 years whereas for RRII 105 it is shown as 4 years. How these data are comparable?

D. PREMAKUMARI: Comparison were made between the tetraploids and respective diploids of the same age. A general observation only has been made regarding the clones.

M. V. PUSHPADAS: In many characters observed there are not marked differences between diploids and tetraploids in the case of RRII 105 while in the case of GT 1 and TJIR 1 the differences are large. Do you attach any significance to this observation?

D. PREMAKUMARI: The extent of variation induced in each character may be clone specific. However there was not much improvement with respect to any of the characters.

E. V. V. B. RAO: In C_2 generation the number of diploids (Polyhaploids) will normally be encountered. Have you got any data on these derived polyhaploids?

D. PREMAKUMARI: We have laid out a field trial incorporating two tetraploids, a triploid and a diploid which has not come to tapping age.

E. V. V. B. RAO: As oil palm variety *Pisifera* is mainly to be used as a male parent it may be worthwhile to look into the differences in pollen characters such as fertility and longevity.

K. U. K. NAMPOOTHIRI: Mostly sterile *Pisifera* have been used and good fruit set is obtained. It will be useful to study the pollen viability in the various *Pisifera* classes.

SAMRESH DWIVEDI: Is *Pisifera* has been used as a maternal parent for improving fruit set in the production of higher yielding *Tenera* plants?

R. S. N. PILLAI: For high yielding *Tenera*, *Pisifera* is used as pollen parent because it is largely female sterile. Now *Pisifera* is used as mother palms for experimental purpose especially breeding for fertile *Pisifera*.

M. S. SREENIVASAN: What is the mechanism of pollination in oil palm?

R. S. N. PILLAI: It is a cross pollinated crop. Efficient pollination is achieved through the weevil *Eleidobius kamerunicus*.

P. R. V. SUBRAMONIA IYER: You have presented data on fertility percentage falling into two sharp categories viz., fertility above 20% and sterile below 10%. How is that such a sharp division exists. Are there any intermediate types?

R. S. N. PILLAI: We have presented data only on 6 palms. Other 12 palms fall into the intermediate categories.

R. V. PILLAI: Do you have hybrids produced using this categories of identified *Pisifera* palms?

K. U. K. NAMPOOTHIRI: Hybrids (*Dura* x *Pisifera*) using different categories of *Pisifera* have been planted during 1988. We will have to wait for the yield to study their effects.

SAMRESH DWIVEDI: In the hybrids of coffee reported here F_1 sterility was observed and did the open pollinated progeny 1 was produced in isolation?

A. G. S. REDDY: No they were surrounded by diploid *Robusta* and tetraploid *Arabica*.

SAMESH DWIVEDI: Was there any crossing over seen in the meiosis division Metaphase 1 (Pachytene stage) to show any similarity?

A. G. S. REDDY: No pachytene analysis was done.

A. O. N. PANIKKAR: Is there any relation between the physical appearance of the bean and cup quality?

M. S. SREENIVASAN: Yes. Blue-green colour of the raw bean is associated with superior quality of liquor.

BIOTECHNOLOGY, CROP PHYSIOLOGY AND BIOCHEMISTRY

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A WHOLE-PLANT STRUCTURE: FUNCTION MODEL FOR COCOA*

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ABSTRACT

A functional model for growth and yield of cocoa is described. The effects of growth parameters viz., relative growth and net assimilation rates on yield as well as partitioning efficiency of dry matter, carbon and nitrogen are considered. The major environmental variables that influence growth and yield components are light and water stress. The relationships developed here will enable efforts to increase cocoa productivity.

INTRODUCTION

Growth and yield component analysis describe quantitatively various parameters of plant development. In cocoa physiological research have been done over the past three decades or so, but little attempt was made to integrate various processes determining productivity (Alvim, 1977; Balasimha, 1988). This paper is an attempt to build a physiological model for structure and function relationships of cocoa plant.

MATERIALS AND METHODS

Cocoa (*Theobroma cacao* Linn.) plants were planted under the shade of 18 year old arecanut palms in 1982 at a spacing of 2.7 x 2.7 m. Each plant was manured annually with 100 g N, 40 g P₂O₅, 140 g K₂O and irrigated once a fortnight during dry periods of the year.

Periodic destructive sampling was done, sample size being 10 plants initially and 5 plants after 40 months. Leaf areas were calculated from 10 representative leaves from each tree using linear measurements (Reynolds, 1971) and computed for

the whole tree. Canopy area was computed from height and radius measurements assuming it to be in the shape of a cone. From this basic data growth analytical parameters were derived (Kvett et al., 1971). Total reduced N was determined by Microkjeldahl method and total carbohydrates by the method of Dubois et al., (1956). The starch residue was digested in perchloric acid (30%) and estimated for sugars.

RESULTS

The cocoa model is shown schematically in Fig. 1. An understanding of sequential plant growth, their inter relationship, photosynthesis and partitioning is necessary to describe productivity.

Structural growth rates

The changes in primary and derived growth variables are given (Figs. 2 and 3). In the classical growth analysis, it is assumed that relative growth rate (R) is the product of leaf area ratio (F) and net assimilation rate (E). Although in the present study

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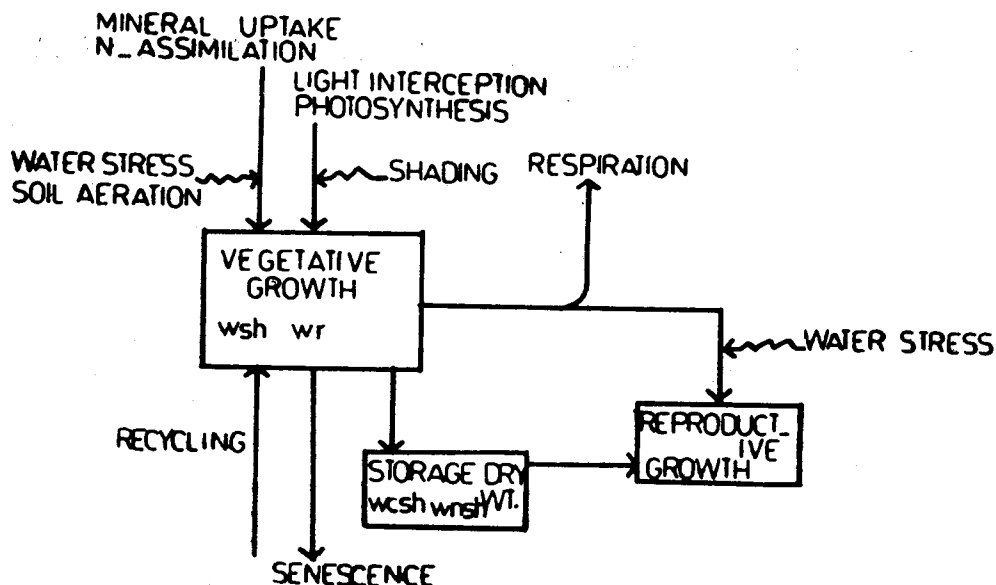


Fig. 1. Schematic diagram showing structural and functional relationship

the values used are from destructive sampling, it is rather difficult to get such data always. To overcome this difficulty, it is desirable to use relative production rate (R_i) instead of classical R (Brand, Weetman and Rehsler, 1987). This can be derived from any growth variable viz., canopy area, stem girth etc. Any limitations on E and F would obviously affect R upto certain

stage of development. This is well illustrated in cocoa where a steady state level is reached at the beginning of reproductive phases (Figs. 2, 3 and 4). Thus any increases in leaf area beyond this optimum level may not have any additive effects on dry matter accumulation (Fig. 5) or yield (Table 1).

Table 1. Correlation coefficients for yield and other yield components

Character	Yield	
	5 years	12 years
Stem girth	0.70*	0.31
Stem height	0.16	-0.05
Stem dry weight	0.73*	0.36*
Total plant dry weight	0.77**	0.36*
Canopy area	0.78**	0.16
Number of fruit bearing branches	—	0.34*
Harvest index	—	0.91**

* Significant $P > 0.05$ ** Significant $P > 0.01$

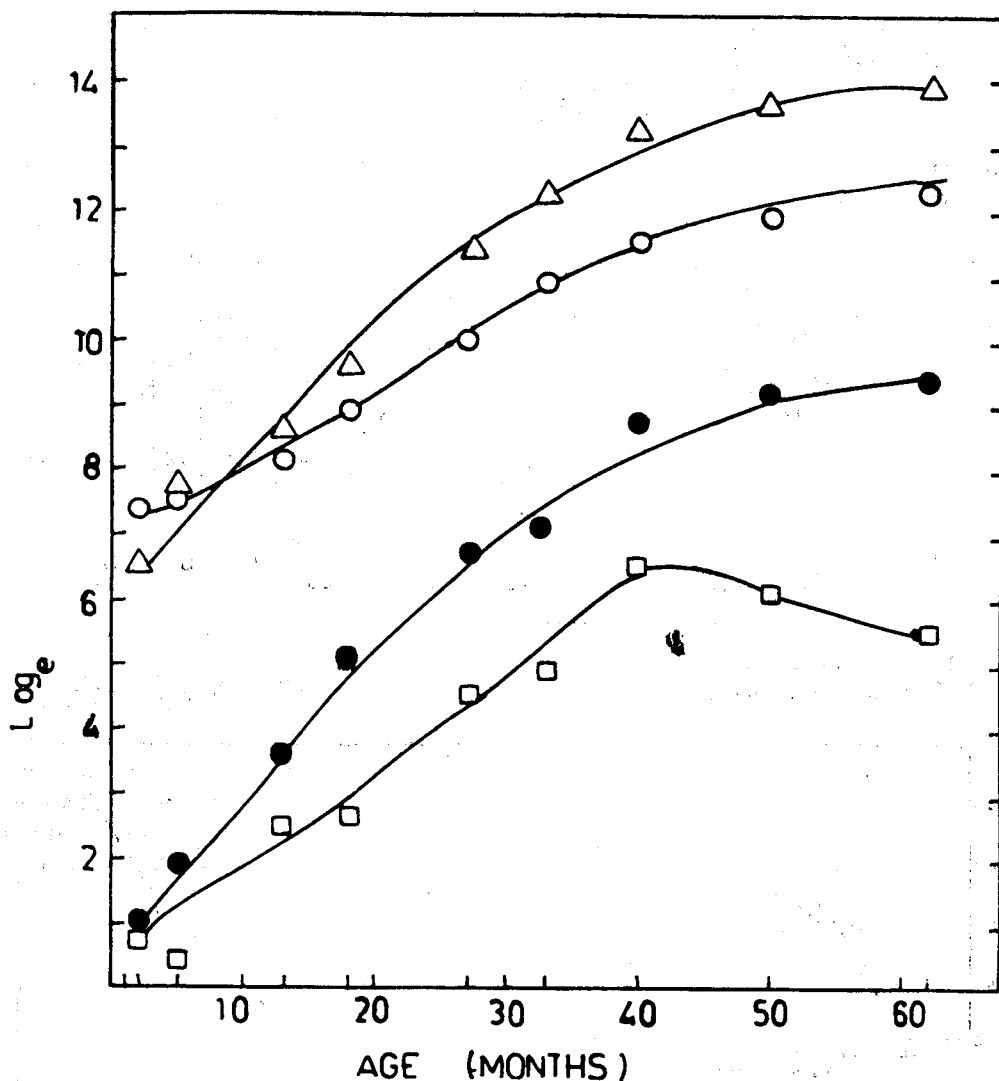


Fig. 2. Mean primary values for canopy area, cm² (○), leaf area, cm² (△), dry weight, g (●) and mean growth rate, g g⁻¹ month⁻¹ (□) per plant during growth

Leaf area index, light interception and photosynthesis

The growth and productivity of cocoa is modulated by light interception efficiency and leaf area index (L); both of which reach optimum levels when reproductive phase is switched on. The photosynthetic

accumulation of assimilates is very low in cocoa (Alvim, 1977) and this can be modified by increasing light availability to a certain extent (50% of total radiation). There is also high correlation between specific leaf weight and yield capacity (Balasimha, 1988).

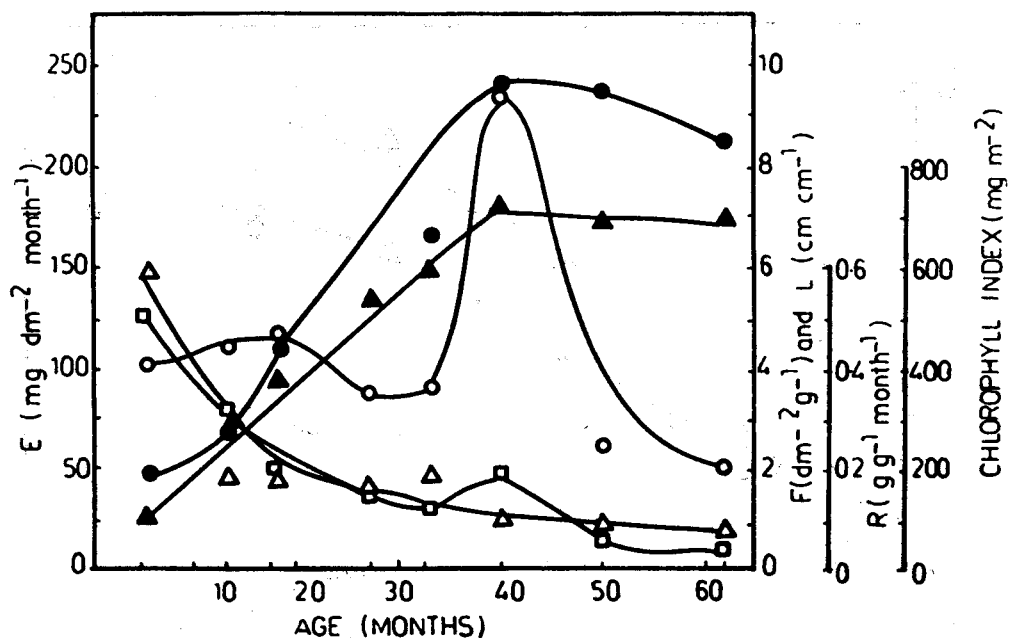


Fig. 3. Derived growth analysis values for net assimilation rate (○), leaf area ratio (Δ), leaf area index (●), chlorophyll index (▲) and relative growth rate (□) during plant growth

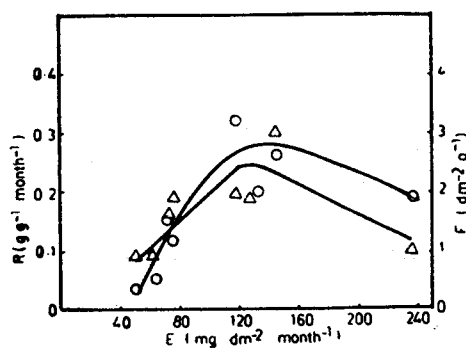


Fig. 4. Relationship of net assimilation rate (E), to relative growth rate (R, ○) and leaf area ratio (F, Δ)

Partitioning

The Reynolds and Thornley (1982) model for total growth rate is denoted as:

$$\frac{dw}{dt} = K \text{ CN } (W_{sh} + W_r)$$

where K is growth rate coefficient.

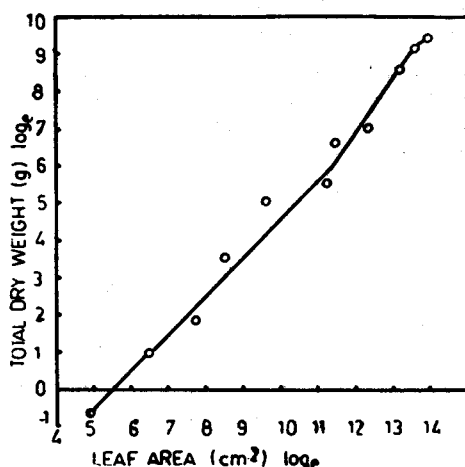


Fig. 5. Relationship between leaf area and total dry matter

The net carbon and nitrogen flow can be represented as $\delta \text{ CW}_{sh}$ and $\delta_N \text{ W}_r$ (Johnson, 1985). The accumulation of carbohydrates and total N was slow initially and rapid after second year of growth (Fig. 6)

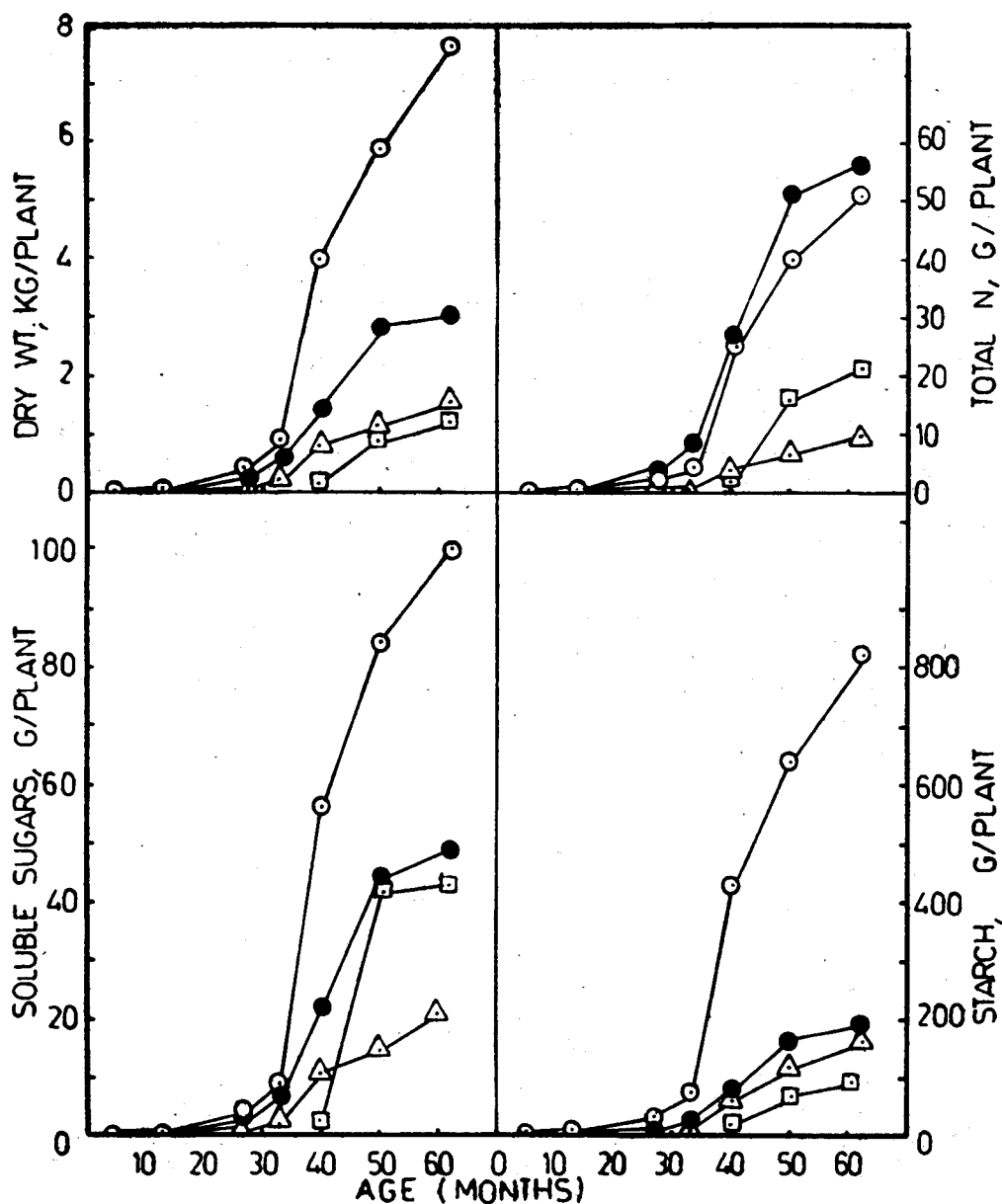


Fig. 6. Changes in dry weight and nutrient composition; stem (○), leaf (●), root (△), pod (□)

The stem was major organ of nutrient storage. The carbon content is influenced by light, LAI and water stress. The ratio of distribution of C and N between vegetative and reproductive parts is dependent

not only on C-assimilation but the reserve capacity. Thus, it is important to know the size of productive organs *e.g.*, roots and leaves and reserve pool to predict yield. The shoot: root ratio is related to the C/N

ratio which in turn will be influenced by δC and δN . There is change in C/N ratio from 8.9 to 11.1 with onset of reproductive phase.

Senescence and recycling

The losses of assimilates/nutrients to the system are in the form of senescence (leaf fall), respiration and removal of pods. Only the latter two can be regarded as totally lost since leaf fall is recycled into the system. The efficiency can however be enhanced by recycling the pod husk which is usually removed and may contribute 10% of nutrients and carbon.

Effects of water stress

The parameters R and E are sensitive to water stress and are reduced by about 30 to 50% (Balasimha, 1987). This is also accompanied by nearly 50% reductions in nitrogen assimilation and chlorophyll contents (Balasimha, 1988). Thus it can be expected that the δN and δC will be reduced proportionately.

Yield components

The increments in growth parameters at pre-bearing age will influence the yields. Once the stem area is fixed, it is difficult to enhance further productivity in cocoa. This is seen in the lack of correlations between stem height, girth or canopy area to yield at a later stage (Table I). The only possibility would be to increase the number of fruit bearing branches which shows significant positive correlation with yield. There were significant correlations of yield with biomass and harvest index (Table I).

DISCUSSION

The model for cocoa described here takes into account data available on various processes with least possible theoretical

considerations. The crop yield is considered here as mainly a product of $R (= E \times F)$, L and partitioning efficiency of C and N. The record annual yield of 3700 kg per ha (Ahenkorah, Akrofi and Adri 1974) can be considered as potential yield of presently known cocoa cultivars and about 60% of this only could be realised in experimental farms. So, shifting excessive vegetative development to greater partitioning into fruits for enhancing harvest index may have to be considered. Concurrently efficient photo-assimilate partitioning and increases in reserve pools should be made possible. The main environmental constraint in cocoa productivity is water stress and any breeding programmes for yield increases should include drought tolerance traits also. There is sufficient evidence to show that stomatal regulation is important in tolerance to drought (Balasimha, et al. 1988) which can be taken as another component for increasing productivity. The selections for high yield and other favourable characters are done taking into account various component characters combined into a score or index. This model thus, will enable attempts to increase productivity by breeding and/or improved agronomic practices.

ACKNOWLEDGEMENTS

I dedicate this paper to the memory of late Dr. K. Shama Bhat, former Joint Director, CPCRI (R.S.). Vittal Grateful thanks are due to Dr. R. V. Nair for providing yield data and Mr. B. P. Nair for statistical analysis.

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INFLUENCE OF *RHIZOBIUM* INOCULATION AND SEED PELLETING ON NODULATION OF GREEN MANURE LEGUMES IN AN ACIDIC COCONUT SOIL*

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ABSTRACT

The effect of rhizobial inoculation and seed pelleting was studied in an acidic soil on nodulation, N₂ fixation and growth of green manure legumes which were found to be suitable for cultivation in coconut gardens. Three *Rhizobium* strains (32 HI, EGI, PAU Cowpea) were used as inoculants for *Calopogonium mucunoides* and an IARI strain (L1) and a local isolate (L2) for *Leucaena leucocephala*. The effectiveness of pelleting materials such as rock phosphate, Ca CO₃, charcoal and dolomite was compared along with different inoculants. *Rhizobium* inoculation resulted in increased growth and nodulation in both legumes and the extent of response varied when different cultures were used. The response in nodulation behaviour, dry matter yield and nitrogen concentration in tissues was significantly more only when pelleting was done on *Rhizobium* inoculated seeds. The difference in response due to the use of different pelleting materials was not significant. The present study indicated the need for pelleting along with rhizobial inoculation to get substantial improvement in nodulation and nitrogen fixation of green manure legumes in acidic coconut soils.

INTRODUCTION

The advantages of growing *Calopogonium mucunoides* as a green manure crop in coconut basins and the suitability of including *Leucaena leucocephala* in coconut-based cropping systems have already been reported (Bavappa et al, 1986; Thomas and Shantaram, 1984). Cultivation of leguminous cover crops is also recommended for other plantation crops such as oil palm, rubber etc. The legume - *Rhizobium* association is one of the most efficient systems of biological nitrogen fixation. Nodulation of *Calopogonium* and *Leucaena* was reported to be poor in acidic coconut soils when compared to other promising green manure/cover legumes (Thomas and Shantaram, 1984). *Rhizobium* inoculation is vital to obtain

maximum benefits from leguminous crops when natural nodulation is not effective.

The soils in coconut growing tract of Kerala are acidic in nature. The survival of introduced rhizobia and nodulation were reported to be severely affected under acidic soil conditions (Vincent, 1965; Holding and Lowe, 1971). Rhizobial population and nodulation could be enhanced by liming of acidic soils (Jones, 1966) but it is very expensive and impractical. The impregnation of rhizobia in lime coatings on legume seeds was reported to alleviate the detrimental effects of soil acidity on rhizobial survival, nodule formation and N₂ fixation (Shipton and Parker, 1967). The present study compares the effectiveness of different rhizobial

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cultures alone and with pelleting using different materials on nodulation and growth of *C. mucunoides* and *L. leucocephala* in an acidic coconut soil.

MATERIALS AND METHODS

A creeping cover legume, *Calopogonium mucunoides* Desv. and a tree legume, *Leucaena leucocephala* (Lam) de wit. were used as test plants in this study. Three *Rhizobium* strains of cowpea miscellany group, *Rhizobium* sp. 32HI, EGI (IARI) and PAU cowpea formed inoculants in case of *C. mucunoides*. A *Leucaena Rhizobium* culture (L1) from IARI, New Delhi and a local strain of *Rhizobium* from *Leucaena* (L2) were tested on *L. leucocephala*. The local culture of *Rhizobium* was isolated from naturally nodulated *Leucaena* grown in CPCRI Kasaragod farm. It was purified and characterised as *Rhizobium* by standard procedures (Vincent, 1970). The effectiveness of the four pelleting materials viz., lime, rock phosphate, charcoal and dolomite was compared alongwith the five rhizobial cultures. Rock phosphate and dolomite were powdered and sieved before use. *Leucaena* seeds were given hot water treatment prior to inoculation with rhizobial cultures.

The rhizobial cells grown in yeast extract mannitol media (Vincent, 1970) were suspended in sterile distilled water. The number of rhizobial cells in the inoculum were 4.1×10^9 , 2.1×10^9 , 4.5×10^9 , 4.6×10^9 and 2.0×10^9 per ml for the cultures 32 HI, EGI, PAU cowpea, L1 and L2, respectively. Drug resistant strains of rhizobia were used to know whether the nodulation by introduced rhizobia is increased by seed pelleting. Resistance to 100 μ g of streptomycin and 100 units of penicillin was developed in *Rhizobium* strains 32 HI and L1 before inoculation to the crops.

Seeds of the two legumes were surface-sterilised and aliquots of rhizobial suspen-

sion were inoculated directly on the seeds using gum arabic as adhesive. Pelleting was done as per the methods described by Roughley (1970). Controls were maintained without pelleting and inoculation treatment. The seeds were sown in acidic (pH 5.2) sandy loam soils in pots. The treatment details for *C. mucunoides* and *L. leucocephala* are given in Tables I and II, respectively. The plants were thinned to one per pot after germination.

The plants were harvested at 60 days growth and roots were examined for nodules. The nodular contents of plants inoculated with rhizobia having antibiotic markers were plated on YEM media supplemented with the antibiotics and occurrence of rhizobia with markers (str⁺P⁺) was recorded. Dry weight of shoot and nodules were determined after drying at 70°C for 48 h. Shoot nitrogen was determined from oven dried and powdered plant samples by microkjeldahl analysis.

RESULTS AND DISCUSSION

Laboratory testing of rhizobial cultures viz., *Rhizobium* sp. 32HI, EGI, PAU cowpea and L1, used in this study showed optimum growth in yeast extract mannitol broth at a pH of 7.0 and there was considerable reduction in growth at the acidic pH range of 5.0–5.5 (Anonymous, 1985). Such low pH values are generally observed in coconut growing soils of Kerala. In inoculation trials with green manure legumes, these rhizobia are to be protected from acidic soil conditions in the period between sowing of inoculated seeds and infection of roots by rhizobia. The effect of seed pelleting has been tested in this study using alkaline or neutral materials.

Nodulation behaviour, shoot dry weight and shoot nitrogen accumulation were the

Table I. *Total nitrogen, shoot dry weight and nodulation in C. mucunoides as influenced by Rhizobium inoculation and seed pelleting*

<i>Rhizobium</i> Treatment	Pelleting Treatment	Nitrogen yield mg plant ⁻¹	Shoot dry wt. g plant ⁻¹	Nodule dry wt. mg plant ⁻¹	Nodule No. plant ⁻¹
Uninoculated	Unpelleted	15.61	0.61	28.67	28.00
<i>Rhizobium</i> sp. EGI	Unpelleted	21.72	0.81	40.67	45.33
"	Calcium carbonate	36.40	1.08	56.00	54.33
"	Rock phosphate	25.16	0.90	63.70	62.00
"	Charcoal	39.22	1.18	61.67	58.00
"	Dolomite	24.76	0.88	44.00	30.67
Mean		29.45	0.97	51.67	48.58
<i>Rhizobium</i> sp. PAU	Unpelleted	22.56	0.76	45.00	37.00
"	Calcium carbonate	27.08	0.87	56.00	46.00
"	Rock phosphate	27.61	0.86	56.67	42.00
"	Charcoal	26.28	0.84	53.33	43.33
"	Dolomite	32.29	0.97	55.67	53.33
Mean		27.16	0.86	53.13	44.33
<i>Rhizobium</i> sp. 32H1	Unpelleted	16.46	0.63	29.33	28.67
"	Calcium carbonate	20.11	0.65	32.00	33.67
"	Rock phosphate	20.23	0.65	36.00	27.33
"	Charcoal	24.83	0.84	40.67	38.38
"	Dolomite	27.14	0.86	43.33	41.33
Mean		21.75	0.73	36.27	33.87
LSD (P=0.05) for comparison of control VS treatments		8.16	0.19	14.89	NS
LSD (P=0.05) for comparison of rhizobial cultures		5.07	0.12	9.29	NS

parameters used to evaluate symbiotic effectiveness of rhizobia. Of the three rhizobial cultures inoculated to *C. mucunoides* significant response to inoculation was obtained in shoot dry weight only with the culture EGI when inoculated without pelleting treatments (Table I). When pelleting was done with the rhizobial inoculation, significant increases were observed in nitrogen yield,

shoot dry weight and nodule weight with all the three rhizobial cultures compared to uninoculated control. The extent of increase in growth and nodulation also varied significantly when different cultures were inoculated. Cultures EGI and PAU cowpea were superior to 32HI in increasing growth and nodulation characteristics. Shoot dry weight and nitrogen (Fig. 1) differed significantly

Table II. Total nitrogen, shoot dry weight and nodulation in *L. leucocephala* as influenced by *Rhizobium* inoculation and seed pelleting

<i>Rhizobium</i> Treatment	Pelleting treatment	Nitrogen shoot mg plant ⁻¹	Shoot dry wt. g plant ⁻¹	Nodule dry wt. mg plant ⁻¹	Nodule No. plant ⁻¹
Uninoculated	Unpelleted	18.70	0.67	20.50	18.25
<i>Rhizobium</i> sp. IARI (LI)	Unpelleted	23.79	0.74	25.50	19.75
„	Calcium carbonate	25.10	0.75	32.75	23.75
„	Rock phosphate	31.82	0.81	33.00	24.00
„	Charcoal	25.76	0.77	26.50	22.50
„	Dolomite	32.16	0.86	28.25	25.50
Mean		27.73	0.78	29.20	23.10
<i>Rhizobium</i> sp. Local (L-2)	Unpelleted	25.90	0.83	24.50	20.75
„	Calcium carbonate	30.19	0.88	36.00	23.75
„	Rock phosphate	33.66	0.97	45.75	30.00
„	Charcoal	28.85	0.82	35.75	34.75
„	Dolomite	38.99	0.99	46.25	30.25
Mean		31.52	0.89	37.65	27.50
LSD (P=0.05) for comparison of control VS treatments		9.44	NS	11.42	6.73
LSD (P=0.05) for comparison of rhizobial cultures		NS	NS	7.30	4.04

when inoculation + pelleting treatments were compared with unpelleted inoculation treatments. The growth and nodulation responses were not significantly different in pelleting treatments using different materials. However, maximum responses was observed when charcoal was used as pelleting material.

The data on the response of *L. leucocephala* to rhizobial inoculation and seed pelleting are presented in Table II. Significant response to rhizobial inoculation was obtained in nitrogen yield, nodule dry weight and nodule number when pelleting was done with

inoculation. The two rhizobial cultures also differed significantly in causing nodulation in the host. As far as the nitrogen yield was concerned, inoculation + pelleting treatments were superior to unpelleted inoculation treatments (Fig. 1). In *Leucaena* also the difference in response due to the use of different pelleting materials was not significant.

Plating of the nodular contents of plants inoculated with rhizobia having antibiotic resistant markers revealed higher colonisation by introduced rhizobia in nodules of plants which received inoculation + pelleting

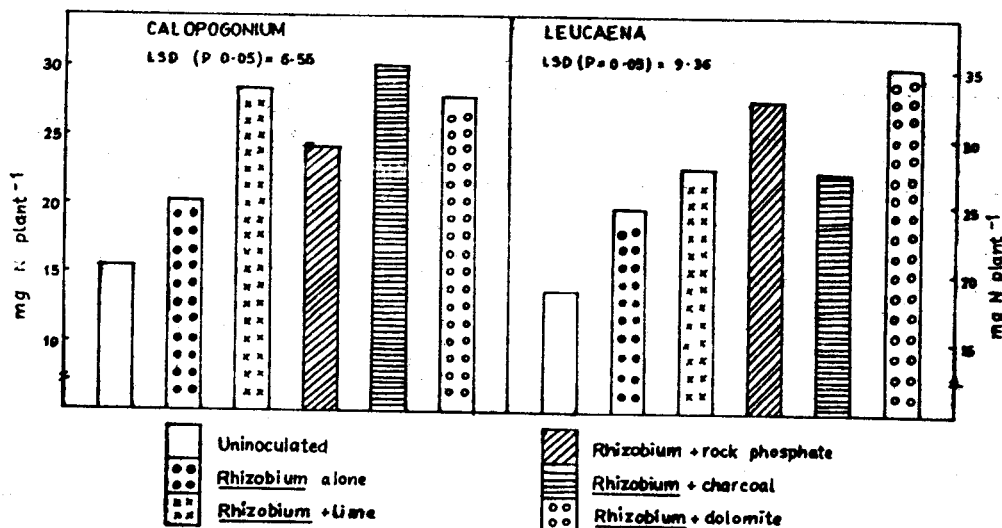


Fig. 1. Effect of *Rhizobium* inoculation and pelleting on nitrogen yield in *Calopogonium* and *Leucaena*

treatments when compared to inoculation alone. Such higher colonisation rates were observed in nodules of both *Calopogonium* and *Leucaena* when inoculated with drug resistant strains of 32 H1 and L1 cultures, respectively. This indicate that increase in the symbiotic efficiency is due to better survival and subsequent infection of roots by introduced rhizobia under pelleting treatments.

Infectivity and effectiveness of the rhizobial cultures varied significantly on both the legumes. This may be due to the factors such as strainal variation in tolerance to acidic soils and compatibility of the rhizobia with a particular host. Strain differences in tolerance to acidic soils have been reported in *R. meliloti* and *R. trifolii* (Ssali, 1981). Variation in the response of different *Leucaena* cultivars was also reported in an earlier study (Thomas et al 1985).

All the rhizobial cultures tested on *C. mucunoides* and *L. leucocephala* elicited significant responses by increasing shoot weight and/or increasing the nitrogen content over

uninoculated control when pelleting was done along with inoculation. Only one rhizobial culture (EGI) could induce significant response in the absence of pelleting. This shows the need for pelleting to protect rhizobia from acidic conditions in the tested soil. Studies conducted in Nigeria (Kang, Hangju and Ayanaba, 1977) and West Africa (Danso, 1988) have demonstrated that lime pelleting of inoculated soybean seeds grown in acid soil increased rhizobial numbers in soil, nodulation and growth of soybean. The pelleting material around the inoculum provides a microenvironment, favourable for survival and growth of rhizobia till the roots develop and rhizobia get a chance to infect the roots. Once infection has taken place the rhizobia are protected from acidic conditions inside the roots. The present study has shown that seed inoculation alone may not give substantial improvement in nodulation and growth of green manure/cover legumes unless pelleting treatment is done in the acidic coconut soils.

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REGENERATION OF COFFEE PLANTLETS THROUGH TISSUE CULTURE TECHNIQUES

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ABSTRACT

Many *in vitro* techniques have been proved successful in *Coffea* spp. and to date plant regeneration from mature leaf, orthotropic stem explants, apical buds and axillary buds and embryos was accomplished by several workers elsewhere. At Central Coffee Research Institute, work on tissue culture aspects was initiated during 1985 with main aim of utilising these techniques for the improvement of cultivated coffee. Starting with the field grown plants of *Coffea arabica* L. and *C. canephora* Pierre, a suitable sterilisation procedure was devised for orthotropic stem explants and callus was obtained in Murashige-Skoog basal medium. Subsequent plantlet regeneration was achieved in secondary cultures through embryogenesis. Plantlet development was also obtained from the cultures of immature embryos of San Ramon cultivar. In this article the procedure adopted for these techniques and results obtained are described.

INTRODUCTION

Many *in vitro* techniques have been reported in coffee. The pioneering work was that of Staritsky (1970). Subsequent progress of *in vitro* methods has been reviewed by Monaco et al (1977); Sondahl, Monaco and Sharp (1981) and Sondahl et al. (1984). Recently regeneration of plantlets through embryogenesis was reported in robusta and arabica coffee (De Pena, 1984) and in arabusta coffee (Owuor, 1987).

To date, plant regeneration from mature leaf and orthotropic stem explants has been accomplished in many cultivated species of the genus *Coffea*. Explants such as apical buds and axillary buds have yielded plantlets but the efficiency of sterilization of these explants was very slow. Partial success was also reported in cultures of anthers, embryos, endosperm and protoplasts (Sondahl et al., 1984).

In India work on tissue culture techniques in coffee was initiated at CCRI during 1985 with the following objectives: (i) Rapid clonal multiplication of cross pollinated robusta coffee and other elite types (ii) Induction of somaclonal variation in case of self pollinated arabica coffee and selection of desirable variants (iii) Embryo culture – in order to rescue the embryos resulting from incompatible interspecific crosses (iv) Anther culture – to obtain suitable haploids and double haploids which would be advantageous in conventional breeding programme.

Till now success has been achieved with callus and immature embryo cultures and the same is discussed hereunder.

MATERIALS AND METHODS

Work was undertaken at CCRI, Belehnur to standardise the procedures for sterilization and culturing of different explants

such as mature leaf, apical and axillary buds, stem pieces, immature embryos and anthers. The procedures adopted for sterilization of explants viz., stem pieces and immature embryos are as follows:

1. Stem explants

(a) Soft internodal portions from orthotropic shoots of *Coffea arabica* L. and *C. canephora* Pierre are collected from field and washed thoroughly in tap water using Teepol.

(b) These material are surface sterilized with 0.5% solution of HgCl_2 containing a few drops of lactic acid for 5 minutes.

(c) They are then rinsed with sterile water for 4–5 times under laminar air flow.

(d) Explants of size 2–3 mm are prepared using a sharp razor and immediately dipped in 1% solution of L-Cysteine HCl for 5 min. before inoculating them into culture tubes.

(e) M. S. medium (Murashige and Skoog, 1962) supplemented with 1 mg/l IAA and 4.3 mg/l KIN was used as a basal medium and all the cultures are incubated in the dark.

2. Embryo culture

(a) Immature fruits of San Ramon (*C. arabica* L) Cv. S.7.3 are collected from field and washed thoroughly in tap water using Teepol.

(b) The fruits are surface sterilized with 0.5% HgCl_2 solution for 10 min. and then rinsed thoroughly 4–5 times with sterile water.

(c) They are then cut open under laminar air flow conditions and torpedo shaped embryos are scooped out aseptically and immediately transferred to culture tubes.

(d) M.S. medium supplemented with 1 mg/l BAP; 1 mg/l IAA and 6 g/l activated charcoal was used for the above inoculations. All the cultures are then kept under high light intensity.

RESULTS AND DISCUSSION

1. Stem explants

The sterilization procedure tried for stem explants was very effective, giving a success rate of 80–100%. The major problem associated with culturing of coffee tissues is the oxidation of phenols leading to the production of quinones which are inhibitory to cellular growth (Monaco et al. 1977). In the present studies this problem was successfully overcome by the use of lactic acid and L. cysteine HCl treatments while preparing the explants. Profuse hard callusing (Fig. 1) was observed in the explants by 3–4 weeks' time. Monthly subculturing of these calluses was undertaken on a M. S. medium containing 0.05 mg/l 2,4-D and 8.6 mg/l KIN. During the initial subculturing callus turned to green under illumination, but by the third subculturing most of the calluses turned brown. When subcultured for a fourth time on M. S. medium containing 4% sucrose; 6.5 mg/l BAP and 2 mg/l IBA, white embryonic tissues (Fig. 2) are observed at the periphery of callus by a week's time. Large quantities of cream white coloured, globular and torpedo shaped embryos (Fig. 3) are seen arising from the embryonic tissues by another 7–8 weeks' duration. Staritsky (1970) observed a similar formation of somatic embryos from stem explants of *C. canephora*.

Individual somatic embryos with root and shoot primordia are picked up and transferred to M. S. medium supplemented with 1 mg/l BAP and 1 mg/l NAA for promoting shoot

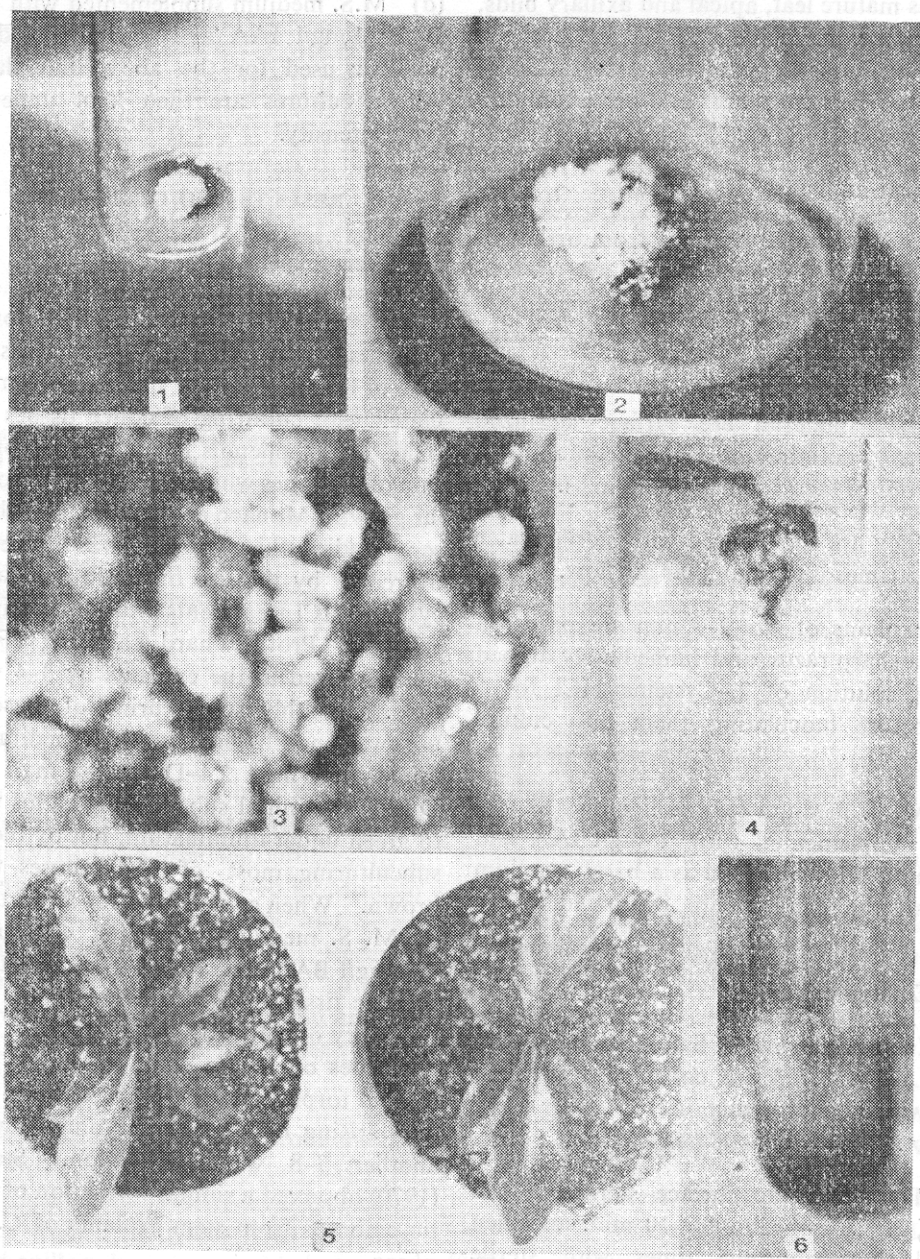


Fig. 1. 1. Callus from stem explants. 2. Embryonic tissues arising from the periphery of callus. 3. Cream white coloured, globular and torpedo shaped somatic embryos. 4. Rooting in regenerated plantlet. 5. Plantlets established in vermiculite medium. 6. Rooting in excised embryos of San Ramon.

and root elongation. Around 25–30 plantlets are recovered from each culture. The formation of somatic embryos continued in the callus for many weeks. Perhaps a stimulatory or inducer substance may be synthesized which promotes the induction of additional embryos (Staritsky, 1979). Most of the plantlets produced long single roots (Fig. 4), but a few plantlets produced 2–3 roots. After sufficient root and shoot elongation, these plantlets are brought out of the cultures, washed thoroughly to remove the medium adhering to the roots and transplanted in sterile vermiculite medium (Fig. 5). Around 90% establishment was observed under ambient conditions.

This protocol enables the large scale recovery of plantlets from stem explants through embryogenesis. Similar successes have been reported from mature leaf explants, (Sondahl and Sharp, 1977; De Pena, 1984; Owuor, 1987). However, further studies on multiplication co-efficients, variations and adaptation of plantlets to soil are required, in order to utilise this technique for selection of desirable somaclonal variants.

2. Embryo culture

The procedure followed for culturing of immature embryos of San Ramon was most effective. There was a 100% efficiency in explant sterilization. The sterilization procedure described elsewhere in this paper is much simpler than the method described by Sondahl et al., 1984 and hence could be adopted easily.

In all the cultures expansion of embryos was observed within a week. Root initials and expansion of cotyledonary leaves were observed by second week. All the embryos produced long single roots (Fig. 6) resembling the tap root of seedlings. Shoot growth was comparatively slow and first pair of leaves could be seen only around 7–8 weeks

time. These plants are transplanted in sterile vermiculite medium and maintained under ambient conditions. Establishment of these plants was found to be good.

These results indicate the feasibility of culturing immature embryos of coffee. Similar success are reported in embryos of robusta and dewevrei (Colonna, 1972); arabica and arabusta (Sondahl et al 1984). By utilising this technique it is possible to culture the embryos of incompatible interspecific cross combinations, and thereby establish the missing genotype.

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EVALUATION OF CERTAIN MORPHOLOGICAL AND PHYSIOLOGICAL FACTORS IN TEA (*CAMELLIA* L. SPP.) CULTIVARS UNDER WATER STRESS

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ABSTRACT

The effect of water stress on leaf wax content, specific leaf weight (SLW), proline accumulation and relative water content in leaf, rate of loss of leaf moisture, chlorophyll content and rate of leaf expansion was studied in six tea clones with the aim of developing an index to assess drought-tolerance of tea cultivars.

Water stress led to a significant accumulation of proline and epicuticular wax in all the clones. Three clones that are generally known to be drought-tolerant in field, accumulated significantly higher levels of proline under prolonged stress; a trend of higher wax deposition was also noticed in the tolerant clones.

The drought tolerant clones exhibited significantly higher SLW over the remaining three; SLW declined under stress. Relative water content was higher and rate of moisture loss under stress was lower in the tolerant clones. Water stress led to a decline in total chlorophyll content in all the clones.

Rate of leaf expansion was significantly reduced by stress in all the clones at the end of the final observation, recorded on eighth day.

INTRODUCTION

Tea in south India suffers from recurrent prolonged drought from mid-December to March. Moisture stress, combined with high temperatures and low relative humidity, not only leads to crop depression during drought, but also, to difficulty in establishing new planted tea clearings. As such, the importance of developing drought tolerant cultivars cannot be over emphasised with reference to tea cultivation in south India. While plants do adapt in a limited way to drought by the operation of escape or tolerance mechanisms (Kramer, 1980), breeding cultivars for drought resistance (Blum, 1979; Quisenberry, 1982; Richards, 1982) is the only long term solution. Evolving an index based on simple morphological and physiological characteristics to evaluate drought tolerance of tea

cultivars becomes an essential prerequisite to such an approach.

The influence of water stress on certain factors like the rate of leaf elongation, rate of moisture loss, specific leaf weight, deposition of epicuticular wax, accumulation of proline and changes in chlorophyll content in relation to drought stress has been investigated in certain other crops as well as in some tea clones (Acevedo, Hsiao and Henderson, 1971; Nagarajah, 1979; Balasimha, 1982; Patil, Panchal and Janardhan, 1984; Anonymous, 1985; Anonymous, 1986). An index based on the characters mentioned above is expected to be of assistance in tea breeding programme as well as in the choice of right clones for planting in drought prone areas in south India. With this in view, an investigation has been undertaken to evaluate the

performance of six released, known tea clones under water stress.

MATERIALS AND METHODS

The experiment was of randomized block design. There were two treatments, replicated thrice, imposed on six tea clones; each replicate in a clone comprised eight potted plants kept in a glass house.

Eight-month old plants of the clones, UPASI-2, UPASI-3, UPASI-8, UPASI-9, UPASI-10 and UPASI-17 were planted in earthen pots; each pot was filled with five kg of soil having a sandy-loam texture. The plants were transplanted into pots during November 1987 and allowed to establish up to February 1988. During the period of establishment, the plants were irrigated at the rate of 500 ml per pot per day. Minimum and maximum temperatures were recorded from a wet and dry bulb thermometer kept in the glass house, throughout the period of investigation.

At the time of imposing the treatments on February 16, 1988, the pots under the standard continued to receive daily irrigation as before; irrigation was withheld in the other plots which were kept under the treatment of water stress.

Rate of leaf expansion was determined in the first leaf from the apical bud by measuring length and breadth of the leaf at two-day intervals. Epicuticular wax was estimated gravimetrically by dipping the second leaf in chloroform and evaporating the solvent to dryness at room temperature.

Proline was extracted from the third leaf and estimated as per the method of Bates, Waldren and Teare (1973). Chlorophyll 'a' and 'b' were determined in the third leaf by adopting Mackinney's method (1941).

Relative water content (RWC) was estimated in leaf discs of 1.75 cm diameter taken from the fourth leaf following the method of Weatherley (1960). Specific leaf weight (SLW) was determined in leaf discs of 1.75 cm diameter from the fifth leaf by oven dry method. Rate of loss of moisture was estimated in the fourth leaf detached from the plant. Leaves from different nodes had to be taken for the determination of various parameters because of the paucity of material from the same source.

Soil moisture at periodic intervals was estimated by oven dry method using 100 g of soil taken from the pots.

Rate of leaf expansion was recorded up to eight days and the rate of loss of moisture from leaf was recorded on the seventh day. The remaining observations were recorded on first, seventh, eleventh and fifteenth day following the imposition of the treatments.

The data arising from the investigation were subjected to analysis of variance. Data on various parameters recorded at different observations were correlated with moisture content in soil obtaining at corresponding intervals.

RESULTS AND DISCUSSION

The mean maximum temperatures ranged from 24 to 33°C and mean minimum between 18 and 24°C during the period of the investigation; relative humidity varied between 62 and 80 per cent.

Soil moisture status

Significant variations in soil moisture status were noticed between pots supporting different clones; the variations have become more pronounced under conditions of water deficit. Under the regime of regular irrigation, the soil moisture status in pots supporting different clones remained nearly at th

initial level throughout the period of study. Under water stress, there was a steep decline in soil moisture status on the seventh day, being more pronounced in the clones, UPASI-3 and UPASI-8, (Fig. 1) which exhibited incipient wilt. However, it was on the eleventh day the soil moisture dropped below the wilting coefficient of about eight per cent; only then, the clones, UPASI-3, UPASI-8 and UPASI-17 manifested symptoms of irreversible wilting damage. The soil moisture status in the pots of the other three clones remained at and above the wilting coefficient; the plants of these clones wilted only on the 15th day. This focuses on the variability in tolerance of clones to moisture stress.

Rate of loss of moisture in leaf

Initial level of moisture in detached leaf on the seventh day of imposing the treatments ranged from 64 to 68 per cent in different clones, irrespective of the soil moisture status under the two regimes. Clonal variations were noticed in the rate of loss of leaf moisture under both regular irrigation and water deficit. The extreme values exhibited by UPASI-9 do not fall into the pattern of other clones and may be the consequence of an error in either the choice of material or experimentation.

The rate of loss of moisture was comparatively more in the first six hours in UPASI-3,

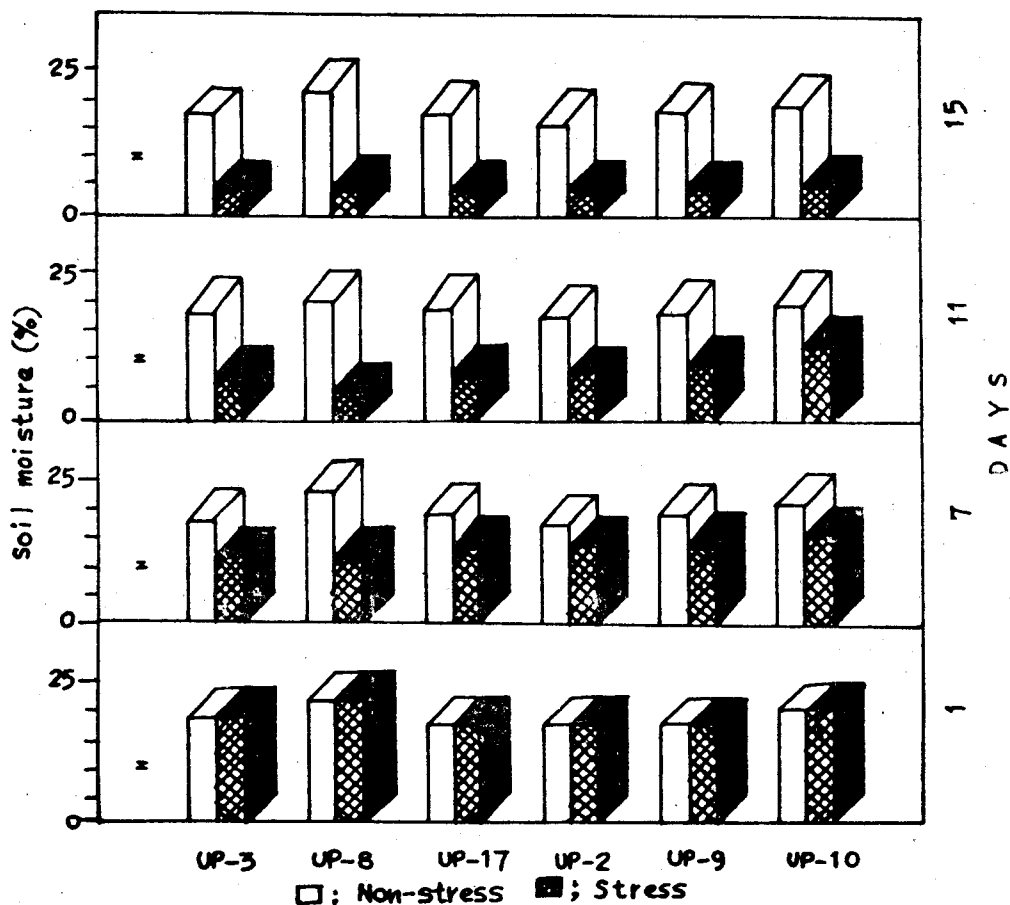


Fig. 1. Soil moisture content under stress (vertical bars represent C. D. at $P = 0.05$)

UPASI-8, UPASI-2 and UPASI-17 under irrigation and UPASI-2, UPASI-3 and UPASI-17 under stress. Excepting in the clone UPASI-3, the rate of loss of moisture declined under stress despite the comparable initial levels under stress and irrigation. The decline in the rate of loss of moisture was more pronounced in UPASI-2, indicating a defensive mechanism not present in UPASI-3. Comparatively lower level of moisture loss in the clone UPASI-2 suggests its hardiness to drought, while greater loss in the clones UPASI-3 and UPASI-17 indicates their proneness to drought. Similar differences in rate of loss of moisture in detached tea leaf were reported by Nagarajah (1979).

The maintenance of internal plant water status depends on the water loss through foliage. Lower water loss indicates higher stomatal resistance (Handique and Manivel, 1987) and cuticular resistance (Harikrishnan and Sharma, 1982); higher stomatal and cuticular resistance could also affect gaseous exchange, and consequently, the rate of photosynthesis.

The observations were recorded only on the seventh day, when soil moisture status was over the wilting co-efficient. Determination of loss of leaf moisture during the following period and at shorter interval is likely to throw up important and interesting information.

Relative water content

Varietal variation in RWC was noticed between clones under irrigation as well as water deficit. Significant drop in RWC was noticed under stress on different days of observation. RWC declined progressively with the period of water stress. The clones, UPASI-3, UPASI-8 and UPASI-17 showed significantly lower values than the other three, the differences widening with the duration of water stress (Fig. 2). The three

clones with higher RWC are likely to be more tolerant to drought as was earlier reported in cocoa (Balasimha, 1982). Higher RWC lends turgidity to the cells assisting in their expansion and growth (Handique and Manivel, 1987).

Specific leaf weight

Significant variations in specific leaf weight between the clones were noticed except between UPASI-2 and UPASI-9 at the time of the first three observations under irrigation. Under stress, there were no differences between UPASI-3 and UPASI-8, and UPASI-2 and UPASI-9 on seventh day, UPASI-3 and UPASI-8 on eleventh day, and UPASI-3 and UPASI-8 on fifteenth day (Fig. 3).

There was a decline in SLW of all the clones under stress from seventh day onwards as reported earlier (Anonymous, 1985). In UPASI-3, UPASI-8 and UPASI-2, the SLW seems to have reached an equilibrium on eleventh day, while in other clones it continued to decline further under stress.

The fairly uniform values obtaining in each clone under irrigation during the period of the study indicate that the ambient temperatures and relative humidity obtaining during the study have little influence on SLW; SLW declined with the decline in soil moisture status and relative water content (Figs. 1 and 2).

SLW, under irrigation as well as water deficit, was noticed to be fairly higher in UPASI-2, UPASI-9 and UPASI-10 known to be tolerant to drought compared to the remaining three clones; SLW under normal conditions and the severity of its drop under water stress may be indicative of drought tolerance of these clones to some extent.

Wax deposition

Variations in cuticular wax deposition were noticed between clones, ranging from

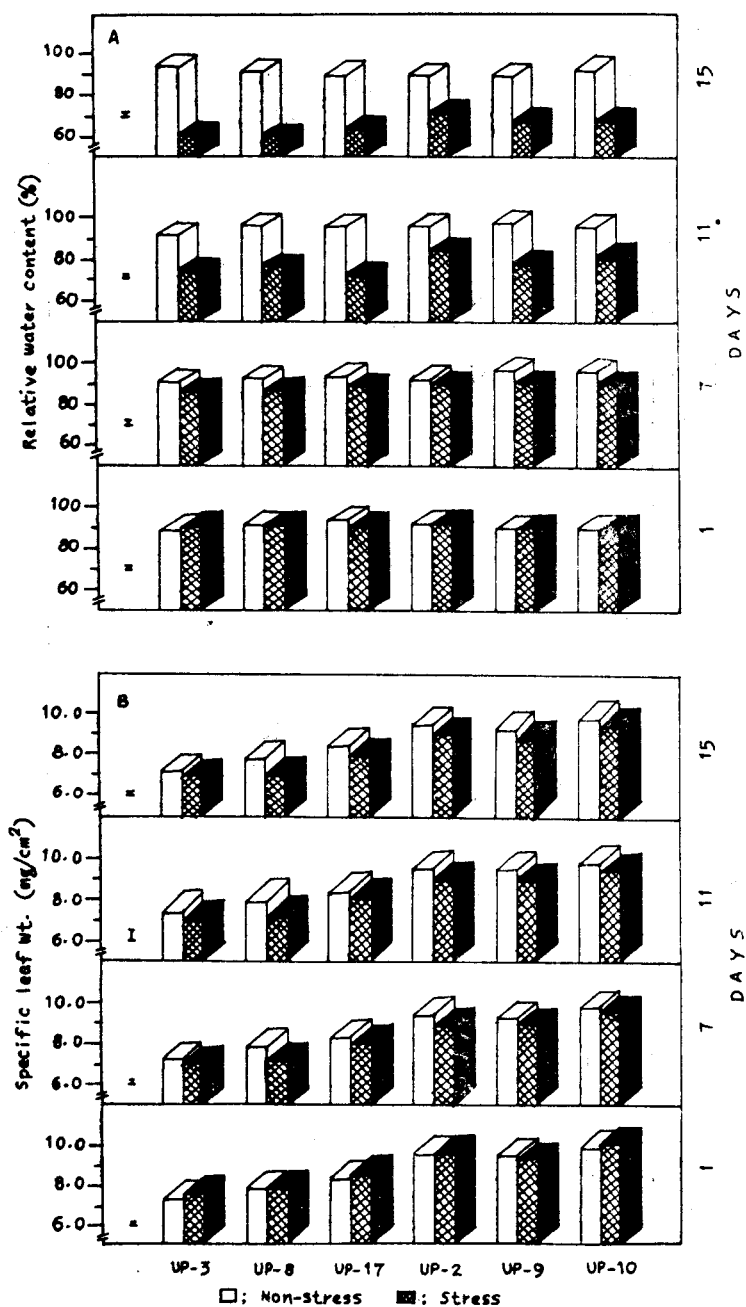


Fig. 2. Effect of stress on (A) relative water content and (B) specific leaf weight (vertical bars represent C. D. at $P = 0.05$)

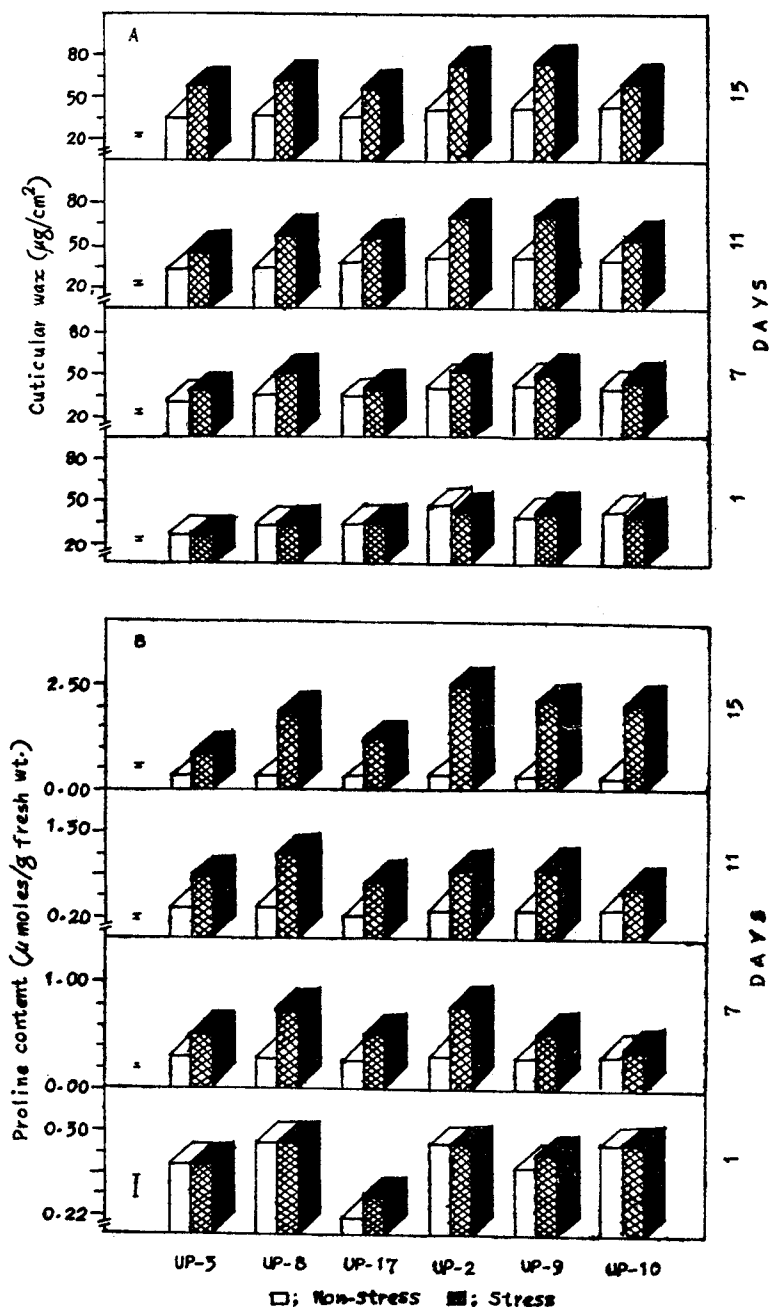


Fig. 3. Changes in (A) epicuticular wax and (B) proline content under stress (vertical bars represent C. D. at $P = 0.05$)

marginal to significant levels, both under irrigation and water stress conditions as was reported earlier in tea and other crops (Bala-simha, 1982; Anonymous, 1985). There was a significant increase in wax deposition in the plants of all clones subjected to water deficit (Fig. 3) the wax deposition further increased significantly with the duration of water stress. It has been reported that water stress induces enhanced deposition of epicuticular wax in cotton (Weete et al., 1978) Soybean (Vanvolkenburgh and Davies, 1977). Epicuticular wax reflects sunlight and curtails transpiration through cuticle (Oval Myers, Yopp and Krishnamani, 1986).

The present study points to the drought proneness of the clones, UPASI-3, UPASI-8 and UPASI-17 in comparison to the remaining three.

Chlorophyll content

The total chlorophyll and its components, 'a' and 'b' varied with the clones; UPASI-3, UPASI-8 and UPASI-17 showed comparatively lower values. The ratio between chlorophyll 'a' and 'b' was markedly low in UPASI-3, while it ranged within narrow limits in the other clones.

The chlorophyll content, both 'a' and 'b' declined under water deficit and had become conspicuous on fifteenth day; the decline was found to be more marked in UPASI-2, UPASI-9 and UPASI-10. Such reduction in chlorophyll content under drought conditions was earlier reported in tea as well as in other crops (Hsiao, 1973; Anonymous, 1986). Reduced ability to form protochlorophyll was considered to be responsible for the inhibition of the development of chlorophyll under water stress (Hsiao 1973).

Proline content

Proline content in the clone UPASI-17

was markedly lower than all the other clones even under continual irrigation; proline in the other clones was more or less at the same level. The sudden increase in proline content on the seventh day was apparently due to the high ambient temperature coupled with low relative humidity prevailing on that day. Generally, UPASI-8, UPASI-2 and UPASI-10 showed marginally higher values than the other three clones under normal conditions (Fig. 3). Clonal differences in proline content increased and became significant in all the clones under stress.

Significant accumulation of proline has been reported to occur under stress condition in tea (Anonymous, 1985) sugarcane (Singh and Singh, 1986) maize (Patil et al., 1984) potato (Bansal and Shantha Nagarajan, 1986) cocoa (Balasimha, 1982) tomato (Kuo, Chen and Ma, 1986) and barley (Hanson, Nelsen and Eversen, 1977).

Proline accumulation appears to be a defensive mechanism to overcome the conditions of water stress. Under water deficit, proline was reported to serve as a compatible solute to maintain the osmotic balance between cytoplasm and vacuole (Flowers, Troke and Yeo, 1977), though the exact trigger leading to proline accumulation is not clearly known (Hanson and Hitz, 1982). Accumulation of higher levels of proline such as was the case in UPASI-2, UPASI-9 and UPASI-10 under prolonged water deficit is indicative of drought tolerance.

Rate of leaf expansion

Rate of leaf expansion at the end of two days was found to be significantly lower in UPASI-10 compared to UPASI-2, UPASI-8 and UPASI-9 under irrigation; however, no such differences were noticed in subsequent observations (Table I). Under water stress, there was a drop in the rate

Table I. *Rate of leaf expansion (cm²/day) during days*

Treatments	1 & 2	3 & 4	5 & 6	7 & 8
<i>Non-stress</i>				
UPASI-3	1.4	1.2	1.2	1.5
UPASI-8	2.0	1.8	2.0	2.4
UPASI-17	1.2	1.1	2.0	2.3
UPASI-2	1.7	1.6	1.9	2.3
UPASI-9	2.0	1.8	2.2	2.4
UPASI-10	1.0	1.2	1.5	1.8
Mean	1.55	1.45	1.8	2.12
<i>Stress</i>				
UPASI-3	1.3 (1.35)	1.2 (1.2)	0.9 (1.05)	0.8 (1.15)
UPASI-8	1.9 (1.95)	1.8 (1.8)	1.6 (1.8)	1.0 (1.7)
UPASI-17	1.4 (1.3)	1.3 (1.2)	1.2 (1.6)	0.9 (1.6)
UPASI-2	1.6 (1.65)	1.3 (1.45)	1.2 (1.55)	1.1 (1.7)
UPASI-9	1.9 (1.95)	1.5 (1.65)	1.5 (1.85)	1.4 (1.9)
UPASI-10	1.0 (1.0)	1.0 (1.1)	0.9 (1.21)	0.9 (0.9)
Mean	1.52	1.35	1.22	1.0
CD at P = 0.05 C	0.6	0.8	1.0	0.9
T	NS	NS	NS	0.5
CxT	NS	NS	NS	NS

Figures in parentheses are the means of individual clones, under both the treatments

of leaf expansion showing a relationship with the drop in relative water content; however, the decline became significant only on seventh and eighth days, corresponding to the drop in soil moisture status and relative water content. In soybean, a relationship between leaf water potential, leaf area expansion and relative growth rate were demonstrated; they were also correlated with soil moisture (Sivakumar and Shaw, 1978).

Reduced soil moisture status leading to lower relative water content which in turn

makes the cell flaccid, interferes with growth and expansion. It is interesting to note that the rate of expansion in all the six clones was affected by the seventh day of water deficit; the differences in rate of growth between clones under stress were significant only between UPASI-3 and UPASI-9, the latter being superior. It is, thus, evident that some clones, while being tolerant to shorter durations of water stress, will be affected by extended period of stress.

Table II. *Correlation coefficient of different parameters with soil moisture

Parameters	1 day	7 days	11 days	15 days	Overall
Relative water content	NS	0.826	0.936	0.964	0.906
Specific leaf weight	NS	NS	NS	NS	NS
Cuticular wax	NS	-0.590	-0.786	-0.884	-0.829
Chlorophyll content	NS	NA	NS	NS	NS
Proline content	NS	-0.779	-0.936	-0.901	-0.849
Rate of leaf expansion	NS	0.812	NA	NA	NA

* at 1 % level

NA : not available

Relative water content was found to be positively correlated, while the levels of proline and wax were negatively correlated with soil moisture status from the seventh day onwards. Understandably, the rate of leaf expansion on the seventh day was positively correlated with soil moisture (Table II).

The six clones varied in their response to identical conditions of soil moisture status and tolerance to water stress. The investigation offers a possibility to identify cultivars that are tolerant to drought, using one or a combination of the parameters studied.

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PRELIMINARY REPORT ON THE EFFECT OF CALCIUM CARBIDE AS AN YIELD STIMULANT IN COMPARISON TO ETHEPHON IN *HEVEA BRASILIENSIS*

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ABSTRACT

An yield stimulation experiment using calcium carbide and ethephon was laid out at the Central Experiment Station of Rubber Research Institute of India. A novel method of application of calcium carbide is used in the present study. The preliminary results are promising. The most important observation is a 50 per cent higher cumulative yield with calcium carbide stimulation in conventionally tapped trees when compared to stimulation with ethephon. The effect of calcium carbide is more in the first two tappings after stimulation, followed by a decline. Due to wintering yield under all treatments declined during February to April and later increased. Calcium carbide may be used as an yield stimulant after assessing its long term effect on yield and brown bast.

INTRODUCTION

The system of yield stimulation has become an established commercial practice in *Hevea*. A systematic research on stimulation was started in 1930's. Two main categories of stimulants were distinguished *i. e.*, compounds which decompose to produce ethylene and analogues of ethylene such as acetylene; and growth regulators which induce the tissue to produce ethylene. Pakinathan (1970) screened 187 compounds including calcium carbide (CaC_2) in search for new stimulants. Wu Kaihua and Wang Hongbo (1986) reported superiority of puncture tapping combined with CaC_2 stimulation over conventional excision tapping. Ethephon stimulation under conventional tapping systems are well studied (Abraham, 1970; Sivakumaran et al., 1983; Sethuraj, George and Sulochanamma, 1975; Eschbach and Tonnelier, 1984; Lee, Ismail and Ng, 1985). However, no information is available on effectiveness of soil application of CaC_2 under conventional tapping systems.

MATERIALS AND METHODS

A field experiment was laid out in a completely randomised design in the Central Experiment Station of Rubber Research Institute of India. Trees with abnormally low or high yields were excluded from the trial based on pre-experiment treewise yield data. The details of various treatments given are presented in Table I. Each treatment has ten trees as replicates. The method of application of CaC_2 is illustrated in Fig. 1. A 30cm long, hollow and perforated bamboo pipe was fixed in the soil, 15-20 cm away from the plant, adjacent to the tapping panel. Twenty gm CaC_2 granules were sprinkled around the neck of the bamboo pipe and sealed using a porcelain cup.

The method of puncture tapping adopted is as given in Fig. 2. Four vertical bands of 40 cm length were made on the tree, 20 cm above the bud union and four punctures/band were made on each tapping. Calcium carbide stimulation was repeated

Table I. *Details of various treatments*

Treatment Number	Treatment	Type of stimulant	Method of application	Frequency
T ₁	Puncture tapping (PT) + CaC ₂	CaC ₂	Soil application 20 g/tree	Once in 15 days
T ₂	Puncture tapping + Ethephon (ET)	Ethephon 5%	On vertical bands (4 nos)	Once in 30 days
T ₃	1/2 S d/2 + CaC ₂	CaC ₂	Soil application 20 g/tree	Once in 15 days
T ₄	1/2 S d/2 + Ethephon (ET)	Ethephon 5%	Bark application (5 cm, below tapping cut)	Once in 60 days
T ₅	1/2 S d/2 (control)	—	—	—

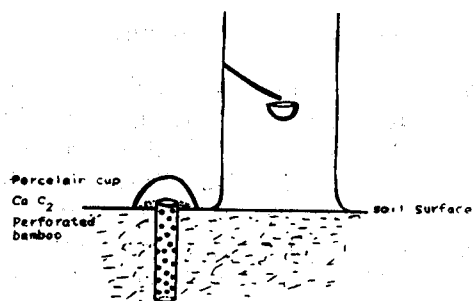


Fig. 1. Method of application of calcium carbide

at 15 days interval, whereas ethephon stimulation was carried out at band change (once in a month) for puncture tapping (PT), and at 60 days interval in case of bark application.

The first stimulation was carried out in December and tapping commenced on 2nd January 1988. Tree wise yield data was collected by cup lump method. One CaC₂ stimulation was omitted during wintering.

RESULTS

The mean yield data obtained for the initial five months of the trials are presented

in Fig. 3. The yield differences were significant at 5% error. Half spiral alternate daily tapping system with CaC₂ stimulation gave the maximum dry rubber yield. The yield (g/tree/tap) in this treatment was 73 per cent higher than the 1/2S d/2 control. This was 50 per cent higher than the yield obtained with ethephon stimulation under

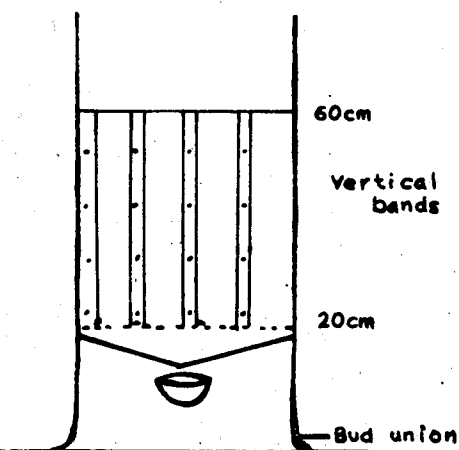


Fig. 2. Puncture tapping under ethephon and calcium carbide treatments (Four vertical bands of 40 cm length and 4 punctures/band)

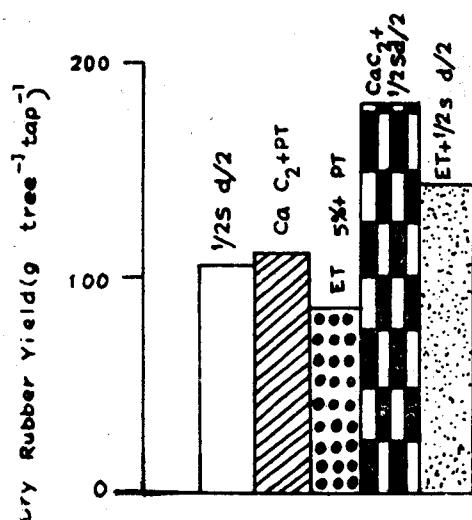


Fig. 3. Mean dry rubber yield ($\text{g tree}^{-1} \text{ tap}^{-1}$) under different treatments

the same tapping system. Similarly with puncture tapping system also higher yield was obtained with CaC_2 stimulation when compared to ethephon stimulation. However, puncture tapping was found to be less effective than conventional tapping system, and the difference between calcium carbide and ethephon effects were non-significant.

Yield stimulation effects of CaC_2 and ethephon on individual tapplings after sti-

mulant application are presented in Table II. Maximum stimulatory effect was observed in the first and second tapplings in trees stimulated with CaC_2 . The response showed gradual decline afterwards. In case of ethephon, the response showed gradual increase initially and was steady afterwards.

Monthly yield data (Fig. 4) shows that increased yield obtained by the application of the two stimulants reduced drastically

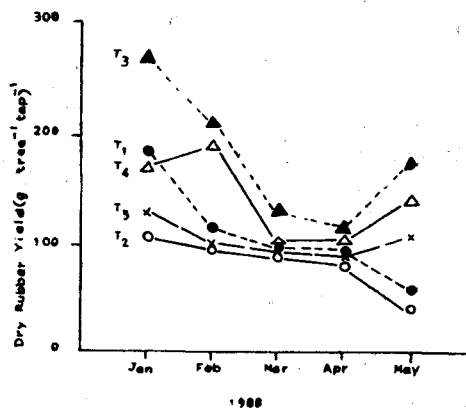


Fig. 4. Monthly dry rubber yield ($\text{g tree}^{-1} \text{ tap}^{-1}$) under various treatments

- T_1 - CaC_2 + puncture tapping
- T_2 - Ethephon + puncture tapping
- T_3 - CaC_2 + $\frac{1}{2}\text{S d/2}$ 6d/7
- T_4 - Ethephon + $\frac{1}{2}\text{S d/2}$ 6d/7
- T_5 - $\frac{1}{2}\text{S d/2}$ 6d/7
- T_6 - $\frac{1}{2}\text{S d/2}$ 6d/7

Table II. Effects of calcium carbide and ethephon stimulations on dry rubber yield (g tree^{-1}) on each tapping day in January 1988 under puncture and conventional tapping systems in clone RRIM 600 (Panel B 1 - 1)*

Treatment	Tapping dates												
	2	5	7	9	12	14	16	19	21	23	26	28	30
PT + CaC ₂	194	221	175	159	—	160	**	—	257	200	—	178	134
PT + ET	70	109	107	107	—	141	—	—	114	93	—	133	93
1/2 S d/2 + CaC ₂	258	282	260	258	—	237	**	—	308	284	—	266	257
1/2 S d/2 + ET	133	145	151	158	—	171	—	—	194	179	—	228	191
1/2 S d/2 (Control)	120	126	127	143	—	125	—	—	118	125	—	133	144

* First stimulation was given on 31 December 1987

** Second application of CaC_2

during the wintering period. However, the stimulatory effects were again evident in the month of May.

DISCUSSION

The results obtained so far from the study indicate that soil application of CaC_2 , with the modifications described can be equally or more effective than bark application of ethephon under the conventional 1/2S d/2 tapping system. The liberated acetylene might be either directly acting as a stimulant to latex flow or a good portion of the acetylene may be getting converted to ethylene by soil nitrogenase enzyme. Pakinathan (1970) demonstrated direct effect of acetylene liberated from CaC_2 on latex flow stimulation.

The present data shows that puncture tapping with CaC_2 or ethephon stimulation may not be remunerative in older trees as compared to conventional tapping with stimulation. However, puncture tapping with CaC_2 stimulation might be comparable with conventional tapping without stimulation, as found in the present study. This is in agreement with the reports from People's Republic of China (Wu Kaihua and Wang Hongbo 1986). However, a lesser yield for puncture tapping with ethephon stimulation is observed when compared to conventional tapping. This is further supported by findings of Samarnayake (1985).

The response to CaC_2 application is for a short period and this is comparable to groove application of ethephon. In further studies CaC_2 stimulation may be compared with groove or lace application of ethephon. Decline in response to stimulation during

wintering is in agreement with other reports (Sivakumaran, Pakinathan and Abraham 1981). The decline was observed for the stimulatory effect of both ethephon and CaC_2 .

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PHYSIOLOGICAL AND BIOCHEMICAL SUB COMPONENTS OF MAJOR YIELD COMPONENTS IN *HEVEA BRASILIENSIS* -CLONAL VARIATION IN BURSTING INDEX AND CARBOHYDRATE PATTERN

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ABSTRACT

Bursting index and distribution of sugars in four clones belonging to the high and low yielding groups were examined. The latex of low yielding clones with high plugging index was shown to have a significantly higher bursting index than that of high yielding clones with low plugging index. The sucrose content of latex of the low yielding clones was lower than that in the high yielding clones. However, the total carbohydrates were found to be higher in low yielding clones. The possible roles of these parameters in relation to yield performances are discussed.

INTRODUCTION

The four major yield components of a rubber tree are initial flow rate, length of the tapping cut, dry rubber content and plugging index. A model for quantifying rubber yield from the major yield components was developed by Sethuraj (1981). Accordingly, the yield of rubber obtained from a day's tapping is expressed by the equation:

$$Y = \frac{F.l.Cr}{P}$$

where Y is yield of rubber obtained from a tree each time it is tapped, F is the average initial flow rate per centimetre of tapping cut during the first 5 minutes after tapping, l is the length of the cut, p is the plugging index, which is a measure of the extent of latex vessel plugging and Cr is the rubber content. Though the contributions of major yield components towards dry rubber yield in *Hevea* are well understood, knowledge regarding the nature and relative significance of the subcomponents is limited.

The latex of *Hevea brasiliensis* can be considered as a cellular cytoplasm (Dickenson, 1964; Hebant and Defay, 1980; Hebant, 1981). Its characteristics at tapping indicates the physiological state of the laticiferous system. (Prevot et al. 1986). The two major limiting factors in latex production are flow and regeneration. The easier and longer the flow the greater the amount obtained and reciprocally. Likewise a plant's ability to replenish the drained latex after tapping, depending on intensity of tapping, limit the production of latex. Although the role of flow restricting process on the latex yield in *Hevea brasiliensis* is now well established (Boatman, 1966; Sethuraj, 1968; Southorn, 1969; Milford, Pardekooper and Ho, 1969), the reasons for the clonal variation in the extent of plugging is less understood. Clonal variation in two parameters viz., bursting index and carbohydrate status in *Hevea brasiliensis* and their roles in the regulation of latex flow and production are discussed in this paper.

MATERIALS AND METHODS

Six trees each of clones RR11 105, PB 235, Ch 4 and Pil B84 were selected for the study from a completely randomised planting in the germplasm garden of the Central Experiment Station, RR11. For each clone the trees were selected based on their yield performance and the selected trees have yields around the mean values. Clones RR11 105 and PB 235 represent high yielders and Clones Ch 4 and Pil B 84 represent low yielders. The trees were in the second year of tapping in the BO 1 panel.

Plugging index was determined by the method of Milford et al (1969) and bursting index by the method of Ribailier (1968). The observations were made during October-November 1987 which was the peak yield period. Total carbohydrates were extracted from a known amount of latex and estimated by the method of Scott and Melvin (1953). Reducing sugars were estimated by the method of Nelson (1944) and Somogyi (1937). Total sugars were estimated by the same method after acid hydrolysis of the nonreducing sugars.

RESULTS

Data on dry rubber yield, dry rubber content, total carbohydrates, nonreducing

sugars and reducing sugars are presented in Table I. The dry rubber yields of the low yielders were around 80% less than that of high yielders. The dry rubber contents were also low for the low yielders. The concentrations of total carbohydrates were higher for the low yielders when compared to those of the high yielders. The concentrations of nonreducing sugars were however high in the latices of high yielders. A definite pattern was not found in the concentration of reducing sugars in the latices of high and low yielders.

Data on plugging indices, initial flow rates, total volumes and bursting indices are presented in Table II. Plugging indices were low for high yielders. Initial flow rates and total volumes were high for the high yielders when compared to those of low yielders. Bursting indices were high for the low yielders when compared to those of the high yielders.

DISCUSSION

The observation that high yield of dry rubber is associated with high dry rubber contents in the latices and lower values of plugging indices is in conformity with the earlier findings of Sethuraj, et al, 1980. The associated lower values of bursting

Table I. *Dry rubber yield, dry rubber content, total carbohydrates, non reducing sugars and reducing sugars in four clones of Hevea*

Clone	Yield of rubber (gm tree ⁻¹ tap ⁻¹)	Dry rubber content (%)	Total carbohydrates (mg gm ⁻¹ fresh wt)	Non reducing sugars (mg gm ⁻¹ fresh wt)	Reducing sugars (mg gm ⁻¹ fresh wt)
Ch 4	25.29	35.29	8.58	0.79	0.492
Pil B 84	18.05	35.08	9.84	0.72	0.758
RR11 105	97.75	39.98	5.82	3.90	0.966
PB 235	104.41	41.45	3.90	3.4	0.446
CD 0.05	10.05	2.15	1.65	0.47	0.077

Table II. *Plugging index, initial flow rate, total volume and bursting index of four Hevea clones*

Clone	Plugging index	Initial flow rate		Total volume (ml)	Bursting index
		(ml min ⁻¹ tree ⁻¹)	(ml min ⁻¹ cm ⁻¹)		
Ch 4	5.54	2.36	0.064	71.48	36.41
Pil B 84	7.04	2.00	0.058	54.77	30.20
RRII 105	3.53	7.84	0.187	271.28	21.20
PB 235	2.78	4.80	0.093	279.55	16.12
CD 0.05	1.23	0.667	0.026	17.35	4.89

indices with lower values of plugging indices are also in agreement with the earlier findings (Ribaillier, 1968; Sherief and Sethuraj, 1978). The lower bursting indices observed in the latices of high yielders indicate better stabilities of the lutoids of these clones. The delay in plugging is often associated with better stability of lutoids.

The higher concentrations of carbohydrates in the latices of low yielders might be associated with low utilisation of the same for rubber biosynthesis. However, the higher sucrose concentrations in the latices of high yielders are associated with higher rubber production which is in agreement with earlier findings (Eschbach et al., 1984; D' Auzac and Pujarniscle, 1961). Under many situations negative correlations have also been reported (Jacob et al., 1985). The lower plugging indices of high yielders are due to large volumes of latex in spite of higher initial flow rates. Eventhough, the total volumes are comparable for clones RRII 105 and PB 235, a low plugging index for PB 235 is due to lower initial flow rate and prolonged duration of flow. The higher initial flow rate and higher plugging index for clone RRII 105 might be associated with higher turgor pressure in the latex vessels of RRII 105. However, more studies are essential on the pressure and

osmotic potentials of the laticiferous systems of different clones.

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AMINO ACIDS IN BLACK PEPPER (*PIPER NIGRUM* L.) CULTIVARS WITH AN EMPHASIS ON ENDOGENOUS PROLINE

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ABSTRACT

Free amino acids of 10 black pepper (*Piper nigrum* L.) cultivars viz., Karimunda, Kottanadan, Neelamundi, Thommankodi, Narayakodi, Kuthiravally, Kalluvally, Arakulam munda, Aimpirian and Panniyur-1 were characterized and quantified by paper chromatography. Absolute proline content ranged from 1.96-3.48 μ moles. The role of proline is discussed with reference to the build up of stress.

INTRODUCTION

Studies on physiological mechanisms in black pepper are scanty and except an isolated report (Ramadasan, 1988), no systematic attempt is made to understand the physiological mechanism. Early studies, in wheat and sorghum (Munns, Brady and Barlon, 1979; Jones, Osmond and Turner, 1980), have indicated that sugars, amino acids (especially proline) which appear to have translocated from the apical and meristematic regions of the plant are responsible for the decrease of osmotic potential resulting in complete turgor pressure maintenance with expanding tissues and leaves.

In the present paper extraction of free amino acids, their characterisation and quantification by paper chromatography are described. Proline content in 10 pepper cultivars is presented and its role in drought tolerance/resistance is discussed.

MATERIALS AND METHODS

Ten popular pepper cultivars *Piper nigrum* L. viz., Karimunda, Kottanadan, Neelamundi, Thommankodi, Narayakodi, Kuthiravally, Kalluvalli, Arakulam munda, Aimpirian and Panniyur-1 were selected for the study. The rooted cuttings were planted in cement tubs (50 x 75 cm) filled

with forest soil sand mixture supplemented with NPK mixture (2:2.5:1). Irrigation was given as and when required for the first two years of establishment. These plants were trained on teak poles. The youngest mature leaves from the runners were collected for the estimation of free amino acids and proline. Free amino acids were separated and characterised as per the method of Yemm and Cooking (1955) and assay for proline was as per the method of Bates, Waldren and Teare (1973).

Paper chromatography

Whatman No. 1 chromatography grade paper was channelled into 22 segments and 0.5 μ l of the concentrated plant extract and standard mixture containing equi-proportions of individual standards were co-chromatographed in duplicate. The spot areas were transferred into a trace paper and computed and the individual amino acids were quantified as % of the total free amino acids present.

RESULTS AND DISCUSSION

Relative percentages of free amino acids of ten black pepper cultivars are presented in Table I. Cysteine ranges from 4.3-7.8%, highest being in Panniyur-1. In most of the

Table I. *Relative percentage of free amino acids in some popular black pepper cultivars of Piper nigrum L.*

rf value	Expressed as % of total free amino acids										
	Amino acids										
	Cysteine 0.08	Histidine 0.16	Arginine 0.21	Glycine 0.27	Threonine 0.36	Proline 0.43	Tyrosine 0.47	Amino butyric acid 0.50	Methionine 0.52	Valine 0.60	Leucine 0.70
Cultivar											
Karimunda	Tr	Tr	Tr	13.0	19.6	9.8	9.8	14.7	12.3	10.7	9.8
Kottanadan	Tr	Tr	Tr	Tr	16.0	16.0	14.4	8.0	12.0	16.0	17.6
Neelamundi	Tr	Tr	12.0	Tr	13.3	13.3	11.3	10.0	13.3	13.3	13.3
Thommankodi	6.8	Tr	13.5	Tr	13.5	6.8	11.3	9.0	13.5	13.5	11.3
Narayakodi	6.0	Tr	2.0	12.1	17.2	10.1	10.1	9.1	14.1	6.1	13.1
Kuthiravally	6.7	Tr	3.4	17.9	11.2	11.2	6.7	5.6	10.1	13.5	13.5
Kalluvally	5.8	Tr	3.9	Tr	13.1	9.1	10.4	15.8	10.4	13.0	18.8
Arakulam munda	4.3	2.5	12.0	10.9	7.6	8.6	8.6	10.9	7.6	8.6	14.6
Aimpirian	6.7	Tr	4.5	Tr	14.6	8.5	11.2	15.7	11.2	15.7	11.2
Panniyur-1	7.8	5.5	8.0	12.5	7.8	10.0	4.6	6.9	10.0	13.7	12.6

Tr : Traces

cultivars histidine levels are negligible. Arginine ranges from 3.9–13.5% and glycine from 10–18%. In Karimunda, Kottanadan, Neelamundi, Kalluvalli and Thommankodi, the above amino acids were below detectable limits. Threonine ranges from 7.6–19.6%, proline from 7.0–16.0% and tyrosine from 4.6–14.4%. In Kottanadan, tyrosine and proline levels are highest. Amino butyric acid varies from 6.9–15.8% highest being in Kalluvalli. Methionine content varied from 7.6–14.1% highest being in Kottanadan, while valine varies from 6.1–16.0% highest being in Kottanadan. Leucine varies from 9.8–18.3% highest being in Kalluvalli. Among the 18 amino acids separated by the technique adopted, 8 appear to be present in abundant quantities.

Absolute proline content in ten black pepper cultivars is presented in Table II.

Proline content ranges from 1.96–3.48 μ moles/g fresh weight, highest being in Cvs. Karimunda and Kalluvalli. Proline content in Cv. Arakulam munda is the lowest among cultivars (1.96 μ moles/g). Among other cultivars proline content did not show much variation.

Table II. *Proline content in black pepper cultivars (μ moles/g fr. wt)*

Cultivar	Proline content
Karimunda	3.48 $\pm$ 0.29
Kottanadan	2.88 $\pm$ 0.62
Neelamundi	2.69 $\pm$ 0.75
Thommankodi	2.32 $\pm$ 0.35
Narayakodi	2.28 $\pm$ 0.11
Kuthiravally	2.05 $\pm$ 0.17
Kalluvalli	3.46 $\pm$ 0.21
Arakulam munda	2.32 $\pm$ 0.66
Aimpirian	1.96 $\pm$ 0.29
Panniyur-1	2.37 $\pm$ 0.14

The role of accumulated proline is discussed elaborately and the role of added proline was also established (Thompson, Stewart and Marne, 1966; Stewart, 1972). Proline oxidation in leaf tissue is not concomitant with the added proline. This led to the conclusion that proline accumulated (Synthesised) during stress condition is very rapidly oxidized upon rehydration. However, the native proline does not appear to undergo such rapid oxidation. This indicates that there are two distinct pools of proline; one accumulated during stress, which undergoes oxidation rapidly and the other endogenous (native) proline which is at equilibrium in all the situations (Stewart, 1974). However, utility of native proline as a sole parameter for screening for drought tolerance/resistance may be misleading.

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COMPARISON OF PHYSIOLOGICAL AND BIOCHEMICAL PARAMETERS OF COCONUT HYBRID SEEDLINGS

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ABSTRACT

Annual rate of leaf production, leaf area, leaf dry weight, increase in height and girth of four year old seedlings of MYD x WCT were higher than those of COD x WCT and MOD x WCT. Activities of enzymes such as nitrate reductase and malate dehydrogenase was higher in MYD x WCT whereas that of acid phosphatase and glutamic-oxalic acid transaminase more in COD x WCT. Thus under irrigated conditions, the superiority of MYD x WCT hybrid from nursery stage is being maintained over the other two hybrids.

INTRODUCTION

The relationship between the seedling characters and the yield of adult palms was reported in coconut (Liyanage, 1959) and oil palm (Tan and Handon, 1976). Recently Shivashanker and Kasturibai (1988) reported certain selection criteria based on the relationship obtained with crop growth rate, relative growth rate, net assimilation rate and induced nitrate reductase activity in the seedlings of three coconut hybrids namely, Malayan Yellow Dwarf (MYD) x West Coast Tall (WCT), Chowghat Orange Dwarf (COD) x WCT and Malayan Orange Dwarf (MOD) x WCT. The growth attributes as well as induced NR activity were found to be higher in MYD x WCT than the other two hybrid crosses. Being a perennial crop, the coconut has to withstand the changes in agroclimatic conditions throughout the growth period. Whether the advantages expressed during the nursery stage is maintained at later stages of growth in the above three hybrid combinations was investigated through various physiological and biochemical processes.

MATERIALS AND METHODS

Fourteen seedlings each of MOD x WCT, MYD x WCT and COD x WCT were

planted in 1985 at a spacing of 7.5 m x 7.5 m and were maintained with the normal cultural practices and application of recommended doses of fertilizers. Five plants of each hybrid were selected for the present investigation. Total number of leaves produced per year were counted. Leaf area was measured by using the electronic leaf area meter (LI-COR - 3000). Dry weights of the six leaflets were determined and the total leaf, dry weights were computed using the formula developed.

The contents of chlorophyll and sugars were estimated as per the procedure of Arnon (1949) and Dubois et al (1956) respectively. Free amino acids and protein were estimated according to Ya pin Lee and Takahashi (1966) and Lowry et al (1951) respectively. Respiration rate was measured by manometric technique (Umbreit, Burris and Stauffer, 1972). Induced nitrate reductase activity (NR), Acid Phosphate (APH) and Glutamic-Oxalacetic Transaminase (GOT) activities were measured as per the procedures of Shivasanker and Ramadasan (1983); Linhardt and Walter (1963) and Bergmeyer (1963) respectively. For all the estimations sixth leaf with two replications were taken during May 1987.

RESULTS

In general, MYD x WCT exhibited higher growth rates than the other two hybrids (Table I). Higher rate of leaf production, with lower leaf senescence rate was observed in MYD x WCT, whereas MOD x WCT had lower rates of leaf production and higher leaf senescence rate. The increase in leaf area ranged from 41 and 25% and leaf dry matter production 26 and 17% in MYD x WCT and COD x WCT respectively in comparison with MOD x WCT. A similar increase in height and girth was also observed.

Of all the three hybrids, COD x WCT had higher sugar content and lower respiration

rate. However, the free aminoacid and protein contents were found to be lower (17% and 68%) in COD x WCT when compared with MOD x WCT. MOD x WCT had lower chlorophyll and sugar contents. This hybrid had higher free aminoacid and protein contents than the other two hybrids. (Table II)

Induced NR activity and MDH were found to be 61% higher in MYD x WCT than in MOD x WCT. The percentage increase in degradative enzymes *i.e.*, APH and GOT was 143% and 162% respectively for COD x WCT as compared to MOD x WCT; the increase was less marked in MYD x WCT (Table III).

Table I. *Growth attributes of hybrid seedlings*

Parameter	MOD x WCT	MYD x WCT	COD x WCT
Rate of leaf production	5.70	7.86	6.20
Rate of leaf senescence	3.40	2.10	3.50
Leaf area cm ² x 10 ³	31.27	44.32	39.00
Leaf dry weight x 10 ³	163.5	206.15	191.50
Total height (m)	1.34	1.56	1.45
Girth (cm)	32.75	38.00	38.00

Table II. *Biochemical constituents of hybrid seedlings*

Constituents	MOD x WCT	MYD x WCT	COD x WCT
Chlorophyll mg.g.fr.wt ⁻¹	4.85	5.55	5.19
Total soluble sugars mg.g.fr.wt ⁻¹	7.38	9.82	13.49
Free aminoacids ..	35.62	32.50	29.70
Protein ..	2.50	2.05	0.81
Respiration μ l. O ₂ consumed hr ⁻¹ . dm ⁻²	743	633	554

Table III. *Enzyme activities of hybrid seedlings*

Enzyme	MOD x WCT	MYD x WCT	COD x WCT
Induced NR activity Nanomoles	22.5	36.2	33.0
Malate dehydrogenase	0.375	0.447	0.332
Acid phosphatase mg. prot. hr ⁻¹	49.5	60.1	120.6
GOT μ g. h ⁻¹ mg. prot ⁻¹	5.13	6.12	13.50

DISCUSSION

Plant growth is controlled by the interaction of hereditary and environmental factors operating through a complex of internal processes. The maintenance of higher leaf number with lower rates of leaf senescence associated with favourable biochemical mechanisms results in higher photosynthetic rates which contribute towards growth and consequently yield, (Kriedmann, Kliever and Harris, 1970; Kinerson 1975). The metabolic processes involved in synthesis are found to be higher in MYD x WCT. Induced NR activity and free aminoacids contribute to higher amounts of protein. The sugar content and respiration in MYD x WCT can be correlated with the processes involved towards anabolism which is reflected on growth attributes. The present data is in agreement with earlier report in which Shivashanker and Kasturi bai (1988) had shown higher growth rate and induced NR in MYD x WCT. In other words MYD x WCT is able to maintain its seedling vigour from nursery through vegetative phase.

During seedling stage in the nursery MOD x WCT had higher growth rate than COD x WCT while under field conditions COD x WCT surpassed MOD x WCT in growth. This behavioural difference perhaps, could be due to a slower growth rate in the nursery or rapid acclimatization to field which results in a steep growth curve rather than a

smooth sigmoidal curve reported in many species. Interestingly, COD x WCT exhibited higher activities of degradative enzymes such as APH and GOT with low protein content. These enzymes increased with age and in senescent tissues (Wollgiehn 1967; and Kramer and Kozlowski 1979).

It is evident that the superiority expressed by MYD x WCT at the nursery stage is still being maintained through vegetative phase. Whether this will be carried through the pre-flowering and reproductive phases have to be monitored before arriving at the predictive value of seedling characters in their yield potential.

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STRUCTURE, DEVELOPMENT AND PRODUCTIVITY OF THE TEA BUSH

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ABSTRACT

The arboreal stature of the tea plant (*Camellia sinensis*) (L.) O. Kuntze in natural condition is modified into a low, flat-topped leafy bush in cultivation. Harvestable shoots produced on the primary shoot system renewed periodically over the bush frame by pruning. Therefore, the productivity of the tea bush is determined by the structure of the bush frame and development of the top hamper, which differ between clones. Different tipping measures alter crop production, the optimum tipping measure being different for annual prune and extended pruning cycle systems.

In view of the observed interaction between clone tipping measure and pruning cycle it is evident that a clone required specific tipping measure and pruning cycle for maximum crop production. However, in general, 20 cm and 25 cm tipping measures can be advantageously adopted for the *sinensis* type and *assamica/cambodiensis* types, respectively under 4-years pruning cycles.

INTRODUCTION

Productivity of the tea bush depends on the structure of the supporting organs composed of the bush-frame and the top-hamper. The regeneration of the axillary buds on the plucked primaries and laterals in the top-hamper ultimately determine the quantity and quality of the crop. Thus, cultural and environmental factors which promote the number and growth of the active axillary buds as well as the volume of the supporting organs are desirable for maximising productivity of the tea bush. Selection of varieties which possess highly efficient supporting organs and growth parameters would further raise the yield per unit area. For achieving these objectives, it is essential to understand the basic structures and developmental processes of the cultivated tea bush in relation to its productivity. However, investigations on the developmental-morphology of tea bush has been scant in the past. Barua and Wight (1959) and Barua (1961) studied the developmental morphology of light pruned tea bushes

of an *assamica* hybrid clone (clone 16/10/22). However, their study on the effect of tipping measures on yield was limited to the pruned year only as the annual prune system was, then, in vogue in the tea plantations of Assam. With the introduction of clones as popular planting materials, and pruning cycles of three to four years' duration in the majority of the tea estates in North-east India by the early seventies, the suitability of their recommended tipping measure of 20 cm for different types of pruning cycles need to be examined. In this investigation, the clonal differences in bush structures and developmental processes involved in shoot production, and optimization of tipping measures for different pruning cycles and clones were studied. Various aspects of bush-morphology in relation to clonal differences in yield and productivity under different pruning cycles and tipping measures have been discussed in the light of the data obtained in the present investigation.

