

ARECANUT

Research and Development

Proceedings of the Silver Jubilee Symposium on Arecanut Research
and Development, held at Central Plantation Crops Research Institute,
Regional Station, Vittal 574 243, Karnataka, India
(December 13 and 14, 1982)

Editors

K. SHAMA BHAT
C. P. RADHAKRISHNAN NAIR

Published by

K. V. AHAMED BAVAPPA
Director
Central Plantation Crops Research Institute
Kasaragod 670 124, Kerala, India
1985

Editors

K. SHAMA BHAT

Joint Director

Central Plantation Crops Research Institute
Regional Station, Vittal 574 243, Karnataka,
India

and

C. P. RADHAKRISHNAN NAIR

Scientist (Entomology)

Central Plantation Crops Research Institute
Regional Station, Vittal 574 243, Karnataka,
India

G 1420

Price : Rs. 75

US \$ 20



Printed at

Rajesh Power Press

Darbe, Puttur 574 202, India

FOREWORD

Arecanut, *Areca catechu* L. is an important tropical palm, the nuts of which are used as masticatory in a number of countries. Its cultivation in India is in about 1,84,500 hectares and more than four lakhs of people depend on this industry for their livelihood. Research on arecanut was initiated in the late fifties at the Central Arecanut Research Station, Vittal and its five Regional Stations located in Assam, West Bengal, Karnataka and Kerala. Though 25 years for a perennial crop like arecanut is not too long a period it is gratifying that the efforts of research and development could indeed make a dent on production. It was possible to double the production of the crop and also increase its productivity by about 23 per cent making the country self-sufficient in its requirement of arecanut by early seventies. Thus the story of arecanut research and development in the country may be considered as a successful one.

The Silver Jubilee of Arecanut Research and Development (SIJAR) was organised during December, 1982 for enabling the scientists and extension experts working in different parts of the country to interact so that the promotional activities on arecanut could get further impetus. Though the country achieved self-sufficiency about ten years back, some of the burning problems affecting the crop viz., yellow leaf disease, tender nut fall etc., warranted immediate attention. For finding solutions to these complex problems the Silver Jubilee Symposium indeed paved the foundation. Well planned co-ordinated programmes involving the University of Agricultural Sciences, Kerala Agricultural University and CPCRI were drawn up so that concerted team work could be mounted. In addition, from the point of view of the producers, the long term needs of the crop cannot be underestimated. Many of the arecanut farmers have this crop as the only source of income. In this context, diversifying arecanut farming with other crops such as cocoa, pepper, banana, clove etc., which are all high cash value crops becomes most relevant. The arecanut crop will have to be viewed as one of the component crops of a highly economically viable cropping system. High interdisciplinary work is called for in this area as well.

This publication is the Proceedings of the Silver Jubilee Symposium on Arecanut Research and Development which gave a chance to the scientists and developmental agencies to examine these issues in great depth. It is hoped that this proceedings will provide the researchers and extension personnel a clear picture of the present position of the industry as well as certain guidelines about its future.

July, 1985

K. V. Ahamed Bavappa
Director
CPCRI, Kasaragod 670 124

PREFACE

Areca nut industry in India was passing through a crisis during midforties due to heavy crop loss caused by fruit rot (*Koleroga* or *Mahali*) on one side and loss of a sizable area to Pakistan due to partition. The Indian Central Areca nut Committee which was constituted in 1949 to look into the problems of the commodity initiated several research and development programmes in the important areca nut growing regions either by setting up research stations directly under its control or supporting research schemes sponsored by State Agricultural Departments, Universities or Institutions. One of the important programmes was setting up of the Central Areca nut Research Station at Vittal (now the Regional Station of CPCRI, Kasaragod) in 1956 and a net work of Regional Stations at different areca nut growing regions of the country during the Second Five Year Plan period (1956-'57 to 1960-'61).

The Silver Jubilee of Areca nut Research (SIJAR) in India was celebrated during December, 1982 at CPCRI, Regional Station, Vittal to commemorate the completion of 25 years of areca nut research and development. During the celebrations a Symposium on Areca nut Research and Development was organised which brought together 170 scientists, extension workers and farmers from all the important areca nut growing areas of the country. A *Kisan Mela* was also organised for the benefit of the farming community. Awards were presented to the designers of prototypes of devices like tree-climbers, husking machines etc. Silver Jubilee Medals were awarded to 17 persons who served the cause of areca nut research and development for twenty five years.

This publication, 'Areca nut Research and Development' contains 54 papers presented and discussed in five sessions of the Symposium. It covers different disciplines: Genetics, Plant Breeding and Plant Physiology; Agronomy and Soil Science; Plant Protection; Technology, Biochemistry and Pharmacology and Marketing and Extension.

The SIJAR was organised with the financial support from various agencies like ICAR through ISPC; Department of Horticulture, Government of Karnataka; Kerala Agricultural University; Governments of Maharashtra and Kerala and others. On behalf of the organising committee of the SIJAR, we gratefully acknowledge the gesture of these Institutions and agencies. The successful conduct of the various programmes was possible due to the untiring efforts made by various committees to whose chairmen and members also the SIJAR owes its gratitude. The keen interest and guidance from Dr. M.V. Rao, Deputy Director General (CS), ICAR, New Delhi needs special mention. To Dr. N.M. Nayar (former Director of CPCRI), who initiated the preliminaries of SIJAR and to Dr. K.V. Ahamed Bavappa, Director, CPCRI, Kasaragod with whose guidance the entire celebrations were conducted, we are very grateful. The sustained efforts of Mr. K.N. Murthy, former Joint Director, CPCRI (RS), Vittal in organising the SIJAR

needs special mention. In the actual conduct of the Symposium we had the privilege of the participation of Dr. N. G. Perur, Vice-Chancellor, UAS, Bangalore; Prof. Sheik Ali, Vice-Chancellor, Mangalore University, Mangalore and Mr. M. Mohan Rao, former Arecanut Specialist. Our gratitude is due to them. To all the Chairmen and the Rapporteurs of various sessions of the symposium and to the scientists who contributed papers also we extend our sincere thanks. The editorial help received from Drs. K.K.N. Nambiar, P. K. Das, C. C. Biddappa, M.V. Shantaram, M/s. G.B. Pillai, Jacob Mathew, N. Subramonian and S. Devasahayam is gratefully acknowledged. Our thanks are due to Mr. M. K. Muliya, who extended his co-operation in organising the *Kisan Mela*. The help rendered by M/s. V. A. Bava, H. Thimmappa and C. Padmanabhan in typing various correspondences and manuscripts is received with thanks. We extend thanks to all our colleagues for the co-operation in the successful conduct of SIJAR. We are also grateful to M/s. Rajesh Power Press, Puttur, who printed this proceedings nicely.

July, 1985

K. Shama Bhat

C. P. Radhakrishnan Nair

Contents

Foreword

Preface

Page

Session 1

GENETICS, PLANT BREEDING AND PLANT PHYSIOLOGY

Path analysis in arecanut (<i>Areca catechu</i> L.) <i>S. Bhagavan</i>	..	3
Performance of areca selections under 'Upghat' regions <i>P. Bhadraiah, H. V. Pattanshetti and K. Krishnamurthy</i>	..	7
Performance of arecanut (<i>Areca catechu</i> L.) cultivars in Konkan region of Maharashtra <i>M. J. Salvi, S. P. Singh and S. B. Deshpande</i>	..	10
Performance of VTL cultivars of arecanut (<i>Areca catechu</i> L.) at Coimbatore <i>T. Thangaraj, S. Muthuswamy, C. R. Muthukrishnan and JBM. MD. Abdul Khader</i>	..	13
Physiological studies on arecanut palm - A review <i>R. B. R. Yadava</i>	..	17
Epicuticular waxes of arecanut leaf <i>C. Chenchu Subbaiah</i>	..	19
* Floral biology of arecanut (<i>Areca catechu</i> L.) variety Shriwardhan local <i>M. J. Salvi, S. P. Singh and S. B. Deshpande</i>	..	22

Session 2

AGRONOMY AND SOIL SCIENCE

Irrigation requirements of arecanut (<i>Areca catechu</i> L.) <i>K. B. Abdul Khader, N. Yadukumar and K. Shama Bhat</i>	..	27
Scheduling irrigation for arecanut with pan evaporimeter <i>N. Yadukumar, K. B. A. Khader and K. Shama Bhat</i>	..	33
Nutritional studies in areca under 'Upghat' region <i>P. Bhadraiah, H. V. Pattanshetti and K. Krishnamurthy</i>	..	38

	Page
Effects of manuring on the nutrients contents of soil and leaf in arecanut <i>A. R. Mohapatra</i>	41
Contribution to the micromorphology of a lateritic sandy loam soil profile growing arecanut <i>V. Gopalaswamy and M. Subramonia Iyer</i>	49
Morphology, mineralogy and taxonomy of some arecanut growing soils of Kerala <i>M. Subramonia Iyer and V. Gopalaswamy</i>	53
Biomass productivity of different intercropping systems in arecanut <i>A. Muralidharan and K. Krishnamurthy</i>	58
Normalising transformations for the yield of arecanut <i>S. Bhagavan</i>	65
* Effect of intercultivation on production of arecanut, <i>Areca catechu</i> L. <i>A. K. Sadanandan, C. K. George, A. Muralidharan and K. J. Abraham</i>	68
* Evaluation of banana varieties for intercropping in arecanut gardens <i>T.V. Ramakrishnan Nayar, A. Muralidharan and K. Shama Bhat</i>	70
* Beneficial micro-organisms in the root region of arecanut palm <i>B. M. Bopaiah</i>	74
* Standardisation of leaf sampling technique in arecanut palm <i>A. R. Mohapatra and N. T. Bhat</i>	78