MATERIALS AND METHODS

Vegetatively propagated tea plants (clones) were used in the present investigation. Six genetically different vegetative clones released by the Tocklai Experimental Station for commercial cultivation (TV. series) were taken for the study. These represent all the different types of tea under cultivation in tea estates of North-east India. Description of the clones is given in Table I.

The plant type given in Table I is based on aggregate of vegetative features; leaf type is based on description of Tocklai released clones given by Barua and Bezbaruah (1970) and leaf shape is defined after Hickey (1973).

The selected clones, seven year old at the time of commencement of the experiment, had been planted out in plots in rectangular single-hedge design at spacing of 105 cm x 60 cm, in 4 rows of 8 plants per row, and replicated thrice in Randomized Block Design. These young tea plants were last pruned at 40 cm above ground and decentered 3 years ago, then brought under plucking by tipping at 20 cm over the prune-level.

The experimental tea area was completely unshaded and was provided with adequate

drainage system. Pest and disease control measures were undertaken as and when required. During the experimentation period the plots were manured with N.P.K. (2:1:2) mixture @ 130 Kg N/ha.

With the objective of studying the bush-frame structures and development of a new crop-producing top hamper, over it, the bushes of all the clones were light-pruned (LP) at 45 cm ground measured and cleaned-out with knife in January. The investigation was conducted under the agroclimatical conditions of Tocklai Experimental Station, Jorhat, Assam from 1977 to 1981.

Out of 8 bushes in each row per plot, 4 bushes were selected as samples at random for observing the different bush structures and developmental aspects enumerated below:

Studies on structure and development of tea bush

1. Area of pruned bush surface at 45 cm above ground;
2. Number of pruning sticks in the bush frame at 22.5 cm above ground;
3. Number of stubs on pruning sticks;
4. Girth of pruning sticks and collar

Table I. Description of clones used for the experiments

Clone	Plant type	Growth habit	Leaf size, pose and shape
TV. 1	assamica (hybrid)	Small tree	Medium, erect, elliptic
TV. 7	sinensis	bushy	small, erect, elliptic
TV. 12	assamica	medium tree	large, horizontal, elliptic
TV. 14	assamica (hybrid)	small tree	medium, horizontal, elliptic
TV. 18	cambodiensis (hybrid)	small tree	medium, semi-erect, elliptic
TV. 20	assamica (hybrid)	medium tree	large, semi-erect, elliptic

at 22.5 cm and 1 cm above ground level, respectively; 5. Bud content and bud-break in the top .5 cm, next 5 cm, and rest of the bush frame; 6. Number of primaries per pruning stick; 7. Internode length in first-flush primary shoot; 8. Rate of shoot extension in primaries and pluckable laterals, as indicated by the 'Leaf-period'; 9. Growth rate of leaf in primaries and pluckable laterals, as determined by the changes in dry weight of leaf in 10 days (Barua, 1963).

Studies on development of top hamper in relation to tipping

Four tipping measures: 10 cm, 15 cm, 20 cm, 25cm over the current prune level constituted the four sub-treatments, each of the six clones being the main treatments. Each of the four tipping treatments was assigned at random to a row, consisting of 8 bushes, in each plot per replication. The primaries were tipped as soon as the primaries in the different sub-treatment plots overgrew the predetermined tipping level, at intervals of 7 days and all the tipping weights were recorded. The following observations were recorded:

1. Number of primaries tipped per pruning stick; 2. Number of leaf per tipped primary; 3. Initial Leaf Area (ILA) per primary; 4. Regeneration of pluckable lateral shoots. Under this (i) Number of first-order laterals (F.O.L.) (ii) Number of lateral shoots produced per F.O.L.; (iii) Rate of regeneration of laterals shoots; (iv) Number of orders of lateral shoots produced; (v) Number of lateral shoots produced per primary; (vi) Contribution by different orders of lateral to yield of primary shoots were recorded. 5. Yield per sq dm of pruned bush surface under the standard system of plucking as defined by Rahman and Barua (1980); 6. Dry matter content of plucked standard shoots; 7. Over-all bush-growth as indicated by the Apical

Activity Index, top growth and radial growth of collar. (Apical Activity Index: This was determined as the reciprocal of Dormancy Index as defined by Wight & Barua (1955); Top-growth : The combined weight of skiffed litter, tipplings, and net yield of the two bushes in each sub-treatment plots represents the average top-growth made by a bush during the year; Radial growth of collar: The rate of radial growth was expressed as per cent increase in girth of the collar in one growing season).

Studies on effects of tipping measure and pruning cycle on yield of clones

The pruning cycle experiment was incorporated into the experiment on "Tipping measures" consisting of the same set of 6 clones. Each sub-treatment plot of the latter experiment was further sub-divided into the following four sub-sub-treatment plots, each having a pair of adjacent bushes:

- (i) LP-DS-MS-LP (Control)
- (ii) LP-UP-UP-DS
- (iii) LP-UP-UP-UP
- (iv) LP-UP-DS-UP

LP = Light prune; DS=Deep skiff; MS=Medium skiff; UP=Unprune *i.e.*, level-off skiff or light skiff.

The pruning cycle experiment commenced with the light prune of the previous experiment on developmental-morphology and effect of tipping measures on development of the top hamper. At the end of the first plucking season deep skiffing as one of the treatments was done mid-way between the last pruning level and the tipping levels. Bushes kept under UP had their plucking surfaces hand-levelled. Tipping of deep skiffed bushes was done at measures equivalent to the DS measures, and subsequently the standard system of plucking was followed. Plucking of unpruned bushes commenced over the janams.

At the end of the second plucking season deep skiff and medium skiff treatments were carried out over the prune level at measures equivalent to half and three – fourths of the initial tipping measures, respectively; tipping was done over half, and one-fourth, of the original tipping measures, respectively. In UP bushes plucking commenced over one full leaf owing to severe drought; in all the treatments the standard system of plucking was followed.

Immediately after the cessation of third plucking season, the three-year pruning cycle was light-pruned at 5 cm above the last LP level and knife-cleaned out. Deepskiff in one of the treatments was done as in the previous years. Bushes under unprune were hand levelled.

RESULTS

Structure of bush frame

Data presented in Table II show that clones differed significantly in all the basic bush-frame structures except pruned bush-surface area. Clones with thicker pruning sticks possessed more number of stubs and buds thinner pruning sticks were more nume-

rous in the bush-frame. The typical assamica clone, TV.12, possessed thicker collar and thicker but fewer pruning sticks compared to the assamica hybrids and sinensis types.

Development of top hamper

It was observed that only about 75 per cent (range 62–92 per cent) of the buds seen on the bush-frame broke the dormancy and resumed growth into primary shoots (Table III). Of these, the majority of the bud-break occurred on the stubs composing the top 10 cm layer of the bush-frame. Exceptions were TV.18 and TV.20 where majority of bud-breaks occurred on comparatively old wood. The number of primary shoots developing on a pruning stick differed significantly between clones; an average of 90 per cent of the bud-breaks developed into primary shoots.

The size of a primary shoot of the first-flush growth is important in relation to the tipping horizon and productivity and is dependent on the length of the internodes. It is evident from Table IV that clones differ significantly in the internode length of primaries during the first flush growth. The rate of extension

Table II. *Structures of a light pruned tea bush frame*

Clone	Pruned bush surface area (Sq. dm)	Pruning stick/bush (No.)	Stubs per pruning stick (No.)	Girth of pruning stick (mm)	Girth of collar (cm)	Bud content per pruning stick (No.)
TV.7	32	9.37	3.04	16.34	17.99	14.20
TV.1	29	6.95	4.08	21.18	19.87	15.10
TV.14	33	6.37	4.47	23.73	18.91	18.25
TV.18	34	9.04	2.98	19.76	16.79	16.37
TV.20	39	11.02	2.98	18.13	17.12	14.59
TV.12	33	4.75	6.03	22.15	15.60	23.99
L.S.D. at P=0.05 : NS		1.18	0.91	1.38	0.89	3.14

Table III. *Development of primary shoots on light pruned bush frame*

Clone	Bud-break per pruning stick (%)	Bud-break in top 5 cm (%)	Bud-break in top 10 cm (%)	Primaries per pruning stick (No.)
TV.7	92.05	36.11	66.37	11.39
TV.1	82.94	29.09	61.02	11.16
TV.14	72.87	27.94	63.38	12.83
TV.18	70.38	20.38	48.66	10.81
TV.20	61.82	17.44	44.06	7.47
TV.12	69.75	35.37	73.15	14.92
L. S. D. at P=0.05 :	6.84	6.51	6.13	1.76

Table IV. *Components of the primary shoot growth*

Clone	Av.internode length of primary shoot (cm)	Leaf period of primary shoot (Days/leaf)	Rate of leaf growth (10 days)	Mean leaf area (Sq cm)
TV.7	1.87	6.69	0.07	27.42
TV.1	4.62	7.03	0.12	37.36
TV.14	3.35	7.27	0.15	41.34
TV.18	3.56	6.61	0.10	44.60
TV.20	4.12	7.82	0.10	45.27
TV.12	3.79	7.43	0.24	51.83
L. S. D. at P=0.05	0.09	0.13	0.06	11.50

of the internodes, indicated by the leaf-period, also differed significantly between clones, without any definite relationship to internode-length. Mean leaf area also differed significantly between clones, the typical assamica clone TV.12 having significantly the largest leaf and the typical sinensis clone having the smallest leaf, with the intermediate hybrid types having leaf size between the two extreme sizes; similar trend was observed in case of leaf-growth rate, too. Leaf size did not appear to bear any relationship with the internode length.

Growth and arrival of the primaries at the pre-determined tipping level influences the development of the top hamper. The number and percentage of primaries tipped per pruning stick, number of maintenance leaf left on a tipped primary, and initial leaf area on a primary immediately after tipping are shown in Table V. When tipped at heights between 10 cm-25 cm above the current prune-level, all these features differed significantly between clones. An average of 58 per cent (range: 50 to 67 per cent) of the primaries could be tipped, the rest remaining as

Table V. *Development of top-hamper in different clones**

Clone	Primaries tipped/ Pruning stick (No).	Tippable** prys. (%)	Maintenance leaf/ Primary (No.)	Initial leaf area/Primary (Sq cm)
TV.7	5.70	49.91	6.20	170.00
TV.1	6.47	55.79	5.61	209.81
TV.14	8.03	60.90	5.79	239.36
TV.18	5.80	52.95	6.39	285.25
TV.20	5.20	67.38	6.03	273.05
TV.12	9.44	62.23	5.64	292.36
L. S. D. at P=0.05	1.16	5.57	0.38	13.50

* Average number at 4 tipping measures, *i. e.*, 10, 15, 20 & 25 cm.

** Tippable primaries out of total primaries produced per pruning stick.

dwarf shoots below the tipping levels. Although clones with longer internodes tended to produce more tippable primaries than those with shorter internodes, no definite relationship could be made out between them. The number of maintenance leaves left on a tipped primary also differed significantly between clones, with TV.7 having significantly higher number than TV.1, TV.14 and TV.12; however TV.18 and TV.20 with significantly longer internodes have the same number of maintenance foliage compared to TV.7. Total leaf area on a tipped primary increased with increasing mean leaf area, irrespective of leaf-number.

Tipping heights and productivity in clones

Tipping at different measures significantly altered the volume of the top hamper (Table VI). With increasing tipping height the number of tippable primaries on a pruning stick decreased, although there was no significant difference at 15cm and 20cm tipping measures. However, the percentage of tippable primaries declined significantly at every higher level of tipping. The number of maintenance leaf and initial leaf area on a

primary increased significantly with increasing tipping measures.

The main bulk of the tea crop consists of the lateral shoots regenerated after majority of the primaries are tipped. The different aspects of lateral shoot regeneration from the axillary buds on the tipped and plucked primaries of the various clones are presented in Table VII. Significant clonal differences were observed in the number and percentage of F.O.L. on a primary, number of pluckable lateral shoots regenerated on a F.O.L., the rate of regeneration of a pluckable shoot, orders of laterals regenerated and number of pluckable shoots regenerated on a plucked primary. Excepting TV.1 where unusually numerous F.O.L. was produced, the other clones showed a steady declining trend in the number of F.O.L. per primary from *sinensis* type to the typical *assamica* type through *assamica* hybrids. The same trend was observed in the percentage of F.O.L. regenerated on a plucked primary. However, the number of pluckable shoots on a plucked primary declined progressively from the *sinensis* type to *assamica* hybrids to the

Table VI. *Development of top-hammer at different tipping measures*

Tipping ht. (cm)	Primaries tipped/ pruning stick (No.)	Tippable prys/total prys. (%)	Maintenance leaf/Primary (No.)	Initial leaf area per primary (Sq cm)
10	8.60	69.76	4.54	187.70
15	6.82	61.30	5.52	227.12
20 (Control)	6.48	54.49	6.32	260.22
25	5.18	47.22	7.40	304.86
L. S. D. at P=0.05 :	0.83	3.68	0.20	7.94

Table VII. *Regeneration of lateral shoots in different clones*

Clone	F. O. L. per primary (No.)	*F. O. L. per primary (%)	Pluckable shoots per F.O.L. (No.)	Leaf period	**Rate of regenern. (days/generation).	Leaf growth rate (g)	Genern. laterals/ Pry. (No.)	Pluckable laterals per pry. (No.)
TV. 7	3.62	52.87	21.27	4.71	26.62	0.055	7.41	76.54
TV. 1	4.39	76.93	12.90	5.70	29.39	0.080	7.08	56.67
TV. 14	3.44	51.95	13.29	6.08	30.10	0.120	6.25	45.47
TV. 18	2.64	40.12	11.84	5.15	26.43	0.092	6.08	30.97
TV. 20	2.41	42.92	13.92	6.36	28.94	0.125	6.41	32.56
TV. 12	2.49	38.10	10.57	6.43	29.87	0.152	5.75	26.16
L. S. D. at P=0.05	0.62	7.62	1.96	0.179	0.80	0.010	0.67	10.65

* F. O. L. out of total axillary buds present per primary.

** Rate of regeneration of axillary bud into lateral shoot

typical assamica type, although TV.18, TV. 20 and TV.12 were similar in this respect. TV.1, inspite of its significantly higher number of F.O.L., produced significantly lower number of pluckable shoots per primary than TV. 7 because of the significantly slower regeneration of axillary buds and lesser number of shoots produced per F.O.L. The sinensis clone produced upto eight orders of

laterals whereas the assamica clone produced upto six orders only.

Tipping at different measures significantly altered the number of F.O.L. per primary, number of pluckable shoots per F.O.L., and number of pluckable laterals per primary but had no significant effect on the percentage of F.O.L. per primary, rate of regeneration and

orders of lateral produced per primary (Table VIII).

A notable feature is that irrespective of the tipping measures, only half the number of the potential buds on a plucked primary develop into F.O.L. (Table VIII); the stimulus of tipping and plucking reaches only upto the fourth axillary bud below the tipping level (Table VIII).

Consequent to tipping the simple single-stemmed primary shoot begins to proliferate into a complex branch system through repeated branching of the first order laterals into higher orders of lateral till the end of the plucking season as a result of the periodical pluckings. The shoots of different orders of laterals plucked at regular intervals contribute to the yield of the primaries, and ultimately, to bush yield. Data presented in Table IX show that in the clones TV.7 and TV.14, maximum contribution (53 percent approx.) is made by the fourth and fifth orders while in TV.18, TV.20 and TV.12 the third and fourth orders made the maximum contribution (58 percent approx.). Total number of pluckable shoots produced by 30 primaries were higher in the clones where maximum contribution was made by the

fourth and fifth orders of lateral. The highest number of pluckable shoots was produced by the sinensis clone TV.7 and the lowest by the assamica clone TV.12; clones with larger leaf produced lower number of pluckable shoots.

The fourth order laterals made maximum contribution (28 percent) at all the tipping measures (Table IX). However, the total number of pluckable shoots decreased by about 35 per cent at 10 cm, and by 20 per cent at 15 cm, compared to that at 20 cm and 25 cm.

Clones differed significantly in yield per primary, yield per unit area of pruned bush-surface, and dry matter content and fresh weight of standard shoots (Table X). Area to area of pruned bush-surface, TV.7 produced significantly higher yield than TV.12, the hybrids, excepting TV.1, falling in between these two extreme types of clones. TV.1 produced the highest yield, significantly higher than that of TV.20, TV.12, and TV.18 but not significantly different from TV.7 and TV.14.

Tipping height significantly altered the yield per primary, yield per unit area of

Table VIII. *Regeneration of lateral shoots at different tipping measures*

Tipping ht. (cm)	F. O. L. per pry.(%) (No.)	F. O. L. per pry.(%)	Pluckable shoots per F. O. L. (No.)	Leaf period (days/leaf)	Leaf growth rate (g)	Regern. rate (days/genern.)	Ord. of lateral/pry. (No.)	Pluckable laterals per pry. (No.)
10	2.58	48.04	13.10	5.75	.099	29.11	6.61	33.82
15	2.87	50.40	14.47	5.74	.107	28.45	6.50	41.61
20 (control)	3.38	52.17	15.20	5.71	.104	28.40	6.55	52.28
25	3.83	51.31	13.10	5.75	.106	28.28	6.33	51.21
LSD at P=0.05 :	0.34	NS	1.43	NS	NS	NS	NS	3.84

Table IX. *Per cent contribution by different order of laterals towards yield of 30 primaries in different clones and tipping measures*

Clone	Order of laterals								Total No. shoots
	I	II	III	IV	V	VI	VII	VIII	
TV.7	5	9	15	26	29	14	2	0	2296
TV.1	8	13	18	21	23	14	3	0	1661
TV.14	8	13	19	27	25	8	0	0	1364
TV.18	8	16	26	31	17	2	0	0	930
TV.20	8	14	23	31	21	3	0	0	962
TV.12	9	18	28	33	11	1	0	0	785
Mean	7.66	13.83	21.50	28.16	21.00	7.0	0.83	0	1333
Tipping height									
10 cm	8	13	21	27	22	7	2	0	1008
15 cm	7	13	21	28	21	8	1	0	1232
20 cm (control)	7	13	21	28	21	8	1	0	1568
25 cm	8	14	23	28	20	5	1	0	1523
Mean	7.50	13.50	21.50	27.75	21.25	6.50	1.25	0	1333

pruned bush surface and fresh weight of standard shoots, but not the dry matter content. Yield per primary and fresh weight of shoots increased significantly at every higher level of tipping measure, but the yield per unit area declined significantly above 15 cm tipping height.

The overall growth of the tea bush is indicated mainly by the Apical activity index, top-growth, and Radial growth of the collar and pruning sticks. Data on the growth of the clonal bushes as influenced by tipping measures are presented in Table X. It is evident that the apical activity index, which indicates the general vigour of growth of the bush as conditioned by the activity of the growing apices at any particular period of

time, is significantly highest in TV.14, lowest in TV.7, and seems to be strictly clonal characteristic regardless of varietal affiliation of the clones.

Clones differed significantly in the top growth made during the course of each growing season. TV.1 made significantly more shoot growth than TV.12, TV.18, and TV.20 but was similar to TV.7 and TV.14. Lowest tipping measure of 10 cm significantly suppressed top-growth compared to other higher measures. A slight depression, though not significant, was observed at 20cm tipping measure above which the top growth increased significantly.

Increase in girth of collar per unit of time represents the effect of integration of all vital

Table X. *Yield (fresh weight), dry matter content, standard shoot weight and bush growth*

Clone	g/Primary	g/sq dm of P.B.S.*	D.M.Content in standard shoots(%).	Fresh wt. of standard shoot(g).	Apical activity index.	Top growth g/sq dm of P. B. S.	Radial growth of collar (% increase).
TV.7	25.41	21.59	24.45	0.35	2.18	35.59	4.71
TV.1	30.94	22.79	23.49	0.52	6.16	39.88	6.07
TV.14	27.89	18.69	24.35	0.54	15.47	36.88	7.04
TV.18	17.10	12.72	24.02	0.47	6.82	27.25	5.58
TV.20	20.39	16.85	23.45	0.59	4.17	30.46	8.44
TV.12	19.15	13.64	23.41	0.67	6.79	26.54	7.27
LSD at P=0.05	6.59	5.84	0.36	0.02	1.67	7.09	NS
Tipping height							
10 cm	17.31	18.46	23.86	0.51	6.41	28.30	4.41
15 cm	21.43	19.69	23.92	0.52	5.79	33.48	5.80
20 cm (control)	27.17	16.27	23.89	0.53	6.78	32.90	7.12
25 cm	28.01	16.42	23.79	0.54	8.75	36.39	8.74
LSD at P=0.05	2.47	2.14	NS	0.007	1.37	2.97	1.01

*P. B. S = Pruned bush surface

activities of the plant. The per cent increase in girth of collar in the course of one growing season did not differ significantly between the clones. However, significant increase was observed at every higher level of tipping measure.

Tipping heights, pruning cycles and productivity in clones

Yield of clones is significantly altered by tipping measures and pruning cycles, which is evident from the comparative yields presented in Table XI. TV.18 produced significantly the highest, and TV.7 the lowest, comparative yield under the pruning cycles, thus registering a highly significant change in

yield potential during the pruning cycle compared to the actual yield in the first year of the cycle; the average annual increase in crop production was to the tune of 139 per cent in TV.18 and 29 per cent in TV.7, the other clones registering from 49 to 84 per cent increase. Annual productivity of the four-year cycles were significantly higher than that of the quality-oriented three year cycle of LP-DS-MS; amongst the four-year cycles the LP-UP-UP-UP cycles was significantly better than the other two cycles of LP-UP-UP-DS; and LP-UP-DS-UP which were similar in productivity. A significant increase in productivity was observed at every higher tipping measure. Compared to 10cm

Table XI. *Comparative yield of green leaf (mean of 4 years) of clones under different tipping measures and pruning cycles*

1. Clones	TV.7	TV.1	TV.14	TV.18	TV.20	TV.12	L.S.D.at	P=0.05
Yield	129.01	151.97	148.98	239.09	184.23	168.97	40.90	
*1st year actual yield(kg/sq.m.)	2.16	2.28	1.87	1.27	1.68	1.36	0.58	
2. Pruning cycles	LP-DS-MS-LP	LP-UP-UP-DS	LP-UP-UP-UP	LP-UP-DS-UP	L.S.D.at	P=0.05		
Yield	132.77	173.63	193.10	182.00	8.95			
3. Tipping heights	10 cm	15 cm	20 cm	25 cm	L.S.D. at	P=0.05		
			(Control)					
Yield	147.90	160.89	176.58	196.13	11.74			

* Actual yield: Kg per square metre of pruned bush-surface.

and 15cm measures which produced significantly higher yields in the first pruned-year of the cycles, the production potential shifted significantly towards the higher tipping measures later during the cycle.

Significant effect of interaction of clone x pruning cycle, and pruning cycle x tipping measure on yield, have been observed (Tamang, 1985), e.g., in TV.1, TV.14, TV.18 and TV.20 all four year cycles were similar but superior to LP-DS-MS in yield, but in TV.7 LP-UP-UP-DS was similar to LP-DS-MS and only the other two four year cycles, though similar, were superior to LP-DS-MS, whereas in TV.20 LP-UP-UP-UP was superior to LP-UP-DS-UP; in LP-UP-DS-UP cycle every higher tipping measure was superior whereas in LP-DS-MS cycle 10 cm, 15 cm and 20 cm were similar but inferior to 25 cm in yield.

DISCUSSION

Clonal differences in yield

Bush-frame size, indicated by the pruned bush-surface area, does not differ significantly

between the various clones when planted out at identical spacings and planting design, but yield of the clones differed significantly. Wight (1956), for the first time, recorded the difference in yield per unit area of bush surface between clones. Clonal differences in yield have been observed even in tea plantations whenever clones have been planted out and maintained under identical cultural practices. Investigations on bush structures and development of the productive shoot system showed that clones differ in all the basic bush frame structures and developmental stages of the top-hammer. No single character has been found to be linked to the variable yield of clones. However, amongst the many structural and developmental characters known to contribute towards yield the more important ones are the pruning sticks, stubs, bud-break, growth rate of the primaries, regeneration of first-order laterals, regenerative capacity of the first-order laterals, apical activity and shoot-weight.

According to Barua (1961) and Barua and Dutta (1959) under field conditions shoot

number but not shoot-weight is the main criterion determining yield of a tea bush. However, this alone did not explain the observed clonal differences in yield per unit area of bush surface. In this investigation shoot size has been found to have an overriding influence in determining yield of clonal tea bushes. Higher apical activity also influences yield by reducing the percentage of dormant shoots which cause heavy loss in average weight of the plucked shoots. Both shoot weight and apical activity are observed to be clonal characteristics, the assamica types being significantly superior to the sinensis type.

Yield of a tea bush has been defined as the product of the number of primaries and yield per primary (Barua and Wight, 1959). The number of productive primaries would depend on the bud-content and per cent bud-break per pruning stick and the number of pruning sticks per bush. Yield per primary is the product of number of first-order laterals and yield per first order lateral, yield always being the product of shoot number and shoot-weight. The number of shoots produced on a first-order lateral as a result of repeated pluckings is greatly influenced by the rate of regeneration of axillary buds on the plucked stubs of successive orders of laterals and the number of generations (orders) of laterals produced in the course of a plucking season. The number of generations of laterals, in turn, is influenced by the earliness of tipping, and the rapidity of plucking operation; the latter depending on the rate of leaf-period and rate of leaf growth. Clones have been known to differ significantly in all the above developmental aspects. In this investigation, TV.1 produced the highest, and TV.18 the lowest, yield per unit area of pruned bush surface. TV.1 was found to be superior to TV.18 in the following characters and hence, these could be considered as of primary importance: (a) number of stubs per pruning stick; (b) girth of

collar; (c) per cent bud-break per pruning stick; (d) per cent bud-break in the top 10 cm of bush frame; (e) internode length; (f) number of first-order laterals per primary; (g) percentage first-order laterals out of total potential buds on a primary; (h) generations of laterals; (i) number of pluckable lateral shoots per primary; (j) standard-shoot weight (k) yield per primary and, (l) over-all bush growth. TV.18, inspite of its superiority over TV.1 in the following characters, could not produce higher yield than TV.1; hence, these characters can be considered as of secondary importance: (a) number of pruning sticks; (b) number of maintenance leaf per primary; (c) initial leaf area per primary and (d) rate of regeneration.

The above findings throw light on the desirable characters of a tea bush, and should be useful to the plant breeders and the agronomists. Incorporation of the desirable characters in one or a few clones through breeding and improving the cultural practices to increase the productive structures and developmental stages of the tea bush would help to increase the productivity. In the light of the above findings, an ideal light-pruned tea bush of 7-8 years of age should possess the following minimum requirements of bush frame structure and rate of growth and development of the shoot system:

1. Number of pruning sticks per sq. m. of pruned bush surface — 36
2. Number of stubs per pruning stick — 6
3. Bud content per pruning stick — 24
4. Average internode length — 5 cm
5. Number of primaries tipped per pruning stick — 10
6. Per cent bud breaks per pruning stick — 95
7. Per cent bud-breaks on top 10cm of bush-frame — 75

8.	Per cent first-order laterals on the primary	—	80
9.	Average leaf period in first flush primary (days)	—	5-6
10.	Average leaf-period of pluckable laterals (days)	—	4-5
11.	Growth rate of leaf on first flush primary (g)	—	0.25
12.	Growth rate of leaf on pluckable laterals (g)	—	0.16
13.	Rate of regeneration of axillary buds into pluckable shoots (days/generation)	—	26
14.	Number of generations of laterals in a growing season	—	8
15.	Number of pluckable laterals per primary	—	76
16.	Weight of standard shoot (g)	—	0.75
17.	Yield per primary (g)	—	30

Tipping at different measures above the light pruned level of the bush-frame was tried as a means of increasing the yield potential of the clonal bushes. The standard tipping measure of 20 cm, as advocated by Barua and Wight, (1959), was taken as the standard comparison. Compared to this measure, significantly higher yield per unit area of bush surface in the year of prune was obtained at 15 cm measure, is in conformity with the findings of Barua and Wight, (1959). Though no significant increase in any parameter was observed at this tipping measure over the standard measure the slightly higher number of tipped primaries per pruning stick was strong enough to push the yield difference to significant level. Tipping measure (25cm) significantly increased the number of maintenance leaves, initial leaf area, number of first-order laterals, standard shoot weight, apical activity, top growth and rate of collar growth. Several characters *e.g.*, rate of regeneration, number of generation of laterals, and dry matter content of shoots were not

affected by tipping measures, but the significant difference between clones in these characters show that these are strictly clonal characters.

The importance of pruning cycles for increasing the tea crop, particularly the more valuable early season crop, has been highlighted by many workers (Awasthi, Ghosh and Venkatakrishnan, 1979; Chakravartee, 1971; Chowdhury, 1969). Studies on clonal variation in response to the various pruning cycles under tipping measures show that the yielding potential of clones change drastically during the period of pruning cycle compared to that in the first pruned year of the cycle; the optimum tipping height also shifted from the 15 cm measure of pruned year to 25cm in the subsequent unpruned years. TV.18 which had produced the lowest yield in the pruned year registered a very high increase in yield during the unpruned years to produce the second highest yield annually during the four year period of the cycle. This shows that the optimum tipping measure is different for tea under annual prune and under pruning cycle. Increased yield of the clones at the higher tipping measure of 25cm, accommodating an average of 7 maintenance leaves below the tipping level, resulted possibly due to higher initial vigour and photosynthates reserves. An important feature observed but not recorded as data during the investigation was the high degree of proliferation of the shoot system due to the drastically reduced diebacks of the plucking points during the dry cold weather period at every higher tipping measure. The physiological causes for this phenomenon needs to be studied. The changes in yield potential of the clones during the pruning cycle may be attributed to the inherent genetical and physiological capabilities such as photosynthetic capacity under change of maintenance canopy, photosynthate reserves in roots, feeder root stimulus at the beginning of the next growing

season, resistance to pests, disease, weeds, and drought, etc. Further investigations to understand the physiological reasons behind the phenomena are necessary. Pruning cycles with more years of unprune seem to be more productive per cycle; in this investigation the maximum length of unprune after the light prune was three years. The result with more years of unprune cannot be assessed from these data.

Since 25 cm measure was the highest tipping measure studied at which positive yield response have been achieved in this study, it is surmised that better result could be obtained at a slightly higher measure, too. However, increase in flushing alone is not the main interest in commercial tea plantations, the ability to efficiently harvest all the crop produced on the bushes is also to be considered. Inconveniently high plucking table due to very high tipping measure, reduced shoot size, and higher proportion of dormant shoots caused by leaving tea unpruned for unnecessarily long period results in reduction of plucking efficiency, considerable increase in the cost of plucking, and loss of quality of made tea, besides increasing the cost of pest-diseases and drought control in the return for only a slight increase in crop after a few years of unprune. Under these circumstances, pruning cycles where the bushes are kept unpruned continuously for not more than three years seem to be suitable for majority of the clonal varieties.

Considering the maximum contribution to bush yield by the fourth and fifth orders of laterals in the pruned year, it appears that mid-season pruning for obtaining high percentage of the early season crop should be timed such that by the end of the plucking season the majority of the third order lateral shoots should have been plucked.

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ALLELOPATHY BETWEEN TEA (*CAMELLIA* L. SPP.) CULTIVARS

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ABSTRACT

Investigations were carried out to elicit information on the influence of leachates/extracts of "China" (*C. sinensis* (L.) O. Kuntze) and "Cambod" (*C. assamica* ssp. *lasiocalyx* (Planch. ex Watt) Wight) type of cultivars, on each other.

The leachates/extracts of the two clones, applied to each other, induced increasing trend of various growth characteristics; however, only the increment in dry matter was found to be significant in both the clones. It is thus evident that these two taxonomic types of tea are compatible in field.

INTRODUCTION

Commercial tea populations as they exist in the field today are a mixture of various genotypes derived from *Camellia sinensis* (L.) O. Kuntze ("China type"), *C. assamica* ssp. *assamica* (Masters) Wight ("Assam type") and *C. assamica* ssp. *lasiocalyx* (Planch. ex Watt) Wight ("Cambod type") or hybrids thereof and/or between them and their close allies (Sharma and Venkataramani, 1974). As such, in a tea field, either clonal or seedling in nature, plants belonging to diverse parentage being planted in mixed populations and adjoining each other at close spacing, there exists a scope for allelopathic interaction between them.

Reports on allelopathic interaction between cultivars of a crop (Rice, 1974), effect of exudates and leachates of roots on the growth of plants in other crops (Rice, 1979) the presence of chemicals with allelopathic potential in various plant parts (Putnom, 1987) and the factor of auto-toxicity in some perennial crops (Putnom and Duke, 1978) focuses on the lack of such information with regard to tea.

Scanty reports such as toxicity of tea seed coat to tea seedlings (Suzuki and Waller,

1987) and positive influence of tea leaf residues on soil micro-flora (Menzies and Gilbert, 1967) indicate the possibilities of an interesting study in this direction.

Results of an investigation on the allelopathy between two tea clones of different taxonomic origin are reported in this paper.

MATERIALS AND METHODS

Two experiments on the allelopathy between two cultivars of different origin were carried out under controlled conditions obtaining in the glass house of UPASI Tea Research Institute.

The clones UPASI-17, a "Cambod" type, and UPASI-10, a "China" type, (Mohan and Sharma, 1981) were chosen for the investigation. About eight-month old plants were transplanted into pots of uniform size, containing about 5 kg of sandy loam; the plants were allowed to establish in the pots between July and September 1984, before the treatments were imposed. In the first experiment, the soil used in the pots was subjected to analysis for pH, EC, organic matter content, N, P, K, Ca and Mg before imposing the treatments and at the end of the experiment.

Both the experiments were of randomised block design, with nine treatments in the first and four in the second; there were three replicates with three potted plants each in the former and five with a single potted plant each in the latter.

Leaf extract was prepared by macerating 25 g of leaf material in 100 ml of water; the extract was applied as such at full strength under one treatment, while it was diluted further by adding 100 ml of water under another treatment of the first experiment (Tables I and II).

The remaining treatments in the first experiment comprised leachates from leaf, stem and, the debris collected from the base of the plant of the respective clones, in the field.

Individual plant parts and debris were soaked at the rate of 25 g each in 100 ml of water, separately, for 72 hr, to obtain the

leachates. The leachate of each, thus obtained was used at its full strength under one treatment; its concentration was reduced to 50 per cent by adding required quantity of water for another treatment (Tables I and II).

For the purposes of the second experiment, water leaching out from the pots, following daily irrigation at the rate of 250 ml per pot, was collected in a tray in which each pot was placed. The leachate, expected to contain root exudates, was applied at three rates; at full strength, 50 and 25 per cent of full strength.

Each treatment, applied to the soil, was repeated 24 times, successively at an interval of 72 hr; during the intervening periods of repeat treatments, irrigation was given at the rate of 100 ml per pot, at 24 hr interval.

Under the standard treatments maintained for comparison in the two experiments, the

Table I. *The effect of leachates from UPASI-10 on the growth of UPASI-17*

Treatments Leachates/extracts (%)	Post-treatment observations								
	After 12 applications			After 24 applications					
	Height (cm)	Girth (cm)	No. leaves	Leaf area (cm ²)	Height (cm)	Girth (cm)	No. leaves	Leaf area (cm ²)	Total dry wt. (g)
Standard	28	0.4	12	33	44	0.5	15	41	13
Leaf: Full strength(L)	27	0.4	12	37	53	0.5	25	60	25
Leaf:50(L)	30	0.4	14	36	50	0.5	20	51	21
Stem:Full strength	23	0.4	11	33	47	0.5	19	47	15
Stem: 50	25	0.4	11	33	47	0.5	23	47	15
Leaf:Full strength(E)	29	0.4	17	34	44	0.5	22	42	18
Leaf: 50 (E)	30	0.4	11	34	54	0.5	23	57	20
Debris: Full strength	32	0.4	16	34	50	0.6	25	51	23
Debris: 50	27	0.4	11	34	48	0.5	21	44	19
	NS	NS	NS	NS	NS	NS	NS	NS	C. D.=0.75 % C.V.=2.3

L = Leachate

E = Extract

Table II. *The effect of leachates from UPASI-17 on the growth of UPASI-10*

Treatments Leachates/extract (%)	Post-treatment observations								
	After 12 applications				After 24 applications				
	Height (cm)	Girth (cm)	No. leaves	Leaf area (cm ²)	Height (cm)	Girth (cm)	No. leaves	Leaf area (cm ²)	Total dry wt. (g)
Standard	22	0.3	12	32	26	0.5	17	32	10
Leaf: Full strength(L)	23	0.4	16	23	33	0.6	18	48	13
Leaf: 50(L)	25	0.4	14	33	26	0.5	19	36	12
Stem: Full strength	18	0.4	16	30	30	0.5	24	40	12
Stem: 50	24	0.4	18	30	26	0.5	19	34	10
Leaf: Full strength(E)	29	0.4	17	30	41	0.5	23	52	22
Leaf: 50 (E)	26	0.4	14	32	33	0.5	18	36	18
Debris: Full strength	27	0.4	14	41	28	0.5	16	43	16
Debris: 50	30	0.4	14	38	31	0.5	16	39	16
	NS	NS	NS	NS	NS	NS	NS	NS	C.D. = 1.24 % C. V. = 4.95

L = Leachate

E = Extract

plants were irrigated at the above rate at 24 hr-interval, throughout the period of the study.

Height of the plants, girth of the collar, number of leaves and total leaf area were determined prior to and after 12 and 24 applications of the respective treatments in the first experiment; in the second experiment, the observations were recorded only at the end of 24 repeat applications of the treatments. Total dry weight of the plants under different treatments was determined separately by oven dry method, at the conclusion of the experiments.

The data emerging out of the experiments were subjected to analysis of covariance.

RESULTS AND DISCUSSION

The soil leachates, expected to contain root exudates, from the pots in which the two clones were grown separately did not exert any influence on each other, unlike the reports on certain other crops (Sadhu and Das, 1971).

Various growth parameters like height of the plant, girth of the collar and leaf area were not affected significantly in either of the clones, by any of the treatments, in the first experiment. However, a positive trend of improved plant height and leaf area was noticed in both the clones under all the treatments, by the end of the experiment (Tables I and II).

The total dry weight of the plant enhanced significantly under all the treatments in both the clones, at the end of the experiment (Tables I and II).

The maximum significant response in terms of total dry weight of the plant was induced in the clone UPASI-17 by leaf leachate at full strength, followed by debris leachate at full strength, leaf leachate at 50 per cent and leaf macerated extract at 50 per cent, derived from UPASI-10, in that order (Table I).

A similar response by way of increase in total dry weight was also noticed in plants of

the clone UPASI-10 subjected to various treatments with leachates derived from UPASI-17. However, the treatment of leaf macerated extract at full strength induced the highest response in this clone, followed by leaf macerate at 50 per cent, debris leachate and leaf leachate, in that order (Table II).

The response to the treatments was higher in the clone, UPASI-17.

There was a conspicuous drop in the EC values of the soils at the end of the experiments; it might be due to the continued irrigation leading to leaching losses. The marked decline in potash levels noticed is also attributed to the same reason, since, there are no permanent/temporary fixation sites in the soils used. Soils, otherwise, were not affected markedly.

Njuguna (1984) reported that tea clones of different genetic parentage grown in pure or mixed stands did not exhibit any variation either in the vigour of their growth or yield, indicating mutual compatibility in the field.

The present investigation indicates a favourable influence of "Cambod" and "China" type of jats, on each other, in terms of increased production of biomass and sanctions approval to the cultivation of these two jats together. Such a study involving the cultivars of the three known types - "Assam", "Cambod" and "China" - will be of interest and use.

The absence of adverse effect of the root exudates, debris and leachates from plant parts on the growth of tea plants also indicates that the nursery soils once used to raise the cuttings could be reused without harmful effects on young plants.

Unlike in certain other perennial crops like apple and peach (Proebsting, 1950; Borner, 1959) tea plant does not seem to leave toxic residues in the soils to the detri-

ment of replanting with tea. As such, a long term investigation along these lines is likely to resolve the controversy over the need to rehabilitate tea soils, before replanting, to overcome the problem of crop residual toxicity.

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EMBRYONIC NUTRITION IN COFFEE: IMPLICATIONS ON 2N-3N INCOMPATIBILITY

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ABSTRACT

Nutrition of the developing embryo was studied by cytochemical methods for nutrient constituents starch, insoluble polysaccharides, proteins and lipids as well as the two categories of enzymes: hydrolytic and oxidative; in the materials of *C. arabica* and *C. canephora* (normal as well as that manifesting 2n-3n incompatibility). Results indicated that the embryonic nutrition in *C. arabica* and *C. canephora* is different in that the oxidative enzymes assume a primary role in the former while hydrolytic enzymes play a key role in the latter. In the material manifesting 2n-3n incompatibility the enzyme activity pattern indicated a competition between endosperm and embryo for nutrients.

INTRODUCTION

Embryo-endosperm incompatibility (2n-3n incompatibility) is known to be the reason behind several hybridization failures (Cooper, 1951; Cooper and Brink, 1942; Sachet, 1948; Buell, 1953; Satina, Rappaport and Blakeslee, 1950; Rappaport, Satina and Blakeslee, 1950). It is reported in *Coffea canephora* (Sreenivasan and Vishveshwara, 1978). While physical failure of the embryo was noticed at the time of seed germination (Sreenivasan and Vishveshwara, 1978), the mechanism of embryo abortion was not understood. In an attempt to understand this mechanism, the present work was undertaken.

MATERIALS AND METHODS

Embryonic nutrition in the species *Coffea arabica* L. and *C. canephora* Pierre ex Froehner (normal as well as the plants manifesting 2n-3n incompatibility) was studied by cytochemical methods which can be classified into two categories:

1. Methods concerning the study of the movement of nutrients into the embryo.

2. Methods concerning the localization of enzyme activity in embryo-endosperm complex.

Fresh fruit materials were collected and the endosperm-embryo complex was dissected from the ovules.

Methods of nutrient movement into the embryo

- (i) Starch: IKI reaction (Johansen, 1940).
- (ii) Insoluble polysaccharides: PAS reaction (McManus, 1948).
- (iii) Proteins: Ninhydrin-Schiff reaction (Yasuma and Ichikawa, 1953) with control by deamination in a mixture of 20 ml of 60% Na NO₂ and 60 ml of 1% acetic acid.
- (iv) Lipids/Free fatty acids: Nile blue procedure (Cain, 1947).

Methods for enzyme activity

- (i) Hydrolases: Enzymes activities of the following hydrolytic enzymes were localized in the embryo-endosperm complex.

(a) Acid phosphatase: Lead sulfide procedure (Gomori, 1952).

(b) Alkaline phosphatase: Cobalt sulfide method (Gomori, 1952).

(c) Esterase: Indigogenic method (Holt, 1958).

(d) Peroxidase: α -naphthol method (Pearse, 1960).

(e) Cytochrome oxidase: Nadi reaction (Gomori, 1952). Suitable controls were also run alongside the treatments.

(ii) Dehydrogenases: Activity of the following dehydrogenase enzymes was localized by the method of Hess, Scarpelli and Pearse (1958).

(a) Lactic dehydrogenase (LDH)

(b) Pyruvic oxidase

(c) Isocitric dehydrogenase (IDH)

(d) α -keto Glutaric dehydrogenase (α - k GDH)

(e) Succinic dehydrogenase (SDH)

(f) Malic dehydrogenase (MDH)

(g) Glutamic dehydrogenase (GDH)

(h) Glucose-6-phosphate dehydrogenase (G6PDH)

Suitable controls were run alongside.

RESULTS AND DISCUSSION

Results presented in Table I gives an insight into the nutritional requirements of the embryo. Thus, the starch was localized in the outermost layers of endosperm cells only while PAS⁺ granules were found dispersed in the entire endosperm as well as the embryo (Fig. 1A). Similarity of stain distribution in the protein and PAS tests indicated the possibility of abundance of glycoproteins in the embryo-endosperm complex (Fig. 1B). (Hesslop-Harrison, 1975). Normally, the cells of endosperm are laden with reserve lipids, phospholipids and free fatty acids. In the materials showing 2n-3n incompatibility the endosperm manifested the accumulation of free fatty acids/phospholipids besides very small quantities of reserve lipids in the outermost layers of cells. Embryonic cells gave a positive indication of the accumulation of free fatty acids/phospholipids. Movement of the above nutrients into the embryo presumably takes place through the surface of the embryo. However, in *C. canephora* it was observed that the free fatty acids and/or phospholipids accumulate in large quantities in the suspensor part of the embryo indicating the possible activity of lipid hydrolyzing

Table I. Nutrient localization patterns in the embryo-endosperm complex of coffee

Nutrient constituent	<i>C. arabica</i>		<i>C. canephora</i>			
	Embryo	Endosperm	Normal Embryo	Normal Endosperm	2n-3n Incompatible Embryo	2n-3n Incompatible Endosperm
<i>Carbohydrates</i>						
Starch	—	+	—	+	—	+
PAS+ granules	+	+	+	+	+	+
Total Protein	+	+	+	+	+	+
<i>Lipids</i>						
Reserve lipids	—	+	—	+	+	±
Phospholipids/ Free fatty acids	+	+	+	+	±	+

— = negative, + = positive, ± = trace amount

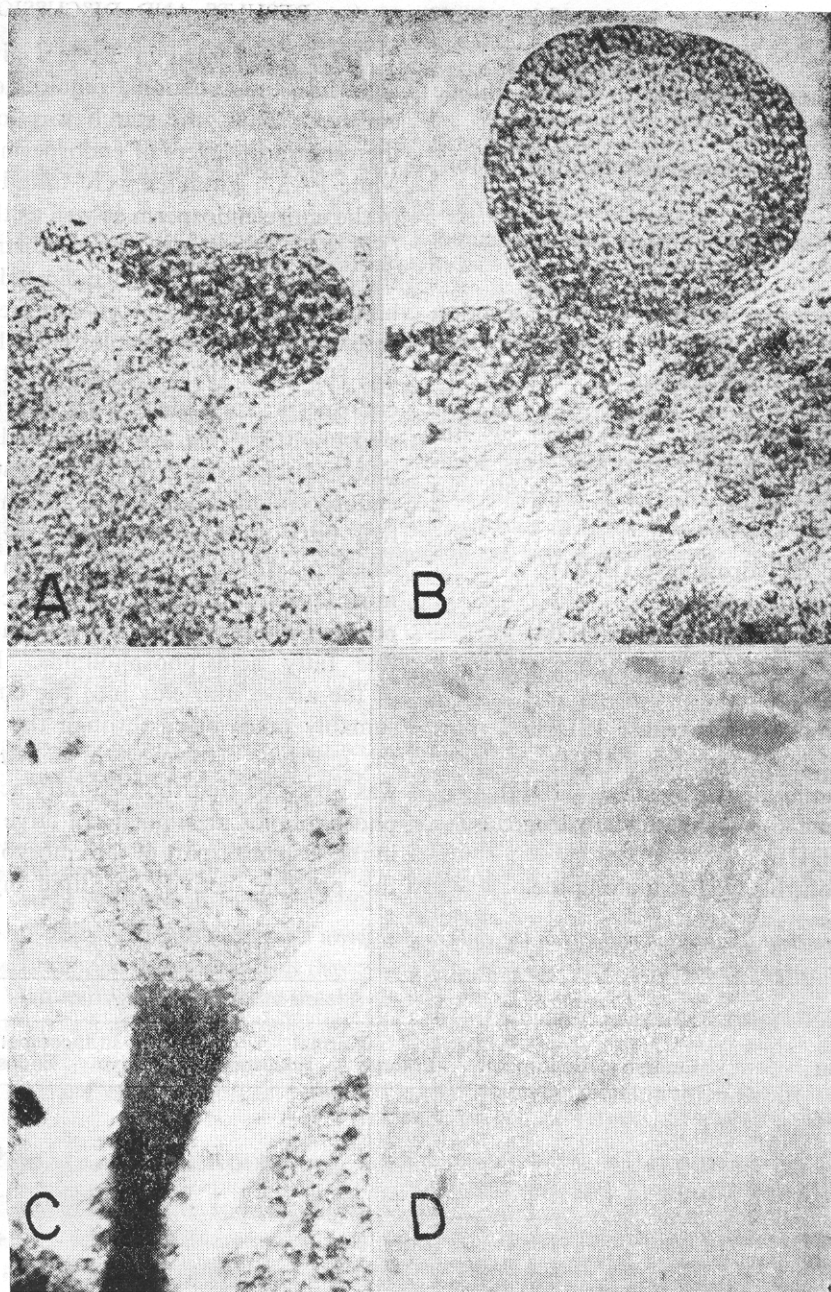


Fig. 1A, B: *Coffea arabica* C, D: *Coffea canephora*

A. Embryo-endosperm complex showing the localization of PAS+ granules (x 600); B. Embryo-endosperm complex showing the localization of proteins (x 600); C. Localization of lipids/free fatty acids in the Embryo-endosperm complex (Note: high concentration of free fatty acids in the suspensor (x 600)); D. Localization of lipids/free fatty acids in the Embryo-endosperm complex in the material showing

enzymes in these cells (Fig. 1C). In the materials of *C. canephora* manifesting 2n-3n incompatibility the suspensor did not show any such activity (Fig. 1D). Besides, the accumulation of reserve lipids in the cytosol of embryonic cells was observed in these materials in contrast to the regular pattern.

The enzyme activity distribution in the embryo-endosperm complex (Table II) also indicated the possible nutritional needs of the embryo.

Hydrolytic enzymes acid phosphatase, alkaline phosphatase, esterase, peroxidase and cytochrome oxidase were observed to be very active in the peripheral layers of endosperm cells abutting the integument (Table II). This is in general agreement with the presumption that the endosperm grows at the expense of integumentary tissue (Maheshwari, 1950; Georgieva, 1982). The activity of these enzymes in the deep seated endosperm cells could be attributed to the product utilization within the endosperm and/or

Table II. Enzyme activity patterns during embryo development in coffee

Enzymes	<i>C. arabica</i>		<i>C. canephora</i>			
	Embryo	Endosperm	Normal		2n-3n Incompatible	
			Embryo	Endosperm	Embryo	Endosperm
HYDROLASES						
Acid phosphatase	—	+ ^{oo}	—	+ ^{oo}	+	++
Alkaline phosphatase	—	+ ^{oo}	+ ^o	+ ^{oo}	+	++
Peroxidase	+	+	+	+	+	+
Esterase	+	+ ^{oo}	++ ^o	+	+	++ ^{oo}
Cytochrome oxidase	+	++	+	++	+	+
DEHYDROGENASES						
(i) GLYCOLYSIS						
LDH	+ ^o	++	++ ^o	+	++	++
(ii) KREBS' CYCLE						
Pyruvic oxidase	—	+	—	—	+	++
IDH	+	++	++	++	++	+
α -k GDH	—	—	—	—	—	—
SDH	+	++	+	—	+	++
MDH	—	—	—	—	—	—
GDH	+	+	—	—	++	+
(iii) PENTOSE CYCLE						
G6PDH	+	++	—	—	++	++

^o = localization in suspensor only

^{oo} = localization in the peripheral cells of endosperm only

+ = positive, ++ etc. = intensity of reaction, — = negative

making it available to the embryo, as certain of these enzymes are not active in the embryonic cells. Cytochrome oxidase activity, however, showed a uniformly dense pattern in the embryo also. This could be attributed to the universal necessity of this enzyme in neutralizing the excited electrons in the terminal oxidation of the cellular systems (Pearse, 1960). The activity of esterase in the embryonic suspensor of *C. canephora* could be reconciled with the accumulation of free fatty acids in this part of the embryo.

Dehydrogenase enzymes presented an interesting picture (Table II). Pyruvate, the product of glycolysis can enter either the anaerobic pathway or Krebs' cycle depending upon the prevailing conditions. During the present study both pathways were found to be operative in the embryo-endosperm complex of coffee. Some degree of anaerobic respiration could be explained as this was deeply embedded in the integumentary tissue and expectably the LDH activity was localized in the endosperm and the suspensor region of embryo. Pyruvic oxidase activity found in the endosperm of *C. arabica* and 2n-3n incompatible materials of *C. canephora* indicated the entry of this substrate into the citric acid cycle also in this tissue. Other enzymes of Krebs' cycle active in this tissue are IDH and SDH. Glutamic dehydrogenase activity was localized in the endosperm of *C. arabica* as well as those materials showing 2n-3n incompatibility. This is a key enzyme which diverts the citric acid cycle intermediate α -keto glutaric acid into the protein metabolism through glutamic acid (Georgieva and Atanasov, 1986; Pearse, 1960). Thus, the activity of IDH and absence of activity of α -k GDH in these cells could be attributed to the removal of α -keto glutaric acid into protein metabolism. However, in *C. canephora* this could be explained upon assuming the presence of lipoate dehydrogenase (Pearse, 1960) which diverts the

product succinyl Co A into lipid metabolism; on the basis of the accumulation of free fatty acids/phospholipids in the suspensor of the embryo. This product could enter the citric acid cycle also. SDH activity was localized in the endosperm of *C. arabica* and 2n-3n incompatible *C. canephora*. This is one of the two dehydrogenases (the other being MDH) whose activity in any tissue is considered an index to the citric acid cycle of glucose metabolism (Pearse, 1960). Thus, in the endosperm of *C. canephora*, the products of this pathway were rapidly diverted into other pathways rather than circulating in the same cycle as indicated by the absence of activity of these two dehydrogenases (Table II). However, the embryos of all three materials appear to be metabolizing glucose via this pathway. Absence of activity of MDH in all the materials studied could be attributed to rapid reaction of oxaloacetate with pyruvate (Pearse, 1960).

G6PDH activity was localized in the endosperm of *C. arabica* and *C. canephora* showing 2n-3n incompatibility. This indicates the metabolism of glucose via pentose cycle (Pearse, 1960). This is another enzyme which provides pentose phosphate molecules that can be utilized in the biosynthesis of nucleotides/nucleic acids in the cell system (Pearse, 1960; Georgieva, 1982).

From the foregoing account it can be concluded that in *C. arabica* the embryo derives its nutrition primarily from the oxidation of glucose which is supplemented by the activity of hydrolases whereas in *C. canephora* the activity of hydrolytic enzymes indicates that nutrition of embryo is primarily dealt by the hydrolases which is supplemented by the oxidation of glucose via Krebs' cycle. In *C. canephora* manifesting 2n-3n incompatibility both hydrolytic and oxidative enzymes were active in the embryo as well as the endosperm indicating a possible competition between the two for nutrients.

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IN VITRO PROPAGATION OF TEA (*CAMELLIA SINENSIS* (L.) O. KUNTZE) — A PRELIMINARY STUDY

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ABSTRACT

Direct shoot buds and direct root generation were observed from cotyledon and leaf explants respectively when cultured on modified Murashige and Skoog's (MS) medium. Although, callusing was achieved from leaf, stem, embryo, cotyledon segments and young anthers but differentiation there from has not been observed. In addition to this, embryo rescue technique yielded rooted plants within 3 months in certain combinations. Apical bud culture showed shoot proliferation in one month's time. Efforts are being made to induce rooting in such shoots.

INTRODUCTION

Tea occupies an important place among the plantation crops. India ranks first amongst the producers of tea and contributes about 30% to the world's total production. Tea plants are generally raised by vegetative propagation. Recent reports of the occurrence of Tea phloem necrosis virus (Arulpragasam, 1982) and Tea mosaic virus (Zaidi, personal communication), have underlined the importance of adopting tissue culture methods for elimination of viral diseases including the latent ones which are, otherwise, likely to be perpetuated through cuttings. These techniques could be effectively utilized for its rapid multiplication, development of new clones either spontaneously or through induced mutations, generation of haploids through anther culture for breeding purposes, somaclonal variations, somatic hybridisation and germplasm conservation.

Keeping these aspects in mind, investigations were initiated at CSIR Complex, Palampur on *in vitro* culture of tea growing in this region.

MATERIALS AND METHODS

Several explants like shoot buds, cotyledons, excised embryos, leaf segments and anthers were used to examine their suitability for regeneration and exploitation for propagation purposes. Plant materials were obtained from tea bushes (*Camellia sinensis* var. China hybrid) growing at the institute's tea farm. An aqueous solution (3.5%, w/v) treatment with Calcium hypochlorite for 5-6 minutes was sufficient for sterilizing the explants excepting for cotyledons, which were surface sterilized in the same sterilizing agent in (7%, w/v) for a period of 60 minutes (Kato, 1986) and embryos excised therefrom and cultured separately. Repeated sterilized distilled water washings were given to remove traces of sterilizing agent and explants (4-8 mm) transplanted on the surface of variously modified Murashige and Skoog's (1962) medium. Cultures were incubated at $25 \pm 2^\circ\text{C}$ with 16 h light and 8 h dark periods.

RESULTS

Explant response varied with the media combination. Direct regeneration of shoot

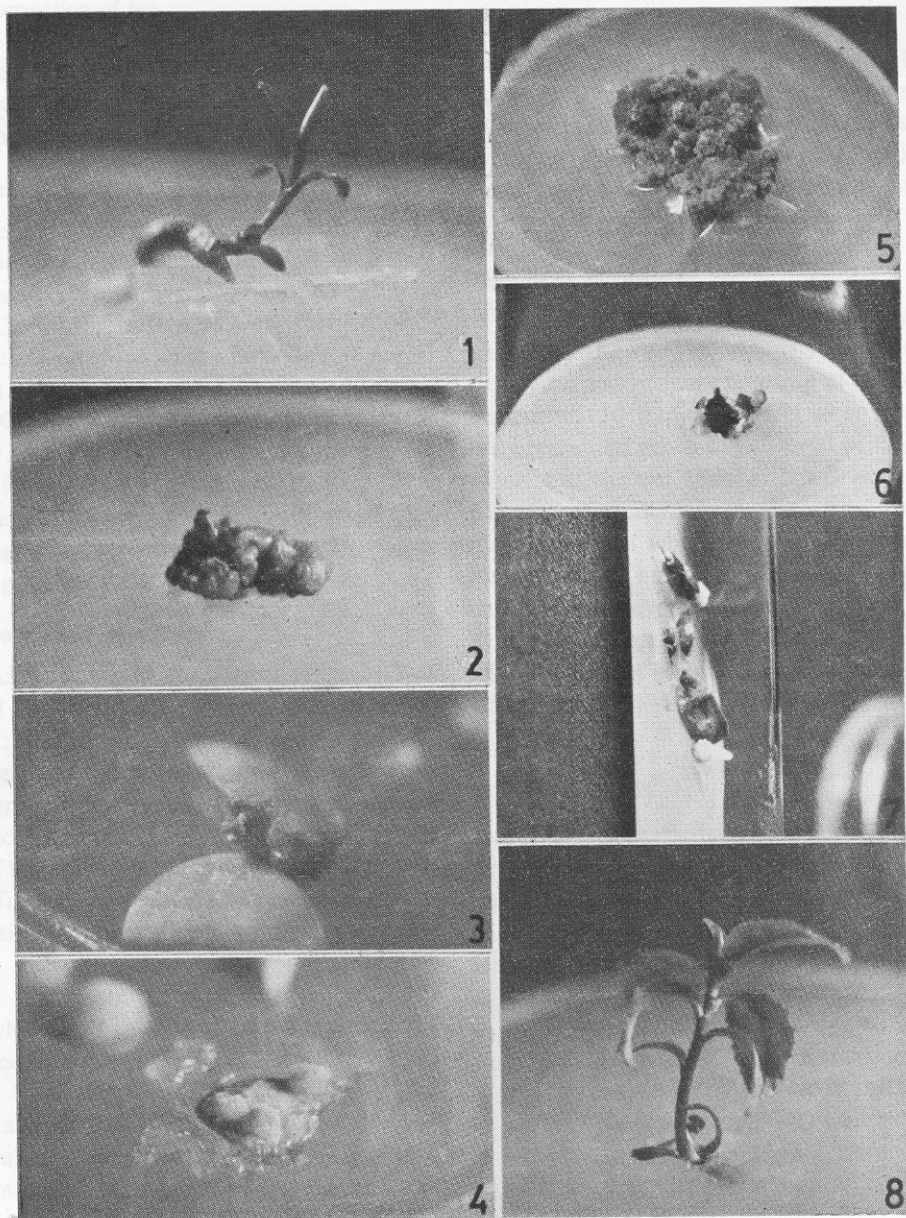


Fig. 1-8. Tea tissue culture. 1. A well developed 3 month old plantlet formed from excised embryo on BM+NAA (1.0 mg/l). 2. Embryo callusing to form compact, nodular lumps (BM+BAP (2.5 mg/l)+NAA (1.0 mg/l). 3. Direct shoot buds formation from the cut sides of the cotyledon segment (BM+KN (5.0 mg/l). 4. Cotyledon callusing from near the cut surface on BM+IBA (1.0 mg/l)+BAP (2.5 mg/l). 5. Proliferating anther culture on BM+BAP (2.5 mg/l)+NAA (1.0 mg/l). 6-7. Leaf segments showing callus initiation on BM+KN (10.0 mg/l) and spontaneous root formation also on the same medium. Note the roots are small, thin, white and profusely hairy structures. 8. A well grown shoot is formed after 3 months on BM clone. Root formation has not taken place so far.

buds was noticed in cotyledon segments besides callusing in other explants. Efforts are being made to induce organogenesis.

(a) Embryos

These grew well in the basal medium (BM) alone or in combination with KN (0.5–5.0 mg/l) and formed well developed shoots within 3 months but roots were formed only when transferred to BM+NAA (1.0 mg/l) (Fig. 1). Both IAA and IBA proved inhibitory. Out of the two cytokinins employed, KN, (0.5–2.5 mg/l) was more responsive for shoot formation whereas, BAP (0.5–10.0 mg/l) either alone or with additional NAA (1.0 mg/l) induced callusing (Fig. 2). Slow growing callus was pale yellow.

(b) Cotyledon segments

Direct shoot bud formation (Fig. 3) was noticed at varying concentrations of cytokinins : KN (0.5–10.0 mg/l) and BAP (0.5–5.0 mg/l). The latter at higher concentrations proved deleterious and explants turned necrotic. However, presence of additional NAA (1.0 mg/l) also favoured simultaneous callus formation at the basal region of the regenerating young shoots which ultimately turned necrotic after initial promising response. Callus initiation along the cut ends of cotyledons (Fig. 4) was also noticed in the presence of BAP (2.5 mg/l) and either of the auxins IAA, NAA or IBA (1.0 mg/l). Of all the auxins, NAA was found to be the most favourable. Sometimes, callus assumed green nodular configuration but no differentiation.

(c) Anthers

Carefully excised anthers remained yellowish green for considerably long periods (8–10 weeks) in the presence of either KN (0.5–2.5 mg/l) alone or in its combination with IBA (1.0 mg/l). Similar response was noticed in case of BAP (0.5–2.5 mg/l). But KN (2.5 mg/l) along with IAA or NAA

(both at 1.0 mg/l) and BAP (2.5 mg/l) with NAA (1.0 mg/l) induced callus formation which was slow growing, nodular and slightly compact (Fig. 5). Such lumps of calli resumed faster growth in the presence of BAP (2.5 mg/l) and NAA (5.0 mg/l).

(d) Leaf segments

Leaf segments 4–5 mm long (2nd and 3rd leaf from the top) in majority of the cases slowly turned brown excepting at higher concentration (10.0 mg/l) of KN where these not only remained green but showed proliferation of cells at the cut ends within 2 weeks (Fig. 6). Occasionally, there was direct root formation as well which were small, thin, white and profusely hairy structures (Fig. 7). The callus, whenever formed, was pale green, slow growing and slightly compact but turned friable and fast growing in the presence of KN (2.5 mg/l), NAA (1.0 mg/l) and 2,4-D (2.5 mg/l).

(e) Shoot buds

Apical shoot buds with and without the first axillary buds (after removing first and second leaf from top) grew into shoots (Fig. 8) in MS medium and also in the presence of either GA₃ (1.0 mg/l), KN (0.5–2.5 mg/l) alone or in the combination with NAA (0.5 mg/l). But, so far no root formation was observed in such shoots. Experiments are also underway to subject virus infected tea shoot buds to both thermo- as well as chemotherapy treatments employing tissue culture techniques for virus eradication.

Though rooted plants from cultured embryo were obtained, but these could not be transferred to the field. Shoot formation from cotyledon segments as well by growth of axillary and apical buds was achieved, however, no root formation in such shoots could be induced and experiments are underway to get rooted plantlets by suitably modifying the culture medium.

DISCUSSION

There are few reports on the regeneration of tea plantlets by callus tissue from the epidermal layers of stem (Kato, 1985) or callus formation only (Doi, 1980, Frisch and Camper, 1987). Recently, Arulpragasm and Latiff (1986) reported from Srilanka shoot proliferation using shoot tips and nodal segments but leaf segments as such apparently have not been used.

Doi (1981) had obtained roots from anther callus in MS medium supplemented with KN ($10^{-5}M$) but no bud formation. Presently, their findings could not be repeated in our material so far. Raina and Iyer (1983) also did not succeed in their endeavour with tea anther cultures.

Kato (1986) found a limited number of adventitious embryo differentiation from cotyledon surface without mediation of callus phase which grew into shoots and roots on medium supplemented with BAP and IBA. However, in the present studies, callusing was initiated along the cut sides which occasionally assumed green nodular configurations but no differentiation.

It is probable that slow growth, seasonal fluctuations which has a direct bearing on the morphogenetic response and suitability of the culture media besides varietal differences pose a big challenge to the researchers for ultimately developing methods for quick and cheap propagation of planting material to cope with its ever increasing demand by the tea industry.

ACKNOWLEDGEMENT

The authors are grateful to Prof. N. K. Jain, Co-ordinating Director, CSIR Complex, Palampur for his constructive criticism and invaluable suggestions during the course of this work.

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DISCUSSIONS

R. S. R. MURTHY: Is there any correlation between photosynthesis and yield in cacao?

D. BALASIMHA: There is no correlation *per se* with yield. However, there is an indirect effect through the canopy level photosynthesis.

SAMRESH DWIVEDI: Simple correlations are not of much importance until and unless they are partitioned into genotypic and environmental correlations. Hence it is suggested to break up the correlation into genotypic and environmental components.

M. S. SREENIVASAN: Is flowering cushions on the main stem of cacao genetic or physiological? How it could be physiologically manipulated?

D. BALASIMHA: It is genetically determined. Physiologically it cannot be manipulated.

R. NAGARAJAN: What is the effect of rhizobium inoculation and seed pelleting on nodulation?

GEORGE V. THOMAS: Inoculation with rhizobium resulted in dry matter yield and nodulation but the response was much more when pelleting was also done with rhizobial nodulation.

R. NAGARAJAN: What is the action of charcoal on pH of the soil?

GEORGE V. THOMAS: Charcoal protects rhizobia from acidic soil conditions. It is not used to change the pH of the soil.

R. KOTHANDARAMAN: Did you consider the population of native rhizobia? Did you maintain a control with CaCO_3 alone?

GEORGE V. THOMAS: Nodulation by native rhizobia was poor in the legumes viz., *Calopogonium mucunoides* and *Leucaena leucocephala*. A control was not kept with CaCO_3 alone.

ASHOK B. JEVOOR: Did Molybdenum and Cobalt increased nodulation and how it is related?

GEORGE V. THOMAS: It is known that application of Mo and Co increased nodulation in some legumes. Studies to elucidate the effect on green manure and cover legumes under particular soil conditions can be undertaken.

T. S. GOVINDARAJAN: Rhizobia are low under acidic condition. How the pelleting trials have helped in raising pH of the medium? When the charcoal is found to be effective what effect it had on the pH of the medium?

GEORGE V. THOMAS: The objective of the pelleting experiment was to provide less acidic microenvironment around the roots for the bacteria to survive till the roots develop. Here the amount of pelleting material used is very little and is not sufficient to change the pH of the soil.

R. S. R. MURTHY: At the height of 45 cm pruning, tipping at 25 cm is recommended by the author and it was told that there will be 7 tiers of leaves. This amount of leaf load was more than adequate as observed in the studies at UPASI on tea.

M. B. TAMANG: Tipping at 25 cm above light prune level is in relation to extended pruning cycles. When yield is considered in the year of prune 25 cm tipping was not suitable as it produced lower yield than that by tipping at 15 cm measure. But over the pruning cycle of 4 years the shoot proliferation was maximum at 25 cm, die back of plucked point was minimum and wood thickening was maximum. Therefore 25 cm tipping in sharp contrast to annual prune system has been found to be suitable for maximisation of yield under pruning cycles.

B. V. SURESH : Normally Ethephon application in rubber is recommended after the pre-monsoon showers and after monsoon recedes. Why are you going for application during summer periods? Will it not have adverse effect on the trees as the soil moisture will be at lower levels?

K. U. THOMAS: In this study we have skipped the application of Ethephon during summer. In the experimental year the soil moisture was sufficient and the trees were older which were to be cut down in the subsequent years. Hence higher frequency

of stimulant application is admissible to extract maximum yield.

R. C. MANDAL: What was the objective of studying aminoacids in black pepper?

S. VASANTHA: The objective of the study was to understand the aminoacid profile of cultivated black pepper varieties. Since we obtain higher proline content in some varieties more emphasis has been given to proline as this aminoacid is known to be associated with drought tolerance.

R. C. MANDAL: What is the purpose of comparison of different coconut hybrids without specifying the effects of high chlorophyll and high NR activity of MYD x WCT to yield/resistance or some other effect?

S. R. VOLETI: The paper is a comparison of biochemical and physiological parameters of coconut seedlings of three hybrids. Since the palms are only at flowering stage yield could not be given. Seedling characters of these hybrids is already known and during vegetative stage the superiority of MYD x WCT is clearly seen.

CROP MANAGEMENT

Chairman : V. RANGANATHAN

Rapporteurs : W. KRISHNAMURTHY RAO
C. KUNHIKRISHNAN NAIR

CONSUMPTIVE USE OF WATER IN RELATION TO CUMULATIVE PAN EVAPORATION (CPE) WITH AND WITHOUT MULCHING IN ARECANUT*

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ABSTRACT

Mulching reduced the consumptive use of water during dry months with increase in yield. Optimum water requirement and frequency of irrigation were worked out based on evapotranspiration and open pan evaporation rates. Irrigation at IW/CPE ratio of 1 to a cumulative pan evaporation of 30 mm gave maximum yield followed by irrigating at the same ratio to a cumulative pan evaporation of 60mm. Both organic mulch and polythene cover were equally effective; but the latter is prohibitively expensive for wider adoption.

INTRODUCTION

Arecanut (*Areca catechu* L.) is an extensively cultivated tropical palm. In coastal Karnataka it requires irrigation during summer months from December to May. Though the annual rainfall is high, the major portion is received during June to October and water scarcity during the dry months is a common phenomenon. Hence, there is a need to optimise irrigation needs of the crop to make the best use of available water. Results of an experiment carried out to study the possibility of reducing the consumptive use of water by the use of mulches and to determine the optimum quantity and frequency of irrigation based on IW/CPE ratio are reported in this paper.

MATERIALS AND METHODS

The experiment was conducted in a 16 year old areca garden adopting split plot design with five replications and four levels

of irrigation viz., irrigation of 30 mm of water with a CPE of 30 mm (I_1), irrigation of 30 mm of water with a CPE of 60 mm (I_2), irrigation of 60 mm of water with a CPE of 60 mm (I_3) and irrigation of 60 mm of water with a CPE of 120 mm (I_4) as main treatments and mulching with dried arecanut husk @ 6 kg per palm (M_1), mulching with white polythene sheet of 600 gauge thickness (M_2) and unmulched control (M_0) as sub plots.

The soil of the experimental field is lateritic clay loam, with 48% sand, 14% silt and 34% clay and bulk density varying from 1.4 g to 1.59 g/cc, moderately deep, well drained, and slightly acidic with a pH of 5.24. The field capacity of the soil is 20.6 per cent with a permanent wilting point of 9 per cent. The meteorological data recorded during the experimental period with their decennial mean are presented in the Figures 1, 2 and 3.

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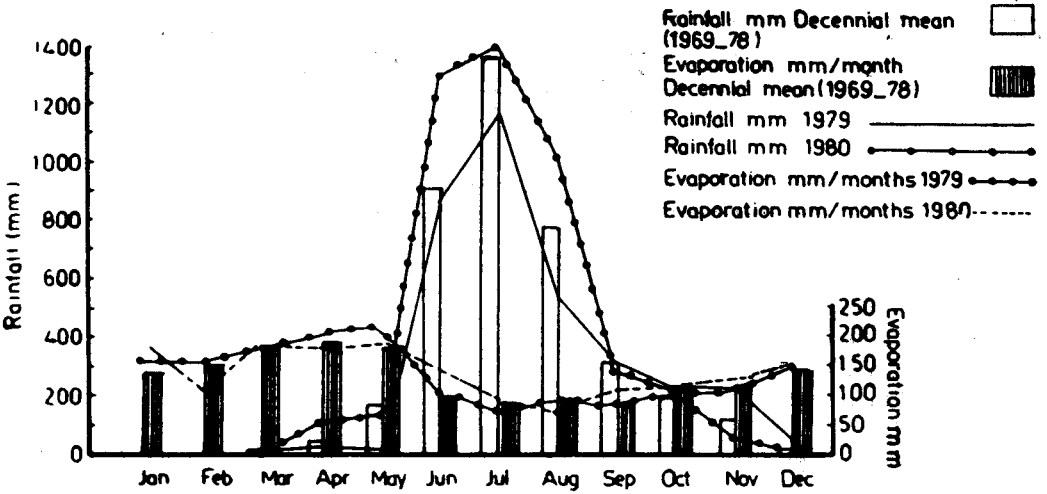


Fig. 1. Rainfall and evaporation

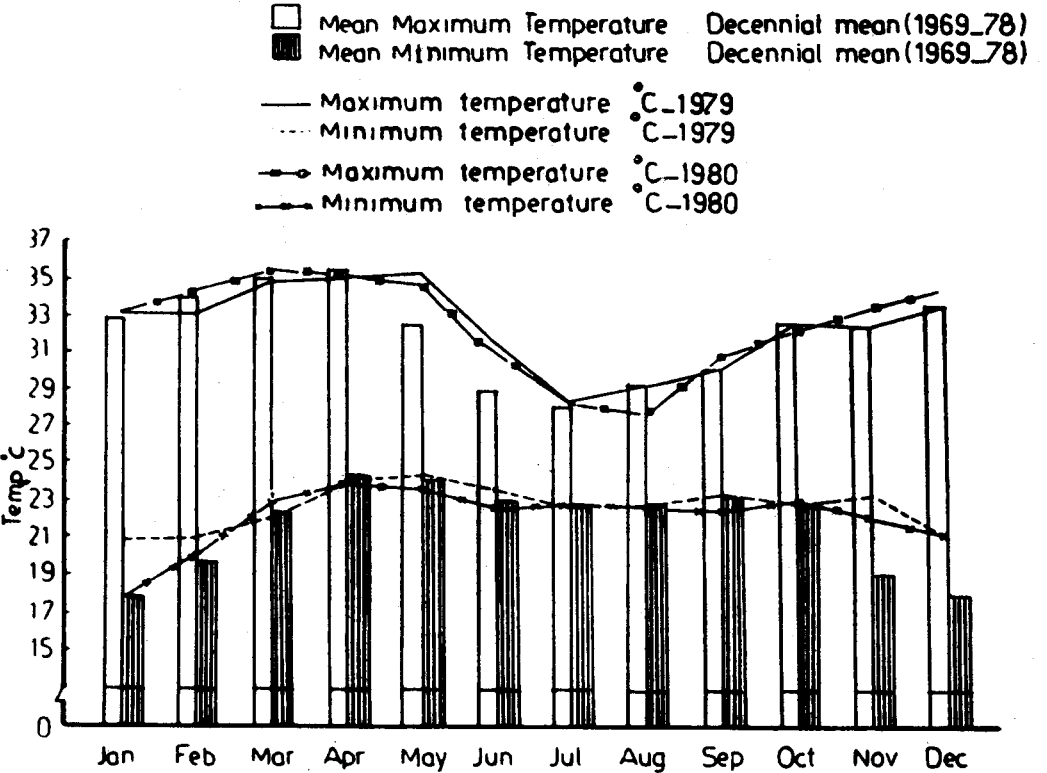


Fig. 2. Maximum and minimum temperature

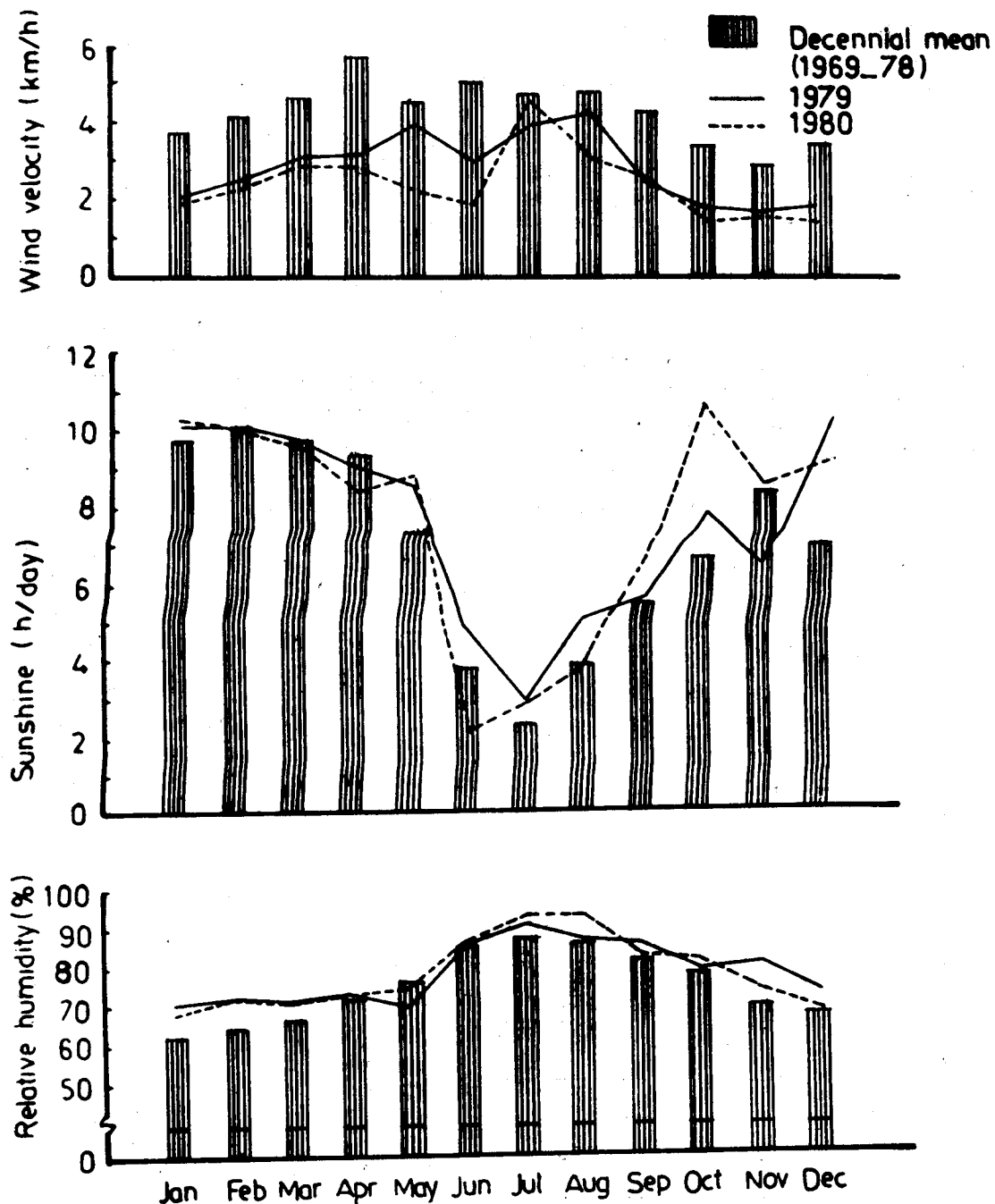


Fig. 3. Wind velocity, sunshine hours and relative humidity

The areca palms were irrigated from January to May as per the treatment schedule. Measured quantity of water was applied to each plot by using a 'U' shaped syphon and the quantity of water was adjusted to the quantity evaporated from the USWB Open Pan evaporimeter installed in the centralised meteorological observatory of the Station.

Soil moisture content was determined upto a depth of 50 cm by gravimetric method (Dastane, 1972) and converted to volume basis using the method described by Israelsen and Hansen (1962) and the stored moisture in the root zone was determined. The open pan evaporation was recorded daily. The frequency of irrigation, consumptive use of water and the relationship between ET/E pan were determined and different parameters have been worked out.

RESULTS AND DISCUSSION

United States Weather Bureaux (USWB) Open Pan Evaporation

The mean data on monthly evaporation from USWB Open Pan evaporation are presented in the Table I. The lowest rate of evaporation was recorded during January, with a mean of 4.88 mm/day and the highest was during May (6.48 mm/day). The rate

Table I. Mean monthly evaporation from USWB Open Pan

Months	Mean monthly evaporation		
	1979	1980 mm/day	Mean
January	4.12	4.64	4.88
February	5.31	5.79	5.55
March	5.71	5.82	5.76
April	6.48	5.96	6.22
May	6.86	6.10	6.48

of evaporation is dependent on climatic factors such as temperature, humidity and wind velocity (Ritchie 1971). In the present investigation the temperature of the experimental site gradually increased as summer advanced (Fig. 2) which had resulted in a corresponding increase in the rate of evaporation from the open pan.

Frequency of irrigation

When the irrigation was based on IW/CPE ratio, for I_1 level of irrigation, the number of days required to have a cumulative total of 30 mm of evaporation from the open pan varied from 6.32 days (January) to 4 days (May), for I_2 and I_3 levels of irrigation the number of days required for a cumulative total of 60 mm was 12.65 days (January) to 10.68 days (May). Similarly for I_4 treatment, the number of days required to have a cumulative total of 120 mm it has taken 25.3 days (January) to 21.36 (May) (Table II).

The results reveal that as could be discussed later, it is reasonable to irrigate areca garden once in a week during January–February and with a shorter interval during April–May and it comes closer to weekly irrigation practised in the areca at present.

Soil moisture

Studies on soil moisture revealed that after 24 hours of irrigation, there was not much difference in soil moisture content of different irrigation treatments (Table III) while by the time of next irrigation in I_1 level of irrigation there was 16.78 per cent moisture and in I_4 level it was 8.91 per cent. In I_2 and I_3 treatments 13.64 and 15.50 per cent of moisture was observed, respectively.

In mulching treatments, there was 14.26 per cent moisture in plots mulched with arecanut husk while under polythene cover it was 14.31 and in unmulched control plot,

Table II. *Time in days taken for scheduling irrigation based on USWB Open Pan evaporation as per the treatment to different irrigation levels*

Irrigation levels	Mean for 1979 and 1980					
	January	February	March	April	May	Mean
I ₁	6.32	5.30	5.16	4.91	4.00	5.33
I ₂	12.65	10.60	10.33	9.83	10.00	10.68
I ₃	12.65	10.60	10.33	9.83	10.00	10.68
I ₄	25.30	21.20	20.66	19.66	20.00	21.36

I₁ = Irrigation of 30 mm with a CPE of 30 mm
 I₂ = Irrigation of 30 mm with a CPE of 60 mm
 I₃ = Irrigation of 60 mm with a CPE of 60 mm
 I₄ = Irrigation of 60 mm with a CPE of 120 mm
 M₀ = Unmulched control
 M₁ = Arecanut husk mulch
 M₂ = Polythene mulch

Table III. *Percentage of soil moisture before and after irrigations (Mean for 1979 and 1980)*

Treatments	After 24 hrs of irrigation				Just before the next irrigation			
	M ₀	M ₁	M ₂	Mean	M ₀	M ₁	M ₂	Mean
I ₁	20.94	21.63	22.14	21.57	15.12	17.10	18.12	16.78
I ₂	20.40	21.84	22.60	21.61	12.55	14.96	13.43	13.64
I ₃	22.78	22.96	20.70	22.14	14.40	15.97	16.32	15.56
I ₄	20.70	20.94	22.54	21.39	8.32	9.01	9.40	8.91
Mean	21.20	21.84	21.99	21.67	12.59	14.26	14.31	13.72

the moisture content observed was 12.59 per cent. The results indicated that the I₁ level of irrigation had received water much before the soil reached to 50 per cent of the available soil moisture while the I₄ treatment received irrigation only after the soil moisture depleted beyond permanent wilting point. Depletion of soil moisture was observed more in unmulched control plot as compared to mulched plots. Moisture conservation and reduction in the rate of surface evaporation from the mulched soils have been observed by Russel (1940), Pennman (1952), McCalla (1943), Gardener (1960), Benoit and Kirkham (1963) and Bond and Willies (1970).

Evapotranspiration (ET)

The rate of evapotranspiration was relatively reduced as the frequency of irrigation was lowered from 5.62 to 3.63 mm/day (Table IV). The maximum was observed in I₁ treatment and the minimum was in I₄ with no appreciable difference between I₂ and I₃. As the moisture level falls below the field capacity there will be an increase in soil water suction and the availability of water to the plant decreases correspondingly. In other words, as the soil dries up the evapotranspiration rate decreases. When the soil moisture decreases greater energy is required to

draw a given amount of water since the water is held in the soil pore space with greater force (Namken, Gerand and Brown 1968). Prashar and Singh (1963) have also observed an increase in evapotranspiration from 376 to 503 mm of water by increasing the number of irrigation from one to three.

Mulching with polythene sheet and with arecanut husk reduced the evapotranspiration (Table V). In unmulched plot the mean ET observed was 4.96 mm/day. In the plot mulched with arecanut husk and under the polythene cover the above figures were 4.40 mm/day and 3.79 mm/day respectively. Mulches act as a barrier for the diffusion of vapour from the soil resulting in minimisation of evaporation loss (Lal, 1974; Chandler, Boneta and Abruha, 1969 and Waggoner,

1960). Mulches also reduce the intensity of radiation and wind (Hanks, Bower and Bark, 1961 and Bond and Willes, 1970).

Crop coefficient (ET/E pan)

Among the different irrigation levels the widest ratio between consumptive use and USWB open pan evaporation was observed (0.94) in I_1 level of irrigation while the lowest ratio was noticed in I_4 treatment (0.58). In I_2 level of irrigation it was 0.68 and in I_3 level it was 0.79 (Table VI). The possible reason is that as the soil moisture suction increases, the potential gradient from the soil water to the leaves decreases and the effect being a reduction of evapotranspiration compared to the potential rate. When the soil moisture is not limiting the rate of evaporation is constant and dictated by the external

Table IV. *Evapotranspiration as affected by irrigation levels irrespective of mulches (mm/day) (Mean for 1979 and 1980)*

Irrigation levels	Months					Mean
	January	February	March	April	May	
I_1	4.96	5.40	5.71	6.06	6.19	5.62
I_2	3.33	3.88	4.01	4.32	4.58	4.02
I_3	3.86	4.48	4.48	4.95	5.07	4.56
I_4	2.78	3.24	3.52	3.54	3.75	3.36
Mean	3.68	4.24	4.43	4.64	4.89	4.39

Table V. *Evapotranspiration as affected by mulches irrespective of irrigation levels (mm/day) (Mean for 1979 and 1980)*

Treatments	Months					Mean
	January	February	March	April	May	
M_0	4.15	4.76	4.76	5.29	5.68	4.96
M_1	3.71	4.27	4.40	4.79	4.86	4.40
M_2	3.20	3.64	3.84	4.06	4.15	3.79
Mean	3.68	4.24	4.38	4.79	5.06	4.38

evaporativity acting on the soil surface. If the evaporation persists and the soil surface dries, the ability of soil profile to transmit water to the surface falls below the evaporativity of the atmosphere and the actual evaporation rate falls below the optimum (Lemon 1956). The plant roots can absorb moisture at a certain rate for a given soil conditions. As the soil moisture content decreases and suction increases, a corresponding decrease in the absorption rate of water by plants results and leads to a lower evapotranspiration and reduced ratio of ET/E pan.

Table VI. *Crop coefficient (ET/E pan)*

Treatments	Mean for 1979 & 1980			
	M ₀	M ₁	M ₂	Mean
I ₁	1.06	0.92	0.83	0.94
I ₂	0.75	0.70	0.59	0.68
I ₃	0.90	0.80	0.67	0.79
I ₄	0.61	0.59	0.53	0.58
Mean	0.83	0.76	0.66	0.75

Among the different mulching treatments, unmulched control plot had shown the highest ratio between the consumptive use and open pan evaporation (0.83) and when organic mulch was applied, the ratio was reduced to 0.76 and the use of polythene sheet as a mulch it had further reduced to 0.66 (Table VI). Mulches act as a vapour movement barrier and minimise the evaporation loss from the soil (Lal, 1974, Chandler et al., 1969 and Waggoner, 1960) resulting in a lower ratio of ET/E pan.

The seasonal water requirement of arecanut was found to be 105.0 cm for I₁, 75.8 cm for I₂, 82.2 cm for I₃ and 63.4 cm for I₄ treatments respectively. In the case of mulching treatments, the seasonal water requirement under unmulched control was 93.6 cm;

under arecanut husk it was 83.0 cm and under polythene cover mulch it was 71.4 cm respectively.

Yield

The results on the yield of arecanut (Table VII) revealed that irrigation of 30 mm of water with a CPE of 30 mm gives significantly more yield. The treatment I₁ had resulted in a production of 10672 kg of ripe nuts/ha as against 8521 and 8891 kg/ha respectively in the treatment that received irrigation of 30 mm and 60 mm with a CPE of 60 mm (I₂ and I₃). The treatment irrigated with 60 mm with a 120 mm of CPE (I₄) had only 4973 kg of nuts per hectare. Similarly in the plots mulched with arecanut husk and polythene sheet, the yield increased significantly (8795 and 8878 kg per ha respectively) compared to unmulched control (7110 kg/ha).

The maximum expected crop coefficient, ET/E pan ratio, is I. However, in the present investigation, with 30 mm of irrigation with a cumulative pan evaporation of 30 mm

Table VII. *Effect of irrigation levels and mulches on weight of ripe arecanut (kg/ha)*

Treatments	Mean for 1979 and 1980			
	M ₀	M ₁	M ₂	Mean
I ₁	9604	11357	11070	10672
I ₂	7247	8946	9371	8521
I ₃	7453	9535	9700	8891
I ₄	4166	5370	5370	4073
Mean	7110	8795	8878	8261
	I	M	I x M	
'F' test	S**	S**	NS	
CD (P=0.05)	881	391	—	

S** = Significant at 1%

NS = Not significant

the ratio observed was 0.94 and for the practical purposes, this may be taken as nearer to 1 which was also found to be the optimum ratio for irrigating areca garden. It is possible to reduce the above ratio by the application of mulches.

The results suggested that though the potential ET observed was 0.94 whenever flood irrigation is given to arecanut, water will have to be applied with slightly in excess quantities providing sufficient allowances for compensating the percolation and run-off losses. The results also indicated that by the use of organic mulches it is possible to bring down the water requirement of arecanut from IW/CPE ratio of 1 to 0.76 with a cumulative pan evaporation of 30 mm. Though by the use of polythene mulch it is possible to bring down the above ratio to 0.66, the high cost of polythene sheets makes it prohibitive and uneconomical for adoption in arecanut gardens.

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EVALUATION OF HERBICIDAL ACTIVITY OF GLYPHOSATE WITH LOW COST ADDITIVES

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ABSTRACT

Four additives – kaolin, ammonium sulphate, urea and muriate of potash were tried as additives to glyphosate (N-phosphonomethyl glycine) to enhance its herbicidal efficacy in rubber plantations. Kaolin and ammonium sulphate increased the efficacy of glyphosate, while urea and muriate of potash did not show any pronounced effect. Results showed that glyphosate can be used at a lower dose of 0.62 kg ai/ha compared to the currently recommended rate of 0.82 kg ai/ha if additives, kaolin and ammonium sulphate are used at 2.25 and 1.25 kg/ha respectively resulting in considerable saving of 150 to 175 Rs./ha on cost of herbicide and indirectly helping to reduce the herbicidal load in environment.

INTRODUCTION

Glyphosate (N-Phosphonomethyl glycine) at 0.82 kg a.i./ha controls most of the narrow leaved weeds and some broad leaved weeds in rubber plantations (Mani Jacob et al., 1987) and has been recommended for weed control in rubber plantations from 1987 onwards (Anonymous, 1987). However, because of the high unit cost of Glyphosate formulations currently available, several studies on the feasibility of reducing Glyphosate dosage with additives for effective weed control and thereby also lowering the herbicide load in the environment are made. The effect of several low cost additives like kaolin, ammonium sulphate, urea and muriate of potash in enhancing the herbicidal activity of Glyphosate has been reported by various workers (Blair, 1975; Costa and Appleby, 1986; Pura, 1985; Sharma and Sundar, 1981; Wills and Mc Worther, 1985). Results of one such study on weed control in rubber plantations are reported in this paper.

MATERIALS AND METHODS

A field experiment with 12 treatments replicated thrice in R.B.D. was laid out in the

interrow spaces of rubber at the Chittady Estate in Kottayam District in 1986. The individual plot size was 20m². The experimental area was predominantly infested with narrow leaved weeds like *Axonopus compressus* (SW), Beauv, and *Paspalum conjugatum* Berg. The broad leaved weed spectra consisted of mainly *Borreria ocymoides* DL *Mimosa pudica* (L), *Chromolaena odorata* (L) and *Sida rhombifolia* (L).

The treatments consisted of Glyphosate alone at 0.82 kg a.i./ha, 0.62 kg a.i./ha, and 0.31 kg a.i./ha. The lower rates of Glyphosate namely 0.62 and 0.31 kg a.i./ha were sprayed in combination with medical grade kaolin at 2.5 kg/ha and fertilizer grades of ammonium sulphate, urea and muriate of potash at 1.25 kg, 2 kg and 0.75 kg/ha respectively. The herbicides were sprayed with an Aspee Knapsack sprayer fitted with a WFN 40 flood jet nozzle at a constant pressure of 1 kg/cm² in September, 1986. All the treatments were imposed in 400 litres of water/ha.

The weed flora was evaluated prior to treatment imposition and afterwards at 29

and 64 days after spraying. The evaluation was done visually on a subjective scale of 0 to 100 per cent. Zero denotes complete absence of weeds and 100 denotes complete coverage of weeds.

The data on percentage weed canopy coverage recorded were statistically analysed after transforming the percentage values to values of angles.

RESULTS

The statistical analysis of the pre treatment weed flora distribution showed no significant differences. Weed canopy coverage at 29 days after spraying (DAS) showed significant differences between treatments on statistical analysis. All the herbicide treatments gave significantly better overall weed control as compared to control (Table I). The overall

Table I. Overall weed canopy coverage after herbicide treatment – Mean per cent

Treatment	29th day after spraying	64th day after spraying
Glyphosate – 0.82 kg a.i.ha ⁻¹	34.15 (31.7)	90.00
Glyphosate – 0.62 kg a.i.ha ⁻¹	52.97 (63.3)	90.00
Glyphosate – 0.31 kg a.i.ha ⁻¹	65.19 (81.7)	90.00
Glyphosate – 0.62 kg a.i.ha ⁻¹ + Kaolin 2.5 kg ha ⁻¹	36.24 (35.0)	90.00
Glyphosate – 0.31 kg a.i.ha ⁻¹ + Kaolin 2.5 kg ha ⁻¹	49.83 (58.3)	90.00
Glyphosate – 0.62 kg a.i.ha ⁻¹ + Ammonium sulphate 1.25 kg ha ⁻¹	37.12 (36.7)	90.00
Glyphosate – 0.31 kg a.i.ha ⁻¹ + Ammonium sulphate 1.25 kg ha ⁻¹	50.88 (60.0)	90.00
Glyphosate – 0.62 kg a.i.ha ⁻¹ + Urea 2 kg ha ⁻¹	50.97 (60.0)	90.00
Glyphosate – 0.31 kg a.i.ha ⁻¹ + Urea-2 kg ha ⁻¹	62.40 (78.3)	81.15
Glyphosate – 0.62 kg a.i.ha ⁻¹ + Muriate of potash-0.75 kg ha ⁻¹	56.84 (70.0)	90.00
Glyphosate – 0.31 kg a.i.ha ⁻¹ + Muriate of potash-0.75 kg ha ⁻¹	59.06 (73.3)	90.00
Control – Slash weeding	59.06 (100)	90.00
S. E.	3.55*	2.56
C. D. at 5%	10.41*	..

S. E. & C. D. are for the transformed values viz; angles.
Data in parenthesis are the actual percentages.

weed control obtained by Glyphosate at 0.02 kg a.i./ha in combination with 1.25 kg/ha ammonium sulphate and Glyphosate at 0.62 kg a.i./ha in combination with 2.5 kg/ha kaolin were at par. The above two herbicide treatments gave similar overall weed control to that obtained by the highest dose of Glyphosate alone (0.82 kg a.i./ha) and were significantly superior to all other treatments. Glyphosate alone at 0.62 kg a.i./ha was superior to the lowest dose of Glyphosate alone (0.31 kg a.i./ha). The lowest dose of Glyphosate (0.31 kg a.i./ha) with 1.25 kg/ha ammonium sulphate and 2.5 kg kaolin/ha respectively were at par with Glyphosate at 0.62 kg a.i./ha + 2 kg urea. These treatments were significantly superior to Glyphosate alone at 0.311 kg a.i./ha and Glyphosate at 0.31 kg a.i./ha + 2 kg urea in overall weed control. Both the doses of Glyphosate (0.62 kg a.i./ha and 0.31 kg a.i./ha) with 0.75 kg/ha of muriate of potash were at par with the similar doses of Glyphosate alone. However, at 64 DAS no significant differences were obtained in the overall weed canopy coverage by any of the treatments.

DISCUSSION

The relatively lower weed control observed in this experiment with Glyphosate was probably due to the cloudy weather and light showers after the herbicide application.

However, the herbicidal activity of Glyphosate was evidently enhanced by the addition of two of the additives namely kaolin and ammonium sulphate. Costa and Appleby (1986) reported that ammonium sulphate could to some extent compensate for the loss in efficacy of Glyphosate spray by immediate rainfall and Suwunnamek and Parker (1975) reported the beneficial effect of ammonium sulphate as additive to Glyphosate in the control of *Cyperus rotundus*. The absorption, retention and release of Glyphosate from the anionic exchange sites of kaolin as postulated by Sharma and Sundar (1981) and abrasive action of kaolin on leaf surfaces (Eveling and Elisa 1976) could be reasons for the enhanced activity of Glyphosate when sprayed with kaolin as an additive. The addition of these low cost additives could reduce the effective dosage of Glyphosate from 0.82 kg a.i./ha to 0.62 kg a.i./ha. Thus saving Rs. 150–175/ha (Table II) is possible when Glyphosate is used for controlling weeds in rubber plantations. The beneficial effect of additives was seen even in the lowest doses of Glyphosate, although overall weed control was not satisfactory at this level. In this experiment, urea did not appreciably increase the activity of Glyphosate contrary to the findings of Pura (1985). Wills and Mc Worther (1985) reported increased efficacy of Glyphosate with potassium ions though this

Table II. Economics of using additives to enhance the efficacy of Glyphosate

Treatment	Cost Rs. ha ⁻¹	Amount saved Rs. ha ⁻¹	Saving on cost (%)	Quantity of her- bicide saved kg ha ⁻¹	Glyphosate saved in %
Glyphosate 0.82 kg a.i.	720.00*				
Glyphosate 0.62 kg a. i. + Ammonium sulphate – 1.25 kg	545.00*	175.00	24*	0.20	24
Glyphosate 0.62 kg a. i. + Kaolin – 2.5 kg	570.00*	150.00	21	0.20	24

* Approximate cost, subject to change based on prevailing market prices

was not observed in the present experiment. Effect of the two additives, urea and muriate of potash in enhancing the herbicidal efficacy of Glyphosate was not pronounced and the reasons are to be further investigated.

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GROWTH AND DRYMATTER PRODUCTION IN THE COMPONENT CROPS UNDER MONOCROPPING AND HIGH DENSITY MULTISPECIES CROPPING SYSTEMS*

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ABSTRACT

Growth and dry matter production of the crops grown under monocropping and coconut based high density multispecies cropping systems (HDMSCS) have been compared. Canopy growth and economic yield of intercrops under HDMSCS were considerably affected. The energy output/input based on NPK as active ingredients also was lower for the intercrops under HDMSCS system. Lower light intensity reaching the canopy of intercrops due to interception by coconut canopy appears to be the limiting factor for their growth and productivity. Shade loving species which require low light intensities are likely to perform better under HDMSCS system. Identification of such species of economic importance for trying in HDMSCS system is desirable.

INTRODUCTION

Central Plantation Crops Research Institute, Kasaragod had developed new approaches in the planting systems like multi-storied cropping and mixed cropping (Nelliath, Bavappa and Nair, 1974) which indicate the possibilities of cultivating compatible combinations of other crops along with coconut. Nair et al (1975) explained the synergistic effects of crop combinations of coconut and cocoa on growth and productivity under mixed cropping. Creencia (1978) suggested that by multiple cropping the productivity of coconut can be increased. Bavappa (1975) reported that coconut utilizes only 30 to 40% of the total airspace available in the system and by the high density planting under coconut and arecanut plantations the yield of both the main crops as well as subsidiary crops could be increased (Bavappa et al

1986). Better utilization of environmental resources is the prime objective of these planting systems. In an intercropping system even if all other conditions are favourable for the growth of intercrops, light is the limiting factor since light penetration of a plant stand is reduced through interception and absorption by the taller canopy (Trenbath 1976). Biomass production of various crops in mixed system gives a rough indication of their compatibility (Okigbo 1979). The present study reports the growth and dry matter production of component crops under a coconut based HDMSCS i.e., a closed system as compared to the open condition i.e., as monocrop.

MATERIALS AND METHODS

The data was collected from a coconut based HDMSC model established during

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1983 at CPCRI, Kasaragod with eighteen crop species planted with minimum crop competition between the species (Bavappa et al, 1986). A control plot without coconut was laid out with 13 species with the recommended spacing and cultural practices. Eventhough the original HDMSC experiment consisted of three fertilizer levels, for comparison purpose only the full dose of the recommended level of fertilizer for each species was taken into consideration. As the establishment of some of the crops like clove, nutmeg and pepper planted in the open as well as HDMSC system was very poor the comparison was made only between the established crops in both the systems. The crops selected were one annual-Tapioca, two biennials - Pineapple and banana and the perennials - Sapota, guava and subabul.

Canopy growth was estimated taking into consideration of the shape of the canopy, canopy surface, area as well as canopy volume (Jamaluddeen and Jacob, 1983). Total height of the plant, number of branches produced and girth of the stem were measured along with the measurements. The fresh weight and dry weight of the harvestable produce were determined. The energy output, input ratio on each crop was calculated based on NPK as active ingredients (Pimental, 1980).

Incident light was measured for one week during the summer month with the Steady State Porometer (Li 1600, Lambda Instruments, U.S.A.) from 7 A. M. to 6 P. M. at an interval of 3h.

The cultural practices recommended for each crop were adopted in both the systems.

RESULTS

Light profile

The incident light on each crop is given in Fig. 1. The PAR range from 10 to

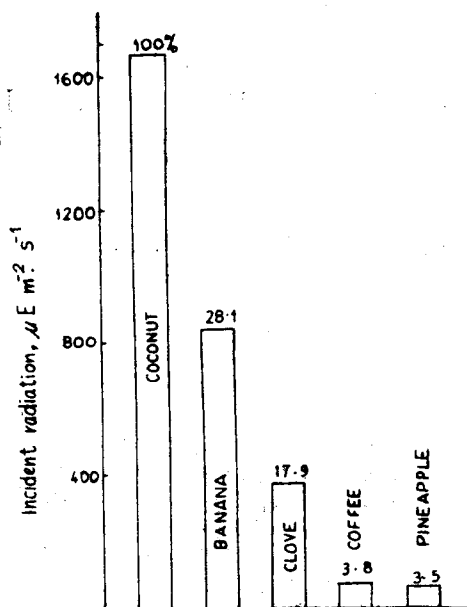


Fig. 1. Incident light on different crops

$15 \mu E m^{-2} S^{-1}$ from 7 A.M. with a peak at 12 noon when the PAR is about $1800 \mu E m^{-2} S^{-1}$ in the open on a clear day. Below the coconut canopy the incident PAR is 40–50% less than in the open. At any time of the day the incident PAR received by the crops at the ground level is $40-80 \mu E m^{-2} S^{-1}$ which is only 3.8% to 4.5% of the open. But the PAR input of the sunflecks is as high as 80% of the total PAR in the open.