Session 3

PLANT PROTECTION

PLANT PATHOLOGY

On the mechanism of spore dispersal in <i>Phytophthora arecae</i> the causal organism of 'Koleroga' of arecanut <i>M. Anandaraj</i>	83
Control of 'Koleroga' of arecanut <i>M. N. L. Sastry and R. K. Hegde</i>	86

	Page
* Taxonomic identity of arecanut <i>Phytophthora</i> isolates from the gardens of Sirsi, Uttara Kannada <i>M. N. L. Sastry and R. K. Hegde</i>	92
* Disease surveillance on 'Koleroga' of arecanut caused by <i>Phytophthora arecae</i> <i>M. Anandaraj and N. Saraswathy</i>	95
Changes in foliar pigments in yellow leaf disease of arecanut <i>N. Srinivasan</i>	97
Yellow leaf disease of arecanut. III. Root region microflora and involvement of toxin <i>B. M. Bopaiah</i>	100
* Frequency of occurrence and intensity of yellow leaf disease of arecanut (<i>Areca catechu</i> L.) in relation to water table <i>R. Chandra Mohanan and B. P. Nair</i>	104
A comparative study of the rhizosphere microflora of healthy and diseased arecanut palms affected by yellow leaf disease <i>K. J. Alice, S. Balakrishnan and P. Karunakaran</i>	107
* Survey of 'Anabe' (Foot Rot) and 'Band' diseases of arecanut (<i>Areca catechu</i> L.) <i>M. J. Salvi, S. P. Singh and S. B. Deshpande</i>	114
Epidemiological studies on inflorescence dieback of arecanut caused by <i>Colletotrichum gloeosporioides</i> <i>R. Chandra Mohanan and K. M. Kaveriappa</i>	116
Epidemiology of bacterial leaf stripe disease of arecanut palm (<i>Areca catechu</i> L.) caused by <i>Xanthomonas campestris</i> pv <i>arecae</i> . I. Effect of age of palm and age of the leaf on disease manifestation <i>S. N. Sampath Kumar</i>	120
* Epidemiology of bacterial leaf stripe disease of arecanut palm (<i>Areca catechu</i> L.) caused by <i>Xanthomonas campestris</i> pv <i>arecae</i> . II. Involvement of management practices on the disease incidence <i>S. N. Sampath Kumar</i>	124
Control of 'Band' disease of arecanut (<i>Areca catechu</i> L.) <i>M. J. Salvi, S. P. Singh and S. B. Deshpande</i>	128

ENTOMOLOGY

	Page
Seasonal fluctuations in population of the Spindle bug <i>Carvalhoia arecae</i> M. and C. (Heteroptera: Miridae) <i>B. Sathiamma, K. M. Abdulla Koya, V. A. Abraham,</i> <i>T. S. S. Rawther and Chandy Kurian</i> ..	133
Control of arecanut spindle bug, <i>Carvalhoia arecae</i> M. and C. using granular insecticides in the field <i>B. Sathiamma, K. M. Abdulla Koya, T. S. S. Rawther and</i> <i>Chandy Kurian</i> ..	137
Chemical control of palm mite <i>Raoiella indica</i> Hirst on arecanut <i>S. Devasahayam and C. P. Radhakrishnan Nair</i> ..	140
Distribution of phytoparasitic nematodes on arecanut in South India <i>P. Sundararaju and P. K. Koshy</i> ..	143
Bioecology and management of white grubs on arecanut <i>G. K. Veeresh, M. Vijayendra, N. Vijayamohan Reddy,</i> <i>C. Rajanna and P. S. Rai</i> ..	147

Session 4

TECHNOLOGY, BIOCHEMISTRY AND PHARMACOLOGY

The use of arecanut husk fibre for fibre reinforced plastic product <i>C. R. Debnath</i> ..	153
Use of areca leaf sheaths for making plyboard and packaging materials <i>S. J. K. Annamalai and N. M. Nayar</i> ..	156
Biochemical changes during storage of arecanut (<i>Areca catechu</i> L.) <i>B. Chempakam and N. Saraswathy</i> ..	163
Mutagenicity and tumorigenicity of arecanut extracts and its constituent alkaloids <i>S. V. Bhide</i> ..	167
Miotic activity of arecanut <i>A. M. Mujumdar, A. H. Kapadi and G. S. Pendse</i> ..	172
* Polyphenols of arecanut <i>A. G. Mathew</i> ..	177

	Page
* Technological aspects of arecanut <i>S. Shivashankar and E. S. Nambudiri</i>	181
* Xylose and activated charcoal from arecanut husk <i>A. H. Kapadi, Vandana Deshpande, A. M. Mujumdar and G. S. Pendse</i>	188

Session 5

MARKETING AND EXTENSION

* Arecanut situation in India (An economic analysis) <i>Prafulla K. Das</i>	195
An analysis of production and productivity trends of arecanut in different states in India <i>R. K. Sikka</i>	201
* A study of marketing arecanut in Jalpaiguri district of West Bengal <i>R. K. Singh and M. M. Bhalerao</i>	205
* Arecanut development in Karnataka state <i>G. N. Appaiah</i>	207
A study on the progress of CAMPCO and its impact on arecanut sector in Karnataka and Kerala <i>Prafulla K. Das</i>	209
Profitability of arecanut cultivation in Jalpaiguri area of West Bengal - A sample study <i>M. M. Bhalerao and R. K. Singh</i>	217
Profitability of arecanut cultivation in Dakshina Kannada District, Karnataka <i>R. K. Singh, K. S. Bhat and M. Vijayarajan</i>	220
* An evaluation of investment in areca gardens in Dakshina Kannada District, Karnataka <i>E. Krishnaraja and J. V. Venkataram</i>	223
* On the significance of environmental resources in sustaining the productivity of arecanut gardens of Uttara Kannada <i>V. S. Hegde, D. M. Bhat, K. M. Hegde, S. N. Prasad and Madhav Gadgil</i>	227
Author index	230

Session 1

**Genetics, Plant Breeding
And
Plant Physiology**

Chairman : K Gopinathan Nair

Rapporteurs: R S N Pillai

K V J Mohan

✓ Path Analysis in Arecanut (*Areca catechu* L.)

S. Bhagavan*

Abstract

The study on direct and indirect effects of seed weight, days taken for germination, seedling girth, seedling height, number of leaves, time taken for flowering on the yield characters of arecanut by path analysis suggested that the selection of heavy nuts (35 g and above) plays a major role for raising better seedlings resulting in higher yield. The seedling which comes to early flowering (less than 4½ years) resulted in better yield. The thinner seedlings must substantiate with early flowering for better yields.

Introduction

Plant yield, in general is the resultant of growth functions of several yield components, mainly the plant morphology. Whenever the number of such components in a crop is more, it becomes essential to measure the contribution of each component to the observed correlation and partition the correlation coefficient into components of direct and indirect effects. Such studies are done in various crops (Chang and Lal, 1971; Dewey and Lu, 1959; Miller *et al.* 1958; Povilaitis, 1965; Venkatarao *et al.* 1973) but so far no attempt has been made in arecanut.

Materials and Methods

Progenies of the 50 selected nuts from each of the six selected mother palms were considered for the study. Morphological data on seed weight (X_1), time taken for germination (X_2), seedling height (X_3), seedling girth (X_4), number of leaves (X_5) and time taken for flowering (X_6) were recorded. Yield data viz., number of nuts

and wet weight of nuts were collected for four years (1972-73 to 1975-76) and the average yield was considered for fitting a multiple regression equation with the morphological characters.

Two models of regression viz., (i) linear model of the form $Y = \alpha + \sum_{i=1}^6 \beta_i X_i$ and (ii) exponential model of the form $Y = \alpha \prod_{i=1}^6 (X_i)^{\beta_i}$ were fitted.

Taking into consideration the exponential model of regression, path interrelation coefficients were obtained from the partial regression values of the multiple regression between the yield and morphological characters, using the genotypic variances and covariances, according to Tukey (1954). These were represented as P_{iy} , where $i=1, 2, \dots, 6$. All the residual factors were represented by P_{xy} which is calculated as $P_{xy} = \sqrt{1-R^2}$, where R^2 is the multiple correlation coefficient.

Results and Discussion

Large variation was found to exist in all the characters under study excepting for seedling girth and number of leaves. The

* Central Plantation Crops Research Institute,
Regional Station, VITTAL 574 243, Karnataka.

mean values and range of all the characters studied are given in Table 1.

Table 1. Mean values and range of characters

Character	Mean	Range
Seed weight (g)	35.40	24.0-56.0
Time taken for germination (days)	60.69	32.0-93.0
Girth of 3 month old seedling(cm)	0.99	0.8-1.4
Height of 3 month old seedling (cm)	41.40	20.0-65.0
No. of leaves of 3 month old seedling	2.31	2.0-2.9
Time taken for flowering (years)	4.27	3.3-6.2
No. of nuts (averaged for 1972-76)	141.85	4.4-437.0
Wt. of nuts in kg (averaged for 1972-76)	5.14	0.1-18.0

Both the models of regression were fitted separately for both the yield data viz., (i) number of nuts and (ii) wet weight of nuts and found that the exponential model of regression was quite satisfactory (R^2 values being 49.83% for number of nuts and 78.42% for wet weight of nuts). The exponential model regression equations and R^2 values for both the yield characters are given in Table 2.

Table 2. Yield-morphology relationship and R^2

Dependent Characters	Equation	R^2 (%)
No. of nuts	$Y = 1.61 X_1^{1.02} X_2^{0.18} X_3^{-1.77} X_4^{0.30} X_5^{0.09} X_6^{-0.55}$	49.83*
Wt. of nuts	$Y = 1.68 X_1^{1.67} X_2^{0.34} X_3^{-1.24} X_4^{0.45} X_5^{0.09} X_6^{-0.48}$	78.42**

*Significant at $P=0.05$ **Significant at $P=0.01$

The estimates of genotypic correlations (Table 3) between the yield and the morphological characters, revealed that the

yield has significant positive correlation with the seedweight and is negatively correlated with the seedling girth and time taken for flowering. The remaining characters did not show significant correlations. Two characters viz., days taken for germination and seedling height, because of their poor correlations with the yield, were deleted for further calculation of path interrelation coefficients in order to give more emphasis for the strongly related characters.

The path interrelation coefficients of different characters and residual factors are presented in Figure 1.

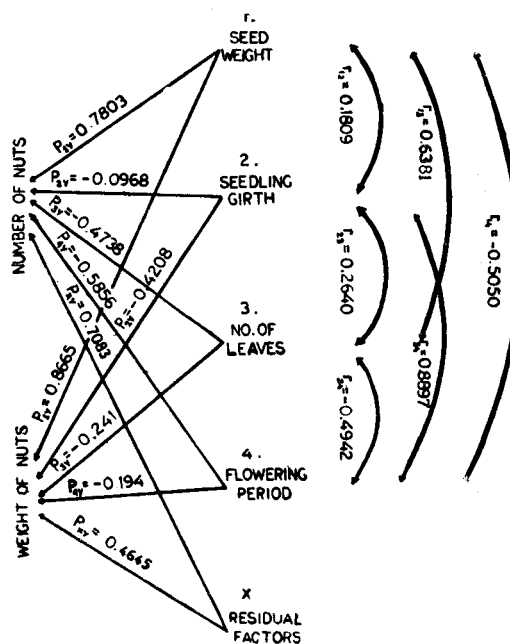


FIG. 1. PATH DIAGRAM OF FACTORS INFLUENCING ARECANUT YIELD

The direct and indirect effects of individual characters on the yield are presented in Table 3.

Table 3. Genotypic correlations, direct and indirect effects of morphological characters on yield characters

Morphological characters	Particulars	Yield characters	
		No. of nuts	Wt. of nuts
Seed weight	Genotypic correlation	0.7562**	0.7346*
	Direct effect	0.7803	0.8665
	Indirect effect through seedling girth	-0.0175	-0.0761
	Indirect effect through no. of leaves	-0.3023	-0.1537
	Indirect effect through time taken for flowering	0.2957	0.0980
Seedling girth	Genotypic correlation	-0.6017**	-0.5002*
	Direct effect	-0.0968	-0.4208
	Indirect effect through seed weight	0.1411	0.1567
	Indirect effect through number of leaves	-0.0251	-0.0636
	Indirect effect through time taken for flowering	-0.5210	-0.1725
Number of leaves	Genotypic correlation	0.0879	0.2967
	Direct effect	-0.4738	-0.2410
	Indirect effect through seed weight	0.4979	0.5530
	Indirect effect through seedling girth	-0.0256	-0.1111
	Indirect effect through time taken for flowering	0.2894	0.0959
Time taken for flowering	Genotypic correlation	-0.8316**	-0.8868**
	Direct effect	-0.5856	-0.1940
	Indirect effect through seed weight	-0.3941	-0.4377
	Indirect effect through seedling girth	-0.0861	-0.3743
	Indirect effect through number of leaves	0.2342	0.1191

*Significant at P=0.05

**Significant at P=0.01

Seed weight vs. yield

The results show that the correlation coefficient between seed weight and yield is almost equal to its direct effect, thereby explaining the true relationship that a direct selection through this trait will be effective.

Number of leaves vs. yield

Although the number of leaves is positively correlated with the yield, it shows negative direct effect and its indirect effect through seed weight is high. This suggests that number of leaves need not be taken as a causal factor and instead more emphasis may be given for the seed weight in the role of selection.

Time taken for flowering vs. yield

The direct effect of time taken for flowering is considerably low and negative, when compared to its correlation with the yield. Whereas its indirect effect through seed weight is considerably high but negative revealing that large sized nuts might nullify this indirect effect and the early flowering factor becomes one of the causal factors for the better yield.

Seedling girth vs. yield

Though the seedling girth had a significant negative correlation, its indirect effect is slightly less in the case of weight of nuts and negligible in the case of number of nuts. The indirect effect through time taken for flowering is high and negative, thereby revealing that selection of seedlings with thinner girth must be compensated by the early flowering for getting better yield.

In all it can be said that the selection of heavy nuts (say 35g and above) is one of the important causal factors for getting better yield. The time taken for flowering (less than 4½ years) also plays a major role in improving the yield.

Acknowledgement

The author expresses his deep sense of gratitude to Mr. K. N. Murthy and Mr. K. Shama Bhat, Senior Scientists of

CPCRI Regional Station, Vittal for providing facilities and encouragement. Thanks are

also due to Mr. B. P. Nair for the help rendered in the analysis.

References

CHANG, E. Y. and LAL, D. C. 1971. Genotype, phenotype correlation and Path-coefficient analysis of six important characters in tobacco crosses. *Agr. Ass. China J.* **76**: 15-22.

DEWEY, D. R. and LU, K. H. 1959. A correlation and path co-efficient analysis of components of crested wheat grass seed production. *Agron. J.* **51**: 515-518.

MILLER, P. A., WILLIAMS, V. C., ROBINSON, H. F. and COMSTOCK, R. E. 1958. Estimates of genotypic and environmental variances and co-variances in upland cotton and their implications in selection. *Agron. J.* **50**: 126-131.

POVILAITIS, B. 1965. Genotypic correlations among certain quantitative characters in tobacco. *Canad. J. Genet. Cytol.* **7**: 523-529.

TUKEY, J. W. 1954. Causation, regression and path analysis. *Statistics and Mathematics in Biology*, PP. 47-53 Kempthorne, O. (Ed.). The Iowa State College Press, Ames, Iowa.

VENKATARAO, C., NARASIMHAYYA, G. and APPARAO, K. 1973. Path analysis in Flue-cured tobacco (*Nicotiana tabacum*). *Indian J. Agric. Sci.* **43**: 198-210.

Discussions

T Krishnappa:

It has been suggested that nuts weighing 35 g and above should be selected. Does it apply to a particular variety?

Bhagavan:

The study was restricted to the South Kanara variety. (Chairman suggested that the work may be extended to *Mangala* also)

KUK Nampoothiri:

What is the stage at which weight of nuts is recorded?

Bhagavan:

Immediately after harvest.

KVJ Mohan:

What is the advantage of selecting for yield on the basis of seedling girth?

Bhagavan:

The thinner seedlings substantiate with early flowering.

M K Muliya:

Is there any additional information regarding the weight of nuts other than what is already recommended in the package of practices?

Bhagavan:

The results of the present study obtained from path analysis corroborate the earlier findings.

Performance of Areca Selections under 'Upghat' Regions

P. Bhadraiah*, H. V. Pattanshetti** and
K. Krishnamurthy***

Abstract

To study the performance of seven areca selections viz., VTL-3, VTL-11, VTL-12, VTL-13, VTL-17, Mohitnagar and Thirthahalli, a trial was laid out at Sirsi with local as control. Growth parameters for all the selections are given. VTL-11 was found to be most vigorous in growth and produced stem of highest girth and a crown of highest number of leaves. The plants have just commenced reproductive growth. From the number of inflorescences opened, VTL-11 and local collection appeared to be more precocious in bearing. Other particulars recorded in respect of the plant performance are also discussed in detail in this paper.

Introduction

Areca (*Areca catechu* L.) is one of the intensively cultivated plantation crops. There is considerably a high capital outlay in developing an areca garden. High genetic variability and longer prebearing age pose a great problem in establishing a plantation and raising a successful crop. The common practice of raising planting material from an indiscriminate seed source poses great problem in having an economically viable plantation. It was, therefore decided to study the performance of some progenies selected at the Central Plantation Crops Research Institute, Regional Station, Vittal.

* Agricultural Research Station, Sirsi, 581 401, Karnataka.