Canopy growth

Table I gives the per plant canopy area in the two cropping systems. Since the canopy growth do not show much variation among the plants under a particular system, the mean values are only given. The data show that there is a drastic reduction in the canopy growth under the HDMSCS. The growth of guava is found to be more affected (93%) followed by pineapple (76%) under the system as compared to the open system. The canopy growth of banana and sapota was comparatively less affected under HDMSCS.

The reduction was 27% and 35% respectively as compared to open conditions. Subabul showed lanky growth under the HDMSCS. The total height of the plant varied between 5 to 6 m and the girth of the stem ranged between 7 to 13 cm as compared to the open condition where the height was 2 to 3 m and the girth 14 to 22 cm.

Table I. *Canopy growth*

Crop	Canopy area HDMSCS	m ² /plant OPEN
Banana	6.42	8.84
Pineapple	0.07	0.29
Guava	4.80	68.70
Sapota	5.00	7.70

Dry matter production

Only the economic yield is taken into consideration. Table II gives the fresh weight and dry weight of the harvestable produce as well as the energy output, input ratio.

From the table it is very clear that the fresh and dry weight of the fruits are affected under the HDMSCS. For instance fruit dry weight

is reduced by 28 and 25 respectively in banana and pineapple. Similar trend is exhibited by tapioca.

Energy ratio

Energy output, input ratio is low under the HDMSCS. Tapioca shows very low ratio which is 81% less than the open system. In the case of pineapple and banana it is only 39% and 31% respectively.

DISCUSSION

The effect of light on the growth and development of the crop plants are well known (Vince and Cockshull, 1981). Watson (1952) pointed out that the amount of light incident on the field is not the limiting factor for yield but the amount of light intercepted by a crop is the major discriminant. Earliness in flowering under the open condition also was reported in many crops (Evans, 1969). In the present study earliness in the flowering was noticed in the case of papaya (later removed) banana, pineapple and sapota in the open condition. This is corroborated by the data on light profile (Fig. 1).

The reduction in the growth under the system can be mainly attributed to the incident PAR on each crop. It was observed

Table II. *Dry matter production and energy output/input ratio*

Crop	Dry matter production				Output/input ratio*	
	Fresh Wt HDMSCS	Fresh Wt OPEN	Dry Wt HDMSCS	Dry Wt OPEN	HDMSCS	OPEN
	Kg/plant				No.	
Tapioca	0.96 ±0.117	2.82 ±198	0.22	0.65	0.084	0.25
Pineapple	1.4 ±0.081	1.9 ±0.15	0.18	0.24	0.086	0.116
Banana	9.42 ±0.094	13.0 ±1.08	1.60	2.2	0.018	0.026

* Based on NPK as active ingredient

that the coconut canopy intercepts 50% of the light. The incident light on the banana was 28.1% and the pineapple receives only 3.5% of the total intercepted radiation. Since the adult gardens are characterized by large number of sunflecks, offer another possibility to the growth of intercrops by alternating with shady and bright light during the movement of the coconut leaf. Earlier observation revealed that the larger canopy tree crops influence the growth of under plants within one metre of its radius more than those at 2 metre radius and beyond. The incident PAR at 1 metre radius was lower ($560 \mu \text{Em}^{-2} \text{S}^{-1}$) than at 2 metre radius ($920 \mu \text{Em}^{-2} \text{S}^{-1}$). This may be because of the greater absorption of light by the taller canopy (Trenbath 1976).

It has been well established that the capacity of crop plants to adapt to shade is a major physiological limitation to productivity (Smith, 1981). Trenbath (1976) reported, in an intercropping system competition for various factors may be involved but there are also adaptive mechanisms of crops in response to competition for light, space and nutrients.

Although the yield potential could not be fully realized in tapioca, pineapple and banana under shaded conditions (HDMSCS) as much as that under open system, the reduced yield showed their adaptability to low light profiles. The partitioning of dry matter in tapioca was found to be more towards the tuber growth (1.13 kg) than for shoot growth (0.94 kg) when grown as a monocrop while the reverse trend occurred under HDMSCS *i.e.*, tuber growth (0.22 kg) lower than shoot growth (1.46 kg). Tuber yield in yams also was found to be reduced when grown as intercrop (Okigbo 1979).

The extreme extension growth of stems and reduced branches of subabul, guava

and tapioca is another adaptive nature of these crops under shaded condition. It was noticed that when there was 2 to 3 branches for guava plant in the open system only a single branch was seen under HDMSCS. The thin spikeless leaves of pineapple with small fruits under HDMSCS as compared to the thick leaves with spikes and bigger fruits in the open condition show the modifications of plants to adapt in the less favourable environments. More than 40% of the pineapple fruits in the open weighed above 2 kg.

The energy output/input revealed higher ratios in the open condition. This may be because of the use of light to the fullest extent which is another form of energy whose input is less under HDMSCS.

Effective utilization of land, airspace and inputs with maximum returns are the advantages of HDMSCS. Eventhough the system gave an additional income from the increased coconut yield (Bavappa et al 1986) as well as from the yield of inter crops, effective utilization of all the inputs were not seen as compared to open condition. This is mainly because of the lower light intensity reaching the canopy of inter crops by interception by the coconut canopy. Therefore identification of suitable species such as shade loving ones which give a better yield when grown as intercrop as compared to the open is highly desirable.

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CASHEW-BASED FARMING SYSTEM

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ABSTRACT

With a view to find out suitable intercrops in the early stages of cashew plantation (for first 5 years), an attempt has been made at National Research Centre for cashew, puttur to grow cashew as main crop and pigeonpea, tapioca (annuals); pineapple, papaya (biennials) and tree species like *Casuarina*, *Acacia*, *Subabul* (Perennials) as inter and mixed-crops and these are being compared with a cover crop (*Mucuna* sp.) and a control (without any inter crop).

Preliminary studies indicated that both the food crops as intercrop can be successfully grown in the laterite undulating land. Growth of fruit crops and tree species were found to be very satisfactory under rainfed condition. It is thus possible to utilize the wider interspace (spacing 8m x 8m) profitably during the pay-back period of cashew and thereby to get additional income which has been illustrated in this paper.

INTRODUCTION

In Dakshina Kannada, cashew has already been successfully brought under cultivation over a sizeable area. This is situated in the Western Coast, lies between 12.25°N latitude and 75.42° E, longitudes, at an altitude 90 m above MSL and is characterized by highly undulating topography. This region has the warm climate of humid tropics with temperature ranging from 22°-38°C, relative humidity 75 to 85 per cent and mean annual precipitation about 3500 m which keeps plantations evergreen and provides a dense vegetation. The soils are mainly laterite or gravelly in hill tracts, porous and mostly acidic in reaction. Because of undulating topography, soil erosion is a constant feature in the exposed areas.

The large canopy cover of the grown up cashew trees protects the top-soil from erosion; but at its early growth period, a systematic inter and mixed-cropping system including compatible combination of crops,

having varying morphological frame and rooting habits, will be desirable and such a cropping system will be ideal to maintain a balanced eco-system (Mandal 1984). Cashew-based farming system, especially in the first 5-6 years of orchard establishments can enhance the overall return per unit area.

In cashew plantations, so far no systematic efforts are made to grow intercrops and therefore, there is a need for developing suitable cashew-based farming system and work out its economics. Research efforts are therefore required for understanding root and canopy architecture of different crop species, the energy input and output, PAR, the influence of different crop combinations on micro and macro-climate (Bavappa and Mandal, 1984). Attempts are now made for in-depth study of the inter-species competition for nutrients, light and moisture, changes in micro-climate, total biomass production and the economic returns of the total system. Keeping these points in view, an experiment has been initiated including food crops, fruit crops,

cover crops and forest species as inter/mixed crops in cashew plantations. The preliminary observations made in the initial stage of the experiment revealed certain facts which are discussed in this paper.

MATERIALS AND METHODS

The experiment was laid out in 1987 at National Research Centre for Cashew, Puttur in a RBD (3 replications) with 9 treatments. The cashew grafts of the variety M 10/4 were planted at 8m x 8m apart and in the wide interspace, the following inter/mixed crops were planted 1.5 m away of the main cashew crop, by adopting recommended spacings, to both main and intercrop. The details of the experiment are given in Table I.

The recommended doses of fertilizers were given to both main and intercrops. In addition, 2 kg of poultry manure/pit was applied to cashew and tree species, and 1 t/ha poultry manure was applied to pigeonpea, tapioca and cover crop plots at the time of planting.

Morphological observations like height, girth and canopy of cashew, tree species and fruit crops were taken one year after planting, while shoot and root weight of tapioca, shoot weight and yield of pigeonpea, were recorded at the time of seasonal harvest. Light interception by the main crop and all the intercrops (except cover crop) were measured with the help of 'Portable Photosynthetic System'.

Table I. *Crops grown in the HDMSC system*

Treatments	Variety	Spacings (m)	Plants/plot (Nos.)	Population/ha (No.)
Main Crop				
Cashew	M 10/4	8 x 8	6	156
Inter/mixed crop				
(a) Annual food crops				
Tapioca	M-4	1.0 x 0.75	280	7,300
Pigeonpea (Redgram)	ICPL-87	0.75 x 0.40	920	23,000
(b) Biennial fruit crops				
Pineapple	Kew	0.55 x 0.40	600	15,625
Papaya	Honeydew	2.8 x 2.4	44	1,056
(c) Forest species				
<i>Casuarina</i>	Local	2.0 x 2.0	55	1,430
<i>Acacia</i> spp.	Local	2.0 x 2.0	55	1,430
Subabul	Local	2.0 x 2.0	55	1,430
(d) Cover crop				
<i>Mucuna</i> sp.	Local	2.0 x 2.0	55	1,430
(e) Control (no intercrop)				
	—	—	—	—

RESULTS AND DISCUSSION

The preliminary observations on the main and inter/mixed crops were recorded during 1988, after one year of their growth period, except redgram and tapioca which was done at the time of their harvest.

Cashew

More height, girth and spread of the main crop was recorded in the plots inter/mixed cropping with redgram, pineapple, *Mucuna* spp., *Casuarina* and *Acacia*, while the corresponding values were minimum when intercropped with tapioca, indicating thereby competition by tapioca in the initial growth stage of cashew (Table II). The canopy coverage of cashew was ranging from 1.3 to 3.2 % of the given area. The light interception by cashew in different intercropping plots ranged from 68.88 to 75.26% within one year of its growth period (Table III).

Food crops

Tapioca: At the time of harvest (after 10 months of planting), average height of

shoot was 2.28 metres which was more than double the height of cashew plant (1.0 m) in the same plot. Average root length of tapioca was 30.43 cm. Tapioca plants utilised maximum light, intercepting (86.29%) of light. The root and shoot ratio was found to be 1.25 : 1.97 showing high harvest index and the total fresh tubers harvested from the interspace worked out to 6.25 tonnes/ha.

The cost of production worked out to Rs 2244/ha and the amount realised from the sale of fresh tubers @ Rs. 1.00/kg was Rs. 6250/ha. However, there was not much local demand of tapioca for home consumption in Dakshina Kannada.

Redgram: The variety ICPL-87 developed by ICRISAT which is a semi-dwarf and a determinate type, was planted in July and harvested during December. The total biomass production was 46 g/ha (dry weight of shoot and pods) out of which the grain yield turned out to be only 2.08 g/ha, because the crop was frequently attacked by pod borer, especially *Heliothis armigera*

Table II. Growth characters of cashew as affected by inter/mixed cropping systems (Av. of 3 replications)

Treatment	Height (cm)	Girth (cm)	Av. canopy EW & NS (cm)
Cashew + Tapioca	99.0	10.49	103.2
Cashew + Redgram	121.6	13.16	156.3
Cashew + Pineapple	124.9	13.03	160.7
Cashew + Papaya	110.4	11.00	117.3
Cashew + <i>Mucuna</i> spp.	111.8	12.18	130.9
Cashew + <i>Casuarina</i>	118.0	12.64	131.9
Cashew + Subabul	106.6	11.05	118.2
Cashew + <i>Acacia</i>	115.9	11.09	118.5
Cashew alone (Control)	109.2	10.96	131.8

Table III. *Ground coverage and light interception by cashew and inter/mixed crops (%)*

Treatment	Ground coverage/plot			Light inter- ception by cashew	Light in- terception by intercrops
	Cashew	Inter-crop	Total		
Cashew+Tapioca	1.3	75	76.3	72.4	86.3
Cashew+Redgram	3.0	75	78.0	73.0	69.3
Cashew+Pineapple	3.2	63	66.2	75.0	97.6
Cashew+Papaya	1.7	13.9	15.6	72.5	79.6
Cashew+ <i>Mucuna</i> spp.	2.1	30.0	32.1	68.9	—
Cashew+ <i>Casuarina</i>	2.7	16.7	19.5	71.6	85.8
Cashew+Subabul	2.1	5.7	7.8	72.6	50.7
Cashew+ <i>Acacia</i>	1.7	38.0	39.7	74.4	61.6
Cashew alone (Control)	2.1	—	2.1	75.3	—

in spite of spraying and dusting of insecticides at flowering and pod formation stages. The cost of cultivation was calculated at Rs. 2832/ha in the first year of its cultivation in a virgin land and the amount realised from the redgram seeds was only Rs. 3328/ha (@ Rs. 16/kg), thereby realising the net profit of Rs. 496/ha only.

Fruit crops

Pineapple: This is a biennial fruit crop commonly grown in laterite tracts of this region. This has established well and the growth observations were recorded. The average height of each plant was 85.66 cm bearing 53 to 56 leaves. The crop intercepted light by 97% in the first year which appears to be the highest of intercrops. The crop is at the fruiting stage. The cost of cultivation worked out to Rs. 10,250/ha in the first year. Out of this, Rs. 3000 being the cost of pineapple suckers and the remaining amount spent for opening 1 metre width, 1½ metre depth trenches of convenient length for planting suckers, fertilizer application and weeding.

Papaya: This is a biennial fruit crop which was planted after the establishment of the main cashew crop. Within five months of its planting, the canopy of the crop has covered 13.89%. The plants have already started flowering. At this stage, these plants intercepted light upto 79.60%.

The cost of cultivation worked out to be Rs. 2800/ha which includes initial cost of opening pits, manure, etc.

Cover crop

Mucuna spp. was found to be the best cover crop in rubber plantations and particularly in laterite soils of the Dakshina Kannada district and hence this was included as cover crop in cashew. The crop was established by planting of cuttings which has been established but covered only 30% of the given area, because of gap filling.

Tree species

Casuarina: The casuarina plants attained just double the height of cashew in the same

plot (Casuarina 239.7 cm; Cashew 118.0 cm). The canopy coverage was also more (16.75%) in casuarina which is only 2.7% in case of cashew. Both crops have covered so far totally 19.45% of the given area. Casuarina has also utilised maximum sunlight, by intercepting upto 85.83 per cent. The crop is allowed to grow straight by cutting side branches upto 50 cm height, the biomass of which worked out to be 1.5 tonne dry weight/ha which has been recycled by incorporating around the base of the plant.

The cost of cultivation/ha in the initial year was Rs. 3000/ha. This includes the cost of opening 60 cm³ sized pits also.

Leucaena (Subabul): In the first year, the average height of the subabul plant was more than the height of the main crop (subabul 141.3 cm, cashew 106.0 cm). The ground coverage by the canopy of subabul plants was only 5.66% of the given area which is minimum among all the intercrops, only because the canopy did not develop much as compared to the height. The coverage by cashew plants was only 2.1% of the area and both crops have thus covered only 7.76% of the given area. Light measurements showed that subabul plants utilised only 50.66% of the fallen light in the first year (Table III). Initially some of the subabul plants suffered from attack by goats and rabbits but later the same was protected by providing thorny bamboo fence around each plant. As a result, the cost of cultivation has slightly increased which worked out to Rs. 3500/ha.

Acacia: The average height of *Acacia* plants was 119.26 cm which was more than the height of cashew plants (115.9 cm) in the same plot. The area covered by acacia plants was 38.06% of the given area which is more than double as that of casuarina. Cashew and acacia plants put together have covered 39.7% of the given area within one year. Acacia plants intercepted 65% of the fallen light in the plot (Table III).

Thus, out of the tree species tried, *Acacia* spp. has grown very fast and covered 38% of the given area in the very first year of planting. This indicates that the main crop is likely to suffer due to lack of light from second year onwards, suggesting thereby lopping of lower branches at least up to two metres height of the acacia plants in stagewise as and when branches touch each other.

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PRODUCTIVITY RESPONSE SURFACES IN ROBUSTA COFFEE

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ABSTRACT

Productivity response surface functions are fitted to field survey data of robusta coffee (*Coffea canephora*) with yield, nutrient quantity and age of the bushes as variables. The major objectives are to indicate the choice of polynomial functions to study the yield response in different regions. The results bring out the importance of age of the bushes as a variable in the functional analysis. Among the two types of the functional forms, the bush-based response function in which nutrient and yield are quantified as g/bush, is better than the area-based response function, in which the above variables are expressed in kg/ha. The yield maximising levels of nutrients and age groups are derived for two regions from the respective functions. Given the levels of inputs, yield response varies in the two regions studied. Regionwise bush-based fertilizer recommendations and rationalization of fertilizer nutrient application are the major suggestions emerged out of this study.

INTRODUCTION

In a perennial crop like coffee, study of fertilizer response assumes importance on agronomic and economic counts. Besides helping in the estimation of agronomic and economic optima and marginal productivities, they also reveal the general fertilizer use efficiency. Such surfaces fitted to different agro-climatic zones would help to locate input-wise efficient production zones. The concepts and principles of agricultural production functions together with many empirical response surfaces were discussed by Heady and Dillon (1961). As the evaluation of response to inputs through specifically designed perennial crop experiments would take considerable time, probably many decades, before useful conclusions could be drawn, field surveys offer excellent alternative, evaluation method. Hence, based on survey data, this study was undertaken with the following objectives: 1. To discuss the characteristics of different yield response functions in order to bring out the choice

of appropriate functions and variables and 2. To estimate regionwise yield response to age groups and fertilizer nutrients in small-holder robusta plantations.

METHODOLOGY

The present study forms a part of the research project Yield-gap analysis in coffee for which 200 randomly selected small-holdings (≤ 10 ha) in Karnataka were surveyed during 1986-87 (Anonymous, 1987). The selected holdings are post-stratified for the species grown viz., arabica (*Coffea arabica*) and robusta (*Coffea canephora*). As the present study is confined to robusta alone, a total of 96 holdings in two agro-climatic zones of Kodagu viz., Virajpet (Region I) and Mercara (Region II) are taken up for analysis. The robusta holdings are further stratified into age groups. Owing to year to year variability in productivity of coffee in Indian (Ramaiah and Radhakrishnan, 1986), any study with single year yield as a variable may lead to misleading

interpretations. Hence, for this study, average yield for four to five years is used. In the process of computation of average yield the identity of age is lost and 'age groups' are formed as follows:

Age group :	1	2	3	4	5	6	7	8
Age (years):	4-7	8-10	11-15	16-20	21-25	26-30	31-40	≤ 41

Homogeneity tests by ANOVA revealed that the two regions are significantly different from each other. Hence, the data of the two regions are separately analysed. Significant differences among age groups also exist; the middle age groups *i.e.*, three to seven are different from primary or terminal age groups suggesting it as an important variable in yield response surfaces.

In all the functional analysis, yield is regressed against two independent variables *viz.*, fertilizer input (represented by quantity of nitrogen) and age group. Age group enters the function as a 'natural' biological variable input, since, as any other material input, it has a curvilinear relation with yield. The diminishing nature of yield to increments of nutrients as well as age groups are established through curve fittings, based on which the following second degree polynomial model is specified for the study:

$$Y = \alpha + \beta_1 N + \beta_2 N^2 + \beta_3 A + \beta_4 A^2 + \beta_5 (AB) \dots (1)$$

The equation is fitted both by expressing the productivity (yield/ha) and nutrient input variables on area basis (kg/ha) and bush basis (g/bush) and in this equation Y, N, and A represents respectively yield of clean coffee, quantity of nutrients and age group; α is a constant and β_i are coefficients. As vast majority of respondents (about 95%) applied N, P and K in equal proportion, the nutrient inputs are represented by the quantity of nitrogen in this model.

The optima in fertilizer nutrient quantity and age group are derived from equation (1) by setting the respective partial derivatives *viz.*, dY/dN and dY/dA to zero and solving for N and A.

RESULTS AND DISCUSSION

The estimated function along with the coefficient of multiple determination (R^2), the adjusted R^2 (R^{-2}), calculated F values with their d.f and the optimum quantities in N(N-opt) and A (A-opt) and the maximum yield (Y-max) obtainable at the optimum levels of N and A, are presented in Table I.

It could be seen from the Table I that the optimum quantities could change with respect to the type of function chosen *viz.*, the unit area-based function in which spacings or bush populations per unit area is ignored and the bush-based function in which spacing or bush population per unit area are considered. The computed R^2 indicated that a considerable proportion, about 70% in Region I and 59% in Region II, of variation in yield was explained by the selected variables thus bringing out the dominant influence of these input on yield of robusta. To choose the best one among the two functional alternatives, the usual indicators of selection *i.e.*, R^2 and R^{-2} could not be taken as a guide in this case because, within any given region, the values of these coefficients for the two functions were found to be almost equal. In such circumstances, one has to resort to other characteristics which could bring out the difference in functional forms. As indicated in Table I, the derived optima of the two functions of a region differed vastly. In Region I, for example, the optimum

Table I. *Estimated response surface functions*

Function model	Estimated function	R ²	R ⁻²	Calculated F	N-opt	A-opt	Y-max
REGION I							
(i) Unit area-based	$Y = -212.03 + 11.22N - 0.03N^2 + 211.67A - 21.87A^2 - 0.45(NA)$	0.73	0.70	23.4** (5,44 d.f.)	179	3.0	1110 kg/ha
(ii) Bush-based	$Y = -169.93 + 8.13N - 0.02N^2 + 182.21A - 22.08A^2 + 0.30(NA)$	0.70	0.67	20.1** (5,43 d.f.)	205	5.5	1171 g/bush
REGION II							
(i) Unit area-based	$Y = -48.16 - 0.12N + 0.03N^2 + 167.61A - 17.40A^2 - 0.03(NA)$	0.69	0.65	18.1** (5,41 d.f.)	NR	NR	NR
(ii) Bush-based	$Y = -71.71 + 3.37N - 0.02N^2 + 142.32A - 14.79A^2 + 0.24(NA)$	0.59	0.54	11.3** (5,40 d.f.)@	137	5.9	581 g/bush

** Significant at 1% level

@ Reduction of d.f. is due to elimination of samples with irregular plant spacing

NR — Not reported as N is of non-diminishing form

quantity of N (and hence P and K also) is found to be 179 kg/ha. This is irrespective of whether it is for 2.7m x 2.7m (9' x 9' with 1329 bushes/ha) or 3m x 3m (10' x 10' with 1075 bushes/ha) spacings. On the contrary, the bush-based optimum quantity of 205 g/bush (of N, P and K each) would suggest an application rate of 272 kg/ha for the first

spacing and 220 kg/ha for the second spacing. Thus the bush-based functions alone would be able to bring out the true quantity of fertilizer by eliminating the effect of bush population on yield per unit area, and also would be able to show the optimum age group without under-estimating it. For these reasons, a change from the present

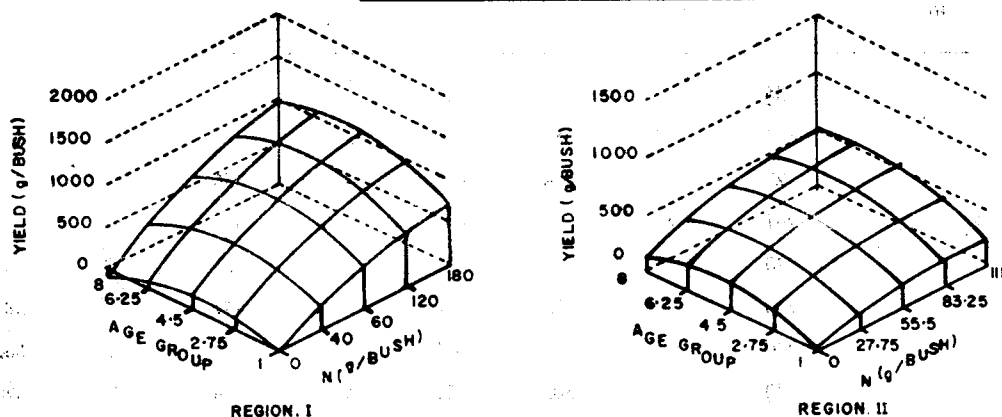
ROBUSTA: RESPONSE SURFACE

Fig. 1. Response surfaces for both regions

area-based fertilizer recommendations to bush-based recommendation becomes imperative. Owing to their appropriateness, the bush-based response surface functions are taken up for further discussion. The response surfaces corresponding to the estimated functions in both the regions are shown in Fig. 1. The calculated yields corresponding to various levels of inputs are presented in Tables II and III.

The yield response to a given level of input is not similar in both the regions. For example, in Region I, at 140 g/plant and in age group 4-6 (20-30 years) the yield is almost double (about 1 kg/bush) that of Region II. This might be attributed to the difference in the agro-climatic conditions that prevail in these regions coupled with the comparatively quite low level of input use and management practices in Region II.

Table II. *Region I: Calculated yields (g/bush) for various levels of fertilizer nutrients and age groups*

Age group	N (g/bush)					
	0	40	80	120	160	200
1	0	289	512	—	—	—
2	106	417	652	811	893	899
3	178	501	749	919	1014	1032
4	206	541	801	983	1090	1120
5	189	537	808	1003	1122	1164
6	129	489	772	979	1110	1165
7	24	396	692	911	1054	1120
8	0	259	423	799	954	1032

— extrapolation avoided

Table III. *Region II: Calculated yields (g/bush) for various levels of fertilizer nutrients and age groups*

Age group	N (g/bush)							
	0	20	40	60	80	100	120	140
1	56	121	172	209	—	—	—	—
2	154	224	280	322	349	363	363	348
3	222	297	354	405	437	456	460	441
4	261	341	406	458	496	519	528	524
5	270	355	425	482	524	553	567	567
6	250	339	415	476	523	557	576	581
7	200	294	374	441	493	531	555	565
8	120	219	305	376	433	476	505	520

— extrapolation avoided

To sum up: (1) yield of robusta varies with the age of the bushes and hence age groups must be considered as one of the variables while fitting production functions, (2) the bush-based function is found to be more relevant than the area-based function, (3) for any given level of inputs, yield response in Region I of Coorg district is much higher than Region II warranting region-wise bush-based fertilizer recommendations.

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AGRICULTURAL DROUGHTS WITH REFERENCE TO COCONUT

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ABSTRACT

Intensity and occurrence of drought in coconut belt of West Coast of Kerala was studied using index of moisture adequacy, the ratio between actual and potential evapotranspiration. Analysis of index of moisture for the period from December to April for the 46 year period shows that out of thirty three drought years, large and severe ones occurred each in 10 years, moderate ones in 9 years and disastrous once in 4 years. A declining trend in the moving averages of index of moisture adequacy during the study period suggests the increasing probability of occurrence of high intensity drought period in the recent years. Soil moisture deficit during January to May is 801 mm in a disastrous drought year (1983) and 378 mm in no drought year (1984) against the 40 year mean of 531 mm. Both the duration and the intensity of drought influence the nut yield of the following year.

INTRODUCTION

Agricultural droughts are not uncommon in the northern region of Kerala which falls under high rainfall zone and the distribution of rain fall is uni-model, concentrating most of its rainfall during the southwest monsoon. Unlike annual crops which are adapted to seasonal rainfall under rainfed conditions, perennial crops like coconut suffer due to want of soil moisture during summer in which the rainfall received is insignificant if the pre-monsoon showers fail. This is one of the limiting factors for productivity of coconut even under good management. The decline in nut yield is felt more in recent years due to failure of summer rains. The effect of drought in summer on nut production of coconut is seen in the following year, beginning from the eighth month after the drought period is over and continues for twelve months (Prasada Rao, 1986). The impact of agricultural droughts on annual crops was studied in detail by several workers

(Subrahmanyam, Subba Rao and Subramaniam, 1963; Krishnan, 1976; Sastri, 1979 and Subramaniam and Prasada Rao, 1980) using the critical limit of index of moisture adequacy at which the optimum crop yields are obtained. An attempt has been made for analysing the intensity and frequency of occurrence of agricultural droughts in relation to coconut productivity at the Regional Agricultural Research Station, Pilicode for the period from 1942-43 to 1987-88.

MATERIALS AND METHODS

The index of moisture adequacy (Ima) which is the ratio between the actual evapotranspiration and potential evapotranspiration expressed as percentage is worked out for the period from December to April from 1942-43 to 1987-88 using the Thornthwaite's book-keeping water balance procedure (Subramanyam, 1982) based on the monthly rainfall and potential evapotranspiration. The potential evapotranspiration is substituted by the pan evaporation

as these values are very close to the crop-water requirement. The actual evapotranspiration is nothing but the precipitation plus the amount of moisture drawn from the soil moisture storage which can be obtained through water balance procedure if the water holding capacity of the soil is known. The available water is assumed as 150 mm per metre depth in laterite soils. The coefficient of variation and twenty year moving averages are worked out for explaining the variability of index of moisture adequacy during the study period. The following classification of the index of moisture adequacy for the period from December to April and the nut yield of coconut in the following year is used for analysing agricultural drought years. Mean Ima (%) and intensity of drought are given in Table I.

To understand the length and intensity of soil moisture deficit, the monthly water balances are also worked out for three selected years viz., 1983, disastrous

drought; 1942-81, normal year; 1984, 'no drought' year.

Table I. Mean index of moisture adequacy (Ima) and intensity of drought

Mean Ima (%) during December to April	Intensity of drought
> 30	No drought
25 — 30	Moderate
20 — 25	Large
15 — 20	Severe
< 15	Disastrous

RESULTS

The mean index of moisture adequacy for the period from December to April from 1942-43 to 1987-88 at Pilicode is depicted in Fig. 1. It can be seen that the index of moisture adequacy during summer is high (65.9%) in the year 1946-47, followed by 1965-66 (43%) and it is low

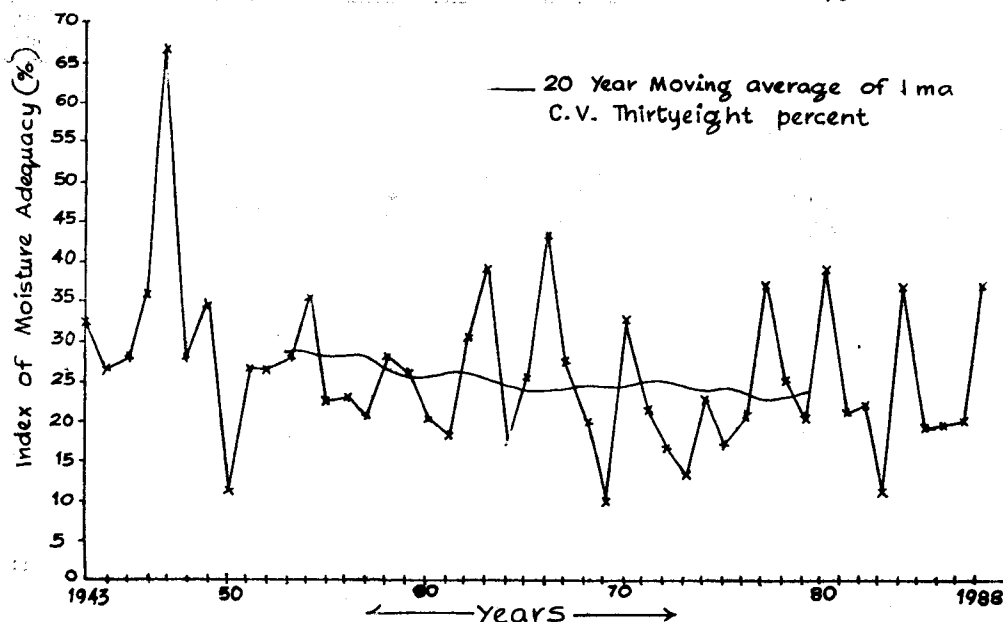


Fig. 1. Mean index of moisture adequacy (Ima) from December to April 1942-43 to 1987-88

in the years 1949-50 (11%), 1968-69 (9.6%), 1972-73 (13.4%) and 1982-83 (11.4%). The 20 year moving averages of index of moisture adequacy shows a decreasing trend and its coefficient of variation is thirty eight per cent.

The decade wise frequency of occurrence and intensity of agricultural droughts for the period from 1942-43 to 1987-88 are given in Table II. Out of thirty three agricultural drought years, moderate drought occurred nine times (27.3%), large and severe drought ten times each (30.3% each) and disastrous drought four times (12.1%). Number of agricultural drought years was more (nine out of ten years) during the decade 1951-60, followed by 1971-80 (eight out of ten years) and least (4 years out of eight) in the decade 1943-50. Though

the number of agricultural drought years was more in the decade 1951-60, the intensity of drought was high in the decades 1971-80 and 1981-88. During the later two decades, the number of severe droughts was higher compared to the decades 1943-50 and 1951-60. All the five decades had one disastrous drought year except the decade 1951-60.

The monthly water balance for the normal year (1942-1981), disastrous drought year (1983) and 'no drought year' (1984) are shown in Fig. 2. Soil moisture deficiency was 801 mm from January to May in 1983 while it was only 378 mm in 1984 as against 531 mm in the normal year (1942-81). Moreover, duration of low moisture adequacy (<15%) occurred for more than four months in 1983 as against one month in

Table II. *Decade wise frequency of occurrence of agricultural drought intensities from 1942-43 to 1987-88 at the Regional Agricultural Research Station, Pilicode*

Decade	Agricultural drought intensity				No. of Agri. drought years
	Moderate	Large	Severe	Disastrous	
1943-1950	1943-44, 44-45 and 47-48	Nil	Nil	1949-50	4
1951-1960	1950-51, 51-52, 52-53, 57-58 and 58-59	1954-55, 55-56 and 56-57	1959-60	Nil	9
1961-1970	1966-67	1964-65 and 67-68	1960-61 and 63-64	1968-69	6
1971-1980	Nil	1970-71, 73-74 and 77-78	1971-72, 74-75, 75-76 and 78-79	1972-73	8
1981-1988	Nil	1980-81 and 81-82	1984-85, 85-86 and 86-87	1982-83	6
Total No. of agri. drought years	9 (27.3)	10 (30.3)	10 (30.3)	4 (12.1)	33

Figures in parenthesis indicate the percentage frequency of occurrence of agricultural drought

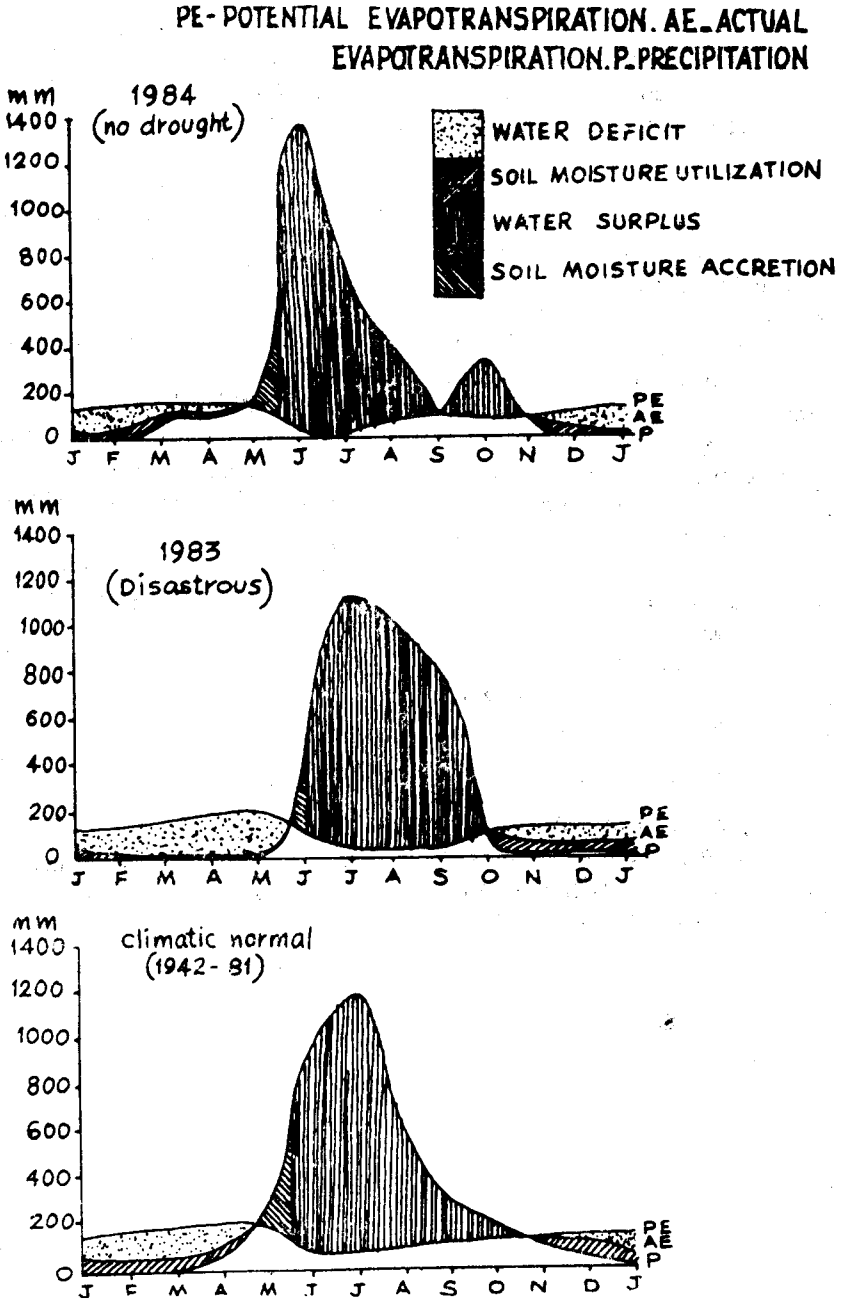


Fig. 2. Monthly water balance of climatic normal, disastrous agricultural drought and no drought years

1984. This resulted in poor nut yield (0.117 million nuts) at Pilicode in the following year 1984 and the nut yield was high (0.215 million nuts) in 1985 due to high moisture adequacy during summer 1984.

DISCUSSION

There is an increasing frequency of severe agricultural droughts in the recent decades. It is well known that any improvement in soil moisture status during December to April will help to obtain better nut yield as coconut palms in the northern region of Kerala which is subjected to soil moisture deficit during that period under the rainfed conditions. This could be seen by the beneficial rains received in March, April and May 1984 which helped to get higher nut yield in 1985 in spite high intensity drought from January to February in that year. Analysis indicates that both the length and the intensity of drought influence the nut yield of the following year.

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permitting me to utilise the past data from the Station records. Thanks are due to the scientists who were involved in recording data in the past and for meticulous maintenance of records.

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ZINC REQUIREMENT OF CARDAMOM (*Elettaria cardamom* MATON)

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ABSTRACT

Results of a study on the effect of foliar application of zinc sulphate solution at 0, 250, 500 and 750 ppm zinc on the yield of cardamom are reported in the paper. Significant increase in yield in two out of three years of study to foliar application of zinc and increase in zinc content of leaves show the presence of incipient zinc deficiency which when corrected will result in increase in productivity of plants. Failure to maintain the difference in zinc content observed at 2nd month after treatment between treatment and control at the pretreatment sampling of the following year (9 months after the last treatment) suggests the need for more number of applications during that period.

INTRODUCTION

Wide spread zinc deficiency occurs in the plantation crops such as tea, coffee and cardamom (Venkataram, 1968; Ananth, Iyengar and Chokkanna 1965; Anonymous, 1979) and foliar application with zinc salt solutions is adopted to correct the deficiency. In tea, zinc application has become a routine one and schedule of its application has been worked out (Ranganathan et al., 1987). Cardamom nursery plants benefit by incorporating zinc sulphate in the fertilizer mixture (Ranganathan and Natesan, 1985), but such information on cardamom in the field is lacking. As zinc deficiency symptoms in cardamom are not well defined or documented so far an experiment was conducted to find out the effect of zinc foliar application.

MATERIALS AND METHODS

The experiment was conducted in the experimental farm of the Indian cardamom Research Institute, Myladumpara,

Idukki Dist., Kerala. The area receives a mean annual rainfall of 2200 mm, distributed over six to eight months. The mean monthly temperature varies from 20-25°C. The surface soil (0-15 cm depth) has a pH of 4.8 and is high in organic matter (organic carbon 2.0 per cent). Bray II extractable phosphorus is about one ppm and ammonium acetate extractable K is about 50 ppm. Sodium chloride extractable calcium and magnesium are 60 ppm and 14 ppm respectively. The experiment was conducted in a field planted in 1983, with monoclonal materials, adopting a spacing of 2.5 x 2.5 m. A completely randomised block design with six replications was adopted. The treatments were foliar application with zinc sulphate ($\text{Zn SO}_4 \cdot 7\text{H}_2\text{O}$) solution of 0, 250, 500 and 750 ppm Zn at the rate of 1 litre per clump using knapsack sprayer, twice a year (June and September). The field was manured @ 75 : 75 : 150 kg NPK/ha/year in two split applications and the crop was raised under rainfed conditions.

Growth and yield data were recorded periodically from all the plants. The third and fourth leaves from the apex of the mature tillers were sampled from each plot immediately before zinc application and also after two months. The samples were cleaned, dried at 70°C and analysed for zinc content using Perkin-Elmer 2380 atomic absorption spectrometer after wet ashing the sample with tri-acid mixture.

RESULTS

Significant increase in the cardamom yield was recorded with zinc treatments during 1985-86 and 1987-88 (Table I). During 1986-87, though the yield difference was not statistically significant, the highest yield was recorded from the plants sprayed with 750 ppm zinc. The yield increase was related to the overall growth improvement as shown by the data on number of mature tillers, height of clumps, number of panicles per clump and length of panicle (Table I). Significant difference in the

zinc concentration was seen in the foliage, collected after two months of zinc application, but the samples collected prior to the treatments did not vary significantly among the treatments.

DISCUSSION

The symptoms of zinc deficiency in cardamom plantations are believed to be poor growth, narrow curled leaves, interveinal chlorosis and sometimes rosetting (Anonymous, 1979). But under thick shade these symptoms are not manifested sharply. Zinc deficiency is often manifested with a decrease in crop yield, as is indicated in the present study. Though deficiency symptoms had not been exhibited in control plots, significant increase in yield was recorded under zinc fertilization. The levels of zinc in leaves prior to zinc application did not vary significantly between the treatments, but in leaves developed following the zinc application, significant higher levels of zinc were recorded. Similar

Table I. *Growth and yield data under various levels of Zinc application in cardamom plantations*

Year of observation	Levels of Zinc	Number of mature tillers	Height of clumps (cm)	Number of panicles	Length of panicles (cm)	Yield wet weight(g) /clump
1985-86	250 ppm	11.05	205.38	15.11	29.21	269.89
	500 ppm	25.33	218.46	31.66	32.63	741.00
	750 ppm	18.77	227.76	26.39	40.67	705.55
	Control	7.30	196.73	9.75	28.35	170.11
	CD at 5%	10.02	NS	11.83	NS	396.16
1986-87	250 ppm	18.90	257.27	31.83	56.92	841.45
	500 ppm	14.55	240.13	22.05	47.78	742.38
	750 ppm	19.05	271.57	29.12	57.92	1030.73
	Control	12.00	237.00	21.23	52.22	524.73
	CD at 5%	5.46	NS	NS	NS	NS
1987-88	250 ppm	3.77	177.38	6.40	36.13	74.98
	500 ppm	5.61	164.37	8.05	29.06	71.52
	750 ppm	7.78	189.35	13.33	43.61	290.87
	Control	3.99	176.02	6.00	32.28	46.82
	CD at 5%	2.57	NS	4.42	7.11	184.44

translocation of zinc from the sprayed leaves to those developed immediately after the spray in small amounts has been noticed in orange trees (Razeto and Salas, 1986).

In the present study, maximum level of zinc sulphate used is 9.6 Kg/ha/year and the yield maximum has not been reached. This suggests the need for taking up further studies with increased levels of zinc sulphate. The period of application of zinc in this experiment has coincided with the maximum growth and flowering in cardamom. Zinc content is not maintained at high level at the time of pre-treatment sampling of the following year and this indicates the need for more number of sprays. Further studies in this direction are warranted.

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RESPONSE OF DARK LEAF CHINERY HYBRID TEA(*CAMELLIA SINENSIS* L.) TO NITROGEN, PHOSPHORUS AND POTASSIUM IN NORTH WEST HIMALAYAS

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ABSTRACT

Results of a manuring trial in a 130 year old dark leaf chinery hybrid tea in a silty loam soil in Himachal Pradesh are reported. Over a four year pruning cycle, N at 90 and 180 kg per ha increased the yield by 50.9 and 59.3% respectively over control, P at 39 and 78 kg per ha by 7.4 and 10% respectively over control and K at 33 and 66 kg per ha by 4.1 and 5.0%. Nutrient interactions further suggest the possibility of getting high yields with balanced rates of application of the major nutrients.

INTRODUCTION

Tea is grown for its vegetative part and hence nitrogen manuring has drawn considerable attention in all tea growing areas. N application varies widely from 90 kg/ha in North West India to 480 kg/ha in Japan for an yield of 2000 kg made tea per hectare (Jain, 1988).

Response to P have always been inconsistent in different tea growing countries of the world, which varied with soil types and agricultural practices (Sen, 1967; Willson et al., 1975a). No response to P application was observed by several workers (Wu, 1957; Sahxson, 1966; Rahman and Nandi, 1978). However, Rahman and Jain (1985) observed the delayed response to P application. Work done in Russia, demonstrated benefits from P application on the size of bush frame (Journbitsky and Strausberg, 1966; Ondani, 1969).

Responses to K applications have been reported to vary under different conditions. Muriate of Potash showed no response in a soil of pH 5.4 where N was applied in the form of Calcium ammonium nitrate (Willson, 1975). Lin (1967) obtained significant

responses to K on soils of pH 4.4 to 5.2. Rahman and Jain (1985) reported response to K upto levels as high as 180 kg/ha from N. E. India.

Application of K is essential to get the full benefits of N (Journbitsky and Strausberg, 1966; Rahman and Jain 1985 and Ranganathan and Natesan, 1984).

MATERIALS AND METHODS

A 3³ NPK trial partially confounded with 3 blocks of 9 plots each and replicated three times was carried out in 130 year old chinery hybrid at Tea Experimental Station, Himachal Pradesh Krishi Vishva Vidyalaya, Palampur from 1983 to 86. The station is located at 1291 m above mean sea level receiving an average annual rainfall of about 2500 mm, of which major portion is obtained during July-August. The experimental area is under a partial shade of *Albizia chinensis*.

The treatments comprised of all combinations of three levels each of N and P (each at 0, 90, 180 kg/ha) and K (0, 40 and 80 kg/ha) applied in the form of sulphate

of ammonia, single superphosphate and muriate of potash once in February end every year. The plot size is 30 bushes planted at 1.5m x 1.5m, which were kept under a four year pruning cycle, (Prune-level off skiff-Medium skiff-light skiff-Prune).

Regular plucking was carried out from April to October at 7-9 days interval. Crop yield has been expressed in terms of kg made tea/ha (KMTH) taking into account an average recovery of 25% during the entire growing season in this region.

The experimental area has a silty loam texture (43.0% sand, 34.9% silt, 22.1% clay) with an average pH of 5.3, cation exchange capacity 11 m.e./100 g soil (Piper, 1966); organic carbon 0.93%, total soil N 0.152% (Jackson, 1967); available P as 9 ppm and available K-140 ppm (Merwin and Peech, 1951) in the top soil layer (0-22.5 cm).

RESULTS AND DISCUSSION

Effect of N

The application of N exhibited the most

pronounced effect on the yield of tea (Table I). An increase in yield to the extent of 50.6 and 59.3% over control was recorded with the application of N₉₀ and N₁₈₀ respectively. The crop return at these levels was 5.30 and 3.11 kg made tea/kg N. Willson (1975a) also reported a diminishing crop return with the increase in N application rate due to the limited availability of other nutrients. However, the response to N as high as 270 kg/ha has been reported by Marwaha, Mehta and Sharma (1977).

Effect of P

Significant response to P was observed only in the pruned year, *i. e.*, 1983 (Table I). Application of P₂O₅ at 90 and 180 kg/ha gave a crop increase of 7.4 and 10.0% over control with crop to nutrient out turn of 1.0 and 0.68 kg made tea per Kg P₂O₅.

Effect of K

Response to Potassium was less pronounced than that of N and K. Application of K₂O at 40 and 80 Kg/ha increased the yield to 4.1 and 5.1% over control with a crop to

Table I. Influence of nitrogen, phosphate and potash applications on the yield of tea (KMTH)

Nutrient (kg ha ⁻¹)	1983	1984	1985	1986	Mean	Per cent increase over control	Response (kg made tea kg nutrient)
N ₀	733	961	1134	945	943	—	—
N ₉₀	1265	1400	1598	1418	1420	50.6	5.30
N ₁₈₀	1378	1453	1659	1519	1503	59.3	3.11
P ₀	1030	1236	1394	1212	1218	—	—
P ₉₀	1162	1241	1497	1330	1308	7.4	1.00
P ₁₈₀	1183	1335	1500	1342	1340	10.0	0.68
K ₀	1109	1240	1391	1263	1251	—	—
K ₄₀	1125	1268	1509	1304	1302	4.1	1.28
K ₈₀	1141	1304	1492	1317	1314	5.0	0.79
Mean	1125	1271	1464	1294	1289	—	—
SE (m) ±	64.8	64.2	73.2	63.7	18.2	—	—
CD 0.05	127.0	125.8	143.4	128.3	37.5	—	—
C.D. 0.01	166.9	165.3	188.4	171.4	50.8	—	—

nutrient out turn of 1.28 and 0.79 Kg made tea/Kg K_2O .

N x P interaction

N x P interaction was absent in the present study. Differences in yield increments with the increasing level of P at a given level of N was not pronounced. (Table II). The probable reason for the increased response of N in the presence of P may be the availability of magnesium in the soil and increased activity of feeding roots of the plants (Willson, 1975b).

N x K interaction

N x K interaction was not significant. However from third year onwards K has helped to increase the yield achieved by N

application and this effect showed an increased trend. Ranganathan and Natesan (1984) observed that it takes 3-4 years of continued application of fertilizers and in particular Potassium to show their full beneficial effect on yield (Table II).

P x K interaction

Significant response in yield of tea was recorded with PK combination during 1983 and 1986 (Table II). Yield of tea increased from 5.8 to 14.7% at $P_{90} K_{40}$ and $P_{180} K_{40}$ levels. Further increment of K at any level of P did not produce much difference in yield.

N x P x K interaction

Significant responses to NPK fertilizer combinations was observed in the present

Table II. *Influence of nitrogen X phosphate, nitrogen X potash and phosphate X potash interactions on the yield of tea (KMTH)*

Nutrient combination	1983	1984	1985	1986	Mean	Per cent increase over control
$N_0 P_0$	739	966	1066	943	929	—
$N_{90} P_{90}$	1253	1335	1535	1394	1379	48.4
$N_{90} P_{180}$	1311	1396	1612	1462	1445	55.5
$N_{180} P_{90}$	1486	1481	1762	1624	1588	70.9
$N_{180} P_{180}$	1525	1601	1746	1635	1627	75.1
Mean:	1263	1356	1544	1412	1394	
$N_0 K_0$	831	1001	1101	1007	985	—
$N_{90} K_{40}$	1310	1480	1712	1412	1479	50.2
$N_{90} K_{80}$	1334	1409	1631	1483	1464	48.6
$N_{180} K_{40}$	1400	1432	1635	1517	1496	51.9
$N_{180} K_{80}$	1388	1517	1723	1555	1546	57.0
Mean:	—	1253	1368	1560	1395	1394
$P_0 K_0$	1086	1264	1388	1277	1254	—
$P_{90} K_{40}$	1139	1227	1581	1360	1327	5.8
$P_{90} K_{80}$	1083	1204	1397	1240	1231	(—) 1.8
$P_{180} K_{40}$	1308	1395	1595	1452	1438	14.7
$P_{180} K_{80}$	1265	1449	1635	1450	1450	15.6
Mean:	1176	1308	1519	1356	1340	
SE (m)±	112.1	111.1	126.7	110.3	26.4	
C.D. 0.05	219.7	217.8	248.4	222.2	53.2	
C.D. 0.01	288.8	286.2	326.4	296.9	71.1	

Table III. Influence of nitrogen x phosphate x potash interactions on the yield of tea (KMTH)

N:P ₂ O ₅ :K ₂ O	1983	1984	1985	1986	Mean	Per cent increase over control	Fertilizer cost per kg of made tea (Rs.)
0:0:0	923	1154	1236	1207	1130	—	—
90:90:40	1274	1375	1607	1441	1424	26.0	4.72
90:90:80	1210	1283	1444	1327	1316	16.5	7.92
90:180:40	1418	1452	1784	1603	1564	38.4	4.43
90:180:80	1471	1531	1771	1621	1599	41.5	4.28
180:90:40	1404	1379	1753	1578	1529	35.3	5.39
180:90:80	1472	1527	1695	1584	1570	38.9	5.09
180:180:40	1744	1739	1840	1792	1779	57.4	4.14
180:180:80	1569	1630	1788	1679	1667	47.5	5.17
Mean	1387	1452	1658	1537	1509		
SE (m)±	194.3	192.5	219.5	191.0	42.7		
CD 0.05	392.6	387.8	442.3	384.9	88.1		
CD 0.01	519.5	518.0	590.9	514.2	119.3		

studies (Table III). It has been observed that K application at the highest level i.e., 80 Kg/ha in combination with N and P did not produce much effect on the yield of tea. A marginal increase in yield of 12.4% between N₉₀ P₉₀ K₄₀ to N₉₀ P₁₈₀ K₄₀ and 22.1% between N₁₈₀ P₉₀ K₄₀ to N₁₈₀ P₁₈₀ K₄₀ over control was recorded in the present investigations. At the lowest and the highest level of nutrient combinations cost of fertilizers per kg of made tea was worked out to Rs. 4.72 and Rs. 4.14 respectively.

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EVALUATION OF BOWL SLUDGE AS FERTILIZER FOR IMMATURE RUBBER AND COVER CROP

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ABSTRACT

Bowl sludge, a waste material obtained from latex concentrate factories was evaluated as a source of phosphorus for rubber budded stumps and *Pueraria phaseoloides*, the commonly cultivated cover crop in rubber plantations. Results of incubation and field studies indicated that bowl sludge was as good as super phosphate in promoting growth and uptake of phosphorus. Utilisation of the bowl sludge as an alternative source of phosphorus not only results in saving of fertilizer cost but also solves disposal problems of the waste material which when left to accumulate could lead to environmental pollution problems.

INTRODUCTION

Bowl sludge is a waste product and it contains magnesium ammonium phosphate formed by the reaction between magnesium present in the latex and diammonium phosphate added to it. The sludge material is formed in the bowl of the machinery used for latex concentration and hence the name bowl sludge. Since this material contains magnesium ammonium phosphate, the possibility of utilising it as a source of plant nutrients was undertaken in Malaysia and it is being recommended for fish ponds and pasture grasses as a source of phosphorus. (Tan et al, 1975). Results of investigations carried out to evaluate this material as an alternate source of phosphorus under Indian conditions are presented in this paper.

MATERIALS AND METHODS

Bowl sludge collected from the centrifuge factory at Mundakkayam was dried, powdered, sieved and analysed for N, P, K, Ca and Mg as per standard procedure, (AOAC, 1970). Nutrient contents of the bowl sludge are given in Table I. The material was compared against mussoorie rock phosphate and

super phosphate by incubation and pot culture studies with budded stumps and cover crops.

Table I. Nutrient content of bowl sludge (%)

N	P	K	Mg	Ca
5.1	14.27	0.68	8.52	7.1

Incubation study

Three phosphatic sources under test were added in the soil and the soil physicochemical properties are given in Table II. The soil was incubated at field capacity. Soil samples were drawn at 15, 30, 45, 60, 75 and 90 days interval and analysed for available phosphorus (Bray and Kurtz, 1945) and pH at soil water ratio of 1:2.5 using glass electrode.

Pot culture study - with rubber

The experiment was carried out with 7 treatments and 20 replications in polybags. The treatments consisted of the 3 sources of phosphatic fertilizer viz; super phosphate, mussoorie rock phosphate and bowl sludge each applied at 30 and 45 kg P_2O_5 /ha with a

control. Growth measurements, height and diameter of the plants, were recorded at periodic intervals. At the end of one year, the plants were uprooted for determining the dry matter content and uptake of nutrients.

Pot culture study – with cover crops

The experiment was carried out with the same 7 treatments but with 25 replications. Fertilizers were applied on the surface of the soil in which 3 pre-germinated seedlings were grown. Plants were uprooted after a year and dry matter content and uptake of nutrients were estimated.

RESULTS

Results obtained in the incubation study are given in Table III. More phosphorus

was found to be extracted from super phosphate, mussoorie rock phosphate and bowl sludge, when different doses were tried. A gradual increase in available phosphorus content was noticed in the 15th and 30th day of incubation with a sharp decline in the 45th day in all the treatments. Significant difference in pH was not noticed in soil by the application of these different sources and at different incubation periods.

The effect of different phosphorus sources on dry matter production and uptake of nutrients by covercrop, *Pueraria phaseoloides* is given in Table IV. Application of phosphate sources significantly increased the dry matter production in cover crop. Of the three sources tried, 30 kg P_2O_5 /ha bowl

Table II. *Physico chemical properties of soil*

Organic carbon (%)	pH	Av. nutrients (Mg/100 g soil)				Sand (%)	Silt (%)	Clay (%)
		P	K	Ca	Mg			
2.01	5.0	0.63	1.82	7.40	1.46	33.9	9.1	50.0

Table III. *Available P content on mg/100 g soil at different sampling dates*

Source	Dose kg ha ⁻¹	Days after incubation					
		15	30	45	60	75	90
Super phosphate	20	0.12	0.12	0.15	0.22	0.35	0.30
	40	0.23	0.27	0.23	0.25	0.37	0.32
	60	0.24	0.30	0.24	0.27	0.40	0.33
Mussoorie rock phosphate	20	0.24	0.27	0.24	0.27	0.37	0.29
	40	0.30	0.33	0.30	0.33	0.40	0.27
	60	0.33	0.39	0.33	0.37	0.45	0.39
Bowl sludge	20	0.09	0.11	0.09	0.20	0.37	0.24
	40	0.18	0.23	0.18	0.23	0.40	0.29
	60	0.18	0.33	0.30	0.27	0.47	0.32
Control	0	0.03	0.07	0.09	0.08	0.10	0.12
CD 0.05%		0.112	0.101	0.104	0.108	0.076	0.069
CD 0.01%		0.154	0.138	0.142	0.148	0.105	0.094
SE		0.037	0.034	0.035	0.034	0.026	0.023

sludge was found superior to mussoorie rock phosphate and super phosphate. Application of phosphate fertilizer has significantly increased the uptake of nitrogen, phosphorus and potassium in cover crop. Regarding the uptake of nutrients, bowl sludge was found superior than super phosphate and mussoorie rock phosphate. Data on the effect of super phosphate, mussoorie rock phosphate and bowl sludge on dry matter production and uptake of nutrients by rubber is given in Table V. Bowl sludge was found significantly superior in increasing the dry matter

production in rubber budded stumps. In the case of rubber budded stumps also bowl sludge was found superior in the uptake of nitrogen, phosphorus, potassium and magnesium. Effect of these phosphate sources on growth parameters is given in Table VI. Bowl sludge, mussoorie rock phosphate and super phosphate were found to be significantly superior in increasing the height and diameter of rubber budded stumps.

DISCUSSION

The results of the laboratory as well as

Table IV. *Effect of different phosphorus sources in dry matter production and uptake of nutrients by Pueraria phaseoloides*

Source	Dose P_2O_5 $kg\ ha^{-1}$	Nitrogen g	Phosphorus g	Potassium g	Dry wt. g/plant
Super phosphate	30	1.31	0.063	0.59	37.9
	45	2.81	0.164	1.36	80.0
Mussoorie rock phosphate	30	1.00	0.037	0.44	27.1
	45	0.92	0.048	0.48	27.3
Bowl sludge	30	1.98	0.103	0.98	55.9
	45	2.59	0.150	1.18	71.3
Control	0	0.57	0.019	0.27	16.8
	CD 5%	0.33	0.025	0.166	9.6
	SE	0.12	0.009	0.06	3.4

Table V. *Effect of different phosphorus sources on dry matter production and uptake of nutrients by rubber*

Source	Dose $kg\ ha^{-1}$	Nitrogen g/plant	Phosphorus g/plant	Potassium g/plant	Magnesium g/plant	Dry wt. g/plant
Super phosphate	30	2.48	0.08	0.85	0.20	141.15
	45	2.62	0.10	0.91	0.21	141.95
Mussoorie rock phosphate	30	2.31	0.09	0.75	0.19	147.93
	45	2.56	0.12	1.21	0.22	165.74
Bowl sludge	30	2.83	0.15	1.41	0.58	188.91
	45	3.79	0.23	1.62	0.75	236.95
Control	0	1.73	0.07	0.72	0.18	125.95
					CD 5%	46.11
					SE	16.43

Table VI. *Effect of different phosphorus sources on growth of rubber*

Source	Dose P ₂ O ₅ kg ha ⁻¹	Height cm	Diameter mm
Super phosphate	30	75.1	12.7
	45	79.9	13.1
Mussoorie rock phosphate	30	76.2	12.4
	45	79.8	13.0
Bowl sludge	30	82.6	13.2
	45	98.5	14.2
Control	0	58.0	10.5
	CD 5%	15.0	1.8
	SE	5.3	0.7

glass house studies highlighted the possible utilisation of bowl sludge, a waste product obtained from latex centrifuging factories as a source of nutrient for cover crop as well as rubber budded stumps. Results of incubation study indicated that addition of phosphatic fertilizer resulted in an increase in the available phosphorus content of soil which is in conformity with the observations of Pushpadas, Subbarayulu and George, 1978. During the initial phase of incubation an increase in phosphorus extracted was obtained at the three levels tried. At 45th day of incubation a decrease in phosphorus extracted was noticed for all the three sources. This might be attributed to the temporary dying up or immobilisation of phosphorus by micro organisms. Similar observation of reduction in phosphorus content was reported by Dasrath Singh et al (1976). After 45th day a gradual increase is noticed in the quantity of phosphorus extracted. A possible explanation for this phenomenon may be the reduced fixation of phosphorus by iron and aluminium due to the chelating effect of organic acids produced in soil (Firman Bear, 1965). The beneficial effect of phosphorus application for cover crop is illustrative from Table IV. The advantages obtainable due to manuring of cover crop

has been established earlier. (Karthikakutty Amma and Krishnakumar, 1986, Mathew, Pushpadas and Abdul Kalam, 1978). For dry matter production as well as in uptake of nutrients by cover crop, bowl sludge was found superior than the other sources tried. The results confirmed the suggestion of Mahmud Bin Hj. Wahb (1976) that bowl sludge as an effective source of manure for cover crop. Effect of bowl sludge as a source of nutrient for rubber budded stumps is evident from Table V and VI. Phosphorus present in sludge as ammonium phosphate could be attributed to the superiority observed in bowl sludge applied plants in growth as well as in uptake of nutrients. Favourable effect of soluble form of phosphatic fertilizer in early immaturity period of rubber is in conformity with previous finding Sivanadyan et al (1973). The presence of rubber particles in sludge also might have encapsulated the nutrients, thereby releasing the nutrients slowly to the crop.

To conclude, it can be stated that bowl sludge can be recommended as a nutrient source for cover crop. For recommending the same for budded stumps, further investigations in field conditions are envisaged. Being a waste product obtainable at cheap

rate, use of bowl sludge as a nutrient source for cover crop is worth considering not only from economic point of view but also as a novel method for reducing atmospheric pollution problem.

ACKNOWLEDGEMENT

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RAIN FALL ANALYSIS OF THE CARDAMOM TRACT

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ABSTRACT

Annual rainfall and its seasonal distribution of the cardamom tract of South India were studied in 32 locations based on the data recorded for the period from 1963-87. Eight rainfall zones, viz., Varushanadu, Thandigudy, Vandanmettu, Kallar, Palghat, Wynad, Manjurabad and Somwarpet zones were delineated in the tract. It was observed that the distribution of annual rainfall was better in the southern tracts, than in the northern tract, although the latter received higher rainfall. Also, there was a declining trend in annual rainfall of the Wynad zone. In contrast, in the Varushanadu zone, the rainfall showed an increasing trend. At Vandanmettu zone the trend in annual rainfall was decreasing till the end of sixties, but started increasing during the seventies.

INTRODUCTION

Of all the environmental factors of crop production, climate is considered as the most important, the other factors of environment such as geology, soil and biotic features play their role within the general climatic zones. The chief elements which constitute the climate are rainfall, temperature, humidity, sunshine, winds etc. Of this, rainfall assumes greatest importance as this is the prime source of water to plants. Rainfall affects the plant growth directly and indirectly. Low rainfall sets in dessication; heavy rainfall is destructive as it brings about soil erosion and other disturbances in soil. Rainfall has got influence on flowering, pollination, fertilization and fruit set. In cardamom (*Elettaria cardamomum* (L.) Maton), it has been reported (Anonymous, 1958) that the variation in the distribution of different types of cardamom along the tract might be due to the evolution of ecotypes adapted to the ecogeographical conditions. The high productivity of cardamom in Guatemala was attributed to the fairly well distributed rainfall (Korikanthimath, 1987). In spite of the importance

attached to rainfall and cardamom production, only very few studies were done on this aspect. These studies (Subbarao and Korikanthimath, 1983; Rathnam and Korikanthimath, 1985), though valuable, pertain to a small portion of the tract. Therefore, the present study was carried out to understand the variation in the annual rainfall, its seasonal distribution, intensity and trends, in the entire cardamom tract.

MATERIALS AND METHODS

Monthly rainfall data from 32 locations for 25 years (1963-87) were collected and studied. Based on the annual rainfall and its seasonal distribution eight rainfall zones were delineated in the tract. 25 years daily rainfall data from three locations, were used to work out the dry periods and intensity of rainfall. A standard week (IMD, Pune) with less than 20 mm rainfall was defined as a dry week. Weekly rainfall exceeding 100 mm was considered as heavy rains, and that exceeding 250 mm as very heavy rainfall. The 20 years moving averages were worked out to find out the trends in annual rainfall.

RESULTS AND DISCUSSION

The cardamom tract of South India lies within $8^{\circ} 30'$ N latitudes, and 75° and $78^{\circ} 30'$ E longitudes. The cardamom is mainly cultivated at elevations ranging from 800 to 1300 M above MSL and the tract lies on both the windward and leeward sides of the Western Ghats. The high hill ranges of the Ghats behaved as a climatic barrier in the spatial distribution of seasonal rainfall.

The monthly rainfall data for the eight rainfall zones delineated in the tract is depicted in Figs. 1-3, and the percentage distribution of seasonal rainfall is shown in Table I. The cardamom areas which belong to each rainfall zone and the approximate area under cardamom are also shown in the Table. The Varushanadu and Thandigudy zones received the rains mainly from retreating monsoons during October to December, as they lie on the eastern flanks of Western Ghats. The Varushanadu zone receive a higher amount of rainfall, mostly from the occasional winter and summer rains owing to the depressions or cyclonic storms in the Bay of Bengal (Singh, 1974). The Vandanmettu zone received a fairly well distributed rainfall from April to November and this zone represent the important cardamom producing centre in Kerala, namely the Udumbanchola Taluk. Under the Kallar zone all the high rainfall areas of the Idukki district were included, which lie at the foot hills of Munnar and

Peerumedu hill ranges, the highest peaks of the region. The rainfall distribution pattern in the Palghat zone is similar to that of Kallar zones, but the total precipitation is less in the former, comparatively. The Wynad, Manjurabad and Somwarpet zones have been delineated along the Malnadu Plateau. Of this, Wynad zone received the maximum rainfall (exceeding 5000 mm), as it lies on the windward side of the plateau. The Somwarpet zone which lie along the eastern parts of the plateau received the minimum rainfall of the region. Though there was marked variability in the annual rainfall from zone to zone, it was found that the majority of the area under cardamom production received an annual rainfall in the range of 2000-2500 mm, which is considered optimum for cardamom production (Subbarao and Korikanthimath, (1983).

The duration of dry period in the three zones, viz., Varushanadu, Vandanmettu and Wynad was compared in the Table II. The probability of occurrence of dry spell at any period of the year is very high in the Varushanadu zone, except for the two months of October and November. In the Wynad zone, which is a high rainfall zone, the dry spells are continuous from October to the beginning of May. In the Vandanmettu zone the dry period is comparatively shorter, as the zone receives assured rainfall during the post monsoon period.

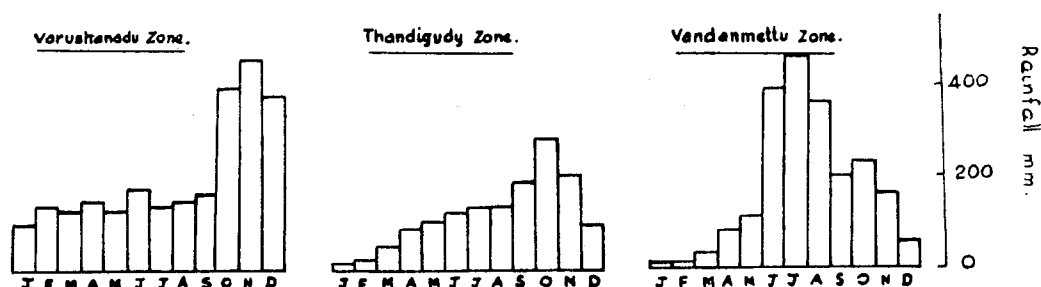


Fig. 1. Monthly rainfall in Varushanadu, Thandigudy and Vandanmettu zones

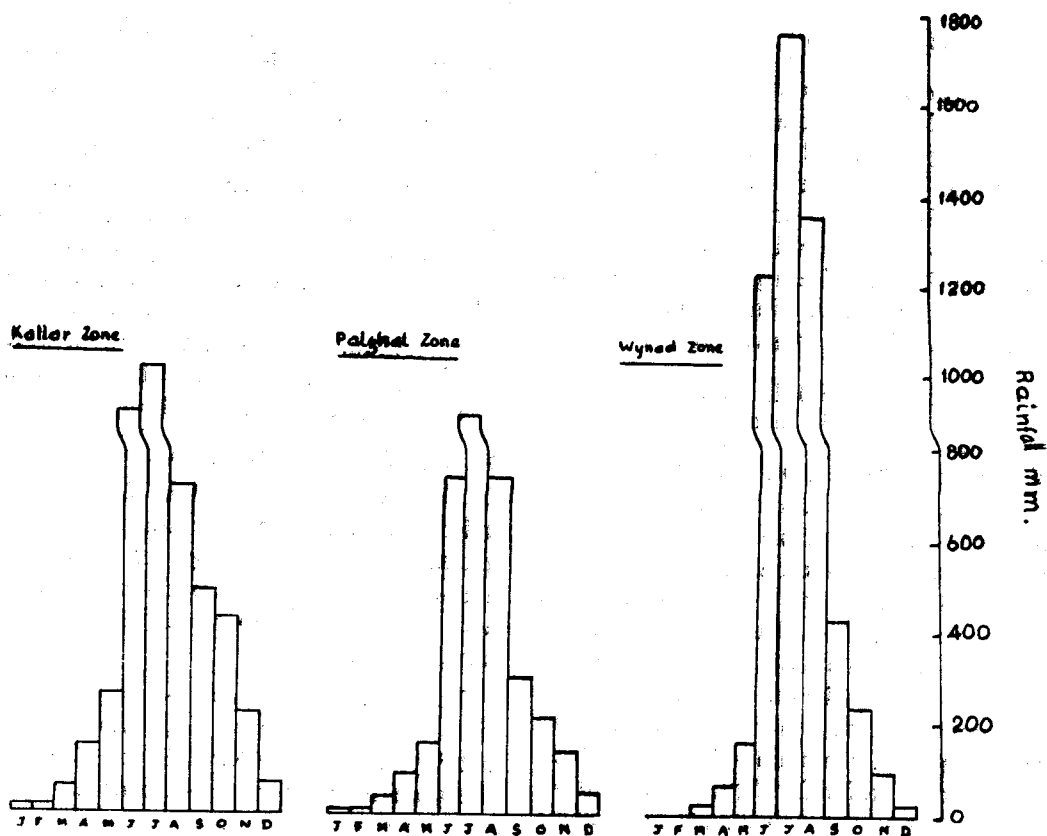


Fig. 2. Monthly rainfall in Kallar, Palghat and Wynad zones

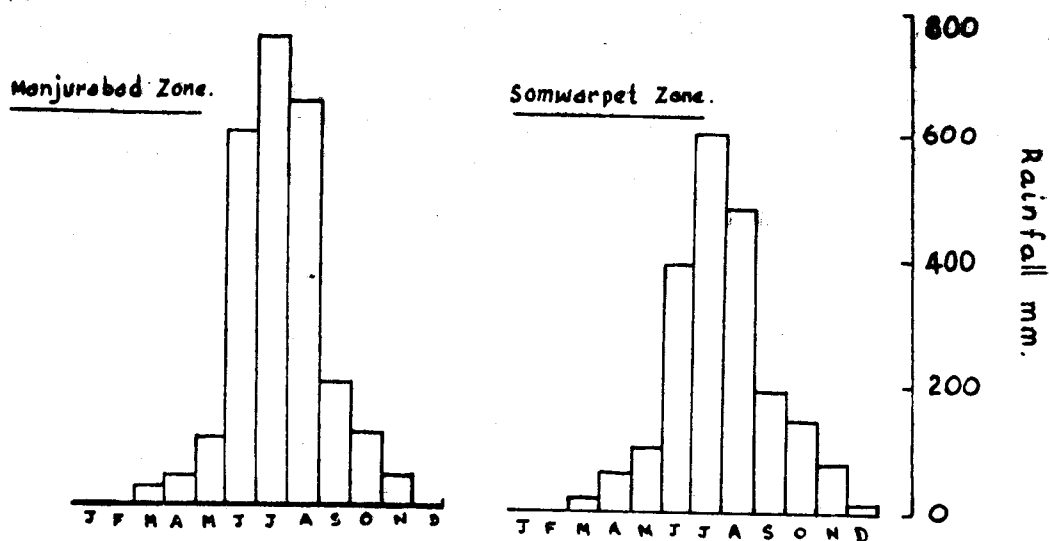


Fig. 3. Monthly rainfall in Manjurabad and Somwarpet zones

Table I. *Rainfall zones of cardamom tract*

Geographical zone	Rainfall zone	Mean annual rainfall (mm)	Percentage distribution of seasonal rains			Locations coming under rainfall zone	Approximate area under cardamom (in ha.)
			Winter	Summer	Monsoon		
1. South Zone	(a) Varushanadu	2500	24.0	16.0	26.0	Varushanadu hills, Sethur hills and Agastiamalays.	3000
	(b) Thandigudi	1525	9.0	16.0	41.0	Pulney hills, Attappady hills and Poopara (Idukki)	5000
	(c) Vandannmettu	3200	4.0	11.0	65.0	Chakkuppalam, Vandannmettu, Pampadumpara, Kalkoonthal, Udumbanchola and Chanthurangapara villages in Udumbanchola Taluk, Idukki.	40000
2. North Zone	(d) Kallar	4400	3.0	10.0	73.0	Pallivasal and Elappara villages in Idukki District.	8000
	(e) Palghat	3300	2.0	9.0	77.0	Nelliampathy hills and Anamalais	5000
	(f) Wynad	5400	0.5	4.5	88.0	Wynad Dist, Western parts of Virajpet, Mercara, Somwarpet, Saklespur and Mudigeri Taluk.	10000
	(g) Manjura bad	2800	0.5	7.5	85.0	Central parts of Virajpet, Mercara, Somwarpet, Saklespur and Mudigeri Taluk & Beethangudy Taluk.	20000
	(h) Somwarpet	2100	0.5	9.0	81.0	Eastern parts of Somwarpet and Saklespur Taluk, Chickamagalur Taluk and Sirsi.	5000

Table II. *Percentage occurrence of dry weeks (with less than 20 mm rainfall) in Varushanadu, Vandanmettu and Wynad zones*

Period No. & Weeks No.	Dates	Percentage of dry weeks		
		Varushanadu	Vandanmettu	Wynad
1. 1 to 5	Jan. 1—Feb. 4	82	97	99
2. 6 to 9	Feb. 5—Mar. 4	69	93	99
3. 10 to 13	Mar. 5—Apr. 1	66	85	94
4. 14 to 18	Apr. 2—May. 6	43	68	73
5. 19 to 22	May. 7—Jun. 3	51	53	59
6. 23 to 26	Jun. 4—Jul. 1	36	15	13
7. 27 to 31	Jul. 2—Aug. 5	45	8	0
8. 32 to 35	Aug. 6—Sep. 2	56	20	3
9. 36 to 39	Sep. 3—Sep. 30	42	32	14
10. 40 to 44	Oct. 1—Nov. 4	22	17	42
11. 45 to 48	Nov. 5—Dec. 2	25	45	74
12. 49 to 58	Dec. 3—Dec. 31	42	70	94

There is great variation in the intensity of rainfall also between the three locations studied (Table III). The S. W. monsoon rains are weak in the Varushanadu zone and the weekly rainfall seldom exceeds 100 mm. In the Vandanmettu zone heavy rainfall is experienced only occasionally. But in the Wynad zone persistent very heavy rainfall is experienced throughout the rainy season.

The trends in annual rainfall for the last three to four decades showed a declining trend in the Wynad zone, whereas a slight increasing trend is indicated in the Varushanadu zone. In the Vandanmettu zone, the declining trend exhibited during fifties and sixties disappeared, and a clear increasing trend can be seen.

From the above analysis it is clear that there is considerable variation in annual rainfall, its seasonal distribution, intensity

and trends. The cardamom tract which lies north of Palghat gaps receive the rains mainly from S. W. monsoons and these zones experience very heavy rains during this period. The long continuous dry spell as well as the heavy monsoon showers may affect the crop performance in this region. Among the zones that lie south of the Palghat Ghats, Palghat and Kallar zones experienced heavy rainfall from June to September and these rains can be detrimental to crop production in many ways. The Vandanmettu zone received a fairly well distributed rainfall. The rainfall was mild and thus could provide an optimum condition for the growth and productivity of cardamom. However, the increasing trend in rainfall from the seventies had to be viewed with caution. The important limitation in cardamom production in Thandigudy and Varushanadu zones appeared to be the frequent occurrences

Table III. *Percentage occurrence of weeks with more than 100 mm and 200 mm rainfall during S. W. monsoon season*

Period No. and Week No.	Dates	100 mm			250 mm	
		Varushanadu zone	Vandanmettu zone	Wynad zone	Vandanmettu zone	Wynad zone
VI. 23	Jun. 4-10	12	16	60	0	16
24	11-17	8	32	84	4	40
25	18-24	8	32	88	0	52
26	25-Jul. 1	4	36	84	4	60
VII. 27	Jul. 2-8	16	40	84	4	64
28	9-15	0	32	92	0	60
29	16-22	4	24	84	0	56
30	23-29	16	32	76	0	52
31	30-Aug. 5	4	28	92	4	56
VIII. 32	Aug. 6-12	16	32	88	4	64
33	13-19	16	36	80	0	56
34	20-26	0	12	80	0	32
35	27-Sep. 2	0	4	60	0	16
IX. 36	Sep. 3-9	4	0	48	0	8
37	10-16	16	4	24	0	4
38	17-23	28	8	40	0	8
39	24-30	24	8	24	4	0

of dry spells extending to two to three weeks in between the wet spells.

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CANOPY CHARACTERS AS CRITERIA IN DETERMINING PRODUCTIVITY OF TEA BUSH

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ABSTRACT

Canopy characters like surface area of the bush, distribution of leaf area and dry matter partitioning into foliage and wood in different strata in the productive zone of the bush extending upto a depth of 30 cm from the surface were studied in four tea clones; influence of age from pruning on these parameters was also investigated in one clone.

Clonal variations were noticed in certain parameters; only the ratio between leaf and stem in terms of dry matter accumulation exhibited a significant negative correlation with yield.

A progressive increase in surface area, leaf area and dry weight of leaf in the top 20 cm and the dry weight of stem in all the profiles was recorded with advance in age.

Correlations between surface area, leaf area, dry matter accumulation in foliage and wood in the top 20 cm and yield were significantly positive. The ratio of dry matter between leaf and stem revealed a negative correlation with the productivity of the bush.

INTRODUCTION

Light incidence, its interception and progressive attenuation at different levels in a plant depends on the distribution of foliage in different strata of the canopy. Likewise, other microclimatic factors like temperature and relative humidity are influenced by the pattern of distribution of leaves in different profiles (Hadfield, 1968; Obago and Othieno, 1984). Productivity in a foliage crop like tea, with its unique bush architecture, should hence be influenced by the density and area of leaf in different strata of the canopy.

Total leaf area, leaf area in the top 20 cm and leaf area index were reported to be influenced by the method adopted to bring young tea into bearing; these parameters were also correlated with yield (Barbora, Jain and Rahman, 1983).

The proportional partitioning of dry matter into different organs suggests its relationship with yield (Barua, 1981; Magambo, 1981; Magambo and Cannel, 1981). Certain trends were also indicated in a study on dry matter partitioning into different strata of the canopy (Murty and Sharma, 1986).

It will be appreciated that various canopy characters that are responsible for productivity are influenced by the cultivar and age of the bushes, besides the cultural practices. An investigation has been undertaken to determine correlations between various canopy characters and yield in four clones and bushes of three ages from pruning in one clone.

MATERIALS AND METHODS

Four clones, UPASI-2, UPASI-3, UPASI-8

and UPASI-17, varying widely in their morphological characters and yield levels, were chosen for studying the clonal variation. The bushes were five year old from planting and under regular plucking for about three and a half years prior to recording observations. Yields monitored regularly for one year prior to taking observations on stratification were used for correlations.

Bushes of the clone UPASI-9 going through second, third and fourth year from pruning were selected for the study on the influence of age on canopy characters.

All the clones were planted at a spacing of 120 x 75 cm in single hedge along the contour; the bushes were subjected to the package of practices recommended by UPASI Scientific Department.

Observations were made on three bushes, each serving as a replicate. The bushes were given a horizontal cut across at a depth

of 10, 20 and 30 cm from the plucking surface to monitor observations in the respective strata. The leaves below 30 cm from the plucking surface of the bush were also collected to facilitate the estimation of total leaf area.

Leaf area in each profile as well as for the entire bush was determined by regressing the dry weight with actual leaf area (Satyanarayana and Rao, 1981).

The plant material obtained from different strata 0-10, 10-20 and 20-30 cm from the plucking surface (Fig. 1) was separated into leaves and stems; their dry weights were determined by oven dry method.

The data emerging from the study were subjected to regression analysis; path coefficient* analysis was carried out as suggested by Singh and Chowdhary (1976) for leaf dry weight and stem dry weight in different profiles of the canopy.

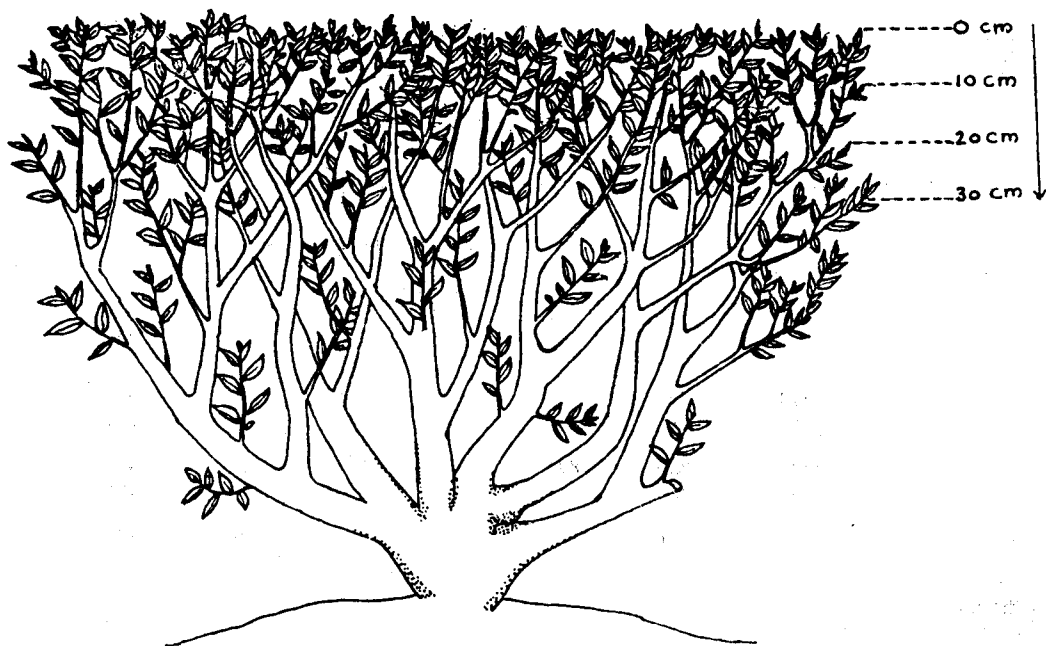


Fig. 1. Canopy structure of tea bush – different strata

RESULTS AND DISCUSSION

Plucking surface area

Area of the plucking surface was greater in the clone UPASI-3 than in the others which possessed comparable values among themselves (Table I). Age from pruning exerted a positive influence on the area of plucking surface (Table II).

Surface area of the plucking table is not only determined by the type of branching but also the population density and certain important cultural operations like initial training of young tea, and the mode and severity of successive prunings. The surface area in the four clones of the same age and density, not yet given first pruning, did not show significant correlations with

Table I. *Clonal variation in plucking surface area and leaf area*

Clone	Pl. surface area, cm ²	Leaf area at different profiles, cm ²						
		Profile from top, cm						Total
		0-10	10-20	0-20	20-30	0-30	30	
UPASI-2	6208 ± 185	5541 ± 740	7749 ± 1131	13290 ± 995	2780 ± 957	16070 ± 1051	3253 ± 1146	19323 ± 1765
UPASI-3	7333 ± 225	13140 ± 2608	4425 ± 952	17574 ± 1537	4679 ± 916	22253 ± 1851	6157 ± 539	28410 ± 1654
UPASI-8	6767 ± 525	20530 ± 2445	4154 ± 142	24684 ± 2009	5179 ± 705	29863 ± 2003	9428 ± 296	39291 ± 2154
UPASI-17	6742 ± 339	7621 ± 2389	7888 ± 816	15509 ± 1007	6283 ± 1620	21792 ± 833	7197 ± 1658	28989 ± 2105
Correlation coefficient with yield	+ 0.44	+ 0.39	- 0.24	+ 0.26	- 0.53	+ 0.09	- 0.15	- 0.10

Table II. *Plucking surface area and leaf area in relation to age from pruning*

Age from pruning yr.	Pl. surface area, cm ²	Leaf area at different profiles, cm ²						
		Profile from top, cm						Total
		0-10	10-20	0-20	20-30	0-30	Below 30 cm	
II	8787 ± 575	6597 ± 882	4162 ± 701	10759 ± 1578	3249 ± 102	14008 ± 1674	2989 ± 401	16997 ± 2997
III	11466 ± 692	8850 ± 1463	6894 ± 1479	15744 ± 1560	2139 ± 417	17883 ± 1269	2311 ± 467	20194 ± 1718
IV	13223 ± 303	8931 ± 1869	8068 ± 884	16999 ± 1747	1343 ± 404	18342 ± 1759	1472 ± 1461	19814 ± 2745
Correlation coefficient with yield	+ 0.99*	+ 0.94	+ 0.96	+ 0.98**	- 0.95	+ 0.70	- 0.98**	- 0.76

*Significant at P = 0.05

**Significant at P = 0.10

yield, though a positive trend was discerned.

The progressive expansion of the surface area in different years from pruning, which exhibited a positive and significant correlation with yield (Table II) was brought about by regular plucking, severely restricting the vertical growth. Repeated removal of crop shoots stimulates multiplicity of plucking points, which in turn contributes to increased productivity.

Leaf area

The clonal variations in total leaf area and the latter's distribution in different profiles (Table I) did not show significant correlations with yield.

However, the leaf area in top 10, 20 and 30 cm profiles indicated a trend of positive relationship with yield in all the clones and years from pruning. On the other hand, the leaf area in 10 to 20, 20 to 30 and below 30 cm profiles as well as the total leaf area exhibited a negative trend (Table I).

Leaf area alone may not be a helpful indicator in predicting yield because light interception depending on leaf posture and its conversion at different profiles influence productivity. The trend of positive relationship between leaf area in the top 10 cm and yield indicates efficient utilization of incident light in this stratum.

Leaf area increased progressively with age in the top 10, 10 to 20, 0 to 20 and 0 to 30 cm profiles (Table II). But in the lower profiles, between 20 and 30 cm from the top and below 30 cm a progressive decline in leaf area with age was noticed. This is apparently due to the progressive defoliation of the senescent leaves. The total leaf area per bush appears to have reached an equilibrium in the third year from pruning. The

positive correlation noticed between the leaf area in the top 20 cm and yield indicated not only the need for retaining maintenance foliage in this zone, but also its efficiency in the conversion of energy. The negative correlation found between the leaf area below 30 cm and yield suggests the futility of plucking practices that lead to retention of excessive foliage in the lower profiles. This is further corroborated, by the trend of negative relationship between the total leaf area and yield. The negative relationship between the yield and leaf area in the strata measuring between 20 and 30 and below 30 cm down from the plucking surface is indicative of foliage distribution that is required in different subprofiles for higher productivity.

Increased yields were reported following defoliation in the tiers below 20 cm from the surface (Kilavuka and Magambo, 1978; Satyanarayana and Sharma, 1984), substantiating the present findings; this increase in yield had come by way of increased shoots per unit area and the weight of shoots.

It has been reported in other crops that senile foliage consumes the growth promoters generated and transported to actively growing sites, thus depriving the expanding buds from their full requirements; it is also known that old leaves produce certain growth inhibitors in some species (Huxley, 1975). In tea also such mechanisms might be operating with regard to shoot growth *vis-a-vis* old foliage.

Dry matter partitioning

Allocation of dry matter into foliage in different strata of the canopy and its relationship with yield follows the same patterns as has been observed in the case of distribution of leaf area. In the four clones studied, the leaf dry matter declined

from top to lower profiles, while that of stem increased progressively downwards resulting in a decline in the ratio between leaf and stem dry matter (Table III). The increase in stem dry matter could be due to progressive secondary thickening. The drop in foliage dry matter from second to third profile downwards, both in the case of clones and different years from pruning, was steep as in the case of leaf area.

Dry matter in both leaf and stem increased with age in the profiles at 0 to 10 and 10 to 20 cm; it continued to be so in the case of stem at 20 to 30 cm from the top, while leaf material in this profile declined with age (Table IV). Both these factors are explained by ageing process.

Dry matter accumulation in the stem exhibited a trend of positive relationship with yield at different profiles, though significant only at zero to 20 cm and zero to 30 cm strata in the pruned bushes. The negative relationship observed between yield and leaf/stem ratio was significant only at 0 to 20 cm profile in the case of clones and 0 to 10 in pruned bushes. The variance of present findings with that of earlier (Magambo, 1981) could be explained only due to variation in cultural practices, particularly plucking and pruning.

Correlation coefficients of the pooled data

The highly significant positive correlation between the plucking surface area of the bush and the yield indicates that a larger area supports a greater number of plucking points which contribute to crop.

The positive correlations noticed between leaf area and yield and leaf dry matter and yield at the profiles measuring 0 to 10, 10 to 20 and 0 to 20 cm indicate the need to retain the maintenance foliage in these profiles to sustain high productivity (Table V);

the negative correlations observed between leaf area and yield and leaf dry matter and yield at 0 to 30, 20 to 30 and below 30 cm indicate that excessive foliage left on the bush, particularly at lower levels, does not necessarily lead to high productivity, since it is more than the physiological needs demand (Hadfield, 1968). On the contrary, excessive senile foliage on the bush is likely to depress crop, as indicated earlier.

The dry matter accumulation in stem at all the profiles showed a highly significant correlation with yield (Table V).

The strong negative correlations observed between yield and leaf/stem ratio at the profile measuring 20 to 30 cm from the top became weak, when the entire top 20 and 30 cm profiles were correlated with yield; this further substantiates the need for retention of maintenance foliage only in the top 20 cm and the futility of foliage below 30 cm from the top.

The leaf dry matter at 0 to 10 cm was highly correlated with that at 10 to 20 cm; both of them were also correlated positively with the stem at 0 to 10, 10 to 20 and 20 to 30 cm profiles (Table VI). Thus, the productivity is jointly influenced by the leaf material in top 20 cm and wood in the top 30 cm profiles. The leaf at 20 to 30 cm, on the otherhand, had no correlation with stem in any of the profiles or yield (Table VI).

Path coefficient analysis

Leaf dry weight at 0 to 10 cm had highest direct and positive effect on yield (Table VII). The direct contribution of leaf in other profiles and stem in all the tiers was low; their contribution to yield was chiefly through leaf at the top ten cm.

Table III. Clonal variation in dry matter + partitioning

Clone	Profile from top, cm											
	0-10			10-20			20-30			0-30		
	L	S	L/S	L	S	L/S	L	S	L/S	L	S	L/S
UPASI-2	45.7 ±6.1	33.0 ±6.2	1.4 ±0.40	45.3 ±6.6	61.7 ±10.3	0.7 ±0.07	91.0 ±6.4	94.7 ±16.3	1.0 ±0.10	27.3 ±9.5	65.0 ±10.8	0.4 ±0.10
UPASI-3	115.0 ±33.4	60.0 ±14.7	1.9 ±0.60	69.7 ±15.1	76.7 ±18.3	0.8 ±0.15	184.7 ±17.5	136.7 ±8.7	1.4 ±0.20	52.7 ±10.3	140.0 ±40.8	0.4 ±0.06
UPASI-8	97.3 ±11.6	52.0 ±18.5	1.9 ±10.60	68.3 ±2.4	103.3 ±20.5	0.7 ±0.11	165.6 ±11.4	155.3 ±15.6	1.1 ±0.10	30.0 ±4.1	108.3 ±12.4	0.3 ±0.04
UPASI-17	71.7 ±22.5	36.7 ±10.3	1.9 ±0.40	67.0 ±13.3	72.3 ±12.6	0.9 ±0.15	138.7 ±10.8	109.0 ±6.5	1.3 ±0.09	44.0 ±11.3	80.3 ±6.8	0.5 ±0.09
Correlation coefficient with yield	+0.47	+0.66	-0.16	-0.20	+0.49	-0.62	+0.34	+0.68	-0.92*	-0.31	+0.62	-0.70

*Significant at P = 0.10 + in g per bush L : Leaf S : Stem

Table IV. Partitioning of dry matter + in relation to age from pruning

Age from pruning, yr.	Profile from top, cm											
	0-10			10-20			20-30			0-30		
	L	S	L/S	L	S	L/S	L	S	L/S	L	S	L/S
II	161.7 ±11.8	66.7 ±10.3	2.4 ±0.30	128.3 ±33.0	110.0 ±14.5	1.2 ±0.16	290.0 ±22.2	176.7 ±17.2	1.6 ±0.03	46.0 ±3.3	120.0 ±4.1	0.4 ±0.01
III	235.0 ±43.0	155.0 ±15.3	1.5 ±0.15	134.0 ±12.1	240.0 ±28.3	0.6 ±0.08	369.0 ±53.7	395.0 ±78.8	0.9 ±0.06	38.0 ±7.0	226.7 ±36.8	0.2 ±0.01
IV	280.0 ±14.7	272.0 ±29.5	1.0 ±0.10	140.3 ±27.4	250.0 ±21.6	0.6 ±0.07	420.3 ±41.2	522.0 ±39.2	0.8 ±0.10	35.3 ±5.9	247.3 ±34.3	0.1 ±0.02
Correlation coefficient with yield	+0.99*	+0.93	-0.99*	+0.96	+0.95	-0.85	+0.96	+0.99*	-0.96	-0.70	+0.97	-0.93

* Significant at P = 0.05 + g per bush L : Leaf S : Stem

Table V. *Correlation coefficients of different parameters (Pooled data) with yield*

Profile from top, cm	Leaf area	Correlation coefficient, r		Leaf/Stem ratio
		Leaf dry weight	Stem dry weight	
0—10	+0.93****	+0.94****	+0.96****	—0.15
10—20	+0.28	+0.79**	+0.94****	—0.53
0—20	+0.68*	+0.90***	+0.97****	—0.67*
20—30	—0.85***	—0.14	+0.95****	—0.93****
0—30	—0.70*	—0.88***	+0.97****	—0.67*
Below 30	—0.70*	—0.62*	NA	NA
Total	—0.45	—0.53	NA	NA

NA = Not analysed;

* Significant at P — 0.10

*** Significant at P — 0.01

** Significant at P — 0.05

**** Significant at P — 0.001

Table VI. *Correlation coefficients between leaf dry weight (L) and stem dry weight (S) in different profiles*

Profile from top, cm	Profile from top, cm						Yield
	L:0-10	L:10-20	L:20-30	S:0-10	S:10-20	S:20-30	
L : 0 - 10		0.90*	—0.19	0.93*	0.95*	0.97*	0.94*
L : 10 - 20			—0.01	0.78*	0.85*	0.83*	0.70**
L : 20 - 30				—0.12	—0.15	0.06	—0.14
S : 0 - 10					0.93*	0.93*	0.96*
S : 10 - 20						0.95*	0.94*
S : 20 - 30							0.95*

* Significant at P = 0.01

**Significant at P = 0.05

Table VII. *Path coefficients of leaf dry weight (L) and stem dry weight (S) at different profiles*

Profile from top, cm	Profile from top, cm						Yield
	L:0-10	L:10-20	L:20-30	S:0-10	S:10-20	S:20-30	
L : 0-10	<i>1.5067</i>	—0.3959	—0.0268	0.1588	—0.2154	—0.0870	0.94
L : 10 - 20	1.3740	<i>—0.4399</i>	—0.0014	0.1331	—0.1927	—0.0745	0.78
L : 20 - 30	—0.2863	0.0044	<i>0.1358</i>	—0.0205	0.0340	—0.0054	—0.14
S : 0 - 10	1.4512	—0.3431	—0.0163	<i>0.1707</i>	—0.2108	—0.0834	0.96
S : 10 - 20	1.4904	—0.3739	—0.0204	0.1588	<i>—0.2267</i>	—0.0852	0.94
S : 20 - 30	1.4615	—0.3651	0.0081	0.1588	—0.2154	<i>—0.0897</i>	0.95

Figures in italics indicate direct effects.

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STARCH CONTENT AND YIELD OF GINGER AS INFLUENCED BY N, P AND K MANURING AND TIME OF HARVESTING

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ABSTRACT

Field experiments were conducted during 1979-80 and 1980-81 at Mahatma Phule Agricultural University, Rahuri to study the effect of application of NPK through FYM and fertilizers and time of harvesting on starch content and yield of ginger (*Zingiber officinale* Roscoe). Starch content increased with application of fertilizers and decreased with delay in harvesting. The yield was highest when fertilizers were applied in both organic and inorganic forms. Though harvesting between 6 and 10 months did not show any marked variation in yield, harvesting of ginger at 8 months gave maximum green ginger yield.

INTRODUCTION

Starch content is an important quality constituent of dry ginger. It ranges from 40 to 60% in different varieties. This decreases as the harvesting is delayed beyond 8 to 9 months after planting. Some factors which influence starch content are elevation, rainfall and manurial inputs. Application of 25-30 t FYM and 60 to 120 kg N, 60 to 100 kg P_2O_5 and 80 to 120 kg K_2O /ha gave optimum yield (Kannan and Nair, 1965; Aiyadurai, 1966; Randhava and Nandpuri, 1969; Muralidharan Nair and Balakrishnan, 1973; Paulose, 1973; Lee and Asher, 1981 and Nair and Das, 1982). In Maharashtra, cultivators apply heavy doses of FYM, to the extent of about 40 to 50 t/ha. As FYM is becoming increasingly scarce and also costly, the possibilities of substituting it partially, by chemical fertilizers for obtaining higher yields were investigated. The stage of maturity and climate are important in deciding the quality of ginger. Harvesting of ginger is delayed upto 15 months in Maharashtra. Results of a study on the influence of manuring and age of harvesting are reported in this paper.

MATERIALS AND METHODS

The experiment was conducted during 1979-80 and 1980-81 with 36 treatment combinations in a split plot design replicated three times. The main-plot treatments were 225 kg N, 50 kg P_2O_5 and 180 kg K_2O /ha applied in different combinations of FYM and fertilizers. [Only an inorganic fertilizer (A); 10 t FYM/ha + fertilizers (B), 20 t FYM/ha + fertilizers (C); 30 t FYM/ha + fertilizers (D); sawdust which will supply the carbon equal to that supplied by 10 t FYM/ha + fertilizers (E) and control (F)]. The sub-plot treatments were different periods of harvesting; 6(H_1), 7(H_2), 8(H_3), 9(H_4), 10(H_5) and 15(H_6) months after planting. The gross and net plot size were 5.85 x 3.0 and 4.50 x 2.10 m², respectively. The planting was done at 22.5 x 22.5 cm² spacing on raised beds in third week of May during both the years on sandy clay loam soils, low in total N, low in available P, medium in available K content and alkaline in reaction. The starch content in rhizomes was estimated by direct acid hydrolysis method (A. O. A. C. 1975).

RESULTS AND DISCUSSION

The data on starch content and yield of ginger as influenced by various treatments are presented in Table I.

Effect of manuring

The differences in starch content and yield of ginger rhizomes due to manuring were statistically significant during both the years. Starch content was maximum from treatment D (30 t FYM/ha + fertilizers). This was significantly superior to the treatments, A, B and F and at par with C and E in 1979–80. However, in 1980–81 only treatment C was at par with D. Further, treatment F in 1979–80 and treatment F and E in 1980–81

recorded significantly less starch content. Thus, manuring helps to increase the starch content in rhizomes. The maximum effect was seen when fertilizers are given in the form of organic and inorganic fertilizers. However, Aclan and Quisumbing (1978) from Philippines reported that the starch content of ginger was not affected by the fertilizer nitrogen.

Application of NPK increased the green ginger yield significantly over control. Further, it was observed on pooled average, as well as in 1980–81 that application of 20 t FYM/ha + fertilizers (C) recorded significantly more yield. It was also found that the application of NPK through FYM +

Table I. Starch content (%) and yield (q/ha) of ginger as affected by various treatments

Treatment	Starch content (%)		Ginger yield (q/ha)		
	1979–80	1980–81	1979–80	1980–81	Mean*
<i>Nutrition</i>					
A	54.2	53.0	120	116	116
B	54.1	52.3	139	133	134
C	54.6	53.8	137	140	140
D	55.2	54.1	136	135	135
E	54.4	50.9	144	108	108
F	52.1	51.1	75	57	59
C, D, at 5%	0.9	0.5	14	4	3
<i>Harvesting time (Months after planting)</i>					
6 months	64.9	64.0	114	115	115
7 months	61.3	60.7	125	131	128
8 months	58.2	56.7	129	136	132
9 months	56.2	53.3	119	128	124
10 months	50.8	47.7	119	117	118
15 months	31.2	32.7	115	63	89
C, D, at 5%	0.9	0.9	9	4	43

* Weighted mean for nutrition

fertilizers increased the ginger yield significantly over the application of NPK entirely in organic fertilizers. Similar findings were reported by Mohanti and Sarma (1978). Incorporation of sawdust alongwith fertilizers decreased the ginger yield as compared to the other nutritional treatments either with or without FYM.

Effect of harvesting time

Difference in starch content and yield of ginger due to different harvesting treatments were statistically significant during both the years. Significantly maximum starch content was recorded from harvesting at 6 months treatment. This significantly decreased as the harvesting was delayed. It has been stated that as the maturity of ginger increases, the fibre content increases and thereby there is decrease in starch content. Aiyadurai (1966) reported that optimum time for harvesting ginger was 245 to 260 days, during which there was maximum starch content. Delay in harvesting beyond this decreases the starch content. This was due to the development of fibres. Jayachan-

dran, Vijayagopal and Sethumadhavan(1980) observed maximum starch content at 8 months from planting.

Harvesting of ginger at 8 months after planting recorded maximum green ginger yield. This was significantly superior to the yield from harvesting at 6 and 15 months in 1979-80. It was significantly superior to all the other harvesting treatments in 1980-81. However, on pooled average basis it was observed that harvesting ginger at 8 months was significantly superior only to the harvesting at 15 months. The low yield from 6 months treatment was mostly due to immature rhizomes, while in the case of harvesting at 15 months treatment it might be due to over-maturity and reduction in moisture content (Jogi et al., 1972). Vaidya, Sahasrabudhe and Khuspe al. (1972) also recommended to harvest the ginger in Maharashtra at 8 months after planting.

Effect of interaction

The interaction between manuring and harvesting time was present for starch content (Table II) as well as for green ginger yield (Table III) during both the years.

Table II. *Effect of interaction between nutrition x harvesting time on starch content of ginger*

Nutrition	Harvesting time (months after planting)													
	1979-80							1980-81						
	6	7	8	9	10	15	Mean	6	7	8	9	10	15	Mean
A	62.3	61.7	58.1	54.9	51.2	34.1	54.2	65.7	61.2	58.4	54.6	44.2	34.0	53.0
B	65.1	60.3	57.9	55.2	51.9	34.4	54.1	64.0	59.7	54.5	53.2	48.9	33.3	52.3
C	65.8	62.4	58.3	56.1	50.1	34.8	54.6	65.6	61.4	58.5	53.6	49.9	33.8	53.8
D	66.1	63.0	59.3	57.4	52.7	32.6	55.2	65.2	62.3	58.5	55.2	50.5	32.6	54.1
E	64.7	61.5	58.0	59.5	50.5	32.0	54.4	52.5	60.1	54.9	51.7	45.3	30.8	50.9
F	62.5	59.1	57.4	53.8	48.6	31.2	52.1	61.1	59.6	55.7	51.7	47.5	31.9	51.2
Mean	64.9	61.3	58.2	56.2	50.8	33.2	54.1	64.0	60.1	56.7	53.3	47.7	32.7	52.5

Particulars	1979-80		1980-81	
	S. E. $\pm$	C.D. at 5%	S.E. $\pm$	C.D. at 5%
1. Nutrition	0.3	0.9	0.2	0.5
2. Harvesting time	0.3	0.9	0.3	0.9
3. Difference between two nutrition treatments at the same harvesting time	0.8	2.2	0.8	2.2
4. Difference between two harvesting treatments at the same nutritional level	0.8	2.2	0.7	2.1

Table III. *Effect of interaction between nutrition x harvesting time on yield of green ginger (q/ha)*

Nutrition	Harvesting time (months after planting)													
	1979-80							1980-81						
	6	7	8	9	10	15	Mean	6	7	8	9	10	15	Mean
A	95	107	120	119	117	161	120	109	121	153	136	122	54	116
B	134	134	143	136	160	127	139	115	149	159	152	133	91	133
C	142	136	141	134	132	140	137	140	160	175	145	133	90	140
D	151	160	164	120	111	109	136	150	158	160	146	133	63	135
E	89	123	127	135	126	85	114	104	112	130	129	127	45	108
F	75	90	76	70	68	68	75	72	89	40	56	55	32	57
Mean	114	123	129	119	119	115	120	115	131	136	128	117	63	115

Particulars	1979-80		1980-81	
	S. E.±	C.D. at 5%	S. E.±	C. D. at 5%
1. Nutrition	4	14	1	4
2. Harvesting	4	9	2	4
3. Difference between two nutrition treatments at the same harvesting time	8	24	4	11
4. Difference between two harvesting treatments at the same nutrition level	9	24	4	11

Decline in starch content with age was faster in control (no manuring) plots than in manured plots. Sharp decline in starch content started at 9 months in control plots compared to 10 months for manured plots. Among the manured plots, the starch was the same.

The yield was maximum in 7th month in control plots while it was 8th month for manured plots. Rate of decline after attaining maximum yield was higher in control plots than in manured plots. The trends were the same in all manured treatments although plots receiving combination of organic and inorganic fertilizers recorded comparatively higher yields. Lee, Edward and Asher (1981) also observed the interaction between nitrogen and harvesting time.

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EVALUATION OF TURMERIC AND SWEET POTATO TO MANURING IN ARECANUT GARDENS

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ABSTRACT

Response of turmeric and sweet potato to manuring as intercrops in arecanut gardens and as pure crops was evaluated by studying the growth attributes like number of leaves, tillers, LAR, RLGR, RGR, NAR, bio-mass production and yield of economic end products. Response behaviour of turmeric and sweet potato was the same as inter crops and pure crops. Number of functional leaves, tillers or branches/plant and biomass production showed increase with manuring; but these were not reflected in yield of economic end products.

INTRODUCTION

Intercropping in arecanut plantations is a common practice and farmers generally have their preferences in choosing seasonal crops in the interspaces especially when the plantations are young. Crops such as turmeric, ginger, sweet potato, elephant foot yam, dioscorea, banana, betelvine, pineapple, cacao and other crops are raised in arecanut gardens. Abraham (1956) reported that ginger, turmeric, black pepper and cardamom could be grown successfully as intercrops in arecanut gardens. Bhandary (1974) showed that the additional income could be obtained by intercropping. Turmeric responds to manuring and 70:60:120 kg NPK/ha have been recommended (Anonymous, 1977). Response of sweet potato to manuring has been inconsistent. Studies were undertaken to study the response of these two crops to manuring as intercrops as compared to those of pure crops so that appropriate recommendations could be made for different situations.

MATERIALS AND METHODS

The experiment was conducted during 1978-'80 at the Central Plantation Crops Research Institute, Research Centre, Hirehalli in a 8 x 3 Randomised Block Design with four levels of fertilizer, (i) 0, 70, 140, 210 kg N/ha, (ii) 0, 60, 120, 180 kg P₂O₅/ha, (iii) 0, 120, 240, 360 kg K₂O/ha to turmeric and (i) 0, 70, 140, 210 kg N/ha, (ii) 0, 50, 100, 150 kg P₂O₅/ha, and (iii) 0, 70, 140, 210 kg K₂O/ha to sweet potato. The intercropping experiment was laid out in a 15 year old arecanut garden. The pure crop experiment was laid out separately. Turmeric and sweet potato were planted in June, 1978 and again in May 1979 on ridges adopting a spacing of 25 x 15 cm for turmeric and 25 x 20 cm for sweet potato both as pure crops and as intercrops in arecanut. In arecanut garden, the total population of intercrops in one hectare was one third of the total population of pure crop. The soil of the experimental site was clayey loam with a pH of 6.3 and EC of 0.25 m.mhos/cm. It had an organic matter of

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0.95%, total N of 2.06%, P_2O_5 of 0.30% and total K_2O of 0.62% for a depth of 25 cm. Biometric observations of turmeric and sweet potato both as intercrops and pure crops were recorded. Sampling procedure and processing were made according to Kvet et al (1971). The plant parts were separated into leaves, stem, root/tuber and then were dried at 80–85°C to constant weight. The data were used to compute net assimilation rate (NAR), leaf area ratio (LAR), relative growth rate (RGR) and relative leaf growth rate (RLGR) using the formulae suggested by Power et al. (1947) and Krishna-

murthy et al. (1973). For other morphological characters five plants were randomly selected and tagged for making observations during the crop growth.

RESULTS AND DISCUSSION

Leaf production in turmeric during 1978–79 either as intercrop or pure crop did not show any significant change due to different levels of fertilizers (Table I). During 1979–80, fertilizer levels produced significantly more number of leaves when compared to control (0 level). Fertilizer levels did not influence the functional leaves of

Table I. Number of functional leaves produced by intercrops and pure crops of turmeric and sweet potato as influenced by fertilizer levels.

Crop	Treatment			Inter crop			Pure crop		
	Fertilizer applied								
	N	P ₂ O ₅	K ₂ O	78-79	79-80	Mean	78-79	79-80	Mean
	kg ha ⁻¹			No. plant ⁻¹					
Turmeric	0	0	0	13	12	13	14	16	15
Turmeric	70	60	120	16	14	15	15	22	19
Turmeric	140	120	240	16	14	15	15	22	19
Turmeric	210	180	360	15	16	15	14	19	16
Mean				15	14	—	15	20	—
F. Test				NS	S	NS	NS	S	S
C. D.				—	2	—	—	3	2
CV %				16	9	10	17	8	5
Sweet potato	0	0	0	232	147	189	239	165	202
Sweet potato	70	50	70	217	170	194	302	198	250
Sweet potato	140	100	140	205	185	195	235	194	214
Sweet potato	210	150	210	211	159	185	334	203	268
Mean				216	165	—	277	190	—
F. Test				NS	NS	NS	NS	NS	S
C. D.				—	—	—	—	—	58
CV %				19	20	10	21	9	12

S = Significant at 5%

NS = Not significant

sweet potato either as a pure crop or as an intercrop in both the years. The mean data indicated that the number of functional leaves in the intercrop sweet potato increased with the increase in the fertilizer schedules upto second level (195) and thereafter declined, whereas in pure crop there was a significant increase in the number of functional leaves (268) over the 0 level (202).

In turmeric, there were no marked difference in the pattern of production of tillers either as a pure crop or as an intercrop during 1978-79 (Table II). During 1979-80, turmeric when grown as an intercrop produced

significantly higher number of tillers at all levels of fertilizers (4.6 to 4.8) compared to 0 level (3.8). However, there were no differences among the fertilizer levels. Sweet potato did not exhibit any improvement in branching with the increase in the level of fertilizers either as intercrop or as pure crop during 1978-79. Pure crop of sweet potato at 70:50:70 kg NPK/ha produced significantly higher number of branches (21.7) compared to all other treatments in 1979-80.

Turmeric as an intercrop in 1978-79 did not show any significant differences in the production of biomass to varying levels of

Table II. *Number of tillers/branches produced by the inter and pure crops of turmeric and sweet potato as influenced by fertilizer levels*

Crop	Treatment								
	Fertilizer applied			Inter crop			Pure crop		
	N	P ₂ O ₅	K ₂ O	78-79	79-80	Mean	78-79	79-80	Mean
	kg ha ⁻¹			No. plant ⁻¹					
Turmeric	0	0	0	3.2	3.8	3.5	3.8	4.9	4.3
Turmeric	70	60	120	3.1	4.8	3.9	3.6	4.5	4.0
Turmeric	140	120	240	4.5	4.6	4.6	4.0	5.3	4.6
Turmeric	210	180	360	3.4	4.7	4.0	3.5	4.5	4.0
Mean				3.5	4.5	—	3.7	4.8	—
F. Test				NS	S	S	NS	NS	NS
C. D.				—	0.5	0.8	—	—	—
CV %				20.5	5.0	12.8	32.6	13.4	23.0
Sweet potato	0	0	0	17.5	13.8	15.7	22.3	20.0	21.1
Sweet potato	70	50	70	17.9	16.4	17.1	24.3	21.7	23.0
Sweet potato	140	100	140	14.5	15.1	14.8	21.8	19.3	20.5
Sweet potato	210	150	210	16.6	13.9	15.2	23.7	19.7	21.7
Mean				16.6	14.8	—	23.0	20.2	—
F. Test				NS	NS	NS	NS	S	NS
C. D.				—	—	—	—	2.4	—
CV %				21.2	12.5	12.4	20.3	5.8	13.5

S = Significant at 5%

NS = Not significant

fertilizers whereas a fertilizer level of 140:120:240 kg NPK/ha produced significantly higher amount of biomass (10.4 tonnes) than the other levels of fertilizers during 1979-80 (Table III). In the pure crop of turmeric in both the years it is observed that there was no significant difference in the biomass production due to different levels of fertilizers. In sweet potato the difference due to various levels of fertilizers both in pure as well as intercropping systems did not bring significant differences in biomass production.

Leaf area ratio (LAR) in the intercrop of turmeric was found to be three times higher

(0.04 to 0.09) than the pure crop of turmeric (0.01 to 0.03) (Table IV). LAR was highest under fertilizer dose of 210:180:360 kg NPK/ha both under sole crop (0.03) as well as intercrop (0.09). In case of sweet potato also the LAR values were nearly two times higher (0.07 to 0.08) in the intercrop than under pure crop (0.03 to 0.04). There is no marked difference in LAR values among the fertilizer treatments in both the aspects of cropping systems.

The Relative Leaf Growth Rate (RLGR) in turmeric ranged from 4.0 to 8.9 in the intercrop whereas in pure crop it varied from

Table III. Biomass production of inter and pure crops of turmeric and sweet potato as influenced by fertilizer levels

Crop	Treatment			Inter crop			Pure crop		
	Fertilizer applied								
	N	P ₂ O ₅	K ₂ O	78-79	79-80	Mean	78-79	79-80	Mean
	kg ha ⁻¹			Ton ha ⁻¹					
Turmeric	0	0	0	8.1	9.3	8.7	7.5	9.5	8.5
Turmeric	70	60	120	7.8	8.0	7.9	7.5	9.0	8.2
Turmeric	140	120	240	7.8	10.4	9.1	8.1	9.7	8.9
Turmeric	210	180	360	8.8	9.6	9.2	8.2	11.1	9.7
Mean				8.1	9.3	—	7.8	9.8	—
F. Test				NS	S	NS	NS	NS	NS
C. D.				—	0.2	—	—	—	—
CV %				26.7	11.3	8.1	16.89	21.9	16.8
Sweet potato	0	0	0	14.9	12.6	13.7	25.6	27.5	26.5
Sweet potato	70	50	70	13.3	11.9	12.6	29.2	26.1	27.6
Sweet potato	140	100	140	18.1	14.1	16.1	24.4	30.4	27.4
Sweet potato	210	150	210	16.0	12.9	14.4	28.5	30.0	29.0
Mean				15.6	12.8	—	26.9	28.5	—
F. Test				NS	NS	NS	NS	NS	NS
C. D.				—	—	—	—	—	—
CV %				30.6	10.6	14.3	27.2	7.9	4.4

S = Significant at 5%

NS = Not significant

Table IV. *Effect of fertilizer levels on the growth attributes of inter and pure crop of turmeric and sweet potato*

Crop	Treatment			Intercrop				Pure crop			
	Fertilizers applied										
	N	P ₂ O ₅	K ₂ O	LAR	RLGR	RGR	NAR	LAR	RLGR	RGR	NAR
	kg ha ⁻¹			cm ² g ⁻¹	gg ⁻¹ d ⁻¹	gg ⁻¹ d ⁻¹	gm ⁻² d ⁻¹	cm ² g ⁻¹	gg ⁻¹ d ⁻¹	gg ⁻¹ d ⁻¹	gm ⁻² d ⁻¹
Turmeric	0	0	0	0.04	4.0	15.4	3.4	0.01	5.8	20.0	6.6
Turmeric	70	60	120	0.04	6.2	15.4	3.8	0.02	5.9	20.1	7.7
Turmeric	140	120	240	0.08	8.2	17.3	3.8	0.02	6.4	22.5	8.7
Turmeric	210	180	360	0.09	8.9	18.1	4.2	0.03	6.2	26.3	8.9
Sweet potato	0	0	0	0.07	2.7	20.9	2.8	0.03	8.8	22.3	6.3
Sweet potato	70	50	70	0.08	4.6	25.1	3.1	0.04	9.4	22.3	5.8
Sweet potato	140	100	140	0.08	4.5	27.1	3.0	0.04	9.6	23.6	6.6
Sweet potato	210	150	210	0.07	5.7	26.5	3.8	0.04	9.8	25.1	7.6

LAR = Leaf area ratio

RGR = Relative growth rate

RLGR = Relative leaf growth rate

NAR = Net assimilation rate

5.8 to 6.2. In the intercrop of turmeric RLGR values increased as the fertilizer levels increased whereas in the pure crop of turmeric it increased upto the third level (6.4) afterwards it decreased (6.2). In the case of sweet potato the values of RLGR in both the cropping systems increased as the fertilizer dose increased. RLGR values almost doubled in the pure crop of sweet potato when compared to intercropping sweet potato.

The Relative Growth Rate (RGR) in turmeric was higher in pure crop compared to intercrop. Highest level of fertilizer (210:180:360 kg NPK/ha) recorded RGR value of 26.3 compared to the values of 20.0 to 22.5 in other treatments in the pure crop. The RGR values in the intercrop ranged from 15.4 to 18.1 whereas it ranged from 20.0 to 26.3 in the pure crop. In both the cropping systems RGR values increased as the fertilizer dose increased. In sweet potato, the pure crop recorded a range of

RGR values of 22.3 to 25.1. In the intercrop, the highest dose of fertilizer provided a RGR of 26.5 compared to 25.1 to 27.1 in other fertilized treatments.

Net Assimilation Rate (NAR) in the pure crop of turmeric was nearly two times (6.6 to 8.9) that of the intercrop (3.4 to 4.2). In case of sweet potato also the NAR values in the pure crop were nearly two times (6.3 to 7.6) those of intercrop (2.8 to 5.8). NAR values in pure crop as well as intercrop increased with the increase of fertilizer levels both in turmeric as well as sweet potato.

Application of fertilizer to turmeric when grown as pure crop or intercrop in arecanut did not have any significant impact on turmeric yield during 1978-79 (Table V). During 1979-80, fertilizer application had a significant difference in yield of turmeric in both the systems of cropping. Turmeric as intercrop with 140:120:240 kg NPK/ha provided the maximum yield of 2.2 tonnes/ha

Table V. *Effect of fertilizer levels on the yield on inter and pure crops of turmeric and sweet potato*

Crop	Treatment			1978-79		1979-80		Mean	
	Fertilizer applied								
	N	P ₂ O ₅	K ₂ O	IC	P	IC	P	IC	P
	kg/ha			Tonnes/ha					
Turmeric	0	0	0	2.8	6.5	1.5	5.3	2.4	5.9
Turmeric	70	60	120	2.7	6.8	2.0	7.7	2.5	7.2
Turmeric	140	120	240	3.1	7.9	2.2	6.6	2.6	7.3
Turmeric	210	180	360	3.1	6.8	2.1	10.2	2.8	8.5
Mean				2.9	7.0	1.9	7.4	2.6	7.2
F. Test				NS	NS	S	S	NS	S
CD				—	—	0.4	3.7	—	2.3
CV. %				11.8	18.6	10.9	25.5	8.4	16.4
Sweet potato	0	0	0	5.1	17.8	2.9	16.3	4.1	17.1
Sweet potato	70	50	70	1.6	14.8	1.0	15.8	1.3	15.3
Sweet potato	140	100	140	1.5	19.7	1.0	15.8	1.2	14.5
Sweet potato	210	150	210	1.6	18.5	0.9	17.6	1.2	18.1
Mean				2.4	17.7	1.4	16.4	1.9	16.2
F. Test				NS	NS	S	NS	S	NS
CD				—	—	0.6	—	1.6	—
CV %				63.3	32.6	23.4	6.9	41.6	16.9

IC = Intercrop
P = Pure crop

S = Significant at 5%
NS = Not significant

whereas turmeric as pure crop provided an yield of 10.2 tonnes with the highest dose of fertilizer application. No significant variation amongst the treatments were observed in the mean values of the intercropping system. However, a significant difference was observed in the pure cropping system. The yield of turmeric was increased as the fertilizer doses increased. Maximum yield of 8.5 tonnes/ha was obtained with the highest fertilizer level of 210:180:360 kg NPK/ha but this was on par with other low fertilizer level applications. Intercropping sweet potato in arecanut with different levels of fertilizer had a significant effect

on the yield of tubers only in the second year of cropping. Highest yield of 2.9 tonnes/ha was obtained with no fertilizers in the intercropping system which was significantly superior to all other fertilizer treatments. Fertilization did not have any influence either in the intercrop or pure cropping system. Mean data showed that all levels of fertilizers to intercrop brought down the tuber yield (1.3 to 1.2 tonnes/ha) when compared to control (4.1 tonnes/ha). As a pure crop, sweet potato did not respond to applied fertilizers significantly.

From this study it is very clear that both turmeric and sweet potato either as intercrop in arecanut or pure crop did not respond to the fertilizers applied. Probably nutrient that is available in the soil is optimum to get economic yields of turmeric and sweet potato.

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EFFECT OF ORGANIC ACIDS ON THE UPTAKE OF ZINC, ALUMINIUM AND MANGANESE BY COFFEE

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ABSTRACT

The occurrence of zinc deficiency of coffee in India is widespread and the most effective current means of correcting the disorder is the foliar spray of zinc sulphate neutralized with lime. The soil application of Zn SO_4 was found to be ineffective. Application of Zn SO_4 along with oxalic, citric or tartaric acids into soil was found to increase the zinc content in plant tissues considerably. On the other hand aluminium and manganese uptake by plants decreased when soils were amended with organic acids.

INTRODUCTION

Zinc availability in coffee cropped soils is a limiting factor as many soils in southern India cropped with coffee are found to be deficient in this element. Zinc deficiency was noticed in many coffee plantations (Anantha, Iyengar and Chokkanna, 1965). Experiments conducted at coffee research station revealed that, soil application of zinc sulphate could not effectively correct (Anantha, Iyengar and Chokkanna, 1966). the deficiency of zinc in coffee, however, foliar spray of this ion was found to be effective. Apart from zinc, other two important metal ions among the micro-nutrients are manganese and aluminium which are found abundant in coffee soils posing a potential threat of inducing toxicity to coffee (Iyengar, 1972). It was indicated in the literature (Geering and Hodgson, 1969) that organic compounds in the soil have the ability to chelate many metal ions, thereby decreasing or increasing the availability of these micronutrient elements. Thus, keeping in view of the properties of chelation of metal ions with organics in the soil, laboratory as well as green house experi-

ments were conducted using synthetic organic ligands to know their effect on the availability of Zn, Al and Mn to coffee and in coffee soils. These three ions namely Zn^{2+} , Al^{3+} , and Mn^{2+} were selected due to their importance to coffee, their availability in coffee soils and solubility. In the present paper the stability of these metal ion complexes with oxalic, citric and tartaric acids as chelating agents and the availability of these micro-nutrients in coffee soils and in plants in the presence of these organic ligands are described.

MATERIALS AND METHODS

Oxalic, citric and tartaric acids, aluminium sulphate, manganese sulphate, zinc sulphate, potassium hydroxide used in the studies were of analar grade. Standard methods were used in the estimation of all the organic acids and metal ions. DTPA and 0.01 N HCl were used as extracting agents whenever soil samples were used. Two soil samples were selected with pH values 5.7 and 6.43.

The soil samples were sieved in a 2mm screen and air dried. 1:1 soil extract was prepared by combining 100 g of dry soil and 100 ml of deionised water in a 500 ml Erlenmeyer flask and the contents were uniformly shaken for one hour in a shaker and filtered through Whatman No. 1 filter paper and clear filtrate was used for soil solution studies. The metallic content in soil solution was estimated by standard methods. Using the soil extract, the studies on the interaction between metal ions and various organic acids were conducted pH metrically. Soil incubation studies were performed in two soils of pH 5.7 and 6.43 in order to find out the availability of zinc, aluminium and manganese in the presence and absence of organic acids. Organic acid concentrations tested in the studies ranged from 100–1000 ppm while metal ion concentrations used were 10–200 ppm.

Pot culture studies were conducted using S.795 coffee seedlings of 1½ years.

Stability constants of Zn, Al and Mn complexes of oxalic, citric and tartaric acids were calculated potentiometrically (Bjerrum, Schwarzenbach and Sillen, 1957).

RESULTS AND DISCUSSION

The solubility and availability of zinc, manganese and aluminium in coffee soils are critical and have appreciable influence on the growth and yield of coffee. Complexes with organic acids with these metals have been studied by large number of research workers (Pleaslee and Frint, 1969; Gary et. al, 1983; Kim, 1982). The acids include both natural and synthetic organic acids. However, studies involving Zn, Al and Mn ions with synthetic acids like oxalic, citric and tartaric acids are limiting. The stability constants and typical experimental curves are given in Table I and Figs. 1–3.

From the values of the stability constants it was found that aluminium forms most stable complexes with these organic acids followed by manganese and zinc. The order of stability with respect to acids is citric > tartaric > oxalic. The stability constants of the complexes of aluminium with various synthetic organic acids have been reported earlier (Martell and Smith, 1980). The effect of pH on aluminium availability (Samuel et al. 1986) has also been discussed in detail. In the present study, it was found that the organic acids had significant capacity to detoxify aluminium and to a little extent manganese. Such results on aluminium detoxification effect of organic acids have been published based on the stability constant calculations at pH 5 by chromatographic technique with a cation exchange column (Zolotakhin and Paschnik, 1970). Thus, based on the stability constant data, the role of aliphatic acids in soils is important as far as the availability of micronutrients in soils is concerned. Among the three acids tried, citric acid has the greater potential to form stable complexes with metal ions, thus rendering them unavailable till the concentration of the acid falls to certain level in the reacting medium.

Table I. *Stability constants of complexes of Zn, Mn and Al with organic acids (29±1°C)*

Metal	All over stability constant (Log k)		
	Citric	Tartaric	Oxalic
Zn	3.53	3.01	2.57
Mn	9.21	4.21	3.17
Al	12.30	6.61	6.43

The stability constants of zinc, aluminium and Manganese complexes of citric, tartaric and oxalic acids measured

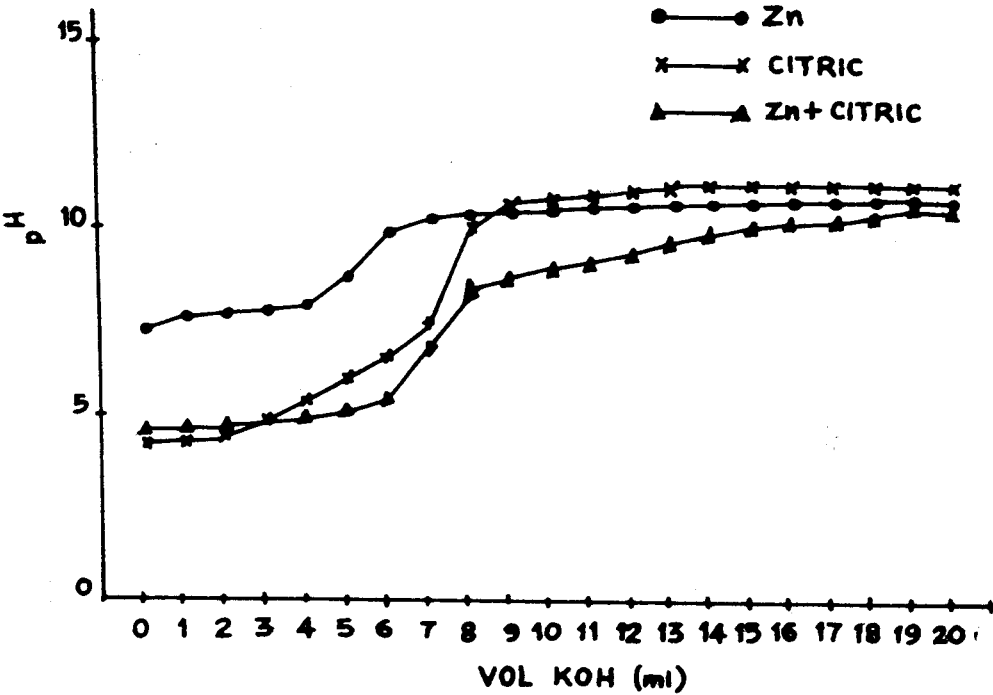


Fig. 1. pH Metric titration of Zn complex of citric acid

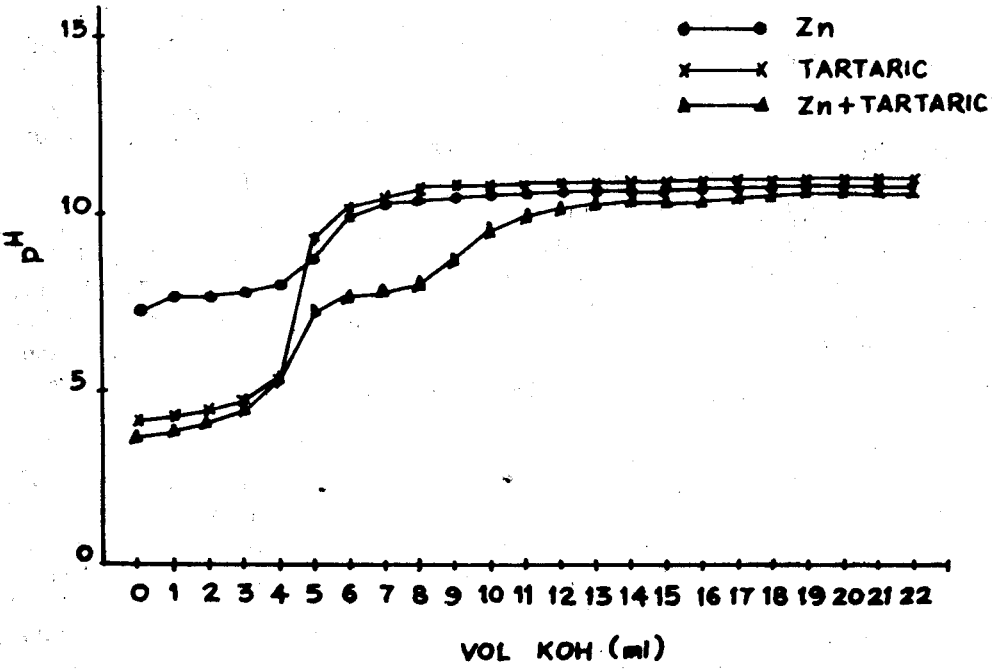


Fig. 2. pH Metric titration of Zn complex of tartaric acid

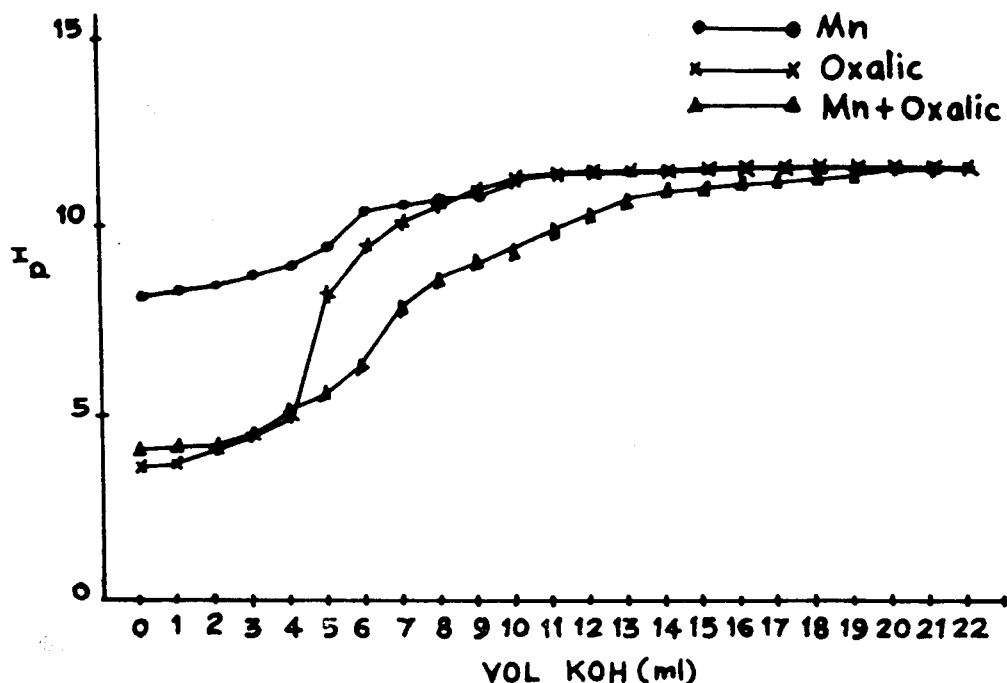


Fig. 3. pH Metric titration of Mn complex of oxalic acid

in soil extract showed the same trend in order of reactivity but with smaller values to stability constants. This might be attributed to the change in pH of the reacting medium. The pH above 4.5 might have favoured the hydrolysis of these complexes as suggested by Rajan et al 1981. Further, the presence of some other unmeasured organic matters in soil solution may also play role in disturbing the reaction between organic acids (added) and metal ions.

In soil solutions, the availability of added Zn, Al and Mn were determined in the presence of added organic acids. The results of the experiment showed that addition of organic acids found to decrease the amount of Al, Mn and Zn in soil solutions at a given pH with increasing concentrations of acids. However, this result was only temporary, since exchangeable aluminium and manganese increased gradually

after a month of treatment. Thus, increasing the concentration of organic acids in soil solutions, the amount of aluminium and manganese content (exchangeable) could be reduced thereby toxicity of these elements could be prevented.

The soil incubation studies were performed with two soils (red laterite) of pH 5.7 and 6.43. It was found that the availability of and Mn considerably decreased, but the availability of Zn has shown an increasing trend. This result is in contrast to the result obtained in solution studies. The reason for this might be due to the low stability of zinc complexes in soil system and its faster degradability and solubility in the extracting medium (DTPA and HCl). The results of incubation studies are given in Tables II and III. The change in pH of the soils incubated with organic acids for a period

Table II. Soil incubation studies (Soil treated with only acids)

	Zn (ppm)					Al (ppm)					Mn (ppm)				
	DAYS					DAYS					DAYS				
	0	15	30	45	90	0	15	30	45	90	0	15	30	45	90
SOIL - pH 5.7															
Citric	100	12	14.1	14.8	16.7	16.8	129	132.1	128.1	118.0	110.1	16.2	15.0	12.0	9.0 10.1
	500	11	15.0	14.9	17.1	18.0	132	132.4	126.2	119.2	108.4	17.0	14.7	12.2	8.8 10.2
Tartaric	100	12	12.5	13.2	14.1	14.9	130	131.7	129.2	116.2	102.8	17.0	16.2	15.2	14.7 11.8
	500	10	12.5	13.3	14.4	14.4	131	132.7	120.4	118.4	109.4	16.9	16.1	14.9	14.5 10.9
Oxalic	100	13	12.1	12.4	14.1	14.3	130	131.2	130.1	126.1	116.8	16.8	16.7	16.0	13.1 12.2
	500	12	12.4	12.5	13.2	12.2	132	130.8	131.8	124.2	122.4	17.2	16.3	15.9	14.9 12.4
SOIL - pH 6.43															
Citric	100	12	12.5	13.1	14.7	15.7	126.5	123.1	122.4	122.1	118.0	16.5	16.7	15.9	15.6 14.1
	500	12	12.7	13.0	14.5	16.1	126.8	122.7	120.5	120.5	118.2	16.4	16.6	15.6	15.5 14.2
Tartaric	100	11.5	12.2	13.8	15.1	16.1	126.9	124.2	123.7	122.2	116.3	16.6	16.1	16.0	15.8 13.8
	500	12	12.4	14.1	14.2	16.7	126.2	122.6	122.8	122.6	120.2	16.4	15.9	16.1	15.1 14.5
Oxalic	100	12	12.0	14.1	15.2	15.2	126.5	125.3	124.8	120.8	119.4	16.5	16.2	15.9	16.1 15.4
	500	12.5	12.6	12.7	15.8	15.3	126.4	125.1	123.2	121.9	119.8	16.5	16.2	16.1	16.2 15.2

Initial availability Zn = 12, Mn = 17 and Al = 130 (Soil pH 5.7)

Zn = 12, Mn = 16.5 and Al = 126 (Soil pH 6.43)

of 90 days was not appreciable, however, the pH decreased by about 0.2–0.5 units.

The pot culture studies conducted using S. 795 seedlings of arabica coffee showed considerable reduction in aluminium and manganese content in leaves and roots. The plants were healthy and greenish in appearance. Addition of aluminium, manganese and zinc salts alongwith organic acid did not show any toxicity

symptoms even at a rate of 5–10 g of salts per plant. In contrast to the Al and Mn, contents the Zn content in plant leaves increased considerably (Table IV). In all the experiments conducted with and without the presence of organic acids, it was found that in the presence of organic acids, Zn content was more in plant leaves compared to the leaves from plants which were not treated with organic

Table III. *Soil incubation studies (treated with 500 ppm of acid and 50 ppm of metal ions–soil pH 5.7)*

	Zn (ppm)				Al (ppm)				Mn (ppm)			
	Days 0	15	30	90	0	15	30	90	0	15	30	90
Citric	32	32.8	35.1	36.7	160.2	159.8	148.1	141.8	38.2	37.6	30.2	30.1
Tartaric	30.6	34.1	35.0	35.2	159.8	158.8	148.2	140.8	39.6	38.1	35.4	34.2
Oxalic	29.2	30.2	31.2	32.1	160.0	159.1	152.8	142.8	37.8	35.2	36.7	35.7

Table IV. *Effect of organic acid and micronutrient addition on coffee leaf micronutrient content*

Citric	Tartaric	Oxalic	Zn	Al	Mn	Final (ppm) (after 60 days)		
						Zn	Al	Mn
—	—	—	—	—	—	31.8	60.0	58.1
50	—	—	—	—	—	32.8	59.7	50.0
500	—	—	—	—	—	34.2	52.1	43.1
50	—	—	50	50	50	36.9	56.2	51.2
500	—	—	50	50	50	37.2	54.6	41.7
—	50	—	—	—	—	32.8	59.6	52.1
—	500	—	—	—	—	33.0	53.4	50.0
—	50	—	50	50	50	35.1	57.1	53.5
—	500	—	50	50	50	35.6	56.5	53.4
—	—	50	—	—	—	32.7	59.9	56.8
—	—	500	—	—	—	32.9	56.3	55.3
—	—	50	50	50	50	33.1	61.2	57.2
—	—	500	50	50	50	33.8	56.8	56.7

Initial content before imposition of treatment Zn = 32.6 Al = 60.2 and Mn = 57.29 ppm.

acids. Zinc content was comparatively higher in the plants treated with citric acid followed by tartaric and oxalic acids. Blank treatment of acids to plants did not show any toxicity symptoms even at 10,000 ppm level of each acid. However blank treatment of aluminium sulphate and manganese sulphate (10 g/plant) showed tip scorching of leaves after 2 days of treatment. Thus, from the above experiment, it was concluded that application of organic acids such as citric, tartaric or oxalic acids alongwith metallic salts to soils can bring down the levels of certain metal ions (Al and Mn) in plants while increasing certain metal concentrations (Zn) in plant tissues.

From the foregoing discussion, it was concluded that amendment of organic acids to soils can help in detoxifying the effect of certain metal ions which have the potential to cause toxicity to coffee. It might also enhance the plant uptake of certain metal ions, which are needed for proper growth of the plant. From the studies, it was found that, if ZnSO_4 is applied to the soil in the presence of organic acids, the relative uptake of this micronutrient by coffee is higher compared to simple application of Zn SO_4 alone.

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DISCUSSIONS

JACOB POTHEN: How did you irrigate the polythene mulched plot? You could have punched the polythene to save labour? Using thinner polythene (40 gauge) this method may prove economical.

K. B. ABDUL KHADER: Before each irrigation, polythene sheets were removed and spread again after irrigation. If we punch, the water vapour may diffuse through punched holes and will not serve the purpose of reducing evaporation from the soil surface. Moreover in both the seasons same polythene sheets were used. Thick polythene sheet will be more durable and can be used without damage.

R. C. MANDAL: Under high irrigation I_1 treatment recorded maximum yield and both organic and polythene mulch showed similar trend. Since drought is a common phenomena optimum/minimum water use and moisture conservation techniques for retaining the moisture need to be worked out.

K. B. ABDUL KHADER: If enough water is available for irrigation during summer months then I_4 treatment may be recommended. If there is a shortage of water I_2 i. e. half the quantity of I_1 with organic mulch may be recommended.

P. R. V. SUBRAMONIA IYER: You have reported maximum yield for I_1 whereas you have mentioned that E T demand is reduced in I_3 and I_4 . I suggest that you may use $WUE = \gamma/E T$ as a measure of comparison. Eventhough E T demand was low in I_3 and I_4 it does not mean that the plant does not stress itself for water uptake. Parameters like WUE etc could be worked out.

K. B. ABDUL KHADER: Significantly more yield was obtained from I_1 treatment. In I_3 though the same quantity of water was

used with wider intervals there was significantly lesser yield. In I_4 the yield was the least. Hence I_1 treatment was recommended. We can work out W U E but it is not the objective of the study. The objective of the study is to find out the optimum depth of irrigation based on IW/CPE ratio.

H. K. PAWAR: In I_4 treatment the moisture content in soil before irrigation was less than PWP. Was there any mortality of plants?

K. B. ABDUL KHADER: Though in I_4 treatment the soil moisture was beyond PWP, as soon as the CPE reached 120 mm it again received 30 mm water. Unlike annual crop a perennial crop like arecanut will not die for one or two days delay of irrigation but yield will reduce and this might be the reason for low yields in I_4 .

A. RAMADASAN: While choosing intercrops in cashew cultivation care should be taken to select non competitive crops especially since the trial is conducted under marginal rainfed conditions. With competitive intercrops the growth of cashew will be affected. Similarly the root system of component crops also should be studied along with cashew.

S. BHAGAVAN: What is the final fertilizer recommendation you propose for tea in North-West Himalayas?

K. L. SHARMA: The final fertilizer recommendation for North West Himalayas is 180 kg N, 180 Kg P_2O_5 and 40 Kg K_2O /ha. There is a necessity to apply higher doses of these three major nutrients in tea plantations of North-West Himalayas.

CROP PROTECTION

(Disease Management)

Chairman : K. K. N. NAMBIAR

Rapporteurs : Y. R. SARMA
B. CHANDRA MOULI

INFLORESCENCE BLIGHT AND SHOOT DIE-BACK OF CASHEW*

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ABSTRACT

A severe shoot die-back disease of cashew is reported from eight year old cashew plantations from Chalakudy, Kerala. The disease which manifests initially as shoot and inflorescence blight, spreads gradually to woody branches resulting in die-back. *Botryodiplodia theobromae* was found to be the causal organism of the die-back disease. Involvement of fungi in initiating the shoot and inflorescence blight appeared doubtful as no fungal pathogen could be isolated from freshly affected twigs. Though association of *C. gloeosporioides* and *Pestalotiopsis* sp., was observed at the advanced stage of blight disease, *B. theobromae* was the only pathogen which caused die-back disease.

INTRODUCTION

During June 1987, severe shoot die-back of cashew (*Anacardium occidentale* L.) was reported from two 8-year-old cashew plantations from Vellikkulangara forest range under Chalakudy division. The symptoms of the disease were shoot blight and progressive die-back which usually started from the tip of twigs and later advanced towards the base of the branch. The dead leaves and lateral branches became greyish brown and mostly remained attached to the moribund shoots for many weeks. Some of the large branches with 5 to 15 cm girth were also found affected with die-back. Such trees showed stunted growth and were unproductive.

Inflorescence blight and shoot die-back are considered as the major diseases of cashew resulting in considerable loss in yield (Nair et al., 1979; Devasahayam and Radhakrishnan Nair, 1986). Feeding by tea mosquito (*Helopeltis antonii* Sign) and subsequent infection by fungal pathogens like *Colletotri-*

chum gloeosporioides and *Phomopsis anacardii* were earlier considered as the cause of the blight (Anonymous, 1966; 1969). But later Nambiar, Sarma and Pillai (1973) reported that the disease was primarily caused by the feeding of tea mosquito and the fungi found associated with it were only secondary saprophytic colonisers. Recently *Colletotrichum*, *Fusarium* and *Botryodiplodia* were isolated from twigs affected by blossom blight (Anonymous, 1983). However, it is not known whether the pathogenicity tests of these fungi were attempted.

The present study is undertaken to investigate the cause of die-back of large shoots and subsequent decline of the trees reported from Vellikkulangara and other places.

MATERIALS AND METHODS

Isolation of causal organism

Fungal isolations were made from partially live stem collected from trees affected with varying degrees of blight and die-back. Bits of tissues taken at a depth of 3.5 mm

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from the following diseased samples were plated on potato dextrose agar medium.

(1) Woody shoots affected with die-back; (2) Tender vegetative and inflorescence shoots showing initial symptoms of die-back; (3) Vegetative shoots and peduncle with lesions and initial blight symptoms presumably caused by the feeding of *H. antonii*; (4) Peduncle showing wilting and blackening but apparently no insect injury.

The isolates were identified based on cultural and morphological features in comparison with those of authentically identified cultures and confirmed through Commonwealth Agricultural Bureaux, International Mycological Institute, Kew, England.

Pathogenicity tests using shoot isolates

Field testing of the pathogenicity of the fungi isolated from woody and vegetative shoots was done on twigs of varying sizes on two 8-year-old trees at Vellikkulangara. Inoculation of *C. gloeosporioides* and *B. theobromae* was done with and without artificial wounding adopting a procedure described by Sharma, Mohanan and Florence (1984) for *Botryodiplodia* stem canker on eucalyptus. Ten twigs, each belonging to the following three groups were inoculated using a suspension containing conidia and hyphae.

(1) Tender portions of growing shoots (unwounded); (2) Tender portions wounded with a sharp needle; (3) Mature shoots wounded by making small inverted 'V' cuts with a sterile scalpel so that a small portion of woody tissue was opened out.

The wounds on woody shoots were inoculated with mycelial discs (5 mm in dia) cut out from a two-week-old culture, covered with a piece of moist absorbant cotton and then tied with polythene ribbon. The first two groups of shoots were covered with polythene bags for a week after inoculation.

Suitable controls were also maintained. The plants were observed once every month.

Pathogenicity tests using inflorescence isolates

The pathogenicity was tested on inflorescence present on a six-year-old tree in the Kerala Forest Research Institute campus during January, 1988. Conidial and mycelial suspensions were sprayed on needle-wounded and unwounded inflorescences. There were six replicates for each species of fungi. The inoculated inflorescences were covered with polythene bags for a week. Observations were taken daily.

RESULTS

Shoots showing severe and initial die-back symptoms as well as fresh lesions of insect attack were observed during all the months. However, the intensity depended upon the seasons. The severely die-back affected trees appeared stunted and unhealthy, whereas healthy and mildly attacked trees had spreading crown with profuse lateral branches.

Isolation of causal organisms

The only fungus consistently isolated from die-back affected woody branches was *B. theobromae*. The isolates from vegetative and floral shoots showing initial die-back symptoms were also mostly *B. theobromae* and occasionally *C. gloeosporioides*. But *C. gloeosporioides* was repeatedly isolated from inflorescence and twigs showing symptoms of blight. However, no fungus could be isolated from very fresh lesions caused by tea mosquito feeding and associated blight symptoms present on vegetative shoots and peduncles.

Isolations from diseased peduncle always yielded *C. gloeosporioides* and occasionally *B. theobromae* and *Pestalotiopsis* sp.

Pathogenicity tests

Pathogenicity tests with *B. theobromae*, with and without needle wounds on tender shoots did not produce any symptoms of shoot blight or die-back. Instead, at the point of injury, purplish brown scab-like scars, filled with callus and gum exudations were formed. However, mature woody tissues inoculated through 'V'-cut wounds developed canker and characteristic depressions on the bark at the inoculated site. Within 2 months, greyish black discolourations were observed along the shoot spreading from the infected site killing fresh tissues. *B. theobromae* was reisolated from the advancing discoloured portions. Tender shoots which were wound-inoculated with *C. gloeosporioides* produced brownish black lesions at the inoculated areas. Occasionally shoot tip blight and consequent shrinkage of tissues were also observed. Shoots inoculated without wounding remained unaffected. *C. gloeosporioides*, however, was not found to cause symptoms on mature woody branches.

Inflorescences inoculated with *C. gloeosporioides*, showed greyish black discolouration along the peduncle within a week. The peduncle became flaccid and rapidly dried out. Inoculation studies with needle wounds showed that the fungus always produced brownish black lesions on peduncle and individual flowers; flowers withered from such inflorescences within a week. At the end of two weeks all the inoculated peduncle got dried. *Pestalotiopsis* sp. also produced brownish lesions at the peduncle resulting in withering of flowers from sixth day onwards. At the end of two weeks the peduncle got dried up. However, the death of the inflorescences were not as rapid as those inoculated with *C. gloeosporioides*. The peduncle inoculated with *B. theobromae* showed only brownish black scars at the point of injury.

There was no scorching of inflorescence and the withering of flowers was negligible.

DISCUSSION

The study has shown that there are three different types of symptoms on cashew presumably caused by the association of the bug *H. antonii* and fungal pathogens viz., vegetative and floral shoot blight, inflorescence and vegetative shoot die-back and woody shoot die-back.

Shoot and inflorescence blight

Nambiar, Sarma and Pillai (1973) reported that inflorescence blight of cashew is caused by tea mosquito feeding and the fungi isolated from blight affected inflorescence (*C. gloeosporioides* and a non-sporulating fungus) were only secondary saprophytic colonisers. It is not possible to agree with this view because *C. gloeosporioides* is a well known pathogen affecting numerous host plants (Mordue, 1971). Moreover, its pathogenicity on cashew inflorescence is proved by Singh et al. (1967) who reported that *C. gloeosporioides* is the causative agent of anthracnose disease in cashew. They also reported the occurrence of reddish brown, shiny water soaked lesions which grow longitudinally and radially killing the affected shoots. As no fungus could be isolated from the purplish black lesions on vegetative shoots and inflorescence, and also from shoots showing initial stages of blight, it is confirmed that shoot blight and inflorescence blight are not initiated by any fungus. The formation of necrotic area and subsequent blight symptoms might have been caused by the feeding of the bug *H. antonii* on the tender portions of vegetative shoots and inflorescence (Devasahayam and Radhakrishnan Nair, 1986). The injury caused by the bug feeding might be a predisposing factor facilitating the establishment of a pathogen like *C. gloeosporioides* which might be aggravating the disease. It is clear from the study

that *C. gloeosporioides* is capable of causing tender shoot blight in cashew. *C. gloeosporioides* and *Pestalotiopsis* sp. are observed to cause inflorescence blight.

Shoot die-back

The present study has indicated that *B. theobromae* is the causative agent for the progressive die-back of mature and woody vegetative and inflorescence shoots beyond the site of insect feeding. The progress of *Botryodiplodia* infection in cashew could be slow and typical die-back symptoms could appear several months after infection. In nature the predisposition of tender shoots to infection by the pathogen might be due to damage caused by *H. antonii*. This aspect has been dealt elsewhere (Varma and Balasundaran, 1988). The capability of *B. theobromae* to cause shoot die-back of cashew is reported for the first time in India.

B. theobromae is a facultative wound pathogen widely distributed in the tropics and subtropics. It is reported to cause several types of diseases such as damping-off, seedling blight, die-back, stem canker, stump rot, root rot, leaf spot and pre and post harvest fruit rots (Punithalingam, 1980). A severe floral shoot die-back of cashew caused by *B. theobromae* was reported from large cashew plantations in Western State of Nigeria (Olunloyo and Esuruoso, 1975). Infection starting from tips of small floral stalks, causing their gradual die-back, later advanced to the main floral shoots. In Kerala, *B. theobromae* has been reported to cause die-back on several other tree species like *Eucalyptus* (Sharma, Mohanan and Florence, 1984), *Ailanthus triphysa* (Sharma, Mohanan and Florence, 1985) and *Albizia falcataria* (Venkataram, 1964; Sharma and Sankaran, 1988).

It was interesting to note that 4 out of 6 inflorescences of cashew inoculated with

B. theobromae showed typical shoot die-back symptoms by April 1988 though the fungus did not produce any inflorescence blight. By September, 1988 the die-back progressed down to 10 to 25 cm from the base of the main moribund inflorescence rachis. This indicated that though *B. theobromae* could not produce any blight symptom, it could survive as a saprophyte on the moribund inflorescence and subsequently attack the woody tissues during favourable seasons causing die-back symptoms. The ability of *B. theobromae* to perennate over dead tissues and turn pathogenic during favourable environment has been reported (Sharma and Sankaran, 1988).

The study has indicated that *B. theobromae* is the causative agent for the progressive die-back of vegetative and inflorescence shoots. *C. gloeosporioides* and *Pestalotiopsis* sp. are capable of causing inflorescence blight. As *C. gloeosporioides* is a known pathogen, it is likely that the inflorescence blight primarily caused by tea mosquito can be aggravated by *C. gloeosporioides* or even *Pestalotiopsis* sp.

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SOIL MICROFLORA AND VA-MYCORRHIZAE IN ARECA BASED HIGH DENSITY MULTISPECIES CROPPING AND ARECA MONOCROPPING SYSTEMS*

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ABSTRACT

Soil microflora in the root zone and rhizosphere of areca based high density multispecies (HDMS) cropping and areca monocropping systems were studied. The population of bacteria, fungi, actinomycetes, N_2 -fixers and P-solubilizers were more in the rhizosphere as compared to their respective root zone soils in various crops. The bacterial numbers were more in the root region and rhizosphere of areca, cacao and pineapple in HDMS cropping system as compared to areca monocropping system. The N_2 -fixers were more in rhizosphere and root region of cacao as compared to other crops. The spore count, VAM root infection (%) and extent of root colonization (%) was least in banana and coffee. Microbial biomass in soil (CO_2 -C, N and P in biomass) was higher in areca HDMS cropping system as compared to areca monocropping system.

INTRODUCTION

The practice of growing other crops in areca gardens is a common practice. The intensive cropping systems involving areca are essentially crop combinations, which envisage the cultivation of other compatible crops in the interspaces between the palms. The nature and the activity of microflora and fauna in a given environment depends upon the crops grown and management practices. The activity of rhizosphere and root zone microflora can affect the nutrient uptake (Bower and Rovira, 1968; Nair and Subba Rao, 1977). The distribution of microflora in soil profile and the nature of rhizosphere microorganisms of areca monocropping system have been studied (Bopaiah, 1979; Bopaiah and Koti Reddy, 1982). The nature and activity of microorganisms associated with perennial monocrop, can change with introduction of other crops.

This study compares the microflora in the root zone and rhizosphere of areca based high density multispecies cropping and areca monocrop.

MATERIALS AND METHODS

The experiment on areca based high density multispecies cropping consisting of cacao, banana, pineapple, pepper, coffee and clove crop combinations in the interspaces was initiated in a 17 year old areca garden at CPCRI, Regional Station, Vittal in 1983. The samples were collected in October, 1986 for the various studies from the root zone and rhizosphere of various crops and from the areca monocropping plot. The bacterial, fungal and actinomycetes were enumerated quantitatively using soil extract agar, Martins' rose bengal agar and Kusters' agar medium respectively by soil dilution and plate count method (Allen, 1957). The

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enumeration of N_2 -fixers was carried out using Waksman's media No. 77 and Beeking's medium (Beeking, 1959). The phosphate solubilizing organisms were counted following method of Katznelson and Bose (1959).

The enumeration of nitrifying bacteria such as *Nitrosomonas* and *Nitrobacter* from the root region soils of various crops was carried out by following the most probable number method (Alexander and Clark, 1965). The endogone spores were extracted by wet sieving and decanting technique (Gerdemann and Nicolson, 1963). Roots were collected from five plants each (10 roots from each plant) for the VA-mycorrhizal colonisation studies. The processing and staining of roots for VA-mycorrhizal infection was carried out following the procedure outlined by Phillips and Hayman, (1970).

The soil microbial biomass was determined following the chloroform fumigation technique (Jenkinson and Powlson, 1976) and the biomass C and N were calculated (Jenkinson and Ladd, 1981).

RESULTS AND DISCUSSION

The microflora population in the rhizosphere and root zone of areca based high density cropping system and areca monocropping system are presented in Table I. In general, the bacterial, fungal and actinomycetes numbers were more in the rhizosphere of various crops than their respective root zone soils. Bacterial and fungal counts were more in the rhizosphere and root region of pineapple. The population of actinomycetes did not reveal any difference in the various crops studied. The greater microbial population in the rhizosphere might be due to the availability of root exudates. Rhizosphere is characterized by greater

Table I. *Soil microflora in the rhizosphere and root zone of areca based high density multispecies cropping system*

Crop		Soil moisture (%)	Bacteria* (R x 10 ⁶) (RZ x 10 ⁶)	Fungi* (x 10 ⁵)	Actinomycetes* (x 10 ⁶)
<i>High density cropping system</i>					
Areca	R**	14.1	12.0	10.5	1.4
	RZ**	13.8	9.5	5.9	0.6
Cacao	R	13.7	16.5	8.4	1.1
	RZ	13.3	10.6	5.3	0.4
Banana	R	15.3	9.7	10.0	2.1
	RZ	12.3	4.5	2.1	0.7
Pineapple	R	17.7	20.1	10.3	1.6
	RZ	17.5	19.6	8.3	0.7
<i>Monocropping system</i>					
Areca	R	13.0	10.5	10.2	0.7
	RZ	12.1	8.1	6.1	0.4

* Average of three replications

** R = Rhizosphere soil RZ = Root zone soil

microbial activity (Lakshmikumari, 1964). Coconut-cacao mixed cropping have shown greater microbiological activities than coconut monocropping system (Nair and Subba Rao, 1977).

The asymbiotic N_2 -fixers and P-solubilizers were enumerated from the rhizosphere and root zone of the various crops (Table II). The N_2 -fixers were fairly high in the rhizosphere as compared to the root zone of various crops. Similar trend was also recorded for the phosphate solubilizer counts. The enumeration of *Nitrosomonas* ($53-72 \times 10^3$) and *Nitrobacter* ($47-64 \times 10^3$) did not reveal much variation among the various crops.

The endogone spore counts and VAM colonisation of roots in various crops are presented in Table III. The data revealed that the endogone spores were less in banana

as compared to areca, pepper and cacao. The percentage VA-mycorrhizal colonisation was also low in coffee (10.0%) and banana (35%) as compared to other crops (45-56%). Satyanarayana and Venkataraman (1979) have reported 70-80 per cent infection of VAM in tea and other weeds in the soils of North Eastern India.

The microbial biomass estimation of soils in areca high density cropping and areca monocropping has indicated higher CO_2 -C flush in HDMS cropping system (Table IV). The nitrogen and phosphorus in the biomass flush was also higher in HDMS cropping systems as compared to areca monocropping system. This can be attributed to the rhizosphere effect and higher biological activities in the HDMS cropping system. Thus, the high density multispecies cropping system does not influence on the soil

Table II. Population of N_2 -fixers and P-solubilizers in the rhizosphere and root zone of areca based cropping system*

Crop		N ₂ -fixers (x 10 ³)		P-solubilizers (x 10 ⁴)
		Azotobacter medium	Beeking's medium	
<i>High density cropping system</i>				
Areca	R**	3.17	4.22	8.34
	RZ**	0.92	1.39	2.04
Cacao	R	6.32	6.35	2.10
	RZ	1.75	2.20	3.16
Banana	R	2.16	3.25	9.65
	RZ	0.34	1.04	2.41
Pineapple	R	5.02	4.54	4.30
	RZ	3.42	0.34	2.20
<i>Monocropping system</i>				
Areca	R	3.13	4.59	6.27
	RZ	0.83	0.69	1.37

* Average of three replications

** R = Rhizosphere, RZ = Root zone soil

Table III. *VA-mycorrhizal spore counts and root colonisation in areca HDMS and areca monocrop*

Crop	Endogone spores No./50 g soil	VAM colonisation (%)	
		Root infection	Extent of colonisation
<i>High density cropping system</i>			
Areca	126.6	56.0	40.0
Cacao	96.0	55.0	31.9
Pepper	99.0	42.0	30.8
Banana	73.0	35.0	37.5
Pineapple	ND	50.0	35.0
Coffee	ND	7.5	10.9
<i>Monocropping system</i>			
Areca	118.0	52.0	35.4
Pineapple	ND	43.8	32.2
Banana	60.0	28.0	35.0
Coffee	ND	10.0	9.4
C. D. at 5%	—	13.7	6.9

ND = Not determined

Table IV. *Soil microbial biomass in areca based high density multispecies cropping and areca monocropping system*

	High density cropping	Mono. cropping
Flush of $\text{CO}_2\text{-C}$, μg per gram of soil	366.67	322.2
Microbial biomass from flush kg C/ha	806.7	708.9
Nitrogen in biomass kg N/ha	134.4	118.2
Phosphorus in biomass kg P/ha	16.1	14.2

multispecies cropping system on soil microflora and microbiological activities will have to be studied after 5 or 10 years to monitor the changes.

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microflora after three years substantially as compared with the monocropping system. Further, the long term effect of high density

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VARIABILITY IN GROWTH OF *COLLETOTRICHUM GLOEOSPORIOIDES* ISOLATES PATHOGENIC ON CACAO IN RESPONSE TO FUNGICIDES, ANTIBIOTICS AND DETERGENT*

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ABSTRACT

Growth rates of three virulent isolates of *Colletotrichum gloeosporioides* Penz. causing foliar diseases viz., blight, shot hole and irregular spot on cacao were compared on potato dextrose agar medium containing different concentrations of fungicides (Carbendazim and Mancozeb), antibiotics (Nystatin and Actidione) and a detergent (Cetavlon). The three isolates varied markedly from each other in their growth response in the presence of these chemicals. Of the two fungicides tested, the isolates were more sensitive to Carbendazim than Mancozeb. The growth of all the three isolates was completely inhibited in the presence of Carbendazim at 5 and 10 μ g/ml medium, whereas the growth of irregular spot isolate was completely inhibited even at 3 μ g/ml medium. The isolates were found to be sensitive to Nystatin and Actidione though complete inhibition of growth was not observed at any of the concentrations tested. All the three isolates also showed marked variation in growth in response to Cetavlon. The irregular spot isolate was more sensitive to Cetavlon than the other two.

INTRODUCTION

Colletotrichum disease of cocoa (*Theobroma cacao* L.) is wide spread in South India. It has been found in greater intensities in some of the cacao growing areas. In India, *Colletotrichum gloeosporioides* Penz. has been reported to cause rotting of immature pods and produce three kinds of foliar symptoms viz., blight, shot hole and irregular spot (Chandra Mohanan and Kaveriappa, 1983). The isolates of *C. gloeosporioides* collected from various cacao growing areas of South India were classified into leaf blight, shot hole and irregular spot isolates based on the symptoms produced on cacao leaves. There was great variation in pathogenicity among the isolates of the three groups (Chandra Mohanan and Kaveriappa, 1984).

To use fungicides, antibiotics and other antimicrobial compounds more effectively in disease control, it is important to know the intraspecific variations in response to fungicides and other antimicrobial compounds.

MATERIALS AND METHODS

Among the 299 pathogenic isolates of *C. gloeosporioides* collected from different cacao growing areas of Southern India, the most virulent isolates causing blight, shot hole and irregular spot symptoms on cacao leaves were selected for the present studies. The three most virulent isolates TN I/139, Ke II/55 and Ka III/9 causing blight, shot hole and irregular spot on cacao leaves respectively were tested on potato dextrose agar medium (PDA) containing different concentrations of fungicides, antibiotics and a detergent.

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Fungicides: (1) Carbendazim (Bavistin WP) – (technical 99.5%) at 3, 5 and 10 $\mu\text{g/ml}$ medium; (2) Mancozeb (Dithane M-45) (technical 80%) at 500, 800 and 1000 $\mu\text{g/ml}$.

Antibiotics: (1) Nystatin (mycostatin, B-grade) at 20, 30 and 40 $\mu\text{g/ml}$ of medium; (2) Actidione GR (Cycloheximide Naramycin) at 40, 50 and 60 $\mu\text{g/ml}$.

Detergent: (1) Cetavlon (Cetyltrimethyl ammonium bromide) – 800, 900 and 1000 $\mu\text{g/ml}$ medium.

The range of concentrations of the above chemicals were selected on the basis of their effect on other fungi and bacteria and by conducting a pilot study using a range of concentrations. Suspensions of the fungicides, antibiotics and the detergent were added to autoclaved and cooled PDA, immediately, before pouring into petri plates, so as to obtain required concentrations.

The PDA containing the chemicals was dispensed uniformly into 90 mm diam. petriplates at 15 ml per plate. To determine the mycelial growth, each plate was inoculated with a 6 mm diam. disc from the periphery of 10-day-old cultures of each isolate maintained on PDA. Each disc was placed upside down in the centre of the

petri plate. Three replications were used for each concentration of the chemical.

The plates were incubated at room temperature ($27 \pm 2^\circ\text{C}$) for 10 days and radial growth of colonies was measured in two directions at right angles to each other and the mean values were taken as the colony diameter for each plate. The mean values were used to find out the per cent inhibition of growth and to find out the variability in the growth rate. The per cent inhibition of growth was calculated by using the following

$$\text{equation (Vincent, 1927)} : I = \frac{100(C-T)}{C}$$

where, I = inhibition of fungal growth; C = growth in check; and T = growth in treatment.

RESULTS AND DISCUSSION

The three isolates of *C. gloeosporioides* varied markedly from each other in their growth response in the presence of fungicides, antibiotics and the detergent (Fig. 1).

Among the two fungicides tested, the isolates were more sensitive to Carbendazim than Mancozeb. The growth of the isolate Ka III/9 was completely inhibited in the presence of Carbendazim at 3, 5 and 10 $\mu\text{g/ml}$ whereas TN I/139 and Ke II/55 exhibited

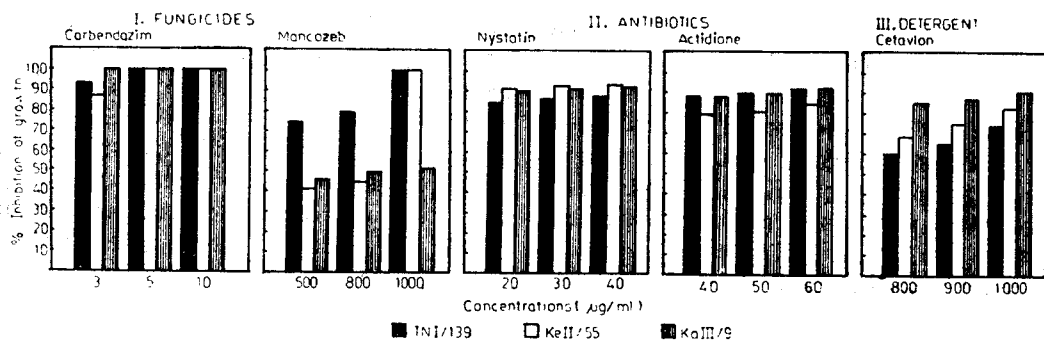


Fig. 1. Variability in growth of three isolates of *C. gloeosporioides* in presence of fungicides, antibiotics and a detergent

slight growth at 3 $\mu\text{g/ml}$. While Ka III/9 was moderately tolerant to Mancozeb at 1000 $\mu\text{g/ml}$, the growth of other two isolates was completely inhibited at 1000 $\mu\text{g/ml}$ concentration. The isolate TN I/139 was more sensitive to Mancozeb, the growth being inhibited to an extent of 74 to 79 per cent at 500 and 800 $\mu\text{g/ml}$ respectively. Isolates tolerant and sensitive to Carbendazim have been reported in *Helminthosporium maydis* Nishikado & Miyake pathogenic on maize (Bains and Mohan, 1982). The isolate Ka III/9 showed a differential reaction in response to Carbendazim and Mancozeb. It was highly sensitive to Carbendazim and less sensitive to Mancozeb. Such differential reactions have also been reported with some isolates of *Phytophthora cinnamomi* Rands in response to antibiotics (Leary et al., 1982).

All the isolates were sensitive to Nystatin and Actidione. Complete inhibition of growth of the isolates was not observed in the presence of these two antibiotics at the concentrations tested. The rate of growth of the isolates Ke II/55 and Ka III/9 did not vary much in the presence of Nystatin at 20, 30 and 40 $\mu\text{g/ml}$. They were more sensitive than TN I/139. In the presence of Actidione the growth was more in Ke II/55 than the other two isolates at the three concentrations tested. Most of the studies on variability in the growth of the isolates in response to antibiotics were conducted on *Phytophthora* sp. (Zentmyer, 1955; Vaarataja, 1960; Leary et al., 1982). Majority of the isolates of *P. cinnamomi* showed complete inhibition in growth in the presence of 10 μM Cycloheximide. On the other hand the growth of all *P. cinnamomi* isolates tested was faster on media containing Nystatin than any normal media (Leary et al., 1982). In the present study, though all the isolates of *C. gloeosporioides* were sensitive to the two antibiotics tested TN I/139 was

comparatively more tolerant to Nystatin and Ke II/55 was more tolerant of Actidione. In the presence of Nystatin Ke II/55 and Ka III/9 showed similarity in growth while in the presence of Actidione TN I/139 and Ka III/9 showed a close similarity in growth.

All the isolates showed variation in growth in the presence of Cetavlon. The inhibition was more in Ka III/9 followed by Ke III/55 and TN I/139. Thus there was marked variation in the inhibition of growth of the three isolates on PDA incorporated with Cetavlon at 800, 900 and 1000 $\mu\text{g/ml}$ concentration. Inhibition of growth in the presence of detergents has also been reported in pathogenic fungi like *Sclerotium rolfsii*, *S. oryzae* and *Macrophomina phaseolina* (Mukherjee, 1974, 1976).

Most of the studies on tolerance to fungicides have been reported from the fungal isolates collected from localities where the fungicides have been in use (Bolton, 1976; Davidse, 1981; Gutter et al., 1981; Papavizas and Bowers, 1981; Webster, Ogawa and Bore, 1970). In such cases the pre-existing tolerance in the natural population could not be determined because the chemicals had already been in use for varying periods before the isolates were collected. Large scale application of fungicides may favour dominance of fungicide-tolerant strains and in due course these tolerant strains may predominate in the natural population posing problems in effective implementation of fungicidal control of diseases. Such problems have been noticed when Benomyl was used in large scale to control plant diseases (Schroeder and Provvidenti, 1969; Bollen and Scholten, 1971; Dekker, 1976). The fungicidal control of *Colletotrichum* disease of cacao has not yet begun in India. Therefore, the response of the isolates of *C. gloeosporioides* to the fungicides, antibiotics and detergent noticed in the present studies can be considered as their natural tolerance

rather than the induced tolerance in response to the application of these chemicals.

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IN VITRO INTERACTION OF ANTAGONISTIC FUNGI WITH *THIELAVIOPSIS PARADOXA*, THE PATHOGEN OF COCONUT STEM BLEEDING DISEASE*

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ABSTRACT

In vitro interaction of three antagonistic fungi, viz., *Aspergillus niger*, *Trichoderma harzianum* and *T. viride* with four isolates of *Thielaviopsis paradoxa* (de Seynes) von Hohnel, the causal agent of stem bleeding disease of coconut was studied. Three methods of inoculation, viz., (1) *T. paradoxa* inoculated 12 hrs before the inoculation of antagonistic fungus; (2) both *T. paradoxa* and antagonistic fungus were simultaneously inoculated, and (3) *T. paradoxa* inoculated 12 hrs after the inoculation of the antagonistic fungus were tested. Minimum growth inhibition of different isolates of *T. paradoxa* was observed when *T. paradoxa* was inoculated 12 hrs before the inoculation of the antagonist and maximum growth inhibition of *T. paradoxa* was observed when *T. paradoxa* was inoculated 12 hrs after the inoculation of the antagonistic fungus. Among the three antagonistic fungi tested, an isolate of *Trichoderma viride* exerted maximum growth inhibition (90%) of the pathogen.

INTRODUCTION

The coconut palm, *Cocos nucifera* Linn. is grown in all the tropical countries. The coconut palm, though hardy in nature, is affected by a number of diseases which are responsible for enormous economic losses. 'Stem bleeding disease' is one such disease of coconut reported from all coconut growing countries. Recently Nambiar et al. (1986) established the pathogenicity of the fungus, *Thielaviopsis paradoxa* (de Seynes) von Hohnel in causing the disease.

T. paradoxa is a weak pathogen. Earlier work (Anonymous, 1976) had reported the presence of other fungi viz., *Aspergillus* sp., *Diplodia* sp., *Fusarium* sp., *Penicillium* sp., *Rhizoctonia* sp., *Trichoderma* sp. etc. from the bark and/or soil samples of stem bleeding affected palms. There are many reports where *Aspergillus* sp. and *Trichoderma* sp.

are used as biocontrol agents of plant pathogens. Perhaps the presence of these fungi in the old lesions of affected palms may be a reason why it is difficult to isolate the pathogen from such lesions. Hence *in vitro* studies on the interaction of *T. paradoxa* with *Aspergillus niger*, *Trichoderma harzianum* and *T. viride*, isolated from tissues and soils from stem bleeding affected gardens was taken up in the present study. An understanding of antagonistic fungi may be useful in developing biocontrol measures against the stem bleeding pathogen.

Stem bleeding disease of coconut was first reported from Sri Lanka (Petch, 1906). Sundararaman (1922) reported the disease from India. Now the disease is known to occur in nearly all the coconut growing countries like Philippines (Lee, 1922),

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Malaysia (Sharples, 1923), Andaman Islands (Mitra, 1929), Trinidad (Britton-Jones, 1940) Papua New Guinea (Dwyer, 1953) and Fiji (Mc Paul, 1962), Indonesia (Renard, Brahmana and Rognon, 1984). Ohler (1984) reported *T. paradoxa* (de-Seynes) von Hohnel as a suspected pathogen. Recently, Nambiar et al. (1986) could establish pathogenicity with this fungus. The presence of many fungi viz., *Aspergillus* sp., *Diplodia* sp., *Fusarium* sp., *Mucor* sp., *Penicillium* sp., *Rhizoctonia* sp., *Trichoderma* sp. etc. from bark and/or soil samples of stem bleeding affected palms has been reported (Anonymous, 1976). In literature many instances are there where *Aspergillus* spp., *Trichoderma* spp. are used as biocontrol agents of plant pathogens. *A. niger* was reported as an antagonist to *Rhizoctonia solani* causing rice sheath blight (Gokulapalan and Nair, 1984) and collar rot of coffee seedlings (Venkatasubbaiah and Safeeulla, 1984). *T. harzianum* was reported as biocontrol agent of many plant pathogenic fungi like *Rhizoctonia solani* affecting coffee seedlings (Venkatasubbaiah, Safeeulla and Somasekhar, 1984), *Cytospora personii* and *C. cineta* causing cankers on peach, plum and cherry trees (Schulz, 1981), *Fomes connatus* in red maple wounds (Smith, Blanchard and Shortle, 1981). *T. viride* as biocontrol agent *Ceratocystis ulmi* causing Dutch elm disease (Ricard, 1983; Webber and Hedger, 1986) and *Pythium* sp. causing root rot of sugarcane seedlings in nurseries (David, 1987).

MATERIALS AND METHODS

Four isolates of *T. paradoxa* isolated from the advancing margins of young lesions from stem bleeding affected palms collected from Pilicode, Kallangai, CPCRI Campus at Kasaragod and Shiria (all in Kerala) were taken for the study and designated as *T. paradoxa* isolate No. 1, 2, 3 and 4 respectively. These isolates showed variability in

the cultural and morphological characters (Gowda, 1987). One isolate of *Aspergillus niger*, two isolates of *Trichoderma harzianum* and three isolates of *T. viride* were tested for their antagonistic reactions with *T. paradoxa*. Direct opposition method used by Webber and Hedger (1986) was adopted for the *in vitro* studies as detailed below:

Individual cultures of *T. paradoxa* and the respective test fungi were established on culture media in petridishes of 9 cm diameter. Using sterile cork borer of 5 mm diameter mycelial discs were cut separately from the edge of the growing cultures of *T. paradoxa* and the test fungi. The discs of *T. paradoxa* and the test fungus were placed (with the fungal side facing the growth medium) at 3.5 cm distance from each other at the centre of the petridish. There were five replications and the dishes were incubated at 23°C in darkness. Radial growth was measured in two opposite directions at 24 hr intervals. From these measurements the percentage of inhibition of *T. paradoxa* caused by each test fungus was found out.

For *T. paradoxa* isolate No. 1, Kirchoff's Agar medium was used while for *T. paradoxa* isolate Nos. 2 and 3, Dextrose Asparagine Phosphate Agar and for *T. paradoxa* isolate No. 4 Potato Dextrose Agar were used since the best growth of the isolates was obtained in the respective media (Gowda, 1987).

The inoculation was done in three different ways:

1. *T. paradoxa* was inoculated 12 hrs before inoculation of the antagonistic fungus;
2. Both *T. paradoxa* and the antagonistic fungus were simultaneously inoculated, and
3. *T. paradoxa* was inoculated 12 hrs after inoculation of antagonistic fungus.

The percentage of growth reduction of *T. paradoxa* 72 hrs after inoculation was determined.

RESULTS AND DISCUSSION

Interaction of *A. niger* with *T. paradoxa*

In the three methods of inoculation tested, inhibition of different isolates of *T. paradoxa* was the best in 72 hrs after inoculation ranging from 13.3% to 30.0% (mean 23.3%) when *T. paradoxa* was inoculated 12 hrs before inoculation by *A. niger* (Table I). In simultaneous method of inoculation, the inhibition percentage ranged from 30.0% to 40.0% (mean 35.0%) while maximum percentage of inhibition was discernible in the third method of inoculation. The percentage of inhibition ranged from 36.7 to 50% (mean 44%) among the different isolates of *T. paradoxa* tested.

Interaction of *Trichoderma harzianum* with *T. paradoxa*

Among the three methods of inoculation tested, inhibition of *T. paradoxa* was minimum (23.3% to 50%) when *T. harzianum* (both isolates) was inoculated 12 hrs after the inoculation of *T. paradoxa* (Table II).

In simultaneous method of inoculation, the inhibition percentage ranged from 43.3

to 60.0 in 72 hrs after inoculation. But maximum percentage of inhibition was observed when *T. harzianum* was inoculated first and *T. paradoxa* was inoculated after 12 hrs (50 to 86.6%).

Interaction of *T. viride* with *T. paradoxa*

Minimum growth reduction of *T. paradoxa* was observed (13.3% to 43.3% for the three isolates of *T. viride*) when *T. paradoxa* was inoculated 12 hrs before *T. viride* (Table III). In simultaneous method of inoculation, growth inhibition of *T. paradoxa* ranged from 26.7% to 66.7% for the three isolates of *T. viride*. However, maximum growth reduction of *T. paradoxa* was found (50% to 90%) when *T. viride* was inoculated 12 hrs before *T. paradoxa* inoculation.

A significant role is played by fungus succession or precedence in development of diseases, survival of the pathogen, damages to the host etc. In the present studies in all the three cases of antagonistic fungi viz., *A. niger*, *T. harzianum* and *T. viride*, maximum percentage of inhibition of *T. paradoxa* was observed when the pathogen was inoculated 12 hrs after the antagonist inoculation. The

Table I. In vitro interaction of *A. niger* with *T. paradoxa**

<i>T. paradoxa</i> isolates	Growth inhibition of <i>T. paradoxa</i> by <i>A. niger</i> (Percentage)		
	A	B	C
No. 1	13.3	36.7	50.0
No. 2	23.3	33.3	39.3
No. 3	30.0	40.0	50.0
No. 4	26.7	30.0	36.7
Mean	23.3	35.0	44.0

A = *T. paradoxa* inoculated 12 hrs before the antagonist

B = *T. paradoxa* and antagonist were simultaneously inoculated

C = *T. paradoxa* was inoculated after 12 hrs growth of antagonist

* Results observed 72 hrs after inoculation of both the fungi

Table II. *In vitro* interaction of *Trichoderma harzianum* with *T. paradoxa**

<i>T. paradoxa</i> isolates	Growth inhibition of <i>T. paradoxa</i> by <i>T. harzianum</i> (Percentage)		
	A	B	C
<i>T. harzianum</i> isolate No. 1			
No. 1	23.3	50.0	84.0
No. 2	40.0	50.0	80.0
No. 3	40.0	56.7	85.1
No. 4	30.0	46.7	66.7
Mean	33.3	50.8	78.9
<i>T. harzianum</i> isolate No. 2			
No. 1	23.3	46.7	86.6
No. 2	50.0	50.0	50.0
No. 3	50.0	60.0	62.5
No. 4	26.7	43.3	63.3
Mean	37.5	50.0	65.6

A = *T. paradoxa* inoculated 12 hrs before *T. harzianum*B = *T. paradoxa* and *T. harzianum* were simultaneously inoculatedC = *T. paradoxa* was inoculated after 12 hrs growth of *T. harzianum*

* Results observed 72 hrs after inoculation of both the fungi

fact that this is only *in vitro* studies calls for further investigations to test whether same results can be applied to *in vivo* conditions also. Venkatasubbaiah and Safeeulla (1984) reported that seed treatment with *A. niger* significantly reduced collar rot of coffee seedlings due to *R. solani*. Similarly Schulz (1981) reported good inhibition of canker caused by *Cytospora personii* on peaches, plum, etc. when the trees were prophylactically treated with *T. harzianum*. Ricard (1983) treated fifteen Dutch elm disease (*C. ulmi*) affected elm trees with *T. viride* pellets and reported that there was no progress of the disease. *Pythium* root rot of ugar cane seedlings could be effectively con-

trolled by incorporation of *T. viride* to seed beds (David, 1987).

This preliminary studies on *T. paradoxa* indicate the possibility of using *A. niger*, *T. harzianum* and *T. viride* as potential antagonists or biocontrol agents to the stem bleeding pathogen in coconut. Studies in this direction are required to screen more biocontrol agents. On the other hand, all fungi antagonistic to the pathogen in *in vitro* need not be antagonistic *in vivo* also, as has been well documented in case of Dutch elm disease (Webber and Hedger, 1986). Hence more studies in this line are required before these antagonists can be employed as biocontrol agents under natural conditions.

Table III. In vitro interaction of *T. viride* with *T. paradoxa**

<i>T. paradoxa</i> isolates	Growth inhibition of <i>T. paradoxa</i> by <i>T. viride</i> (Percentage)		
	A	B	C
<i>T. viride</i> isolate No. 1			
No. 1	16.7	34.5	56.6
No. 2	40.0	60.0	67.9
No. 3	36.6	60.0	90.0
No. 4	33.3	50.0	76.7
Mean	31.6	51.1	72.8
<i>T. viride</i> isolate No. 2			
No. 1	33.3	53.3	90.0
No. 2	40.0	50.0	57.1
No. 3	40.0	66.7	90.0
No. 4	38.0	50.0	80.0
Mean	37.8	55.0	79.3
<i>T. viride</i> isolate No. 3			
No. 1	13.3	26.7	50.0
No. 2	43.3	45.8	50.0
No. 3	40.0	60.0	68.0
No. 4	16.7	33.3	60.0
Mean	28.3	41.5	57.0

A = *T. paradoxa* inoculated 12 hrs before *T. viride*B = *T. paradoxa* and *T. viride* were simultaneously inoculatedC = *T. paradoxa* was inoculated after 12 hrs growth of *T. viride*

* Results observed 72 hrs after the inoculation of both the fungi

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CHEMICAL CONTROL OF TEA BLISTER BLIGHT IN KANGRA VALLEY, HIMACHAL PRADESH

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ABSTRACT

Blister blight, caused by *Exobasidium vexans* Massee in tea (*Camellia sinensis* (L.) O. Kuntze) is a serious foliar disease affecting tender shoots. Epidemic outbreaks of the disease were noticed in Kangra Valley (Himachal Pradesh) during the last ten years.

Field trials on disease control were conducted using Blitox, Fytolan and Calixin. Treatments imposed at weekly intervals were : Blitox and Fytolan 600 and 1200 g/ha; Calixin 180 ml/ha; Calixin 180 ml + Vinofan-In 500 ml/ha; Calixin 180 ml + Vinofan-In 500 ml + Blitox 600 g/ha; and untreated control. In another series, black plucking was practised on bushes receiving 600 g/ha Blitox. Effect of various treatments was non-significant initially upto third spraying round. Thereafter, disease incidence exhibited a significant decline under various treatments excepting Blitox and Fytolan 600 g/ha, and Calixin 180 ml/ha. Fytolan 1200 g/ha exhibited the highest disease control, followed by Blitox 1200 g/ha, black plucking on Blitox 600 g/ha, Calixin 180 ml + Vinofan-In 500 ml + Blitox 600 g/ha, and Calixin 180 ml + Vinofan-In 500 ml/ha, respectively. However, Blitox 1200 g/ha, black plucking coupled with Blitox 600 g/ha, and Calixin 180 ml + Vinofan-In 500 ml + Blitox 600 g/ha were at par with Fytolan 1200 g/ha. The results suggest that black plucking could help to reduce quantity of fungicide(s) applied in blister control.

INTRODUCTION

Blister blight of tea (*Camellia sinensis* (L.) O. Kuntze), caused by *Exobasidium vexans* Massee, is an important leaf disease in the principal tea growing countries. The fungus infects young succulent shoots, thus affecting the harvestable tea leaves. Young nursery plants may die as the stems snap off at the points of infection. The crop losses are enormous, amounting to 50 per cent of the total annual crop, if left untreated (Venkata Ram, 1968).

The effective control of blister blight is achieved by fungicide spray during active infection phase. Among the several fungicides screened for blister control, copper formulations containing oxides or oxychlorides of 50 per cent metallic copper, nickel chloride, dithiocarbamates, Sicarol (2 methyl

-5, 6-dihydro- 4H pyran-3 carboxylic acid anilide), and Calixin (N-tridecyl-2, 6-dimethyl-morpholine) are reported to be effective in disease control (Satyanarayana et al., 1974; 1975; Venkata Ram, 1974; Satyanarayana and Barua, 1975; Satyanarayana, 1987).

In North East India, spraying four to five rounds of copper fungicides at seven to ten-day interval, following a plucking round, effectively controls the disease (Satyanarayana, Barua and Barua, 1978). In South India, however, application of Calixin on extended spraying rounds at the beginning and end of blister season, with copper-nickel combination at shorter intervals during intervening monsoon spell, is recommended for most economic control of blister blight (Venkata Ram and Chandra Mouli, 1976).

Spraying copper fungicides and nickel chloride combination at short intervals under severe monsoon weather conditions, and longer intervals thereafter also offers adequate control (Venkata Ram and Chandra Mouli, 1983).

During the last two years, severe epiphytotic outbreaks of blister blight were recorded in Kangra Valley. The disease outbreaks threatened large area of tea plantations, warranting extensive fungicide application. But little information was available under Kangra Valley conditions to enable a proven recommendation. Therefore, comparative efficacy of Blitox and Fytolan (copper fungicides), and Calixin were evaluated against blister, and the results are discussed.

MATERIALS AND METHODS

Blitox, Fytolan, and Calixin were tested for disease control in a commercial tea estate at the following doses : Blitox and Fytolan 600 and 1200 g/ha; Calixin 180 ml/ha; Calixin 180 ml + Vinofan-In (polyvinyl acetate binder) 500 ml/ha; Calixin 180 ml + Vinofan-In 500 ml + Blitox 600 g/ha; and Blitox 600 g/ha in conjunction with black plucking. Untreated plots were included as controls. Treatments were replicated thrice in a randomized complete block design. Within each plot, 58 bushes, in two linear rows at 120 cm spacing, were used for sampling. Two guard rows separated the adjacent plots. Treatments were imposed on individual bushes with double-nozzle low volume (200 l/ha) Maruyama power sprayer at discharge rate of 90 litres spray fluid per hour. Spray applications, following each plucking round, were conducted at seven-day intervals.

Disease determinations were made at regular seven-day intervals, commencing immediately before initial fungicide application. From the harvest of each plot,

hundred shoots were randomly picked, examined individually for blister infection and quantified as per cent disease incidence. Results were statistically analysed, and efficacy of test fungicides was evaluated in comparison with untreated control.

RESULTS

Effect of various fungicide treatments on blister blight control is presented in Table I. The blister incidence showed a continuous decline, following an initial increase for three weeks, in the untreated plots. A similar trend in disease development was observed in the treated plots, although disease decline in the treated plots was more pronounced and started earlier *vis-a-vis* the untreated plots. However, various treatments showed non-significant disease control upto third spraying round. Following the fourth spraying round, disease incidence exhibited a significant decline under various treatments, excepting Blitox and Fytolan 600 g/ha, and Calixin 180 ml/ha. Fytolan 1200 g/ha provided best disease control, followed by Blitox 1200 g/ha, black plucking on Blitox 600 g/ha, and Calixin 180 ml + Vinofan-In 500 ml + Blitox 600 g/ha, and Calixin 180 ml + Vinofan-In 500 ml/ha, respectively. However, Blitox 1200 g/ha, black plucking coupled with Blitox 600 g/ha, and Calixin 180 ml + Vinofan-In 500 ml + Blitox 600 g/ha were at par with Fytolan 1200 g/ha. Almost similar trend was observed in disease control, following the fifth spraying round, except that Calixin 180 ml + Vinofan-In 500 ml/ha showed little disease control.

DISCUSSION

Effective control of blister blight is achieved by spraying fungicides during acute infection phase. Fungicides used in blister control include protectants, eradicants, and systemics. In South India, integrated spray schedule, incorporating systemic Calixin with protectant copper and eradicant nickel

is recommended (Venkata Ram and Chandra Mouli, 1983). However, in North East India copper oxychlorides and oxides are considered superior to other formulations, as Calixin provided inconsistent disease control, and nickel caused leaf-scorching (Satyanarayana and Barua 1975). Under Kangra Valley conditions, copper fungicides viz., Blitox and Fytolan, and Calixin were tested against blister blight (Table I).

As is evident from the results, the experimental plots under various fungicide treatments showed lowered disease incidence, following four spray rounds, as compared to the untreated plots. This decline was more marked with higher dosage of both Blitox and Fytolan, black plucking on Blitox, and Calixin and Vinofan-In in combination with Blitox. These treatments were significantly beneficial in disease control as compared to untreated control. However, these copper

fungicides at lower dosage, and Calixin alone showed little effect; disease incidence being equivalent to untreated control. Thus, only copper fungicides were effective in disease control when used at correct dosage. Calixin alone was not effective, and its efficacy could be manifested only to reduce the quantity of copper fungicides in blister control, when used in combination with these fungicides.

Practising black plucking, instead of standard plucking, in conjunction with chemotherapy during blister season, provided more effective disease control. This is evident from the data (Table I) that disease control was comparable when Blitox was tested at half the rate on black plucking and when Blitox was tested at full dosage on standard plucking. Likewise, disease control was at par when equal dosages of Blitox were tested on black plucking singly and on standard plucking in conjunction with Calixin and

Table I. *Effect of Blitox, Fytolan, and Calixin on blister blight incidence in tea*

Treatment	Per cent disease incidence*					
	0. Dat**	7 Dat	14 Dat	21 Dat	28 Dat	35 Dat
Control	70.00	73.33	74.33	65.00	61.33c	58.33c
Blitox 600 g/ha	71.33	71.67	67.33	57.00	53.67bc	53.33b
Blitox 1200 g/ha	70.00	72.33	65.00	54.67	44.67ab	40.33a
Fytolan 600 g/ha	78.67	80.33	71.00	61.00	56.33bc	51.67
Fytolan 1200 g/ha	69.00	73.33	66.33	55.67	42.33a	38.00a
Calixin 180 ml/ha	70.33	78.33	64.67	61.00	55.00bc	52.33b
Calixin 180 ml + Vinofan-In 500 ml/ha	66.33	71.67	64.00	54.00	51.67b	50.33b
Calixin 180 ml + Vinofan-In 500 ml + Blitox 600 g/ha	75.00	79.00	76.67	58.67	49.67ab	46.33ab
Black plucking + Blitox 600 g/ha	69.00	74.33	65.33	53.67	45.33ab	43.67ab
CV%	7.33	7.79	8.50	13.23	9.79	10.24

* Average three replicates

** Days after treatment

Vinofan-In. The results suggested that black plucking could help reduce quantity of fungicide(s) applied in blister control, economising the cost of spraying. The effect of black plucking *vis-a-vis* standard plucking on yield is under study to analyse the cost-benefit ratio of fungicide treatments.

Calixin shows poor retention under wet weather conditions. Presence of binder is reported to enhance Calixin efficacy (Chandra Mouli et al., 1986). In the present studies also, higher disease control was achieved with Calixin in combination with Vinotan-In than with Calixin alone.

Another interesting aspect in blister blight control is the economic threshold level, delineated at 35% disease incidence (Webster and Park, 1956). Although, application of Fytolan, Blitox or Calixin in conjunction with Blitox provided adequate disease control, disease incidence exceeded the desired critical threshold level. This is possibly related to the high atmospheric inoculum load, as is suggested by the high disease incidence recorded from the beginning of experiment. The blister severity, in addition to atmospheric temperature, relative humidity, and leaf wetness, is directly influenced by the atmospheric spore-load (Chandra Mouli, 1983; Chandra Mouli and Premkumar, 1984; Satyanarayana, 1987). The fungicide efficacy is also directly correlated to atmospheric spore-load (Venkata Ram, 1984). Histopathological studies under light and transmission microscopy also showed enormous production and liberation of basidiospores into the atmosphere, following disintegration of host-surface under mechanical pressure of fungal growth in infected leaf-tissue. These basidiospores initiated fresh infection. The present studies, therefore, point to the need for further experiments with dosage and combinations of different fungicides for blister blight control within economic threshold level under Kangra Valley conditions.

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PHYTOSANITARY SEED TREATMENTS IN OIL PALM *ELAEIS GUINEENSIS* J.

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ABSTRACT

The seeds of oil palm harbour several fungi on the mesocarp remnants. To prevent the spoilage of seeds by fungi and to check their spread to new areas (when germplasm introductions are made) the effects of methyl bromide fumigation and five fungicides were tried before preheating the seeds. The seed microflora, germination and seedling vigour were monitored. Methyl bromide fumigation reduced germination and had no effect on external microflora. Hence it cannot be recommended for seed treatment. Fungicide treatments increased seed germination and seedling vigour. Wet fungicide treatments with Emisan 6 (Methoxy Ethyl Mercury Chloride) 0.1% and Foltaf 80W (Captafol 80% WDP) 0.2% for 20 min. before preheating were effective in eliminating external microflora and helped in increasing seed germination and seedling vigour. Thus seed treatment with fungicides was the best for phytosanitary treatment of oil palm seeds.

INTRODUCTION

A total area of about 5000 ha has been brought under oil palm in Kerala and Andamans by introduction of seed materials/pollen from Africa and Malaysia. The expansion of oil palm cultivation warrants import of large number of seeds of promising lines from other oil palm growing countries. However utmost care should be taken to avoid introduction of pathogens / diseases especially vascular wilt (*Fusarium oxysporum* f. sp. *elaeidis*), freckle (*Cercospora elaeidis*), fatal yellowing and cadang-cadang (Turner, 1981).

As a precautionary measure for the oil palm seeds transported from Kerala, where spear rot (unknown etiology) prevails, to other states, seed treatment against micro-organisms was felt necessary though it is not foolproof against all pathogens. Spoilage of seeds due to brown germ disease during storage also required treatment techniques. With the above objective a seed treatment experiment was carried out during 1987-88.

MATERIALS AND METHODS

A total of 1500 seeds were collected from 3 *dura* palms at Palode in 1987. The seed preparation was done by retting, smashing in sand mixture, cleaning and shade drying for one day. The seeds were stored in polythene bags of 600 gauge at room temperature for one month. The moisture content of the seeds were estimated by oven method. The external and internal microflora of the seeds were isolated, identified and estimated. The seeds were divided into 10 lots of 150 seeds each and the following treatments were given: Methyl bromide fumigation at room temperature : 16 gm/m³ for 12h, 24 gm/m³ for 12 h, 32 gm/m³ for 6 h and 40 gm/m³ for 6 h; Wet fungicide treatments for 20 min. in Emisan 6 (Methoxy Ethyl Mercury Chloride) 0.1% solution; Thiride 75 WDP 0.2%, Sten 50 0.2%, Foltaf 80W (Captan) 0.2%, Benlate 0.1% and control. The seeds treated with fungicides were dried in shade for 6 h, transferred to polythene bags of 600 gauge

and preheated in oven at a temperature of 40°C for 90 days. The post treatment microflora population was estimated. The moisture content of the seeds increased to about 21% by soaking in water for 5 days. After shade drying for 6 h the seeds were kept in moist polybags for germination. The germination count was recorded every week for five months. The viability of ungerminated seeds was ascertained by tetrasolium test. Sprouted seeds were planted in polythene bags of size 40 x 35 cm and the percentage of emergence was recorded. The height and number of leaves of the seedlings were also recorded 4 months after planting.

RESULTS

The moisture content of the seeds before treatments was 18 per cent. The microorganisms associated with the seeds in the pre-treatment isolations were *Rhizopus nigricans*,

Aspergillus niger, *A. terreus*, *A. fumigatus*, *Schizophyllum commune* and *Bacillus subtilis*. The seeds treated with Emisan and Captan did not yield any external microflora. Lesser population of fungi was noticed in the seeds treated with Thiram and Benlate. Microbial population of methyl bromide fumigated seeds and Sten 50 were similar to the untreated seeds. Changes in internal microflora population were not noticed in any of the treatments.

The effect of treatments on seed germination are presented in Table I. The percentage of germination under different chemicals ranged from 20.7 to 93.8 while the control had 87.6. Methyl bromide fumigation was found to reduce the germination percentage (23.7 to 79.3%). The impact of methyl bromide on germination percentage and the time taken for germination increased with

Table I. Effect of seed treatment on germination

Treatment	Percentage germination					Total
	at different intervals (in days)					
	20	25	50	110	140	
Methyl Bromide 16 gm/m³-12h	0	0	45.5	29.0	2.1	76.6
Methyl Bromide 24 gm/m³-12h	0	8.3	29.0	30.3	1.4	69.0
Methyl Bromide 32 gm/m³-6h	0	0	33.1	20.0	0	53.1
Methyl Bromide 40 gm/m³-6h	0	0	15.9	4.8	0	20.7
Emisan 0.1 %	60.7	21.4	5.5	0	2.7	90.3
Thiram 0.2 %	32.4	38.6	14.5	4.1	0	89.6
Sten 50 0.2 %	15.2	39.3	29.6	3.4	2.1	89.6
Captan 0.2 %	49.6	35.9	6.9	0.7	0	93.1
Benlate 0.1 %	53.8	26.2	11.0	2.8	0	93.8
Control	40.7	17.9	20.0	9.0	0	87.6

the increase in dose. Wet fungicide treatments increased the germination over control. Higher percentage of germination was noticed in treatments with Benlate, Captan and Emisan. These treatments gave higher percentage of early germination (in 25 days time).

Data on seedling emergence and seedling vigour are given in Table II. The wet fungicide treatments improved the percentage emergence and seedling vigour over control.

DISCUSSION

Since species of *Aspergillus*, *Rhizopus*, *Schizophyllum* and *Penicillium* causing brown germ disease are usually present in the seeds prepared by the recommended method of seed preparation, it is necessary to take up proper seed treatments. Methyl bromide fumigation at the optimum seed moisture content of 18 per cent was found to delay germination indicating the penetration of the chemical to the embryo. Mok (1970) reported that methyl bromide fumigation affected viability of seeds with moisture content above 15 per cent and also suggested that *Dura* seeds at moisture content of 10 per cent can be fumigated at 23.89–29.44°C with 32 gm/m³ of methyl bromide for 18 h without impairing the viability, germina-

tion, emergence and vigour of seedlings. As a phytosanitary measure for importation, treatment of seeds (ungerminated and pre-heated) with methyl bromide 32 gm/m³ at room temperature for 2 h followed by 5 min soaking in 0.1% benlate solution has been earlier recommended (Kang, 1986). But methyl bromide fumigation is not practical in view of the impairment in viability and germination at low moisture levels. A trial on seeds with suspected seed borne pathogens in the embryo at different moisture levels ranging from 10–18% would give clues on the elimination of different pathogens.

Increase in germination observed in fungicide treated seeds is an indication of the elimination / reduction in microflora causing seed spoilage. This reduction in microbial spoilage has increased the emergence and vigour of seedlings. It is possible to reduce the internal microflora by increasing the period of exposure to fungicides, thus enabling absorption of fungicide solution. Among the fungicides Captan, Emisan and Thiram which reduced the microbial population and enhanced seed germination and seedling vigour are being recommended for phytosanitary seed treatments in storage and importation of seeds.

Table II. *Effect of seed treatment on seedling emergence and vigour*

Treatment	Percentage emergence	Mean height in cm.	Per cent increase over control	Mean No. of leaves	Per cent increase over control
Emisan 0.1%	93.3	21.51	22.56	4.30	26.47
Thiram 0.2%	94.8	23.27	32.59	4.25	25.0
Sten 50 0.2%	94.3	21.95	25.07	3.45	1.44
Captan 0.2%	85.8	22.20	26.49	4.19	23.23
Benlate 0.1%	88.4	20.91	19.14	4.08	20.0
Control	57.0	17.55		3.40	

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INTEGRATED CONTROL OF RED ROOT DISEASE OF COFFEE

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ABSTRACT

A preliminary survey for root diseases in Kodagu indicated that the red root disease was around 0.72% (confined to in and around Gonicoppal) while brown root disease was 0.73% (in Napoilu, Virajpet and Srimangala zones) and *Poria* has got a wide range of collateral hosts. Silver oak appears to be an ideal host. *Maesopsis emini* of exotic origin, sparsely planted as shade in coffee estates were found free from red root disease.

Effective uprooting, destruction of diseased coffee and shade trees followed by isolation of sites by trenches gradually reduced the fresh attack by red root disease. Collar opening of healthy coffee inside the trench around infected coffee has maintained them disease free for over 38 months. Selections of Arabica, Robusta including Excelsa were observed to be susceptible in screening programme. The disease symptoms are exhibited after 21-31 months of inoculation. Injury does not seem to be a precondition for infection.

Of the 7 chemicals tried, Plantvax 0.1% a.i. concentration afforded control of diseased plants while others were totally ineffective.

Integrated control stresses the advantage over selective methods and demonstrated the possibility of eradication at the same time reviving the health of infected plants to normal condition thereby reducing loss of plants.

INTRODUCTION

Red root disease, a common disease of tea was reported in coffee during 1975 (Venkata Ram and Muthappa, 1975). Studies on red root disease are scanty. Venkata Ram (1975); Gadd (1929, 1939) and Shanmuganathan (1967) suggested phytosanitary measures for effective control of red root disease.

Preliminary survey conducted in Kodagu to identify root disease problems showed that red root disease caused by *Poria hypolateritia* Berk was confined mostly in and around Gonicoppa while brown root disease caused by *Fomes noxius* Corner, was seen in Napoklu, Virajpet and Srimangala zones. *Syzygium jambolana*, *Pterocarpus marsupium*, *Dalbergia latifolia*, *Cedrella toona*, *Ficus tsiela* *Ficus tjakela*, *Ficus glomerata*, *Acrocarpus*

fraxinifolius, *Artocarpus integrifolia*, *Erythrina lithosperma* and wild cinnamon were found to be collateral hosts.

Venkata Ram (1974) opined that incubation period of *Poria* might vary from 2-5 years. Hence a study was undertaken to know precisely the incubation period of *Poria* on coffee.

Opening the soil at collar and cleaning of the plants in the diseased area rendered them disease free (Haryono Semangun, 1983).