** Regional Research Station, Mudigere, 577 132 Karnataka

*** University of Agricultural Sciences, GKVK, Bangalore, 560 065, Karnataka

Materials and Methods

The studies on comparative performance of the selected progenies are being conducted at the Agricultural Research Station, Sirsi, which is located at an elevation of 619 m. The annual rainfall of the Station is 2600 mm. More than 75 per cent of the total rainfall is received during the active southwest monsoon period between June and August. The following seven selected progenies with a control formed eight treatments of the experiment. They are: (1) VTL-3, (2) VTL-11, (3) VTL-12, (4) VTL-13, (5) VTL-17, (6) Mohitnagar, (7) Thirthahalli and (8) Local. These were replicated four times. The experimental site was located in the flat bed of the valley. The seedlings were spaced 2.7m x 2.7m and planted in the year 1975. Each treatment plot consisted of 8 palms in two rows. Since the palms are still in prebearing stage, growth parameters pertaining to thickness and height of stem and number of opened leaves in the crown only are

given in detail. These figures were recorded in 1980-'81. Some of the initial observations made in respect of reproductive growth till 1982 were also recorded.

Results

VTL-11 recorded highest girth of the stem (45.2 cm). Least girth of the stem was found in VTL-12 (30.1 cm). VTL-3 recorded stem girth (38.6 cm) which approximated mean girth of 38.4 (Table 1).

Table 1. Mean values of stem girth, palm height, no. of leaves and no. of bunches.

Cultivars	Girth of stem(cm)	Palm height(cm)	No. of leaves	No. of bunches (till 1982)
VTL-3	38.6	96.9	7.1	8.7
VTL-11	45.2	112.3	8.0	14.0
VTL-12	30.1	73.9	6.4	4.2
VTL-13	41.2	88.6	7.2	4.7
VTL-17	33.8	79.5	6.3	3.0
Mohitnagar	42.6	103.4	7.8	7.5
Thirthahalli	34.9	93.0	6.5	3.2
Local	40.9	113.9	7.9	17.5
Total	307.3	761.5	57.2	62.8
Mean	38.4	95.2	7.1	7.8

As regards height of palms, local cultivar ranked first in the list (113.9 cm). This was followed by VTL-11. VTL-3 attained a height of 96.9 cm, which was slightly more than the mean height of 95.2 (Table 1).

VTL-11 had highest number of leaves (8.0). This was followed by Local which had 7.9 leaves. VTL-3 recorded 7.1 leaves and this value remained same as the mean value (Table 1).

The initial yield obtained during 1981-'82 is also presented in Table 2. The local cultivar recorded maximum weight of the raw nuts harvested. The end produce of areca on dehusking was found to be highest in VTL-3 (2.98 kg).

Table 2. Yield data for the year 1981-'82

Cultivars	Raw nuts (kg)	Dry nut (kg)	Chali (kg)
VTL-3	8.00	5.00	2.98
VTL-11	7.50	3.50	2.24
VTL-12	1.00	0.50	0.23
VTL-13	10.00	3.00	1.25
VTL-17	7.50	3.10	1.78
Mohitnagar	3.00	1.00	0.35
Thirthahalli	0.00	0.00	0.00
Local	18.00	6.00	2.57

Discussion

Both exotic and indigenous collections of arecanut cultivars have been made with a view to broaden the genetic base (Bavappa, 1977). Cultivars under trial in this study are from such a collection. Although some cultivars like VTL-11 and Mohitnagar were found to be more vigorous by way of their vegetative growth pattern, it was noticed at the initial stage of their bearing that they were not equally productive. VTL-3 now released as *Mangala* recorded highest yield in the initial stages at higher elevations. But the difference in yield is not markedly high compared to the Local. In Table 1 the current trends in reproductive growth as indicated by the number of bunches are depicted. The number of bunches in Local are twice as that of VTL-3. It remains to be seen how this reproductive growth is going to be reflected in the economic yield of areca kernel.

Reference

- ✓ BAVAPPA, K.V.A. 1977. Mangala - A superior arecanut variety. *Arecanut and Spices Bull.* 3 : 55.

Discussions

KVA Bavappa:

What is the view of the author with regard to acceptability of the introduced variety in the Malnad area?

Pattanshetty:

It is too early to draw conclusions on this.

KVJ Mohan:

You have mentioned that VTL-11 and Local are precocious. How did VTL-3 behave in this context?

Pattanshetty:

VTL-3 also was precocious.

K T Krishnappa:

How far these introduced varieties be amenable to the methods of processing adopted in the area?

Pattanshetty:

Such studies are yet to be undertaken.

Performance of Arecanut (*Areca catechu* L.) Cultivars in Konkan Region of Maharashtra

M. J. Salvi*, S. P. Singh** and S. B. Deshpande**

Abstract

A varietal trial consisting of eight promising varieties viz., VTL-3 (Mangala) VTL-11, VTL-12, VTL-13, VTL-17, Mohitnagar, Vittal local and Shriwardhan local was laid out at Dapoli in order to find out suitable arecanut variety for the Konkan Region. VTL-3 (Mangala) recorded lowest palm height (5.20 m) and VTL-13, the highest (7.14 m). The differences in girth and number of leaves in all the varieties were not significant. The duration for first flowering taken by VTL-3 was minimum (69.75 months) and that of VTL-17 was maximum (84.0 months). As regards yield, Shriwardhan local produced highest yield and Vittal local lowest. However, remaining varieties were medium yielders.

Introduction

Arecanut is a cash crop in Ratnagiri and Raigad Districts in Konkan region covering an area of 2800 ha. As arecanut is neither a food crop nor a substitute for food items, it is not advisable to increase the area under areca but the yield per unit area can be increased substantially. The local varieties growing in Maharashtra are said to be superior in quality but are prone to attack by pests and diseases. They are also characterised as late bearers. To identify cultivars suitable for cultivation in the region this study was conducted and it indicated the suitability of introducing a few cultivars for large scale adoption by the farmers in the region.

Materials and Methods

Eight varieties were used in the study and were planted during 1973 at the experimental plots of the Department of Horticulture, College of Agriculture, Dapoli, Dist. Ratnagiri. The varieties were: (1) VTL-3 (Mangala), (2) VTL-11, (3) VTL-12, (4) VTL-13, (5) VTL-17, (6) Mohitnagar, (7) Vittal Local and (8) Shriwardhan Local (as a standard). The experiment was laid out following randomised block design with 4 replications. The observations on palm height, girth, number of leaves, duration taken for first flowering and yield were recorded.

Results and Discussion

This is the ninth year (1982) of the experiment. The observations recorded on growth and yield of palms after 8 years are presented in Table 1. The variety VTL-3 recorded significantly lower palm height (5.20 m), compared to Vittal

*Department of Horticulture, College of Agriculture, Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri, Maharashtra.

**Arecanut Research Station, Shriwardhan 402 110, Maharashtra.

(5.93 m), Mohitnagar (5.98 m), VTL-17 (6.43 m), VTL-12 (6.74 m) and VTL-13 (7.14 m). However, the height of VTL-3 has been at par with that of Shriwardhan Local (5.41m) and VTL-11 (5.64m). The variety VTL-13 grew taller than the others (7.14m). The girth of the palms as also the number of leaves in the different varieties did not vary to any significant extent.

The time taken for first flowering varied considerably from 69.75 to 84 months. The variety VTL-3 flowered early (69.75 months) as compared to the varieties VTL-11 (77.25 months), Shriwardhan Local (82.75 months), Mohitnagar (83.75 months) and VTL-17 (84.0 months). However, it was at par with the varieties viz., VTL-12 (74.75 months), Vittal (74.75 months) and VTL-13 (75.75 months).

In the present study, the performance of variety VTL-3 appeared to be different

from performance reported by other workers. Bavappa (1977) reported the first flowering in VTL-3 to have occurred as early as 36 months at Vittal and Thangaraj et al. (1980) recorded the first flowering in VTL-3 in 45 months at Coimbatore. The variation in duration of first flowering by VTL-3 is possibly due to differences in agro-climatic conditions viz., temperature, humidity, rainfall, fertility level of soil, type of soil etc. which are bound to affect growth and development of plant species.

As regards the yield per palm, variety Shriwardhan Local produced highest yield whereas Vittal the lowest. However, remaining varieties were medium yielders (Table 1).

Acknowledgement

The authors are grateful to the Konkan Krishi Vidyapeeth, Dapoli, for providing necessary facilities.

Table 1. Mean palm height, girth, number of leaves and yield per palm at 9th year of planting.

Sl. No.	Varieties	Height of palm (m)	Girth of palm (cm)	No. of leaves per palm	Time taken for 1st flowering (months)	Nut yield/palm (kg)
1.	VTL-3 <i>Mangala</i>)	5.20	53.14	7.67	69.75	3.71
2.	VTL-11	5.64	56.90	6.75	77.25	3.19
3.	VTL-12	6.74	59.56	8.56	74.75	2.76
4.	VTL-13	7.14	59.29	8.02	75.75	3.84
5.	VTL-17	6.43	58.71	7.39	84.00	3.36
6.	Mohitnagar	5.98	54.64	7.13	83.75	4.34
7.	Vittal	5.93	61.56	7.70	74.75	1.38
8.	Shriwardhan Local	5.41	57.20	7.42	82.75	5.62
	SE \pm	0.26	2.76	1.61	2.37	1.11
	CD at 5%	0.64	N.S.	N.S.	6.23	N.S.

References

BAVAPPA, K.V.A. 1977. Mangala-A superior arecanut variety. *Areca nut and Spices Bull.* 3:55.

THANGARAJ,T., SUBBAIAH,R.,PONNUSWAMY, V., MUTHUSWAMY, S. and NANJAN, K. 1980, Preliminary observations on the varietal performance in Arecanut (*Areca catechu*). *South Indian Hortic.* 28 (4): 152-153.