MATERIALS AND METHODS

Studies on disease incubation period

Ten earthen pots of 45 cms height and 30 cms wide were filled to the capacity with autoclave sterilised soil. The pots were divided

into two sets of five each. In one set, roots of test plants were injured slightly with sterile knife. In the other set, roots were left intact. Two pots from each set were soil inoculated with four bits each, *Poria* naturally infected silver oak root measuring 7.5 cms. Another two pots from each set were soil inoculated with *Poria* naturally infected roots of coffee, at the same inoculum level. One pot from each set without inoculum served as control. All the pots were planted with 18 months old S 795 plants and maintained. Visual observations on the conditions of the plants were recorded periodically (Table I).

Table I. *Incidence of red root disease in the incubation studies*

Method of inoculation	% Infection
Roots injured, inoculated with naturally infected coffee roots	100
Roots intact, inoculated with naturally infected coffee roots	100
Roots injured, inoculated with naturally infected silver oak roots	50
Roots intact, inoculated with naturally infected silver oak roots	50
Roots injured/ intact with inoculum	0

Field trials

Field control trials were initiated during 1985 in two locations viz., A. Santicoppa and B. Chettalli. At Santicoppa plot, 18 coffee and 3 shade trees were affected by disease whereas at Chettalli the corresponding disease affected plants were 134 and 98. Red root disease affected shade trees and coffee plants were got uprooted periodically and destroyed, followed by isolation trenches covering a ring of healthy plants.

Collars of healthy coffee plants inside the trenches surrounding the infected coffee in

location A and B were got opened from soil and soil adhering on such collars were got cleaned with coir rope.

Fungicides/chemicals like Bavistin 50 WP, Bayleton 25 EC, Vitavax 75 WP, Derosal 50 WP, Plantvax 20 EC (at 0.1% a. i. con.) Bordeaux mixture 1.0% and concentrated liquor ammonia (Commercial grade at 0.5 lt/plant) were used as soil drench around affected coffee plants. Fungicides were used @ 5 l. of solution per plant. As Plantvax was highly effective and others were ineffective, the same was continued at monthly intervals. Monthly applications varied from 9 to 15 depending on the recovery of the plants.

RESULTS AND DISCUSSION

In the incubated plants, initial symptoms like stunted growth, reduction in the size and paleness of leaves appeared in about 21 months. The leaves started turning yellow with poor anchorage. Symptoms become more pronounced in one plant where the roots were injured and inoculated with *Poria* naturally infected silver oak roots. The infected plant was removed by 28th month to check for the infection and it was positive. The rest of the plants, were taken out of pots by 31st month. Infection of hosts varied in the two different sources of inoculum. Control plants in both the sets were free of infection. Infection was seen in the sets where the roots were injured and also maintained intact. Infection was 100%, where infected coffee roots were used as source of inoculum, while it was 50% when infected silver oak roots were used as inoculum source.

In the field trials in location A, no fresh attack of shade trees was seen since 1986. In coffee the fresh attack was 44.5% during 1986, 12.5% in 1987 and nil in 1988. In location B, fresh attack of shade

trees was 40.8% in 1986, 18.4% in 1987 and 12.2% in 1988. Fresh infection of coffee was 52.5% in 1986, 22.4% in 1987 and 14.9% in 1988.

Collar opened and cleaned plants within the trenches remained disease free even after 38 months.

Of the 7 chemicals tried, Plantvax at 0.1 % concentration has afforded 33% control in location A and 66% in location B. Hormonol at 1 ml/litre was incorporated to Plantvax solution to facilitate early initiation of roots. Recovery of plants has been remarkable.

Coffee selections 795, 5, 6, 7, 274, 2464, Tafari-kela and excelsa were planted in red root disease affected estate in Kodagu during 1985 and all were found susceptible to *Poria*.

Survey indicated that the incidence of red root disease was around 0.72%, while brown root disease was 0.73% in Kodagu.

Progressive reduction in the fresh attack of coffee and shade trees was noticed by cultural means of control in both the locations. Good control was noticed in location A, where the problem was identified quite early and with the conventional cultural means of control (Uprooting, destruction and isolation) no more fresh attack of shade trees and coffee was recorded. This strongly indicated that the early detection of the disease followed by effective control measures would contain the disease spread. Protection of healthy plants beyond 38 months in the vicinity of affected ones by collar opening and cleaning was found effective in maintaining healthy plants. Plantvax was found most effective in checking the disease. Since root disease occur in pockets, the application of fungicides is location specific and hence overall requirement of chemical is much less. Incorporation of Hormonol helped

in the speedy recovery of affected plants. There is a need to identify resistance to *Poria* in coffee as well as in suitable shade trees.

Maesopsis emini from East Africa, sparsely planted as shade trees in coffee estate has been observed to be free from *Poria* infection so far. High susceptibility of silver oak is in conformity with observations made by Venkata Ram (1974). Since infected coffee root were found as the best source of inoculum removal of infected plants in the plantation would reduce the inoculum buildup and consequent disease spread. Spot soil sterilisation of *Poria* infected patches would reduce inoculum build up. As reported, broadcasting *Crotolaria* seeds in *Poria* patches might help in detecting the soil borne inoculum in soil for safe planting.

(Precise method of early detection would help in taking effective disease control measures. The cultural practices of roguing infected plants, opening the soil at collar region of the healthy plant in infected area, and isolation, coupled with plantvax application would be the ideal strategy for controlling the disease based on the present study.)

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STANDARDISATION OF SCREENING TECHNIQUES AGAINST 'AZHUKAL' DISEASE OF SMALL CARDAMOM (*Elettaria cardamomum* MATON)

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ABSTRACT

Screening techniques were standardised for evaluating the susceptibility of cardamom cultivars against 'Azhukal' disease caused by *Phytophthora meadii*. A number of screening experiments were carried out in the laboratory and in the field using different forms of inocula such as zoospores, mycelial culture discs and infected cardamom seeds. In young seedlings, zoospore sprayings was found to be superior to seedling dip method. Mature plant parts such as leaves, rhizomes, panicles and capsules were inoculated with zoospores, mycelial culture discs and artificially infected cardamom seeds in laboratory and field conditions. Among the various methods tested, inoculation on cut tips of capsules of detached panicles with mycelial culture disc was found to be an easy and effective method of screening. Inoculation of panicles with artificially infected cardamom seeds was also found to be effective but inferior to culture disc method.

INTRODUCTION

Small cardamom (*Elettaria cardamomum* Maton) is cultivated on a large scale in the tropical evergreen forests of Western Ghats. Among the many diseases that the crop, 'Azhukal' or capsule rot is the most serious one (Menon et al, 1972). The disease occurs in the high ranges of Kerala and brings about crop losses upto 30% (Nambiar and Sarma, 1976). Recent studies on the etiology of the disease showed that it is *Phytophthora meadii* Mc Rae of A₂ mating type (Anonymous, 1986). The field control of the disease through fungicides alone is not possible always since azhukal incidence is closely linked with heavy and continuous rainfall. It has been reported that crop resistance together with plant sanitation and fungicidal application plays an important role in achieving satisfactory disease control (Jacob, Okaisabor and Adebayo, 1973).

The objective of the present study was for evolving an effective and easy method for testing the resistance/tolerance of cardamom cultivars against *P. meadii* infection.

MATERIALS AND METHODS

Pure culture of *P. meadii* was obtained from 'azhukal' affected capsules following the selective isolation technique described by Tsao and Guy (1977). For standardizing the techniques cv. Malabar LBC was used throughout.

Preparation of inocula

P. meadii was grown on carrot agar in darkness for 48 hours and the cultures were incubated in light for 24 hours at 25°C to induce sporulation. Zoospore suspension was prepared from sporulated culture discs by cold shock treatment (Tsao and Garber, 1970). For the culture disc inoculation

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method, 10 mm sized mycelial discs were cut from 48 hrs. old culture using a cork borer. Seed inoculum was prepared by artificially inoculating green capsules with culture bits and incubating them for 7 days under humid conditions. Seeds extracted from fully infected capsules were used for inoculation.

Methods of inoculation

(a) *Seedling dip method*: Four months old seedlings grown under sterile conditions in green house were removed, washed thoroughly and kept in a beaker containing 25 ml zoospore suspension at a concentration of 1.5 lakh spores/ml. Assessment of infection was made as percentage mortality after 4 days.

(b) *Zoospore spray method*: Spraying with zoospore suspension was done in 4 months old potted seedlings as well as on panicles of mature plants using an atomiser. Zoospore spraying was done on detached panicles in the laboratory and also on intact panicles in the field. One set of panicles sprayed in the field was kept in polythene cover to retain humidity while other set was kept without cover. The seedlings and panicles sprayed in the laboratory were also kept in moist chamber at 24–25°C with an R. H. of 75–80%.

Leaf and rhizome bits were also inoculated by placing a drop of zoospore suspension on them using a syringe.

(c) *Culture disc inoculation*: Inoculation of detached panicles was done in the laboratory as follows: A 5 mm culture disc was cut from actively growing culture and placed on the panicles at 10 cm distances at the nodal regions. A piece of moistened cotton was also kept and the inoculated panicles were placed in polythene bags to retain humidity.

Individual capsules on the panicles were inoculated by cutting their tips and placing

2 mm size culture disc as described by Weststeijn (1969). The inoculated panicles were incubated in moist chamber.

(d) *Inoculation with infected seeds*: Inoculation of panicles and capsules with artificially infected seeds was done as follows: Each nodal portion of the panicle or capsule tip was inoculated with infected seeds and incubated in moist chamber. Five to six panicles were screened each time and the experiments were repeated until consistent results were obtained. In all cases, the percentage of capsule infected was taken as the criteria for assessing the tolerance.

RESULTS

Observations on seedling mortality and percentage of capsules/leaf bits infected were recorded upto 15 days after inoculation. Results of the screening methods in seedlings are presented in Fig. 1. In the seedlings, spraying with zoospores gave a high percentage of infection than the seedling dip method. In the dip method, infection was noticed as early as 4 days after inoculation. In the zoospore spray method the infection began on the 8th day and thereafter steadily increased upto 90% on 14th day.

Inoculation by zoospore spraying on detached and intact panicles also gave a high percentage of infection. In detached panicles, early symptom development was seen on the 4th day after inoculation while in the field the symptoms appeared after 8 days. Fig. 2 shows comparison between laboratory and field inoculations by spraying and also the difference in percentage infection between open and covered panicles in the field. Infection percentage was generally high in detached panicles. In field, a slightly higher percentage infection was noticed in covered panicles.

Inoculation on rhizomes with drops of zoospore suspension did not give infection to

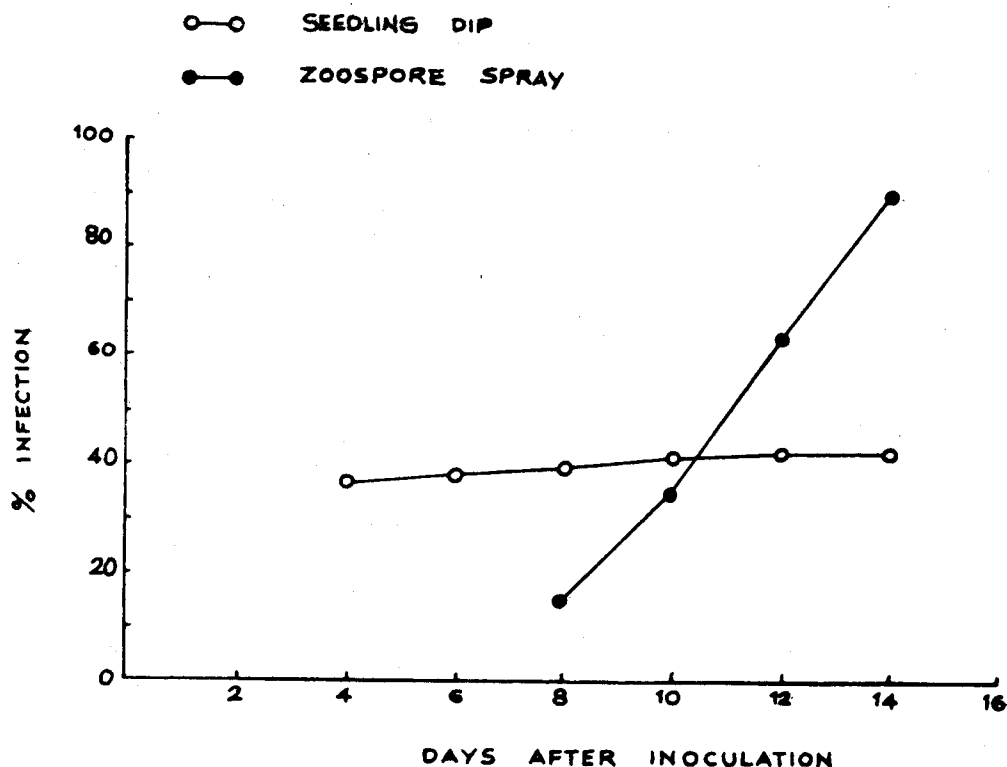


Fig. 1. Percentage infection of cardamom seedlings under seedling dip and zoospore spray methods

detectable levels. In leaf bits, upto 35% infection was noticed within 5 to 6 days after inoculation. However, no consistent results were obtained with leaves and rhizomes. Results of culture disc and seed inoculation methods are presented in Table I. Inoculation on detached panicles with 5 mm size mycelial culture discs showed infection on the panicles and capsules. On the 8th day upto 24% infection was seen on the capsules. Lesions developed on panicle axis and these extended both upwards and downwards. A high percentage of capsule infection and early symptom development was noticed when cut tips of capsules were inoculated with 2 mm culture discs. Lesions appeared on the 4th day after inoculation from the cut portions and slowly extended towards the pedicel. Inoculation of panicles and capsule tips with

infected cardamom seeds also resulted in considerable extent of infection but only second to that of culture disc inoculation.

DISCUSSION

Different methods of inoculation tried showed considerable variation in the percentage infection. It has been shown that for a comprehensive assessment of resistance/susceptibility status of a cultivar, two or more methods of screening is desirable in addition to field resistance (Kularatne and Jacob, 1980). In seedlings, spray inoculation with zoospores was found to be more effective than seedling dip method.

Inoculation in the laboratory and field showed that in detached panicles the percentage of infection and severity are much higher

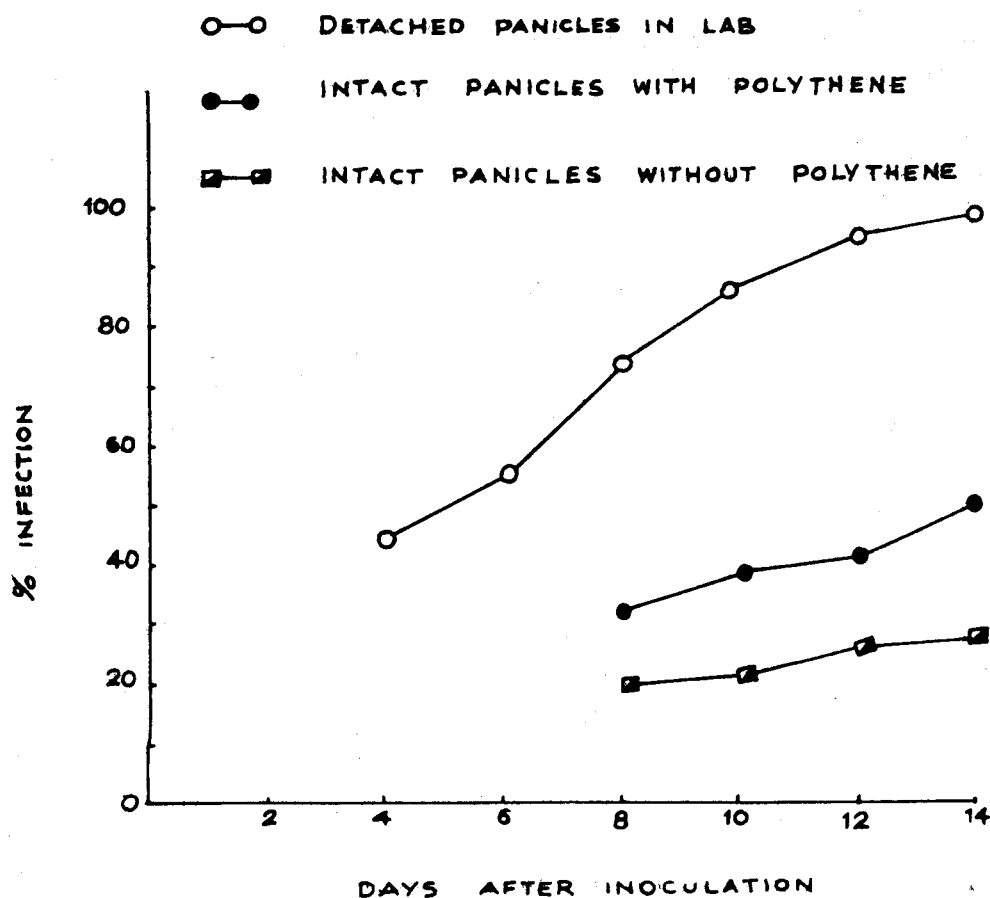


Fig. 2. Percentage infection of cardamom panicles in detached and intact conditions

Table I. Screening of bearing panicles of cardamom using different forms of inoculum

Treatment	No. of Panicles	No. of capsules inoculated	No. of capsules infected	Per cent infection on 8th day	Time taken for rotting
Zoospore spray	8	190	123	64.7	4-8 days
Culture disc (5 mm size) on panicles	6	112	27	24.0	8-10 days
Culture discs (2 mm size) on cut tips of capsules	8	190	126	66.5	4-5 days
Infected seed on panicles	6	178	72	40.5	8-10 days
Infected seed on cut tips of capsules	6	160	38	32.7	10-14 days
Infected seed inoculation on panicles in the field	12	227	46	20.30	14 days

than those in attached panicles. Similar differences have been observed in the case of cacao (Blaha, 1967). However, the degree of resistance in detached panicles under laboratory conditions could be used as an indication of a higher resistance that can be expected under field conditions (Lellis and Peixoto Filho, 1960).

Though spraying of seedlings and panicles with zoospore suspension showed higher disease incidence, the preparation of inoculum is much cumbersome and time consuming for large scale inoculations. For the quick production of large quantities of inoculum in the shortest period and getting maximum infection percentage, the culture disc inoculation method is superior to other methods. Placing culture bits on cut tips of capsules is advantageous in getting early and uniform capsule infections which can be rated as per severity. Though production of large quantities of inoculum as infected seeds is much easier than other methods, the seed inoculation method is time consuming and less effective as compared to the former.

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A COMPARISON OF ISOLATES OF *KOLEROGA NOXIA* ON *COFFEA ARABICA*

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ABSTRACT

A comparison of isolates of *Koleroga noxia* Donk. (= *Pellicularia koleroga* Cooke, *Corticium koleroga* (Cooke) V. Hohnel, *Ceratobasidium* sp.) from three different zones of Chikmagalur District, causing black-rot disease of coffee, showed variation in their morphology *in vitro* and in basidial characteristics.

The pathogenicity tests carried out on *Coffea arabica* L. under modified propagation chamber in the nursery, using pure cultures of these isolates revealed difference in their virulence.

INTRODUCTION

Black-rot or koleroga disease on *Coffea arabica* L. by *Koleroga noxia* is prevalent in most of the coffee growing regions of the world and considered to be the second important disease in India. Blackening and rotting of the affected leaves, twigs and developing berries are the common symptoms. Affected leaves get detached from the branches and hang down by means of slimy fungal strands. The fungus develops on the surface as a film, which can be easily peeled off when wet. Continuous south-west monsoon without a long dry spell, atmosphere saturated with 95-100% relative humidity, thick over-head shade, sheltered from sun light and wind in valleys, frequent or continuous mist during monsoon are essential for the outbreak of black-rot.

Cooke (1876 a,b) first described the disease from the material collected in Mysore State and identified it as *Pellicularia koleroga*, as a hyphomycetous fungus. Hohnel (1910) re-

examined the collection of Cooke and identified basidia and basidiospore and re-named the pathogen as *Corticium koleroga* (Cooke) v. Hohnel. Coleman, Venkata Rao and Narasimhan (1923) isolated the fungus first time and proposed the name *Hypochnus koleroga*. Roger (1943) suggested for the revival of old name *P. koleroga*. Venkatarayan (1949) rejected the Cooke's nomenclature and opined that coffee black-rot fungus should be known as *Botryobasidium koleroga* (Cooke) Venkatarayan. Donk (1958) proposed new genus and species and re-named it as *Koleroga noxia* Donk. Talbot (1965) considered *Koleroga noxia* as synonym of *Ceratobasidium* sp. Talbot. Opinion differed between the investigators on the morphology of this fungus. Coleman et al. (1923), Narasimhan (1933), Mathew (1954 a) and Muthappa (1979) described the sclerotial stage apart from basidial or pellical stage. But Donk (1958) described it without sclerotia. Talbot (1965) observed the repetitive

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spore and others described it without repetitive spore. More than one species of pathogen i.e., *Rhizoctonia ramicola* (= *Ceratobasidium ramicola*) and *Pellicularia koleroga* (= *Ceratobasidium* sp.) have been recorded on the leaves of *Pittosporum tobira* (Roger, 1943; Weber and Roberts, 1951).

The conflicting opinion on the morphology and taxonomy of this fungus might be due to the examination of the specimen collected from different locations by earlier investigators. The present studies were carried out to compare the isolates of the black-rot pathogen from different locations in Chikmagalur District.

MATERIALS AND METHODS

Cultural and morphological characteristics

Koleroga noxia was isolated from three different locations viz., Sanjignekhan estate

(isolate I), Alageswara estate (isolate II) and CCRI farm (isolate III) of Eastern Giris, Koppa and Balehonnur zone respectively (Table I) by adopting the method of Coleman et al. (1923). They were grown on 2% potato dextrose agar (PDA). The cultures were maintained on PDA and malt extract agar (MEA) slants supplemented with trace of thiamine. Observations were made after 15 days of growth of each isolate. Basidia, basidiospores and sterigmata were compared by collecting the fresh specimen.

Pathogenicity

Inoculations were carried out in the propagation chamber under nursery conditions. Required temperature and humidity were maintained by spreading gunny bags inside the chamber and watering it four times on each day. Ten seedlings each of one-year-old *C. arabica* (cv.S.795) were used for

Table I. Details of the locations from where *K. noxia* was isolated for comparison

Aspect	Location		
	Sanjignekhan	Alageswara	Central Coffee Research Institute
Coffee zone	Eastern Giris	Koppa	Balehonnur
Altitude	1212 m.	909 m.	904 m.
Rainfall	2000-2150 mm.	3000-3100 mm.	2500-2750 mm.
Material and spacing	S. 795, 1.98 m.	S. 795, 1.98 m.	S. 795, 1.98 m.
Age of the material	15-35 years	20-25 yrs.	15-20 years
Shade pattern	Thin	Thin	Medium
Shade trees	<i>Grevillea robusta</i> <i>Ficus tjakela</i> <i>Ficus tsiela</i> <i>Ficus glomerata</i> <i>Bischofia javanica</i>	<i>Grevillia robusta</i> <i>Albizzia stipulata</i> <i>Ficus tsiela</i> <i>Ficus tjakela</i> <i>Mangifera indica</i>	<i>Grevillia robusta</i> <i>Ficus tsiela</i> <i>Ficus glomerata</i> <i>Dalbergia latifolia</i>
Plant protection operations attended to	Pre & Mid-monsoon spray with 1% and post-monsoon 0.5% Bordeaux mixture	Pre & Mid-monsoon with 1% and post-monsoon 0.5% Bordeaux mixture	Pre & Mid-monsoon with 0.5% Bordeaux mixture
Incidence of black-rot	Medium to severe	Low to medium	Low

inoculation. Approximately of same age, one pair of leaves were inoculated by using the respective isolates, by adopting the method of Sudhakar Bhat (1985). Inoculated plants were kept inside the chamber and leaves were kept wet by spraying water. Humidity and temperature were recorded throughout the experiment by using thermohygrograph. Observations were recorded each day upto 15 days after inoculation.

RESULTS

Cultural and morphological characteristics

Isolate I: Growth of the colony was 90 mm in three days, hyaline when young, turning dark brown. Hyphae hyaline and changes to brownish, diameter ranging from 5.83 (7.13) to 9.16 μm . Sclerotia oval, hard and developed between 8–10 days, hyaline to dark brown on the surface of the media and also on the walls of the tube. Oozing of the brown liquid from the sclerotia was seen on the surface of the medium. Sclerotia measured 425 x 283 (900 x 625) to 1912 x 1473 μm . Basidia were simple, club shaped, size varied 8.32 x 5.83 (10.02 x 6.99) to 11.65 x 9.16 μm . Basidiospore smooth, hyaline, not repetitive, size 4.16 x 2.49 (5.49 x 2.90) to 6.66 x 4.16 μm . Sterigmata four in number, length ranging from 3.33 (5.03) to 6.66 μm (Plate I, Figs. 5–8).

Isolate II: Growth of the colony was 90 mm in three days. Hyaline when young and turning pale brown, diameter 2.5 (5.99) to 6.66 μm . Sclerotia oval to round, developed both on the surface of the media and walls of the tube, dark brown in colour, smooth, size 283 x 283 (664 x 534) to 1770 x 1204 μm . Basidia simple, club-shaped, size 7.49 x 6.66 (10.42 x 9.52) to 11.65 x 9.99 μm , bearing four sterigmata, length varied 2.5 (4.53) 6.66 μm . Basidiospores smooth, not repetitive, size ranging from 6.66 x 2.49 (9.36 x 3.45) to 11.65 x 4.16 μm . (Plate I, Figs. 1–4).

Isolate III: Growth of the colony was 90 mm in eight days. White to cream colour. Hyphae hyaline to pale brown, diameter 4.16 (5.78) to 7.5 μm . Sclerotia developed only between 13–15 days on the walls of the tubes, round to oval, smooth, size 170 x 142 (380 x 292) to 708 x 566 μm . Basidia simple, formed at the end of the lateral branches, club-shaped and measuring 8.2 x 6.66 (9.36 x 7.33) to 11.68 x 9.16 μm . Sterigmata four in number, length 4.16 (7.83) to 17.83 μm . Basidiospore smooth, hyaline, not repetitive, size 6.66 x 2.49 (6.69 x 3.16) to 9.99 x 4.16 μm (Plate I, Figs. 3–6).

This isolate after 3–4 sub-culturing failed to grow on PDA. Hence, the cultures are maintained on 2% MEA supplemented with trace of thiamine (Plate II, Figs. 1 and 2).

Mycelial branching nearly at right angles and anastomosis of hyphae were common in all the three isolates. Fructification resupinate, white, form slimy pollicle on the under surface of the affected leaves in all the three isolates.

Pathogenicity

The visual symptoms of the black-rot disease viz., formation of brown to black slightly depressed irregular patches were observed in all the three isolates between 3–10 days. All the inoculated leaves were infected between 3–6, 4–7 and 6–10 days in isolate I, II and III respectively. Percentage of leaves infected by each isolate on respective day are presented in Table II. However, pellicle stage of the fungus was not observed in any of the three isolates.

DISCUSSION

The results of the comparison of the three isolates of coffee black-rot pathogen *Koleroga noxica* showed considerable variability. Isolate III differed from the other two isolates on slow growth and pale to cream colour

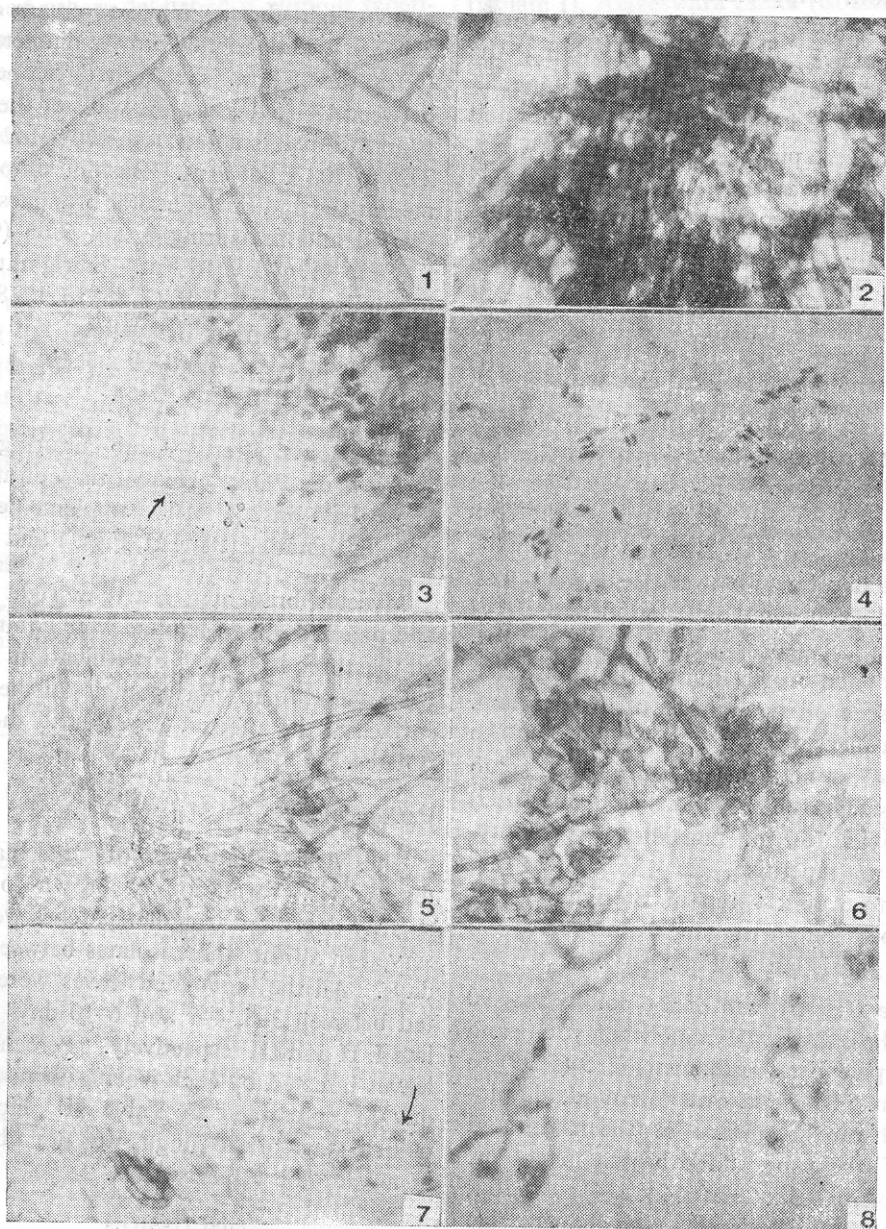


PLATE I

Fig. 1-4. Isolate II of *K. noxia*. 1. Hyphae, 2. Sclerotia, 3. Basidia with sterigmata and 4. Basidiospores
Fig. 5-8. Isolate I of *K. noxia*. 5. Hyphae, 6. Sclerotia 7. Basidia with sterigmata and 8. Germinating basidiospores

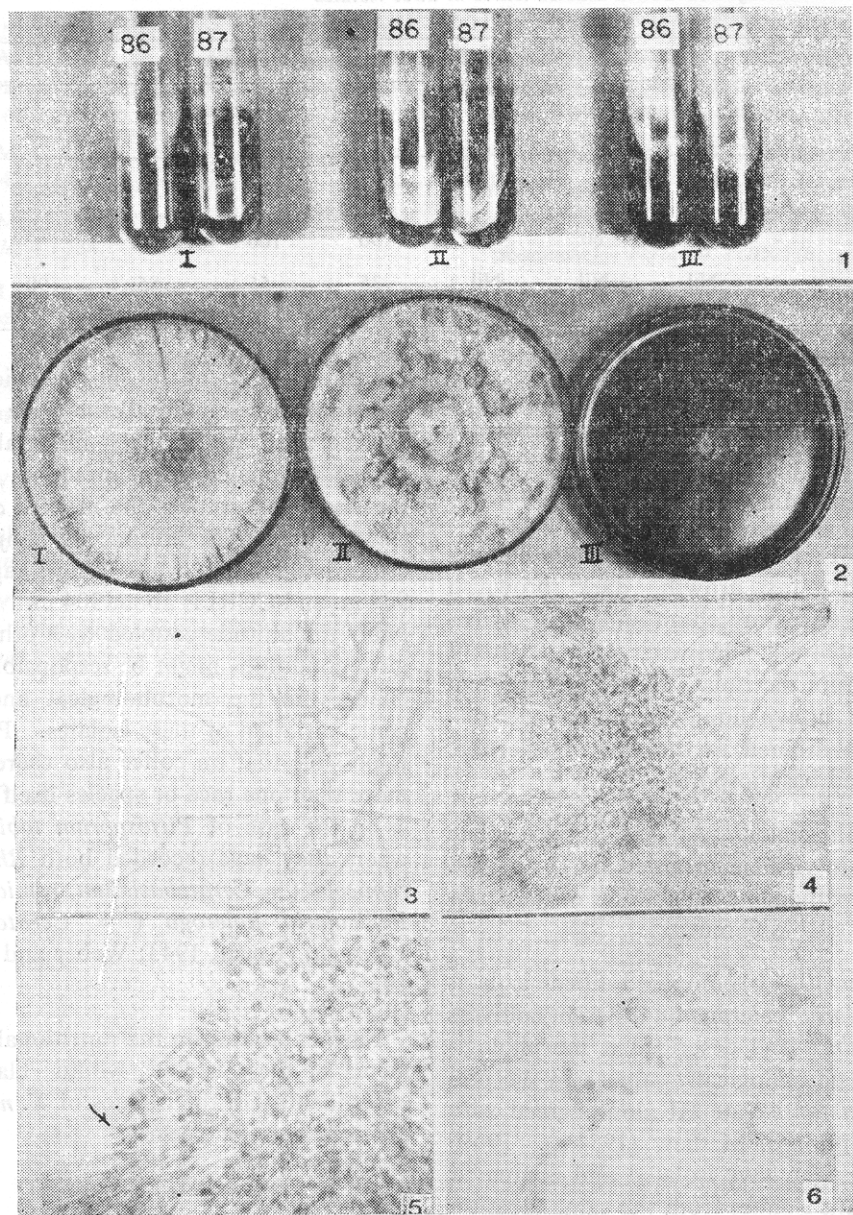


PLATE II

- Fig. 1. 20-day old culture of *K. noxia* isolates I, II, and III on MEA of two seasons.
 Fig. 2. Ten day old *K. noxia* isolates I, II & III on MEA after one year of isolation.
 Fig. 3-6. Isolate III of *K. noxia* 3. Hyphae, 4. Sclerotia, 5. Basidia with sterigmata and 6. Basidiospores.

Table II. *Per cent infected Coffea arabica leaves in three isolates*

Isolate	Per cent infected leaves							
	No. of days							
	3	4	5	6	7	8	9	10
I	55	80	90	100				
II	Nil	60	80	90	100			
III	Nil	Nil	Nil	35	55	85	90	100

colony. Further, this isolate failed to grow on PDA after 3-4 sub-culturing. Cultural and morphological characters of this isolate agreed with the earlier works of Mathew (1954 a) and Muthappa (1979).

Isolates I and II have a few similar characteristics like fast growth, dark brownish colony, broader mycelium and early formation of sclerotia. However, the isolate I differed from the isolate II having hard and oozing of brown liquid from the sclerotia. They also differed in the size of sclerotia, basidia and basidiospores.

The pathogenicity test showed that isolate I was more virulent followed by II and III. Thus the pathogenic capabilities of these isolates are also different.

Mathew (1954 b) compared fifteen isolates of *Pellicularia koleroga* on different cultivars of *C. arabica* and described it morphologically and physiologically same. In the present study the isolate III alone agreed with the description of Mathew (1954 a). Probably, he might have isolated and compared the different isolates from the same location i.e., at C. C. R. I. Farm.

The differences in the morphological and pathogenicity characters between the three isolates from the three different estates clearly indicated that physical conditions might be responsible for the marked changes between

the three isolates of this fungus which caused the same disease. In all the three locations the material, age of the material, rainfall and other management practices were almost same except for the marked change in the altitude: The altitude of Sanjignekhan estate is 1212 m., while Alageswara estate 909 m. and CCRI is about 904 m. It is probably the altitude coupled with other ecological conditions might be responsible for the changes in the morphological and pathogenic variation of these isolates. Perhaps it is possible that on coffee also there may be more than one race or species itself involved as in the case of *Pittosporum tobira* leaves where they have recorded both *Rhizoctonia ramicola* (= *Ceratobasidium ramicola*) and *Pellicularia koleroga* (= *Ceratobasidium koleroga*) (Roger, 1943; Weber and Roberts, 1951).

Further studies on the nutritional requirements of these isolates would clarify the exact identity of the isolates of *K. noxia* into different race or species.

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CAPSULE ROT DISEASE OF CARDAMOM (*Elettaria cardamomum* MATON) AND ITS CONTROL

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ABSTRACT

Etiological studies on the 'azhukal' disease of *Elettaria cardamomum* Maton showed that the disease is caused by *Phytophthora meadii* Mc Rae of A2 mating type. *In vitro* and *in vivo* studies on the pathogenicity showed that *P. meadii* readily infected all plant parts and produced similar disease symptoms as seen in natural infection.

Fourteen different fungicides of various formulations were evaluated under field conditions against 'azhukal' disease during 1981-86 seasons. Field control trials with different fungicides showed varying degrees of protection. In all the trials, Bordeaux mixture gave consistently good disease control. In addition to Bordeaux mixture, fosetyl aluminium (Aliette) a systemic fungicide was found to be on par with Bordeaux mixture in controlling 'azhukal' disease. Phytosanitary measures such as trashing and removal of diseased plant parts coupled with pre-monsoon application of the fungicide were very effective in disease control.

INTRODUCTION

Capsule rot popularly known as 'azhukal' is one of the most serious diseases of small cardamom (*Elettaria cardamomum* Maton). The disease is prevalent in Idukki District of Kerala and in some parts of Anamalai in Tamil Nadu. Disease occurs with the onset of monsoon and becomes severe during August-September months. The disease is characterised by rotting of capsules, panicles, leaves and tillers leading to leaf shredding, shedding of capsules and the whole plant rots and perishes in extreme cases of infection. Etiological studies conducted earlier showed that the pathogenic fungi involved are *Phytophthora* sp. (Menon et al. 1971). *P. nicotianae* var. *nicotianae* (Thankamma and Pillai, 1973) and *P. palmivora* (Radha and Joseph, 1974). In addition to these, Nambiar and Sarma (1976) reported the involvement of *Pythium vexans* de Bary

as the causal organism. The symptomatology of the disease has been studied in detail by Nair (1979).

Fungicidal control of azhukal has been reported earlier by several workers. Prophylactic spraying with 1% Bordeaux mixture or copper oxychlorides, (Menon et al. 1973; Nambiar and Sarma, 1974; Nair, Zachariah and George, 1982), fenaminosulf or BAY-5072 (Balakrishnan and Joseph 1982; Alagianagalingam and Kandaswami, 1981) and drenching with agallol (Nair, 1979) were reported to control the disease. However, no fungicide was reported to give consistently good disease control. It has been observed that the intensity and spread of the disease vary considerably during different years. Therefore, evaluation of fungicides for different seasons is necessary to obtain consistently good results which can be transferred to the growers for large scale application.

Studies undertaken at this Institute on the etiology of the disease as well as its control measures with systemic fungicides in different seasons are reported here.

MATERIALS AND METHODS

For studying the etiology, disease affected plant parts such as panicles, capsules and leaves collected from representative plantations in Idukki Dist. were plated on PDA and carrot agar media. Pathogenicity tests were conducted both *in vitro* and in the field using mycelial culture bits and zoospores of the fungus.

Field evaluation was carried out with eleven fungicides during 1981 and 1982 and nine fungicides during 1983 seasons in disease affected gardens. The trials were laid out in randomised block design with three replications and 12 plants per plot. The fungicides used were fosetyl aluminium (Aliette 0.3%), metalaxyl (Ridomil 0.15%), copper oxychlorides (Fytolan 0.3%; Emulsicop 0.3% and perecloud dust 25 g/plant) mancozeb (Dithane M 45, 0.3%), methoxy-ethyl mercuric chloride (Emisan 0.3%), dexton (BAY 5072 0.3%) Bordeaux mixture (1%) carbendazim (Bavistin 0.15%), Kitazin 0.3% and Rovral 0.2%. Fungicides were applied to the plants three times a year at 30 days interval starting from the month of June just before the onset of monsoon. Phytosanitary measures such as trashing and removal of mulch materials from the plant base were done prior to fungicidal application. All the fungicides were applied as spraying cum drenching at the plant base using hand compression pumps at the rate of three litres of fungicidal solution per clump while Aliette was applied as a foliar spray (1 lit/clump).

During 1984, 85 and 86 seasons, field trials were carried out at Myladumpara using the fungicides *viz.*, Aliette, Bordeaux mixture and Dithane M 45 which were

proved to be effective during the previous seasons. Observations on the number of healthy and diseased capsules were counted in any five affected panicles per plant in each treatment and the percentage of disease incidence was calculated. The pooled data was statistically analysed and the percentage disease incidence was calculated.

RESULTS AND DISCUSSION

Studies on the causal organism showed that *Phytophthora meadii* Mc Rae of A2 mating type is the pathogenic fungus causing azhukal disease. The identity of the isolate was confirmed by CMI, Kew, England. Inoculation studies on different plant parts showed that *P. meadii* readily infected all plant parts tested and produced similar disease symptoms within 4 to 7 days after inoculation. The fungus produced hyphae approximately 4.8 μm in breadth and abundant sporangia measuring 41.5 μm x 27.4 μm (average).

The results on the field trials are presented in Tables I, II and III. In the field trials conducted during 1981, two systemic fungicides *viz.* Aliette and Ridomil were found to be on par with Bordeaux mixture in disease control (Table I). Among the nine fungicides tested during 1983, only two fungicides *viz.*, Aliette and Bordeaux mixture were found to be effective in controlling the disease. Field trials conducted during 1985 and 1986 seasons also these two fungicides were found to be on par (Table II) and the fungicides showed varying degrees of protection (Table III) during different years. As disease incidence and severity often depend on the rainfall pattern, such differences are expected in field control trials (Sarma, Nambiar and Brahma 1979). The systemic fungicide Aliette gave the best disease control but was on par with Bordeaux mixture. The efficacy of Bordeaux mixture in controlling

Table I. *Comparative incidence of 'āzhukal' under different fungicidal treatments during 1981 and 1983*

Fungicides	Conc. %	% disease incidence	
		1981	1983
Aliette	0.3	4.4 *(12.10)	9.5 *(18.08)
Bavistin	0.15	** —	16.8 (24.29)
BAY 5072	0.3	15.4 (23.12)	— —
Bordeaux mixture	1.0	9.5 (15.11)	13.6 (21.65)
Captaf	0.3	14.4 (22.31)	— —
Difolatan	0.3	16.3 (23.85)	— —
Dithane M 45	0.3	15.0 (22.80)	14.4 (22.31)
Emisan	0.3	13.9 (21.90)	18.8 (25.69)
Emulsicop	0.3	15.1 (21.69)	21.8 (27.31)
Fytolan	0.3	14.5 (22.4)	18.5 (25.47)
Kitazin	0.3	— —	22.2 (27.94)
Perecloud dust	25 g/pl	16.4 (23.92)	— —
Ridomil 25 WP	0.15	9.4 (17.80)	— —
Ridomil 5 g	5 g/pl	14.5 (22.4)	— —
Rovral	0.2	— —	17.1 (24.39)
Control	—	27.2 (31.46)	22.2 (27.43)
C.D. at 5%		7.34	5.76

* angular values

** not tested

Table II. *Incidence of 'āzhukal' in field trials with selected fungicides 1984, 85 and 86 seasons*

Treatments	Conc %	% disease incidence		
		1984*	1985	1986
Aliette	0.3	16.9 (23.76)**	19.3 (20.1)	2.2 (10.2)
Bordeaux mixture	1.0	14.5 (22.12)	21.5 (27.62)	1.0 (5.7)
Dithane M 45	0.3	17.10 (23.92)	40.1 (39.27)	9.6 (18.07)
Control	—	28.9 (32.52)	61.1 (51.43)	26.8 (31.8)
		N.S.	C.D. 5% 11.8	8.3

* First spray was given after the onset of monsoon

** Figures in parenthesis are angular values

Table III. Comparative efficacy of selected fungicides in 'azhukal' control during different years

Fungicides	% disease control			
	1981	1983	1985	1986
Aliette	80.80	57.25	68.4	91.80
Bordeaux mixture	65.10	43.77	64.80	96.30
Dithane M 45	44.80	35.93	34.40	64.20
Ridomil	65.40	*	*	*

* not tested

azhukal disease, has earlier been discussed (Menon et al. 1973; Nambiar and Sarma 1974 and Balakrishnan and Joseph 1982). It was observed that satisfactory disease control was effected only when the first application was given before the onset of monsoon. Application of fungicides after the appearance of the 'azhukal' was not effective in controlling the disease. The systemic fungicide Aliette when applied as foliar sprays at one litre (2.4 gm/plant) could equally protect the plants as three litres of Bordeaux mixture spraying and drenching. It is quite possible that the consistent disease control with Bordeaux mixture could be due to its suppressive action of the soil inoculum. (Nair, 1979). Although, a number of systemic fungicides were reported to be very effective against many fungi, only a few chemicals were found to be useful against pythiaceae fungi (Papavizas et al. 1979 and Schwinn, Staub and Urech, 1977). Systemic activity of Aluminium tris (3-ethyl phosphonate) or Aliette against *Phytophthora* disease has recently been reported (Frossard, 1978 and Benson, 1980). Aliette has been shown to be very effective in controlling *Phytophthora* disease of several crop plants (Olivera, Santos and Silva, 1981; Davis, 1982). Disease management involving plant sanitation and timely application of fungicides only would ensure protection from disease.

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EFFICACY OF TWO CARRIER FORMULATIONS IN THE CONTROL OF PINK DISEASE OF *HEVEA* CAUSED BY *CORTICIUM SALMONICOLOR* — A COMPARATIVE STUDY

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ABSTRACT

Comparison of two existing carrier formulations used in the pink disease control operation viz., a petroleum compound (Sopkot) and Pidivyl China clay water compound after incorporating two effective fungicides (TMTD 7500 ppm and tridemorph 10,000 ppm) against *Corticium salmonicolor* causing pink disease in rubber trees was done by field testing on 3 year old, pink disease affected, rubber trees. The result indicated that the petroleum compound carrier formulation was superior to Pidivyl compound. Bordeaux paste treatment was not as effective as the treatments using carrier formulations. It was also confirmed that the early detection and treatment of the disease at cob web mycelial stage ensure maximum recovery.

INTRODUCTION

Several fungicide carriers like tar (Wijibrans and Tong, 1957), linseed oil (Ramakrishnan and Radhakrishna Pillai, 1962), natural rubber latex concentrate (Wastie and Yeoh, 1972), pre-vulcanised latex (Yeoh and Tan, 1974), Rubberkote (Thomson and Radhakrishna Pillai, 1976), field latex (Thomson, George and Radhakrishna Pillai 1978) and Pidivyl China clay water compound (Jacob and Thomson, 1986) were used for the preparation of brush on formulations for effective control of pink disease of *Hevea* from time to time. Some of these carriers were later observed to cause phytotoxicity and were discarded subsequently. The present investigation was carried out for the comparison of two existing carrier formulations viz., Pidivyl China clay water compound and a petroleum product (Sopkot) considering their loose consistency for easy application with a brush.

MATERIALS AND METHODS

The fungicides, tridemorph (Calixin) and tetramethyl thiuram disulphide (Thiride)

which were proved effective against pink disease in previous experiments were used in the present investigation (Thomson and Radhakrishna Pillai, 1976; Thomson and Jacob, 1983; Jacob and Thomson, 1986). Pidivyl China clay water compound was prepared by the method described by Jacob and Thomson (1986). TMTD (Thiride-7500 ppm) and tridemorph (Calixin - 10000 ppm) were incorporated in petroleum wound/panel dressing compound (Sopkot) by motorised stirrer and hand stirring. They were incorporated in Pidivyl China clay water compound by hand stirrings only. The treatments were imposed on 3 year old, pink disease affected, *Hevea* trees of the clone PB 28/59. Based on the symptoms the trees were graded and were categorized in 4 groups. These groups with the index values are given hereunder: Cob web mycelial stage (5); Mycelial penetration indicated by oozing of latex (7); Bark partially rotten (10); Branches with wilting symptom or dried (15). Only the trees in the first three categories were treated.

The fungicide formulations were applied to affected region of the tree covering 30 cm below and above, with a brush, after scraping the bark in the affected region. Trees treated with Bordeaux paste served as control. The affected trees were treated during October 1987 @ 25 trees per treatment.

The experimental trees were observed every month and the dried branches if any, were removed after recording them. Observation was continued upto May after which no further drying was noticed. Trees which did not show any further development of the disease symptoms subsequent to treatment were recorded as recovered. The percentage disease incidence in each treatment was calculated as per the method of Horsfall and Heuberger (1942). The final mean percentage disease intensity (PDI) in each treatment was computed as per the formula.

$$\text{Final PDI} = \frac{\text{PDI at the final observation}}{\text{PDI at the time of treatment}} \times 100$$

RESULTS AND DISCUSSION

The data indicated that both the fungicides incorporated in Sopkot performed better, whereas in Pidivyl compound only Calixin performed better. (Table I) Fre-

quent rains during October–December might have washed off the contact fungicide (Thiride) from this carrier formulation and efficacy of Calixin might be due to its systemic activity. Among the treatments, Thiride incorporated in Sopkot by mechanical stirring was superior to that of hand stirring which might be due to the uniform mixing of the fungicide. This difference was not much noticed in the case of Calixin since it is of liquid formulation. However, Bordeaux paste application, recorded lesser percentage recovery compared to other fungicides incorporated in the petroleum compound. The early detection of this disease is very important in the successful control operation of this disease (Jacob and Thomson, 1986). The data indicated in Table II corroborates this finding and this is more pronounced in the case of Sopkot used as a carrier.

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Table I. *Recovery of treated parts of Hevea from pink disease after application of fungicides in two carrier formulations*

Treatments	Number of trees		Mean per cent disease index
	Treated	Recovered	
TMTD 7500 ppm in Sopkot M.S.*	25	23	10.20
TMTD 7500 ppm in Sopkot HS**	25	21	21.98
Tridemorph 10,000 ppm in Sopkot M.S.	25	20	28.25
Tridemorph 10,000 ppm in Sopkot H.S.	25	20	24.39
TMTD 7500 ppm in Pidivyl compound	25	14	56.99
Tridemorph 10000 ppm in Pidivyl compound	25	20	24.50
Bordeaux paste (control)	25	17	40.82

*M.S. — Mechanical stirring

**H.S. — Hand stirring

Table II. Percentage recovery of *Hevea* trees from pink disease when treated at different stages of disease development in two carrier formulations and control

Stage	Sopkot			Pidivyl compound			Bordeaux paste (Control)		
	No. of trees			No. of trees			No. of trees		
	Treated	recovered	%recovery	Treated	recovered	%recovery	Treated	recovered	%recovery
Cob web	42	42	100	17	13	76	9	8	89
Latex oozing	10	10	100	6	3	50	3	2	67
Bark rotten	48	32	67	27	18	67	13	7	54

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DISCUSSIONS

R. NAGARAJAN: Why there is variation in bacterial population between monocropping and high density cropping?

VAM is known efficient solubilizer of Phosphorus. Do you have any information on this?

B. M. BOPAIAH: In the high density cropping system only the economic produce is removed and the older biomass is incorporated back into the system. The increase in organic matter may be one of the reasons for increasing bacteria. In addition the crops like cacao and pineapple may favour the proliferation of bacteria.

VAM helps in only the absorption of Phosphorus in the soil and it does not have any capacity to solubilise Phosphorus. However no studies have been conducted on Phosphorus uptake.

B. CHANDRA MOULI: What is the reason for differential performance of two copper formulation tested? viz., Blitox and Fytolan in control of blister blight of tea.

A. GULATI: This is possibly related to pH differences of these two formulations. pH is known to affect spore germination and blister blight incidence in tea.

R. S. R. MURTY: An attempt has been made to try for the blister blight control with systemic fungicide. Why not a contact fungicide at shorter intervals be tried?

A. GULATI: Efficacy of Calixin a systemic fungicide was tested along with protectant copper fungicides because use of Calixin in blister blight control has been recommended

in South India in integrated spray schedule. Application of copper fungicides at shorter intervals at 3 or 4 days may not be a practical proposition for tea plantation in view of the labour shortage during plucking season.

B. CHANDRA MOULI: What was the idea of using Calixin with copper since the former is a systemic with long residual action and latter is protectant?

A. GULATI: Field trials conducted on the efficacy of copper fungicides (Blitox and Fytolan) against blister blight revealed a time lag of 2-3 weeks in the efficacy of these fungicides. This time lag in the efficacy of copper fungicides appear to be due to invisible manifestation of infection which was latent in the bud at first plucking and spraying rounds. This result points out the necessity for integrations of a systemic with copper fungicide in order to maximise the efficacy of latter.

A. O. N. PANIKKAR: What is the viability period of oil palm seeds?

M. KOCHU BABU: If the seeds are stored at a moisture content of 17% in polythene bags of 600 gauge the viability can be maintained upto two years.

SAMRESH DWIVEDI: The percentage of infection of redroot of coffee indicated is based on the limited number of plants and hence the percentage basis of elucidation of infection and no infection condition may not be appropriate.

T. NATARAJ: There is some limitation in taking large number of plants in plantation

crops. While introducing inoculum in the field one has to be more careful and hence minimum number of plants was taken for easy management.

A.O.N. PANIKKAR: Can the laboratory method of screening against 'azhukal' be relied upon for large sample under field condition?

Do other species of *Phytophthora* like *P. palmivora* and *P. nicotianae* also infect cardamom or is it only *P. meadii*? Did you use only one isolate or more than one isolate for screening?

JOSEPH THOMAS: Large scale screening under field conditions, the zoospore method is effective and reliable.

P. meadii is of common occurrence in cardamom. Under experimental inoculation *P. palmivora* infects small cardamom. *P. nicotianae* (var) *nicotianae* also infect cardamom but its occurrence in various cardamom tracts is to be ascertained.

In screening technique one isolate was used throughout.

R. KOTHANDARAMAN: What is the zoospore population of *Phytophthora* used in screening programmes? How did you separate the sporangia?

JOSEPH THOMAS: The zoospore population was 15 lakh zoospores per ml. These sporangia were not separately harvested. For preparation of zoospore suspension the sporulated culture discs were incubated in water under light and the liberated zoospores after filtration were used for inoculation.

CROP PROTECTION

(Pest Management)

Chairman : G. B. PILLAI

Rapporteurs : T. PREMKUMAR
B. GOPAKUMAR

EFFECT OF DIFFERENT FOOD PLANTS ON GROWTH AND DEVELOPMENT OF THE COCONUT WHITE GRUB *LEUCOPHOLIS CONEOPHORA* BURM*

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ABSTRACT

Effect of different food plants on the development and biotic potential of the coconut white grub, *Leucopholis coneophora* was studied in specially designed field cages. Three-day-old first instar grubs were individually reared upto adult stage on coconut seedlings, cassava, cacao and wild sunn-hemp. Duration of different stages of *L. coneophora*, size and body weight, percentage survival, fecundity and viability of eggs were recorded. The duration of development was least in cassava and coconut followed by those in cacao and wild sunn-hemp. The observations indicated that cassava and coconut were more favourable hosts of *L. coneophora*. A higher build up of pest population is, hence, likely in coconut gardens in which cassava is grown as an intercrop.

INTRODUCTION

The coconut white grub, *Leucopholis coneophora* Burm. (Coleoptera: Melolonthidae) is one of the major pests of coconut palm in Kerala and Karnataka states of India. The grubs feed on the roots resulting in the yellowing of leaves and shedding of buttons and nuts. The grubs also feed on the roots and tubers of various intercrops grown in coconut gardens. The present study was undertaken to find out the influence of various host plants grown in coconut gardens on the growth and development of *L. coneophora*. Coconut and three crops commonly grown as intercrops viz., *Manihot esculenta* Cranz. (cassava) *Theobroma cacao* L. (cacao) and *Crotalaria striata* DC. (wild sunn-hemp, grown as green manure) were used as food plants. The development and biotic potential of insects reared on these hosts were studied and the results are reported here.

MATERIALS AND METHODS

Three-day-old first instar grubs of *L. coneophora* reared from eggs of adult beetles collected from field were caged individually in earthen pots (25 x 30 cm) planted with different host plants. In the case of coconut the grubs were released in three month old seedlings and in the case of cassava, cacao and sunn-hemp two-month old plants were used.

Two hundred grubs were exposed to each crop @ one grub per plant. When the host plant got killed the grubs were transferred to fresh, potted plants. The larvae were periodically examined for ascertaining the moultings/mortality and thus recording the duration of different life stages and their survival percentages. Adults emerging from each host plant were maintained in pairs in egg laying chambers for recording longevity of adults and fecundity and hatching percentage

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of eggs laid. The data obtained were subjected to χ^2 test of independence.

The length and width as well as the weight of different life stages of *L. coneophora* reared on different hosts were recorded using individual life stages obtained from the rearings maintained separately for the purpose. The data thus obtained were subjected to the analysis of variance.

RESULTS AND DISCUSSION

Data relating to the larval and pupal duration of *L. coneophora* raised on different host plants are presented in Table I. The duration of the first instar grubs reared on different hosts did not vary significantly. The development periods of the second instar, third instar grubs and pupae (in both sexes)

were shorter on cassava and it was followed by those reared on coconut. In terms of the duration of development from egg to adult, cassava was found to be the most suitable host plant, followed by coconut. Cacao and wild sunn-hemp were on par and significantly inferior to the former two hosts. The favourable influence of nutrition manifested in the second stage persisted in the subsequent stages too. Influence of nutrition in the larval duration among root grubs was reported on *Aphodius howitti* Hope (Crane, 1958) and *Holotrichia consanguinea* Bl. (Kalra and Kulshreshtha, 1961) also.

The data relating to the body size of grubs reared on different host plants are presented in Table I. Body length and width of the

Table I. Effect of different host plants on the duration of life stages and body size and weight of different stages of *L. coneophora*

	Cassava		Coconut		Cacao		Sunn-hemp		Critical difference	
	M	F	M	F	M	F	M	F	M	F
Duration of life stages (days)										
First instar grub	38.2	40.2	40.3	40.9	40.5	41.6	42.0	41.4	NS	NS
Second instar grub	48.8	48.8	51.6	51.6	55.7	55.5	63.4	67.7	6.19	5.92
Third instar grub	166.0	172.8	168.1	177.5	181.9	188.7	179.7	185.1	8.61	7.45
Pupae	23.3	22.9	25.3	25.7	26.8	26.1	24.7	25.2	1.45	1.89
Egg to adult	299.3	307.7	308.3	318.7	327.9	334.9	332.8	342.4	10.09	7.83
Body size (mm) and weight (g)										
Third instar grub Length	49.3	56.3	48.8	56.3	46.8	53.9	44.1	50.3	2.3	1.57
Width	14.1	15.9	13.9	16.3	12.8	15.5	13.4	15.2	0.85	0.72
Weight	3.4	5.8	3.4	5.7	3.1	4.9	2.9	4.4	NS	0.51
Pupae Length	31.3	36.0	31.3	35.5	28.7	33.2	28.1	27.3	2.11	1.80
Width	15.0	17.0	15.0	17.0	13.7	15.7	13.2	15.2	0.91	1.10
Weight	2.7	4.6	2.7	4.3	2.2	3.4	2.3	2.8	0.26	0.51
Adult Length	26.8	30.8	26.8	30.9	25.2	29.9	23.8	27.5	1.48	1.47
Width	13.5	16.1	13.6	16.9	13.1	14.3	12.7	15.6	NS	1.05
Weight	1.8	3.2	1.7	3.2	1.5	2.5	1.2	2.2	0.21	0.34

M — Male, F — Female, NS — Not significant.

grubs reared on cassava was the maximum, followed by those reared on coconut there being no significant difference between them. The body weight of male grubs reared on different host plants did not vary significantly. The highest weight of female grubs was observed in cassava, followed by coconut. Similarly the length, width and weight of pupae obtained from cassava and coconut were higher than those obtained from the other two hosts. Body length and weight of adults (male and female) obtained from coconut and cassava were on par and significantly higher than those obtained from other host plants. But, body width of adults obtained from different hosts did not vary significantly. Kalra and Kulshreshtha (1961) recorded more length and width of grubs of *H. consanguinea* fed on sugarcane than on grass roots. Weight gain of grubs of *Costelytra zealandica* White was significantly different on *Lotus pedunculatus* than on a hybrid of this species (Farrel and Sweney, 1974). Greater overall weight increase in *Melolon-*

tha melolontha was recorded on broad leaved plants (Hauss and Schutte, 1976).

The data relating to the survival of different life stages of *L. coneophora* reared on different host plants (Table II), when subjected to χ^2 test of independence, revealed that there were no significant variations in the survival upto the third instar. But, maximum number of pupae were obtained from cassava, followed by coconut, cacao and wild sunn-hemp. The adult emergence also showed the same trend. The gradual increase in the χ^2 values from the second instar to the adult stage indicated increasing influence of the hosts in later instars of the insect. The differences got manifested in the pupal and adult stages only. Population build up is likely to take place much faster when fed on cassava and coconut root than on cacao and sunn-hemp. Hauss and Schutte (1976) found that mortality of *M. melolontha* was less for grubs fed on broad leaved plants than on roots of grasses and the effect of food on

Table II. Effect of different host plants on the survival of the immature stages of *L. coneophora* and the longevity, pre-oviposition period and fecundity of adults

Host plants	No. of first instar grubs observed	First instar grub surviving till attaining				Mean				
		Second instar	Third instar	Pupal stage	Adult stage	Adult Sex longevity (days)	Pre-oviposition period (days)	No. of eggs/female	Per cent of eggs hatched	
Cassava	200	150	128	86	69	M 44.7 F 48.7	34.0	19.4	96.8	
Coconut	200	140	126	72	63	M 42.3 F 42.6	34.8	18.5	95.0	
Cacao	200	140	124	62	42	M 38.7 F 34.5	30.9	8.9	58.2	
Sunn-hemp	200	150	124	67	40	M 37.8 F 33.2	30.5	7.2	65.5	
χ^2	2	2.51	4.91	8.33*	17.13**	CD M 4.42 CD F 2.89	2.15	2.52	13.24	

M — Male

F — Female

CD — Critical difference

mortality and weight gain was not apparent until the grubs reached the second instar stage. Wilson (1978) reported that survival of *C. zealandica* was highest on large leaved lines of white clover.

With regard to the longevity of adults, cassava and coconut were superior to others. Similarly the adults reared on these two plants had significantly longer pre-oviposition period and higher fecundity. Initial body weight of adult also was higher in these insects. Higher rate of egg production was seen in females, having higher body weight. Besides the eggs laid by them showed a higher hatching percentage. Farrel (1973) reported that egg production of *C. zealandica* varied significantly with the initial body weight.

The results indicated the possibility of certain favourable nutritional factors in cassava and coconut roots which increased the biotic potential and the survival rates of *L. coneophora*. In general, different host plants seen to have some influence on the grubs of both sexes of *L. coneophora*. The overall results indicate the possibility of a higher population build up of *L. coneophora* in coconut gardens grown as a monocrop or intercropped with cassava. The feasibility of raising cassava as a trap crop in coconut

gardens for management of the pest is also suggested from this study.

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TOXICITY OF CERTAIN INSECTICIDES AND FUNGICIDES TO *LEPTOMASTIX DACTYLOPII*, AN INTRODUCED PARASITOID OF *PLANOCOCCUS CITRI*

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ABSTRACT

Eight insecticides viz., quinalphos, fenitrothion, fenthion, malathion, methyl parathion, monocrotophos, phenthoate and dimethoate and the two fungicides viz., bordeaux mixture and oxycarboxin, which are commonly used in coffee pest and disease management, were evaluated for their toxicity on the pupae and adults of *Leptomastix dactylopii* Howard (Hymenoptera: Encyrtidae), an introduced parasitoid of mealybug, *Planococcus citri* (Risso) (Homoptera: Pseudococcidae) in two laboratory experiments.

Of the insecticides tested, malathion and phenthoate were highly toxic to the pupae, while the others were less toxic. In the case of adults, the residual toxicity of quinalphos and fenitrothion lasted for 3 days after treatment and that of fenthion for 4 days. Dimethoate and methyl parathion caused mortality of adults upto 5th day, while malathion, phenthoate and monocrotophos were highly toxic for 9 days. The two fungicides viz., bordeaux mixture and oxycarboxin were absolutely safe for both the pupae and adults of *L. dactylopii*.

Further, the observations, made on the establishment of *L. dactylopii* in an estate, where the chemical control was integrated along with the biological control of *P. citri* are also discussed.

INTRODUCTION

The application of pesticides frequently disrupts the natural enemy - pest balance resulting pest resurgences and secondary pest outbreaks (Bartlett, 1964). Selective chemicals and selective means of application can furnish an immediate first step towards integrated control by substituting them for the hard chemicals that kill a broad spectrum of natural enemies (Paul De Bach, 1974). It is widely known that many hymenopterous parasitoids are susceptible to insecticidal residues and so the successful development of integrated control programmes demand that all pesticides intended for use, are carefully screened. Such evaluation in the first instance is to be conducted in the laboratory (Hussey and Scopes, 1976).

Leptomastix dactylopii Howard was introduced into India in 1983 from Trinidad against the mealybug, *Planococcus citri* (Risso) (Anonymous, 1984). This parasitoid was multiplied in the glasshouse and released in many coffee estates in South India for colonisation against *P. citri* (Anonymous, 1985, 1986 and 1987). While evaluating its establishment it was observed that the parasitoid continued to persist on Kathlekhan Estate, Chikmagalur from the releases made during 1984 and 1987. The parasitoid could be observed in some of the blocks of this estate where insecticide sprays were carried out using either quinalphos or fenthion for controlling mealybugs. The percentage parasitism observed was as high as 52 in some blocks. This prompted to take up a

study in the laboratory on the relative toxicity of insecticides and fungicides which are commonly used for insect pest and diseases management in coffee to the pupae and adults of *L. dactylopii* in two experiments, with a view to identifying the safer ones.

MATERIALS AND METHODS

Effect of pesticides on the pupae of

L. dactylopii

The mealybugs, *P. citri* reared on pumpkin were exposed to *L. dactylopii* for 24 hours and the mummified bugs, having the pupae of the parasitoid, were collected on the 12th day after exposure and used for the study. The treatments included eight insecticides, two fungicides and a check. The mealybug mummies were kept in petri plates (10 cm dia) and the treatments were imposed using an atomiser. In the check the mummies were treated with water alone. Each treatment was replicated thrice with 15 mummies per replication. Excess solution was drained off and the mummies were air dried at room temperature and observed for adult emergence.

Effect of pesticides on the adults of

L. dactylopii

The treatments used in this experiment were the same as those in the experiment mentioned above. Thirty-year-old *Coffea canephora* (robusta) plants were sprayed with the chemicals to run off level by using a Bakpak sprayer. Control plants were sprayed with water alone. Leaves collected from the sprayed plants were brought to the laboratory and placed them in 2 lit. plastic containers. Three replications were maintained per treatment with two treated leaves per replication.

Five freshly emerged adults of *L. dactylopii* were introduced into each container and covered with muslin cloth to prevent their

escape. Honey solution was provided as diet to the adult parasitoid. Mortality count was taken after 24 hours. The observations were continued for 9 days and every time freshly picked leaves and newly emerged parasitoids were used. The data of the two experiments were transformed into angular values and statistically analysed (Tables I and II).

RESULTS

Effect of pesticides on the pupae of

L. dactylopii

Table I shows that the effects of insecticides on the emergence of *L. dactylopii* from mealybug mummies. Phenthoate was the most toxic followed in decreasing order by malathion > dimethoate > fenthion > methyl parathion > fenitrothion > quinalphos > monocrotophos.

Effect of pesticides on the adults of

L. dactylopii

Table II shows that the toxicity of quinalphos and fenitrothion lasted for 3 days whereas that of fenthion for 4 days. Dimethoate and methyl parathion caused mortality upto the 5th day while malathion, phenthoate and monocrotophos were toxic till 9th day.

The fungicides Bordeaux mixture at 0.5% and oxycarboxin at 0.03% a.i. did not have any toxic effect on pupae and adults of *L. dactylopii* and hence they were excluded for the purpose of analysis.

DISCUSSION

Among the insecticides phenthoate and malathion were highly significant in their toxicity to the pupae than the other insecticides tested. The other insecticides are less toxic. But all the insecticides caused mortality to the adults for different periods. Quinalphos, fenitrothion and fenthion which

Table I. *Effect of insecticides on the emergence of L. dactylopii*

Insecticides	Concentration % a.i.	Per cent of adult emergence
Quinalphos 25 EC	0.0375	80.02 (95.56)
Fenitrothion 50 EC	0.075	77.87 (93.33)
Fenthion 1000	0.075	72.50 (86.67)
Malathion 50 EC	0.05	29.58 (24.44)
Methyl parathion 50 EC	0.03	74.00 (88.89)
Monocrotophos 36 W/W	0.026	80.02 (95.56)
Phenthoate 50 EC	0.03	8.98 (6.67)
Dimethoate 30 EC	0.025	65.17 (75.56)
Check (Water)		89.81 (100)
Significance		**
C.D. at 5%		21.60
C.D. at 1%		29.59

** Significant at 5 and 1%

(Figures in parenthesis are absolute values)

Table II. *Effect of insecticides on the adults of L. dactylopii*

Insecticide & Con. % a.i.	% of adult mortality in different days						
	1	2	3	4	5	7	9
Quinalphos 25 EC 0.0375	0 (0)	36.13 (46.66)	47.30 (53.33)	0 (0)	0 (0)	0 (0)	0 (0)
Fenitrothion 50 EC 0.075	64.22 (73.33)	42.35 (53.33)	26.21 (26.66)	0 (0)	0 (0)	0 (0)	0 (0)
Fenthion 1000 0.075	81.14 (93.33)	47.21 (46.66)	64.22 (73.33)	17.07 (20.00)	0 (0)	0 (0)	0 (0)
Malathion 50 EC 0.05	89.94 (100)	89.94 (100)	89.91 (100)	89.94 (100)	89.94 (100)	89.94 (100)	81.14 (93.33)
Methyl parathion 50 EC 0.03	89.88 (100)	64.22 (73.33)	51.14 (60.00)	8.98 (6.66)	9.11 (6.66)	0 (0)	0 (0)
Monocrotophos 36 W/W 0.026	89.98 (100)	89.94 (100)	73.10 (80.00)	39.31 (46.66)	51.21 (60.00)	51.14 (60.00)	47.30 (53.33)
Phenthoate 50 EC 0.03	81.14 (93.33)	89.94 (100)	89.94 (100)	98.94 (100)	81.14 (93.33)	76.92 (86.66)	64.22 (73.33)
Dimethoate 30 EC 0.025	89.81 (100)	89.81 (100)	89.81 (100)	68.10 (80.00)	38.86 (40.00)	0 (0)	0 (0)
Check (water)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

Treatment comparison

'F' value

C.D.

Between insecticides

97.27**

9.14

Between periods

42.44**

8.064

Interaction

04.22**

24.1926

** Significant at 1%

(Figures in parenthesis are absolute values)

are recommended for mealybug control (Anonymous 1985) were safer to the pupae and adults of *L. dactylopii*. Mazzone, Tranfaglia and Viggiani (1980) reported that demeton-s-methyl, phosalone and dinoseb were highly toxic to the adults of *L. dactylopii*.

The observations made on the establishment of the parasitoid on Kathlekhan estate revealed that the parasitoid could establish even in the blocks where the insecticides were sprayed for the control of mealybug. In the present studies all the insecticides except phenthoate and malathion caused less mortality to the pupae of the parasitoid. In the case of adults, though the insecticides recommended for mealybug control viz; quinalphos, fenthion and fenitrothion caused initial mortality, the toxicity lasted for only 3 to 4 days. Since the parasitoid emerging from the pupae after 3 or 4 days of spraying, are completely safe from the toxic effect of the insecticides which results in the establishment of the parasitoid.

In summary, current recommended rates of quinalphos, fenitrothion and fenthion against mealybug control did not have any deleterious effects on the establishment of *L. dactylopii*. Hence these insecticides can be integrated with the biological control of mealybug by spraying in endemic spots leaving less affected patches to maintain the reservoirs of the parasitoid.

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TOXICITY AND FIELD EFFICACY OF BROMADIOLONE AGAINST *RATTUS RATTUS WROUGHTONI* HINTON*

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ABSTRACT

The toxicity and field efficacy of bromadiolone, a single dose second generation anti-coagulant rodenticide, was tested against the black rat *Rattus rattus wroughtoni* Hinton. The LD₅₀ value with 95% confidence limits of this poison to *R. r. wroughtoni* was found to be 0.51 (0.40-0.60) mg/kg body weight. One and two days exposure of rats to bromadiolone baits (0.005%) resulted in 93% and 100% mortality, respectively. The days to death varied from 3 to 20. The rats did not show any aversion to the poison baits. In coconut fields, application of 10g bromadiolone baits, two times, at an interval of 12 days, on the crown of the infested coconut palms completely reduced the rat damage.

INTRODUCTION

The black rat, *Rattus rattus wroughtoni* Hinton is a predominant rodent pest in coconut and cacao gardens of Kerala (Advani, 1982; Bhat and Sujatha, 1986a). Among the anti-coagulant rodenticides presently available in India for rodent control operations, bromadiolone, a single dose second generation anti-coagulant rodenticide, is reported to be highly toxic and very effective against several rodent pests in India (Jain, 1980; Subaiah and Mathur, 1984) and abroad (Marsh, Howard and Jackson, 1980). In this report, the results on the toxicity of bromadiolone to *R. r. wroughtoni* and the efficacy of this poison in reducing the infestations of this rat on coconut palms are discussed.

MATERIALS AND METHODS

The animal

Live specimens of *R.r.wroughtoni* were trapped from coconut fields near Kasaragod (12°30' N; 75°E) Kerala, where they had no

prior experience of feeding on any poison baits. The animals were brought to the laboratory and caged individually (45x30x25 cm). After acclimatising the rats for the caged conditions for a period of three weeks they were used in the experiment. Only healthy and non-pregnant rats were selected for the study.

Acute oral toxicity

Acute oral toxicity tests were conducted using 100% technical grade bromadiolone powder. The poison was dissolved in polyethylene glycol 300 and administered to each animal by oral intubation. Four different doses ranging from 0.25mg/kg to 1.25mg/kg were tried on 12 animals each. Another set of 12 animals was kept as control by administering 0.5 ml of polyethylene glycol without poison. The animals were kept on the laboratory diet and mortality recorded upto 21 days (Anonymous, 1970). The data were subjected to probit analysis (Finney, 1971).

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Feeding trials

Feeding experiments were carried out with both 'no-choice' and 'choice' tests. The bromadiolone baits (0.005% a.i) were prepared in cake form by mixing bromadiolone with broken rice and paraffin wax (Subaiah and Mishra, 1980). In 'no-choice' tests, only the bromadiolone cakes were provided for one and two days to individually caged animals. In the 'choice' tests both the poisoned and unpoisoned cakes were provided in separate containers for three consecutive days. The position of the containers was changed daily in order to avoid 'position effect' on feeding. In both the experiments water was provided *ad libitum*. The consumption of each cake was recorded daily. After the completion of the experiments, the test animals were maintained on plain food for 21 days and mortality recorded. The symptoms of death were also noted carefully.

Field efficacy

The field efficacy of bromadiolone against the *R. r. wroughtoni* was evaluated on 45 rat infested coconut palms. Pre-control assessment of damage was done by counting the rat-damaged shed nuts for seven days. On the eighth day one bromadiolone cake (10g)

was kept on the crown of each palm. Post-control assessment of damage was done for another seven days after 12 days of poison baiting. One more baiting was carried out in those palms which still showed rat damage. Another coconut garden (1.5 ha) having rat damage was kept untreated for recording the natural variations in damage.

RESULTS

Acute oral toxicity

Table I gives the data on the mortality of *R. r. wroughtoni* different doses of bromadiolone. The LD₅₀ value with 95% confidence limit was 0.51 (0.40–0.60) mg/kg. Mean days to death varied from 4 to 20 (mean 8.08 days).

Feeding trials

In no-choice feeding tests (Table II) one day feeding on bromadiolone baits killed 83.3% of the test animals. The quantity of poison intake before death varied from 2.00 to 10.00 mg/kg (mean 6.03 mg/kg). One rat survived a dose of 7.6 mg/kg. Cent per cent mortality in *R. r. wroughtoni* was achieved by two days feeding on bromadiolone baits.

Table I. Toxicity of bromadiolone against *R. r. wroughtoni* ($N = 12$ in each treatment)

Dose (mg/kg)	Mortality (%)	Days to death	
		mean	range
0.25	0	—	—
0.50	50.0	7.33	4–12
0.75	66.7	8.62	5–17
1.00	91.7	8.45	4–20
1.25	100.0	7.75	4–13
Untreated	0	—	—

In choice-feeding tests (Table III) rats did not show any significant aversion towards bromadiolone mixed baits. Out of the 30 animals used in these experiments, 12 (40%) animals showed a preference for the poisoned baits, 13 (43.3%) animals showed a preference for the plain baits and five (16.7%) animals consumed both the poisoned and plain baits equally. Even when the baits were exposed for three days the preference between the poisoned and plain baits did not deviate from 1:1.

The pooled data on the mortality of test animals are graphically represented in Fig. 1. Maximum death was noticed on the fifth day. Out of 116 animals exposed to bromadiolone only four (3.4%) animals took more than 11 days for death.

Field efficacy

Among the 45 rat-infested coconut palms baited with bromadiolone cakes, 37 (82.22%) palms did not show any symptom of rat infestation afterwards (Table IV). Even

Table II. No-choice feeding of bromadiolone cakes (0.005%) to *R. r. wroughtoni* ($N = 30$ in each treatment)

Exposure days	Poison consumed		Mortality (%)	Days to death	
	mean	(mg/kg) range		mean	range
One	6.03	2.0-10.0	93.3	5.28	3-13
Two	11.63	3.4-19.1	100.0	5.80	3-10

Table III. Choice feeding with plain and bromadiolone cakes to *R. r. wroughtoni* ($N = 10$ in each treatment)

Exposure days	Mean daily bait consumption (g/animal)		Preference (%)			Mortality (%)	Days to death	
	Plain	poison	plain	poison	neither		mean	range
One	3.30	2.30	40.0	40.0	20.0	60.0	7.33	6-11
Two	2.75	3.74	50.0	40.0	10.0	70.0	5.14	5-14
Three	3.85	2.05	40.0	40.0	20.0	100.0	4.12	3-5

Table IV. Percentage of reduction in rat infested coconut palms and damaged tender nuts after bromadiolone baiting

Plot	No. of rat infested palms/tender nuts					
	Pre-control		After 1st baiting		After 2nd baiting	
	Palms	nuts	palms	nuts	palms	nuts
Treated	45	103	8 (82.2)	21 (79.6)	0 (100.0)	0 (100.0)
Untreated	16	47	23	78	22	60

Percentage reduction is shown in parenthesis.

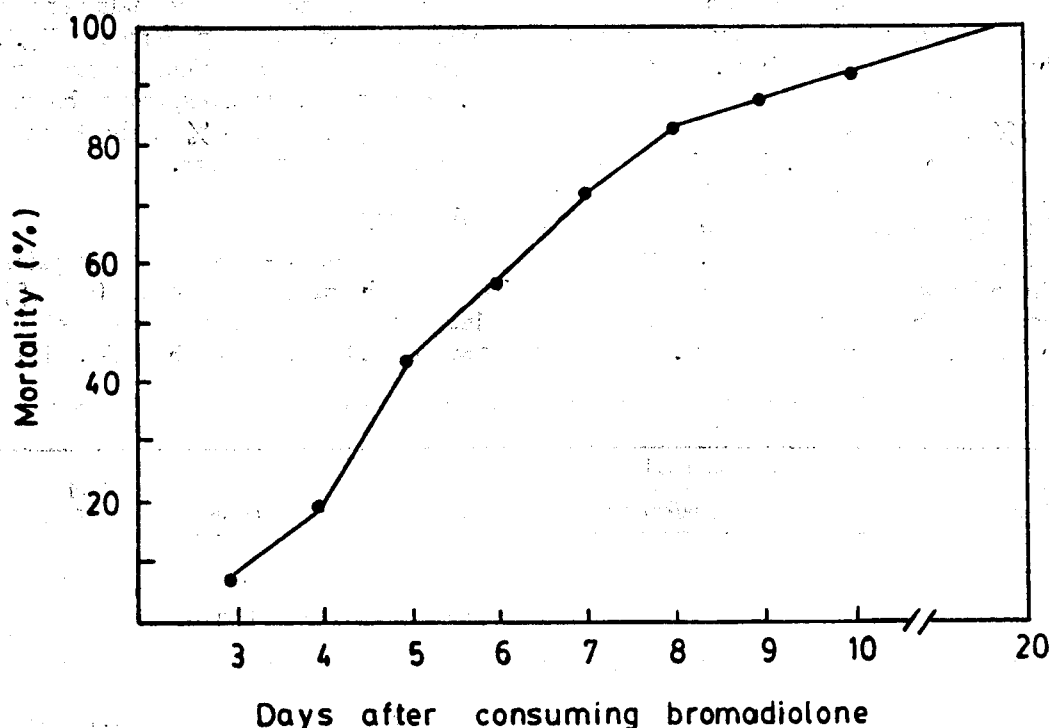


Fig. 1 Cumulative mortality(%) in *R.r. wroughtoni* in different days after consuming bromadiolone baits (N=116).

the adjoining palms were free from rat damage. The total number of damaged nuts was reduced from 103 during pre-control to 21 (79.61 % success) during post-control. Such reduction in the damage was not noticed in the untreated plot.

DISCUSSION

The results of the present study indicated that bromadiolone is a potent anti-coagulant rodenticide against *R. r. wroughtoni* with a single dose oral LD_{50} of 0.51 mg/kg. Compared to the conventional acute rodenticide zinc phosphide, bromadiolone is about seven to eight times more toxic (LD_{50} of zinc phosphide to *R. rattus* was 40.1 mg/kg; Prakash and Mathur, 1987). Unlike zinc phosphide the rats did not develop any bait shyness towards bromadiolone mixed baits. Even on the third day of exposure to broma-

diolone baits, *R. r. wroughtoni* did not develop any aversion towards that poison. With zinc phosphide, *R. rattus* developed bait shyness after one exposure itself (Prakash, Rana and Jain, 1975).

The present study also revealed that bromadiolone is much more toxic than the other anticoagulant rodenticides marketed in India, viz, warfarin and fumarin. The lethal feeding periods with warfarin and fumarin for *R. r. wroughtoni* varied from 10 to 12 days (Bhat and Sujatha, 1986b) whereas with bromadiolone the lethal feeding period was only two days.

The results on the no-choice feeding showed that there was considerable variation in the susceptibility of *R.r.wroughtoni* to bromadiolone. One animal survived a dose

of 7.60 mg/kg compared to the lowest lethal dose of 2.00 mg/kg. It could be possible that this animal was inherently more tolerant than the others. Resistance to the conventional anti-coagulant rodenticide such as warfarin was already reported in several countries (Drummond and Rennison, 1973). Hence, prolonged use of bromadiolone might give rise to resistant strain in the years to come.

Mathur and Bhadauria (1985) reported that the success of control operation with bromadiolone baits against the lesser bandicoot, *Bandicota bengalensis* was manifested only 12 days after the poison treatment in sugarcane fields. In a similar experiment with brodifacoum (another single dose slow poison) on rice field rat, *R. argentiventer* Buckle, Rowe and Husin (1982) allowed 10 days' gap between poison treatment and post-treatment assessment of damage. In the present study, more than 76% of *R.r.wroughtoni* died within 12 days of consuming the lethal dose of bromadiolone (Fig 1). Hence, a time gap of 12 days was fixed for the post-control assessment of damage.

The field study with bromadiolone revealed that application of 10 g baits, twice, with a gap of 12 days, on the crown of the infested coconut palms completely reduced the rat damage. In order to achieve similar results in coconut plantations with other anticoagulant rodenticides such as warfarin and fumarin more than 200g of the baits are to be applied in three split doses (Bhat and Sujatha, 1988). Thus application of bromadiolone not only reduced the expenditure on the bait material, but also on the labour.

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REACTION OF ARABICA AND ROBUSTA COFFEES TO FIVE SPECIES OF *PRATYLENCHUS* (NEMATODA) WITH A STUDY ON THE BIOLOGICAL RACES OF *P. COFFEA*

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ABSTRACT

In a laboratory study, arabica (*Coffea arabica* L.) and robusta (*C. canephora* Piere ex Fr.) coffee plants reacted differently to the five *Pratylenchus* spp - *P. brachyurus*, *P. coffeae*, *P. flakkensis*, *P. vulnus* and *P. zae*. The commonly occurring nematode species in the coffee tracts of South India *P. brachyurus* and *P. coffeae* readily infested and multiplied fast on both the coffee species while multiplication at a medium rate was noticed in the case of *P. flakkensis* and *P. zae* on arabica. *P. vulnus* failed to multiply on both the coffees. *P. zae* however, did not multiply on robusta. Based on the results obtained, a pathogenicity study involving *P. brachyurus* and *P. coffeae* and the two coffee species was conducted in the laboratory and found that *P. brachyurus* was highly pathogenic to both the coffee species while robusta showed tolerance to *P. coffeae*. In another study existence of four biological races in *P. coffeae* i.e., coffee, cardamom, pavetta and bamboo races was confirmed. Possibility of existence of 'robusta race', which is more virulent to robusta, in Kodagu District of Karnataka was discussed. As a result of these two factors i.e., highly pathogenic nature of *P. brachyurus* to robusta and existence of a robusta race, the departmental recommendation to manage nematode problem which hitherto included the replacement of arabica with robusta or arabica-robusta grafted plants, however, has to be recasted.

INTRODUCTION

The five species of *Pratylenchus* - *P. brachyurus* (Godfrey) Filipjeve & Stekhoven, *P. coffeae* (Zimm.) Filip. & Stek., *P. flakkensis* Seinhorst, *P. vulnus* Allen & Jensen and *P. zae* Graham which are commonly associated with plantation crops, weeds and shade trees in the coffee tracts of South India (D' Souza and Kumar, 1969; Kumar, 1988; Sekhar, 1963) were studied for their ability to infest arabica (*Coffea arabica* L.) and robusta (*C. canephora* Piere ex Fr.) coffee seedlings in the laboratory. A pathogenicity study was undertaken in the case of *P. brachyurus* and *P. coffeae* since they were found associated with the coffee plants showing typical nematode damage symptoms in

the field and also they were frequently encountered in routine soil testing than the other three species.

Existence of biological races among plant nematodes is an established phenomenon (Sturhan, 1971). Earlier studies carried out at C. C. R. I. had indicated the existence of four biological races in *P. coffeae* i. e., coffee, cardamom, pavetta and bamboo races (Kumar, 1985; Kumar and Kasiviswanathan, 1972) and further studies were undertaken to confirm the finding.

MATERIALS AND METHODS

Studies with five *Pratylenchus* spp

The populations of *P. brachyurus* and *P. coffeae* (coffee isolate) were maintained on

arabica coffee plants; *P. flakkensis* and *P. vulnus* on orange plants (*Citrus reticulata* Swingle) and *P. zeae* on ragi (*Eleusine coracana* Gaertn.) grown in steam sterilized soil in the green house. The nematodes from these hosts were utilized for inoculation studies.

Arabica (var. S. 795) and robusta (var. S. 274) were raised in a denematized nursery bed. Forty-day old plants from this bed were then transplanted individually to each of 25 numbers of perforated polythene nursery baskets (22 x 37 cm) which were filled with a mixture of steam-sterilized jungle soil, sand and compost at 2:1:1 proportion. After 7 days, each of 5 baskets under arabica and robusta were inoculated with 500 numbers of each of the five nematode species. After 10

months the nematode population were assessed (Table I).

Pathogenicity study with *P. brachyurus* and *P. coffeae*

Thirty numbers each of 40-day old arabica (S. 795) and robusta (S. 274) previously raised in a denematized nursery bed were transplanted to individual nursery baskets filled with steam sterilized nursery soil. Fifty nematodes of *P. brachyurus* and *P. coffeae* were inoculated individually to each of 10 baskets of arabica and robusta plants retaining the remaining 10 baskets under each group as check. After 10 months the data on stem height, root length and fresh root weight were recorded (Table II)

Table I. Multiplication of five *Pratylenchus* spp on arabica and robusta coffee

Host/Nematode	<i>P. brachyurus</i>	<i>P. coffeae</i>	<i>P. flakkensis</i>	<i>P. vulnus</i>	<i>P. zeae</i>
arabica	+++	+++	++	—	++
robusta	+++	+++	+	—	—
—Negative + (low) Population less than the initial inoculum			++ (Medium) Multiplication between 2–5 times +++ (High) Multiplication more than 5 times		

Table II. Effect of *Pratylenchus brachyurus* and *P. coffeae* on arabica and robusta coffee seedlings

Treatment		Stem height cm	Root length cm	Fresh root weight g
<i>Arabica</i>				
Inoculated <i>P. brachyurus</i>	Mean	19.20**	9.82**	3.50**
Inoculated <i>P. coffeae</i>	Mean	18.62**	10.60**	2.84**
Check	Mean	32.50	23.20	9.28
<i>Robusta</i>				
Inoculated <i>P. brachyurus</i>	Mean	17.80**	10.22**	7.43**
Inoculated <i>P. coffeae</i>	Mean	33.25 (NS)	21.40 (NS)	14.92 (NS)
Check	Mean	34.38	21.8	15.30

**Significantly different at 1% level

NS Not Significant.

Studies on biological races of *P. coffeae*

Populations of *P. coffeae*, from arabica coffee, cardamom, Pavetta and bamboo meant for inoculation studies were collected from the field and maintained on their respective hosts in the green-house.

The plants of arabica, robusta, cardamom and pavetta were raised from seeds and bamboo from the previously denematized suckers in a nematode free nursery bed. After 60 days they were transplanted to 20 cm earthen pots filled with steam sterilized nursery soil. A total of 60 pots - 30 each for arabica and robusta - were maintained. To each of 3 pots under each group were inoculated 500 nematodes from each of the four isolates. All the pots were kept free from weeds for 10 months after which the plants were uprooted for nematode estimation and host parasitic interaction (Table III)

RESULTS AND DISCUSSION

Studies with five *Pratylenchus* spp

P. brachyurus and *P. coffeae* readily multiplied on both arabica and robusta coffee plants. The rate of multiplication in the case of *P. flakkensis* was medium on arabica and low on robusta. *P. vulnus* failed to multiply on any of the hosts while *P. zeae*

multiplied at a medium rate on arabica but it did not thrive on robusta.

Pathogenicity studies

Stem height, root length and fresh root weight were significantly reduced in arabica plants inoculated with *P. brachyurus* and *P. coffeae*. *P. coffeae* had no effect on robusta but *P. brachyurus* significantly reduced stem height, root length and root weight of robusta.

Biological races

As per the Table III four biological races in *P. coffeae* can be recognised. Coffee isolate multiplied fast on arabica and robusta coffee, maintained low population on pavetta but failed to multiply on cardamom and bamboo. Cardamom isolate registered a low population on arabica and robusta plants, multiplied fast on cardamom but failed to infest pavetta and bamboo. Pavetta isolate multiplied at a low rate on arabica, medium on robusta, high on pavetta but failed to infest cardamom and bamboo. Bamboo race, however, was specific to bamboo where it registered a high population but failed to multiply on the rest of the hosts.

P. coffeae has a very wide host range in South India and probably more

Table III. Effect of four isolates of *Pratylenchus coffeae* on five plant species

Isolate/Host	Arabica Coffee	Robusta Coffee	Cardamom	Pavetta	Bamboo
Coffee	+++	+++	—	+	—
Cardamom	+	+	+++	—	—
Pavetta	+	++	—	+++	—
Bamboo	—	—	—	—	+++

—Negative

+ (Low) Population less than initial inoculum

++ (Medium) Multiplication between 2-5 times

+++ (High) Multiplication more than 5 times

racess are involved. One such indication is, as per a preliminary study, the existence of a 'robusta race' in Kodagu District of Karnataka which has been found to be highly virulent to robusta besides arabica. The study revealed that *P. brachyurus* to be pathogenic to robusta and arabica. *P. brachyurus*, however, has been confined to a limited area in Chikmagalur, Hassan in Karnataka and Wynad in Kerala. The recommendation to manage nematode problem which includes replacing infected arabica plants with robusta (tolerant material) or arabica-robusta grafted plants is likely to be jeopardised due to these factors.

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DISSIPATION OF FENTHION IN CARDAMOM

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ABSTRACT

The mean deposit of fenthion on fresh cardamom capsules was 3.338 to 5.801 and 4.839 to 9.243 ppm at 0.45 and 0.10 per cent spraying respectively a day after application. When this was expressed on dry matter basis, the residues were 16.553 to 23.297 and 24.674 to 36.038 ppm at the recommended dose and double the dose respectively. The loss in residues due to curing, works out to be 68.8 to 91.3 per cent in the first trial at Yercaud and 34.0 to 69.7 per cent in the second trial at Thadiyankudisai. The half life of fenthion was 6.8 to 8.8. days in fresh capsules and 7.1 to 15.2 days in cured capsules for the recommended dose. A waiting period of 20 days for fresh and 25 days for cured capsules is suggested.

INTRODUCTION

Cardamom (*Elettaria cardamomum* (L.) Maton), the queen of spices is an important spice crop in the Lower Pulneys. Among the various insect pests attacking cardamom (Kumaresan, Regupathy and Bhaskaran, 1988) the stem borer *Conogethes punctiferalis* Guen. and thrips *Sciothrips cardamomi* Ram, are the major pests of this crop in this region. In the recent past, a number of insecticides were evaluated for their bioefficacy against these pests and fenthion is one of the insecticides recommended for the control of thrips and capsule borer (Anonymous, 1987 and Kumaresan et al., 1988). Any toxic residues accumulating in the capsules might cause serious health hazard problem to consuming public. Hence investigations were undertaken to study the dissipation of fenthion in cardamom and the results are presented in this communication.

MATERIALS AND METHODS

Two supervised trials were conducted to study the dissipation of fenthion applied to control thrips on cardamom, one during February-March, 1986 at Horticultural Research Station, Tamil Nadu Agricultural University, Yercaud and another during September-October, 1986 at Regional Research Station of Indian Cardamom Research Institute, Thadiyankudisai. The trial was replicated four times; 30 clumps constituting one replication. Buffer zones were left between plots to prevent cross contamination. Spray fluid @ 300 ml was applied per clump using high volume sprayer.

Matured and uniform sized capsules were collected using forceps on 1, 4, 8, 15, and 30 days after application in the first trial and 0, 1, 3, 7, 15 and 30 days after application in the second trial. From each plot about 250 g of fresh capsules representing the plot

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was collected. Sub-samples of 25–50 g of fresh capsules and 20 g of cured capsules were used for extraction. The weight of capsules before and after curing was recorded from each plot to work out the residues on moisture free basis.

To 25 g of fresh capsules, 50 ml of redistilled acetone was added and the residues were extracted by blending in mixi and filtered. In the case of cured capsules, water was added by 30% W/W and acetone allowed to soak for 6 hrs before proceeding for extraction. The condensed extract was mixed with 75 ml distilled water and 10 ml saturated sodium chloride and portioned into dichloromethane. The condensed dichloromethane extract was cleaned up through a chromatographic column packed with anhydrous sodium sulphate (2 cm) and florisil and acid washed charcoal (8:1.5 g) and eluted with 1:1 dichloromethane acetone mixture. The eluant was evaporated to near dryness and taken in n-hexane and injected for final determination (Shimadzu Model GC) fitted with Dexil-300 column. The operating parameters were: Temperature (°C), column 220°, injector 240, detector 250, gasflow N₂-40 ml/min H₂-0.9 kg/cm² and air-0.5 kg/cm². The dissipation curve was fitted and the statistical parameters were estimated as suggested by Time and Frehse (1980).

RESULTS AND DISCUSSION

The recovery of the fortified fenthion at 1 ppm level was 89 per cent. The fenthion residues were detected at 5.801 at 0.05 per cent and 9.243 at 0.1 per cent on fresh capsules a day after application at Horticultural Research Station, Yercaud and more or less same level was observed in fresh capsules in the second trial conducted at Thadiyankudisai (Tables I and II). However, the residues in cured samples varied greatly in two different places, perhaps the variation in curing process adopted and variations in the meteorological factors in the two locations. The residues dissipated to as low as 0.321 to 1.061 in the first trial and to 0.1766 to 0.4818 in the second trial 30 days after application. Considering the residues in fresh capsules on moisture free basis and in the corresponding cured samples, the loss in residues due to curing works out to be 68.77 to 91.28 per cent in the first trial at Yercaud and 34.00 to 69.71 per cent in the second trial at Thadiyankudisai. Chozhan (1988) has also reported that the loss of residue in curing was found to be 86.4 to 94.3 per cent quinalphos, methyl parathion, fenthion and monocrotophos in cardamom. The half life was to be 8.1 to 8.7 days in the first trial and 6.8 to 8.8 days in the second trial in fresh capsule and 13.2 to 15.2 and 7.1 to

Table I. *Residues of fenthion in cardamom (ppm) - February-March 1986 - Yercaud*

Days elapsed	Fresh		Cured		Moisture free basis	
	0.05	0.10	0.05	0.10	0.05	0.10
1	5.801	9.243	2.032	5.754	23.297	36.038
4	1.546	8.436	0.890	5.148	6.290	34.759
8	0.988	4.742	1.006	4.152	4.195	19.411
15	0.440	1.772	0.600	1.870	1.921	7.741
30	0.321	1.061	0.420	1.380	1.345	4.825

Table II. Dissipation of fenthion in cardamom - February-March 1986 - Yercaud

Parameters with confidence limits	Fresh		Cured		Moisture free basis	
	0.05	0.10	0.05	0.10	0.05	0.10
	-0.0028	-0.0150	-0.0010	-0.0092	-0.0018	-0.0126
K ₁ (b)	-0.0371	-0.345	-0.0198	-0.0229	-0.0365	-0.0325
	-0.077	-0.0540	-0.0386	-0.0365	-0.0748	-0.0523
	11.7625	18.6681	2.8471	9.4886	45.5722	74.8170
K ₂ (a)	2.8203	9.3004	1.4528	5.8291	11.5824	36.7282
(ppm)	0.6874	4.6559	0.7413	3.5801	2.9444	18.0343
r ²	0.7449	0.9137	0.7894	0.9048	0.7419	0.8998
	16.8176	13.6562	29.5836	21.0178	16.8880	14.9606
T _{1/2}	8.1046	8.7272	15.1805	13.1653	8.2429	9.2753
(days)	0.6085	3.7983	7.7744	5.3198	4.0234	3.5900
	38.3476	41.6063	32.0982	55.1249	49.8738	89.4771
T _{tol}	20.2292	36.8064	23.3621	46.6463	37.3726	57.4969
(days)	10.7400	32.0065	14.6262	38.1677	24.8714	25.5167
	0.7521	0.7480	0.6253	0.7297	1.0176	1.1216
fx (ppm)	0.5	0.5	0.5	0.5	0.5	0.5
	0.3324	0.3343	0.3999	0.3427	0.2457	0.2290

Table III. Residues of fenthion in cardamom (ppm) - September - October 1986 - Thadiyankudisai

Days elapsed	Fresh		Cured		Moisture free basis	
	0.05	0.10	0.05	0.10	0.05	0.10
0	4.0238	5.8375	8.4516	12.5454	17.2335	25.8410
1	3.3381	4.8394	6.5821	10.5248	16.5527	24.6739
3	1.9478	2.4399	2.7184	7.8128	8.9732	12.0294
7	0.8012	1.6743	1.1630	4.2279	3.7130	8.2281
15	0.4203	0.9128	0.7899	2.5841	1.7644	4.4995
30	0.1766	0.4818	0.3683	1.4415	0.9081	2.1841

Table IV. Dissipation of fenthion in cardamom - September- October, 1986 Thadiyankudisai

Parameters with confidence limits	Fresh		Cured		Moisture free basis	
	0.05	0.10	0.05	0.10	0.05	0.10
K_1 (b)	-0.0244	-0.0315	-0.0397	-0.0290	-0.0387	-0.0192
	-0.0443	-0.0342	-0.0422	-0.0306	-0.0431	-0.0348
	-0.0642	-0.0369	-0.0447	-0.0322	-0.0475	-0.0504
K_2 (a)	5.3150	4.1486	5.9649	10.2424	14.5044	23.4315
	2.7246	4.0207	4.7742	9.7230	12.5806	19.5299
	(ppm)	1.4302	3.8967	3.8212	9.2300	10.9119
r^2	0.9050	0.8864	0.8221	0.9122	0.8774	0.9054
$T_{1/2}$ (days)	9.8468	9.4960	7.5533	10.3509	7.6968	12.5267
	6.7946	8.8012	7.1327	9.8366	6.9838	8.6494
	3.7424	8.1060	6.7101	9.3223	6.2708	4.7721
T_{tol} (days)	22.6963	28.1593	26.1138	44.0028	33.7828	76.0309
	16.8533	26.4708	23.2204	42.1176	32.4988	45.7385
	11.0586	24.9961	20.4245	40.4099	31.7708	33.7626
F (x) (ppm)	0.9045	0.5660	0.6602	0.5681	0.6471	1.9552
	0.5	0.5	0.5	0.5	0.5	0.5
	0.2764	0.4418	0.3796	0.4401	0.3864	0.1279

9.8 in cured cardamom respectively in the first and second trials (Table III and IV). Considering the tentative tolerance limit of 0.5 available for other crops (Anonymous 1981), the waiting period arrived was 16.9 to 20.2 days for fresh capsules and 23.2 to 23.4 days for cured capsules at the recommended concentration of 0.05 per cent.

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EFFECT OF INTERCROPS ON OCCURRENCE OF *RADOPHOLUS SIMILIS* IN ARECANUT PALMS*

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ABSTRACT

Survey conducted in the major arecanut growing tracts of Kerala, Karnataka and Tamil Nadu revealed the widespread occurrence of the burrowing nematode, *Radopholus similis* in South India. Maximum percentage occurrence of *R. similis* was recorded from arecanut palms (55.1%) intercropped with banana, followed by 45.2, 43.9, 29.8 and 11.1 per cent when inter/mixed cropped with black pepper, cardamom, coconut and cacao, respectively, whereas in pure areca plantations, the percentage occurrence was only 25.4. Maximum percentage occurrence of *R. similis* was also noticed in banana (64.5%) compared to black pepper (26.0%), cardamom (19.5%), coconut (16.6%) and cacao (Nil). Banana as an intercrop was found to favour multiplication of *R. similis* in arecanut gardens, whereas when cacao was used as mixed crop nematode population was lowest and cacao was found to be free of infestation.

INTRODUCTION

The arecanut palm, *Areca catechu* L. is extensively cultivated in South India. The burrowing nematode, *Radopholus similis* was first reported from the root zone of arecanut by Kumar, Viswanathan and D'Souza (1971). Later, Koshy, Sundararaju and Sosamma (1978) recorded the widespread distribution of *R. similis* in South India associated with coconut, arecanut, banana and black pepper. In general, arecanut is inter/mixed cropped with either one or more crops like banana, black pepper, cardamom, coconut, cacao etc. Hence, a survey was undertaken to study the effect of inter/mixed crops on *R. similis* population in arecanut plantations.