Discussions

C K George:

How does the yield of 5.6 kg/palm/year obtained for Shriwardhan compared with that of VTL-3 and VTL-11?

S P Singh:

Yield of VTL-3 and VTL-11 are 3.71 kg and 3.19 kg respectively.

K V A Bavappa:

Is the Shriwardhan variety identified on quality basis or by shape of nuts?

S P Singh:

Quality is more considered than the shape

N T Bhat:

Whether yield is given in wet or dry weight basis?

S P Singh:

On wet weight basis.

K Shama Bhat:

Are the size and shape of Shriwardhan nuts uniform?

S P Singh:

They are variable.

Performance of VTL Cultivars of Arecanut (*Areca catechu* L.) at Coimbatore

T. Thangaraj, S. Muthuswamy, C. R. Muthukrishnan and
JBM. MD. Abdul Khader

Abstract

A trial on the comparative performance of five VTL cultivars of arecanut, viz., VTL-3 (Mangala), VTL-11, VTL-12, VTL-13 and VTL-17 with a Local (Mettupalayam) is in progress since 1974 at the College orchard, Tamil Nadu Agricultural University, Coimbatore. Biometric observations recorded in this study showed that the mean height of palms of these six cultivars ranged from 7.26 to 8.19m while the girth varied from 38.25 to 47.75cm. VTL-13 and the Local (Mettupalayam) cultivars flowered earlier in 42 months. The mean nut weight varied from 17.9g to 24.9g among the varieties. The cultivars VTL-3, 12, 13 and 17 performed alike in giving a higher processing out-turn of 5.4 per cent as compared to 4.9 per cent in the local variety. The cultivar VTL-3 consistently maintained higher yield over others with 14.81, 17.65 and 16.27kg of green nuts for the years 1979, '80 and '81 respectively which worked out to 43.0, 15.7 and 3.03 per cent more than the yield recorded by the local in the three years respectively.

Introduction

Genetic manipulations for higher yield and quality through varietal evaluation and selection is one of the earliest and known methods of crop improvement. One such attempt by Bavappa (1977) with several cultivars of arecanut including exotic types led to the isolation of *Mangala* (VTL-3) for better yields and early bearing. Some preliminary observations on the performance of five VTL cultivars including *Mangala* and Local (Mettupalayam) cultivar have been made by Thangaraj et al. (1980). This paper presents the results of further observations recorded during 1978 to 1980 in the same experiment.

Materials and Methods

The trial was laid out during 1974 in the Faculty of Horticulture, Tamil Nadu Agricultural University, Coimbatore with five arecanut cultivars, viz., VTL-3 (*Mangala*), VTL-11, VTL-12, VTL-13 and VTL-17 from CPCRI Vittal and one Local (Mettupalayam) cultivar, under the All India Co-ordinated Coconut and Arecanut Improvement Project in a randomised block design with four replications. Each treatment consisted of twelve palms.

The data on prebearing age, height of palms, girth of palms, weight of nuts and processing out-turn were gathered in different varieties.

The mean yield of raw green nuts of the cultivars were also collected and the yield data for 1979, '80 and '81 were statistically interpreted.

Results and Discussions

The data on mean height, girth, prebearing age, weight of nuts and processing out-turn are presented in Table 1.

The height of palms in the different cultivars ranged from 7.26 to 8.19 m. The palms of Mettupalayam Local were the tallest (8.19 m) followed by VTL-3 (8.13 m). The height was least in VTL-13 (7.26 m).

The girth of palms among the cultivars varied from 38.25 to 47.75 cm. The highest girth (47.75 cm) was registered in VTL-12, closely followed by VTL-3 (47.50 cm). The lowest girth was recorded in the palms of the Mettupalayam Local cultivar.

The time taken for flowering among the cultivars varied considerably from 42 to 57 months. VTL-13 and Mettupalayam Local flowered early in 42 months followed by VTL-3 and VTL-12 (45 months). VTL-11 took the longest period of 57 months for flowering.

The nut weight varied greatly from 17.9 to 24.9 g among the six cultivars. The boldest nuts were harvested from VTL-11 (24.9 g) followed by VTL-12 (23.3 g). The nuts were the smallest (17.9 g) in Mettupalayam Local.

The cultivars VTL-3, 12, 13 and 17 behaved alike in processing out-turn with 5.4 per cent recovery while the Mettupalayam Local gave the lowest recovery of 4.9 per cent.

The mean annual tree yield of raw nuts and the percentage increase or decrease over the Mettupalayam Local cultivar are presented in Table 2.

Table 1. Palm and nut characters of six arecanut cultivars at Coimbatore

Cultivars	Mean Height (m)	Mean girth (cm)	Prebearing age (months)	Mean wt. of nuts (g)	Processing out-turn (%) (wet basis)
VTL - 3	8.13	47.50	45	22.9	5.4
VTL - 11	7.65	40.30	57	24.9	5.0
VTL - 12	7.93	47.75	45	23.3	5.4
VTL - 13	7.26	45.80	42	21.1	5.4
VTL - 17	7.78	45.00	52	20.0	5.4
Mettupalayam Local	8.19	38.25	42	17.9	4.9

Height of palms (m) : The height from base to the growing bud.

Girth (cm) : The girth was measured at 30 cm height from the ground level.

Weight of nuts : The nuts were harvested at three-fourth ripe stage. 100 nuts were weighed and the mean worked out and expressed in g per nut.

Processing out-turn : Three kg of nuts were harvested at three-fourth ripe stage and processed as practised locally, weighed and the recovery of processed nuts was expressed as percentage of fresh nuts.

The yield in 1978-'79 ranged from 7.53 to 14.81 kg in the different cultivars with VTL-3 and VTL-12 recording the highest and the lowest yields respectively. VTL-12 and VTL-11 gave lower yields than Mettupalayam Local to the tune of - 27 and - 12 per cent while VTL-13 and VTL-17 recorded only a marginal increase of + 4 and + 7 per cent respectively. VTL-3, excelled in yield with a 43 per cent increase over the Local.

In 1979-'80, the yields of the cultivars ranged between 11.32 and 17.65 kg. In contrast to the previous year, VTL-12, VTL-11, and VTL-13 registered lower yields than Local by -25.7, -5.6 and - 5.8 per cent respectively. VTL-3 and VTL-17 alone excelled in yields registering an increase of + 15.7 and + 3.7 per cent over Local respectively.

The cultivars registered a mean tree yield ranging narrowly from 13.98 to 16.27 kg in 1980-'81. All the four cultivars VTL-11, 12, 13 and 17 gave lower yields than Local by - 3.16 to - 11.46 per cent. VTL-3 alone recorded a marginal increase of +3.03 per cent over Local.

The three years yield data indicated that VTL-3 excelled in performance in 1978-'79 while all the other cultivars including Local registered a gain in yields in the later two years though with a poor early start. The difference in yields in the first two years was significant whereas the difference in the third year was too low to be statistically significant. While VTL-3 was significantly superior to all the other cultivars in 1979-'80, it was on par with VTL-17 in 1978-'79 and the increase was negligible and non-significant in 1980-'81. As such it appears that no definite conclusion could be drawn from the present findings except that the cultivar VTL-3 gives higher yields in earlier years. The results of a few more years would be required for a better assessment in this crop of long life span.

Acknowledgement

The authors express their gratitude to the I.C.A.R., New Delhi for financial assistance through the All India Co-ordinated Coconut and Arecanut Improvement Project.

Table 2. Mean annual tree yield of fresh nuts during 1978-'79, 1979-'80 and 1980-'81 in six arecanut cultivars

Cultivars	1978-'79		1979-'80		1980-'81	
	a	b	a	b	a	b
VTL - 3	14.81	+43	17.65	+15.7	16.27	+3.03
VTL - 11	9.02	-12	14.39	- 5.6	14.37	- 8.99
VTL - 12	7.53	-27	11.32	- 25.7	13.98	-11.46
VTL - 13	10.79	+4	14.36	- 5.8	15.29	- 3.16
VTL - 17	11.10	+7	15.81	+ 3.7	14.39	- 8.86
Mettupalayam local	10.32	—	15.25	—	15.79	—
'F'test	HS		HS		NS	
SE ±	1.25		0.54		1.23	
CD at 5%	3.75		1.76		—	

a=Mean yield (kg)

b= Percent increase/decrease over local

References

BAVAPPA, K.V.A. 1977. Mangala - A superior arecanut variety. *Arecanut and Spices Bull.* 3:55.

THANGARAJ,T., SUBBAIAH,R., PONNUSWAMY, V., MUTHUSWAMY, S. and NANJAN, K. 1980. Preliminary observations on the varietal performance in Arecanut (*Areca catechu*). *South Indian Hortic.* 28 (4): 152-153.

Discussions

T Krishnappa:

Is *Mangala* better in quality than the Mettupalayam variety?

Thangaraj:

Quality analysis has not been done.

M Mohan Rao

Have you score-carded the varieties for the market acceptability?

Thangaraj:

We will study this aspect in due course

S Sivashankar:

Have you carried out any chemical analysis of different varieties? How does alkaloid content vary?

Thangaraj:

It has not been done.