MATERIALS AND METHODS

Survey was carried out in pure arecanut garden and gardens intercropped/mix-

cropped with other crops such as coconut, banana, cardamom, black pepper and cacao. A total of 882 each of soil and root samples was collected from the rhizosphere of arecanut in Kerala, Karnataka and Tamil Nadu. Root samples were also collected from coconut (271), banana (274), black pepper (73), cardamom (41) and cacao (18) which are grown in arecanut gardens. For arecanut, soil and root samples were collected 75 cm away from the bole of the palm at a depth of 10 to 50 cm with a 75 mm diameter soil auger. Three such samples were taken within the basin at 120° to each other, mixed well and an aliquot of 250 cc samples drawn. In addition to the root bits collected through auger, 50-60 g tender main feeder roots were also collected wherever possible from the base of the palm. In the case of coconut, samples were collected one metre away from the bole of the palm to a depth of 10-50 cm as in the case of arecanut.

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Root samples of black pepper, cardamom and cacao, were collected mostly from arecanut gardens wherever it was convenient. Soil samples were processed by Cobb's sieving and sifting method and root populations were extracted by the method reported by Koshy, Sosamma and Nair (1975) and counts made under a stereoscopic microscope.

RESULTS AND DISCUSSION

The percentage occurrence of *R. similis* in arecanut palms grown with inter/mixed crops are given in Table I. It is interesting to note that *R. similis* was observed in 55.1 per cent of samples from arecanut palms intercropped with banana, followed by

45.2, 43.9, 29.8 and 11.1 per cent when inter/mixed cropped with black pepper, cardamom, coconut and cacao, respectively. In pure areca plantations, the percentage occurrence of *R. similis* was only 25.4. The crop combinations of arecanut, banana and cardamom were practised only in Karnataka, whereas inter cropping of arecanut with banana is practised in all plantations in Kerala, Karnataka and in some parts of Tamil Nadu. Another factor was the influence of irrigation in areca gardens in Karnataka area and the resultant increased occurrence of *R. similis* irrespective of the crop combinations involved. It was also seen from Table II that high percentage occurrence of *R. similis* was recorded from

Table I. *Effect of intercrops on occurrence of Radopholus similis in arecanut palms*

Crop combinations	No. of samples collected from arecanut	No. of samples yielded <i>R. similis</i>	Percentage
Arecanut + Banana	274	151	55.1
Arecanut + Pepper	73	33	45.2
Arecanut + Cardamom	41	18	43.9
Arecanut + Coconut	271	81	29.8
Arecanut + Cacao	18	2	11.1
Arecanut alone	205	52	25.4

Table II. *Occurrence of Radopholus similis in different intercrops grown in arecanut gardens*

Crops	No. of samples collected	No. of samples yielded <i>R. similis</i>	Percentage
Arecanut	882	338	38.3
Coconut	271	45	16.6
Banana	274	177	64.5
Black pepper	73	19	26.0
Cardamom	41	8	19.5
Cacao	18	0	0.0

the roots of banana (64.5%), followed by black pepper (26%), cardamom (19.5%) coconut (16.6%) and cacao (nil) which are commonly grown in arecanut gardens.

Banana and black pepper are favoured hosts of the burrowing nematode which has been reported as the agent of the root rot disease of banana (Blake, 1961) and yellows black pepper (Van der Vecht, 1950).

Studies conducted at CPCRI Regional Station, Vittal and Research Centres at Kahikuchi and Hirehalli showed that yield of arecanut decreased by growing banana as an intercrop (Sannamarappa and Muralidharan, 1982) Bhandary (1974) reported 54.4 per cent decrease in the yield of arecanut due to mixed cropping with black pepper, though it is not known whether pepper was manured adequately in this trial, nematode populations were not monitored in any of these investigations. Arecanut, banana and black pepper being highly susceptible to burrowing nematode, it is likely that root rotting on these crops would have increased consequent to increase in nematode populations, particularly, under irrigated conditions. This certainly could be the possible reason for reduction in yield even with adequate manuring of all the crops involved. On the contrary, yield of arecanut was found to increase when cacao a non-host of the burrowing nematode was grown as a mixed crop in the arecanut gardens. Thus, the present investigations have clearly brought out that banana and black pepper as intercrops in arecanut based farming system favoured the multiplication of *R. similis* in arecanut palms, whereas

cacao could be used as an ideal intercrop for mixed cropping with arecanut, since cacao is free from nematode infestation. There is a need for introducing only nematode free planting materials as well as regular application of nematicides in such farming systems.

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DYNAMICS OF LIFE-CYCLE OF CARDAMOM SHOOT BORER, *CONOGETHES PUNCTIFERALIS* GUEN.

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ABSTRACT

The castor capsule borer, *Conogethes (Dichocrocis) punctiferalis* (Guen.), is a serious pest on cardamom causing upto 80% damage. The management of the pest becomes difficult as its occurrence is sporadic over the year. So, a detailed study on the bio-ecology is very essential for efficient management of the pest. This paper reports the study of the biology and ecology of the pest during 1986-88. The life cycle was completed within 41-57 days in summer season (March-June), but it was prolonged upto 84-123 days in winter months (November-February). Again it was only 46-68 days during August-October. These variations in the duration of the life cycle are discussed in relation to the seasonal occurrence of the pest and abiotic factors.

INTRODUCTION

The cardamom shoot borer (CSB) *Conogethes (Dichocrocis) punctiferalis* Guen, a polyphagous species, is economically injurious to cardamom, *Elettaria cardamomum* Maton. Successful control is heavily dependent on precise timing of insecticide application coinciding with adult emergence. Over the years the adult emergence in the field is erratic and precise timing of adult emergence could not be forecast making the planning of plant protection difficult. The life cycle of *C. punctiferalis* was completed within 33-52 days in castor and ginger, but there was prolongation in the duration of larval and pupal stage during winter season (Jacob, 1981). The present study on the bioecology of CSB was taken up to see whether any such prolongation occurs so that the bio-ecology of the pest over the years would give indication on the period of adult emergence and exact time of insecticide application.

MATERIALS AND METHODS

The studies were carried out from 1986 to 1988 at the Regional Research Station of Indian Cardamom Research Institute, Thadiyankudisai, Tamil Nadu. The percentage of attack of CSB was calculated based on monthly observation on the number of bore holes with frass in the pseudostems of fifty cardamom clumps, which did not receive any plant protection measure. The biology of CSB was studied under laboratory conditions. The larvae and pupae collected from the field were reared in laboratory and as soon as the adults emerged they were sexed and caged in large plastic container @ 3 females and one male per container. The adults were fed with 20% honey solution and exposed to indirect sunlight from 8 am to 11 am till they started oviposition. If there was no sunlight the containers with adults were exposed to 40 watts light for the same period. The first instar larvae after hatching were reared in small containers @ 4 larvae per container by providing unopened leaf bud,

immature capsule and later on by providing with pseudostem cuttings as the larvae grew up. The duration of the individual stages including preoviposition and incubation periods as well as abiotic factors in the laboratory conditions for two consecutive years were recorded.

RESULTS AND DISCUSSION

Biology

The duration of different life stages was studied during summer and winter months as well as during the intervening months between summer and winter (Table I). There was significant difference in oviposition period, larval, prepupal and pupal periods between the summer and winter months. The total period from egg to adult was 41–57 days and 84–123 days during summer and winter, respectively. The prolongation of life stages during winter may be due to 'Dormancy' behaviour which is mainly controlled by temperature (Table I) as influenced by the existing photoperiod. The maximum temperature during summer and winter was between 23–29°C and 19–25°C and the minimum was between 16–23°C and 16–21°C, respectively.

In Nigeria it was reported that in *Plodia interpunctella* (Hubner) (Pyralidae) the developmental periods from egg-hatch to adult of diapausing individuals ranged from 136–151 days, while those of non-diapausing individuals at 30°C and 20°C ranged between 23–34 and 60–72 days, respectively, (Mbata, 1987). Shinkaji and Oho (1970) had observed that low temperature influenced 'diapause' in *C. punctiferalis*. Higher temperature tended to prevent the diapause induction. It was also observed that the incubation period, larval and pupal periods of *C. punctiferalis* infesting castor and ginger varied during winter and summer months. There was always prolongation of these stages during winter seasons/at low temperature (Fletcher, 1914; Srivastava and Awasthi, 1961; David, Narayanasamy and Murugesan, 1964; Patel and Gangrade, 1971 and Jacob 1981).

Population vs Biology

The studies on the percentage of infestation indicate that enen though the symptom of infestation was noticed throughout the year there were five peaks viz; January (9–10%), March (19–25%), June (10–43%), August

Table 1. Life-cycle of *Conogethes punctiferalis* Guen. during different seasons (Duration of each stage is in days)

Month/Season	Abiotic factors			Previ- position	Incuba- tion	Larva	Prepupa	Pupa	Total days
	Max. °C	Min. °C	Hum. %						
<i>Summer</i>									
Mar. Apr. & May	23–29	16–23	65–85	2–3	6–7	21–32	2–3	10–12	41–57
Feb. Mar. & Apr.	23–28	16–23	49–85	2–3	5–7	21–36	3–5	12–16	43–67
Aug. Sept. & Oct.	22–27	19–23	59–98	5–9	3–4	24–35	1–2	13–18	46–68
<i>Winter</i>									
Nov. Dec. Jan. & Feb.	19–25	16–21	49–92	17–19	6–8	40–62	4–7	17–27	84–123

(16–38%) and October (8–17%). The percentage of attack was between 10–43% in March, June and August and 8–17% in January and October indicating that during summer months and during the intervening months between summer and winter, the life-cycle was completed within 41–68 days and so the attack was more; whereas during winter months as the life-cycle was prolonged to 84–123 days there was only upto 17% attack. The overlapping generations as a result of short life-cycle in summer and in the intervening months are responsible for the rapid build up of population which is reflected on the increase in percentage of damage.

The early instar larvae of CSB feed on unopened leaf buds, immature capsules and panicles; only the late instars bore and feed on pseudostem. So for effective control, the insecticide application is to be given before the larvae enter the pseudostem (Varadarasan, Kumaresan and Gopakumar, 1988). The present study on the biology shows that the preoviposition and incubation period in summer was only 8–10 days and it was 23–27 days in winter and hence the application of insecticides can be planned accordingly. In other words during summer months or where the temperature is high the insecticide spray may be started 8–10 days after adult emergence and during winter after 23–27 days of adult emergence. The timing of insecticide application can be planned for effective management considering the adult emergence, preoviposition and incubation period during summer and winter.

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STUDIES ON *HALYOMORPHA MARMOREA* F. (PENTATOMIDAE: HETEROPTERA), ASSOCIATED WITH TENDER NUT DROP IN ARECANUT*

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ABSTRACT

The biology of pentatomid bug *Halyomorpha marmorea* F. which causes tender nut drop in arecanut has been studied. The investigations were conducted during post-monsoon seasons of 1985 and 1986. Under laboratory conditions, the female and male bugs lived for 38.0 and 33.8 days, respectively. Females laid, on an average, 4 egg clusters, each comprising 28 eggs. The incubation period varied from 4-6 days with an average of 5.1 days. There were five nymphal instars each with an average duration of 3.7, 4.1, 5.1, 6.5 and 9.3 days, respectively. The description of different instars is furnished in detail. The nature and extent of damage to arecanut and host range of this pentatomid bug are also discussed.

INTRODUCTION

The tender nut drop in arecanut is a serious malady. It has been estimated that nearly 10-20% palms had this malady irrespective of management practices, in the gardens surveyed in Karnataka (Anonymous, 1984). Many authors reported the association of insects, mites and pathogens in the damage of inflorescence, bunch and tender nut (Rao, 1965; Sadanandan and Antony, 1972; Saraswathy, Reddy and Nair, 1977). The actual causes of the malady and causal organisms involved were not identified till recently. The first report has briefly described the role of *Halyomorpha marmorea* F. (Pentatomidae: Heteroptera) as the causal agent of the tender nut drop in arecanut (Vidyasagar and Bhat, 1986). As this new insect pest has not been reported from any other crop in India, a detailed investigation on the biology and its role in tender nut drop in arecanut was carried out.

MATERIALS AND METHODS

Life history

The study was conducted at Central Plantation Crops Research Institute, Regional Station, Vittal, Karnataka during 1985 and 1986. From the field-collected bugs a laboratory culture was established and biology of the insect was studied. Rectangular glass jars (12 x 15 x 24 cm) covered with muslin cloth were used for maintaining the culture. All nymphal instars were provided with fresh pods of cow pea (*Vigna sinensis*) on alternate days and the studies were carried out under a range of 28-33°C temperature and 70-85% relative humidity. When the insects attained fifth instar fresh tender arecanut bunches were supplemented with pods of cow pea on alternate days. Adults on emergence were sexed and two pairs per jar were released for further studies on mating and egg laying.

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habits. Egg cluster usually laid on the muslin cloth were transferred to small cylindrical glass jars (8 x 18 cm) and the rectangular glass jars covered with fresh cloth. Each egg cluster was kept separately for hatching and allowed to develop till the first moulting. After moulting the second instar nymphs were transferred to rectangular jars. Observations were recorded during September-November 1985 and October-December 1986.

The descriptions and measurements of individuals were made from live specimens and specimens preserved in 80% ethanol. The description of each stage is based on 10 individuals. Drawings were made with a camera lucida and measurements with an ocular micrometer.

Nature and extent of damage

Last instar nymphs as well as adults were used in this study. Freshly cut arecanut bunch with 4-11 tender nuts (3cm length) was provided to each pair of adults/nymphs. After two to three days all the nuts were split and observations recorded on the nature of feeding. Some observations on the length of feeding and site selection were also recorded.

During 1985 and 1986 a few field visits were made to arecanut gardens to collect nymphs and adults from the areca palm.

RESULTS AND DISCUSSION

Egg

The eggs were 0.9-1.00 mm long and 0.75-0.9 mm wide. They are laid in a cluster of 28. Each egg is milky white in colour when freshly laid and turning to cream colour on the 3rd day. The shape of the egg is more or less spherical. The egg cluster is laid in a triangular formation on the rachis.

The first instar is described in detail, but only important changes from the previous instar are described for subsequent instars. The comparative measurements are given in Table I.

First instar

2.29 mm long and 1.86 mm wide (Fig. 1). Body semispherical, yellowish orange, tylus slightly exceeding juga, eyes scarlet; antenna 4-segmented, fusiform with the smallest 1st segment and longest last segment. Thoracic nota with lateral and mid-dorsal black patches. Femora and tibiae fuscorufous, tibiae slightly dilated distally with outer surface grooved along the entire length; tarsi yellowish and 2-segmented; tarsal claws and pulvilli tinged with yellow and translucent; dorsum of abdomen showing two lateral and one mid dorsal black patch.

Second instar

4.08 mm long and 2.62 mm wide. Black and oval. Antocular tooth acute; juga exceeding the tylus; eyes fuscorufous; antenna fuscorufous with the longest distal segment. Lateral margins of thoracic nota acutely dentate with 4 pronotal, 3 mesonotal and 3 metanotal dentations; impunctate area along the mid dorsal line from anterior pronota to posterior metanota. All femora with a subacute tooth at the anterior distal end. Abdomen with 5-fragmented rectangular, medial plates; lateral plates albidous with impunctate area adjacent to lateral margin of abdomen. Last medial fused with albidous pleura. Each lateral plate has a conspicuous central tubercle with central seta.

Third instar

5.65 mm long and 3.24 mm wide. Black and oval; antennal segments 2-4 of ca. equal length; head longer; juga equal to tylus.

Table I. *Measurements (mm) of various stages of Halyomorpha marmorea F.*

Stage		Mean	S. E.	CV (%)
Egg		1.00	0.007	2.24
I instar	L	2.29	0.046	6.36
	W	1.86	0.044	7.44
II instar	L	4.08	0.042	3.04
	W	2.62	0.051	6.20
III instar	L	5.65	0.042	2.33
	W	3.24	0.094	9.16
IV instar	L	7.64	0.023	0.93
	W	4.56	0.017	1.15
V instar	L	12.10	0.272	7.11
	W	7.39	0.106	4.52
Adult ♀	L	17.50	0.100	1.81
	W	10.05	0.085	2.68
Adult ♂	L	16.65	0.124	2.35
	W	8.65	0.124	4.51

L: Length; W: Width

Dorsal side with more numerous punctures. Thoracic nota with dentations laterally and impunctate area along the base of dentations; pro and mesonota with lateral circular patches devoid of punctures, mesonotum with medial area strongly extended posteriorly. Femora with one acute and another subacute tooth at the distal end. One and two abdominal segments with lateral acute dentations; abdominal medial plates 2-6 highly sclerotised.

Fourth instar

7.64 mm long and 4.56 mm wide. Body black, and oval; distal 1/3 of 3rd antennal segment albidous; dorsal side more densely punctate. On dorsal side of head a white, impunctate, crescent at the base of each eye. Lateral margin of each thoracic tergite with

8-shaped impunctate, albidous area near the lateral margin; femora with a few stout setae; protibiae often with one or two white incomplete annulus at the distal end; meso and meta tibiae with a white, complete annulus in the middle 1/3; outer surface of tibiae grooved along the entire length; mesonota subarcuate but not extending posteriorly; meta-nota lacking lateral dentation which was present in the previous instar. Meso and meta-notal wing pads often extending to the posterior margin of 1st abdominal segment. Lateral abdominal tergites without conspicuous tubercles as in the third instar.

Fifth instar

12.10 mm long and 7.39 mm wide (Fig. 2). Body pyriform; punctures more numerous; dorsal side black and ventral side white with

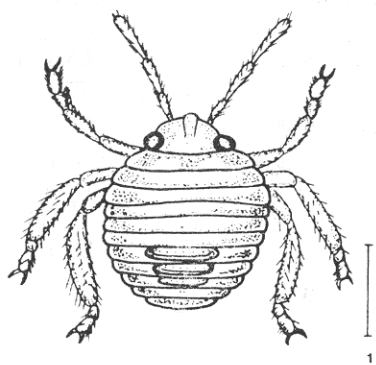


Fig. 1. First instar nymph

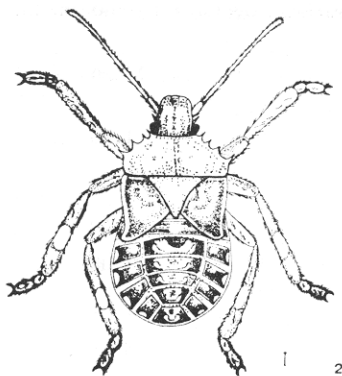


Fig. 2. Fifth instar nymph

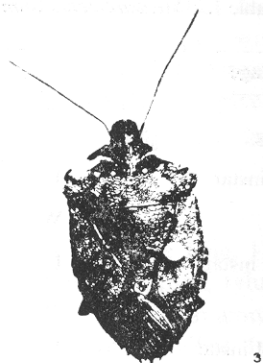


Fig. 3. Adult bug

pinkish tinge on the abdominal sclerites. Head distinctly elongate; ratio of last 3 antennal segments same as in previous instar. Mesonotal wing pads extending upto 2nd abdominal segment while metanotal wing pads extending to the 3rd abdominal segment. Pronota with lateral dentations and meso and metanota completely lacking them. Femora without distal teeth which were present in the earlier instar. Protibiae with an incomplete annulus at the 1/3 distal portion. Meso and metatibiae with complete annulus in the middle region. Acute dentations on the lateral margins of first and second abdominal segments of the previous instar are absent. Lateral plates impunctate, elliptical, white, extending dorsally and ventrally from margin of abdomen.

Adult

Female: 17.50 mm long and 10.05 mm wide (Fig. 3). Body pyriform and stramineous on dorsal side; abdominal tergites black, while ventral sternites are white. The head is elongated with tylus equal to jugus; second segment of antenna longest and third and fourth segments albidous at the 1/3 proximal end; dorsal side of head, pronota and mesonota with numerous punctures. Lateral margins of pro, meso and metanota without dentations; anterior margin of mesonota with four white spots; pro and meso tibiae

with a complete white ring at the middle. Metatibiae with incomplete white annulus on the posterior side and red coloured anterior side. The fused lateral margin of abdomen with five white spots extending from dorsal to ventral side. The female is larger than male in size and the last three abdominal segments are bulged on the ventral side.

Male: 16.65 mm long and 8.65 mm wide. Morphologically it is similar to the female except in the last 3 segments of abdomen. In male a pair of anal cerci are clearly visible on the ventral side of last abdominal segment.

Life history

Adults mated on the rachis of arecanut in the laboratory. The female laid 28 eggs in the form of a triangular cluster mostly during night time. Each female on an average laid about four egg clusters consisting of 112 eggs with a range of 2-6 clusters. The incubation period varied from 4-6 days with an average of 5.1 days. The eye spot was noticed on the opercular side about 24 before hatching. The life span of different stages is given in Table II. The first instar nymphs emerged through the operculum. They were gregarious and remained atop the egg shell on the first day after hatching. Though they moved actively on the food plant from the second day onwards, the feeding activity was

Table II. *Life span (in days) of different stages of Halyomorpha marmorea F.*

Stage	Mean	Range	S.E.	CV (%)
Egg (224)	5.1	4-6	0.12	11.98
Instar I (47)	3.7	3-5	0.12	21.74
Instar II (36)	6.1	5-7	0.12	12.06
Instar III (31)	5.1	5-7	0.12	11.59
Instar IV (18)	6.5	5-8	0.21	13.66
Instar V (12)	9.3	9-10	0.14	5.05
Adult female	38.0	25-55	2.28	20.03
Adult male	33.8	23-58	2.46	22.99

Number of individuals is given in parentheses

almost nil. The first instar period lasted for about 3-5 (mean 3.7) days. The second instar nymphs were active and fed continuously on the food source. The period of development of the second instar varied from 5-7 (mean 6.1) days. The third instar nymphs were also gregarious and completed their growth in 5-7 (mean 5.1) days. From fourth instar onwards the nymphs were observed to form smaller groups of 3-4 individuals and fed voraciously. The fourth instar lasted about 5-8 (mean 6.5) days. The fifth instar nymph fed on tender nuts of arecanut and moulted to adults after 9-10 (mean 9.3) days. The entire development period averaged 35.8 days.

The adults were also observed feeding on the tender nuts of arecanut and mated in about 4-7 days after emergence. The preovipositional period ranged from 9-12 days. The longevity of females on an average was 38.0 days compared to 34.8 days of males.

Nature and extent of damage

Both fifth instar nymphs and adults fed on the tender nuts of arecanut. The bugs pierced the fibrous pericarp and soft kernel with their long proboscis and sucked the sap

The piercing was completed in 10-15 min. and the feeding continued for 2-4 h at a stretch. Interestingly, the bugs were observed to make use of the same puncture repeatedly until the sap is exhausted from the nut. In most of the cases the insects were found to visit the same nut for subsequent feedings. Due to the depletion of sap content, the nuts get detached from the rachis and drop. On an average one bug was able to suck the sap from one nut a day. The results of the damage potential of the insect are given in table III. The feeding activity remained more or less same throughout adult life. Under laboratory conditions the nuts dropped on the third day after damage. When the nuts damaged by bugs were cut and observed they showed the typical discolouration of kernel and total depletion of the sap of the endosperm. (Fig. 4). When the surface of nuts was scraped the usual pin prick-like marks mentioned in the earlier literature were observed. In healthy non-infested nuts, there was neither discolouration of kernel nor depletion of sap and the nuts did not drop as in the case of damaged ones.

In a sample of 106 nuts damaged, 58 (55%) nuts showed punctures in the middle portion,

Table III. *Damage potential of Halyomorpha marmorea F. on tender nuts of arecanut*

S. No.	No. of insects	No. of nuts offered	No. of nuts damaged	Average feeding durations (days)	Daily average damage by one insect
1	11	43	29	2.8	0.94
2	8	38	19	2.4	0.99
3	7	28	21	2.2	1.36
4	7	28	14	2.0	1.00
Average					1.07

whereas, 28 (26%) and 20 (19%) nuts exhibited punctures in the distal and proximal portions of the nut. Earlier reports have stated that the shedding of nuts was more in some palms. This can be easily explained by the fact that the bugs tend to be gregarious resulting in heavy dropping in some palms compared to others. This type of behaviour was reported in other bugs also (Hoffman, 1931; Cuda and McPherson, 1976). Besides arecanut and cowpea, this insect was found feeding on fruits of bitter gourd and fingers of okra in the field. When these hosts were

offered under controlled conditions, the adults/last instar nymphs readily accepted them for feeding. However, their first preference was always arecanut/cowpea.

It has been noticed from farmer's reports and field visits that the tender nut drop begins around April and becomes severe during monsoon. The main alternate/collateral host cowpea which is grown as a vegetable by most of the farmers during monsoon is not grown during summer. During this period the insect migrates to the crowns of area

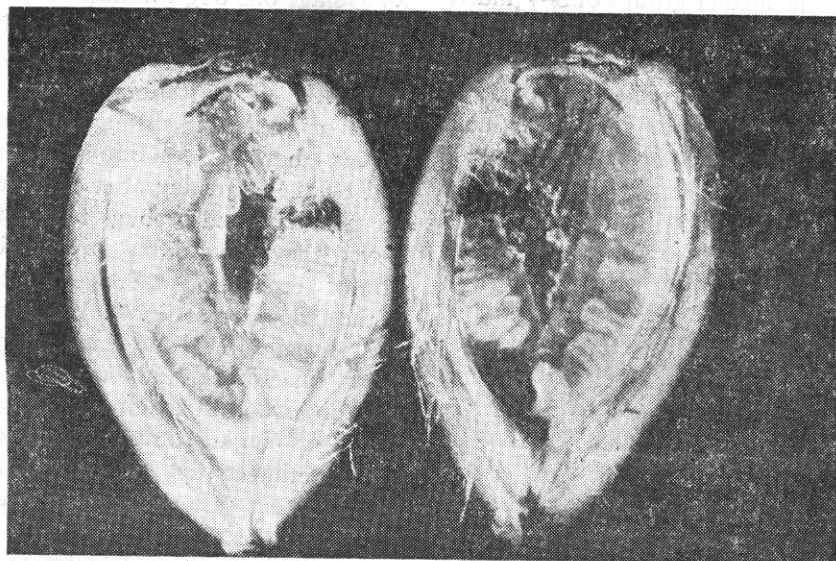


Fig. 4. Longitudinal section of the tender nut showing insect damage to kernel

palms and multiplies there. Several nymphs and adults were collected from the palms showing tender nut drop during the field visits. Once the hardening of kernel begins, the insect moves to other host plants like cowpea, bitter gourd, okra etc. which are available in the field. This way the insect is sustained in the farmers' gardens almost throughout the year.

Pentatomid bugs are known to cause economic damage to many agricultural crops. A related species *Halyomorpha picus* F. was reported as a pest of beans in China (Hoffman, 1931) and as a minor pest on citrus in Ceylon (Hutson, 1936). It has been reported that *Halyomorpha reflexa* Sign. feeds on *Solanum verbascifolium* while *Halyomorpha mista* damages soybean pods and other legumes (Golding, 1941; Kadosawa and Santa, 1981). However, from India *H. marmorea* F. or other allied species has not been reported as pest on any other crop. Hence, this is the first detailed study conducted on *H. marmorea* F. in arecanut.

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Author wishes to record his sincere thanks to late Dr. K. Shama Bhat, former Joint Director, CPCRI Regional Station, Vittal for his keen interest in this study. The encouragement by the Director, CPCRI, Kasaragod is gratefully acknowledged. My sincere thanks are also due to Mr. G. B. Pillai, Head, Division of Entomology for critically going through the manuscript.

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RESIDUES OF DIMETHOATE IN BLACK PEPPER

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ABSTRACT

Two supervised trials were conducted. In one trial dimethoate was applied as a schedule, three times commencing from new flush formation/flowering and repeated at monthly intervals. The harvest time residues in fresh and cured berries were below detectable levels. In the other trial dimethoate was applied at the time of berry formation, to study the dissipation of dimethoate in pepper by taking samples on 1, 3, 7, 15 and 30 days of treatment. The initial deposit was 1.3 ppm in fresh berries at both doses and 2.1 and 3.2 ppm in cured pepper at 0.06 and 0.12 per cent concentrations respectively. Half life of dimethoate was 5 days in fresh berries and 8 days in cured samples. Nearly half of the one to 3 days old residues were lost due to curing. Residues of dimethoate were below the tolerance level of 2 ppm in green pepper and cured pepper.

INTRODUCTION

Cultivation of black pepper (*Piper nigrum* L.) in Lower Pulneys in Tamil Nadu is mainly affected by leaf gall thrips, *Liothrips karnyi* Bagnall, causing characteristic marginal galls on tender leaves and 'pollu' beetle, *Longitarsus nigripennis* Mots. causing hollow berries or 'pollu' berries. The attacked vines get retarded. Pillai and Abraham (1974), Nair and Christudas (1976) had evaluated insecticides for the control of the thrips and pollu beetle. Dimethoate being a systemic chemical is used largely in recent years to control these pests. Since the pesticides are applied to pepper vine very close to harvest also, any toxic residues accumulating in the berries might cause serious health hazard to the consuming public. With this in view investigation was undertaken to study the dissipation of dimethoate in pepper to suggest a safe waiting period for effective management of insecticides.

MATERIALS AND METHODS

Two supervised field trials were conducted. In one trial dimethoate was applied as a schedule, three times commencing from new flush/flowering and repeated at monthly intervals. Three rounds were given during September 29, October 27 and November 25, 1987. Instead of harvesting in April-May, 1988 the harvest was done during June 24, 1988.

A second supervised trial was conducted during September-October, 1987 at Horticultural Research Station, Thadiyankudisai, Tamil Nadu Agricultural University on six year old Panniyur - 1 pepper vines with four replications to study the dissipation of dimethoate. Five vines constituted one replication and three litres of spray fluid was used per vine. Samples were taken at 8 spikes/vine totalling 40/replication for residue estimation on 1, 3, 7, 15 and 30 days after

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application. After taking fresh samples, the remaining samples were cured and the weight of fresh and cured berries of respective samples were recorded for estimating the residues on moisture free basis.

A sub-sample of 30 g fresh berries were extracted with 50 ml of methylene chloride and filtered. In the case of cured berries, samples were powdered, moistened with 30 per cent water kept for 2 hrs with occasional stirring and extracted with methylene chloride as above. The methylene chloride was evaporated to near dryness, 5 ml of methanol was added and the contents were transferred to a separating funnel. The flask was washed with 30 ml of petroleum ether and 25 ml of water and washings were added to the separating funnel. The aqueous layer was retained and this was repeated twice with 10 ml portions of water and the petroleum ether fraction was discarded. The aqueous layer was again washed with 30 ml of light petroleum ether and the ether fraction was discarded.

The aqueous phase was extracted three times with 25 ml portions of chloroform and the extract was combined and evaporated to near dryness. The condensed chloroform extract was transferred to a chromatographic column containing anhydrous sodium sulphate (2cm) and acid

washed charcoal (4 cm) and residues were eluted with 50 ml of chloroform at 2 ml/minute. The cleaned up extract was evaporated to near dryness and redissolved in 5 to 10 ml of n-hexane and injected in to GC-NPD fitted with 5% SE 30 column. The operating parameters are: Temperature (°C) column 200, injector 220, and detector 230; gasflow (ml/minute) N₂-30 ml, H₂-30ml and air-300.

RESULTS AND DISCUSSION

The retention time of dimethoate was 63 sec. The recovery from fortified samples at 1 ppm level was 90-92 per cent in fresh and 92.0 - 95.5 in cured pepper. The residue levels in green pepper, cured pepper and on moisture free basis are furnished in Table I and the statistical parameters (Timme and Frehse, 1980) for residue data in Table II.

The initial residues a day after application was 1.3 ppm in fresh berries at both doses and 2.1 and 3.1 ppm in cured pepper for the recommended dose and double the dose respectively while it was 5.1 and 5.4 ppm when calculated on moisture free basis (considering Ca. 65.2 to 76.8 per cent moisture content) for 0.06 and 0.12 per cent spray respectively. About 41-59 per cent of the one to three day old residues was

Table I. *Residues of dimethoate in pepper (ppm) Sept. - Oct. 1988*

Days elapsed	Fresh		Cured		Dry basis	
	0.06	0.12	0.06	0.12	0.06	0.12
1	1.2663	1.2962	2.0538	3.1700	5.1124	5.3963
3	0.6064	0.8734	1.1769	1.4681	2.0192	3.2038
7	0.1175	0.3154	0.1600	0.4463	0.5642	1.5404
15	0.0828	0.1925	0.1445	0.2361	0.2717	0.5527
30	0.0188	0.0346	0.1310	0.1727	0.0809	0.1154

Table II. *Dissipation of dimethoate in pepper*

Parameters with confidence limits	Fresh		Cured		Dry basis	
	0.06	0.12	0.06	0.12	0.06	0.12
K ₁ (b)	-0.0166	-0.0337	-0.0227	-0.0035	-0.0179	-0.0412
	-0.0573	-0.0516	-0.0363	-0.0390	-0.0563	-0.0557
	-0.0990	-0.0695	-0.0954	-0.0815	-0.0947	-0.0702
K ₂ (a) (ppm)	3.1420	2.1311	7.7304	7.5388	11.0510	7.8235
	0.7430	1.1308	0.9539	1.6696	2.8340	4.6752
	0.1757	0.5999	0.1177	0.3697	0.7268	2.7938
r ²	0.8699	0.9656	0.5605	0.7396	0.8789	0.9802
T 1/2 (days)	8.9841	7.8569	21.781	16.1222	8.8365	6.8144
	5.2531	5.8333	8.292	7.7179	5.2531	5.4039
	1.5221	3.8097	5.1970	0.6924	1.6697	3.9971
T tol (days)	—	—	—	—	9.9406	9.4156
	—	—	—	—	2.6892	6.6212
	—	—	—	—	-19.3745	3.1607
fx (ppm)	—	—	—	—	6.6322	2.9393
	—	—	—	—	2.0000	2.0000
	—	—	—	—	0.6030	1.3608

lost due to curing. The loss of seven day old residues was as high as 71 per cent. After fifteen days the loss in residues due to curing was almost 'nil' perhaps due to small level of bound residues. The residues at both the concentrations dissipated below 1 ppm on 3rd day itself in fresh berries and on 7th day in cured berries. The half life of dimethoate was 5.3 and 5.8 days in fresh berries, 8.3 and 7.7 days in cured pepper and 5.3 and 5.4 days on moisture free basis at 0.06 and 0.12 per cent respectively. Dissipation of dimethoate was faster and the application at two concentrations did not leave any residues above the tolerance limit of 2 ppm prescribed by EPA (Anonymous, 1981).

The initial deposit of dimethoate was low and is in accordance with the findings of Regupathy et al. (1981 and 1982) on hill banana and mango. Ebling (1963) stated that factors like plant form, shape

of the plant parts etc. influence the distribution and ultimate deposition of insecticides on plant surface. Venugopal et al. (1980) reported terminal residues of dimethoate in mango fruits were well below the tolerance limits when the insecticide was applied at 0.1% a.i.

In the supervised trials conducted by applying schedule of treatments, the harvest time residues were below detectable levels both in fresh and cured pepper. This is obvious due to long time interval elapsed between harvest and application. The dissipation of dimethoate is relatively faster, the half life being 5.3 to 8.3 days and the initial deposit of 1.33 to 3.17 ppm.

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BIOECOLOGY OF CARDAMOM ROOT GRUB, *BASILEPTA FULVICORNE* JAKOBY (EUMOLPINAE, CHRYSOMELIDAE: COLEOPTERA)

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ABSTRACT

Biology of the cardamom root grub, *Basilepta fulvicorne*, (Eumolpinae, Chrysomelidae: Coleoptera) was studied at Regional Research Station, Mudigere. A gravid female laid 50 to 60, white, tubular, capsule-like eggs 5 - 8 cm deep in the soil.

The eggs hatched in 10 to 15 days. There were three instars and pupation took place in an earthen, small cap-like case. The larval and pupal periods lasted for about 78 to 80 and 22 to 25 days, respectively. Total life cycle in monsoon period (June-September) extended upto 110 to 120 days. Under confined conditions adult longevity varied from 65 to 70 days.

INTRODUCTION

The cardamom root grub, *Basilepta fulvicorne* Jakoby, is assuming the status of a major pest in most cardamom growing areas in the country. Gopakumar, Kumaresan and Varadarasan (1987) reported it to be a serious pest in Kerala and suggested that two timely applications of phorate 10G (@ 40g/clump) coupled with mechanical collection of adult beetles using a hand net would substantially minimize the infestation.

In Karnataka *Basilepta fulvicorne* was found damaging roots and rhizome portion of one year old cardamom seedlings in nursery in 1983 at Mudigere. Later, this insect has been found principally damaging cardamom seedlings severely in 1 and 2 year old cardamom nurseries, in almost all the cardamom growing areas of Karnataka. Since comprehensive information on *B. fulvicorne* was not available, a detailed study

on the bioecology of the insect was carried out.

MATERIALS AND METHODS

The study was conducted at the Regional Research Station (RRS), Mudigere and the Indian Cardamom Research Institute, Sakleshpur. From April 1988 onwards a three year old cardamom (Malabar type) plot extending to about 2.5 ha at RRS, Mudigere was frequented for recording field activities of the insect.

Adult activity

At RRS, Mudigere the number of adult insects were counted at hourly intervals from 8.30 to 17.30 hrs. The insect counts were made visually without disturbing the cardamom plants. The maximum number recorded in an hour over the day was considered as the number of beetles for that day.

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Laboratory rearing

The adults for laboratory rearing were collected using punched (20 cm x 13 cm) polythene bags. The open end of the polythene bag was gently inserted into the leaf from tip and the leaf was given a gentle tap. The insects collected were sexed and transferred to plastella cups (7 cm x 7 cm) containing 3 to 4 bits of *Artocarpus heterophyllus* leaves which served as a preferred ovipositional substrate as well as food for the adult beetles. The *Artocarpus* leaf-bits were placed on a layer of moist soil, 2 to 3 cm thick. In addition to the *Artocarpus* leaf-bits, the beetles were offered 3 to 5% sugar syrup in cotton wads. One mated pair of *Basilepta* per cup was enclosed. At the central portion of the lid of the cup a piece of fine wire mesh was fixed for aeration.

The eggs were individually transferred from the egg mass on jack leaf-bits, using a fine (No.1) camel hair brush to a glass jar (19 cm x 16 cm) containing a year old *E. cardamomum* (Malabar type) seedlings in a bed of 10 to 12 cm thick moist soil. The eggs were placed about 1.5cm inside the soil Ca. 2 cm away from the main stem. In all, 10 to 20 eggs were placed/jar. The seedling was enclosed in a punched polythene (30 cm x 30 cm) bag. In the glass jar, the growth and development of the insect from egg to the adult were monitored. Growth parameters like size, weight and period were recorded for each developmental stage of the insect.

RESULTS AND DISCUSSION

Adult field behaviour

Observations revealed that the adult *Basilepta* was active in cardamom field from about 8.30 to 17.30 hrs. The adult beetles were not active in field on cloudy days. The

beetles were seen alighting on the cardamom plant mostly from the twigs of *Artocarpus heterophyllus* and *Ficus* sp. and usually perched at 10 to 15m, 1 to 1½ hr after sunrise and leave the cardamom plants at about 17.30 hrs. an hour prior to sunset. Interestingly, even though the beetle is not phototropic, its diel activities seem to be influenced by the photoperiod. The beetles exhibited no definite pattern of activities on cardamom plants.

Usually the beetles sun-basked and made short aerial flights over cardamom plants. Whenever the males encountered females, they were found courting and mating. Females were observed probing the soil at the base of the cardamom plant for egg laying.

About 2 hr prior to sunset, the beetles moved to the margins of the cardamom leaf. Slowly the beetles moved towards the leaf tip. Some beetles were observed moving from ventral to dorsal surface of the leaf and orienting towards the tip. The beetles often moved the antennae and body sideways and revolved around the tip. Eventually about an hour prior to sunset the beetles abandoned the leaf tip to alight on the shade trees.

These observations suggest that the adults of *B. fulvicorne* do not feed on cardamom plant, but utilise the plant for courting and mating. The feeding of adult beetles were recorded on *Ficus* sp. in addition to *Artocarpus*.

Adult numbers

During early April, 10 to 25mm rainfall was received, which was enough to stimulate the beetles for emergence. As a result, nearly 200 beetles were recorded on an average daily upto 3rd week of April. From 4th week onwards the numbers dwindled

to about 60 upto 3rd week of May. From 3rd week of May onwards not more than 25 beetles were noticed upto August 1988, although about 50 mm rainfall was received during this period. Nearly 90% of the *Basilepta* beetles emerged during April-May i.e., as just 10–25 mm rainfall may provide optimum soil moisture conditions for adult emergence. The number of beetles emerged during April–May was significantly higher (χ^2 1 d.f. $P < 0.25$) than that recorded from June to August. Observations recorded on adult numbers at R.R.S. Mudigere and ICRI, Sakleshpur showed a similar trend.

Adult morphology

The adult *Basilepta* exhibits dimorphism. As could be seen from Table I, the sexes varied in size as well as colour. Females were larger than males. While a majority of the males (upto 58%) were metallic green and some (42%) were cuprous red; females were mostly (79%) metallic blue, while some (21%) were metallic green). Under confined conditions adult longevity on an average ($n=20$) varied between 65 to 70 days.

Immature stages

A gravid female laid on an average 50 to 60 eggs. The eggs were laid at a stretch, mostly near the tertiary roots of

cardamom plant, 5–8 cm below the soil. However, under laboratory conditions females also laid eggs on ventral surface of jack leaf along the veins or at the junction of 2 veins. The eggs were white, cylindrical, laid in a mass at varying directions with a gummy ooze. An egg measured 0.66 mm x 0.26 mm ($n=50$). Average percentage of egg hatchability ($n=60$) recorded during May was 60.

The egg on an average hatched in 10 to 15 days ($n=30$). The yellowish white grubs were 'C' shaped and pubescent with brown protruding head. The larva underwent three instars, spanning over 78 to 80 days ($n=50$). Mature larva weighed about 17.0 mg ($n=25$). Pupa exarate, white and often enclosed in an earthen cap-like cell. Pupa weighed 18.5 mg ($n=50$) and the pupal period extended upto 25 days ($n=30$) in the laboratory.

Nature of damage

B. fulvicorne damage on cardamom in Karnataka has been observed mostly in primary and secondary nurseries, (Gopakumar et al., 1987). An assessment of damage to seedlings in Mudigere and Sakleshpur revealed that *B. fulvicorne* causes upto about 30 to 40% seedling mortality. In the main field its damage is negligible and hence *B. fulvicorne* in Karnataka is a major pest primarily in nurseries.

Table I. Size, weight and colour in adult *Basilepta* in relation to sex

Sex	Size (mm)		χ^2 1 d.f.	Adult characters* Weight (mg)		χ^2 1 d.f.	Colour %		
	Length ($\bar{x}$)	Breadth ($\bar{x}$)		$(\bar{x})$	Metallic blue		Metallic green	Cuprous red	
Male	4.0	2.0	P (>0.05)	5.7	(P (<0.05)		0.0	58.0	42.0
Female	6.0	4.0	P (>0.05)	10.3	(P (<0.05)		79.0	21.0	0.0

Grub is the damaging stage. In primary nurseries (One year old seedlings), the grub tunnels and bores into the rhizome portion, killing the seedling. In secondary nurseries (two-year old seedlings), the grub feeds voraciously on the outer layer and pith of the secondary roots irregularly; such seedlings either produce less or no tertiary roots. Aerially, the leaves turn yellow, the plant appears sick and wilted. In severe cases of infestation (*i.e.*, upto 15 grubs/clump), seedlings dry and die. Seedlings affected by *B. fulvicorne* grubs get exposed to infection by pathogens as well. As a result the affected seedlings usually rot.

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HARVEST AND POST HARVEST TECHNOLOGY

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EFFECT OF DIFFERENT WASHING METHODS ON QUALITY OF COFFEE AND THEIR ECONOMICS

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ABSTRACT

In a comparative study to evaluate the effect of 3 different methods adopted for dissolution of mucilage on quality of coffee, it was found that machine wash (attrition), natural fermentation and enzymatic methods had no apparent effect on raw, roast and liquor characteristics of coffee. Use of pectolytic enzyme concentrates for mucilage degradation involved additional cost ranging from Rs. 540/- to Rs. 1242/- over natural fermentation or machine wash method for every tonne of clean coffee processed.

INTRODUCTION

Processing of coffee on the estate is done by two methods; wet processing by which 'plantation' or 'parchment coffee' is prepared and dry processing by which 'natural' or 'cherry coffee' is prepared.

Wet processing is more sophisticated than dry process and by general consent leads to better quality coffee and commands a higher price. This method is commonly used for arabica coffee but also occasionally for robusta coffee.

In Guatemala all arabica coffee produced is processed by wet method (Bernhard Rothfos, 1980), while in India approximately 75% of arabica coffee produced is converted into washed arabica or plantation coffee (Manoharan, Renuka and Sunalini, 1988).

The preparation of parchment coffee requires pulping equipment and adequate supply of clean water. First and foremost important step in this process is picking right type of coffee fruits and pulping fruits on the same day. The mucilage on the parchment is removed by any one of the

following methods: (1) Natural fermentation (2) Treatment with alkali, (3) Enzyme treatment, and (4) Attrition/ frictional removal by machines such as aquapulpers. Wootton (1965) while comparing the quality of coffee processed by natural fermentation and alkali treatment method pointed out that the fermentation process contributed towards upgrading of final appearance of green beans, whereas coffee obtained by alkali treatment had poor appearance.

It is also a matter of debate among the planting community whether dissolution of the mucilage with the aid of enzymes has a positive effect on the liquoring quality of coffee as compared to other washing method.

As the information on the aspect of quality of coffee obtained by adopting different procedures for dissolution of mucilage was meagre, a comparative study was conducted using 3 different washing methods. Results of these experiments and economics of different methods adopted to process coffee are presented in this paper.

MATERIALS AND METHODS

Bulk quantities of right type of arabica coffee fruits were taken and pulped and these pulped beans were processed by 3 different methods, viz., (1) Natural fermentation (2) Enzyme treatment, and (3) Aqua wash method on the same day. The trial was conducted at Central Coffee Research Institute.

Natural fermentation

Natural fermentation of coffee was carried out in the absence of water as normally practised in the estates. Pulped beans were heaped in a fermenting tank, initial time and time taken for complete demucilisation process was noted.

Enzyme treatment

Two pectolytic enzyme concentrates supplied by M/s. Biocon Ltd., Bangalore and M/s. Mycozyme Industries, Mysore were used for enzymatic method.

'Biocoffeezyme' and 'Coffeezyme' were added separately at the recommended levels i.e., 1 g of Biocon/kg of pulped beans and 2% weight/volume of pulped beans in case of coffeezyme. For uniform distribution of enzyme the concentrates were dissolved/diluted in little quantity of water and then were added to pulped beans and thoroughly mixed. Time of addition, time taken for complete dissolution of the mucilage, ambient temperature and temperature of the fermenting mass were recorded.

The complete dissolution of mucilage was assessed in both natural fermentation and enzymatic method by feel method that is when a handful of washed parchment is squeezed makes pebble sound. The parchment was given thorough wash with fresh water for 4 to 5 times.

Aquawash method

The pulped beans with mucilage were fed to a aqua washer of capacity of 35-40 lits per hour and clean washed parchment was obtained.

Thus the parchment coffee obtained from each method was spread on a tiled flooring and coffee was dried to the standard test weight prescribed by the Coffee Board (be 15.5 kg/40 L of parchment coffee). The duration for drying parchment coffee in each treatment was noted.

The experiment had 3 replications and was conducted for two seasons during 1986-87 and 1987-88. Clean coffee samples were processed and 'A' grade coffee was sent for cup evaluation at Bangalore cup tasting centre for their assessment.

RESULTS

Data on time taken for dissolution of mucilage under different temperature conditions by adopting natural fermentation and enzymatic method are presented in Table I.

The labour requirement for different operations while processing by different methods and number of days required for drying coffee to the optimal moisture level are given in Table II. To harvest 6000 kg fruits of arabica approximately 80 workers are needed per day and each worker is expected to harvest 75 kg fruits per day. The cost of harvesting including incentive to be paid will work out to (Rs. 1064 + 394.00) a total of Rs. 1458.00 which is common expenditure for all the processes.

Out turn of coffee processed by different methods are presented in Table III.

Table I. *Data on time taken for demucilisation under different ambient temperature conditions*

Ambient temperature range in °C	Temperature of the fermenting mass	Time taken for dissolution of mucilage	
		By enzyme	By natural fermentation
22–23°C	23.0°C	A) 1 hr. 15 min. B) 3 hrs.	27–28 hrs.
19–21°C	20.5°C	A) 3 hrs B) 4 hrs. 30 min.	31–32 hrs.
15.5–16.5°C	17.0°C	A) 4 hrs. 15 min. B) 6 hrs. 30 min.	37 hrs.

A – Biocoffeezyme B – Coffeezyme

Table II. *Approximate cost involved on the processing of 1 tonne of clean coffee under 3 different methods*

Details of Operation	Aqua wash method		Natural fermentation method		Enzymatic method	
		Rs. Ps.		Rs. Ps.		Rs. Ps.
(a) Pulping, washing and spreading coffee	3 workers*	39.90	4 workers	53–20	4 workers	53–20
(b) Drying, spreading, stirring, heaping, covering and upto final bagging	One worker per day					
(c) No. of days drying of coffee		7 days needed	9 days needed	119.70	8 days needed	106.40
(d) Electricity charges for running 16–20 HP motor for 4–5 hours	75 units	75.00	20 units	20.00	20 units	20.00
Total		208.00		192.90		179.60
(e) Cost of enzyme						
(a) Bio coffeezyme	3.6 kg to process 1 tonne clean coffee @ 1 g/kg pulped beans (Rs. 150/kg)					540.00
(b) Coffeezyme	82.8 lit of the concentrate to process 1 tonne of clean coffee (Rs. 15/lit)					1242.00

* Labour wages – Rs. 13.30 per day

Table III. *Out turn of coffee*

Treatment	Parchment to clean coffee
(a) Bio coffeeyzyme	78%
(b) Mycozyme	79%
(c) Natural fermentation	79%
(d) Aquawash method	79.6%

DISCUSSION

Bio coffeeyzyme and coffeeyzyme used at recommended levels depending on the ambient temperature took varying time for total dissolution of mucilage. At ambient temperature range of 22–23 °C a duration of one and a quarter hour, and 3 hours was required respectively by Bio coffeeyzyme and Mycozyme concentrates. The duration for demucilisation was increased as the ambient temperature decreased. Time required for natural fermentation varied between 27 to 37 hours depending on the ambient temperature that existed at the time of experimentation.

Use of enzyme concentrates reduced fermentation time considerably and hastened the process of mucilage degradation. The time saved due to enzyme usage accounted to approximately 26–33 hours. Jaleel and Sreekantaiah (1981) reported patic enzyme treatment reduced the processing time to one hour from 36–48 hours required for natural fermentation at ambient temperature 25–30 °C.

Approximate cost involved in 3 different methods of coffee processing indicated that Aqua wash method and natural fermentation method will cost almost same, ranging from Rs. 193/- to Rs. 208/-. Processing by using enzyme concentrates involved an additional expenditure of Rs. 540/- and

Rs. 1242-00 over natural fermentation or Aqua wash method which being the cost of enzyme concentrates.

Drying time required to dry the parchment coffee to the standard prescribed was in the following order:

Aquawash method (7 days); Enzymatic method (8 days); Natural fermentation method (9 days).

It was observed that coffee processed without much contact (Aqua wash) with water for a long time dried faster when compared to enzymatic and natural fermentation methods.

The out turn report received from curing works revealed that the percentage outturn varied between 78 and 79.6 per cent. A slight weight gain in Aquawash method was noticed. Similar observations was reported by Gopalan (1972) while processing coffee by Aquawash method. Perusal of the cup taste reports of the coffee samples processed by 3 different methods revealed no apparent difference in raw, roast and liquor characteristics (Table IV). (No. apparent effect of different methods were observed on the raw appearance of the bean).

Wooton in his preliminary studies found that the flavour quality essentially remained unchanged in coffee obtained by different methods but the liquoreness would advance the grading by one or two units because of better appearance of coffee obtained by natural fermentation method (Clifford and Willson, 1985).

However, in the present study no apparent effect of different methods were seen on the raw appearance of coffee.

CONCLUSION

1. Processing of coffee by natural fermentation takes 27–37 hours depending

Table IV. *Raw, roast and liquor characteristics of coffee samples*

Treatment	Raw	Roast	Liquor
(a) Bio coffeeyzyme	Greenish green to greenish blue	Fair to even	Good body and fair acidity
(b) Mycozyme	Greenish green to greenish blue	Fair to even	Good body and fair acidity
(c) Natural fermentation	Greenish green to greenish blue	Fair to even	Good body and fair acidity
(d) Aqua wash	Greenish green to greenish blue	Fair to even	Good body and fair acidity

on ambient temperature; (2) The dissolution of mucilage is achieved at a faster rate when enzymes concentrates are used, involving an additional expenditure ranging from Rs. 540/- to 1242/- for every tonne of clean coffee processed. 3. Parchment coffee obtained by attrition method dried faster compared to natural fermentation method. 4. To sum up the crux for production of quality coffee is largely dependent on selection of right type of fruits and the care bestowed on them to yield quality coffee by adopting any one of the available washing methods.

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AERATION AND ALGAL CULTURING — A METHOD OF BIOLOGICAL TREATMENT FOR CRUMB RUBBER PROCESSING FACTORY EFFLUENT

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ABSTRACT

Crumb rubber processing factory effluent was subjected to aeration with and without culturing *Chlorella vulgaris*. The treated effluent was analysed for pH, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), total nitrogen, total solids, suspended solids and bacterial population. Considerable reduction in the above parameters were noted due to aeration and culturing of *C. vulgaris*. The population of *C. vulgaris* increased remarkably upon aeration. The pH was also found to increase upon aeration with and without algal culturing. The feasibility of aerobic effluent treatment method in reducing the pollution load is discussed.

INTRODUCTION

Processing of technically specified block rubber in the form of crumb was introduced in India during 1970's. Crumb is made either from latex or from field coagulum called scraps. Enormous quantity of water is used for washing and cleaning during this process, which along with non-rubber constituents goes to form the effluent. The quantity and quality of the effluent depend on the type of raw rubber used and the quantum of rubber processed. Over 20 litres of effluent is generated for each kilogram of processed rubber. Indiscriminate discharge of this effluent into water ways and land for irrigation is prohibited by pollution control act.

Many biological treatment methods like trickling filter (Ponniah, Chick and Scow, 1975) anaerobic followed by aerobic ponding (Muthurajah, John and Henry Lee, 1973) were reported to be useful for the treatment of effluent from rubber processing factories. Attempts were also made to treat waste water

by culturing algae (Jayangoundar et al, 1984; Chaudhari, Krishnamoorthi and Lalitha, 1983) in waste water with the aim to reduce pollution and get some return in the form of protein rich algae. (Kulkarni, Peter and Stanton, 1973) also reported the possibility of culturing of *Chlorella vulgaris* in rubber factory effluent. In order to monitor the effect of *C. vulgaris* culturing on crumb rubber processing factory effluent, a laboratory study was carried out and the same is reported in this communication.

MATERIALS AND METHODS

Stock culture of *C. vulgaris* was maintained in the laboratory in specific synthetic media as prescribed by Venkataraman (1969).

Effluent samples were collected from the outlet of crumb rubber processing factory at hourly intervals for 24 hours and pooled. The consolidated samples were analysed for pH, BOD, COD, total nitrogen, total solids suspended solids and bacteria using the methods prescribed in standard methods for

the examination of water and waste water (Apha, Anna and WPCF, 1975). The effluent samples were treated as per the treatments listed below:

1. Effluent samples without either aeration or inoculation with *C. vulgaris*;
2. Aeration only;
3. Inoculation with *C. vulgaris* only and
4. Aeration and *C. vulgaris* inoculation.

Five replications were maintained for each treatment. *C. vulgaris* culture was multiplied in synthetic broth medium and used for inoculating the effluent at the rate of 5×10^4 cells/ml. Air supply was given continuously for 5 days from a compressor at the rate of 146 cc air/min. The experiment was conducted in the laboratory providing artificial light at 10,000 lux for 10 hours daily.

RESULTS

Subjecting the effluent from crumb rubber processing to aeration or *C. vulgaris* inoculation alone and aeration with *C. vulgaris* inoculation have reduced the levels of different parameters like BOD, COD, total nitrogen, total solids, suspended solids and bacterial population (Table I).

The degree of reduction in pollution differed in various treatments. Maximum reduction was recorded in aeration with *C. vulgaris* inoculation followed by aeration alone. Inoculation of *C. vulgaris* without aeration though reduced the pollution it is not appreciable. Algal growth is 80% more when the inoculated effluent was aerated. The pH of

Table I. Effect of aeration along with algal culturing in crumb rubber processing factory effluent

Parameters	Control		Aeration	<i>C. vulgaris</i>	Aeration and <i>C. vulgaris</i> inoculation
	Initial	Final			
pH	5.2	5.7	7.5	7.0	8.2
BOD	290 mg/l	233 mg/l (20)	95 mg/l (67)	190 mg/l (34)	43 mg/l (85)
COD	720 ..	607 .. (15.5)	150 .. (79)	280 .. (61)	70 .. (90)
Total nitrogen	45.8,,	38.5 .. (16)	30.4 .. (34)	35.5 .. (22)	25 .. (45)
Total solids	4670 ..	4580 .. (2)	3245 .. (31)	4062 .. (13)	2960 .. (37)
Suspended solids	1650 ..	1480 .. (10)	968 .. (41)	1340 .. (19)	820 .. (50)
Algae	—	—	—	25x10 ⁶ /ml	45x10 ⁶ /ml
Bacteria	49x10 ⁵ /ml	48x10 ⁵ /ml (2)	30x10 ⁴ /ml (93)	24x10 ⁴ /ml (95)	12x10 ³ /ml (99)

(Figures in parenthesis indicate the percentage of reduction)

the treated effluent was around neutral in all the treatments.

DISCUSSION

The basic principle involved in the biological treatment of effluent is the supply of oxygen to favour the oxidation of organic matter. Obviously low levels of various parameters recorded in aerated effluent is due to the enhanced supply of oxygen. Similar results were obtained by John et al (1974) Muthurajah et al (1973) and Ponniah et al. (1975), while treating anaerobically digested effluent from different types of rubber processing. The values of BOD, COD and total nitrogen are below the limits prescribed for discharging the effluent into water ways. The high levels of suspended solids in the treatment of *C. vulgaris* inoculation with aeration might be due to the biomass of *Chlorella*.

Chlorella sp. grow well in wastes containing low levels of BOD (John et al, 1974) and at higher levels they completely disappear. The low counts of *C. vulgaris* in inoculated effluent without aeration might be due to higher levels of BOD. Aerating the effluent resulted in low levels of BOD, which favoured the multiplication of *C. vulgaris*. This finding is in conformity with that of Kulkarni et al. (1973). The enhanced population of *C. vulgaris* is also due to raise in pH to 8.2 as it requires a pH around 8 (Chaudhari et al, 1983) for maximum biomass production.

Effluent treatments in general are capable of reducing the bacterial population especially indicator bacteria like Coliforms (John et al, 1974). In the present study also the bacterial population is less. Lesser bacterial population in effluent upon aeration with and without culturing of *C. vulgaris* might be due to nonavailability of easily decomposable organic matter or competition for mine-

ralised nutrients by *C. vulgaris* or the antibacterial activity of the algae (Venkataraman, 1969).

Seeding the effluent with *C. vulgaris* and maintaining the tanks aerated in light, were thus effective in promoting a rich algal growth and concomitant reduction in pollution load. Further studies on recovery of *C. vulgaris* by appropriate techniques and use of treated effluent rich in algae for fish culture are being initiated.

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IMPLICATIONS OF MECHANICAL HARVESTING IN TEA

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ABSTRACT

An experiment on harvesting of tea by the use of shears was carried out in Anamallais, Central Travancore, High Range and Nilgiris.

Various combinations of shear-harvesting and hand-plucking were tried in the experiments. The use of shears for harvesting the crop during the high cropping months, May, June, September, October and November led to an increase in the yield only in Central Travancore, while in the other Districts there was no significant influence. However, considerable economy in terms of reduced number of plucking rounds and pluckers utilized per year, leading to an increased plucking average was effected by the use of shears in high cropping months.

Continual shear-harvesting did not give consistent results in different locations; this may be due to the variation in severity of shearing. But, continual shearing led to decrease in the amount of maintenance foliage existing on the bush at the time of pruning. Such a reduction in leaf area, however, did not affect the dry matter accumulation in the branchlets forming the top 20 cm profile of the bush.

There, thus, seems to be a positive advantage in using shears for harvesting tea in the high cropping months during which period there is a considerable stress on the availability of workers. Hand-plucking during the other months seems to remain imperative, if only to ensure the maintenance of adequate leaf area on the bush.

INTRODUCTION

The crop in tea comprises tender apical shoots containing two/three leaves and a bud. The enormity of labour involvement in harvesting the crop could be gauged by the fact that, generally, 5000 to 7500 such shoots are required to manufacture one kilogram of made tea. Ready crop shoots are hand-picked selectively from the surface of each bush, imposing a tremendous demand on labour requirement. About 70 per cent of the labour employed by the estates is deployed for harvesting, making it the most expensive operation, accounting for about 20 per cent of the cost of tea production (Sharma, Haridas and Venkata Ram, 1981).

Because of the dense bush population, steep terrain and progressive increase in the height of tea bushes with age from pruning, particularly three years and above, physical limitation in the operation of the workers results in many ready crop shoots being left behind on the bush. Additionally, the availability of adequate workers has become a serious constraint in harvesting the available crop that has taken a quantum leap in the past decade. Both these problems become all the more accentuated during the high cropping periods, April to June and September to early December, at a time when workers are required for other equally important operations. Consequently, about 14 million kg of tea is estimated as being lost, annually.

Mechanization of harvesting in tea is expected not only to contain the spiralling wage bill, but also ease the demand on plucker requirement by way of increased worker productivity.

Earlier reports on the utility of hand-operated shears and motorised mechanical aids in harvesting tea were at variance with each other (Ananda Rau, 1951; De Jong, 1953; Wright, 1953; Fay, 1954; Anonymous, 1959; Swaminathan, 1975; Haridas, 1976; Sharma et al., 1981; Mwakha and Anyuka, 1982; Mwakha, 1985). But, most of them were based on short-term investigations carried out to the exclusion of hand plucking.

Results obtained from four field experiments carried out in the Anamallais, Central Travancore, High Range and Nilgiris, to explore the possibility of integrating shear harvesting with normal hand plucking and its long term effect on the health and productivity of the bush are reported here.

MATERIALS AND METHODS

The experiment initiated in the year 1976 in the High Range (Sharma et al., 1981) was continued upto the end of the subsequent pruning cycle in 1985. An experiment each was carried out in three other tea Districts over a pruning cycle. Details of the experiments are given in Table I.

Table I. *Experimental details*

Location	Design	Treatments* (No.)	Replicates (No.)	Bushes/replicate (No.)	Duration
Anamallais	RBD	5	6	100	Dec. 1983 – Dec. 1986
Central Travancore	RBD	5	4	100	Sept. 1981 – Jun. 1983
High Range	RBD	7	3	304	Sep. 1976 – Mar. 1981** Oct. 1981 – Dec. 1985
Nilgiris	RBD	5	5	120	May. 1984 – Apr. 1988

The crop in plots under different treatments was harvested at a time when over 75 per cent of shoots expanded three leaves. The interval between harvests varied with the treatment. The crop was harvested only in the afternoon under one treatment (Fig. 2) in Central Travancore, while in others the harvesting commenced in the morning, stretching till noon.

The treatments comprised hand plucking, shear harvesting and their different combinations (Figs 1 and 2; Table II).

Under the standard treatment, hand plucking was carried out to remove all the ready shoots at the plucking surface, taking care to retain immature shoots on the bush. Shoots were detached to a large mature leaf during the slow growing periods, January to March and July to mid-September and to the existing level of the plucking surface, irrespective of the severity, during the other months, as per the recommendations of the UPASI T.R.I. and the general practice. This was the method adopted, appropriate to the season, wherever hand plucking is indicated in the paper.

Topiarist's hand-operated, hedge-trimming shears fitted with a leaf-collecting tray were used for mechanical harvesting. Selectivity, either in the severity of the operation

* Details given in (Figs. I and 2; Table II)

**Source : Sharma et al. 1981.

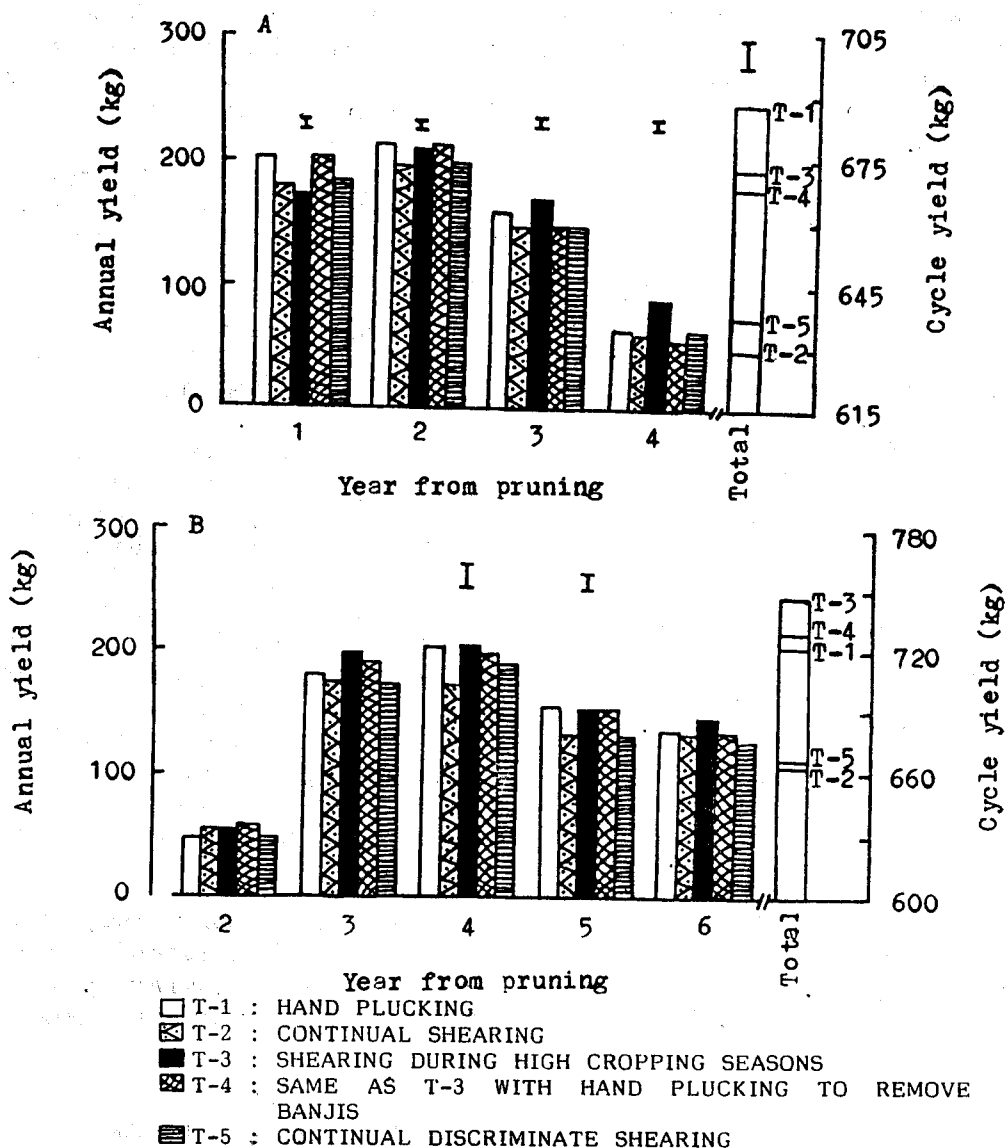


Fig. 1. Effect of shearing on yield (per plot) in A) Anamallais and B) Nilgiris. Vertical bars represent C. D. at $p = 0.05$

or type of shoots harvested, was not possible with the shears; all the shoots of varying maturity above the level of shearing were removed by shears. The intervals between successive shear harvesting were extended because of the removal of immature shoots.

Fresh weight of the crop from each plot was recorded at every round, on the spot.

At the time of pruning before concluding the experiment in the Anamallais, foliage and stem in the top 20 cm profile of the bush were separated, weighed and recorded.

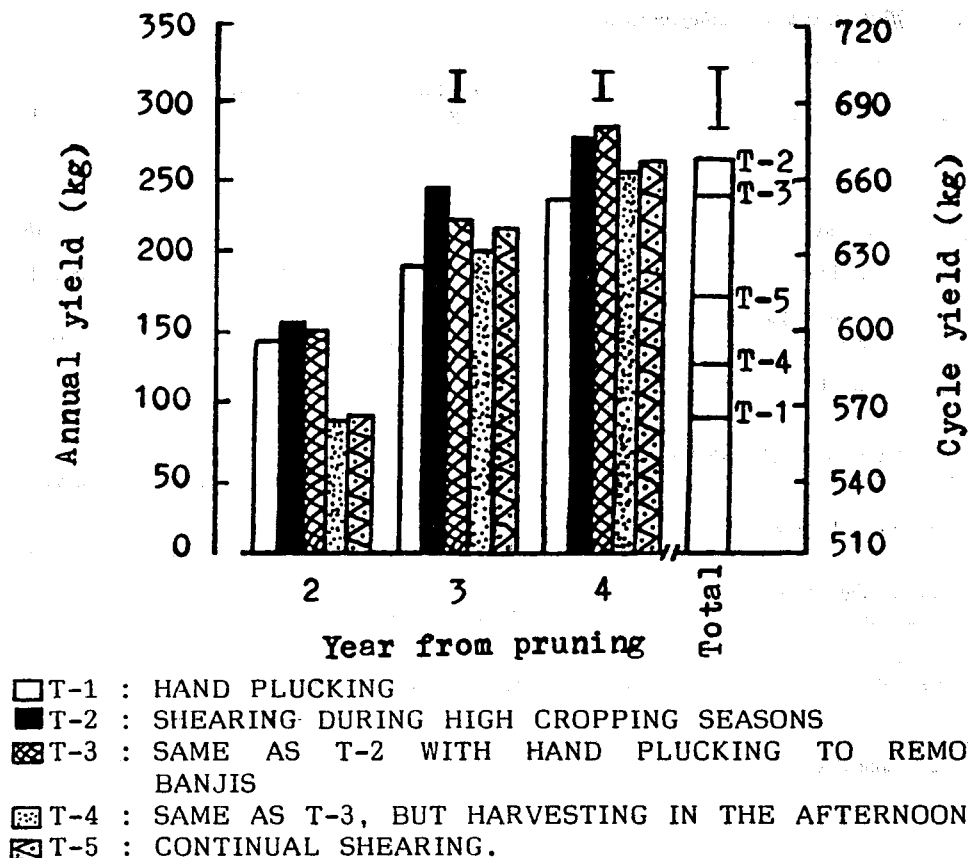


Fig. 2. Effect of shearing on yield (per plot) in Central Travancore. Vertical bars represent C. D. at $p = 0.05$

The data emerging from the experiments were subjected to analysis of variance.

RESULTS AND DISCUSSION

Continual shear harvesting to the level and discriminatory shear harvesting depressed crop in the first three and two years respectively, as also the total yield for the pruning cycle in the Anamallais (Fig. 1), substantiating the earlier findings (Ananda Rau, 1951; Swaminathan, 1975; Haridas, 1976). In the Nilgiris, there was a decline in yield in fourth and fifth year under continual shear harvesting to level, while under discriminatory shearing there was a drop in yield only in the fifth year (Fig. 1); however, yield in the

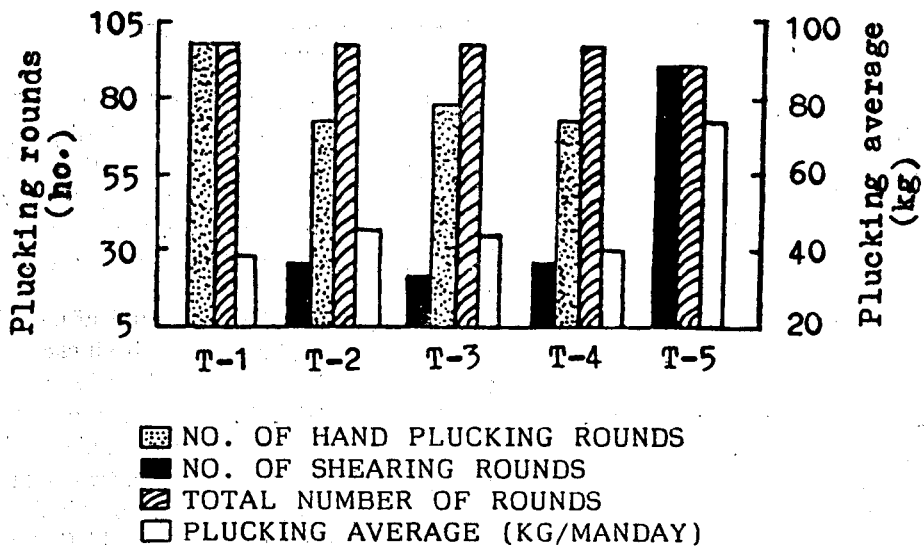
other years as well as total was not affected. There was a crop increase in third year, leading to increased total yield for the cycle due to continual shear harvesting to level in Central Travancore (Fig. 2); the treatment did not have any effect in other years.

A significant depression in leaf material in the top 20 cm layer of the bush canopy was noticed under continual shear harvesting of either type (Fig. 5). The reduced leaf material in this stratum (Fig. 5) explains the reduction in yield under these two treatments in the light of the importance of leaf load in the top 20 cm profile on yield (Satyanarayana and Sharma, 1984). This is further

Table II. *Effect of shear harvesting on yield (High Range)*

Treatments	Mean yield in kg green leaf*/plot in years from pruning					Total
	1	2	3	4	5	
Hand plucking (Standard)	142	495 a	722	606	443 cd	2408 abc
Continual level plucking	156	576 b	802	644	432 bcd	2610 d
Shearing during high cropping seasons in each year	150	484 a	719	632	399 a	2374 ab
Shearing during first high cropping season in each year	149	515 a	733	665	429 bcd	2491 abcd
Shearing during second high cropping season in each year	140	473 a	740	596	419 abc	2368 a
Shearing during high cropping seasons of 1st, 3rd and 5th years	151	505 a	794	641	414 ab	2505 bcd
Shearing during high cropping seasons of 2nd and 4th years	160	504 a	784	630	454 d	2531 cd
C.D. at P=0.05	N.S.	47	N.S.	N.S.	24	136
% CV	5	5	5	6	3	3

* Mean of 3 replicates

Fig. 3. *Effect of shearing on plucking economy (Central Travancore)*

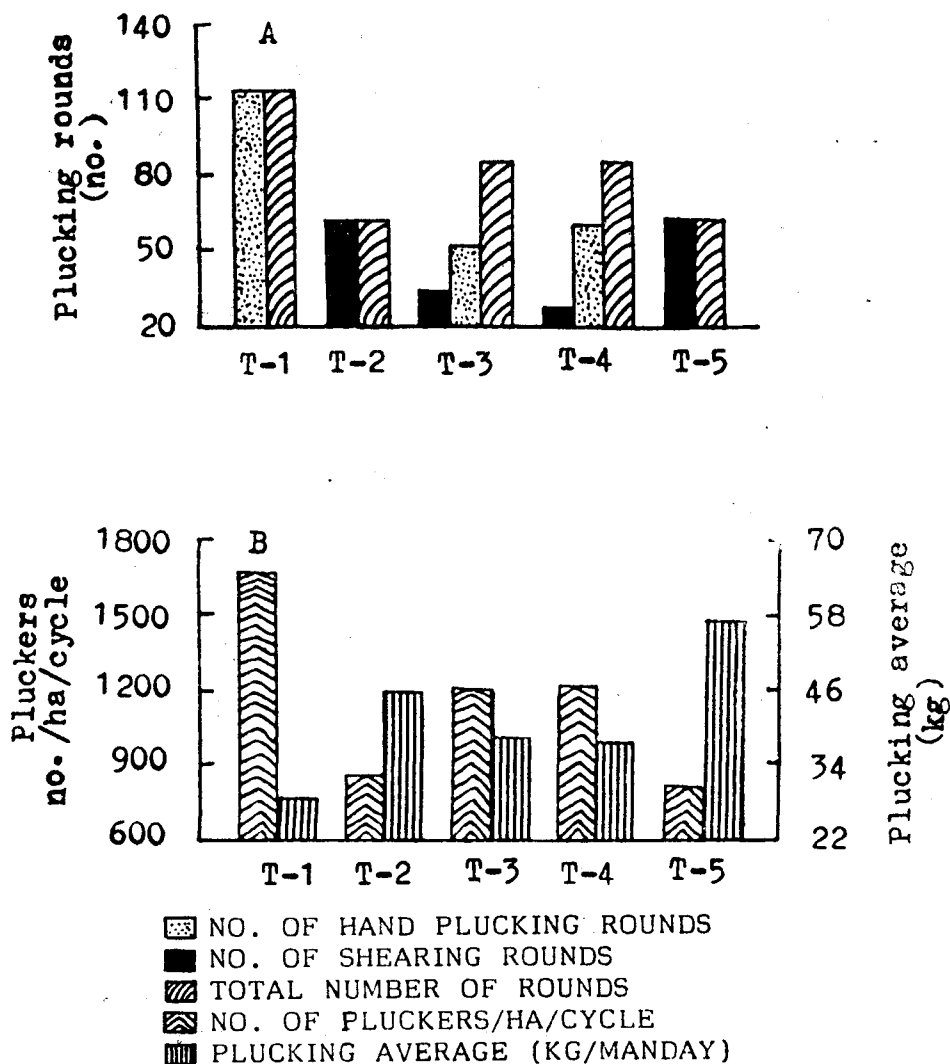


Fig. 4. Plucking economy in relation to shearing in A) Anamallais and B) Nilgiris

substantiated by the positive correlation recorded between the foliage in this layer and yield in another study (unpublished). Thus, because of the possible adverse effects on bush health, continual shear harvesting is not desirable, even though it has resulted in plucking economy (Figs. 3 and 4). Expla-

nation for any variations in response to these treatments could be sought in the variability in shearing intensity and the skill of the workers.

Use of shears during the two fast-growing seasons, April to June and September to early

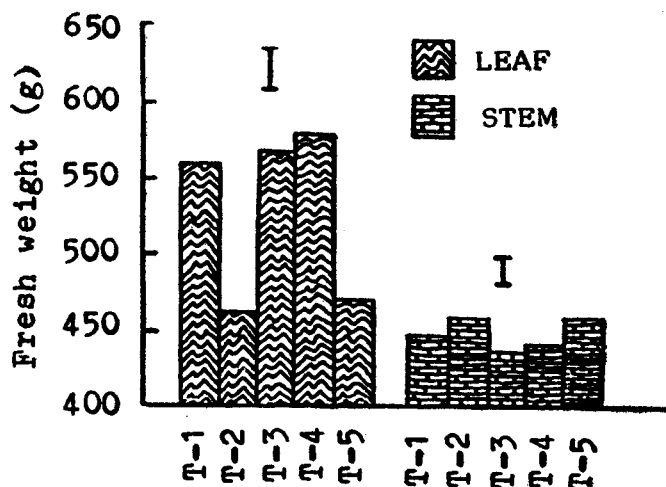
December, alternating with hand plucking during the other periods depressed crop in the first two years of the cycle followed by an increase in the third and fourth year resulting in a total higher yield of the cycle equaling than under the standard in the Anamallais (Fig. 1). The treatment did not induce any response in the Nilgiris and in the first four years, as also the total for the cycle in the High Range; in the fifth year, there was a depression in the High Range (Fig. 1; Table II). In Central Travancore, while the yield was not affected in the second year by the treatment, it has gone up in third and fourth years leading to an increased total for the cycle (Fig. 2).

The increase in yield due to the treatment in the third and fourth years in the Anamallais and Central Travancore is obviously due to the more efficient and complete

harvesting of all the ready shoots. Lack of such a response in Nilgiris and High Range is apparently due to a more efficient harvesting by hand under the standard treatment. The negative result obtained in the fifth year in the High Range could be due to the unwieldy height of the bush at which shears could not be applied effectively.

The depression in yield due to the treatments in the first two years of the cycle in the Anamallais indicates the futility of shear harvesting in the initial years when the bush is at an operable height and hand plucking is efficient; it also rings a note of caution that it is desirable to introduce shears only after building up adequate maintenance foliage on the bush.

Health of the bushes as reflected by the leaf and stem material in the top 20 cm layer



T-1 : HAND PLUCKING

T-2 : CONTINUAL SHEARING

T-3 : SHEARING DURING HIGH CROPPING SEASONS

T-4 : SAME AS T-3 WITH HAND PLUCKING TO REMOVE BANJIS

T-5 : CONTINUAL DISCRIMINATE SHEARING.

Fig. 5. Effect of shearing on dry matter partitioning into stem and leaf.
Vertical bars represent C. D. at $p = 0.05$

was not affected by imposing the shears in the high cropping seasons of different years in the pruning cycle (Fig. 5); the treatment compares with the standard, while it was superior to continual shear harvesting.

Considerable plucking economy has been effected by this treatment by way of reduced plucker requirement as a result of reduced plucking rounds and increased plucking averages (Figs. 3 and 4; Table III).

The treatment of shear harvesting during the two high cropping seasons with hand plucking imposed in between shearing rounds to remove banjis has not induced any response in the experiment in the Nilgiris, while in Central Travancore the response is similar to that of previous treatment (Figs. 1 and 2). However, in the Anamallais (Fig. 1), while there was no response in the first three years, there was a depression in yield in the fourth year and total for the cycle. The discretion of introducing hand plucking in between shearing rounds apparently varied in different centres leading to the discrepancy.

Additionally, intermittent hand plucking in the fourth year fields in which hand plucking is known to be not very efficient at a time when the crop is high possibly accounts for drop in the yield in the fourth year in the Anamallais.

The treatment has not affected the health of the bush in terms of compartmentalisation of dry matter either into leaf or stem (Fig. 5). Plucking economy in terms of plucking average and number of pluckers deployed was much higher than under hand plucking, but, lower to exclusive shear harvesting during the high cropping months (Figs. 3 and 4).

Shear harvesting only in the afternoon, included as a treatment in Central Travancore, had no effect on yield when compared to the standard, but was inferior to shearing commencing from morning (Fig. 2). The reason for including this treatment in the experiment was to find out whether the reported increase of dry matter (Gogoi and

Table III. *Plucking economy in relation to shear harvesting (High Range)*

Treatments	Plucking rounds/ Cycle			Total pluckers used/ ha/ cycle	Plucking average per manday (kg green leaf)
	Shear	Hand	Total		
Hand plucking (Standard)	—	124	124	2079	26
Continual level plucking	—	124	124	2160	27
Shearing during high cropping seasons in each year	16	96	112	1822	29
Shearing during first high cropping season in each year	8	110	118	1969	28
Shearing during second high cropping season in each year	8	110	118	1880	28
Shearing during high cropping seasons of 1st, 3rd and 5th years	8	109	117	1954	28
Shearing during high cropping seasons of the 2nd and 4th years	8	111	119	1925	29

Das, 1980) in the afternoon would increase the weight of the harvested parts.

Continual plucking to level by hand in the experiment at the High Range gave significant increase in yield in the second year and total for the cycle over that of the standard (Table II); there were no differences between treatments in the remaining four years of the cycle. No pronounced differences in yield for the cycle were noticed between the other treatments and standard.

Indications of higher yields due to shear harvesting in the high cropping seasons of alternate years (Table II) deserve a closer attention, despite not too favourable an economy under these treatments when compared to shear harvesting during high cropping seasons of every year (Table III).

It is imperative that shears are given their due place in tea harvesting schedule in the context of progressively escalating labour wages and acute shortage of workers at a time when the yields are increasing significantly. While there is a danger of affecting the health of the bush adversely by the application of shears continually and indiscriminately (Fig. 5), there is a distinct possibility of integrating shear harvesting into the schedule with benefit, with regard to both yields and cost economy.

Use of shears did not induce any favourable response in the initial years of the cycle and hence, is not profitable. It is so, because hand plucking on such bushes with lower height and lesser crop is efficient; the number of workers required for plucking in the first and second year fields is much lower than older fields. Significant increase in yields as well as considerable economy were achieved by shear harvesting in the later years of the cycle.

Earlier reports indicate that it is useful to apply shears in the fields 15 and 18 months

old from pruning of 'China' and 'Assam' hybrids, respectively (Reddy, 1983). By these periods of time, adequate maintenance foliage is normally built up by selective hand plucking so that the bushes are in a condition to absorb any shock that is likely to be imparted by a severe operation such as shearing.

It may be stated that shear harvesting may be resorted to, without detriment to bush health or quality (Ramaswamy, 1983) in the two high cropping seasons, integrated with hand plucking in the intervening slow growing periods, commencing from 15 to 18 months old from pruning.

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EFFECTS OF DIFFERENT EXPLOITATION SYSTEMS ON YIELD AND BROWNBAST INCIDENCE IN RRII 105, A HIGH YIELDING CLONE DURING BO-1 PANEL STAGE

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ABSTRACT

Two tapping systems are compared with conventional $\frac{1}{2}$ S d/2 6 d/7 control system in RRII 105 on virgin bark stage. The systems of tappings studied are $\frac{1}{2}$ S d/3 6 d/7 and $2 \times \frac{1}{2}$ S $\uparrow$ d/2 6 d/7 (t, t). Yield, girth, d.r.c., Plugging index and brownbast incidence were recorded during the initial two years. Yield under third daily tapping system was around 24% less when compared to alternate daily tapping system during the first year and 15% less in the second year. The lowest yields were recorded for quarter spiral change over system. However, plugging index was also higher for the d/3 system of tapping. There was no significant difference in the yields of dry rubber from upward and downward tapped quarter cuts. In the incidence of brownbast also there were no significant differences in the plots under different tapping systems. Similarly there was no difference in the incidence of brown bast in the upward and downward tapped quarter cuts. Girth increments were similar in trees under the different tapping systems.

INTRODUCTION

The exploitation method is an important factor in determining the yield in *Hevea*. Many tapping systems have been evolved through research during the past years. Both longer tapping cuts and more frequent tappings increase yields in the initial periods but may cause subsequent reduction because of increase in the incidence of brownbast as well as decrease in girth increment. Usually high yielders are more prone to these factors. An ideal tapping system would be one which gives the highest yield at the satisfactory growth rate and lowest incidence of brownbast along with the lowest tapping cost. But there is no single tapping system that will give the best results on all clones on all conditions. Yield per tapper is important under the condition of low rubber prices and high wages. Hence investigation of exploitation methods to each clone with a view to obtain high yield with

few tappings is also very important. Generally brownbast is considered as a physiological disorder due to over exploitation (Paranjothy, Gomez and Yeang, 1975). This phenomenon is an important factor in determining the tapping intensity to a particular clone. It is reported that brownbast increases with increase in tapping intensity (Rands, 1921; Sharples and Lambourne, 1924; Sanderson and Sutcliffe, 1921; Bealing and Chua, 1972). The frequency of tapping is said to have a greater effect than the length of the cut on induction of brownbast (Chua, 1966). Propensity to dryness is related to plugging index which is a clonal character (Milford, Paardekoooper and Hochai, 1969).

RRII 105 is a high yielding popular Indian clone (2000 kg/year / ha). High yielding tree responds less to increasing the length of tapping cut because of the larger drainage area (Ng et al., 1969). For RRII 105, the

tapping system generally followed is $\frac{1}{2}$ S d/2. However, higher incidence of brownbust is being reported by some growers. It is probable that the incidence of brownbust might be reduced by changing the tapping system without much reduction in the net profit. Adoption of less intensive system is one such possibility. Hence an experiment on this aspect was initiated in 1985.

MATERIALS AND METHODS

A study was taken up at Central Experiment Station, Chethackal in 1985 on RR11 105 (1975 planting) to evaluate the effects of different exploitation methods on yield and brownbust incidence. The plants were of BO - 1 panel stage. The tapping treatments imposed were (1) $\frac{1}{2}$ S d/2 6 d/7 (Control) (half spiral alternate daily tapping) (2) $\frac{1}{2}$ S d/3 6 d/7 (half spiral third daily tapping) (3) $2 \times \frac{1}{4}$ S $\uparrow \downarrow$ d/2 6 d/7 (t, t) (Quartral spiral change over system). The experiment was laid out on a completely randomised design with eight plots in each treatment having 15 trees in each plot. Same tapper was employed for all the treatments to avoid tappers' influence. Yield, dry rubber content, plugging index, girth and brownbust incidences were recorded. Yield was recorded by volume measurement of total latex for the first year and by cup coagulation method afterwards. Girth was recorded at 150 cm height from the bud union.

RESULTS

The results presented in this paper (Tables I and II) show that maximum yield of dry rubber is obtained from trees under $\frac{1}{2}$ S d/2 6 d/7 system of tapping. Though the yield from trees under $\frac{1}{2}$ S d/3 6 d/7 system of tapping was 23.6% in the first year, the difference was reduced to 14.5% during the second year. However, in the $\frac{1}{4}$ S double cut change over system the yield difference when compared with that of $\frac{1}{2}$ S d/2 system was more in the second year.

Table I. *Yield of latex from clone RR11 105 under different tapping systems during 1986-87*

Tapping systems	Yield of latex (l)/120 trees/year
$\frac{1}{2}$ S d/2 6 d/7	2328.94 (100)
$\frac{1}{2}$ S d/3 6 d/7	1781.41 (76.49)
$2 \times \frac{1}{4}$ S $\uparrow \downarrow$ d/2 6d/7 (t, t)	1653.74 (71.01)

Figures within brackets denote yield as percentage of $\frac{1}{2}$ S d/2 control.

Table II. *Yield of dry rubber from clone RR11 105 under different tapping systems during 1987-88*

Tapping systems	Yield of dry rubber (Kg/120 trees/year)**
$\frac{1}{2}$ S d/2 6 d/7	1160.29 (100)
$\frac{1}{2}$ S d/3 6 d/7	992.73 (85.56)
$2 \times \frac{1}{4}$ S $\uparrow \downarrow$ d/2 6d/7 (t, t)	785.61 (67.71)

C. D. 0.05 7.90

** Significant at 1% error.

(Figures within brackets denote yield as percentage of $\frac{1}{2}$ S d/2 control)

The yield per tapper per tapping was higher for $\frac{1}{2}$ S d/3 6 d/7 and lowest for $2 \times \frac{1}{4}$ S $\uparrow \downarrow$ d/2 6 d/7 (t, t) (Table III).

Table III. *Yield per tapper per tap from clone RR11 105 under different tapping systems during 1987-88*

Tapping systems	Yield/tapper/tap(kg/120 trees/year)**
$\frac{1}{2}$ S d/2 6 d/7	8.74
$\frac{1}{2}$ S d/3 6 d/7	11.03
$2 \times \frac{1}{4}$ S $\uparrow \downarrow$ d/2 6 d/7	5.55

C. D. 0.05 0.514.

** Significant at 1% error.

Statistical analysis of girth data shows no difference in girth increment for the trees under different treatments (Table IV). The data on dry rubber content shows a lower value for more frequent tapping (Table V).

Table IV. *Girth increment of trees of clone RR11 105 (1987-88) under different systems of tapping*

Tapping systems	Girth increment (cm)
$\frac{1}{2}$ S d/2 6 d/7	7.72
$\frac{1}{2}$ S d/3 6 d/7	7.54
$2 \times \frac{1}{2}$ S $\uparrow \downarrow$ d/2 6 d/7 (t, t)	8.10

N. S.

Table V. *Plugging indices in dry and wet seasons of 1987 and the annual mean dry rubber content in clone RR11 105 under different systems of tapping*

Tapping system	d.r.c. (%)	Plugging index	
		Wet season	Dry season
$\frac{1}{2}$ S d/2 6 d/7	36.6	2.68	5.46
$\frac{1}{2}$ S d/3 6 d/7	40.0	3.16	7.74
$2 \times \frac{1}{2}$ S $\uparrow \downarrow$ d/2 6 d/7 (t, t)	41.5	3.55	7.82

The data on plugging indices in wet and dry seasons are presented in Table V. Plugging index was lowest for $\frac{1}{2}$ S d/2 having more frequent tapping and higher for less frequent tapping system.

Data on incidence of brownbust are given in Tables VI and VII. Though not statistically significant, brownbust incidences were higher in plots under $\frac{1}{2}$ S d/2 6 d/7. In double cut change over system even though the frequency of tapping was less for the cut than those of the other treatments, there

was no significant reduction in the incidence of dry trees.

Table VI. *Incidence of brown bast in clone RR11 105 under different systems of tappings for two years*

Tapping system	No. of trees affected/120 trees
$\frac{1}{2}$ S d/2 6 d/7	18
$\frac{1}{2}$ S d/3 6 d/7	10
$2 \times \frac{1}{2}$ S $\uparrow \downarrow$ d/2 6 d/7 (t, t)	13
N.S.	

DISCUSSION

The results presented in this paper show that $\frac{1}{2}$ S d/3 6 d/7 system of tapping has a rising trend in yield when compared to $\frac{1}{2}$ S d/2 6 d/7 system. P' Ng and Lee (1970) reported that in PB 5/63 the yield on S/2 d/3 increased rapidly and out yielded the control in course of time. But no such effect was reported in RRIM 600 and GT1 (Gan Lian Ting et al, 1985). In RR11 105 yield per tapper was significantly high for $\frac{1}{2}$ S d/3 6 d/7 system when compared to control (Table III). This agrees with the findings of Gan Lian Ting et al. (1975). The low yield for $2 \times \frac{1}{2}$ S $\uparrow \downarrow$ d/2 6 d/7 (t, t) is due to the low drainage area, low frequency of tapping and less duration of flow of latex. Even though spillage was observed in many cases on the upper cut, statistically there was no significant difference in yield per tap between the two cuts (Table VIII). Though not statistically significant the lower yield recorded for the upper cut may be due to the loss of latex through spillage.

The low plugging index recorded for $\frac{1}{2}$ S d/2 system is because of the higher intensity of tapping. It is also reported that plugging index increases with shortening the cut length (Paardekooper, Langlois and Sompong, 1975). In this experiment the trend remained same for dry and wet seasons.

Table VII. Incidence of brown bast in the upward and downward cuts in clones RR11 105 under $2 \times \frac{1}{2} S \uparrow \downarrow d/2 \ 6 \ d/7 \ (t, t)$ system of tapping for two years.

Affected cuts	No. of cuts/ 120 trees
Upper cut	5
Lower cut	4
Both cuts	4
Total	13

N.S.

Table VIII. Dry rubber yields from upward and downward cuts in clone RR11 105 under $2 \times \frac{1}{2} S \uparrow \downarrow d/2 \ 6 \ d/7 \ (t, t)$ system during 1987-88

Tapping cut on the tree	Dry rubber yield (kg) /20 trees/year
Lower cut	445.61
Upper cut	340.00

N.S.

The data presented here shows that there is an indication that intensity of tapping has a role in the onset of brownbast, only upto a particular low intensity, below which there is no corresponding decrease. This is evidenced by the higher incidence of brownbast in quarter spiral cuts. The absence of significant difference between downward and upward quarter cuts in the incidence of brown bast shows that there may not be any advantage in adopting upward tapping in RR11 105 for tackling the problem of higher brownbast incidence in the clone. This is in contrary with the findings of Sivakumar, Ismail and Abraham (1985).

The girth data shows no statistical significance between treatments. The probable reason for this is that in all the treatments the length of the cut remained same for the

tree. It has been reported that the lengthening the cut is more deleterious for girth increment than a higher frequency for a given tapping method (De Jonge, 1969; Ng et al., 1969). Reducing the frequency of tapping at a constant length of the cut does not result in any appreciable difference in girthing at a constant length of the cut (Ng et al., 1965).

There is a possibility for exploiting RR11 105 more profitably on $\frac{1}{2} S \ d/3 \ 6d/7$ than $\frac{1}{2} S \ d/2 \ 6 \ d/7$ or $2 \times \frac{1}{2} S \uparrow \downarrow d/2 \ 6 \ d/7 \ (t, t)$, the cost of which has to be worked out under different situations.

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DISCUSSIONS

P.R.V. SUBRAMONIA IYER: Have you considered other forms of biological treatment of rubber processing factory effluent like anaerobic treatment for biogas and raising biofuels like water hyacinth?

JACOB MATHEW: Yes anaerobic treatment for biogas offers tremendous scope. There are reports from Malaysia about the tremendous scope for raising water hyacinth in rubber industry effluents.

W. KRISHNAMURTHY RAO: pH of

the effluent before treatment is 5.3. Is there any necessity to neutralise the acidity?

JACOB MATHEW: Neutralisation with lime and its effect on algal growth will be studied in future.

W. KRISHNAMURTHY RAO: What is the maximum BOD prescribed as standard for release of effluent to natural water course?

JACOB MATHEW: Limit of BOD in effluent discharge into natural water course is 50 mg/lit.

MARKETING, ECONOMICS AND STATISTICS

Chairman : P. K. DAS

Rapporteurs : M. V. GEORGE
R. KOTHANDARAMAN

YIELD AND YIELD ATTRIBUTES IN CASHEW — AN ANALYSIS THROUGH MULTIVARIATE APPROACH

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ABSTRACT

The stepwise regression analysis of ten seed/seedling characters on the nut yield of cashew has highlighted the prominence of six characters namely seed length, days taken for germination - seedling height, length and breadth of first leaf and number of opened leaves. Further study on direct and indirect effects of these characters suggested that the selection of long sized nuts (3cms and above) for raising better seedlings resulted in higher yield. The seedling which germinates early (not more than 20 days) had better yield potential and selection of 45 day old seedlings which has more number of opened leaves (12 leaves or more) preferably with long and narrow first leaf are indicative of high yields.

INTRODUCTION

The importance of seed and seedling selection in crop husbandry has been well recognised for long time. Plant yield in general, a complex entity determined by the interplay of a number of attributes and it is more complex in a perennial crop such as cashew. Adequate knowledge of inter-relation of factors influencing such complex character especially the influence of seed/seedling characters through a multivariate approach is very much essential. Similar such studies are done in various crops (Ramachander and Bavappa, 1972; Bhagavan, 1982; Liyanage and Abeywardhane, 1957; Sukumaran, Narasimhayya and Vijayakumar, 1981). In cashew, Gopikumar, Aravindakshan and Nampoothiri (1984) have attempted to study correlation between nut and seedling characters. In the present study multivariate approach such as stepwise regression analysis (Draper and Smith, 1966) and path co-efficient analysis (Dewy and Lu, 1959) have been attempted to identify factors which contribute directly or indirectly towards high yield potential.

MATERIALS AND METHODS

At NRCC Experimental Farm, Shantigodu 37 germplasm accessions were planted in 1973 for which detailed seed and seedling measurements have been recorded. Data on three seed characters namely seed length, seed breadth, seed weight and 7 seedling characters (45 day old seedlings) namely days taken for germination, seedling height, seedling girth, length from cotyledon to 1st leaf, length and breadth of 1st leaf, number of opened leaves along with yield data in terms of nut weight averaged for 4 years 1977-78 to 1981-82 (excluding 1978-79 years data) were utilized for the present study.

As the data belonged to different accessions refinement of data was carried out by, eliminating the effect due to various accessions. Similar such attempts have been made in arecanut (Bhagavan and Nair, 1986) for selection of vigour variables. Stepwise regression analysis which culls out the characters that may have insignificant contribution towards the yield and suggests the best combination of the characters that are of prime importance was

attempted for the transformed data. After the identification of prime characters through stepwise regression analysis, these characters were subjected to path coefficient analysis to measure the contribution of each component to the observed correlation and to partition the correlation coefficient into components of direct and indirect effects.

RESULTS AND DISCUSSION

Large variation was found to exist in the yield character even after elimination of effects due to various accessions. This is in conformity with the fact that crop yield is a complex entity and it is more so in case of a perennial crop such as cashew. Therefore any attempt made to quantify the contribution of characters that influence yield are to be considered only as indicative contributions. The mean values and the standard deviations of the characters studied are given in Table I.

Table 1. *Mean values at standard deviations*

Characters	Mean	Standard deviation
Seed length (cm)	2.99	0.20
Seed breadth (cm)	1.62	0.15
Seed weight (gms)	5.42	1.00
Days taken for germination	20.09	2.40
Seedling* height (cm)	16.55	2.47
Seedling girth (cm)	6.16	0.48
Length from cotyledon to 1st leaf (cm)	3.95	0.92
Length of first leaf (cm)	7.14	0.85
Breadth of first leaf (cm)	3.81	0.45
No. of opened leaves	11.40	1.88
Weight of nuts averaged for four years (kg)	1.91	0.93

* seedlings are of 45 days age

The stepwise regression analysis of the ten of seed/seedling characters regressed on yield indicated that six characters namely seed length (x_1), days taken for germination (x_2), seedling height (x_3), length of 1st leaf (x_4), breadth of 1st leaf (x_5) and number of opened leaves (x_6) combine together to give a multiple correlation coefficient of 0.58. The regression equation being:

$$Y = 2.89 + 1.01 x_1 - 0.21 x_2 - 0.05 x_3 + 0.55 x_4 - 1.18 x_5 + 0.13 x_6$$

The path coefficients of the 6 selected characters and residual factors are given in Fig. 1 and the direct and indirect effects of individual characters on the yield are presented in Table II.

Seed length vs yield

The results showed that the correlation coefficient between seed length and yield was very low whereas its direct effect was

Table II. *Correlations, direct and indirect effects*

Characters	Particulars	values on yield
Seed length	Correlation	0.10*
	Direct effect	0.19
	Indirect effect through days for germination	-.17
	seedling height	-.01
	length of first leaf	0.04
	breadth of first leaf	-.03
	no. of opened leaves	0.08
Days for germination	Correlation	-.33**
	Direct effect	-.52
	Indirect effect through seed length	0.06
	seedling height	0.02
	length of first leaf	-.16
	breadth of first leaf	0.21
	no. of opened leaves	0.05
Seedling height	Correlation	-.04
	Direct effect	-.07
	Indirect effect through seed length	0.03
	days for germination	0.12
	length of first leaf	0.28
	breadth of first leaf	-.42
	no. of opened leaves	0.03
Length of 1st leaf	Correlation	0.07
	Direct effect	0.60
	Indirect effect through	
	seed length	0.01
	days for germination	0.14
	seedling height	-.03
	breadth of first leaf	-.55
	no. of opened leaves	-.10
Breadth of 1st leaf	Correlation	-.04
	Direct effect	-.65
	Indirect effect through	
	seed length	0.01
	days for germination	0.17
	seedling height	-0.5
	length of first leaf	0.51
	no. of opened leaves	-.04
Number of opened leaves	Correlation	0.19**
	Direct effect	0.34
	Indirect effect through	
	seed length	0.05
	days for germination	-.08
	seedling height	-.01
	length of first leaf	-.18
	breadth of 1st leaf	0.08

* significant at $P = 0.05$ ** significant at $P = 0.01$

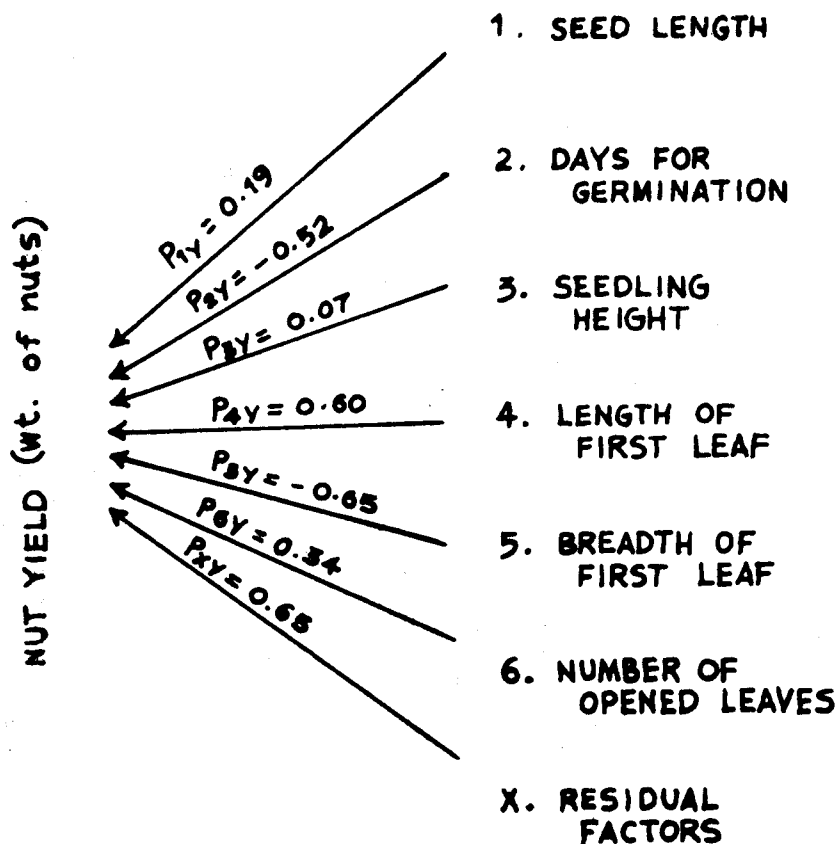


Fig. 1. Path diagram

considerably high in magnitude thereby explaining the true relationship that a direct selection through this trait would be effective in raising better seedlings of high yield potential.