Physiological Studies on Arecanut Palm - A Review

R. B. R. Yadava*

The arecanut palm (*Areca catechu* Linn.) is grown for betel nut which is used as masticatory. India produces ca 1.5 million t of arecanut annually grown over 1.83 million ha. Improvement of yield through proper agronomical practices, plant protection measures and selection have been done in the past two decades. The work on physiology of arecanut, though meagre, is reviewed in this paper, with suggestions for future line of work.

Morphological and Biochemical Characters

The correlation studies on various morphological characteristics and yield components have been carried out. It has been shown that yield is positively correlated with number of nuts set (Yadava et al., 1977).

The total chlorophyll content varied among the species of *Areca* studied. *A. triandra* had highest level of chlorophyll. The levels of organic acids also were significantly different among the species (Yadava and Mathai, 1972). The content of carbohydrates in relation to dry matter production was studied (Yadava et al., 1972). There was diurnal variation in the carbohydrate levels.

Button shedding

Poor fruit set and button shedding is a serious problem limiting yield in areca palm. Application of GA₃ (100 ppm), 2,4-D (50 ppm) and B-995 (200 ppm)

could improve the fruit set (Yadava et al., 1974). Spraying with growth regulators caused more fruit set and kernel yield than the control and this increase was from 5.2 to 129.6 per cent (Yadava et al., 1974).

Nutrients and Carbohydrates in Yellow Leaf Disease Affected Palms

The content of major nutrients like nitrogen, phosphorus, potassium and magnesium was less, but micronutrients like Fe and Al were higher in diseased palms (Yadava et al., 1969, 1973). The symptoms of the disease could not be reproduced in pot culture experiments (Yadava et al., 1972). Seasonal changes in carbohydrate fractions in leaves showed that the contents were higher in diseased as compared to healthy palms (Yadava et al., 1977).

Weed control

An effective control of weeds in arecanut gardens was obtained with a combination of 0.5% 2,4-D, 2,4,5-T or paraquat with 1% 'Dowpan'. Pentachlorophenol would control only the dicotyledonous weeds (Yadava et al., 1971).

Suggestions for future research

The major lines of research work in arecanut are suggested below :

- i) Photosynthetic characteristics of arecanut and its intercrops
- ii) Dry matter partitioning and developing regression equation for non-destructive determinations or related growth rates
- iii) Physiology of fruit development and immature nut fall.

* Indian Grassland and Fodder Research Institute,
Jhansi 284 001, Uttar Pradesh

References

- YADAVA, R.B.R., MOHAPATRA, A.R., MATHAI, C. K., VELLAICHAMY, K., ABRAHAM, K. J. and DEVARAJU, C. 1969. Investigation on yellow leaf disease of arecanut palm. *Ann. Rep. Arecanut Res. Stn, Vittal*. pp. 50-53.
- YADAVA, R. B. R., MATHAI, C. K. and VELLAICHAMY, K. 1971. Knowledge of herbicides as weed killers to arecanut growers. *Arecanut and Spices Bull.* 3:8-10.
- YADAVA, R. B. R. and MATHAI, C. K. 1972. Chlorophyll and organic acid contents of arecanut. *Mad. Agric. J.* 59:305-307.
- YADAVA, R.B.R., VELLAICHAMY, K. and MATHAI, C. K. 1972. Role of nutrient elements and their deficiency symptoms with reference to arecanut. *Arecanut and Spices Bull.* 3 (4) : 4-7.
- YADAVA, R. B. R., BAVAPPA, K. V. A. and MURTHY, K. N. 1972. Diurnal rhythm in dry matter accumulation and carbohydrate contents in the leaves of arecanut palm (*Areca catechu* L.). *Proc. Nat. Acad. Sci.* 42 (B) : 403-405.
- YADAVA, R. B. R., MATHAI, C. K. and VELLAICHAMY, K. 1973. Note on the investigation on the mineral accumulation of arecanut palm affected by yellow leaf disease. *Ind.J.Agric.Sci.* 43:892-894.
- YADAVA, R. B. R., MURTHY, K. N. and PILLAI, R.S.N. 1974. Effect of growth regulators on fruit setting of arecanut (*Areca catechu* L.) palms. *Curr. Sci.* 43:623-624.
- YADAVA, R. B. R., VIJAYAKUMAR, K. and MURTHY, K. N. 1977. Correlation studies in Arecanut. *Proc. Nat. Acad. Sci.* 47 (B) : 226-230.
- YADAVA, R.B.R., RADHAKRISHNAN, R. and MATHAI, C. K. 1977. Carbohydrate metabolism in arecanut (*Areca catechu* L.) leaves affected by yellow leaf disease. *Ankur* 8 (2) : 59-64.

✓Epicuticular Waxes of Arecanut Leaf

C. Chenchu Subbaiah*

Abstract

The epicuticular waxes of arecanut (Areca catechu L.) leaf contains mainly hydrocarbons, β -diketones, esters and fatty acids in that order. The first two compounds are known to offer crystalline properties to the wax and water repellent behaviour to the leaf surface. The influence of leaf waxes on foliar uptake of nutrients and chemicals would be discussed in relation to the induction of nitrate reductase activity in arecanut leaf.

Introduction

Waxy components of the leaf cuticle form a highly effective barrier to water loss from plants. In addition to the influence on cuticular transpiration, wax structure and chemical composition are known to affect the wetting and retention characteristics of foliar sprays (Holloway, 1971). Consequent penetration of these applied substances is likewise a function of wax structure, composition and quantity, all of which are highly variable among species and even on the different portions or growth stages of a single leaf (Leece, 1976; Baker et al., 1979).

Hence, to maximise the efficiency of foliar applied chemicals, an understanding of the nature of leaf surface is essential. Little information exists on the leaf surface morphology and chemical composition of epicuticular waxes in plantation crops. The present study reports the chemical composition of the arecanut leaf surface wax and its relationship to foliar penetration of nutrients.

Materials and Methods

Fully mature leaves from arecanut palms grown in the experimental plots at Vittal were used for analysing chemical composition. The epicuticular waxes were removed by dipping the leaves for 10 sec in 4 successive 50 ml portions of chloroform. All the chloroform was pooled, filtered and evaporated under room temperature. The wax was dissolved in 2 ml chloroform and was chromatographed on silica gel G plates (250 μ m thickness, activated and pre-run) in chloroform : methanol (99 : 1). Durum wheat wax was coplated for comparison. Constituents were localized with 40% H_2SO_4 (V : V) and charring at 180° C (Tulloch and Hoffman, 1971).

Nitrate ion uptake by arecanut leaf was assayed by measuring the inducible nitrate reductase activity by *in vivo* method which was essentially as described by Jaworski (1971) and modified by Subbaiah and Shivasankar (unpublished). Both young and fully expanded leaves were used for comparative purposes.

The effect of wax removal on nitrate uptake was tested by assaying NR activity after, (a) gently brushing the leaf

*Central Plantation Crops Research Institute, Regional Station, VITTAL 574 243, Karnataka.

surface by a camel hair brush 10 times in one direction or (b) by quickly wiping the leaf with 80% acetone and immediately dropping it in water.

Results and Discussion

Hydrocarbons and β -diketones were the major constituents of arecanut leaf surface wax. These are known to offer water repellent properties to the leaf surface (Freeman et al., 1979). The above components have also been shown to be responsible for the crystalline behaviour of wax and thus regulate the leaf wettability (Hunt et al., 1976). Thus the hydrophobic surface of arecanut leaf can be attributed to the nature of its epicuticular wax.

This was tested by assaying the uptake of nitrate ions by arecanut leaf through its cuticle. Nitrate uptake was measured in terms of inducible *in vivo* nitrate reductase activity. This method depends on the entry of nitrate ions into leaf cells and their reduction to nitrate (Leece and Kentworthy, 1972). As shown in Table 1, the enzyme activity was found to be more in the immature leaf than in the fully expanded leaf. This was unexpected, as the young, non-green leaf was yet to develop the full complementation of the metabolic machinery and a low level of nitrate reductase activity is usually expected at this stage of leaf ontogeny. But as the uptake of nitrate

Table 1. Effect of leaf ontogenetic status on inducible nitrate reductase activity of arecanut leaf

	NR activity (μ moles NO_2^- /g dwt/h)
Young leaf	4.73 ± 0.4
Mature leaf	1.74 ± 9.1

was promoted by the absence of any cuticular wax barrier in the young leaf its enzyme activity was higher than that of mature leaf. In a long term experiment where the leaves were incubated for 4 h in nitrate solution, the nitrate contents were similar both in the young and mature leaves. But NR activity was higher in the fully expanded leaves (Table 2), showing that uptake of nitrate was limiting the enzyme activity in the mature leaves in the short term experiment. Long term incubation might have resulted in the entry of nitrate through the stomata or gradually through the cuticle itself. Thus the waxy layer of the cuticle has acted as a barrier for the nitrate ions to enter the leaf. This was further confirmed by the increase in enzyme activity as a result of wax removal by acetone treatment. Brushing might have resulted in mechanical injury to the leaf which explains the lowered NR activity (Table-3).