Days taken for germination vs yield

It was observed that both the correlation and direct effect were significantly high in magnitude but negative. This clearly suggested the selection of seedlings which germinated early to have better yield potential.

Number of opened leaves vs yield

This character correlates significantly and also possessed high direct effect thereby

indicating the importance of selecting seedlings that contain more number of leaves.

Other seedling characters vs yield

Seedling height neither had significant correlation nor any evidence of direct effect. However, linear measurements of first leaf although did not indicate any significant correlation, their contribution of direct and indirect effects suggested that the seedlings which had lengthy and narrow first leaf were preferred.

As evident from the magnitude of variation observed for the yield character, it becomes

an herculian task to pin point all the factors that explained the variation. Attempts made here have atleast explained 58 per cent of this variation highlighting few characters. It is inferred that selection of long sized nuts (3 cms and above) may be preferred for the purposes of raising seedlings that had high yield potential. As a second step, selection of seedlings are preferred by selecting seedlings that germinated early (less than 20 days) and which possessed more number of leaves with its first leaf being lengthy and narrow for realising higher returns.

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EVALUATION OF LER AND ADVANTAGES IN COCONUT/ARECANUT BASED SYSTEMS

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ABSTRACT

Advantages in coconut and arecanut based mixed cropping systems are studied using Land Equivalent Ratio (LER), Monetary Advantage (MA), Aggressivity Index (A) and Competition Ratio (CR). Under the irrigated system, arecanut and cacao combination gave a monetary advantage of Rs. 19,193 per ha per year with an LER of 2.18. Arecanut and pepper combination gave a monetary advantage of Rs. 18,402 per ha per year with an LER of 1.50. Coconut and cacao combination recorded a monetary advantage of Rs. 14,920 per ha per year with an LER of 1.46. Under rainfed system, coconut and ginger gave a monetary advantage of Rs. 29,683 per ha per year with a corresponding LER of 1.56. Coconut and turmeric recorded a monetary advantage of Rs. 16,483 per ha per year with an LER of 1.41.

INTRODUCTION

It has been increasingly felt these days that mixed cropping (growing two or more crops on same area of land) can produce more yields than growing the same crops as sole crops. However, because of the complexities involved in mixed cropping situations it becomes difficult to assess the real advantages of the systems. This paper discusses some of the ratios and indices like Land Equivalent Ratio (LER), Monetary Advantage (MA), Aggressivity Index (A), and Competition Ratio (CR) which can be utilised to evaluate different mixed cropping situations.

METHODOLOGY

Relevant data for the studies were collected from the experimental records of Central Plantation Crops Research Institute, Kasaragod and Central Plantation Crops Research Institute, Regional Station, Vittal. The criteria suggested by Willey (1979) and Mead and Willey (1980) have been adopted.

1. Land Equivalent Ratio (LER)

$$LER = \sum_{i=1}^m \frac{y_i}{y_{ii}}$$

Where y_i is yield of the i th crop in mixed cropping, y_{ii} is the yield of that crop grown as sole crop over an equal area and m is the no. of crops grown

2. Monetary Advantage (MA)

$$MA = \text{Value of the combined intercrops} \times \frac{LER-1}{LER}$$

3. Aggressivity (A)

$$A_{ab} = \frac{Y_{ab}}{Y_{aa} \times Z_{ba}} - \frac{Y_{ba}}{Y_{bb} \times Z_{ab}}$$

Where Y_{ab} is the yield of the crop in a mixed cropping

Y_{aa} is the yield of the crop grown as sole crop, Z_{ab} is the proportion of the crop ('a' grown in combination with crop 'b' and Z_{ba} is *vice versa*

4. Competition Ratio (CR)

Competition ratio of crop 'a' with crop 'b' is given by

$$CRA = \frac{LERa}{LERb} \times \frac{Zba}{Zab}$$

With usual meaning for notations

RESULTS

Rainfed systems in coconut

The estimated LER and other advantages in coconut based systems are presented in Table I.

Coconut + cassava: The total LER was 1.15, and to produce the combined mixture yield by growing pure stands would require

15 per cent more land. Thus mixed system gave a 15 per cent yield increase. The monetary advantage in this system over the coconut monocrop was Rs. 3861/ha/yr. Coconut was found to be dominant over cassava and 9.74 times competitive.

Coconut + ginger: The total LER was 1.56 and the MA was Rs. 29683/ha/yr. Coconut was the dominant partner. The CR between coconut and ginger was 4.16 by which it could be inferred that coconut was 4.16 times competitive.

Coconut + turmeric: The total LER computed was 1.41 and the MA was Rs. 16483/ha/yr. The AI showed that

Table I. LER and other advantages in coconut based systems

	Yield/ha	LER	Total LER	Proportion of area	Monetary advantage (Rs.)	Aggressivity (A)	Competition Ratio (CR)
<i>Rainfed</i>							
1. Coconut + Cassava	8913 Nuts 6.3t	0.9328 0.2234	1.1562	0.30 0.70	3861	+2.7903 -2.7903	9.7428 0.1023
2. Coconut + Ginger	9555 Nuts 8.4t	1.0000 0.5600	1.5600	0.30 0.70	29683	+2.5333 -2.5333	4.1667 0.2400
3. Coconut + Turmeric	9555 Nuts 8.2t	1.0000 0.4100	1.4100	0.30 0.70	16483	+1.9660 -1.9660	5.6911 0.1757
4. Coconut + E F Yam	9555 Nuts 10.3t	1.000 0.4292	1.4292	0.30 0.70	13360	+2.7202 -2.7202	5.4365 0.1839
<i>Irrigated</i>							
1. Coconut + Cacao	17540 Nuts 0.415t	1.0178 0.4448	1.4626	0.30 0.70	14920	+2.7571 -2.7571	5.3010 0.1873
2. Coconut + Banana	17234 Nuts 6.3t	1.0000 0.2100	1.2100	0.30 0.70	10210	+1.1286 -1.1286	11.1100 0.0900

The average yield per ha of coconut, cassava, ginger, turmeric and EF Yam while raised as monocrop under rainfed condition are 9555 nuts, 28.2 t, 15 t, 20 t, and 24 t respectively. The yield of coconut, cacao and banana while raised as monocrop under irrigated condition are 17234 nuts, 933 Kg dry beans and 30 t respectively.

The prices were coconut Rs. 2.50/nut; Turmeric Rs. 4/Kg; Elephant Foot Yam Rs. 2/Kg; Cassava Rs. 1/Kg; Ginger Rs. 7/Kg; Cacao Rs. 8/Kg and Banana Rs. 2.50/Kg.

Table II. *LER and other advantages in arecanut based system*

	Yield/ha	LER	Total LER	Proportion of area	Monetary Advantage (Rs)	Aggressivity (A)	Competition ratio (CR)
Arecanut + Cacao	1573	0.8062	2.1814	0.5	19193	-1.1380	0.5900
Arecanut + Banana	1284	1.3752	1.4468	0.5	16648	+1.1380	1.7000
Arecanut + Pepper	2432	1.2468	1.5000	0.5	18402	+2.0936	6.2300
	6000	0.2000		0.5		-2.0936	0.1600
	1950	1.0000		0.8		-1.2500	0.5000
	600	0.5000		0.2		+1.2500	2.0000

The average yield of arecanut, cacao, banana and pepper were 1.95 t; 0.93 t; 30 t and 1.2 t respectively, when raised as monocrops. The prices: Arecanut Rs. 16/Kg; Cacao Rs. 8/Kg; Banana Rs. 2.50/Kg and Pepper Rs. 40/Kg.

coconut was the dominant partner and was 5.69 times competitive.

Coconut + elephant foot yam: The total LER was 1.42. The MA of this combination was Rs. 13360/ha/yr. Coconut was the dominant partner and was 5.43 times competitive.

Irrigated systems in coconut

Coconut + cacao: The total LER worked was 1.46 which means that the mixture gave a 46 per cent yield increase. The MA of this combination was estimated at Rs. 14920/ha/yr. Coconut was the dominant partner and was 5.30 times competitive.

Coconut + banana: The total LER worked was 1.21 and the MA was Rs. 10210/ha/yr. The AI revealed that coconut was the dominant partner and the CR indicated that coconut was 11.11 times competitive in this system.

Irrigated systems in arecanut

Table II presents the estimated LER and other advantages in arecanut based systems.

Arecanut + cacao: Total LER computed was 2.18 which was very high. The monetary advantage was Rs. 19193/ha/yr. Cacao was found to be the dominant partner with arecanut and was found 1.7 times competitive.

Arecanut + banana: The total LER was 1.45. The monetary advantage was about Rs. 16650/ha/yr. Arecanut was the dominant partner and was 6.23 times competitive.

Arecanut + pepper: The total LER computed was 1.50 and the monetary advantage Rs. 18402/ha/yr. Pepper was found to be dominant and was two times competitive.

This study clearly brought out the relative advantage of palm based cropping systems over the coconut/arecanut sole crop.

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UNIFORMITY TRIALS : OPTIMUM SIZE AND SHAPE OF PLOTS AND BLOCKS IN EXPERIMENTS WITH CASHEW*

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ABSTRACT

Uniformity trials in cashew (airlayers) were laid out in the existing cashew estates at Periya, Kasaragod district, belonging to the Plantation Corporation of Kerala. The yield data from 288 trees (24 rows of 12 trees each) were collected for two years 1982-83 and 1983-84 by daily harvest. Fair field Smith's Law $Y = ax^{-g}$ and its generalisation $Y = ac^{-g^1} r^{-g^2}$ where g's stand for the heterogeneity coefficients expressing the relationship between plot size (x) in r rows of c column and the C. V. (Y) of yield were tried. Graphical method and maximum curvature technique were used for working out the optimum plot size. Further the cost of experimentation per treatment to estimate the means at 10% S. E. was worked out for different price situations. A plot size of 6 rows of 2 trees each forming the plot across the fertility lines was found to be the optimum for experiments with cashew.

INTRODUCTION

In agriculture research, the importance of size and shape of plots and blocks for efficient planning of field experiments is widely known. The size and shape of plots depends on the inherent variability present in the crop and the environment in which it is grown. Fair field Smith (1938) worked out an empirical relationship between plot size and the C. V. % of yield. Several attempts have been made to determine the optimum size and shape of plots and blocks for various plantation crops. Agarwal, Bavappa and Khosla (1968), Abraham, Khosla and Agarwal (1969), George, Sannamarappa and Bhagawan (1979), George et al., (1983), George et al. (1989), George and Sannamarappa, (1984) have worked out the optimum plot size for arecanut, pepper, turmeric, cardamom, ginger and turmeric respectively. In this paper an attempt has been made to evaluate

the optimum size and shape of plots and blocks under different price situations for cashew which is an important cash crop producing about 2.2 million tonnes of kernels and earning about Rs. 215 crores of foreign exchange annually.

MATERIALS AND METHODS

Uniformity trials in cashew (airlayers) were laid out in the existing cashew estates at Peria belonging to the plantation Corporation of Kerala, with 24 rows of 12 trees each at a spacing 8 m x 8 m. The yield data of individual trees were collected by daily harvest for two years 1982-83 and 1983-84. Ultimate unit was taken as the yield of individual trees and plots of varying sizes and shapes were formed, combining adjacent units column wise and row-wise and corresponding C. V. % was worked out for both the years.

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Fairfield Smiths Law $Y = ax^{-g}$ was fitted to find out the relationship between plot size (x) and C. V. (Y) where g is the soil heterogeneity coefficient. Generalisation of the law in the form $Y = ac^{-g1}$, r^{-g2} was also tried to compare the heterogeneity between rows and columns where g 's stand for the corresponding coefficients.

Method of maximum curvature was also tried for getting the optimum plot size. The optimum plot size (x) is that value of the size of the plot which lies just beyond the point of maximum curvature. The curvature of any curve at a given point is defined by $C = \frac{Y_2}{(1+Y_1^2)^{3/2}}$ where Y_1 and

Y_2 are the first and second derivatives of the functional form (Y) of the curve. The point at which the curve attains the maximal value is obtained by differentiating the expression for the curvature and setting $\frac{dc}{dx}$ to zero. For Smiths' function the resultant equation is $X^2(g+1) = \frac{(ag)^2(2g+1)}{g+2}$

The plot size and shape giving the required information at a minimum cost was taken as optimum. The cost of experimentation per treatment to estimate the means at 10% C. V. was worked out under different price situations K_1 , K_2 , K_3 and K_4 using the relationship $c_{ki} = C_1.r + C_2.E + C_3.B$ where

C_{ki} is the cost of the i th price situation
 C_1 the cost of maintaining the experimental plot

C_2 is the cost of maintaining experimental plants

C_3 is the cost of maintaining border plants/ r is the number of replications required

E is the number of experimental plants and
 B is the number of border plants

The arbitrary cost ratios $C_1: C_2: C_3$ for the price situations K_1 and K_2 (without borders) and K_3 and K_4 (with borders) are 1:4:0; 1:8:0; 1:4:1 and 1:8:1 respectively.

RESULTS AND DISCUSSION

The CV decreased with the increase in plot size in both the directions but the reduction was little more rapid row-wise for the year 1982-83. The CV averaged over the different shapes of plots followed closely the relationship $Y = a x^{-g}$. The equations obtained were $Y = 91.82 x^{-0.51}$ ($R^2 = 0.98$) for 1982-83 and $Y = 93.96 x^{-0.50}$ ($R^2 = 0.98$) for 1983-84.

The Smith's index of soil heterogeneity found around 0.5 was indicative of the high variability of cashew crop as well as the heterogeneity, of the soil. The CV of the plot with r rows and c columns were represented by the relationship

$$Y = 90.29 C^{-0.54} r^{-0.46} (R^2 = 0.94) \text{ for } 1982-83 \text{ and}$$

$$Y = 96.03 C^{-0.59} r^{-0.43} (R^2 = 0.96) \text{ for } 1983-84.$$

The maximum curvatures were found at $X = 11.9$ and 12.1 respectively, showing that 12 was the optimum plot size.

Tables I and II showed the minimum number of replications necessary for 10% SE of treatment means and the relative cost of experimentation for blocks of sizes 4 and 12 for 1982-83 and 83-84 respectively. The number of replications decreased rapidly as the plot size increased. A close study of analysis revealed (Table II) that a plot size of 12 i.e., 6 rows of two trees each or 12 trees in a row was found to have the minimum cost for smaller as well as larger number of treatments. In Table I the plot sizes 6 x 2 and 3 x 4 gave the minimum cost with regard to the blocks with larger

Table I. *Relative cost of experimentation per treatment for different price situations in 4 and 12 plot blocks – cashew 1982*

Size	4 plot blocks						12 plot blocks					
	C. V.	r	K1	K2	K3	K4	C. V.	r	K1	K2	K3	K4
1 x 1	90.80	82	1394	2706	2706	4018	91.87	84	4116	8148	8148	12180
2 x 2	49.65	25	1625	3225	2225	3825	48.70	24	4632	9240	6360	10968
3 x 3	32.48	11	1595	3179	1947	3531	0.00	0	0	0	0	0
1 x 2	62.26	39	1287	2535	2067	3315	64.71	42	4074	8106	6594	10626
2 x 4	36.32	13	1677	3341	2093	3757	36.06	13	5005	9997	6253	11245
1 x 3	55.47	31	1519	3007	2263	3751	54.12	29	4205	8381	6293	10469
2 x 6	27.23	7	1351	2695	1631	2975	26.00	7	4039	8071	4879	8911
1 x 4	47.28	22	1430	2838	2046	3454	46.67	22	4246	8470	6094	10318
1 x 6	33.24	11	1067	2123	1463	2519	33.04	11	3179	6347	4367	7535
1 x 12	24.35	6	1158	2310	1518	2670	23.93	6	3462	6918	4542	7998
2 x 1	66.06	44	1452	2860	2332	3740	67.72	46	4462	8878	7222	11638
2 x 3	45.23	20	1940	3860	2500	4420	42.26	18	5202	10386	6714	11898
3 x 1	52.35	27	1323	2619	1971	3267	51.19	26	3770	7514	5642	9386
6 x 2	24.09	6	1158	2310	1398	2550	23.15	5	2885	5765	3485	6365
3 x 2	36.92	14	1358	2702	1750	3094	34.93	12	3468	6924	4476	7932
4 x 1	45.75	21	1365	2709	1953	3297	44.50	21	4053	8085	5817	9849
4 x 2	29.97	9	1161	2313	1449	2601	30.92	10	3850	7690	4810	8650
3 x 4	24.17	6	1158	2310	1374	2526	23.22	5	2885	5765	3425	6305
4 x 3	27.21	7	1351	2695	1603	2947	26.33	7	4039	8071	4795	8827
6 x 1	39.59	16	1552	3088	2128	3664	37.25	14	4046	8078	5558	9590
8 x 1	31.30	10	1290	2570	1730	3010	31.99	10	3850	7690	5170	9010
12 x 1	24.52	6	1158	2310	1518	2670	23.51	6	3462	6918	4542	7998

number of treatments. This also confirmed the results that the optimum plot was around 12 by the method of maximum curvature and about 12 trees by the graphical method. However, in smaller blocks the plot size of 1 x 6 was found to have the minimum cost. But the number of replications required was 10 to 12 whereas for the 6 x 2 plot the number of replications required was only

5 or 6. As such there was no advantage for the smaller plot of 6 x 1 instead of 6 x 2. Hence for a plot size of 6 rows of 2 trees each could be taken as optimum. Further there was no significant reduction in CV in any direction when compared to the other. It indicated that the shape of the plot was not of much importance except that the

Table II. *Relative cost of experimentation per treatment for different price situations in 4 and 12 plot blocks – cashew 1983*

Size	4 plot block						12 plot block					
	C. V.	r	K1	K2	K3	K4	C. V.	r	K1	K2	K3	K4
1 x 1	88.76	79	1343	2607	2607	3871	88.23	78	3822	7566	7566	11310
2 x 2	46.23	21	1365	2709	1869	3213	48.41	23	4439	8855	6095	10511
3 x 3	35.70	13	1885	3757	2301	4173	0.00	0	0	0	0	0
1 x 2	62.93	40	1320	2600	2120	3400	63.45	40	3880	7720	6280	10120
2 x 4	34.59	12	1548	3084	1932	3468	34.73	12	4620	9228	5772	10380
1 x 3	49.84	25	1225	2425	1825	3025	54.88	30	4350	8670	6510	10830
2 x 6	26.92	7	1351	2695	1631	2975	28.22	8	4616	9224	5576	10184
1 x 4	43.88	19	1235	2451	1767	2983	43.82	19	3667	7315	5263	8911
1 x 6	31.86	10	970	1930	1330	2290	35.04	12	3468	6924	4764	8220
1 x 12	27.02	7	1351	2695	1771	3115	31.21	10	5770	11530	7570	13330
2 x 1	61.25	38	1254	2470	2014	3230	62.10	39	3783	7527	6123	9867
2 x 3	40.53	16	1552	3088	2000	3536	44.70	20	5780	11540	7460	13220
3 x 1	52.01	27	1323	2619	1971	3267	49.81	25	3625	7225	5425	9025
6 x 2	23.24	5	965	1925	1165	2125	22.56	5	2885	5765	3485	6365
3 x 2	38.67	15	1455	2895	1875	3315	37.44	14	4046	8078	5222	9254
4 x 1	50.85	26	1690	3354	2418	4082	50.83	26	5018	10010	7202	12194
4 x 2	31.08	10	1290	2570	1610	2890	31.90	10	3850	7690	4810	8650
3 x 4	26.67	7	1351	2695	1603	2947	25.45	6	3462	6918	4110	7566
4 x 3	31.18	10	1930	3850	2290	4210	34.23	12	6924	13836	8220	15132
6 x 1	33.61	11	1067	2123	1463	2519	34.08	12	3468	6924	4764	8220
8 x 1	29.56	9	1161	2313	1557	2709	30.69	9	3465	6921	4653	8109
12 x 1	22.76	5	965	1925	1265	2225	22.13	5	2885	5765	3785	6665

length of the plot should be across the fertility line so that the variability between plots is reduced to the minimum. Hence a plot size of 6 rows of 2 trees each forming the plots across the fertility line would be taken as the optimum plot size for experiments with cashew.

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MEASUREMENT OF BIENNIALITY IN COCONUT*

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ABSTRACT

Based on the rank correlation coefficients for yields obtained in consecutive years and adjacent years, an index has been worked out to measure the bienniality for coconut yields. It was found to be significant in W. C. Tall population of different age groups growing under rainfed conditions. In an irrigated plot, this index came down from 0.99 during pre-irrigation period (1961-72) to 0.57 in the irrigation period (1975-86), while it was devoid of any marked changes for the corresponding periods in the unirrigated plot, where the palms were of comparable age. Changes in the bienniality has been studied in different age groups and under different management practices also. In low yielding palms biennial rhythm was found to be less.

INTRODUCTION

Year to year fluctuation in the annual yields is a common feature in the case of most of the perennial crops and coconut is not an exception. These variations are generally attributed to genetical as well as environmental factors. In any large population, it is possible to see a large number of palms which are biennial in their bearing habits, whereas in the case of many others, the year to year variation may be highly irregular. Also a small proportion of the palms may be giving somewhat steady yield over the years. Shrikande (1958) and Pankajakshan (1960) have referred to the biennial bearing tendency in coconut. Satyabalan, Sankar and Chami (1968) have examined the regularity in the yield of coconut on the basis of CV over the years. Abeywardana (1962) also examined the different methods of calculation of biennial rhythm and has shown that it is a significant feature in coconut, but not of such a magnitude to create concern in commercial circles. Jacob Mathew and Vijayakumar (1984) have

observed that due to the biennial bearing habit shown by some of the palms, the relationship for the yields obtained between immediately preceding and succeeding years is comparatively weak, compared to the correlation obtained between alternate years.

In this paper, the regularity in bearing of yield has been studied under Kasaragod conditions and an index has been suggested to measure the intensity of bienniality in coconut. Using this index, the trends in bienniality have been studied in different yield groups, age groups and management practices in West Coast Tall population.

MATERIALS AND METHODS

Annual yield data of palms collected from the permanent yield register maintained at the Institute were utilised for this study. For demonstrating the methodology of working out the Bienniality Index (BI), sample data of a group of 26 palms for the period (1950-59) has been used (Table I). The data for 187 palms from Block D,

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Plots 4, 5 & 6 (Set 1) for the period 1957-66 were considered on the basis of yield groups (*viz.* ≤ 40 nuts, 40-60 nuts, 60-80 nuts and < 80 nuts per palm/year) to examine whether bienniality is related with yielding habits of the palm. Data from the permanent observation plot, Block B, Plot 1 (Set 2) for the period 1920-68 were used to study the influence of management practices and age on the alternate bearing tendency. While the exact ages of the palms in this plot are not known, since continuous yield data for nearly 50 years are available, it has been assumed that they were in the initial years of bearing at the beginning of this period. To study the effect of irrigation on the regularity in bearing, the yield data from Agrostology Plot (106 palms), Block A, Plot 4 (Set 3) were considered, where irrigation was introduced in 1972 in an existing adult plantation. Most of the palms were above 50 years old during that period. The period 1961-72 was considered as the pre-irrigation period and 1975-86 as the irrigation period. Data for corresponding periods from RS 29, North (Set1), where the palms are approximately of same age and growing under rainfed condition were taken as control for comparison. All the palms considered here belong to the ordinary West Coast Tall variety. They were growing in sandy loam soils, receiving the recommended management practices.

To test for bienniality and to work out a bienniality index, Spearman's rank correlation coefficients obtained between the yields in every pair of consecutive years and alternate years were calculated first. We have proceeded on the assumption that in the presence of biennial rhythm the rank correlation coefficients obtained for yields in every pair of consecutive years will be less than those for the alternate years. For testing this, the Mann-Whitney U statistic (Seigal, 1956) defined as $U = n_1n_2 + n_2$

$(n_2 + 1) / 2 - T$ where n_1 and n_2 are the number of correlation coefficients available in consecutive and alternate years respectively and T is the sum of the ranks obtained for the set of correlation coefficients between alternate years was worked out. This U is assumed to be asymptotically normally distributed for both n_1 and n_2 greater than 8. Since the maximum and minimum values of the standard normal deviate of U is found to be dependent on the number of years considered, this cannot be used for comparison of different populations, especially when they refer to varying number of years. The ratio of T with T' was considered as a measure of the intensity of bienniality, where $T' = n_1n_2 + n_1n_2/2$ is the maximum possible rank sum for alternate years when $n_1 = n_2 + 1$. Since the minimum possible value of T is $n_1n_2/2$, this ratio can vary from $1/3$ to 1 only. From this ratio, with suitable changes in origin and scale of measurement, a Bienniality Index (BI) of the form $(3T - T')/2T'$ was worked out, with a range of 0 to 1 , which can be used for comparing any two populations.

RESULTS AND DISCUSSION

In this study Spearman's rank correlation coefficient has been preferred over Pearson's correlation coefficient, since the correlation coefficient worked out on the basis of ranks, is expected to eliminate year/weather effect. In the sample data used (Table I), the rank correlation coefficients between consecutive years have been found to be generally low, ranging between -0.1884 and 0.3258 , whereas the correlation between alternate years were in the range of 0.4691 and 0.7855 . The bienniality rhythm observed on the basis of 10 year data for 26 palms is statistically significant with an index of 1.0 . Abeywardana (1962) also made similar observations. When the data for the Set 1 were considered, after classifying

them into different yield groups, based on the mean yield for the 10 year period (Table II), it was found that the bienniality index was comparatively less in those palms with a low mean yield. Analysis of the data of Set 2 has shown that bienniality does not change much with age and growth of palms. In Plot 1, where the palms are being regularly cultivated and manured, bienniality was found to be significant in all the five decades considered, its intensity being slightly less in the first

decade, where the palms were probably in the early stages of bearing, with a low mean yield of 31.7 nuts. In plots 2 and 3 the bienniality index was found to be, comparatively higher during the decades where the mean yield was also higher, the only exception being 1930-39 for plot 2, where, though the mean annual yield was over 40 nuts, the biennial rhythm was not significant. Hence the differences in management practices were found to influence

Table I. *Procedure for calculation of Bienniality Index in coconut (Period: 1950-59, 26 palms, Block B, Plot 1)*

Base year	Rank correlation coefficients				Calculation of Bienniality Index
	Consecutive years		Alternate years		
	Actual	Rank	Actual	Rank	
1950	0.1962	6	0.4691	10	$U = n_1n_2 + n_2(n_2 + 1)/2 - T$ $= 9 \times 8 + 8 \times 9/2 - 108$ $= 0.0$
1951	0.2371	8	0.6291	11	
1952	0.3258	9	0.6798	13	
1953	0.1906	5	0.7299	16	$T' = n_1n_2 + n_1n_2/2$ $= 9 \times 8 + 9 \times 8/2$ $= 108$
1954	0.1347	3	0.7029	14	
1955	0.1998	7	0.6421	12	
1956	0.1738	4	0.7270	15	$BI = (3T - T') / 2T'$ $= 1.0$
1957	0.0087	2	0.7855	17	
1958	-0.1884	1			
				108	

Table II. *Bienniality in relation to yielding habits of the palm (Period : 1957-66, 187 palms, Block D, Plots 4,5 and 6)*

Yield group	No. of palms	Mean yield	Mean CV %	Beinnality Index
≤ 40 nuts	28	25.3	56.2	0.75
40-60 nuts	59	51.1	24.4	0.97
60-80 nuts	65	69.8	22.6	1.00
> 80 nuts	35	96.3	24.5	1.00
Pooled	187	62.2	28.6	1.00

the yield and consequently the bienniality index also (Table III).

In an irrigated plot (set 3) with 106 palms, the index has been found to be as low as 0.57 for the 12 year period 1975-86, whereas for the same set of palms, during the pre-irrigation period (1961-72) it was as high as 0.99. In another rainfed garden where the palms are of more-or-less comparable age, the bienniality was significant in both the periods with indices 1.00 and 0.89 respectively. Hence it appeared that bienniality could, to a great extent, be reduced by ensuring adequate water supply.

In this study, the CV for the yields over the years for individual palms had been calculated and the average CV had also been worked out for groups of palms, for the different sets of data. It was observed in all the sets of data that the average CV was comparatively low, in the groups of palms where the mean yield was generally higher and vice-versa. Satyabalan et al (1968) have also pointed out that the incidence of irregular bearing was high among low yielders and low among high yielders. They have observed significant negative correlation between the mean yield

and CV. But in the case of bienniality a low index was observed for palms with a low average yield and vice-versa except in the case of irrigation plot. It is conventional to use CV as a measure of variability over the years. But the present study has shown that CV does not speak anything about the biennial rhythm present in the data as CV cannot distinguish between a systematic variation and irregular variation.

Though theoretically the range for this Index is from 0 to 1, in practice, for coconut it may range between 0.5 and 1.0 only. An Index of 1.0 means that all the rank correlation coefficients obtained between pairs of alternate years is greater than those between consecutive years, and it was around 0.5 when the ranks were evenly distributed in both the sets. It will be near to zero when most of the correlation coefficients between pairs of adjacent years are higher than those of alternate years. Comparison with the standard normal deviate of the U statistic showed that when data for 10, 15, 20, 25, 30, 40 and 50 consecutive years were used the index values above 0.75, 0.69, 0.66, 0.64, 0.63, 0.61, 0.60 respectively could be considered as significant at $P = 0.05$. Though

Table III. *Bienniality in relation to management practices and growth of palms (Block B, 170 palms)*

Period	Plot 1 (n=26)			Plot 2 (n=26)			Plot 3 (n=18)		
	Mean yield	Mean CV %	BI	Mean yield	Mean CV %	BI	Mean yield	Mean CV %	BI
1920-29	31.7	62.1	0.82	17.2	69.3	0.62	24.1	61.8	0.57
1930-39	50.8	53.5	0.99	41.1	68.2	0.64	24.7	68.3	0.74
1940-49	53.6	38.8	1.00	50.6	31.4	1.00	26.8	47.1	0.81
1950-59	43.9	42.9	1.00	39.7	29.9	0.79	24.6	47.5	0.81
1960-68	55.6	31.7	1.00	38.4	31.8	1.00	13.8	56.0	0.64

Plot 1 : Regularly cultivated and manured

Plot 2 : Regularly cultivated only

Plot 3 : No cultivation, no manuring

the rank correlation coefficients were not directly used in the calculation of BI, our studies with different sets of data have shown that the mean difference between the sets of rank correlation coefficients in adjacent years and alternate years is around 0.4 or more, in most of the cases, when the BI was 1.0 and between 0.3 and 0.4 when the BI was between 0.90 and 0.99, with proportionate reduction for lower values of the index.

This index can be conveniently used to compare the alternate bearing habits of different varieties and hybrids, provided data for sufficient number of years are available.

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COSTS AND RETURNS IN DIFFERENT SIZES OF COCONUT HOLDINGS IN NORTHERN KERALA

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ABSTRACT

A size categorywise analysis of the cost of cultivation was done for bearing coconut plantations in Northern Kerala. The study revealed that the cost of maintenance per hectare was Rs. 6,297.65, Rs. 5,431.62, Rs. 5,100.52 and Rs. 4,183.73 respectively for the four size categories of farms. The average cost was worked out to Rs. 4,442.05 per hectare. Sixty five per cent of the total cost was incurred for application of manures and fertilizers. Inputwise analysis showed that 45.19 per cent of the total cost was incurred on manures and 41.16 per cent on labour. Only very limited expenditure was made on plant protection chemicals. The family labour utilisation showed wide variation *i. e.*, 34.73 per cent in Stratum I to 6.59 in Stratum III. The net profit per hectare was worked out to Rs. 10,360.43.

INTRODUCTION

Several studies have been made on the economics of coconut cultivation based on the imputed values of costs and returns. Das (1984) studied the costs and returns for coconut in Kerala and the estimated cost of investment was Rs. 35,292 at 1982-83 factor prices with an annual maintenance cost of Rs. 5,500. The management and expenditure varied with different size categories of farmers. The following paper attempts to study the variation in the cost of cultivation of coconut in different size categories of farms in Northern Kerala.

METHODOLOGY

A two stage random sampling design was used for selecting a sample of 121 farmers from the region with Panchayats as the first stage units and the farmers within Panchayats as second stage units. The primary data relating to the cost of manuring, intercultural operations, and harvesting, irrigation etc. were collected from the selected farmers by holding personal interviews. The annual

costs and returns of bearing coconut gardens alone were considered for the study. The respondents were classified into four categories based on the size of holdings. The size classes were (1) below 0.2 ha (2) 0.2-1 ha (3) 1 — 2 ha and (4) > 2 ha. Tabular analysis of costs and returns were done for each of the above size classes.

RESULTS AND DISCUSSION

The results showed that the unit cost of cultivation was in the descending order as the size of farms increased. This cost per hectare worked out to Rs. 6297.65, Rs. 5341.62, Rs. 5100.52 and Rs. 4183.73 for the four size categories respectively. The average cost of maintenance worked out to Rs. 4442.05 per ha.

The operation wise cost of cultivation showed that about 65 per cent of the cost was incurred for application of manures and fertilizers (Table I). The next important item of expenditure was harvesting operations which

Table I. *Annual cost of cultivation of coconut (operation wise analysis) in Rupees per hectare*

Operations	Stratum I	Stratum II	Stratum III	Stratum IV	Average
Application of manures and fertilizers	4148.24 (65.87)	3474.84 (65.05)	3331.13 (65.31)	2721.18 (65.04)	2888.22 (65.02)
Intercultural operations	535.29 (8.50)	414.29 (7.76)	265.33 (5.21)	334.33 (7.99)	329.32 (7.42)
Irrigation	—	122.44 (2.29)	209.79 (4.11)	247.67 (5.92)	239.17 (5.38)
Pest/disease control	—	90.59 (1.70)	70.80 (1.39)	23.68 (0.57)	35.82 (0.81)
Harvesting	1388.24 (22.04)	1037.42 (19.42)	1101.40 (21.59)	689.04 (16.47)	786.79 (17.71)
Transporting	225.88 (3.59)	202.04 (3.78)	122.07 (2.39)	167.83 (4.01)	162.73 (3.66)
Total	6297.65 (100.00)	5341.62 (100.00)	5100.52 (100.00)	4183.73 (100.00)	4442.05 (100.00)

incurred about 17.17 per cent of the expenditure. Intercultural operations and irrigation required about seven and five per cent of the expenditure respectively. Transporting of the produce incurred an average cost of Rs. 162.73 which contributed 3.66 per cent of the total expenditure.

In the lowest size group the utilisation of manure was much more than the other size categories. This might be due to the fact that in the smallest sized holdings whatever manures produced in the farm was used for manuring the palms, where coconut was the basic crop. The next important item of expenditure formed the harvesting operations.

Considering the percentage contribution of different operations to the total cost, there was not much variation between the different size categories. In the case of manuring and fertilizer application, the percentage contribution was 65 per cent in all the cases. For harvesting operations the percentage ranged from 16.47 to 22.04.

Another notable feature of the study was that in the case of smaller size groups irrigation was not given attention. Pot irrigation was neglected and there was limited scope for mechanical irrigation. In the case of pest and disease control, the smallest size group did not adopt the practice at all.

Input-wise analysis showed that 45.19 per cent of the total cost was on manures and 41.17 per cent on labour (Table II). The expenditure on fertilizers contributed only 8.75 per cent of the total cost. Only a meagre portion of the total cost was spent on pesticides. Among the various manures used, cowdung and green leaf manure were given priority. The expenditure on fertilizers increased both in absolute terms as well as percentage contribution as the size of holding increased.

The labour utilisation pattern showed that the family labour utilisation was to the extent of 34.73 per cent in Stratum I and 20.58 per cent in the case of Stratum II, 6.59 in

Stratum III and 9.09 in Stratum IV (Table III). The family labour contribution was 9.90 per cent on an average and decreased as the size increased. The absolute cost figures also showed a decreasing trend as the size increased.

The returns pattern showed that the

average yield of palms was 45.62 nuts per hectare considering a stand of 200 palms per hectare. The average profit per hectare was worked out to Rs. 10,360.43. The returns ranged from Rs. 6,243.52 to Rs. 14,048.36 in Stratum I and III respectively. (Table IV).

Table II. *Annual cost of cultivation of coconut (inputwise analysis) in Rupees per hectare*

Inputs	Stratum I	Stratum II	Stratum III	Stratum IV	Average
Manures	3652.93 (58.00)	2283.26 (42.74)	2416.45 (47.38)	1859.01 (44.43)	2007.29 (45.19)
Fertilizers	161.18 (2.56)	290.48 (5.44)	343.79 (6.74)	405.86 (9.70)	388.83 (8.75)
Plant protection chemicals	—	21.77 (0.42)	54.65 (1.07)	16.30 (0.39)	23.04 (0.52)
Labour	2483.54 (39.44)	2493.73 (46.68)	2021.82 (39.64)	1722.08 (41.16)	1828.65 (41.17)
Miscellaneous items	—	252.38 (4.72)	263.81 (5.17)	180.48 (4.32)	194.24 (4.37)
Total	6297.65 (100.00)	5341.62 (100.00)	5100.52 (100.00)	4183.73 (100.00)	4442.05 (100.00)

Table III. *Labour utilisation for maintenance of coconut palms (Cost in Rupees per hectare)*

Type of labour	Stratum I	Stratum II	Stratum III	Stratum IV	Average
Family labour (Men)	749.42 (30.18)	390.99 (15.68)	88.13 (4.36)	135.40 (7.86)	148.57 (8.12)
Family labour (Women)	112.94 (4.55)	122.31 (4.90)	45.08 (1.23)	21.16 (1.23)	32.46 (1.78)
Hired labour (Men)	1268.24 (51.07)	1395.52 (55.96)	1298.08 (64.2)	879.12 (51.05)	986.56 (53.95)
Hired labour (Women)	352.94 (14.20)	355.65 (14.26)	233.58 (11.55)	273.40 (15.88)	272.58 (14.91)
Contract labour	..	16.33 (0.65)	63.77 (3.16)	178.58 (10.37)	147.25 (8.05)
Mechanical labour	..	98.64 (3.96)	43.73 (2.16)	72.18 (4.19)	68.53 (3.75)
Animal labour	—	114.29 (4.58)	249.45 (12.34)	162.24 (9.42)	172.70 (9.44)
Total	2483.54 (100.00)	2493.73 (100.00)	2021.82 (100.00)	1722.08 (100.00)	1828.65 (100.00)

Table IV. *Yield and returns from coconut*

Particulars	Stratum I	Stratum II	Stratum III	Stratum IV	Average
Yield (No.)	5224	6762	8873	9422	9125
Returns					
i) Main product (Rs/ha)	11729.41	13378.23	17473.71	12838.65	13651.13
ii) By-product ..	811.76	786.39	1675.17	1068.80	1151.35
iii) Total ..	12541.17	14164.62	19148.88	13907.45	14802.48
Cost ..	6297.65	5341.62	5100.52	4183.73	4442.05
Profit ..	6243.52	8823.00	14048.36	9723.72	10360.43

The analysis showed that the cost of cultivation decreased with increase in size of holding. Though the relative importance of each item of operation, as projected by the percentage contribution to total cost remained almost same, the absolute expenditure varied much. This was prominent in the case of cost of manures. It ranged from Rs. 3652.93 in Stratum I to Rs. 1859.01 in Stratum IV (Table II). This might be due to the fact that the manures applied in smaller holdings belonged to the household waste, ash, cowdung etc. the value of which was imputed. For larger sized holdings they were reluctant to purchase manures due to scarcity and high price. Instead, they purchased fertilizers to meet the requirement. For fertilizers the expenditure increased as the size increased (Table II).

With regard to labour utilisation the smaller holdings showed a higher rate which included imputed value of family labour. In larger holdings the hired labour contribution was more. The farmers of higher strata

depended upon hired labour and contract labour (Table III).

The returns showed no definite pattern. Though the higher expenditure was incurred in Stratum I the yield was the lowest. This might be due to the improper pattern of management. In smaller holdings, more expenditure was made on available inputs like manure, labour etc. while they neglected application of fertilizers, irrigation, pest and disease control.

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DISCRIMINANT FUNCTION ANALYSIS IN COCONUT SEEDLINGS*

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ABSTRACT

Data on 192 seedlings from 16 families of West Coast Tall variety was utilised for constructing a discriminant function for classifying seedlings into high/low yielders at the nursery stage using 11 seedling characters. Time taken for flowering was adopted to judge a palm as high/low yielding. The function based on this criterion was significant. Girth, number of leaves, weight of the seedling and number of thick roots were found to contribute maximum in discriminating between potentially high/low yielders.

INTRODUCTION

It has been widely accepted that seedling selection in coconut is an effective way to realise higher yield. The previous workers Liyanage (1953), Liyanage and Abeywardena (1957), Satyabalan, Jacob Mathew and Radhakrishnan (1972) have worked out phenotypic correlations between different characters. Nampoothiri, Satyabalan and Jacob Mathew (1975) worked out both phenotypic as well as genotypic correlations between seedling characters with adult palm yield. The above authors suggested various seedling characters based on which selection could be made. An index was worked out based on mean and CV for different seedling characters to evaluate various germplasm collections in the nursery. (Bhaskara Rao and Jacob Mathew, 1981). This method however cannot be used to select seedlings within the germplasm. Ramachander and Bavappa (1972) worked out selection indices for arecanut and reported that the index based on number of leaves, girth at collar and height at the time of planting gave a relative improvement of 352% over straight selection.

However, it appears that there has not been any attempt in coconut so far to integrate all the important seedling characters which contribute to make a seedling a future high yielder. The present study makes an attempt in this direction by employing the technique of discriminant function to divide the population into two groups viz., high/low yielders.

MATERIALS AND METHODS

The data used for this study belonged to an experiment laid out at Goa in 1970, with 16 families and four replications. The ultimate plot consisted of 3 seedlings from each family. Eleven seedling characters were recorded at the time of planting. They were; X_1 -Girth(cm) X_2 -Height(cm) X_3 -No. of leaves X_4 -Length of petiole (cm) X_5 -length of leaflet bearing portion(cm) X_6 -No. of midribs(left) X_7 -No. of midribs(right) X_8 -Weight of seedling (Kg) X_9 -No. of thick roots X_{10} -No. of thin roots and X_{11} -No. of days taken for germination. Time taken for first flowering for each palm was noted. Yield data were recorded. However, since

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the yield was low because of poor management conditions, it was not considered in the discriminant function analysis. Nampoothiri et al (1972) have shown that time taken for flowering is phenotypically and genotypically correlated with adult palm yield. Hence this character was considered for classifying the palms into high/low yielders. Palms which flowered after 72 months ($n_1 = 116$) were classified as low yielders and which took 72 months and below ($n_2 = 46$) were classified as high yielders. Discriminant functions were constructed by using the 11 characters mentioned above and time taken for flowering. It was also studied if a convenient subset of 11 characters would suffice in discrimination. Computations were done as per Goulden (1952).

RESULTS AND DISCUSSION

Construction of discriminant functions using multiple measurements is a powerful statistical technique to discriminate between two or more groups. The general problem consists of setting a function of the type

$$Z = \lambda_1 X_1 + \lambda_2 X_2 + \lambda_3 X_3 + \dots + \lambda_P X_P \quad (1)$$

where $X_1, X_2, \dots, X_P$ are the variables measured and $\lambda_1, \lambda_2, \dots, \lambda_P$ are the corresponding weights attached to each of the variables. Fisher (1938) demonstrated the method of calculating the coefficients of the above equation such that the ratio of variance between groups to that of within groups is maximum. The significance of the variance ratio suggests that the function worked out is able to discriminate between the populations.

The discriminant function based on the seedling character and months taken for flowering came out significant. The resulting function is after dividing all the coefficients by the smallest coefficients in the equation is

$$Z = -88.25X_1 + 5.69X_2 + 129.69X_3 - 12.95X_4 + 7.52X_5 - 31.23X_6 + 45.95X_7 + 81.35X_8 + 37.73X_9 + 2.82X_{10} - 1.00X_{11} \quad (2)$$

The absolute values of the coefficients give the relative importance of different characters in discrimination. The maximum value of the coefficient is for No. of leaves (X_3) followed by girth (X_1), weight of the seedling (X_8), No. of leaflets - Right (X_7) and No. of thick roots (X_9).

Based on the frequency distribution of Z values computed for the population, a seedling with a score of 800 and above is expected to be a palm which flowers before 72 months and consequently a future high yielder. However, the seedlings thus selected may contain about 10% of poor yielders also.

To use equation (2) may be cumbersome in practice. Hence fresh discriminant functions were worked out by eliminating the characters with low coefficients in (2). The function using five variables is

$$Z = -1.55X_1 + 3.93X_3 + 1.00X_7 + 2.66X_8 + 1.02X_9 \quad (3)$$

The function is found significant. As per this, seedling with a Z score of 30 and above is expected to be a future early flowering palm or in other words a future high yielder. It was observed that about 15% of the seedlings thus selected may be from the poor yielding group.

The function using four characters is

$$Z = -1.24X_1 + 3.18X_3 + 2.83X_8 + 1.00X_9 \quad (4)$$

The function is significant and thus it is worth noting that even with 4 seedling characters it is possible to discriminate

between the populations. A seedling with a Z score of 22 and above is expected to be a future good yielder. However, about 7% of the seedlings selected may be poor yielders.

The results obtained in this study confirm the importance of no. of leaves and girth in seedling selection reported by earlier workers. However the coefficient observed for girth was negative. A similar observation was made by Bhagavan and Nair (1986) in arecanut wherein they reported that girth at permanent mark had a high negative direct effect and its positive correlation with yield was largely due to highly positive indirect effect *via* palm height. Two other important characters identified in this study are weight of the seedling and no. of thick roots.

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We express our sincere thanks to Dr. K.V.A. Bavappa, former Director of CPCRI, Kasaragod for the initiative he had taken in laying out this experiment and to the Technical assistants in the Division of Genetics for the help in recording the observations regularly.

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PRICE BEHAVIOUR OF COCONUT OIL IN RELATION TO MAJOR OILS IN INDIA *

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ABSTRACT

Studies conducted on the wholesale prices of four edible oils viz., coconut oil, groundnut oil, sesame oil and mustard oil for the period 1970-71 to 1987-88 revealed that coconut oil had commanded a relatively higher price over other oils during most of the years. The compound growth rates worked out for these oil prices was almost of the same order (8 to 9.6 per cent). But instability in prices were more for coconut oil than other oils. Wholesale price indices showed that prices for these edible oils increased rapidly over the years. Relative price indices of different oils in relation to coconut oil revealed that the relative increase in prices of groundnut oil, sesame oil and mustard oil over the years was much higher than that of increase in coconut oil prices. Correlation studies revealed that the prices of these edible oils move very closely with each other with correlation coefficient between 0.88 to 0.90. Regression analysis showed that the wholesale prices of any oils could be predicted with higher precision knowing the price of any other oil.

INTRODUCTION

Indian edible oil sector has the dubious distinction of stagnant production, spiralling prices and massive imports for nearly two decades. Eventhough the imports are being maintained at a very high level it has had hardly any effect on price. The trend indicates that with small setbacks now and then, edible oil prices have been inclined upward most of the times. As it appears this rising trend will remain unabated till the supply meets the surging demand. Indian vegetable oil scenario further indicates that coconut oil has by and large consistently commanded a price premium over other oils. This study has been pursued in order to understand the relationship between the prices of coconut oil and other edible oils.

MATERIALS AND METHODS

For this study the average wholesale prices of four major edible oils viz., coconut oil,

groundnut oil, sesame oil and rapeseed mustard oil for the period 1970-71 to 1987-88 was collected from the Directorate of Economics and Statistics, Ministry of Agriculture, Government of India. The monthly, wholesale price index numbers of edible oils were also obtained from the same source. The figures concerning to the production and imports of vegetable oils were received from the Ministry of Commerce, Government of India.

The absolute differences were worked out to determine the price premium of coconut oil over other edible oils. Compound growth rates (CGR) and coefficient of variations (CV) were worked out for individual oil prices. The annual wholesale price indices for individual oils were constructed by taking 1970-71 as the base, while the relative price indices of different oils in relation to coconut oil were computed by

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dividing the index number of an individual oil with the corresponding year index number for coconut oil. Correlation analysis was carried out between prices of different edible oils. Regression equations were fitted to predict the price of any oil by knowing the price of the other oil.

RESULTS AND DISCUSSION

The average annual wholesale prices of coconut oil, groundnut oil, sesame oil and mustard oil for different years are shown in Table I. It is clearly evident from this table that coconut oil had always commanded a relatively higher price over other oils barring three years out of 18 years under reference. This sort of consistent behaviour of coconut oil could be explained by its distinct advantages over other oils in certain end uses. According to an estimate, while over 90 per cent of the supplies of groundnut oil, sesame oil and mustard oil are used as edible oil, in the case of coconut oil only about 38 per cent of the supplies are being utilised in edible oil sector and the remaining 62 per cent in non-edible oil sector, mainly household toiletry (Thampan, 1988). Coconut oil occupies third place in Indian vegetable oil sector next only to groundnut oil and mustard oil, but its production is about one-seventh of the production of groundnut oil and two-fifth of the mustard oil as it constitutes only 7 per cent of the total vegetable oil production in the country (Das, 1984). It is pertinent to note here that unlike the edible oil sector, in the household toiletry the demand is insensitive to price changes. Coconut oil is considered indispensable and price inelastic for toiletry uses in India because of its special quality which other vegetable oils do not enjoy. Besides, the individual household requirement on toiletry is so small that the total expenditure in this item do not disturb the family budget with the price rise. The processors and traders are well aware of this fact and they

take full advantage of the situation for which coconut oil prices rule much higher than that of other oils in India.

The annual growth rate of coconut oil prices during 1970-71 to 1987-88 was 9.57 per cent, while it was 9.60 per cent in the case of groundnut oil, 8.0 per cent in sesame oil and 8.2 per cent in mustard oil. It reveals that despite the differences in absolute prices of individual oils, the rates of growth were more or less of the same order. However, the C.V. was found out to be higher for coconut oil than other oils. (Table I)

Table II reveals the absolute differences of the average annual wholesale prices of individual oils from that of coconut oil. Though groundnut oil is considered as the kingpin among the Indian vegetable oils the usual premium commanded by coconut oil over the groundnut oil varied between Rs. 130 and Rs. 771 per 100 kg at wholesale level during the period 1970-71 to 1987-88 except for a couple of years when the groundnut oil prices ruled slightly higher than coconut oil prices. Similar situation was noticed in the case of sesame oil and mustard oil. However, while coconut oil prices continued to rule higher than that of the other edible oils in India they became much harder from the year 1983-84 as a result of which the premium for coconut oil appeared to be substantial. In other words, coconut oil which had always commanded a relatively higher price owing to its superior qualities in certain end uses, started commanding an even better premium since 1983-84 with its declining or stagnant supplies. The record premium of 1984-85 was rather more related to the drastic shortfall in the supplies of coconut oil in that year owing to the delayed effect of unprecedented droughts of 1982 and 1983 in the main coconut and copra producing State of Kerala (Das, 1986).

Table I. *Average wholesale prices of the major edible oils in India (Rs./100 kg)*

Year	Coconut oil	Groundnut oil	Sesame oil	Mustard oil
1970-71	700	422	479	518
1971-72	540	410	508	471
1972-73	565	704	740	535
1973-74	1020	809	877	764
1974-75	1115	749	848	874
1975-76	800	518	768	535
1976-77	1055	821	921	707
1977-78	1100	715	786	1008
1978-79	1180	801	903	924
1979-80	1220	968	1260	1024
1980-81	1580	1292	1268	1261
1981-82	1320	1353	1271	1318
1982-83	1545	1550	1434	1170
1983-84	2385	1614	1603	1485
1984-85	3250	1630	1506	1465
1985-86	1710	1353	1263	1039
1986-87	2414	2106	2073	1847
1987-88	3097	2332	2357	2382
C.G.R. (% yr ⁻¹)	9.57	9.60	8.00	8.20
C.V. (%)	53.27	48.97	42.47	45.46

The wholesale price indices and relative price indices of major indigenously produced edible oils of India are presented in Table III. Although the prices of coconut oil seemed to be much better, all through the period since the early seventies in the previous tables, here the picture that emerged out suggests that the prices of all the edible oils were steadily rising over the base year 1970-71 position as it was observed from the CGRs. Relative price indices of different oils in relation to coconut oil revealed that relative increase in prices of groundnut oil, sesame oil and mustard oil over the

years was generally higher than that of increase in coconut oil prices. This phenomenon could be attributed to the widening of the supply-demand gaps in edible oils owing to the population explosion as well as the increasing in the purchasing power of the people in one hand and near stagnation of the production and the higher inflationary pressures on market economy on the other. The monthly wholesale price index numbers for edible oil which has been shown in Table IV further reveals that though the prices of this group of commodities were moving upward, they exhibited a good deal of

Table II. *Price premium of coconut oil over other edible oils in India during 1970-71 to 1987-88 (Rs./100 kg)*

Year	Coconut oil-Groundnut oil	Coconut oil-Sesame oil	Coconut oil-Mustard oil
1970-71	278	221	182
1971-72	130	39	69
1972-73	(—) 139	375	30
1973-74	211	143	256
1974-75	366	267	241
1975-76	282	32	265
1976-77	234	134	348
1977-78	385	314	92
1978-79	379	277	256
1979-80	252	(—)40	196
1980-81	288	312	319
1981-82	(—)33	49	2
1982-83	(—)5	111	375
1983-84	771	782	900
1984-85	1620	1744	1785
1985-86	357	447	671
1986-87	308	341	567
1987-88	765	740	715

instability. The uncertainty in the edible oil price trend could be attributed to several factors, the single biggest factor being the manipulation and manoeuvring techniques of the powerful oil lobby. The seasonality of demand as well as seasonality of supply of edible oils could be second largest factor contributing to the violent price fluctuations (Das, 1987).

The supply position of vegetable oils in India during the eighties is furnished in Table V. While the indigenous production of all the vegetable oils together remained between 2.8 and 3.2 million tonnes, the imports varied between 0.9 and 2 million

tonnes a year. In spite of the record imports of edible oils, per capita consumption stood at 6.45 kg per annum. This figure is much below the world average of 11 kg and far lower the average consumption of developed countries which was estimated at 22 kg a year (Das, 1985). Under this situation, the magnitude of the supply gap in Indian edible oil sector could well be realised. In view of the vast demand-supply gap, even two million tonnes import had no desired effect on edible oil prices. Moreover, it is not only the total availability of edible oils, but also the availability of individual oils, had significant influence on the price behaviour of that commodity on question.

Table III. *Wholesale price indices and relative price indices of major edible oils in India*

Year	Wholesale price indices (Base year 1970-71)				Relative price indices of different oils in relation to coconut oil		
	Coconut oil	Groundnut oil	Sesame oil	Mustard oil	Groundnut oil	Sesame oil	Mustard oil
1971-72	77	97	106	91	126	137	118
1972-73	81	166	154	103	204	190	127
1973-74	146	191	183	147	131	125	101
1974-75	167	177	177	169	106	105	101
1975-76	114	122	160	103	107	140	90
1976-77	151	194	192	136	128	127	90
1977-78	157	169	164	194	108	104	124
1978-79	168	190	188	178	113	112	106
1979-80	174	229	263	198	131	151	114
1980-81	225	306	264	243	136	117	108
1981-82	188	320	265	254	170	141	135
1982-83	220	367	299	226	166	136	103
1983-84	341	382	335	287	112	98	84
1984-85	463	386	314	283	83	68	61
1985-86	268	320	263	201	119	98	75
1986-87	318	499	432	357	157	135	112
1987-88	442	552	492	460	125	111	104

Though some of them are close or near substitutes, the characteristic qualities of each oil and the differential food habits and tastes of the people make the supply management more complex a subject to deal with. Again, it is true that the technological advancements have made it possible to displace one oil by other oils in certain end uses, but there are still several areas in industrial sector such as the pharmaceuticals, cosmetics, plastics, synthetic resins, paints, etc. where coconut oil has an edge over others. Hence, the availability of one or a group of oils has limited influence on the demand pattern of other oils.

The correlation matrix on edible oil prices during 1970-71 to 1987-88 is presented in Table VI. This study indicates that the prices of groundnut oil, sesame oil and mustard oil moved very closely with each other and with that of coconut oil during the period under reference, 'r' values being as high as 0.88 to 0.90. In other words, there was a strong sympathetic movement among the edible oil prices irrespective of the fluctuations in the supply of individual oil prices in the course of the period. As all these four oils are vulnerable to substitution in edible oil uses to certain extent the prices had behaved in the expected lines (Das, 1984).

Table IV. *Wholesale price index numbers of edible oils in India (Base 1970-71)*

Month	1983-84	1984-85	1985-86	1986-87	1987-88
July	292	347	284	359	488
August	307	342	283	390	510
Sept.	313	329	276	402	486
Oct.	309	324	282	399	492
November	309	318	287	388	503
December	319	316	298	403	495
January	327	312	300	418	482
February	319	298	295	411	457
March	310	299	296	407	446
April	317	294	303	413	448
May	323	287	326	440	433
June	339	281	340	463	431
Average for the year	315	312	297	408	473

Table V. *Supplies of vegetable oils in India during the eighties*

Particulars	Unit	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88
Production	Million tonnes	3.051	2.779	3.299	3.231	3.032	3.104	3.232
Imports	..	0.920	1.347	1.575	1.430	1.180	1.486	2.000
Total supplies	..	3.971	4.126	4.874	4.661	4.212	4.590	5.232
Population	Million	699	715	732	750	769	789	811
Per capita supplies	Kg/year	5.68	5.77	6.66	6.21	5.48	5.82	6.45

Table VI. *Correlation coefficients (r) between different edible oil prices in India during 1970-71 to 1987-88*

	Coconut oil	Groundnut oil	Sesame oil	Mustard oil
Coconut oil	1.0000	0.9000**	0.8847**	0.8956**
Groundnut oil		1.0000	0.9832**	0.9550**
Sesame oil			1.0000	0.9628**
Mustard oil				1.0000

** Significant at 0.01 level

Table VII. Regression equations for predicting average wholesale prices of major edible oils in India (Rs./100 kg)

Dep (y)	Index (x)	a	b	r ²
Coconut oil	G. nut oil	31.11	1.2923**	0.810**
	Ses. oil	-162.27	1.4147**	0.783**
	Mus. oil	-72.92	1.4441**	0.802**
G. nut oil	Coc. oil	193.25	0.6267**	0.810**
	Ses. oil	-149.81	1.0948**	0.967**
	Mus. oil	-32.16	1.0724**	0.912**
Ses. oil	Coc. oil	341.60	0.5533**	0.783**
	G. nut oil	170.86	0.8830**	0.967**
	Mus. oil	116.68	0.9709**	0.927**
Mus. oil	Coc. oil	253.00	0.5555**	0.802**
	G. nut oil	121.73	0.8505**	0.912**
	Ses. oil	-33.06	0.9548**	0.927**

** Significant at 0.001 level.

After observing the degree of relationship on the movement of one oil price with the other, an attempt was made to fit regression equations for predicting the average wholesale prices of one oil with the help of another oil price. Table VII shows the twelve regression equations for different combinations in order to predict the prices of one edible oil with any other three edible oils. It could be seen from this table that all the equations give good fit with r^2 ranging between 0.78 to 0.96 suggesting that a high percentage of variation in one oil price is explained by the other oil price.

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DISCUSSIONS

T. S. GOVINDARAJAN: While giving production and productivity statistics of cashew the present area under cultivation as well as the possible expansion in the area anticipated for the next five years or so is to be taken into consideration. These factors should be the basis for working out the requirement of planting material / clonal material.

S. BHAGAVAN: National group meeting for generation of planting material held in January 1988 at CPCRI, Kasaragod has already taken this into account and arrived at the demand figures for planting material and the material that can be generated.

Y. RAGHURAMULU: In your methodology you have selected seeds from different varieties of cashew and studied the characteristics of seedlings in order to correlate seed with yield. Since cashew is cross pollinated crop, selection of seed and seedling characters as indicators of high yield may not be appropriate because segregation in progeny is unavoidable.

S. BHAGAVAN : Data belonging to various accessions was subjected to refinement by eliminating effect due to various accessions. Because of the high amount of segregation only the selection criterion was worked out to select out materials which behave uniformly atleast with respect to yield.

JOSEPH G. MARATTUKALAM: In which class will you include a coconut palm yielding 60 nuts and 80 nuts?

JACOB MATHEW: Conventional method of making frequency distribution have been

followed. Upto 60 nuts in 40 – 60 nut group and 80 in 60 to 80 group.

R. C. MANDAL: Only dwarf coconut palms show biennial or alternate bearing and heavy bearing habit due to genetic factors. In the case of WCT such biennial tendency is not noticed. *i.e.*, due to environmental stress and lack of adequate management with irrigation and fertilizer application. Data presented showing number of years yield is not showing regular trend and hence it can be concluded that WCT is an alternating one.

JACOB MATHEW : In this study only WCT data has been used. This study as well as the earlier reports from Sri Lanka have indicated that the ordinary tall variety show alternate bearing tendency.

K. U. THOMAS: While analysing the cost and returns of bearing coconut palms did you take into consideration the timber value?

C. LATHA BASTINE: In the present study only annual costs and returns of bearing coconut palm alone were studied and not the cash flow analysis of coconut throughout the life span.

P. R. V. SUBRAMONIA IYER: Is it possible to consider percentage establishment of coconut seedlings in the main field rather than days taken for germination as a more accurate measure to consider unit area yield?

K. VIJAYA KUMAR: No. Because management factor is also involved. Establishment may not be a good substitute for days

taken for germination since the latter being a genetic character for seedling selection.

K. RAMAN : Whether leaf splitting character was used for studying seedling vigour?

K. VIJAYA KUMAR: Leaf splitting data was not available for analysis.

A. RAMADASAN: Could this method be used for selecting potential high yielders from the nursery? If this is so it would be useful to take few shoot characters rather than root characters.

K. VIJAYAKUMAR: Yes. It is possible to use this method for selection. Future studies will be conducted.

DEVELOPMENTAL STRATEGIES

Chairman : P. K. RAMAIAH

Rapporteurs : P. SWAMINATHAN
KOSHY JOHN

A CASE STUDY OF LARGE CARDAMOM PRODUCTIVITY IN SIKKIM AND DARJEELING DISTRICT OF WEST BENGAL, INDIA

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ABSTRACT

Seventy plantations of large cardamom (*Amomum subulatum* Roxb) selected at random from the major growing areas of Sikkim and Darjeeling district of West Bengal, India, were studied for their productivity during the year, 1987. The annual mean yields during 1984, 1985, 1986 and 1987 were 110.63, 120.99, 141.58 and 140.25 kg/ha of dry capsules respectively from all the plantations studied. However wide fluctuations in yields were noticed between the years. Amongst the natural factors the localities of West and North Sikkim, the altitude range of 400-970 M above MSL and the plantations on gentle slopes performed better than others. Management factors profoundly affected the cumulative yields. The plantations on the natural terrains, the cultivars of 'Ramla' and 'Golsey', the moderate dense shade conditions and the plantations in the age group of 10-20 years were slightly more productive. Close spacing below 1.50 metre between plants and off-season irrigations were also effective for higher yields. The soil tests indicated that the plantation soils were acidic in pH, rich in organic C, available N and P, whereas K, Ca and Mg were low to medium. The soil pH, available K, Ca and Mg were positively correlated with yield of large cardamom. Among the viral diseases, the 'Chirkey' was more severe than the 'Foorkey'. The leaf spots caused by *Pestalotiopsis* spp., and the spike rot caused by *Rhizoctonia* sp. and *Fusarium* sp. were also common. The main insect pests were the stem borers, aphids, thrips, mealy bugs, leaf-eating caterpillars, leaf-hoppers, etc., and were found in all the cardamom growing tracts.

INTRODUCTION

India is well known for a number of spice crops, and the large cardamom (*Amomum subulatum*, Roxb) is also mainly produced by the country. The crop area has been confined to the hilly forest tracts of eastern sub-Himalayan Sikkim state (23,485 ha) and adjoining Darjeeling district (2200 ha) of West-Bengal with an estimated annual production in the range of 3000-3500 MT of cured cardamom. The crop is also grown in the other two sub-Himalayan countries, Nepal and Bhutan, producing annually about 1000

MT and 1300 MT respectively of cured cardamom. (Anonymous 1983).

No systematic study has been made regarding the productivity of large cardamom so far. Hence a case study was conducted to know the various natural and management aspects influencing the productivity of large cardamom.

MATERIALS AND METHODS

Fifty five plantations from Sikkim and fifteen from Darjeeling district were randomly selected representing the major tracts

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of large cardamom. The study was conducted during Aug–Nov. 1987, at the time of harvesting. A formal questionnaire was prepared to supplement the information, mostly from the small and medium farmers regarding various management aspects and the previous three years yield. The altitude was noted and the mean altitude of each plantation was recorded. The gradient was grouped by measuring the percentage of slope. The extent of shade available was classified according to the percentage light interception at full-day light intensity using Kyoritsu illuminometer, model-5200, and also confirmed visually for plantation shade conditions. The mean plant spacing and the yield was worked out based on the area and harvest covered by 100 clumps and three such spots were selected per each plantation. The dry capsule yield (kg/ha) was worked out to 1/5th of the fresh weight of the capsules. Composite soil samples from each spot from 31 plantations were collected and analysed for soil pH, in 1:2.5 soil water suspension, organic carbon by Walkley–Black method, available P in Bray P₁ extract, available N by alkaline permanganate method, available K in neutral normal ammonium acetate and available Ca and Mg as given by Muhr et al (1965). Per cent disease index (PDI) was derived by counting the number of affected leaves/tiller and the disease rating were made accordingly. The observations were taken on 20 random clumps/spot.

$$\text{PDI} = \frac{\text{Total disease rating for tillers} \times 100}{\text{No. of tillers examined} \times \text{Max. disease rating}}$$

The spike rot incidence was noted on 10 random clumps/spot.

The data was subjected to the analysis of variance 'F' test between years (Snedecor and Cochran, 1967) and the modified t' test (Cochran, 1964) for unequal samples size between sub factors within the same year, as

also for the pooled yield data of the 4 consecutive years (1984–87).

RESULTS AND DISCUSSION

In the present study, the various factors deemed necessarily affecting the productivity of large cardamom were partitioned into natural factors (Uncontrolled) and the management factors. The study also attempted to correlate the available soil nutrients with the productivity. Certain major diseases have been recorded in different cultivars of large cardamom. These aspects have been dealt separately and are presented as follows:

1. Natural factors

Amongst the natural factors the geographical location of plantations the altitude range, and the topographical conditions are included (Table I).

i. *Locality*: West Sikkim plantations were most productive followed by North Sikkim plantations, as compared to other areas, such as South and East Sikkim and Darjeeling district with regard to their cumulative yields, but the significance was reduced during the individual years. The yield trend yearwise also did not vary significantly for any locality.

ii. *Altitude*: The plantations situated at the lower elevations of 400–970 M above MSL, showed significantly higher productivity as compared to those on medium and higher elevations, with regard to their cumulative yields. However, the productivity did not differ significantly during the individual years. There was no significant difference in yield levels between the years in any of these altitude ranges.

iii. *Gradient*: The gentle and medium slopes have contributed to higher yields than the very steep and steep slopes in one of those

Table I. *Productivity of large cardamom under various natural factors in Sikkim and Darjeeling district*

Factor	No. of plantations covered	Mean yield of dry capsule (Kgs ha ⁻¹)				Pooled mean	'F' test		
		1984	1985	1986	1987		±SEM	SD	CD at 5%
<i>Locality</i>									
North Sikkim	35	107.43	128.97	157.45 ^e	160.90 ^e	138.69 ^{ce}	20.17	28.52	NS
South Sikkim	6	115.60	98.80	148.20	94.70 ^d	114.32 ^{dd}	24.22	34.25	NS
East Sikkim	7	113.41	108.22	78.70 ^a	64.85 ^{ad}	91.29 ^{aadd}	25.45	35.99	NS
West Sikkim	7	143.20	160.41	147.61	180.32 ^{bc}	157.88 ^{bbccc}	22.64	32.02	NS
Darjeeling Dist (W.B.)	15	99.62	98.80	128.44	126.79	113.41 ^d	25.75	36.42	NS
<i>Altitude</i>									
Low (400–970 m, amsl)	10	135.85	153.14	193.89	183.08	166.49 ^{bbcc}	20.63	29.17	NS
Medium (971–1515 m, amsl)	28	105.62	113.55	131.53	137.42	122.03 ^{aa}	20.91	29.58	NS
High (1515 m, amsl)	32	107.13	117.45	134.03	129.35	121.99 ^{aa}	18.54	26.21	NS
<i>Gradient</i>									
Very steep (>100%)	10	104.00	94.78 ^{cd}	103.01	148.00	112.45 ^d	23.04	32.59	NS
Steep (61 – 100%)	30	101.09	87.43 ^{cd}	146.48	132.37	116.84 ^d	21.38	30.24	NS
Medium (30–60%)	20	121.83	160.55 ^{ab}	137.86	154.30	143.63	22.73	32.15	NS
Gentle (<30%)	10	123.50	168.75 ^{ab}	172.90	128.07	148.30 ^{ab}	24.15	34.16	NS
Mean of 70 plantations	—	110.63	120.99	141.58	140.25	128.36	12.28	17.37	NS

The diagonal letters indicate 't' values (Cochran, 1964) significant with the corresponding subfactor within the same year and test also applied for the pooled mean, while single letter a, b, c, etc. denotes, $P=0.05$ and the double letter aa, bb, cc etc. denotes $P = 0.01$.

years *ie.*, 1985, and the gentle slope was effective as compared to those plantations on steep and very steep slopes with regard to their cumulative yields. This might be attributed to washing away of the decomposed leaf litter, due to heavy rains, in Sikkim and adjoining Darjeeling district of West Bengal and the situation would be further aggravated due to lack of suitable planting methods and soil conservation measures on these slopes.

2. Management factors

A perusal of the study, indicated that most of the plantations have been established under the natural habitats of available forest

areas or under the man made thin forests. Practically, the planters adopted a very few management aspects, such as land use pattern, selection of cultivar(s), establishing and providing shade in the plantations, weed trashing and clump cleaning, the gap filling and replanting (maintenance of effective plant population), the irrigation provision etc. However it was found that the cultural aspects such as weed trashing and clump cleaning were the integral parts of harvesting, which are normally practised in every plantation before the harvesting. Some of these management aspects have been studied and the yield levels under each are given in Table II.

Table II. *Productivity of large cardamom as influenced by different management practices in Sikkim and Darjeeling district*

Management factor	No. of plantations covered	Mean yield of dry capsules (kgs/ha ⁻¹)				Pooled mean	'F' test		
		1984	1985	1986	1987		±SEM	SD	CD at 5%
<i>Land use pattern</i>									
Natural terrain	60	108.72	128.45	150.54 ^b	144.39	133.02 ^b	13.72	19.41	NS
Terraced	10	122.08	76.22	87.83 ^a	115.43	100.39 ^a	22.28	31.52	NS
<i>Cultivar</i>									
Ramsey	36	90.78 ^b	113.01	120.88 ^d	127.32	113.00 ^{bbdd}	19.66	27.81	NS
Golsey	18	148.20 ^a	137.82	175.54	179.80 ^c	160.34 ^{aaoc}	21.11	29.85	NS
Sawney	11	98.80	116.09	121.44 ^d	104.07 ^b	110.10 ^{bbdd}	21.88	30.95	NS
Ramla	5	144.35	128.61	212.70 ^{ao}	170.61	164.06 ^{aaoc}	20.87	29.51	NS
<i>Shade available</i>									
Dense	14	140.55	164.86 ^{oa}	155.85 ^d	161.18	155.61 ^{ocdd}	21.69	30.68	NS
Moderate	30	114.57	129.83	173.22 ^{da}	149.32	141.73 ^{odd}	20.51	29.01	NS
Scattered	14	94.76	91.24 ^a	118.00	128.46	108.11 ^{aab}	23.31	32.97	NS
Deficit	12	84.39	82.41 ^a	73.35 ^{abb}	106.93	86.77 ^{aabb}	30.96	43.78	NS
<i>Age of the plantation</i>									
Below 10 years	26	91.90	110.56	131.56	166.79 ^d	125.20 ^{bdd}	21.35	30.20	NS
Between 10–20 years	24	148.08 ^d	167.69 ^{odd}	188.57 ^{odd}	141.03	161.34 ^{aoedd}	23.66	33.47	NS
Between 20–30 years	10	95.50	82.33 ^b	109.88 ^b	118.24	101.49 ^{bb}	16.82	23.79	NS
Above 30 years	10	84.59 ^b	74.68 ^{bb}	86.56 ^{bb}	91.40 ^a	84.31 ^{aabb}	16.93	23.95	NS
<i>Water source utilisation</i>									
Perennial	22	—	—	—	144.55	—	23.25	—	—
Seasonal	18	—	—	—	153.47	—	20.81	—	—
Rainfed	30	—	—	—	129.17	—	19.72	—	—
<i>Mean plant spacing</i>									
Below 1.50 metre	15	—	—	—	191.29 ^b	—	22.44	—	—
Between 1.50 – 1.80 metre	44	—	—	—	125.42 ^a	—	16.22	—	—
Between 1.81–2.00 metre	11	—	—	—	129.99	—	26.04	—	—

The diagonal letters indicate 't' values (Cochran, 1964) significant with the corresponding subfactor within the same year, and the test also applied for the pooled mean, while single letter a, b, c etc denote, $p=0.05$ and the double letter as aa, bb, cc etc denotes $p=0.01$.

i. *Land use pattern*: The plantations on natural terrain were more productive than on terraces with regard to their cumulative yields. However, there was no significant difference between them during the individual years, except during 1986. The analysis of variance also showed non-significant difference in yield levels between years in both the cases. The lower yields on terraces was partly due to their previous cases of paddy cultivation, which resulted in compact soil conditions and partly depleted, soils on which the plantations were raised.

ii. *Cultivars*: 'Ramla' and 'Golsey' mostly grown at lower to mid elevations, were more productive with regard to their cumulative yields than 'Sawney' and 'Ramsey', which are grown in mid and high altitudes. The cultivar 'Ramsey' is vigorous and adopted to dense shade conditions. In the present study most of the 'Ramsey' plantations lacked the desirable shade conditions, which also might be the reason for low productivity of this cultivar, than the cultivar 'Golsey' with its comparatively short statured, erect tillers and upright leaves, which thrives well under light shade conditions. 'Sawney' resembles like that of 'Ramsey' in foliage characters, and is grown from low to high altitudes, whereas the cultivation of 'Ramla' is limited to certain areas of North Sikkim only. The analysis of variance indicated that there was no significant change in yield levels in any cultivar between the years.

iii. *Shade available in the plantation*: It was generally observed that the large cardamom plants are grown under dense shade (6-7% full day light interception) to light shade (26% full day light interception) conditions, for normal crop. The shade requirement during the rainy season i.e., from May to October is not very essential due to natural foggy and cloudy weather which is almost a common feature in the cardamom growing

tract, with less sun shine hours/day. However the shade requirement is very high during rest of the season. The most common shade trees were *Utis*, *Chilaune*, *Panisaj*, *Asare*, etc and all the plantations under the study were found to have more than one species, and among these *Utis* was most dominant (Table III). As the plantations were classified according to the extent of shade, and as the shade species were represented in mix, and of different size and age groups, no direct relationship could be made between the number of shade trees/ha to the extent of shade available. However the range of number of trees/ha under each shade conditions for dense shade (105-490), moderate shade (85-265), scattered shade (36-130) and deficit shade (5-60) were recorded.

The results in Table II indicated that dense and moderate shade conditions were more congenial as the cumulative yields were high compared to those plantations having scattered and deficit shade conditions. There was no significant difference in yield levels between years in any of the shade factors.

iv. *Age of the plantation*: Age of the plantations was recorded as given by the planters and also ascertained by visual observations. The plantations in the age group of 10-20 years were more productive as compared to the plantations in the other age groups. The lower yields obtained in plantations below 10 years were partly due to their formative stages and partly due to lack of shade trees. The analysis of variance indicated that there was no significant difference in yield levels between years.

v. *Water source utilization*: The yield during 1987 was not affected significantly whether the plantation was irrigated throughout the year (perennial source), off-seasonal (Oct-March) or rainfed. However, higher productivity was recorded in off-seasonal

Table III. Common shade trees and their relative abundance in large cardamom plantations of Sikkim and Darjeeling district

Name of shade tree and the altitude of its occurrence in metres above MSL.	Relative frequency out of 70 plantations	Density per hectare Number	Constituent %	Percentage of full-day light interception by individual tree	Nature and its use
Utis (600-2000) (<i>Alnus nepalensis</i>)	46	6-480	38-98	13.51-27.02	Tall, semi deciduous and used as minor timber and as fuel.
Chilaune (550-1515) (<i>Schima wallichii</i>)	28	2-65	14-87	10.81-18.91	Tall, semi evergreen, used as fuel.
Asare (850-2000) (<i>Viburnum colebrookianum</i>)	10	24-148	10-42	10.81-13.51	Small, semi deciduous used for crate manufacture.
Malato (670-1515) (<i>Macaranga denticulata</i>)	30	6-186	16-53	13.51-21.62	Medium, quick growing, semi evergreen, used as fuel.
Argeli (1515-2000) (<i>Edgeworthia gardenierii</i>)	14	29-47	13.41	10.81-21.62	A small tree on single stem, the bark used for fibre making.
Gogun (1400-2000) (<i>Saurauvia nepalensis</i>)	6	9-24	12-35	13.51-18.91	Medium, semi deciduous used as minor timber.
Bilaune (670-1515) (<i>Maesa chesia</i>)	8	13-16	7-18	10.81-18.91	Small to medium, used as fuel.
Panisaj (400-1000) (<i>Terminalia myriocarpa</i>)	8	5-38	9-19	18.91-40.54	A tall semi deciduous used as minor timber.
Nevaro, Dudhilo, Chuletro, Khanyum, Bur and Khasro. (850-1800) (<i>Ficus</i> spp)	19	18-46	24-35	10.81-18.91	Medium sized spreading with heavy foliage which is used as fodder.
Others	27	1-43	6-40	— —	Most of them are grown on chance basis and are used as fuel and fodder.

irrigation as compared to the perennial and rainfed conditions. As the rainfall distribution during Oct–March is not sufficient the need for irrigation is more during the period.

vi. *Mean plant spacing*: Close spacing of plants below 1.5 metre between plants was more productive than the medium spaced (1.50–1.80 m) and the wider spaced plantations. However the yields did not differ significantly between the three spacings. This showed that maintenance of effective plant population would depend upon the type of cultivar, altitude and the extent of shade provided in the plantations to get an optimum productivity.

3. Influence of soil chemical properties on yield

Most of the large cardamom plantation soils were acidic in pH, rich in organic carbon, available N and phosphorus, where as K, Ca, and Mg were recorded in low to medium amounts. (Table IV). The yield of cardamom was positively correlated with the soil pH, available K, Ca and Mg. The content of soil organic carbon and available N, did not relate to yield, but soil available P had the negative relationship.

4. Major disease and pest incidence

The results in Table V showed that among the two dreaded viral diseases of large cardamom, the 'chirkey' was more severe than 'foorkey' and the cultivars 'Ramsey' and 'Sawney' were most susceptible. The cultivar 'Golsey' was tolerant to 'chirkey' and moderately tolerant to 'foorkey' disease. Although the cultivar 'Ramla' was free from 'chirkey' it could not be ascertained as tolerant or not, since the sample size was less. The 'foorkey' disease was found in all the 4 cultivars, 'Ramsey' being more susceptible. Leaf spot diseases caused by various strains of *Pestalotiopsis* spp were more common in all the cultivars. Spike rot, a severe malady was present in all the plantations studied. This malady was due to several factors like fungal infections (*Rhizoctonia* sp and *Fusarium* sp), insect pests, and the chirkey infection. However, heavy and continued rainfall during flowering season may also result in severe spike rot. In the present study, the cultivar 'Sawney' recorded maximum (32.78%) spike rot incidence, whereas the 'Ramla' recorded minimum (19.70%). The cultivars 'Golsey' and 'Ramsey' were moderately affected.

Table IV. Chemical composition of soils of large cardamom plantations and their correlation with yield

Soil chemical composition	Range	Mean	C. V.	Correlation with yield
pH	3.85–5.90	4.87	13.42	0.2584
Org. C %	2.06–10.44	5.86	34.65	–0.0045
Av. N mg/100 g.	20.30–63.70	41.13	28.43	–0.0022
Av. P mg/100 g.	1.40–5.40	3.19	31.73	–0.1588
Av. K mg/100 g.	2.91–14.94	6.29	47.82	0.3434
Av. Ca mg/ 100 g.	20.90–184.30	70.36	66.56	0.3342
Av. Mg mg/100 g.	1.14–42.18	10.96	88.95	0.1143

Among the major insect pests, the stem borer (*Glyphipterix* sp) was more severe. The incidence was recorded in different cultivars, viz, 'Ramsey' (15.68%), 'Golsey' (16.95%), 'Sawney' (16.60%) and 'Ramla' (14.64%). The aphids, such as banana aphid (*Pentalonia nigronervosa* Cock) cardamom aphid (*P. nigronervosa*, f. *galadii*, goot) pink-aphid (*Micromyzus kalimpongensis*), and the corn aphid (*Rhopalosiphum maidis*) were present in all the areas. The cardamom thrips (*Rhipiphorothrips cruentatus* Hood) were found during flowering period, the thrips attack was high in North-Sikkim (20-25 thrips/spike) followed by East-sikkim (18-20 thrips/spike). The cardamom mealy bug was seen in all the areas surveyed during Aug-Nov, and the pest attack was more in West - Sikkim (18-20 bugs/clump). The other minor insect pests found were the leaf-eating caterpillar (*Clelea plumbiola* Hampsn) leaf-hopper (*Kolla opponnens* Walker) leaf-beetle (*Lema nigricollis* Jacoby), capsule-borers (scolytid beetle) and the white grubs.

The study indicated that both, the natural factors and managerial practices were effective in large cardamom cultivation. The productivity could be enhanced by adopting proper management and shown a greater scope for scientific approach to get stabilized

higher yields in large cardamom. The present study indicated that the yield levels were not significantly affected between the 4 consecutive years. However, the individual plantations were subjected to wide fluctuations in annual yields. The problem was attributed to the lack of proper management practices like manuring, systematic planting, optimum shade provision, ideal methods of irrigation, proper plant protection methods, etc.

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ROLE OF CO-OPERATIVE SOCIETY AS THE NODAL POINT IN THE DISSEMINATION OF SCIENTIFIC KNOWLEDGE ON RUBBER

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ABSTRACT

The study covers 110 co-operative societies in 12 districts of Kerala. Fifty two per cent of the members of the societies are rubber growers, while the percentage of rubber growers among the office bearers is 80. This indicates that the rubber growers give the leadership to the societies. The activities of the societies are confined to agricultural development, marketing, banking and industry. The majority of societies are Service Co-operative Banks. Ninety three societies have organised seminars and forty seven societies are involved in the promotion of long term development schemes of the Rubber Board. The societies prefer seminars as the most effective medium of dissemination of scientific knowledge, followed by publications and training programmes.

INTRODUCTION

Rubber is a perennial crop which benefited much from the scientific research that was carried out during the last fifty years. The catalyst that accelerated the development in rubber plantation industry has been the timely availability of scientific knowledge to the rubber growers which is being continuously updated by the research institutions. Unless there is an uninterrupted flow of scientific knowledge from the laboratory to the rubber grower, the progress of the rubber plantation industry will be impeded. The small rubber growers occupy an important position in the industry by virtue of the number, coverage of area and contribution to production. Because of the high literacy levels of rubber growers, their ability to absorb scientific knowledge on the cultivation and processing of rubber could be updated without much difficulty. The co-operative societies served as an important channel in the flow of scientific knowledge. The present study was initiated to assess the

extent of involvement of co-operative societies in the dissemination of scientific knowledge.

Evolution of co-operative movement in rubber plantation industry

The Plantation Enquiry Commission examined the scope for introducing co-operative societies in rubber plantation industry in 1956 and recommended that co-operative supply and banking societies should be established. In 1958 the Government of India adopted the recommendation of the commission. For implementing the recommendation an officer of the co-operative department was taken on deputation by the Rubber Board in 1960. This led to the enrolment of more rubber growers in the existing co-operative societies and forming new ones. A study conducted in 1974 found that 28 per cent of rubber growers were members of 23 co-operative marketing societies in 1971-72. Since 1976 the Rubber Board has been implementing World Bank aided scheme for the

improvement of processing and marketing of rubber. The launching of the scheme further accelerated the growth of co-operative societies.

MATERIALS AND METHODS

For collecting the data for the study, a draft questionnaire covering all aspects of dissemination of scientific knowledge on rubber was prepared and the same was sent to 240 co-operative societies associated with the activities of the Rubber Board. Completed questionnaires were received from 110 societies. The study was confined to the twelve districts of Kerala State. Except one society, all the societies had rubber growers as members. The societies which replied were mainly service co-operative banks. (Table I).

Table I. *The details of societies surveyed*

Type of Society	Nos.
Service co-operative bank	76
Rubber marketing co-operative society	20
Farmers' co-operative service bank	7
Service co-operative society	2
Regional service co-operative bank	2
Ex-servicemen joint farming service co-operative society	1
Urban service co-operative bank	1
Joint farming co-operative society	1
Total	110

RESULTS AND DISCUSSION

From the data thus collected the societies were classified according to the year of starting. Out of the 110 societies, 67 were started 30 years before and 32 societies were started between 21 to 30 years. There were 39 societies with membership exceeding 5000. The largest society had 17700 members. (Table II).

Table II. *The number of members in the societies*

Members	No. of societies
Upto 1000 members	9
1001 to 2000	15
2001 to 3000	13
3001 to 4000	13
4001 to 5000	21
Above 5000	39
Total	110

The study showed that 52 per cent of members of the societies were rubber cultivators, while the percentage of rubber cultivators among the office bearers was 80. Out of 926 office bearers in various societies 748 were rubber growers. This clearly indicated that the rubber growers are giving the leadership to the co-operative movement at least in the sphere of agricultural development in Kerala. (Table III).

Table III. *Distribution of rubber growers as office bearers in societies*

Rubber growers as percentage to total office bearers	No. of societies
Societies without elected office bearers	6
No rubber grower among the office bearers	4
Rubber growers upto 25%	10
Rubber growers between 26 to 50%	3
Rubber growers between 51 to 75%	36
Rubber growers between 76 to 100%	51
Total	110

The activities of the societies were confined to four areas viz., banking, marketing, industry and agricultural development. Eighty nine societies were engaged in banking, 98 in

marketing, 101 in agricultural development and one in industry.

This showed that many of the societies were engaged in more than one activity.

The study revealed greater involvement of co-operative societies in the dissemination of scientific knowledge. (Table IV).

Table IV. *Involvement of co-operative societies in disseminating knowledge*

Activity	No. of societies
Conducting seminars	93
Participation in training	29
Visits to the RRII	18
Tappers' training class	10

The societies organised seminars in various frequencies. About 73 societies organised seminars once, 11 societies twice, 7 societies thrice and two societies thrice. Out of 93 societies 83 societies reported increase in turnover of agricultural inputs after the seminars.

Fifty four societies organised special discussions with the Rubber Board officials to

elicit the latest information. Sixty five societies published booklets dealing with scientific rubber cultivation and also gave details of the schemes of the Rubber Board in their annual reports. Thirty one societies displayed in their premises scientific articles published in the dailies on rubber cultivation for the benefit of rubber cultivators.

Agricultural development

One area of activity of the co-operative society is the promotion of scientific cultivation. Accordingly 47 societies were involved in the promotion of long term development schemes of the Rubber Board. There were 104 societies which had facilities for selling inputs to rubber growers. Of these 102 were selling fertilizers, and 90 societies were selling plant protection chemicals. Twenty-two societies maintained their nurseries. Except two societies, all were willing to associate with the Board's activities in spreading scientific knowledge.

As the co-operative society is the nodal point in the dissemination of scientific knowledge, the societies were asked to give their preferences regarding the medium to be adopted for the dissemination. (Table V).

Table V. *Preference of the societies for the medium of dissemination of scientific knowledge*

Medium	Preference						Total No. of societies
	I	II	III	IV	V	VI	
Seminars	50	31	21	5	1	2	110
Publications	28	22	26	23	9	2	110
Training Programmes	19	35	16	23	15	2	110
Visit to the RRII	7	9	16	13	32	33	110
Radio	6	10	25	34	26	9	110
TV	1	3	4	15	27	60	110

Table V showed that the first preference of the large number of societies (50 nos.) is for holding seminars, followed by publications and training. Television and Radio have been relegated down in the scale of preferences.

One hundred and two societies represented the different input suppliers. Of these, twenty-two societies represented 6 or more companies, 11 societies 5 companies and 19 societies 4 companies. Thirty societies received some help from the input manufacturers for the dissemination of scientific knowledge. Of these, 25 societies received help for organising seminars.

Other activities of the societies

Fifty one societies deal in rubber and hold licence from the Rubber Board; seven have smoke house, four have processing factories and one has manufacturing facility. Fifty three societies organised camps for soil and leaf analysis. Fifty four societies were involved in renting out plant protection equipments and sixteen societies organised helicopter spraying.

The study clearly showed the involvement of the majority of societies in the dissemination of scientific knowledge relating to rubber and the rubber growers took the leading role in most societies.

From the study the following policy implications can be drawn up:-

1. The societies prefer seminar as the most useful medium and as such, attempts may be made to organise seminars in areas not covered already. In other areas, seminars may be organised on a regular basis.
2. Publications particularly the 'Farm Feature page' in the newspapers have been the other preferred medium of the societies. As such, the regularity of publications may be increased. The scope for enhancing the coverage may also be explored.
3. Co-operative societies also favoured training programmes. The societies may be informed in advance of the training programmes proposed to be held during a year, through a brochure. It would be desirable if the Rubber Board represents in the annual general body meeting of the societies wherein the members can be enlightened on the various development and training programmes of the Board.

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INCREASING PRODUCTIVITY OF CARDAMOM THROUGH LARGE SCALE DEMONSTRATION OF IMPROVED TECHNOLOGY IN FARMERS FIELDS IN KODAGU DISTRICT OF KARNATAKA

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ABSTRACT

A High Production Technology (HPT) programme was initiated in 1986 in all the key cardamom growing zones of Kodagu district in Karnataka to motivate the growers to increase the per unit production to a level of 650 kg per ha by utilising the information available at the Cardamom Research Centre, Appangala, in collaboration with Spices Board. A series of meetings were held in various field units to enlighten planters for adoption of the HPT programme. Totally 42 farmers were selected covering an area of 94.10 ha by planting 4,70,500 CI-37 seedlings. The preplanting status survey of the HPT cardamom plantations revealed that the yield level ranged from as low as 10 to as high as 125 kg/ha, with the average being 58.0 kg/ha. The establishment of cardamom in all the plots is quite satisfactory (95%). The plots were monitored from time to time by implementing the package of practices as per calendar of operations.

INTRODUCTION

In the recent years, India has lost its near monopoly in world production as well as export of cardamom and has been replaced from some of the traditional markets through intensive competition from Guatemala (Das, 1982). The national average yield of Indian cardamom is only 60 kg/ha as against 350 kg/ha in Guatemala, mainly because 75 to 80 per cent of cardamom area in India faces long dry spells and grown under poor management. Significant decline in growth rate in production of cardamom was recorded in the years 1972-73, 1976-77 and 1982-83 due to drought prevailed during summer (Anonymous, 1984; Cheriankunju, 1985; Mohanachandran, 1983). The projec-

tions of the Spices Board, show that the gap between world supply and demand may touch 5000 tonnes by the year 2000 AD (Chandrasekhar, 1987). Although almost 60 per cent of the produce is exported to more than 60 countries, there is a great scope and need for increasing cardamom production in India which is known for its quality and aroma. As the international market becomes increasingly competitive only high productivity and low cost of production would ensure survival of this industry. At the National Research Centre for Spices, Cardamom Research Centre, Appangala, Kodagu, Karnataka, and its demonstration plots in the farmers fields examples were set to tap a better crop potential of 650 kg/ha

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under irrigated and 162 kg/ha in rainfed condition respectively (average of 3 years). In the above trials it was evident that the increased yield was due to use of high yielding planting material, quality seedlings, high plant population, judicious shade regulation, timely cultural practices, fertilizer and pesticide application and 'Katte' disease management. This success lead the scientists and Spices Board, to work out a feasible strategy to improve the present low production of cardamom in India and narrow down the gaps between actual and the potential yield. In view of the above background a high productivity technology programme was launched in all the major cardamom growing areas of Kodagu and parts of Hassan district which comprises 68% of total area in Karnataka and 20% in India, to demonstrate the high yield potential of cardamom in the farmer's fields.

METHODOLOGY

In the joint meetings of the Scientists and officials of the Spices Board, various constraints were discussed and was decided to launch a programme in all the key cardamom growing zones in 1986 to motivate growers to adopt improved techniques for increasing production per unit area, by utilising the information generated already. It is a collaborative programme of NRCS, Cardamom Research Centre, Appangala and the Spices Board, wherein the role of former is to motivate growers and to offer overall technical guidance. All the monetary inputs by way of subsidy etc. were met by Spices Board.

The package of practices, for HPT both under irrigated and rainfed conditions and calendar of operations (Annexure I) were prepared before initiating the programme.

The sequence of works carried out for implementation of the programme were as follows :

1. Training the officials of Spices Board at all levels.
- (2) Motivation of farmers
- (3) Arranging visit of farmers to the Cardamom Research Centre
- (4) Identification of beneficiaries
- (5) Preplanting inspection
- (6) Training of Extension/Field Assistants
- (7) Collection of information on preplanting history of HPT and regular follow up and
- (8) Monitoring of HPT plots.

An Evaluation committee was constituted for monitoring HPT plots in Karnataka with the Deputy Director, Spices Board, Sakleshpur as convenor and Scientist-in-Charge of NRCS, Cardamom Research Centre, Appangala, RRS Mudigere and ICRI Sub-Station, Sakleshpur as members to review the progress of work and suggest corrective measures if required.

RESULTS AND DISCUSSION

Totally 42 plantations located in the various agro-ecological conditions and rainfall pattern in 5 zones viz., Virajpet (13), Bhagamandala (7), Madikeri (12), Somwarpet (2) and Yeslur (8) were selected (Table I).

The data collected on the preplanting benchmark survey of HPT cardamom plantations revealed that the yield level ranged from as low as 10 to as high as 125 kg/ha, with the average being 58.80 kg/ha, which is almost equivalent to national average yield (62 kg/ha) (Mohanachandran, 1984). The average size of the families selected under the HPT programme was 6.55 with an area of 6.54 ha. The average age of the plantations was 16.98 years before adopting the High Productivity Technology. The mean rainfall in all the units was found to be 3150.5mm per annum. The Bhagamandala unit recorded the highest rainfall of 4197.1mm followed by Virajpet (3808.00 mm), Madikeri (2729.1 mm),

Table 1. *Status of cardamom plantations before initiating HPT*

Name of the unit	Size of the family	Average annual rainfall in mm	Area under cardamom in ha	Age of plantation in years	Previous average yield kg/ha
Bhagamandala	9.42	4197.1	11.80	25.33	32.50
Madikeri	6.91	2729.16	6.6	14.29	73.55
Somwarpet	5.00	2600.00	2.4	10.50	80.00
Virajpet	4.18	3807.69	7.94	12.18	41.81
Yeslur	7.25	2518.75	4.00	22.62	66.16
Average	6.55	3150.54	6.54	16.98	58.80

Somwarpet (2600.00 mm) and Yeslur (2518 mm) respectively. It is interesting to note that the lowest average yield of 32.50 kg/ha was recorded under the heaviest rainfall of 4197.1 mm followed by Virajpet with 41.81 kg/ha (3807.69 mm). The yield of cardamom is influenced more by distribution of monthly rainfall than the total rainfall (Subba Rao and Korikanthimath, 1983). The planting of cardamom in all the 42 HPT demonstration plots was taken up during the planting year of 1986 and the establishment of cardamom seedlings was 94.88%.

The performance of cardamom was quite satisfactory in almost all the HPT demonstration plots and the first crop is expected during 1988 crop season two years after planting. The fluctuating market, recurring drought, rise in the cost of labour and other inputs are adversely affecting the cultivation of cardamom. The good crop prospects just two years after planting in the HPT plots as against 3-4 years in the normal conditions, is an added advantage and due to this advantage many are voluntarily adopting the HPT system in their plantations.

Annexure I

Package of Practices for High Production Technology Programme of Cardamom in Karnataka Region

1. Planting material

Nursery raised from quality seeds of Malabar Variety.

2. Spacing

In uplands: 2 x 1 M spacing accommodating about 5000 plants per hectare.

In low lying lands/flat lands : 2.1 x 1.2 m accommodating about 3,960 plants per hectare. Drainage should be ensured to avoid water stagnation.

3. Method of planting

Uplands : Trench method of planting on contours. Trenches of size 45 cm width, 30 cm depth and convenient length are to be opened during March-April after receipt of summer showers.

In low lying/flat lands and under irrigated conditions: Individual pits of size 45 cms x 45 cms x 30 cms to be filled with top soil and organic manure before planting.

4. Planting time

Uplands : Planting during May-June with onset of monsoon.

Low lying lands: Planting during August onwards after the heavy monsoon. Proper staking and mulching should be taken up.

5. Fertilizer dose

Rainfed condition : For both uplands and low lying/flat lands—fertilizer to be applied @ 125:125:250 kg. NPK/ha (5000 plants). Under irrigated condition higher dose is recommended, based on the location and soil test values.

1st year of planting: Half the dose of fertilizer is given. 1st round of fertilizer to be given after 45 days and 2nd round after three months of planting.

2nd year of planting: The full dose of fertilizer to be given in 2 or more split doses depending on soil moisture availability.

6. Other cultural operations

Light forking to break the hard surface of soil during 1st year *i.e.*, October–November and mulching during summer months.

7. Weeding

Regular weeding to be carried out depending on weed growth.

8. Shade regulation

Irrigated conditions: Minimum with 60–70% of filtered sunlight depending on slope and direction.

Rainfed condition: Shade is to be adjusted to obtain filtered sunlight particularly in Western and Southern aspects.

9. Plant protection

1st year of planting : Two rounds of 1% Bordeaux mixture with a suitable contact insecticide. 1st round after planting and 2nd round during April/May.

2nd year of planting : In addition to above one more round of dusting with insecticide(s) depending upon pest infestation.

Additional plant protection measures will be suggested depending on the outbreak of particular pest and diseases.

Calendar of operations in the HPT cardamom plots in Karnataka

January

1. Irrigation at an interval of 12–15 days.
2. Tracing and roguing of 'Katte' infected plants.

February

1. Continuation of irrigation as above
2. Collection of soil samples for testing
3. Tracing and roguing of 'Katte' infected plants.

March

1. Continuation of irrigation as above
2. Tracing and roguing of 'Katte' infected plants.

April

1. Continuation of irrigation as above.
2. Regulation of shade after the receipt of premonsoon showers.
3. Spraying 1% Bordeaux mixture and the insecticides in the irrigated areas.
4. Tracing and roguing of 'Katte' infected plants.

May

1. Continuation of irrigation till sufficient rain is received.
2. Threshing.
3. Application of insecticides against thrips infestation.
4. Demulching to facilitate pollination by honey bees.
5. Regulation of shade to a height of 8–10m to get filtered sunlight.
6. Application of 62.5:62.5:125 Kg NPK/ha.
7. Opening and filling of pits/trenches.

8. Tracing and roguing of 'Katte' infected plants.
9. Weeding.

June

1. Gap filling by using 18-22 month old seedlings.
2. Application of fertilizer (if not attended during May).
3. Spraying with 1% Bordeaux mixture.
4. Cleaning the drains to provide adequate drainage.
5. Continuation of weeding.
6. Planting the saplings of fast growing shade tree species in the vacant and open areas.

July

1. Cleaning and deepening the drains (Wherever necessary) to ensure adequate drainage.
2. Harvesting of cardamom in the valley bottoms.

August

1. Continuation of picking at an interval of 12-15 days.

September

1. Continuation of picking.
2. Spraying 1% Bordeaux mixture against rhizome and panicle rot.
3. Application of 62.5:62.5:125 Kg NPK/ha.

October

1. Continuation of picking.
2. Light earthing up to cover collar region.
3. Mulching.
4. Spraying for red hairy caterpillars with the recommended insecticides.
5. Tracing and roguing of 'Katte' infected plants.

November

1. Continuation of picking cardamom
2. Continuation of mulching
3. Cleaning and rectification of drains
4. Tracing and roguing of 'Katte' infected plants.

December

1. Continuation of picking cardamom
2. Continuation of mulching
3. Tracing and roguing of 'Katte' infected plants.

Keeping upto date records of the various farm inputs and mandays used for entire year.

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TURMERIC RESEARCH IN MAHARASHTRA

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ABSTRACT

A research scheme for turmeric was initiated at Digras, Sangli Dist. in Maharashtra since 1963. Since then large number of varieties were screened for adaptability and yield potential. Krishna, Tekurpeta, Rajampeta, Cl/S-19 and Cli 320 belonging to *Curcuma longa* and Ca-72 and Ca-91/2 from *C. aromatica* group were found promising. Krishna has been released and recommended for general cultivation in Maharashtra. The package of practices viz., time of planting, spacing, type of planting material, irrigation schedules, period of harvesting and intercropping have been standardised.

INTRODUCTION

Turmeric (*Curcuma longa* L) is an important spice crop grown on commercial scale in India, covering an area of 1045000 ha of which Maharashtra contributes about 8200 hectares (Anonymous, 1987), which is 7.8% is of country's total. Sangli, Satara, Solapur, Parbhani, Nanded, Osmanabad and Chandrapur are the leading districts in turmeric production. Considering the suitability of climate for growing quality turmeric in Maharashtra, a scheme for turmeric improvement was sanctioned in third plan during 1963 at Digras, District Sangli. Since then the research activities were mainly on collection and evaluation of germplasm to identify suitable types for the agro-climatic zone, and to standardise the package of practices for the maximisation of production of elite types identified through the assessment programme. The major achievements of the project are presented and discussed in the paper.

MATERIALS AND METHODS

Varietal assessment

The available germplasm under *Curcuma longa* and *Curcuma aromatica* was screened for yield of green turmeric alongwith Tekurpeta and Krishna as checks. The study was conducted for three seasons during 1985-86, 1986-87 and 1987-88.