Table 2. Effect of leaf ontogenetic status on nitrate uptake through cuticle and inducible NR activity. Leaves were incubated for 4 h in 0.1M KNO_3 and then taken for analysis

	NR activity (μ moles NO_2^- / g. dwt/h)	NO_3^- uptake (μ moles/g dwt/h)
Young	2.46	74.7
Mature	4.00	81.7

Table 3. Effect of wax removal on NR activity of mature arecanut leaves

	NR activity (μ moles/ NO_2^- /g dwt/h)
Control	4.55
Wax removal by	
a) brushing	3.78
b) acetone	5.95

References

- BAKER, E. A., BUKOVAC, M. J. and FLORE, J. A. 1979. Ontogenetic variations in the composition of peach leaf wax. *Phytochem.* **18**:781-784.
- FREEMAN, B., ALBRIGO, L.E. and BIGGS, R. H. 1979. Cuticular waxes of developing leaves and fruit of Blue berry *Vaccinium ashii* Reade cv, Blue Gem. *J. Am. Soc. Hort. Sci.* **104**:398-403.
- HOLLOWAY, P. J. 1971. The chemical and physical characteristics of leaf surfaces. p. 39-53. In 'Ecology of leaf surface microorganisms' (Eds. T.F. Prentice and C. H. Dickinson). Academic Press, London.
- HUNT, G. M., HOLLOWAY, P.J. and BAKER, E.A. 1976. Ultrastructures and chemistry of *Clarkia elegans* leaf wax: A comparative study with brassica leaf waxes. *Plant Sci. Lett.* **6**:353-360.
- JAWORSKI, E.G. 1971. Nitrate reductase assay in intact plant tissue. *Biochem. Biophys. Res. Commun.* **43**:1274-1280.
- LEECE, D. R. 1976. Composition and ultrastructure of leaf cuticles from fruit trees relative to differential foliar absorption. *Aust. J. Plant Physiol.* **3**:833-847.
- LEECE, D. R. and KENTWORTHY, A. L. 1972. Influence of epicuticular waxes on foliar absorption of nitrate ions by apricot leaf discs. *Aust. J. Biol. Sci.* **25**:641-643.
- TULLOCH, A. P. and HOFFMAN, L.L. 1971. Leaf wax of durum wheat. *Phytochem.* **10**:871-876.

Discussions

M Anandaraj:

Is there any difference in the wax content of the surfaces of leaf and fruit?

Subbaiah:

Such a comparative study has not been done.

M Mohan Rao:

Is the wax content high enough for commercial exploitation?

Subbaiah:

The quantity of wax in arecanut leaf is very low and hence not worthwhile for consideration of commercial exploitation.

Floral Biology of Arecanut (*Areca catechu* L.) Variety Shriwardhan Local

M. J. Salvi*, S. P. Singh** and S. B. Deshpande**

Abstract

The floral biology of arecanut (Areca catechu L.) variety 'Shriwardhan Local' was studied at Arecanut Research Station, Shriwardhan during 1980 and 1981. The mean number of spadices produced was 3.53 and 4.29 per palm in 1980 and 1981 respectively. Normally, spadices emerged during the months of January to July. The range of male flower phase was 22 to 30 days with a mean of 26.30 days and that of the female flower was 1 to 8 days with a mean of 5.9 days. Maximum receptivity of stigma was recorded between first day to third day of opening of female flower. The number of female flowers per palm ranged from 65 to 2101 in 1980 and 391 to 1672 in 1981. The average percentage of fruit set, fruit retention and fruit drop was 40.33, 72.46 and 27.54 in 1980 and 39.12, 84.49 and 15.51 in 1981 respectively.

Introduction

Arecanut (*Areca catechu* L.) is an important cash crop of west coast of India, West Bengal and Assam. It is a monocot belonging to family Palmaceae. The stem is slender with dense crown of green pinnately compound leaves with several leaflets. The initiation of flowering is influenced by soil and climatic conditions. In the Konkan region of Maharashtra, the local variety of arecanut commences flowering 6-7 years after transplanting. However, under good crop management, flowering has been found to start as early as 3 years after transplanting. There is much variation in yield up to

the age of about 12 years. Afterwards palms show their maximum yield potential with minimum variations. The studies carried out by Murthy and Bavappa (1960) show a similar result with little variation. However, such variations in the behaviour of certain floral characters and extent of fruit setting under different climatic conditions and soil types are expected. As the knowledge on floral biology is important in breeding programmes the study was carried out to obtain information on the duration of male and female phases, stigma receptivity, formation of spadices, fruit setting, fruit retention and fruit drop.

Materials and Methods

This study was undertaken at the Arecanut Research Station, Shriwardhan, Maharashtra during 1980 and 1981. Seventeen adult areca palms of Shriwardhan Local variety were selected for study. The

* Department of Horticulture, College of Agriculture, Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri, Maharashtra.

** Arecanut Research Station, Shriwardhan 402 110 Maharashtra.

production of spadices was recorded from January to December 1980 and 1981. To study the characters like per cent fruit set, fruit retention and fruit drop, observations were made in both the years from emergence of spadices to harvesting of ripe nuts. For studying the duration of male and female phases, ten adult palms were selected and one spadix of each palm was observed. The duration (days) was counted from opening of first male/female flower to the opening of last male/female flower. In order to study the receptivity of stigma, female flowers of one bunch of an adult palm were bagged and uniform number of female flowers (10) were selected and pollinated from 1st to 10th day after opening. Fruit set was recorded to judge the receptivity.

Results and Discussion

Formation of Spadices

In arecanut, formation of spadix depends upon the formation of leaf in that the production of spadices is limited to leaf axils. Probably, the absence of spadix in any particular node may be due to the abortion of the young spadix at an early stage of its development. The number of leaves and spadices produced by a palm in a year is influenced by cultivation practices, manuring and age of palm (Murthy and Bavappa, 1960). The mean number of spadices produced by each adult palm in the present study was 3.53 in the year 1980 and 4.29 in the year 1981 which is in close conformity with the findings reported by Murthy and Bavappa (1960).

The number of spadices opened was found to vary in different seasons in both the years (1980 and 1981). A large percent-

age of spadices emerged during January to July (95%). Murthy and Bavappa (1960) recorded the largest number of spadices during October to April. The differences can be due to differences in climatic conditions, soil types and variety.

Duration of male and female phases

It has been observed that the male flowers open from the tip of the filament and continue downwards to the base. The data on the duration of male and female phases revealed that the interval between the opening of the first male flower to the last flower ranged from 22 to 30 days with a mean of 26.3 days. It has been observed that normally the male flowers shed on the same day of its blooming. Similar results have been reported by Murthy (1977).

In general, as soon as male flower phase is over, the female flower phase is initiated. The flowers start to open from the base of the rachis and continue upwards. The duration of female phase ranges from 5 to 8 days with a mean of 5.9 days. As mentioned above the female flower phase, in general, starts when the male flower phase ends. However, in the present study, an overlapping of male and female phases has also been recorded for 2 days in one palm and for 4 days in another, out of the ten palms studied.

Stigma receptivity

The observations recorded on stigma receptivity showed that the maximum receptivity of stigma was between first and third day of opening of female flower. Beyond the third day, the receptivity of stigma declined and after 6 days of opening of flower the stigma lost receptivity.

Number of female flowers, fruit set, fruit retention and fruit drop

The number of female flowers per palm was counted and the data are given in Table 1 which show that the range of production of female flowers per palm was from 65 to 2101 in 1980 and from 391 to 1672 in 1981.

The percentage of fruit set ranged from 2.71 to 89.91 with a mean of 40.33 in 1980 and from 16.50 to 65.43 with a mean of 39.12 in 1981. A variation in

fruit set was also recorded which may be due to a failure in pollination and fertilization (Raghavan and Baruah, 1956).

Under the natural climatic conditions the percentage of fruits retained was as high as 100 and as low as 30 with a mean of 72.46 in 1980 and 84.49 in 1981 (Table 1).

Acknowledgement

The authors are thankful to the Konkan Krishi Vidyapeeth, Dapoli for providing necessary facilities.

Table 1. Mean no. of female flowers, percentage of fruit set and fruit retention (1980 and 1981)

Sl. No.	Characters	1980	1981
1.	No. of female flowers	827.52 (65-2101)	1078.23 (391-1672)
2.	Percentage of fruit set	40.33 (2.71-89.91)	39.12 (16.50-65.43)
3.	Percentage of fruit retention	72.46 (30-100)	84.49 (49.07-98.16)

Values in parenthesis indicate the range

References

- MURTHY, K. N. 1977. Floral and pollination biology of betel nut palm. *J. Plant. Crops.* **5** (1): 35-38.
- MURTHY, K. N. and BAVAPPA, K. V. A. 1960. Floral biology of arecanut. *Arecanut J.* **11** (2): 51-55.
- RAGHAVAN, V. and BARUAH, H. K. 1956. On factors influencing fruit set and sterility in arecanut (*Areca catechu* Linn). Studies on pollen grains. *J. Indian Bot. Soc.* **35**:139-151.

Session 2

**Agronomy
And
Soil Science**

Chairman : M A Singlachar

**Rapporteurs : K B A Khader
N T Bhat**

✓ Irrigation Requirements of Arecanut (*Areca catechu* L.)