RESULTS AND DISCUSSION

It is seen from the Table I that Cls-19 (537.82/ha) followed by Cli-320 (493.88 q/ha) and Cli-324 (483.70 q/ha) have recorded considerably higher yields than Tekurpeta and Krishna as well as remaining cultivars. Among the 12 different cultivars belonging to *C. aromatica* group, the culture Ca-72 (Table II) recorded higher turmeric yield (489.57 q/ha) followed by Ca 91/2 (383.98 q/ha) as compared to check Waigaon (336.20 q/ha). The data presented in Table III in respect of some promising cultures of early

Table I. *Yield performance of cultivars belonging to Curcuma longa group*

Name of the cultivar	Yield of green turmeric (q/ha)			(q/ha) Mean
	1985-86	1986-87	1987-88	
Cli-315	305.90	446.59	511.59	421.36
Cli-190/2	306.25	295.20	503.46	368.30
Cli-320	356.59	523.60	601.40	493.88
Cli-321	343.40	278.53	458.74	360.22
Cli-322	321.52	368.88	482.98	391.13
Cli-324	322.91	591.45	536.73	483.70
Cli-325	361.80	458.67	535.83	452.10
Cls-19	431.59	493.81	688.05	537.82
Cli-335	372.22	254.16	475.27	367.22
Cli-355	372.22	274.37	644.64	430.41
Cli-370	388.89	386.59	482.98	419.49
Cls-No. 2	353.12	349.02	686.73	462.95
Cli-364	336.80	238.88	436.10	337.26
Cli-366	341.66	263.81	410.34	338.60
Cli-369	338.88	165.13	311.73	271.91
Cls-No. 1	235.06	181.73	382.28	266.36
Cli-327	357.98	396.03	384.09	379.37
Cli-328	238.19	226.10	410.41	291.57
Tekurpeta (check)	295.13	330.69	415.34	347.05
Krishna (check)	375.69	404.99	454.85	411.84
S. E. $\pm$	40.70	25.20	34.72	36.18
C. D. at 5%	112.83	74.50	102.77	107.08

and late types indicated that Rajempeta has recorded significantly highest yield (535.06 q/ha) than rest of the cultivars including checks, while in late maturity group, Rajempeta (I) produced significantly highest yield of green turmeric (547.29 q/ha) than the other cultivars. However, the yield level was very close to that of Tekurpeta and Krishna.

Twelve promising varieties including Krishna as local check were studied for yield performance for three years (Table IV). The average performance of these varieties over three years indicated that the varieties Tekurpeta and Krishna were the highest yielders and all other varieties exhibited rather poor performance.

Table II. Yield of cultivars belonging to *Curcuma aromatica* group

Treatments	Yield of green turmeric (q/ha)		
	1985-86	1986-87	Mean
Ca-62	307.63	132.36	219.99
Ca-66	362.49	292.35	327.42
Ca-67	499.30	212.01	355.65
Ca-69	459.02	261.66	360.34
Ca-70	442.35	279.37	360.86
Ca-71	341.66	297.08	319.37
Ca-72	554.85	424.30	489.57
Ca-73	436.10	233.33	334.71
Ca-91/2	384.71	383.26	383.98
Cas-20	249.99	215.41	232.70
Cas-67	236.10	219.72	227.91
Waigaon (check)	415.96	256.45	336.20
S. E. $\pm$	30.3	20.27	
C. D. at 5%	88.9	59.51	

From the overall evaluation the cultivars Tekurpeta, Krishna, Rajempeta, Rajempeta (I), and advance cultures like Cls-19 and Cli 320 belonging to *C. longa* group and Ca-72 and Ca-91/2 of *C. aromatica* group were found suitable for Maharashtra State.

Package of practices

The following package of practices were found suitable for optimum production of turmeric in Maharashtra State.

1. Planting of rhizomes during May was found ideal.

2. Mother rhizome as planting material gave higher yields.

3. Planting of rhizomes at 37.5x15 cm gave significantly highest yield of green turmeric (640.83 q/ha) than 37.5 x 30 and 37.5 x 45 cm spacings.

4. Irrigation at an interval of 7 days gave maximum production.

5. Turmeric harvested after 8 months after planting gave maximum curing percentage.

6. Intercropping of french bean followed summer groundnut gave highest monetary return than sole crop of turmeric.

Table III. *Yield performance of some promising cultures*

Treatment	Yield of green turmeric q/ha		
	1985-86	1986-87	Mean
<i>Early group</i>			
Rajempeta	548.60	521.52	535.06
Ca-17-1	233.33	163.75	198.54
Ca-92-1	159.72	92.08	125.90
Chayapasupu	493.05	324.16	408.60
Shillong	344.44	271.38	307.91
Erode (II)	420.83	286.25	353.54
Selam pure	505.55	323.88	414.71
Waigaon (check)	551.94	269.16	425.55
Kasturi (check)	494.44	364.16	429.30
S. E. $\pm$	13.76	9.29	
C. D. at 5%	NS	31.79	
<i>Late group</i>			
Karanje 45-4	491.66	295.41	393.53
Rajempeta (I)	730.55	364.02	547.29
Upparpalli	509.71	254.16	381.93
Durvver	480.55	288.60	384.57
Nandyal-3	570.82	288.19	429.50
Nandyal-19	615.27	403.19	509.23
Guntur-3	516.66	240.13	380.39
Guntur-13	662.49	211.66	437.07
S. R. Palli	505.50	245.97	375.73
Khira	573.60	192.77	383.18
Jyoti	441.66	420.13	430.89
Cli-326	634.71	268.33	451.52
Tasgaon 1-3	397.21	277.49	337.35
Kasturi Tanuka	393.05	194.02	293.53
Tekurpeta (check)	640.27	430.69	535.48
Krishna (check)	590.27	461.52	525.89
S. E. $\pm$	23.6	28.88	
C. D. at 5%	70.9	86.94	

Table IV. *Yield performance of different varieties*

Treatments	Yield of green turmeric (q/ha)			Mean
	1985-86	1986-87	1987-88	
Duggirala	434.27	365.24	503.86	434.39
Sugandham	416.86	259.58	621.50	432.65
Alleppey	436.86	276.25	629.78	447.63
Erode	377.42	309.46	626.72	445.20
Kasturi	337.85	246.33	—	292.09
Selam	468.30	253.24	585.44	435.66
M-221	399.91	215.84	—	307.87
M-222	411.93	265.01	394.83	357.26
Tekurpeta (check)	542.79	425.34	744.06	570.73
Waigaon	354.73	266.58	458.39	359.90
Rajapuri	370.36	263.49	449.44	361.10
Krishna (check)	534.15	453.28	671.06	552.83
S. E. $\pm$	7.20	13.00	7.65	
C. D. at 5%	21.10	38.06	22.08	

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"KERAGRAMS" — FACT'S INNOVATIVE APPROACH

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ABSTRACT

During the last two decades the average yield of coconut crop in Kerala State has been on the decline due to the poor management practices adopted and the widespread occurrence of root (wilt) disease. Fertilizers and Chemicals Travancore Ltd., popularly known as FACT, came forward and adopted three villages - "Keragrams" - since 1973 to demonstrate that proper management practices can double the yield and reduce the spread of the disease. The experience thus gained, made FACT to adopt three districts in the State. The impact of the adoption of villages is presented in this paper.

INTRODUCTION

There was a spectacular growth in agricultural production during the last two decades. The technological breakthrough brought about by the green revolution that swayed the country from the early sixties has been mainly responsible for this progress.

During this period, while the yields of almost all the crops have recorded significant increase, the production of coconut, the major crop in Kerala State, showed a declining trend. This is mainly due to the absence of adequate management practices and the widespread occurrence of the root (wilt) disease. During the last two decades there was a decrease in productivity and the coconut production remained stagnant.

The leading fertilizer manufacturer in the State, The Fertilizers and Chemicals Travancore Ltd., has been actively engaged in undertaking various extension and promotional activities during the last three decades for increasing the agricultural production. It has made many innovations in the field of extension and promotion. It has the distinction of adopting the first village in the country and thus translating the concept of

"Village adoption" into an action plan. FACT made further innovation in the village adoption concept and went ahead to adopt 'coconut villages', popularly called 'Keragrams' in Kerala State since 1973. These were large scale demonstrations adopted with the basic objective to show that productivity of this crop could be increased through proper management. Since then FACT had adopted three more villages and later with the 'District adoptions'.

The experiences of FACT in increasing the productivity of coconut crop in these villages and also districts are presented in this paper.

MATERIALS AND METHODS

Three 'Keragrams' viz., Mannancherry (Alleppey Dist.), Eravipuram (Quilon Dist) and Varandarappilly (Trichur Dist) were adopted. A benchmark survey was carried out on the holding size, productivity of coconut, the farm practices adopted, nutritional status of the soil and the incidence of root (wilt) disease in the villages. Various research and developmental organisations were involved in the extension activities to boost up the production. Demonstration plots were laid out in farmer's gardens and group

meeting and personal contacts with farmers were arranged. Financial assistance was arranged to the growers. The yield increase in the 'Keragram' was evaluated for 3-5 years.

Three districts viz., Trichur, Ernakulam and Kottayam were adopted for conducting intensive promotional drive.

First Keragram – Mannancherry village in Alleppey district

FACT adopted the first 'Keragram' as early as in 1973, in Mannancherry Village of Alleppey District. A total area of 380 hectares with 35,000 coconut trees in 800 farm holdings was adopted for this purpose. Preliminary survey conducted in the village showed that 26% of the trees were affected by root (wilt) disease and very little irrigation facility was available. Soil analysis indicated low content of N, P and K. The annual average yield was only 20 nuts/tree.

In close co-ordination with the State Department of Agriculture (DA), Central Plantation Crops Research Institute (CPCRI) and the local Block Development Office, intensive promotional activities were launched for a period of three years to assist and persuade the farmers to adopt scientific methods of cultivation. Since a large percentage of farmers was having holdings less than 0.5 ha and was in need of financial assistance, the District Co-operative Bank came forward to extend short and medium term loans through their Primary Societies.

Through a series of study classes, seminars, exhibitions, Farm Science Centres and fertilizer festivals the latest techniques in scientific cultivation were brought to the door steps of the farmers. Scientists from CPCRI, officials from the Department of Agriculture and experts from FACT took active role in these promotional activities.

Short term loans were disbursed among the farmers both as fertilizers and in cash. Inter-cropping of banana, vegetables, groundnut and tapioca was popularised to enable the farmers to get additional income. Cultivation of sannhemp in coconut gardens was also popularised. Irrigation was made possible through the availability of adequate loan to purchase pumpsets.

The survey conducted after 3 years in 99 holdings selected for this purpose revealed that the yield had increased by 105% (Table I).

The primary society which had only 844 members and a share capital of around Rs. 43,000/- became major society in the taluk with 1430 members and a share capital of Rs. 1.25 lakhs at the end of the third year. It was able to distribute a loan of Rs. 8.56 lakhs during this period.

Second Keragram – Eravipuram village in Quilon district

FACT adopted the second 'Keragram' in Eravipuram village of Quilon District in

Table I. *Increase in yield of coconut at Mannancherry*

Year	No. of palms	Total yield (Nuts)	Yield/palm
1973-74	5040	100800	20
1974-75	5131	174405	34
1975-76	5448	222296	41

1980. Intensive extension and promotional activities were launched for a period of five years in this village.

A total area of 480 hectares with 97024 coconut palms belonging to 5753 households was adopted from the village for forming this 'Keragram'. Initial benchmark survey revealed that a total number of 52317 were yielding giving an annual average yield was only 21 nuts/tree. Five per cent of the trees were disease affected and only 1% of the farmers were applying fertilizers. Facility for irrigation was absent.

FACT organised a series of promotional activities by laying out demonstrations and organising study classes, group discussions, seminars and fertilizer festivals, with the active participation of the Scientists from CPCRI and Kerala Agricultural University (KAU). Every year, the calendar of operations on interculture, fertilizer application,

plant protection and other management practices were printed and distributed to help the farmers to plan their activities well in advance. To popularise intercultivation in the gardens, banana suckers, tapioca setts pepper cuttings and vegetable seeds were made available at nominal price.

Kitchen gardens were laid out in many households in the village with the co-operation of the Mahila Samajam and other organisations. Improved seeds were distributed for the same. As financial assistance, a total amount of Rs. 1.52 lakhs was disbursed from the Co-operative and other Banks from the locality.

The yields obtained from the demonstrations during the five year period of adoption are presented in Table II.

The survey conducted at the end of the fifth year, revealed the following:

Table II. Increase in yield of coconut at Eravipuram

Plots	Years				
	1980-81	1981-82	1982-83	1983-84	1984-85
1.	16	37	40	45	50
2.	25	30	41	49	43
3.	20	40	41	40	52
4.	27	34	38	53	52
5.	24	33	40	44	48
6.	—	—	34	37	45
7.	30	36	41	45	51
8.	—	26	40	46	52
9.	28	33	40	46	51
10.	24	39	39	49	52
11.	—	—	40	48	50
Total	194	308	434	502	546
Average yield	24	34	39	46	50

1. At the end of 5th year the average yield increased from 21 nuts/palm to 31 nuts per tree. - an increase of 50%; 2. Fertilizer consumption went up from 18 to 117 metric tonnes (increase of 550%); 3. The project created more interest among the farmers about scientific methods of coconut farming.

Third Keragram-Varandarappilly village in Trichur district

CPCRI and Department of Agriculture have been taking steps to check the spread of root (wilt) disease to the northern part of the State beyond Trichur District. Eradication of the diseased palms and popularising better management practices were the objectives of the programme. FACT also joined CPCRI and DA and adopted a 'Keragram' in Trichur District in 1981 as a large scale demonstration. KAU and Indian Overseas Bank were also actively involved in this venture.

An area of 60 hectares having 5800 coconut palms was adopted from the IVth ward of Varandarappilly village to form the 'Keragram.' Preliminary survey indicated that 55% of the palms were bearing, giving an annual average yield of 28 nuts/palm.

During the implementation, FACT was primarily engaged in organising the various promotional activities and supervising the adoption of management practices including the input requirements. CPCRI provided the technical expertise and carried out plant protection measures with the assistance of Agricultural Department. The required financial help was extended by Indian Overseas Bank.

Through a series of study classes, seminars and Science Centres the farmers were exposed to the latest techniques in coconut cultivation. Monthly calendar of operations

prepared by CPCRI was printed and distributed among the farmers. Personal contacts were maintained with the farmers by the expert team of scientists and officials through the assistance of the local special committee formed for implementation of the scheme.

The diseased palms identified by CPCRI and Department of Agriculture were cut and destroyed paying a compensation of of Rs. 75/- per tree and supplied quality seedlings for replanting. Surveillance of the affected gardens was carried out periodically for roguing out the diseased palms. The DA arranged for spraying of Bordeaux mixture during the pre and post monsoon periods. They also provided necessary plant protection measures to the other gardens.

Financial assistance was provided both as fertilizer and in cash. A total amount of Rs. 2.7 lakhs was disbursed during the period of adoption. Further, an amount of Rs. 1.72 lakhs was utilised for distributing 36 pumpsets at subsidised rate.

The farmers were quite enthusiastic in taking up better management practices during the period of implementation, which helped to reduce the root (wilt) disease incidence (Table III) and also to increase the yield.

An average yield increase of 145% was recorded in the gardens where the recommended management was practised. (Table IV).

District adoption for coconut

Based on the knowledge and experience gained in adopting the above three 'Keragrams' FACT undertook intensive promotional drive in Trichur, Ernakulam and Kottayam Districts in the State.

The aim was to apply fertilizers to five lakh coconut palms and to produce an

Table III. *Reduction in root (wilt) disease incidence*

Period	Number of gardens	Palms affected
1982	8	20
1983	4	4
1984	4	4
1985	2	2

Table IV. *Increase in the yield of coconut at Varandarappilly*

Sl. No.	Years			
	1981-82	1982-83	1983-84	1984-85
1.	14	22	18	38
2.	21	37	39	56
3.	16	30	36	58
4.	26	34	36	51
5.	21	36	34	48
6.	29	43	48	64
7.	13	18	16	34
8.	20	36	34	54
9.	21	33	31	54
10.	32	42	34	64
11.	9	13	12	21
Total	224	344	338	542
Average yield	20	31	31	49

additional yield of 5 million nuts. This programme was launched in close co-ordination with DA, CPCRI and KAU.

The following approaches were emphasised in the promotional drive:

(1) Personally contacting 20,000 coconut growers; (2) Making available the fertilizers at the farmers' doorsteps and in small packets as per their requirements; (3) Offering technical assistance and services to the coconut growers in the districts.

(4) Utilising the mass media for persuasive communication; (5) Closely monitoring and reviewing the progress at fixed intervals.

Arrangements were made to extend soil testing facility and on the spot advice on agronomy and plant protection measures. "Coconut clinics" were periodically organised at the different locations by the scientists of CPCRI and KAU on management practices and plant protection methods.

Demonstrations were organised to show the correct method of taking basins, applying fertilizers, preparing of bordeaux mixture and using sprayers. Through a series of group meetings, study classes, exhibitions and seminars the farmers were exposed to the latest cultivation methods. The leaflets and technical literature distributed also helped them to have a better exposure.

Attractive messages were prepared and given wide publicity through AIR, newspapers and audio visuals to persuade the farmers to adopt application of the recommended fertilizers in time.

Fertilizers and plant protection chemicals were brought to the doorsteps of the farmers through the additional retail outlets opened in every village and also the mobile depots organised periodically. Fortnightly meetings were organised in which the officers from D A and FACT reviewed the progress and chalked out the action plan.

The campaign was conducted covering an area of 22,320 ha in Trichur, 18717 ha in Ernakulam and 5800 ha in Kottayam.

The study conducted at the end of the season to assess the impact of the Project indicated that 27891 coconut growers were personally contacted during the period and a total of 4.25 lakh coconut palms were additionally fertilized. The consumption of coconut mixture in these districts during the period went up from 203 to 1477 MT registering an increase of 627%.

The results obtained from the 'Keragrams' and the 'District adoption' prompted DA to launch a massive programme from 1987 onwards to fertilize a total of 5 crore coconut palms from all the districts in the State. FACT as the major manufacturer and supplier of fertilizers in the State has rendered wholehearted co-operation in this massive plan, by rendering assistance to implement the promotional programmes.

SPICES PRODUCTION TECHNOLOGY THROUGH LAB-TO-LAND PROGRAMME*

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ABSTRACT

Spices production technology with major thrust on pepper based cropping system and/or raising pepper as mixed crop in coconut garden was implemented through lab-to-land programme (LLP) in three villages comprising 185 farm families in Kozhikkode district during 1979-85. Bench-mark survey, farmplan for individual farmer and supply of inputs were carried out. A critical assessment at the end of the programme at Muthukad village showed that 98% of the farm families cooperated with the project. Pepper has become the most popular crop amongst the farmers and in the pepper based cropping system the mean yield per pepper vine was 1.13 kg whereas in the mixed cropping system, yield was 0.90 kg. The mean yield obtained in the case of ginger cultivar (Himachal) and turmeric (mixed local) was 24 and 36 Mt/ha, respectively. The mean per capita index per family was 1.99. Fifteen to twenty per cent additional employment was also generated.

INTRODUCTION

About seventy per cent of agricultural technological innovations developed in India have not reached the farming community (Prasad, Choudhary and Nayar, 1987). The Lab-to-Land (LLP) programme was launched by National Research Centre for Spices (NRCS), Kozhikkode during 1979-85. The objectives of the programme were to adopt small and marginal farmers and agricultural labourers and to educate them on the latest High Production Technology (HPT) of spices. The programme also aimed at diversification of labour utilisation and to provide additional employment. It was also aimed to identify the constraints in the low adoption of technology and to establish good rapport between scientists and farmers, thereby improving their economic and social status.

MATERIALS AND METHODS

The programme was implemented in two phases extending six years. During the first phase (1979-81), eighty-nine farm families in the Harijan colony at Pannikottur village (two km from Peruvannamuzhi) was adopted and black pepper (c.v. Panniyur-1 and Karimunda) was introduced as a mixed crop in coconut gardens. Pepper was trailed on *Erythrina indica* planted in the interspaces of coconut.

During the second phase (1982-85) sixty farm families in the Muthukad village (four km from Peruvannamuzhi) was adopted and pepper based cropping system was introduced, using *Erythrina* as standard. Forty farm families at Chelavoor, adjacent to NRCS Campus, Chelavoor was also adopted during this phase. In this village pepper

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was raised as a mixed crop in coconut garden on *Erythrina* standard.

Bench mark survey

Bench mark survey of each village was carried out with relevance to the farming system, material resources and socio-economic condition. Farm plans were prepared, inputs supplied for each farm family with emphasis on improving their entire farming system thereby generating enhanced employment and income.

Climate and soil

The climate is typical of humid tropics and mean annual rainfall received at Pannikottur/Muthukad Transfer of Technology Centres (TTC) was 4200 mm (140 rainy days from June – October). About 70% of the precipitation was received during south-west monsoon (June-August) and the rest during north-east monsoon (September-October). Summer is practically dry. The mean maximum temperature is 38°C (May) and minimum 21°C (January). The elevation of the area ranges from 40 to 60m (MSL). The mean annual rainfall received at Chelavoor TTC was 3200 mm. The soils are acidic, lateritic in character, clayey loam to sandy clay loam in texture, medium in nitrogen, poor in phosphorus and potash status.

Subsidy

Subsidy worth Rs. 500/- annually per family in the form of inputs like improved agricultural implements, planting material, fertilizers, plant protection chemicals, sprayers etc. were distributed.

To tide over the unprecedented drought of 1982–83, one bore well of 300 m depth was also dug through the State Department for augmenting drinking water supply at Muthukad TTC. Financial assistance of Rs. 1750/- was given to the farmers to meet

one fourth of the total cost for deepening seven selected wells to be used on community basis by all the sixty farm families, to augment the drinking water supply and to give irrigation to young plants.

The state government was persuaded to establish one "Anganwady" at Muthukad TTC benefiting 42 wards.

An amount of Rs. 3,000/- was granted to meet one-fourth of the total cost for the development of one km road at Muthukad TTC for easy access to the village. Financial assistance was also arranged to ten farm families through the Agricultural Development Bank under State Bank of India, Perambra for the purchase of milch animals.

Farm enterprises

The details of technology transferred including fertilizer dose are given in Table I. Farm enterprises such as rooted pepper cuttings of hybrid Panniyur-1 and Karimunda cultivars (10,000 Nos.), seedlings of west-coast tall (WCT) coconuts (900 Nos.), ginger rhizomes c. v. Himachal (240 kg), turmeric (470 kg) and tapioca stems (700 Nos.) to be raised as intercrops in coconut/pepper gardens were supplied. Clove and cinnamon seedlings (300 each), congo signal grass seeds (50 kg) for raising green fodder, mango grafts (200 Nos.) for planned development of the homestead, white leghorn poultry layers (150 Nos.) to the needy farmers, inorganic fertilizers (50 tonnes), plant protection chemicals, sprayers, multipurpose trees such as subabul (10,000 Nos.) were also supplied to the farmers.

Training

Pre-season training on spices cultivation was imparted to the farmers. Pamphlets and folders on the various aspects of spices cultivation were also distributed. Media

Table I. *Planting materials distributed and the technology transferred to the farmers*

Planting material supplied (Nos.)	Varieties	Technology transferred
Pepper (10,000)	Panniyur-1 and Karimunda	Spacing 3 x 3 m. NPK 100, 40, 140 g/vine/year. Plant protection.
Coconut (900)	West-Coast Tall	Planting in 1 m cube pits NPK 0.5, 0.32, 1.2 kg/palm/year.
Ginger (240)*	Himachal	Plant protection. Spacing 30 cm. Neem cake 2 t/ha. NPK 75: 50: 50 kg/ha.
Turmeric (470)*	Mixed local	Seed treatment. Spacing 30 cm. Neem cake 2 t/ha. NPK 30: 30: 60 kg/ha.
Tapioca stems (700)	H-2304	Planting 2 m away from coconut. NPK 100: 100: 100 kg/ha.
Clove (300)	Local	Mixed crop. Spacing 6 x 6 m.
Cinnamon (300)	Local	Mixed crop. Spacing 2 x 2 m.
Subabul (10,000)	K-8	Planting along the boundary line @1 t/ha.
Grass seed (50)*	Congo-Signal	Contour planting.
Mango grafts (300)	Local	Spacing 9 x 9 m

* Weight in kg.

support through radio talk in the "Farm and Home" of A.I.R. Kozhikkode was also given. Scientists accompanied by Technical Assistants visited the TTCs periodically and gave instructions in the execution of the programme.

RESULTS AND DISCUSSION

Bench mark survey

Bench mark survey revealed that the holding size of the family ranged from 0.025 to 1.0 ha and all are marginal farmers. Sixty-five per cent of the families belong to backward class, seventeen per cent scheduled caste, eight per cent scheduled tribe and the balance ten per cent belong to other classes. At Pannikottur and Chelavoor TTCs, the main crop grown was coconut, besides this, arecanut, banana and tapioca were also grown. The Muthukad TTC was almost

barren except 40 coconuts palms. This barren land was allotted at one ha per family by the State Department during 1981. This formed part of a collective farm to be established by Kerala Government. Pepper based cropping system was mainly adopted in this TTC.

The farmers were generally poor and economically backward. Most of the families were not following any improved cultivation practices. Consequently the crop yields were very poor. The farmers were earning their livelihood by working as agricultural labourers in the nearby villages. The annual income of the members ranged from Rs. 400-1500.

Impact of the programme

A critical review of the impact of the programme at the end of the period showed that

98% of the farm families cooperated with the programme. Among the seedlings/saplings supplied, 81% of coconut, 69% of pepper, 59% of clove, 70% of cinnamon and 73% of mango grafts got established. The higher percentage of establishment indicates the farmers good response to the programme.

Pepper

In the pepper based cropping system pepper vines started yielding during the second year. The average yield was 1.13 kg dry pepper per vine per year during the fourth year. Pepper has become one of the most favourite crops among the farmers because of the quick monetary return. One of the beneficiaries got one and half quintals of pepper from 132 vines getting an income of Rs. 5,200/- from pepper alone.

Pepper raised in the coconut based cropping system also yielded and the mean return per vine was 0.9 kg as against the initial level of 0.28 kg. The low yield might be due to the excess shade imparted by coconuts.

Ginger and turmeric

Ginger and turmeric were grown as inter-

crops in coconut and pepper gardens. By the adoption of present technology like seed treatment (0.3% Dithane M.45 with 4 ml of Ekalux) and the application of organic amendment (neem cake at 2 tonnes per hectare with NPK at 75, 50 and 50 kg/ha) and following plant protection (using Malathion spray 2.0 ml in one litre), one of the beneficiaries had harvested seven quintals of ginger within two years (season), from four kg of ginger seed rhizome supplied by the Institute, thereby making an average yield (wet) of 24 tonnes per hectare (Table II). In the case of turmeric the average yield obtained (wet) was 36 tonnes per ha.

Tapioca

Tapioca variety H-2304 introduced as an intercrop in coconut garden (obtained from Central Tuber Crops Research Institute, Trivandrum) was planted with a spacing of 90 cm leaving 2 m away from the base of coconut using NPK at 100:100:100 kg/ha. One of the farmers of Muthukad TTC supplied with fifty stem cuttings realized 600 kg of tapioca which was sold for Rs. 500/- (after meeting his home consumption). The yield

Table II. *Impact of Lab-to-Land Programme on productivity of crops and generation of employment*

Name of enterprise	Yield (kg/ha)		Productivity (%)	Additional employment (Manday/ha)
	Before	After		
Pepper based cropping system	FI	1130*	—	20
Pepper (mixed crop in coconut garden)	280*	900*	221	18
Coconut (pure crop)	3150**	11,900**	277	—
Ginger	5 tonnes	24 tonnes	380	15
Turmeric	FI	36 „	—	25
Tapioca	10 „	35 „	250	15
Congo signal grass	FI	28 „	—	25

FI — First introduction

* Dry weight

** Numbers

Tonnes (Wet weight)

obtained was 35 tonnes/ha compared to 10 tonnes obtained from local variety. Fifteen to 20 per cent of additional employment (Table II) was also generated due to the adoption of improved technology by the farmers.

Constraints

1. The basic limiting factor for production is the small size of the holdings and consolidation of holdings in cooperative basis is the only solution for augmenting production.
2. Tendency among the farmers for neglecting early symptoms of wilt diseases of pepper, neglecting to conserve the soil and soil moisture.
3. Inadequate staffing and lack of adequate incentives to the extension field staff and lack of transport facilities.
4. Non-availability of timely financial support from the bank and the tedious procedures for procuring loans.
5. Social constraints identified are non-receptiveness to the new technology by certain farmers, reluctance to the use of inorganic fertilizers and adoption of artificial insemination to cattle and unwillingness to share

new experiences with their neighbouring farmers.

A sense of self reliance was imparted in the minds of LLP farmers for taking up new ventures with the latest spices production technology developed at the Institute. The State Bank of India, Perambra (Kozhikkode district) has adopted Muthukad TTC under their "Gramodaya project" in lending financial support to the farmers by seeing the overall development attained through the LLP initiated by NRCS.

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UPLIFTMENT OF TRIBAL FAMILIES IN THE NILGIRIS THROUGH LAB-TO-LAND PROGRAMME

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ABSTRACT

The results of a survey conducted to study the impact of the Lab-to-Land programme implemented by the UPASI Krishi Vigyan Kendra among the tribal families, under Phase IV, during April, 1986-March, 1988 in the Nilgiris, are reported in this paper. The study compared the socio-economic changes among the beneficiaries from the pre-implementation to post-adoption period, through introduction of various enterprises. The study revealed that planting of tea in the fallow land belonging to the beneficiaries helped each family in getting reasonable income within three years, besides steep appreciation in the land value and creating permanent employment opportunity.

The performance of other allied enterprises like sericulture, apiculture, rabbit rearing and duck farming introduced by the farm families are discussed.

The role of training, demonstrations and other extension activities like follow-up field advisory visits, field days etc., in the process of transfer of technology are assessed. The study also revealed the linkage developed by the beneficiaries with other institutions and their assistance in bringing about an integrated rural development among the farm families in the adopted villages.

INTRODUCTION

Nilgiris, popularly known as the 'Queen of hills', is a tiny district of Tamil Nadu, situated in the western ghats. Its population is around 6 lakhs of which tribals account for 4.2 per cent. There are six major tribes namely Todas, Kotas, Kurumbas, Irulas, Mullukurumbas and Paniyas. While Todas are purely pastoral having the skill of embroidery, the Kotas are mainly artisans with interest in music. Both tribes live closer to Udhagamandalam and Kotagiri and their living standards are better compared to the other tribes. The Paniyas live around Gudalur and they are usually agricultural labourers. The Irulas and Kurumbas are jungle tribes, engaged in agriculture and collection of forest produce.

Eventhough there are many extension agencies working in the district, due to the

secluded habitat of the above tribes, the penetration of extension programmes into these communities is negligible. In view of the remote habitat, the living conditions of the tribes remain unchanged.

The UPASI Krishi Vigyan Kendra implemented the ICAR's Lab-to-Land Programme, under Phase IV, for the first time in the tribal villages of Irulas and Kurumbas, to improve their living condition by introduction of viable technology.

One hundred tribal families from four hamlets were adopted and action plan was drawn based on the data collected from the bench-mark survey. On priority, cropping pattern was changed from the annuals to plantation crops to avoid the recurring failures in the traditional rainfed cultivation. Income generating enterprises like apiculture, rabbit rearing and duck farming were

introduced for the benefit of the landless agricultural labourers.

A careful periodical evaluation and monitoring became necessary for effective implementation of the programme since majority of the target group, in this extension programme were adult illiterates.

Against this background, a study was undertaken with the following objectives:

1. To study the socio-economic characteristics of the beneficiaries.
2. To study the consequential changes with regard to: (a) Farming system; (b) Adoption of recommended technology and its impact on the productivity; (c) Changes in the socio-economic conditions; (d) Social participation and personal characteristics and (e) Linkage developments
3. To measure the impact of the training programmes and other extension activities in the process of transfer of technology and
4. To identify suitable strategies for necessary improvements in the implementation of the programme.

METHODOLOGY

Of the four taluks in the Nilgiris district viz., Udhagamandalam, Coonoor, Kotagiri and Gudalur, Kotagiri and Coonoor taluks were selected for the study where all the one hundred adopted farm families are residing. Out of them, 56 per cent belonged to Kurumba tribe and the rest, Irula. They are settled in Banagudisolai, Kolikarai, Koli-thurai and Palmyrah hamlets situated amidst the jungles, towards the eastern side of the Nilgiris adjoining the Coimbatore district.

Before implementation, a bench-mark survey was carried out to draw the action plan during October, 1986. For evalua-

tion and monitoring purpose, family-wise records were maintained on cropping pattern, technology followed, inputs supplied, yield performance and extension activities carried out, during the course of implementation. After the conclusion of the programme, during March, 1988, all the beneficiaries were interviewed with a constructed pre-tested questionnaire for collection of data, to study the impact of the programme.

RESULTS AND DISCUSSION

The findings of this study and discussions related to them are as follows:

1. Socio-economic characteristics of the beneficiaries

The bench-mark survey indicated that the socio-economic characteristics of these adopted villages were poor and static.

The basic information about the age, education and operational holding size are given hereunder:

a. *Age*: Majority (43%) of the beneficiaries fall under middle age group followed by old age group (32%) and youngsters comprised of 25%. The tribal custom favours the family fragmentation after the marriage; thus in majority of the cases, the middle age group becomes the family heads, which in turn the reflected in the programme.

b. *Educational status*: Majority of the beneficiaries are illiterates (72%) and school drop-outs (28%). This is due to lack of schools in their remote settlements, in the past. In the recent years, in spite of school facilities, the drop-outs were more due to their traditional wandering habits and lack of interest in pursuing studies.

c. *Operational holding size*: The target group consisted of only marginal and landless agricultural labourers.

There was an increase in the number of marginal farmers from 25 to 61 and decrease of landless labourers from 79 to 39% after adoption. This drastic change might be due to the grant of 'patta' to the landless labour after planting tea under Lab-to-Land Programme, in the fallow lands available with them.

2. Consequential changes

a. *Farming system*: The Lab-to-Land Programme influenced the beneficiaries to shift their cropping pattern (Table I).

Table I. *Cropping pattern*

Crops	Before adoption per cent (Area 15.7 ha.)	After adoption per cent (Area 26.0 ha.)
Tea	4	52
Coffee	26	35
Millets	70	4
Mulberry	Nil	9

A drastic change occurred in the cropping pattern from the traditional cultivation of annual crops to perennial plantation crops like tea and coffee. This was mainly due to the recurring failure in the cultivation of

millets in the past and assured returns from the plantation crops. The introduction of mulberry aroused interest among the tribal families especially for cultivation of rocky patches, unsuitable for other crops, which occupied 9 per cent of the total area.

b. *Yield performance*: Subsequent to the implementation of the programme, majority of the area was brought under tea. The performance of high yielding clonal tea established in the holdings of the adopted families is compared with the already planted seedling tea gardens, in the same locality. The average yield of tea almost doubled, (Table II) due to the adoption of proper soil and water conservation measures, planting of high yielding clonal tea (UPASI-9) along the contour, with high density of plant population, proper training of young tea, application of optimum dose of fertilizers in splits, timely plant protection measures and proper method of plucking. The increase noticed in cost of cultivation was due to the utilisation of more labour in harvesting the high crop and use of inputs like fertilizers and plant protection chemicals. This ultimately resulted in about five-fold increase in income. Another interesting finding was that the number of man-days employed was only 13 per cent more for the adopted families, in spite of the

Table II. *Impact of improved method of tea cultivation (Third year from planting)*

Particulars	Non-adopted farm families	Adopted farm families	Per cent increase
Average yield (green leaf kg/ha.)	1200	3855	221.2
Average cost of cultivation (Rs./ha.)	2856	7209	152.4
Gross income (Rs./ha)	3720	11850.5	221.2
Nett income (Rs./ha.)	864	4741.5	448.8
Cost : Benefit ratio	1:1.3	1:1.6	27.7
Number of man-days employed/ha.	217	245	12.9

higher yield. While, majority of the man-days were utilised to harvest high crop in the case of adopted families, most of the man-days were spent on manual weed control in the case of non-adopted farm families. Consequent on the use of weedicides, the man-days were reduced considerably in the adopted holdings.

c. Acceptance of the introduced technology by the landless agricultural labourers: Since the technology introduced were new among the tribal community, the results were analysed based on the net income obtained from each enterprise (Table III). The additional income generated was high with sericulture, compared to others. However, for the landless labourers, apiculture was found to be a good source for additional earnings. Eventhough, rabbit rearing was promising in the beginning, at later stages, the multiplication capacity reduced considerably due to degeneration of hybrid stock and disease problems. Similarly, duckfarming was also a failure at the later stage due to aging of the birds and casualties of the replaced ducklings due to viral infection. Most of the beneficiaries desired to continue with sericulture and apiculture rather than rabbit rearing and duck farming.

d. Economic changes among beneficiaries: The impact of the programme with regard to

the economic changes related to income, savings, marketing etc., is given in Table IV.

IV. Economic changes of the beneficiaries

Economic changes	Before adoption %	After adoption %
Loss due to yield	64	19
Investment and savings	3	12
Increase in area of cultivation	Nil	65.6
Increase in income	Nil	455
Family members' assistance in cultivation	62	78
Change in marketing system	32	81

There was tremendous change in bringing down the loss due to low yield from 64 to 19 per cent. This might be due to the assured crop from tea which ultimately resulted in the hike in the net income to the tune of 455 per cent. Due to the increase in the family income, the savings have increased. The alarming change in the marketing system was due to the supply of green leaf directly to the Industrial Co-operative Tea Factory as against the previous practice of selling through the leaf agents.

Table III. *Acceptance of introduced technology*

Enterprise	No. of beneficiaries	Average yield	Total annual income per person (Rs.)
Sericulture	20	35 kg cocoon/ 100 DFL*	540/-
Beekeeping	9	6 kg/hive	370/-
Duck farming	5	—	225/-
Rabbit rearing	5	—	300/-

e. *Social participation and personal characteristics*: There was remarkable change in the social participation and personal characteristic of the beneficiaries after the implementation of the programme (Table V).

Table V. *Social participation of beneficiaries*

Particulars	Participation per cent	
	Before adoption	After adoption
Village activities	47	65
Contact with institutions	3	76
Contact with extension agencies	8	36
Hobby/leisure time utilisation	15	53
Consultancy to co-farmers	7	27
Acquired habits on smoking/liquor	78	80

There was a positive trend towards participating in the village activities, establishing contacts with the institutions and extension agencies, in spite of their habitual reluctance.

Table VI. *Linkage developed by beneficiaries*

Enterprise	Institutions	Role
Coffee cultivation	Coffee Board	a) Technical advice b) Supply of improved seeds
Sericulture	Regional Sericultural Research Station	a) Technical advice b) Supply of mulberry saplings c) Supply of chawki worms d) Financial assistance for construction of rearing shed
Apiculture	Khadi & Village Industries Board	a) Technical advice b) Supply of hives
Rabbit rearing	Sheep Breeding Research Station (TNAU)	a) Technical advice b) Supply of animals
Tea	1) Tea Board	Supply of planting materials
	2) State Bank of India and Vijaya Bank, Kotagiri	Financial assistance for tea and coffee cultivation

Planting of perennial crops like tea and coffee brought out certain changes like seeking financial assistance from nationalised banks for cultivation purposes and contacting extension agencies for improved planting materials and package of practices. The nominal increase in acquired habits like smoking and consumption of liquor was due to the existence of the habit to a high degree among the tribals, in the past. The leisure time utilisation was more after adoption because of increase in income. The beneficiaries on several occasions acted as contact farmers for the others, thus bringing in a multiplier effect in the technology transfer.

f. *Linkage developments*: As the programme aims at multi-disciplinary approach, several institutional assistance was sought for successful implementation.

The programme has created an awareness among the beneficiaries on the assistance of these institutions and favoured the establishment of contacts. (Table VI). Additionally, these linkages enabled the beneficia-

ries to continue with their enterprises, even after the withdrawal of Lab-to-Land Programme, besides paving the way for an integrated rural development.

3. Impact of the training programmes and other extension activities

The majority of the target group in this transfer of technology project being adult illiterates, much importance was given for extension activities for successful implementation.

Most of the beneficiaries preferred techniques like film shows, individual contacts and demonstrations. This was mainly due to their age and illiteracy levels. Even though radio is a mass medium, since most do not own it, the response was poor. Even the few who own a set, prefer listening to entertainment programmes, rather than educational. The response towards training was poor due to their living in remote areas and lack of transport facilities. The negative response to circulars and newsletters might be attributed to their illiteracy.

CONCLUSIONS

(1) Majority of the beneficiaries are middle aged and illiterates; (2) Programme helped majority of the landless agricultural labourers to become marginal farmers by obtaining title deeds (Pattas); (3) Subsequent to the implementation of the programme, majority of them switched over from annual crops like millets to perennial crops like tea and coffee. (4) The newly introduced technology for the agricultural labourers like apiculture has enabled the farmers to generate additional income, rabbit rearing and duck farming were not successful at later stages due to degeneration

of hybrid stock coupled with disease problems; (5) Tea cultivation has brought about a drastic change in their regular income besides steep appreciation in the land value – a capital asset; (6) Mulberry cultivation has been accepted as a promising enterprise, especially in rocky areas unsuitable for planting tea, (7) the programme has created a social awareness among the beneficiaries and helped in establishing contacts with various institutions and extension agencies, (8) The linkage development with other institutions as enabled them to continue with the technology introduced to them even after the withdrawal of the programme, (9) the majority of the beneficiaries act as contact farmers which had helped in developing leadership and created multiplier effect in the transfer of technology; (10) individual contacts and demonstrations were found to be the effective extension methods among the illiterate tribal farmers.

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PEST CONTROL IN PLANTATION — AT CROSS ROADS

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ABSTRACT

The review outlines various facets of plant protection in plantation crops. The pesticide consumption in plantation crops is about Rs 44 crores per annum amounting to 11 percentage of total pesticides consumed in the country. The use of pesticides in relation to environment and the need to integrate chemical control more effectively with other measures of pest management programmes will require more efficient use of pesticides. The need for the efficient use of pesticide to bring down the cost is emphasised. The importance of pesticide application equipment and the developmental needs in terms of training programmes to different cadres have been emphasised.

INTRODUCTION

The plantation crops *viz.*, tea, coffee, rubber, cashew, cardamom, arecanut, coconut and cocoa have a geographical distribution restricted to the tropics, mostly 20° South latitudes. Many of them have a long history. Coconut and arecanut were cultivated by individual land owners from early days. Large scale plantation of tea, coffee and rubber were started only after the arrival of Europeans. Attempts to introduce the plantation crops to other areas, were not often successful due to their specific requirement of natural habitat.

The development of plantation in our country is the key to our economic growth as we earn considerable amount of foreign exchange from export. The bulk of our country's resources are in the agricultural sector, typically characterized by low productivity. Increasing productivity in the plantation sector is the fulcrum for raising per capita income in the country's economy as a whole. Also we can earn foreign exchange to further economic development.

Demand for labour may also expand, resulting in the increase in employment or higher wages for landless workers. If the gains in production lead to greater exports, then the increase in foreign exchange can finance a higher rate of growth for the economy as a whole or lead to a rise in the value of the nation's currency. In either case, development of plantation crops creates expanded income for the economy.

In the next three decades, the country will experience the most dramatic increase in demand for food and agricultural products in history. The country's agricultural programmes need to be expanded by introducing new production technology. Plantation crops are important in generating the income and employment for the rapidly growing agricultural labour force around the country.

Statistical data

The area available for cultivation is less than 50% (Table I) of the total geographic area. Out of this, plantation crops occupy

Table I. *Utilization of area in the country*
(Area in '000 hectares)

Geographical area	328726
Reporting area land utilization	304113
Forest area	67349
Not cultivable area	39949
Other cultivable area	31847
Fallow land area	24174
Net sown area	142744
Area sown more than once	37617

less than 2% of the net cultivable area (Table II). At present our export of these products is Rs. 1237 crores annually amounting to 50% of our earning from exports of agricultural commodities (Table II). At present, edible oil is imported. If the coconut production is increased, more oil can be produced and foreign exchange can be saved. Natural rubber is basic raw material in industries. At the moment its production in our country is hardly sufficient.

Its consumption is going to increase further with the increase in mechanization in agriculture. The automobile industry is progressing at a high pace. Provision of more raw materials to the industries will create more employment. Plantation needs regular labour force. Not only this, plantations are located in rural areas where labour force is easily available. Thus, by intensifying plantation, more job opportunities can be provided to the labourers in rural areas on regular basis.

Plantations occupy areas which are usually not suitable for cereals, oil seeds and horticulture crops. Mostly they are occupying hilly areas neighbouring the forest. It is generally observed that forests are not maintained due to indiscriminate cutting down of trees, which also damage ecology to a great extent. If plantation crops, are well maintained from the production point of view, then ecology will be balanced to some extent e.g., plantation of rubber and cashew trees will create forestation effect. Similarly tea, coffee and cardamom require

Table II. *Area, production, yield and exports of different plantation crops*

Crops	Area in hectare	Production '000 Kg.	Yield in kg/ha.	Export in Rs. Crores	Max, production available in other countries in kg/ha.
Tea	399929	6,59,0.410	1,648	611.91	36,59 in Zimbabwe.
Coffee	232400	1,05,000.0	507	235.64	15,00 in Zimbabwe.
Rubber	384000	2,19,520.0	926	—	
Cardamom	116000	9,370.0	82	174.47	
Areca nut	186000	2,24,000.0 Dried Nuts.	1,202 in Kg/ '000 bearing palms	—	
Coconut	1229800	64,04.0 in million nuts	5,476	—	
Cashewnut	574260	N/A	N/A	215.33	
	3122389			1,237.35	

shade trees which will provide environment similar to forest. Thus development of plantation will help to balance ecology to some extent.

Importance of pest control

The plantations become more susceptible to natural pests because of intensive cultivation. Significant resources are needed to deal with these problems.

The outbreak of pests and diseases are unpredictable. Some years ago the cotton industry in Brazil was virtually wiped out due to cotton wilt. An intensive research programme, based on resistant lines from other countries and the advice of knowledgeable people outside Brazil, yielded locally adapted resistant varieties in a few years and revitalized the Brazilian cotton industry. The accumulation of knowledge is the only real defence against such events. Hence the necessity of developing new pesticides and new means of pest control.

Pest control in plantation crops has become a necessity of basic importance. The damage caused by pests may jeopardize the success of the most up-to-date production system. The problem will also arise if the quantity and quality of products do not meet market demands. The most effective tool for solving these problems is chemical control. Consumption of pesticides (Table III) in plantation crops per hectare is quite high *i.e.*, pesticides consumed per hectare by tea, cardamom and coffee plantation is about Rs. 594, Rs. 220 and Rs. 216 respectively (Table III). The total consumption of pesticides in plantation crops is about Rs.44 crores which is about 11 % of total pesticides consumed in our country. A deeper look into this necessitates more serious thinking. Pesticide input cost can be saved by using them efficiently, which will bring down the cost of cultivation. Not only this, pesti-

cide if used efficiently, can increase production with the same input. Even though cultural, mechanical and biological control methods are all involved for pest control in plantation, the need for an environment protective and integrated pest management system, based on pest forecasting is increasingly emphasized. However, pest control by chemical still remains the most critical tool to maintain a productive and qualitative plantation growth.

The fundamental principles of pest ecology are generally similar for all plantation crops. However, the technology involving pest control by pesticide is substantially different. The technology is being governed by the phenology of plantation as well as its typical growth (Table IV). The biological characteristics of plantation crops such as height, shape and density largely determine the type of spray equipment that can be usually employed and its mode of operation. The part of the tree or bush or field which are prone or vulnerable to infection and act as reservoirs of inoculum, should be treated by pesticide. Similarly, field condition of plantation are also very important.

The increase of pest control activities have unfortunately led to problems of another nature. Since inputs have reached the tolerable limits, it is necessary to study evolution of pesticide application equipment and techniques.

Evolution of pesticide application equipment and technique

Varieties of pesticide and application equipment are adopted in plantation crops ranging from simple hand operated knapsack sprayer to highly sophisticated ones like ultra low volume aerial application. Between this, is a spectrum of techniques that traverse the different levels of pesticide

Table III. *Area under cultivation of various crops and pesticides consumed by them*

Crops	Area in hectare	Pesticides consumed in Rupees				Pesticides consumed in Rs./ha.
		Insecticide	Fungicide	Herbicide	Total	
Rice	41000000	544000	87800	159700	791500	19.30
Wheat	23000000	16800	11600	255200	283600	12.33
Pulses	23818200	179300	—	—	179300	7.52
Groundnut	7700000	100800	13800	600	115200	14.96
Potato	700000	23300	46800	700	70800	101.14
Chillies	780000	95500	20700	500	116700	149.61
Onion	250000	9000	2000	2000	13000	52.00
Vegetable (except chillies, potato & Onion)	1500000	137600	26000	1200	164800	109.86
Mango	716000	47200	12000	—	59200	82.68
Grapevine	15000	10900	26300	—	37200	2480.00
Apple	177000	14800	107800	—	122600	692.65
Cotton	7400000	1393300	26000	1600	1420900	192.01
Jute	1147900	4300	—	—	4300	3.74
Sugarcane	2990000	128000	7300	7300	142600	47.69
Tea	399929	91700	26100	119800	237600	594.1
Coffee	232400	12300	36500	1500	50300	216.43
Rubber	384000	15360	23040	—	38400	100.00
Cardamom	116000	24400	1200	—	25600	220.68
Arecanut	186000	7440	11160	—	18600	100.00
Coconut	1229800	24596	36894	—	61490	50.00
Cashewnut	574260	7800	50	—	7850	13.66
Misc.		40460	48000	—	88460	
Total	114316489	2928856	571044	550100	4050000	

application technology. This includes techniques like manually operated rocker sprayer, foot sprayer, hand compression sprayer, power operated knapsack mistblower, hydraulic reciprocating power sprayer with many lances, power duster and hand-held control droplet battery operated sprayer.

Motorised knapsack sprayer brought major advancement in pesticide application technology. They allow better manoeuvring and precise direction of the toxic pesticide on to the intended targets, greater power of penetration through thick foliage and higher rate of coverage. However, poor maintenance by unskilled labour and lack of

Table IV. Growth information of plantation crops and their pest control

Crops	Growth Information			Canopy	Number of spray rounds	Spray volume litre/minute	Technical material consumed in kg. or litre/hectare.	Labour required (Number of persons).
	Plant population per hectare	Plantation spacing	Tree/Plant height	Periphery diameter				
Tea	5000/6000	4'-6'	4'-5'	2'	15-20	200/300	4-5	2-3
Coffee	800/900	15'-20'	8'-10'	6'	2-4	1000	20-30	5-6
Cardamom	1600	15'-20'	5'-10'	6'-9'	8-10	1000	2 litres	5-6
Rubber	160/180	20'-25'	23'-27'	15'-25'	2	10 Oil	2 kgs.	1
Cashewnut	60/80				2-4	400/500	1-2 kgs.	2-3
Arecanut	400/450	15'-25'	15'-25'	5'-7'	2-4	300/400	10-20 kgs.	2-3
Coconut	70	25'-30'	20'-38'	15'-20'	2	100	1 kg.	1-2

servicing facility, costly spare parts along with stiff increase in fuel price, made it uneconomic for use. Against these, plastic lever operated knapsack sprayers, are now most common in plantations. They are cheap and more durable. Besides this, they are relatively simple in design and easy to maintain. The properties of plastic material from which the sprayer is manufactured are such that they reduce their deterioration in hot tropical climate. The plastic tanks are less likely to be dented besides fitting more comfortably on the operator's back.

Basic requirements

The above trend has been observed until now as far as pest control in plantation crops is concerned. However, looking to the basic need, few points should be kept in mind for proper selection of equipment and technique in application of pesticides:

Growth and nature of plantation crop: The main criterion depends on the nature of plantation crop to be treated. In tree crops such as rubber, cashewnut, coconut, arecanut, vertical throw is preferable. Similarly in bushy crops such as tea-coffee cardamom horizontal throw is preferable.

Field geography: During normal spraying operation, walking at an even pace is most important. This depends on the geography of the field e.g., tea estates on plains in Assam compared to estates on hills in South India. In sloppy hilly area, regular spacing becomes difficult.

Compactness: Increase in operating width and capacity of tanks, are of great importance in knapsack type sprayer, provided mobility can be maintained.

Simple, robust and multi-purpose equipment: Formulation of certain pesticides play a critical role in the selection of equipment having specific characteristics. There is a

growing need for specific equipment for specific pesticides. However, multi-purpose use of equipment is desirable. Increased utilization of the equipment will result in decreased capital investment cost. This is possible if, in addition to pesticides, other kinds of materials can also be simultaneously applied.

Investment, capacity and essentiality: The size (area held) of plantation is also important. There are many small planters who in turn influence the adoption of technology. This needs to be examined keeping in view their diversity, nature, capital investment and employment. The technology which is adopted in other countries even though better, may not be suitable for our planter. Hand compression sprayer (6 to 9 litre capacity) is more suitable from cost and economy point of view for small planters for use in coconut or arecanut. Tea plucking is carried out in every ten days while coffee in a year. Pest associated with tea should be controlled immediately which otherwise, will affect plucking period. Little pest control delay in coffee may not cause that much damage, which is to be plucked once in a year.

Leak-proof equipment: Equipment must have a drip-proof device to avoid damage to the crop and ensure safety of person which will ultimately result in economy of pesticide.

Stirring mechanism: Some pesticides e.g., water dispersible powders, have a tendency to settle down in the tank even after mixing. Uniform mixing of technical pesticide with the carrier in the tank is indispensable to achieve maximum biological efficacy. Equipment must have permanent stirring mechanism.

Filter strainer: The trend to reduce the spray volume has been counteracted by the

greater risk of nozzle blockages with small orifice. The design of equipment should be such that it will minimize nozzle clogging and ensure that each part can be easily cleaned or repaired.

Besides the above elements, the most important factor is spray volume which is a sum total of active pesticide volume and volume of carrier which is usually water. Not only this, spray volume depends upon the type of nozzles and droplets produced by nozzle.

Spray volume: On one acre of plantation crop about 1 to 4 kgs. active ingredient of pesticide, is sprayed. Pesticides are sprayed with water as a carrier. At least 200 lit. of carrier material is used per hectare. This quantity is still acceptable from the point of view of human health and environment pollution but any substantial increase in this quantity is not desirable. In some plantation crops only 60-70% of the pesticide sprayed, reaches the target area while the rest deposits on the soil surface. The same applies to that outer part of the spray which is lost by drift from the target area.

Plantation labour is becoming more expensive. This could be optimized by reducing the spray volume. It is pertinent to note that with knapsack spraying at rates for medium or high volume, about one worker is required to carry water for every two spray operators working on undulating terrain. Besides reducing labour requirement, low volume spraying would increase operator output (time spent on refilling the sprayer) thereby leading to overall reduction in application cost.

The possible efficiency gains spread far beyond in using less quantity of spray volume in application of pesticides. Much energy can be saved in the transport and application of the surplus pesticide and its

carrier besides a reduction in environmental pollution.

Unsuitable weather conditions limits the period over which a planter have to treat large area. Timing of applications in relation to pest monitoring is most important to the planter. He has to treat his crops rapidly to achieve an economic threshold. The trend is to use reduced volumes of spray down to less than 5 lit/ha in some cases. The increase in cost of energy, forces the user to make use of the pesticides efficiently. The major consideration when the trend is to use lower spray volumes from a logistic view point, calls for a much more detailed appraisal of the effects of spray nozzle, droplet size formed by it and formulation.

Spray droplet: Spray spectrum produced by hydraulic nozzle has got wide range of droplet size. This wide range of droplet causes wastage of pesticide. Hydraulic spraying is no doubt effective, but at the same time it is not economic due to this reason. Much can be done to improve this, by selection, calibration, monitoring of discharge rate, checking of spray pattern and care of the nozzle.

It is important to know what droplet size range is produced under particular operating and environmental conditions with different types of spray techniques. Even with hydraulic sprays containing a wide range of droplet sizes, more details about nozzles should be known and how they should be used, as the same volume rate per hectare, could be obtained by adjusting the pressure and spraying speed when using different nozzles.

Particular attention must be given to the nozzle working pressure, discharge rate and quality of spray. The nozzle orifice should be checked regularly by comparing the dis-

charge rate of the used nozzle with that of a new one. It should be replaced promptly if there is a large variation in discharge rate.

The use of small droplets, if effective, offers massive potential savings. The relationship between droplet size and chemical dosage (i.e., droplet volume) is a cube one: A droplet of 500 micron is not just ten times bigger than the droplet of 50 microns. It is 1000 times bigger in volume. In other words if droplet of 50 micron contain the right quantity of pesticide for the target, the droplet of 500 micron will contain 1000 doses. If droplet of 500 micron is used in place of droplet of 50 micron for the target, then 999 parts of a droplet is wasted. A fear has been evoked that droplets have excessive drift. Appropriate formulation of pesticides and air turbulence restricts the effect of evaporation and can result in improved deposition in foliage.

In the literature published by Agrochemical Industry, only few give details of the method of application of pesticide to be used in field. Generally they mention the volume of application rate. The type of nozzle, orifice size or operating pressure are often omitted. This may be due to difficulty in the measurement of droplet spectra and uncertainty in the validity of results. It is now possible to assess pesticide application techniques. The ability to produce narrower droplet spectra in the field, has changed the situation considerably. Efforts must be made to provide more information on nozzles which can produce fine, medium and coarse droplet to suit the application of different pesticides and to advise on required nozzle working pressure and weather conditions suitable for spraying.

There is an enormous gap between producing a new nozzle and proving that it is biologically and economically effective, when

used by planters. The equipment manufacturers do not have the facilities or expertise to assess the dosage for a range of pesticides on the various plantation crops in which their equipment might be used. The agrochemical industry evaluates new products for the planters. A new pesticide requires specialised nozzles and equipment. There is a need for closer collaboration, not only between biologists, engineers and other disciplines but also between the application equipment and pesticide manufacturing industries. There are now signs of such a beginning to take place.

Development

In the last two decades due to war in Middle East, the price of petrochemicals have gone up, resulting in the continuous increase in prices of agrochemicals. Similarly wages of labour have gone up and shortage has been observed. To compensate the increase in cost of input and labour, planters have to increase their productivity and quality of produce. Looking to this, the scientific adviser in plantation expects development in pesticide application technique and equipment, to have on one hand a decrease in pesticide use and on the other hand, an improvement in the parameters of energy and agrochemical application cost.

General: According to general concept, pesticide application technology is the discipline, in which the methods and parameters obtaining the best biological efficacy of pesticide application are evaluated and optimal values are defined, in practice, through adequate adjustment of existing equipment and introduction of novel methods and devices. Latest pesticide application technology is characterized by a complex concept where safety of the operator, environmental contamination and economy along with efficacy, should not be neglected. The target for a pesticide is seldom a flat hectare of land,

except perhaps for pre-emergent herbicides. Most recommendations simply state "so much" pesticide per hectare. This is particularly inappropriate for plantation crops which have a considerable change in leaf area. Pesticide application should be carried out in accordance with the development stage of the plantation crop. Pests may be localised within a plantation canopy. The pre-requisite in the evaluation of any pesticide application technique is to establish the biological target precisely. Although much may be known about the biology of a pest, the important factor is to define at what stage the pest will be most vulnerable to a pesticide deposit. This period may be quite short, especially for activeness of pesticide on the surface of foliage and target. There is greater need to try and localise spray deposits to minimum side effects on beneficial and other non-target species. Any pesticide penetrating the crop and reaching the soil is not only wasted but detrimental to a number of predators.

One of the problems is that the task and scope of pesticide application technology is not adequately defined. Development work requires specifically defined agrotechnical requirements which, in addition to the technical conditions, take into account also the character of pest control and the features of particular pesticide. Studies on spray coverage have demonstrated the need for a large number of samples to be analysed, (counting of droplets on leaf surfaces). However such work is very tedious. Relatively simple analytical methods and instruments, are needed which allow quick and exact testing of pesticide distribution and other characters of equipment under required conditions.

In equipment: The development of plant protection equipment demands that, in addition to requirements for essential components and gadgets of application equipment,

a much more important point should also be taken into consideration and that is the agricultural requirements which determine the ultimate success of the development. To obtain this, a coordinated effort is needed for the technical, biological and chemical experts. Besides this, the person dealing with design and manufacture of equipment, requires precise and clear definition of pesticide application techniques.

Often the result has revealed that unnecessary technical solutions have been developed. One good example is the pump made of 600 psi. operating pressure. Large amount of development work has been done which has cost a quite good sum. However, there is no need for pressure exceeding 300/400 psi. Similarly the use of new technical solutions do not necessarily result in an increase in the price of machinery.

By investigating the economy of plant protection technology it has been found that machine cost represent generally only 5 to 10% of total plant protection costs and the plant protection materials cost as high as 60 to 80%. An average spraying equipment, for example, spray out during its life-time, plant protection material more than 100 times as much as its own cost.

Therefore, to save on capital investment on equipment is not practical, since the utilization of expensive pesticides will depend on it and on the application technique. The development costs of new pest control equipment is also significantly high but is less if compared with the development cost of pesticides. Presently pest control operation efficiency, can be increased by technical development only.

The cost testing the equipment represents about 20 to 25% of total development costs. Equipment testing therefore, results in significant costs. However, the last phase of

development work, will give important information for decision making regarding production, marketing and operation of pesticide application equipment. The recovery value can be improved by selection of appropriate nozzle, correct adjustment of spray cone angle and sometimes modification of the gadgets. Such adjustment or modification of equipment, nozzle and gadgets can be possible by development work. Such work will offer useful help without significant financial investment by the planter.

In technique: In the present economic situation, it is essential to improve the economics of pest control and to save energy in pest control operations. At the same time one must try to decrease the burden on the ecosystem and maintain or increase the biological efficacy of pesticides. This calls for the development of new application technique.

At present, an extremely intensive and fast development of pest control techniques are witnessed. During the last 6 to 8 years, as a result of research and development all over the world, several novel plant protection techniques have been introduced and many new solutions will be implemented in practice now or in the near future.

There is considerable scope for improving the present methods of application. Experiments have shown that the volume could be reduced to three to four times. Through lower application rates, particularly in combination with mechanised spraying, use of labour could be optimised.

Details on parameters, generally essential for application technique, are not available such as :

1. Droplet size and number of droplets per unit area of target;
2. Dosage (concentration) requirement;
3. Effect of pesticides

when applied with different droplet size;
 4. Volume of carrier to be used and
 5. Spray droplet deposition on different targets in relation to meteorological data especially wind velocity and direction, temperature and humidity.

For calibration and training: Improvement in the method of spraying and the introduction of new techniques is dependent on effective extension and training of supervisors and operators. Government agencies and commercial research organisations, agrochemical companies and manufacturers of spraying equipment should play a significant role in upgrading the standard of pesticide application.

One of the main obstacles to improve the pesticide application technique is the natural resistance to change especially among contract operators. New workers should be given adequate training before they join the spraying team while regular operators be given a refresher course prior to commencement of a spraying programme. Agrochemical companies could assist in improving the standard of spraying by conducting simple courses at the estate or farm levels.

Calibration of sprayers should be done prior to commencement of a spraying programme to ensure effective, economical and efficient application. Random checks should be made during spraying to confirm that the operator has not deviated from the prescribed method. Low to very low volume applications demand accurate spray as small errors can become greatly magnified.

The volume of spray applied on plantation crop is largely controlled by the nozzles. Many planters do not calibrate their equipment regularly or change nozzles for different types of pesticides. Nozzles supplied

with a sprayer have been chosen to give a certain output and "even" coverage.

At crossroad

In pesticide application technology plantations are at cross-road now-a-days. They can continue along the same road, perhaps the new route may turn out better. But looking to the innovation in pesticide formulations along with new application technique and equipment, they have to consider alternative road at this stage. With present evidence, they can forecast that continued use of large volumes of water-based sprays, will require too much energy and continue to waste chemical. The alternative road will require closer integration of application specialists to determine more efficient system of chemical control. The use of pesticides in relation to the environment and the need to integrate chemical control more effectively with other control tactics in pest management programmes, will require more efficient use of pesticides. However, it will be the economic necessity to reduce costs and the risk of pesticide resistance that will perhaps have the greatest impact. Old concept of, one sprayer for several crops, different types of pesticides, should be changed. The equipment should be specialised looking to its use.

In studying the problems, the interest of planters are never overlooked and pesticide application technology as a discipline, puts stress to a greater extent on practice. Under present farming and economical conditions, everyone attribute increased importance to improvement in the efficiency of the spray volume applied, not only because of wasteful usage but because of environmental pollution.

The following aspects are to be taken care of to improve application technique and

equipment, proving beneficial to the plantations from the economic point of view.

- 1 To improve the efficacy of control
- 2 To minimize residues and environmental contamination.
- 3 To ensure that maximum proportion of pesticide reaches and retained on the target.
- 4 To reduce the labour and energy cost of treatment.
- 5 To ensure greater safety and ease of use by the planter.
- 6 To allow rapid and timely application in relation to weather conditions.
- 7 To reduce the volume applied without reduction in efficacy of control.
- 8 To have greater precision in droplet production and also adequate coverage of target.

9 To define precisely the application conditions appropriate for optimal use of a pesticide against a given pest and under meteorological conditions.

10 To have better understanding of the circumstances in which drift occurs and can be avoided.

11 To develop equipment, nozzle and boom which can provide higher work rate and better distribution with less mechanical damage to the plantation.

12 To develop training programme suitable for different cadres of workers viz., planters, supervisors and operators in application technique.

The aim of this paper is to examine and review the diversity of the available pesticide application equipment and technique in our country and to present it to the planter for further thought.

DEVELOPMENT STRATEGIES IN COFFEE

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ABSTRACT

Coffee being a perennial crop with a long gestation period, its production levels could be increased to targeted levels through a planned timeframe. The paper emphasises the need for increasing the present level of coffee production from 1,55,000 to 2, 15,000 tonnes, by 2000 AD at annual growth rate of 3 per cent with an expected internal demand of 75,000 tonnes and export target of 1,40,000 tonnes.

The suggested strategies are the expansion of the existing area especially to non-traditional areas and increasing the low level of productivity in certain areas. This could be achieved through intensive extension programmes on the latest agrotechniques to be adopted by the planters; developmental finance with adequate and attractive incentives and strong support through research efforts. A phased replanting programme with high yielding varieties maintaining a favourable arabica robusta ratio is also suggested.

INTRODUCTION

Development strategy in plantation crops involves large scale planning. The nature of the plantation crops in terms of its multi-faceted structure as well as the long gestation period makes the formulation of development strategy one of the most pertinent pre-requisite for its development. The areas requiring the input of planning lies both at macro and micro levels of the industry. While at the macro level, the expansion of the industry and improvement of the productivity attains the greatest importance, the areas to be planned at the micro level lies under the categories of research, extension, development support (in terms of finance) and post harvest support like marketing, promotion etc. Coffee is not an exception to this, being a perennial crop with a gestation period of 5-7 years. The objectives are set for periods of 15 years, 10 years, 5 years as well as yearly time frames. The production target of 2,15,000 tonnes per annum fixed for the turn of the century is receiving maximum attention, since, it is

function of total area, yield level and other factors like cost price etc., where strategic development is essential.

The development strategy in coffee is described in detail in this paper.

METHODOLOGY

Demand forecast for Indian coffee in the external as well as internal markets for the perspective period has been a major tool in fixation of the production target of 2,15,000 tonnes. Forecasting method adopted was the application of the same growth rate which was achieved historically (Table I) over base levels of exports and domestic consumption.

A growth rate of 4% per annum in the exports of coffee to the quota market and a growth rate of 8% per annum in the exports to the non-quota market and 2.5% per annum in the domestic market were achieved in the last 15 year period (Table I). Considering the Indian share in the global market which is only 2.5 - 3% of the total, it has

Table I. *Data on production, export and domestic consumption of coffee*

Year	Total production (in tonnes)	Export (in tonnes)	Domestic consumption (in tonnes)
1962-63	56,217	25,072	34,651
1963-64	69,320	31,800	33,634
1964-65	60,901	27,558	35,200
1965-66	63,861	23,649	36,850
1966-67	78,473	34,743	35,474
1967-68	57,331	35,356	36,485
1968-69	73,430	34,825	35,822
1969-70	63,619	23,338	38,052
1970-71	1,10,231	38,167	33,582
1971-72	68,948	40,104	37,904
1972-73	91,072	56,451	37,452
1973-74	86,388	49,590	39,381
1974-75	92,506	62,167	37,562
1975-76	83,982	51,321	36,880
1976-77	1,02,248	53,632	36,782
1977-78	1,25,141	60,620	44,088
1978-79	1,10,488	64,622	46,028
1979-80	1,49,835	71,646	49,648
1980-81	1,18,646	99,295	47,683
1981-82	1,52,100	90,228	50,796
1982-83	1,30,000	68,801	53,990
Growth rate and increase	3% p.a	5.5% p.a.	2.75% p.a.

Source : Coffee Board, Bangalore

been accepted as feasible to achieve an average annual production of 2,15,000 tonnes by the turn of the century.

The present four year annual average production of 1,55,000 tonnes (Table II), has to be stepped up by 60,000 tonnes to reach the perspective target of 2,15,000 tonnes.

The strategy adopted to achieve this is by

- 1) Expansion in the area under coffee and
- 2) Improvement in productivity in the low yielding areas of coffee.

The approach for the expansion of area would be through expansion in the non-traditional area and adequate incentives for expansion in the areas available adjacent to the existing plantations in the traditional areas.

Table II. *Production target for coffee*

Season	Production (in tonnes)
1984-85	1,95,800
1985-86	1,22,300
1986-87	1,91,000
1987-88	1,20,000
Provision	
Low average production	1,57,275
Base level considered	1,55,000
Growth rate applied	3 % p.a.
Production target for 2000 A.D.	2,15,000

The thrust to be provided in the non-traditional areas include identification of areas suitable to coffee in the hilly terrains of the tribal zones where there is a great need to prevent shifting cultivation to make tribals settle down to permanent crops like coffee thereby restoring the ecological balance lost through shifting cultivation. It is suggested to induce the state governments to set up their own corporations to undertake large scale coffee expansion on commercial basis and hand over viable size of coffee plots to the tribals in their settlements. These thrust areas are necessarily to be backed up by the infrastructural support programmes in the fields of research, extension, development credit and marketing by expanding the Coffee Board's net work suitably through extension centres, Regional Research Stations, Coffee Demonstration Farms and pooling and processing facilities in non-traditional areas.

In the traditional areas to motivate further expansion of area the strategy would be by introducing high yielding selections, providing financial assistance, ensuring remunerative prices to increase the level of viability of the coffee economics, constant extension

advisory service and assured marketing provided by the Board.

To improve the productivity, the critical inputs identified are – research, extension, financial support, remunerative prices and assured markets. The strategy therefore has to be firstly maintenance of existing non-bearing areas in order to avoid abandonment of the estates. The extension advisory services on rationalisation of cultural practices to reduce input cost would greatly help in maintenance of the existing non-bearing areas and to begin with a sustainable yield pattern.

Secondly, the strategy would be to replant the uneconomic areas with high yielding selections. The back-up support by providing the physical input like planting material as well as financial assistance would hasten the replanting programmes.

Thirdly, to improve the productivity by bringing more areas under intensive cultivation should be through extension advisory services, input assurance, financial assistance and taking up specific research programmes on drought, management, plant protection, production of elite planting material and provision of drip and overhead irrigation for inducing blossoms is essential.

Action plan

1. To avoid opportunity losses in the coffee crop due to abandonment of the present non-bearing coffee plots, the following are to be ensured:

- i) Provision of adequate physical inputs, financial support and extension advices;
- ii) Research programmes are to be undertaken on location specific plant protection, water management, rationalisation of the nutrition requirement for optimum fertilizer application and other input cost reduction studies.

2. For area expansion in the adjacent areas of estates in the traditional states, motivation of traditional planters to increase area through various incentives is essential.

For development of coffee in the non-traditional areas, the approach suggested would be to set up organisations exclusively for taking up coffee programmes under the management of the State Government. The development programmes of coffee can also be taken up by the State departments like soil conservation, forest agriculture etc. Coffee has also to be developed in non-traditional areas under integrated tribal development programmes. The organisational approach for developing coffee has become unavoidable in view of the land laws prevailing in the tribal areas of the non-traditional coffee states. However, the ultimate success of this approach can be felt only when the coffee plots developed by them attains the prime bearing stage and the policy of handing over viable plots to the ultimate beneficiaries is implemented. The development of coffee has also to be effected through encouraging individual tribals to take up coffee cultivation by providing necessary input and financial support.

The following programmes in different areas has to be adopted for achieving the envisaged increase of 60,000 tonnes.

Research and development: To increase the productivity of the small holdings, the research efforts on the following are to be intensified:

1. Development of suitable strains of coffee to increase density of plant population per unit area; 2. Standardisation of efficient water management system; 3. Evolving drought resistant coffee varieties for cultivation in drought prone tracts; 4. Development of integrated pest and diseases manage-

ment; 5. Development of clonal propagation and tissue culture techniques for rapid multiplication of Robusta to ensure uniform material thereby stabilising the Robusta production; 6. Studies on physiological basis of yield in Arabica and Robusta under different agro-climatic conditions and shade regulation; 7. Studies on harvest index and bio-mass production and 8. Studies to standardise newer techniques in estate processing of coffee.

As one of its recommendations the Research Evaluation Committee (September 1986) observed that "7-1-03, *India is considered to be the producer of mild Arabicas - therefore maintenance of adequate proportion of area of Arabica and Robusta at an optimum ratio through adoption of a sound policy of incentives for Arabica production is important.*" In view of the above it is proposed to standardise newer techniques in estate processing especially in wet method of processing.

The following incentives/disincentives have been suggested:

- 1) Encouraging wet processing
- 2) Increasing area and production of Arabica and
- 3) To discourage growing of Robusta in non-Robusta zones.

i) Expansion subsidy for Arabica to be provided at higher rate (Rs. 3750/- ha.) even to the large growers; ii) Replanting subsidy for Arabica should be given to the large growers also; iii) Replanting subsidy for Robusta should be given only in pure Robusta zones and should be discontinued in the non-Robusta areas/zones; iv) In the drive for encouraging intensive cultivation an element of subsidy (@ 10%) should be introduced linking with the existing Intensive Cultivation Loan in Arabica; v) As an incentive to

bringing more areas under irrigation, subsidy should be introduced @ 25% of the investments made or a maximum of Rs. 10,000/- for small growers and Rs. 25,000/- for the large growers. No ceiling for subsidy is being proposed for drip irrigation; vi) However, prominence should be given to bring more areas under irrigation in the category of 4 ha and below where potential for yield improvement is much greater.

Extension services: The intensive extension advisory services are essential in the existing non-bearing areas on the efficient crop management practices like shade regulation, maintaining adequate plant population, plant protection that ensure optimum health and productivity and on processing especially wet method.

The extension advisory service should concentrate on the small holdings with low productivity (of below 2 ha. and 2 to 4 ha. groups) in the identified districts as per district plans so as to.

1. To motivate the growers to adopt intensive cultivation for higher productivity through selections like Cauvery;
2. To draw up individual farm plans and follow up action;
3. To arrange credit requirement as well as input facilities for taking up intensive cultivation;
4. To help arrangement/augmentation of water resources in the small holdings ensuring irrigation facilities/water for wet method of estate processing.

Development credit and finance: Development credit as well as financial assistance with special reference to small holding should be provided for

1. Maintaining young clearings;
2. taking up intensive cultivation for improving their productivity through replanting;
3. replanting the old, moribund un-economic coffee with Cauvery/other suitable

- station selections;
4. maintaining and sustaining the minimum productivity levels;
5. providing financial incentives like subsidy for developing permanent estate facilities for irrigation/wet processing/machinisation etc;

Quantification of the methods: 1) By concentrating on the existing non-bearing area both in the traditional and non-traditional states an additional production of 9000 and 2250 tonnes respectively is expected amounting to 11,250 tonnes. While the production increase expected from the existing non-bearing areas attaining bearing stage by 2000 A. D. is taken for consideration in this approach another important factor of the uneconomical areas in small sector that will be abandoned has also been considered.

- 2) Through expansion programmes of 12,000 ha. in the traditional areas and 15,000 ha. in the non-traditional areas, an increased production of 8,750 tonnes and 2,250 tonnes respectively is expected and thus, totalling to 11,000 tonnes. While the expansion target suggested for non-traditional areas originate out of the Board's Perspective Plan, the areas available for expansion in the traditional areas is estimated to be not more than 5% of the existing planted area.

- 3) By consolidation and extensive infilling in the non-traditional areas and increasing the standard of cultivation in the small holdings of traditional areas to intensive levels, thereby increasing the average productivity and the production by 26,400 tonnes.

- i) In traditional states – 18,950 tonnes

- ii) In non-traditional states – 7,450 tonnes

The areas targeted for intensive cultivation/consolidation for production increase for this approach include those areas with productivity far below the National average

and also the larger size of holdings (4 to 10 ha size) having potential to improve the productivity above the national average. This has to be attempted in order to increase the scope of viability of the holdings.

4) By replanting the old, moribund, low-yielding (un-economical) areas with the recently evolved high yielding strain at a rate of 2% per annum of the remaining area to be replanted approximately 15,000 ha. by 1995-96, thereby increasing the average production level by another 11,350 tonnes. With the evolution of newer planting material with high potential for yield, the conditions are more conducive for a rapid rate of replanting of the coffee areas under old, moribund and uneconomical material.

Coffee expansion programmes in non-traditional areas

The main objectives of coffee expansion programmes in non-traditional areas are prevention of shifting cultivation thereby saving the forest areas from denudation, creation of continuous gainful employment, socio-economic improvement of the tribals and bringing-forth integrated rural development of the hilly tracts of the non-traditional coffee states.

Although, there has been considerable progress on expansion front, the yields obtained have been too low so far. The major constraints seen as factors responsible for the low yield pattern in non-traditional areas are absence of ready financial assistance from the State Governments, land related problems and management constraints.

It is therefore contemplated to consolidate the existing areas in the non-traditional areas in order to improve the yield pattern, if not on par with that of the traditional coffee, at least to reasonable level.

Summary of the approach

	(in tonnes)
i) By concentrating on existing non-bearing area which would be in bearing state by 2000 A. D.	11,250
ii) By expansion programme within the traditional and non-traditional areas	11,000
iii) By consolidation of areas in non-traditional area and intensive cultivation in small holdings of traditional area	26,400
iv) By replanting with high yielding types @ 2% per annum in 15,000 ha. by 1995-'96	11,350
Total	60,000

Development strategy—Outlook for 2000 A.D. and other implications

The average production level would reach 2.15 lakh tonnes, which includes the domestic demand of 75,000 tonnes and export of 1,40,000 tonnes per annum.

Total financial implications of the development strategy has been worked out as

- 1) Working capital requirement : Rs. 141.40 crores/annum
- 2) For expansion, intensive cultivation, replanting and for irrigation project
 - Total investments : Rs. 402.50 crores
 - Total subsidy : Rs. 62.51 crores

The foregoing account gives a detailed prospective approach to increase the production and productivity of coffee to meet the demands of 2000 A. D. both for internal consumption and export.

PLENARY SESSION

SESSION I

GENETIC RESOURCES AND CROP IMPROVEMENT

Of the eight papers presented, three each were on rubber and coffee and one each on cashew and oil palm.

In rubber, the first paper on yield performance of 9 RR II clones of *Hevea* over 13 years showed that the clone RR II 105 is superior and three other clones also performed better than the control. The paper on the "Comparative bark anatomy of three induced polyploids of *Hevea brasiliensis* and their diploids" indicated that the cultivated species being a natural tetraploid, the differences between the diploids and induced tetraploids were not pronounced and that tetraploidy may not have any advantage over diploids in improvement of yield or growth. The third paper on the performance of nine clones of rubber in large scale trial showed that all the clones were on par with respect to yield of dry rubber over ten years with only differences on bark character.

In the paper on "Isolation barriers of diploid species of coffee as reflected in the hybrids", the operation of isolation mechanism delimiting the crossability of the diploid species has been pointed out, based on the sterile F1 hybrids and their cytological behaviour. The model system for hybrid seed production in Arabica coffee, two potential

models for exploitation of hybrid vigour in coffee were presented. Selection procedure adopted to obtain the superior bean characteristics for commercial acceptance was presented in another paper on coffee.

A paper on the effect of time and severity of pruning in cashew (*Anacardium occidentale* L.) showed that leader shoot pruning in August increased the yield over 100% over control shoot followed by leader pruning in July.

The authors of the paper on characterisation of *pisifera* parents and its relevance to oil palm improvement were the first to identify *pisifera* palms in the country. The 18 *pisiferas* were classified by the authors into 7 categories based on sterility and usefulness of testing the performance of the hybrids involving each of these categories as male parents was suggested by the authors.

The following recommendations emerged, based on the discussion.

Rubber

1) Index of different characters in RR II clones will add due weightage and also form a useful approach when location specific planting materials are developed for different agro-climatic regions, as the stress so far has been primarily on yield improvement.

2) Studies be pursued on correlation between the number of latex vessel rings and

yield in view of the observation that some poor yielders in the trial had higher number of latex vessel rings.

3) The possibility of exploiting induced tetraploids, to produce triploids in rubber was indicated which appears to be useful approach.

4) Emphasis may be given for a multidisciplinary approach for identifying early prediction parameters, although it appears to be not easy.

Coffee

1) It is desirable to identify the unknown parents involved in the seed set of F1 hybrids under open pollination and exploit such parents for controlled crossing. Pachytene analysis in hybrids may be undertaken to establish the affinity among species.

2) The use of gameticides and their effect on both the male and female gametes has to be properly assessed before extending the studies to field and to obtain the hybrid seed.

3) Studies on physical characteristics of coffee bean as selection indices form a useful information and already in practice may be continued for stabilisation of these characters in commercial lines.

Cashew

1) The effect of leader shoot pruning in cashew with respect to increased yield is to be established under large scale field trial and cost economics of pruning is to be worked out.

2) Correlation studies between the root carbohydrates and recovery of the pruned

plant will further enhance the scope of such studies in cashew.

3) Pruning should better be done based on canopy and not on weight basis, so that the studies will be more meaningful.

Oil palm

It was suggested to study the pollen viability in various classes as the sterile *pisiferas* have crucial role in seed production.

M. K. NAIR
Chairman

SESSION II

BIOTECHNOLOGY, CROP PHYSIOLOGY AND BIOCHEMISTRY

Out of nine papers presented, two each were on coconut, rubber and tea, one each on cocoa, coffee and pepper. The main points discussed and conclusions drawn are as follows:

1. Physiological characters like girth, canopy area and number of branches were correlated with yield of cocoa. Factors like light intensity, photosynthetic rate, water stress, higher specific leaf weight and epicuticular wax were also found to influence the yield.

2. The growth of *Rhizobium* was found to be optimum for maximum growth at pH value of 7.0 thereby suggesting that the *Rhizobium* growth should be protected in acidic soils. For this purpose a need for pelleting the rhizobial inocula to get substantial improvement in nodulation and

nitrogen fixation of green manure legumes in acidic coconut soils was suggested.

3. A methodology for regeneration of coffee plantlets through tissue culture of stem explants and embryo was reported with the main objective of micropropagation of elite coffee plants. The methodology can also be used for achieving somaclonal variants and for rescue of embryos of interspecific crosses.

4. Accumulation of more proline, less reduction in relative water content and increased epicuticular wax were attributed for drought tolerance in certain UPASI clones of tea.

5. While discussing a study on structure and development of the tea bush in relation to its productivity, it was suggested that four year pruning cycles and a tipping height of 15 cm were more productive.

6. Use of Calcium carbide as a yield stimulant in place of ethephon in rubber resulted in 50 per cent more yield due to its stimulatory effect.

7. Significantly higher bursting index, and high sucrose content were reported to be related to high plugging in rubber clones.

8. Studies on amino acid pattern in black pepper indicated that there was no interference of cystiene with the estimation of proline and that the free natural proline content was found to increase in *Kalluvally* and *Arakkulam munda* clones during water stress periods.

9. A comparison of physiological and biochemical parameters of coconut hybrid

seedlings indicated that MYD x WCT coconut hybrids have higher leaf production, leaf area, chlorophyll content, leaf dry weight and girth as compared to COD x WCT and MOD x WCT hybrids. It is suggested to observe the yield performance of this hybrid to confirm the superiority.

Genotypic and environmental correlations rather than the simple correlations for assessing the high productivity of cocoa will be more useful. Studies on drought tolerance at field level should be multidisciplinary including Soil Chemistry, Agronomy and Plant Breeding. Aspects of stomatal regulation, leaf osmotic potential and solute accumulation could also be considered while assessing drought tolerance. Further, inducing drought tolerance through osmotic adjustments could be explored. Studies are needed to elucidate the effect of application of Molybdenum and Cobalt on green manure/cover legumes under particular soil conditions.

R. SINGH
Chairman

SESSION III

CROP MANAGEMENT

A total of nine papers were presented in this session. It is relevant to mention some of the basic aspects of water relations in crop plants. Consumptive use is the total water transpired and evaporated from a unit area in a specified time and it depends on time factors, vegetation and climate. It is numerically equal to evapotranspiration

which is dependent on the sum of water used by vegetation and that lost by evaporation in a unit area in a specified time. The potential evapotranspiration is the climatological demand for water under turf actively growing with unrestricted supply of water (E).

Consumptive use is the depth of water needed to meet water loss through evapotranspiration. The ratio between consumptive use and E is known as crop coefficient.

The optimum crop coefficient varies between 0.6 and 0.8 for many crops. Irrigation at a higher crop coefficient ratio means over irrigation which increases evapotranspiration and at a lower ratio means under irrigation.

Mulching helps to maintain high crop coefficient ratio even at reduced irrigation rate by decreasing the evaporation rates. As such crop coefficient can be kept at optimum at a lower irrigation rate with mulching.

Water requirements of arecanut as influenced by mulch of organic as well as polythene source worked out based on evapotranspiration and open pan evaporation rates proved to produce maximum yield when irrigation by conventional means at IW/CPE ratio of 1 to a cumulative pan evaporation of 30 mm was adopted. Both mulching materials were effective but use of polythene mulch proved prohibitively costly. Adoption of drip irrigation for the introduction of economy in water use that could be substantial and working out

of WUE of the crop were suggested to be undertaken during the discussions.

In the evaluation of turmeric and sweet potato as intercrops in arecanut gardens manuring increased response in vegetative parameters, however it was not reflected in yield of economic end product.

More frequent foliar application of zinc sulphate at a concentration of 750 ppm and at a rate of one litre per cardamom plant showing incipient deficiency produced increased yield of cardamom in yielding cardamom plantation. Monitoring usage of zinc based on soil and plant zinc levels and working out soil and leaf critical values that could be employed for response assessment were suggested.

Rainfall analysis in tracts cropped to cardamom discussed under poster session showed that rainfall was well distributed in Southern than in the Northern tracts and that total rainfall showed a declining trend in Wynad zone while it was on the increasing trend in Varushanadu Zone.

Evaluation of the effect of additives such as Kaolin, AS and MOP in increasing the herbicidal efficacy of glyphosate in rubber fields proved that glyphosate at 0.62 kg/ha along with Kaolin and AS at 2.25 and 1.25 kg respectively proved economical and effective and reduced herbicidal load. Assessment of Atomin and Atokam as additives to increase the efficacy was suggested. The mode of the action of additives in increasing the efficacy was discussed. Reasons for the contradicting results obtained

with KCl and urea are to be investigated further.

Bowl sludge, a byproduct from latex concentrate factories used as an alternate source of phosphorus for immature rubber proved beneficial and also solved disposal problems and consequent environmental pollution. A caution has to be exercised while industrial wastes such as bowl sludge are employed in general agriculture. Possible toxic effects on crop and soil should be studied on long term usage basis before making recommendation.

Evaluation of *Mucuna* sp, red gram, tapioca, pineapple, papaya, acacia, casuarina and subabul as inter crops in young cashew plantations for achieving reduction in soil erosion and augmentation by additional supplemental income facilitated substantial ground coverage to the tune of 70 per cent and generated additional income. In cashew-nut and tapioca combination studies on root spread activity competition of inter-crops to be undertaken.

Studies on the occurrence of drought in coconut belt of west coast of Kerala indicated that disastrous droughts occurred once in four years and their increasing probability of long duration droughts. Soil moisture deficit between January-May was 801 mm in a disastrous year. Agro-meteorological terms used may be explained for a general scientific proceedings.

Fitting of productivity response functions to field survey data obtained from Robusta growing tracts with quantum of nutrient and age of bushes as variable with the objectives to indicate the choice of polynomial functions brought out the age was an important variable in function analysis. Adoption of bush based fertilizer application

and nutrient rationalisation was the major outcome of both models. Importance of spacing being a definite variable was stressed. It was further stressed that generated inferences from such survey data be used as additional information to results obtained from field trials which were more valuable than the survey data.

A. (1) Stability constants of metal ion complexes of Al, Zn and Mn with organic acids were worked out.

(2) Al and Mn complexes are non stable and availability of these elements will be reduced in soil by this phenomenon.

(3) Stability constant in soil solution show smaller values due to interference from other substances and also to change in pH.

B. Organic acids added to soil reduce the availability of Al and Mn (5 to 20 per cent in the case of Al and 5 to 40% in the case of Mn) but increased that of Zn by 20 to 40% in both soil pH ranges (5.7 and 6.4). With added organic acids, the availability of Zn is increased by 13%, Al decreased by 11% and Mn decreased by 13%.

Increase/decrease is marginal to have any impact on practical terms-particularly when levels of available metal ions and acid soils are taken into account.

C. Pot culture studies

Effect of organic acid and metal ions

	Zn +	Al —	Mn —
Organic acids	4.0	5.3	11.9
Organic acids + metal ions	12.9	4.8	10.0

There is a substantial increase in Zn and reduction in Al and Mn contents; but still the concentration of Al and Mn are high and does not solve the problem.

Application of zinc to coffee with organic acids increased plant zinc content and decreased plant aluminium and manganese contents. Perhaps addition of organic acids may be impracticable. Retrieval and management of organic anions already available in plentiful combination in soils cropped to coffee that receive bountiful organic litter from shade canopies and humus complex is to be examined rather than additions.

Canopy characters as criteria in determining productivity of tea bush were discussed in poster presentation.

Ratio of photosynthetic to non-photosynthetic parts play an important role in determining overall net growth rate and yield. In tea there appears to be less optimum ratios, one for getting highest total dry matter production and one for getting highest harvest.

The optimum ratio for the yield is slightly lower than that for dry matter production.

Some important findings are :

1. The ratio between leaf/stem showed negative correlation.
2. Leaf dry weight at zero to 10 cm had highest direct and positive effect of yield.
3. The direct contribution of leaf in other profiles and stem in all the tiers was low;

their contribution was chiefly through leaf at the top 10 cm.

The implications are

1. The leaves in lower tiers act more as a drag on the photosynthetic than the stems. In spite of their photosynthetic activity their ratio to top leaves should be kept as low as possible.
2. Stems show positive effect though top layer level may provide sink for photosynthites produced in top layer.
3. Leaves at lower layers do not contribute to the carbohydrates reserves as they do not have indirect effects through stems.

In Himachal Pradesh 13 year old tea responds to N,P and K manuring. Data indicated that there is a possibility of using more NPK to increase productivity. However, affordability and availability of nutrients are taken into account in the present levels recommended to tea.

V. RANGANATHAN
Chairman

SESSION IV

CROP PROTECTION (DISEASE MANAGEMENT)

The Chairman in his introductory remarks highlighted important disease problems in plantation crops and stressed the necessity of interdisciplinary approach to tackle the problems. He was of the opinion that there should be enough interaction among Plant Pathologists and Technologists such

as Computer Engineers in order to develop certain early diagnostic parameters especially in case of diseases with a long incubation period – this would help and to plan effective disease management strategies. As a part of the integrated disease management he outlined the need to intensify the biological control programmes using antagonists like *Trichoderma viride* and *T. harzianum*. The role of VAM in disease control has to be examined critically and in perennial cropping systems. The importance of investigations relating to the effect of pesticides on the biotic environment and also the epidemiological aspects of diseases in multispecies cropping system was emphasised. The necessity for crop loss survey once in every five years for crops like coconut, arecanut etc. is required in order to update the data. The correct diagnosis of the disease problem is essential and it should be done by a specialist. There is a greater need for more efficient spraying equipment for tree crops to achieve maximum effective coverage of the canopies at greater heights.

Of the nine papers presented two were on coffee and one each on arecanut, coconut, tea, cardamom, cashew, cocoa, and oil palm. In general the papers covered aspects such as, the integrated disease management, the variability of the pathogens, chemical control, the microbial acti-

with respect to N_2 fixers, P-solubilizers etc. It was pointed out that such studies should be undertaken specifying the stage of the crop during different seasons in order to get meaningful inferences. The implication of pesticide application in these systems should be taken care of, on the microflora. The variability of the *Colletotrichum gloeosporioides* isolates representing three different symptoms on cocoa in relation to both systemic and contact fungicides was presented.

The necessity to study the physiological difference of the isolates was pointed out. The poor isolation of *Thielaviopsis paradoxa* from the stem bleeding infected tissues of coconut was due to the presence of *Trichoderma viride*, *T. harzianum* and *Aspergillus niger*. This observation led to the possibility of utilizing them towards biocontrol of the pathogen. It was suggested to cultivate the antagonists in liquid media for studying the inhibitory effect of their metabolites on *Thielaviopsis*.

The paper on tea blister blight disease control in Kangra Valley indicated relatively poor performance of the systemic fungicide Calixin, which was found quite effective under South Indian conditions. Investigations are needed to identify the right dosage and spray interval with copper oxychloride. The usefulness of eradican nickel chloride should be tested under Kangra Valley condition.

The paper on microbial profile in areca based high density multispecies cropping system outlines the quantitative changes

The efficacy of Emisan-6 and captan as seed dressings in areca and coconut of germination and vigorous seedlings was highlighted in oil palm especially as a package of quarantine measure. It was

suggested to take into consideration the time gap from the point of despatch to point of entry in relation to the seed treatment and its effects on the microbial load.

The limitations of the disease management in red root rot of coffee were mainly due to the long incubation period of the pathogen. The importance of phytosanitation, removal of infected coffee root system and treatment of encircling 'apparently' healthy coffee bushes with Plantavax was also pointed out.

The necessity for an efficient screening technique to locate resistance for 'azhukal' pathogen in cardamom was felt and the possible scope of improvement of the methodology was suggested. Since the variability is high at the seedling stage screening at this stage will be more fruitful even though the panicle and capsule are mainly infected.

Considerable variation in growth and morphology of *Koleroga noxia* the causal agent of black rot of coffee from the 3 different locations was noticed. It was suggested to take into consideration anastomoses groups of the pathogen, which is an important taxonomic criterion.

The involvement of *Botryodiplodia* in cashew die back from a plantation at Chalakudy was discussed. However, this is not a widespread disease and the fungus being a weak pathogen either the injury or insect damage like that of *Helopeltis* would predispose plants to fungal infection. The poster session on the control of capsule rot of cardamom, prophylactic sprays with different fungicides, showed that Aliette and Bordeaux mixture were on par in controlling the

disease. To control pink disease of rubber, Thiram along with sopkot was found more effective and this was followed by Calixin with sopkot. While summing up, the Chairman focussed the need for integrated disease management involving cultural, chemical and biocontrol methods.

K. K. N. NAMBIAR

Chairman

SESSION V

CROP PROTECTION (PEST MANAGEMENT)

Chairman in his introductory remarks highlighted the pest problems in plantation crops. He particularly emphasised the problems involved in the management of polyphagous pests like cardamom shoot and capsule borer *Conogethes punctiferalis*, tea mosquito *Helopeltis antonii* and the different species of root grubs and chafer beetles. Cardamom shoot and capsule borer has got a wide host range and they infest ginger, turmeric, wild species of cardamom, *Alpinia* Sp and *Hedychium* Sp. While studying the seasonal abundance of the pest in cardamom ecosystem, the infestation on the collateral hosts is to be monitored. In the case of tea mosquito, a pest on cashew, cocoa, pepper etc. while studying the seasonal abundance the infestation on the different crops is to be assessed for scheduling effective management practices. With regard to root grub he gave a detailed account of the infestation on different crops and cited the peculiarity of *Leucopholis coneophora*, the adults of which do not congregate or feed on any plant species

with the result, tackling them on such plants becomes difficult as is being practised in the case of some other cockchafers.

Of the eight papers presented orally, five were in Entomology, two in Nematology and one in Rodentology.

Among the crops evaluated *viz.*, coconut, cassava, cocoa and wild sunnhemp, the white grub *L. coneophora* showed preference to coconut and cassava. For development, survival etc. the grubs preferred cassava and *Leucaena*. The result also indicated using cassava as a trap crop in coconut plantations for tackling the grubs as one of the components in the pest management of white grubs in coconut.

On the evaluation of the toxicity of insecticides to *Leptomastix dactylopii* a parasite of *P. citri*, it was found that quinalphos, fenitrothion and fenthion are less toxic to adults and pupae of *L. dactylopii*. This indicated a possibility of integrating chemical and biological control in the management of *P. citri*.

The paper on the evaluation of second generation anticoagulant rodenticide bromadiolone on black rat found that it was more effective than warfarin compounds in controlling rodents in coconut plantations. The LD 50 was found to be 0.51 mg/kg body weight.

The reaction of Arabica and Robusta coffee to five species of *Pratylenchus* was found variable. They are *P. brachyurus*, *P. coffeae*, *P. flakkensis*, *P. vulnus* and *P. zaeae*. Out of these, *P. brachyurus* was highly pathogenic to both species. The existence of four

biological races in *P. coffeae i. e.*, coffee, cardamom, pavetta and bamboo has been identified.

The paper on dissipation of fenthion in cardamom for the control of thrips in cardamom showed that the half life of fenthion was found to be 8.1 to 8.7 days on fresh capsules and 15.2 and 13.2 days on cured capsules at 0.05 and 0.1 % *a.i.*, respectively. Based on the EPA tolerance level (0.5 ppm) the waiting period has been suggested for safe consumption.

In a study on the effect of intercrop on the occurrence of *Radopholus similis* in arecanut palms and intercrops, it was found that the arecanut yield is reduced when banana and black pepper were grown as intercrops. In areca-cocoa combination, yield increased. The use of nematode free planting material and managing the nematode population by the use of nematicides was emphasised.

In the studies on cardamom shoot and capsule borer, it was found that the life cycle was completed in 41-57 days in summer season but was prolonged in winter months. A suggestion was made to develop a sequential sampling procedure as was done in ginger which will be helpful in developing a control schedule. Detailed studies on the natural enemy complex of *C. punctiferalis* were also suggested. A detailed account on the biology, nature and extent of damage and morphology of immature stages of *Halyomorpha marmorea* responsible for tender nut drop in arecanut was presented. It was suggested to take up detailed studies on seasonal abundance of the pest on arecanut and its collateral hosts like cowpea, bhindi,

bittergourd etc. This information is quite essential for fixing treatment schedules against the pest.

G. B. PILLAI
Chairman

SESSION VI

HARVEST AND POST HARVEST TECHNOLOGY

There were four papers presented in this session, out of which two were on harvesting proper, one on post-harvesting and one on industrial microbiology linking the post-harvest technology of plantation crops.

A paper on coffee processing entitled 'Effect of different washing methods on quality of coffee and their economics' did bring out utility aspects of the use of enzymes in food production, particularly, demucilisation of coffee with considerable reduction in the processing time leaving no ambiguity on quality deterioration in whatever manner one can assume. Considerable economy could be however envisaged, if cost control methods would be adopted for the production and availability of the most useful, hydrolytic enzyme, namely, pectolytic enzymes which find greater application in this process of demucilization of coffee. Definitely ways and means should be evolved to produce low-cost-more-effective-enzyme to prove this process an economical one.

According to the paper on 'Aeration and algal culturing - A method of biological treatment for crumb rubber processing factory effluent', which is applied microbiolo-

gical nature towards the abatement of water pollution in rubber industry warrants further bio-chemical engineering developments evolving controllable high Oxidation-Reduction systems. It was considered useful if R and D efforts are directed towards exploring possibility of producing single cell protein which might have an economic bearing on pollution control in toto.

The paper on tea entitled "Implications of mechanical harvesting in tea" received appreciation on the basis of its merit for economic use of this technique for harvesting tea during high cropping seasons. Shear harvesting as tried out in some districts of South India has now been extended to other regions also.

Keeping in view of the evidence of brown bast as the determining factor for health of the tree and yield of rubber, tapping techniques have been reported as standardised. The paper high-lighted the trend of occurrence of brown bast in relation to different tapping techniques.

S. RAMASWAMY
Chairman

SESSION VII

MARKETING, ECONOMICS AND STATISTICS

Of the 7 papers presented, two were on cashew and four on coconut and one on coconut and arecanut together.

In the first paper on cashew Mr. S. Bhagavan studying 10 seed/seedling characters of 37 accessions observed that the best

seedling can be selected based on the size of seed nuts and then on the early germination with long and narrow first leaf. He suggested that selecting the seeds based on this procedure will help to fill the gap in the supply of seed material till sufficient seedling supply is guaranteed by clonal multiplication.

In cashew, based on the study it was recommended that a plot of 6 x 2 trees forming the plot across the fertility line as the optimum plot size for experiments with cashew.

In coconut an index to quantify the biennial bearing tendency was worked out. It was observed that the biennial bearing tendency is more among the higher yield groups though irrigation reduces the same.

It was pointed out that the biennial bearing tendency should not be confused with alternative bearing tendency generally seen very predominantly in T x D coconuts. It was suggested that this study may be carried out in other varieties and hybrids and also in relation to weather factors.

The cost of cultivation of coconut in various strata was compared and concluded that the contribution of cost on manures was 45% and that of labour was 41%. It was suggested to include timber value also for calculating the out put value.

The paper on Discriminant function analysis in coconut seedlings, brought out the criteria based on cumulative yield and time taken for germination for discriminating high and low yielders.

On the price behaviour in coconut sector it was found that coconut product markets

are highly competitive and the prices of copra and coconut can be predicted from the oil price.

In coconut and arecanut based systems LER and its advantage was evaluated. The monetary advantages under the irrigated system, arecanut and cocoa combination, arecanut and pepper, coconut and cocoa and coconut and ginger were compared.

P. K. DAS
Chairman

SESSION VIII

DEVELOPMENTAL STRATEGIES

Out of nine papers presented one was on development strategy in coffee, suggesting the short, medium and long term perspectives to produce 2,15,000 metric tonnes of coffee by the turn of the century, to keep up the export commitments and meet the domestic requirements.

Three papers were presented on maximizing the yield of small cardamom, large cardamom and turmeric. The observations reported by the authors warrants indepth studies before making recommendations.

Four papers were presented on transfer of technology projects, one each on tea, rubber, coconut and spices. The multi-disciplinary approach adopted for integrated rural development and upliftment of tribal families in the Nilgiris by the UPASI Krishi Vignan Kendra is worth emulating by the other extension agencies. The spices production technology through lab to land programme adopted by the National Research Centre

for Spices, Kozhikkode is enlightening which concentrated on augmenting the supply of drinking water, construction of approach roads etc., besides transfer of appropriate agricultural technology to the weaker sections of the society.

The role of co-operatives in bringing about change in the socio-economic conditions of the small growers in rubber was brought to light by the paper presented from the Rubber Board. The innovative extension method

of improving the coconut yield in Kerala through 'Keragrams' was explained in the paper presented by M/s. Fertilizers and Chemicals Travancore Ltd.

The paper on plant protection techniques presented by Mr. Sharad Patel, M/s. American Springs and Pressing Works was interesting and educative on the vital aspect of crop protection.

P. K. RAMAIAH
Chairman

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