K. B. Abdul Khader, N. Yadukumar and K. Shama Bhat*

Abstract

For determining the optimum depth of planting areca seedlings and optimum intervals of irrigation, an experiment was laid out at Central Plantation Crops Research Institute, Regional Station, Vittal in 1966 using a 4 × 3 × 5 strip plot design with four intervals of irrigations viz., 5, 10, 15 and 20 days and three depths of planting at 30, 60 and 90 cm. Irrigation once in 5 days at 200 l of water per palm had better growth and produced significantly higher yield than the rest of the irrigation treatments. Palms irrigated once in 5, 10, 15 and 20 days resulted with a cost benefit ratio of 3.1, 2.9, 1.02 and 0.19 respectively. The seasonal water requirement of arecanut was found to be 80.80 cm.

Planting seedlings at 90 cm depth had given significantly more weight of nuts than planting at 30 and 60 cm depths. The treatment combination of planting at 90 cm depth and irrigation frequency of 5 days interval proved significantly superior to the rest of the treatment combinations.

Introduction

Arecanut is grown both under irrigated and rainfed conditions. In places with high sub soil moisture and in areas where the rainfall is fairly uniform and well distributed, no irrigation is practised. The palms are irrigated in places having a long dry spell from December to May. Nambiar (1949) pointed out the need for investigating the effect of irrigation on growth and yield of areca palms. Sadanandan (1973) reported that irrigation once in 3 days at the rate of 189.2 l of water per palm, giving a duty of 1309 cusec / ha resulted in maximum production at Peechi (central Kerala). The depth at which the areca seedlings are planted depends on the nature of the soil, the level of water table

and topography of land. Sadanandan(1973) observed that planting arecanut seedlings at a depth of 90 cm gives significantly more yield than planting at 30 and 60 cm depths.

The object of the present investigation was to study the effect of planting arecanut seedlings at different depths and frequency of irrigation on its growth and yield under conditions prevailing in coastal Karnataka.

Materials and Methods

The trial was laid out at CPCRI Regional Station, Vittal, Karnataka in 1966 using 4 × 3 × 5 strip plot arrangement in R. B. design with four intervals of irrigation, viz., 5, 10, 15 and 20 days and three depths of planting viz., 30, 60 and 90 cm. The soil contained 29% clay and is texturally classified

*Central Plantation Crops Research Institute,
Regional Station, Vittal 574 243, Karnataka

as sandy clay (Mohapatra, 1977). Moisture content at 0.15 atm. pressure at 0 to 50 cm depth was 23.54% and at 50 to 100 cm depth it was 23.64% (pressure plate apparatus). At 15 atm. pressure, from 0 to 50 cm depth the moisture content was 13.01% and from 50 to 100 cm depth, it was 14.42%. The saturated hydraulic conductivity was 95 m / hr at 0 to 50 cm depth and at 50 to 100 cm depth it was 99 m/hr.

Irrigation channels were provided in between two rows of arecanut palms and water was supplied by splashing to the basins as well as interspaces.

Irrigation was given at the rate of 200 l per palm per irrigation. Water was diverted to the plots from channels plastered with cement and measurement of water was done by using 'U' shaped syphons. Four syphons were used at a time for 15 min to deliver 13,000 l of water per plot distributed uniformly among 65 palms. The palms were irrigated from second fortnight of November to first fortnight of May.

The palms were manured with urea, super phosphate and muriate of potash to supply 100g N, 40g P₂O₅ and 140 g K₂O per palm per year in two split doses, one in September and another in February. In addition, 12 kg each of green leaf and cattle manure were also applied in September - October. Forking the garden once in a year and spraying Bordeaux mixture against Mahali disease (*Phytophthora arecae*) were the cultural operations practised. The mean monthly maximum and minimum temperature, relative humidity, rainfall and evaporation rates were recorded during

the experimental period (Fig. 1). The study was conducted for seven years (1966 to 1973). The observations on growth and yield were recorded and subjected to statistical analysis.

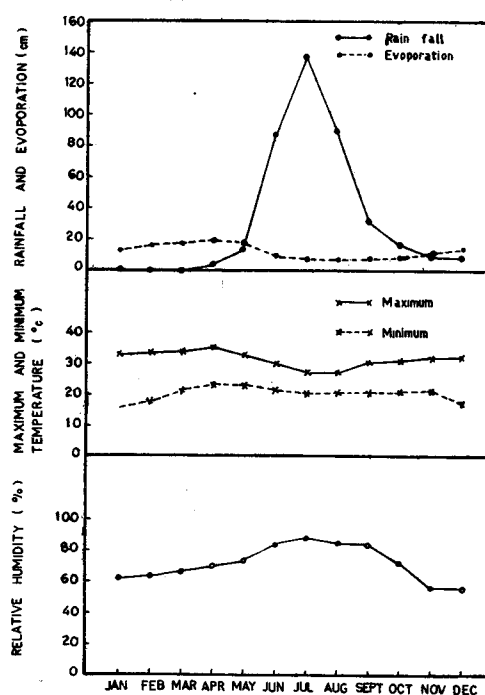


FIG. 1. METEOROLOGICAL DATA DURING THE EXPERIMENTAL PERIOD (1966 - 1972)

Results

The growth characters (Table 1) of palms recorded during 1971 (five years after planting) revealed that the palms under irrigation once in 5 days recorded significantly more girth (50.1 cm) than the rest of the treatments. The palms which received irrigation once in 5 and 10 days produced significantly more number of nodes (13.9 and 13.3 respectively) than those which received irrigation once in 15 days and 20 days (11.2 and 11.3 respectively). Similarly the palms irrigated once in 5 and 10 days had

produced significantly more number of leaves (10.2 and 9.8) than irrigation once in 20 days. There was no significant difference in the height of palms.

The yield data (Table 2) recorded during 1970-'71 to 1973-'74 revealed that the palms irrigated once in 5 and 10 days had produced significantly more number and wet weight of nuts than those received irrigation once in 15 and 20 days intervals.

Among the depth of planting, the seedlings planted at 90 cm depth had produced significantly more number and wet weight of nuts. The interaction between irrigation and depths was also found to be significant. Irrigation once in 5 days and planting seedlings at 90 cm depth was found to be the best and resulted in production of maximum number of nuts (1784.6).

Table 1. Growth characters as affected by irrigation and depth of planting (1971)

Growth parameters Treatments*	Height (cm)				Girth (cm)				No. of nodes				No. of leaves			
	D ₁	D ₂	D ₃	Mean	D ₁	D ₂	D ₃	Mean	D ₁	D ₂	D ₃	Mean	D ₁	D ₂	D ₃	Mean
I ₁	169.6	206.2	178.8	184.9	49.4	51.6	49.4	50.1	13.1	15.0	13.6	13.9	9.8	10.3	10.5	10.2
I ₂	150.8	177.1	165.5	164.5	45.5	47.9	48.8	47.4	12.6	13.8	13.4	13.3	9.5	9.9	10.0	9.8
I ₃	107.2	134.3	138.7	126.7	43.5	43.9	47.3	44.9	10.3	11.6	11.6	11.2	9.5	9.4	9.9	9.6
I ₄	107.6	121.8	115.0	114.8	45.4	45.2	47.8	46.1	10.8	11.5	11.5	11.3	9.0	9.3	9.4	9.2
Mean	133.8	159.9	149.5	147.7	45.9	47.1	48.3	47.1	11.7	13.0	12.5	12.4	9.5	9.7	9.9	9.7
CD (P=0.05) for irrigation	NS				1.6				1.9				0.4			
CD (P=0.05) for depth	NS				NS				NS				0.5			

Table 2. Yield of arecanut as affected by irrigation and depth of planting (Mean for 1970-'71 to 1973-'74)

Treatments *	No. of nuts / plot				Wt. of nuts / plot (kg)			
	D ₁	D ₂	D ₃	Mean	D ₁	D ₂	D ₃	Mean
I ₁	1070.3	1348.6	1784.6	1401.2	36.7	47.9	58.8	47.8
I ₂	1056.2	1019.4	1644.9	1240.2	35.2	32.9	52.6	40.3
I ₃	376.6	680.6	654.5	570.6	13.8	23.9	22.9	20.2
I ₄	416.9	386.0	355.8	386.3	12.2	11.7	11.6	11.8
Mean	730.0	858.7	1110.0	899.5	24.5	29.1	36.5	30.0
CD (P=0.05) for irrigation	315.2				10.6			
CD (P=0.05) for depths	234.2				6.6			
CD (P=0.05) for IxD	299.3				8.3			

*Treatment	Irrigation interval (days)	Treatment	Depth of planting (cm)
I ₁	5	D ₁	30
I ₂	10	D ₂	60
I ₃	15	D ₃	90
I ₄	20		

The economic analysis (Table 3) indicated that the treatment receiving irrigation once in 5 days resulted in a gross income of Rs. 19,400/ha as compared to Rs. 4712.0/ha in treatment receiving water once in 20 days. The net income in the treatment with irrigation once in 5 days was Rs. 14,675.0 and Rs. 779.0 with irrigation once in 20 days. The highest cost benefit ratio of 3.1 was obtained in the irrigation treatment of once in 5 days. In the treatments receiving irrigation once in 10 and 15 days the cost benefit ratios were 2.9 and 1.02 respectively.

Discussion

The experimental site at Vittal is characterised by tropical climate with high air temperature and evaporation (Fig.1) which results in high evapotranspiration demand of the crop. Therefore, the higher frequency of irrigation resulted in significantly higher yield over wider intervals. As the frequency of irrigation increases the average soil water potential also increases which eliminates the fluctuations of water content in the soil. The significant increase in crop yield at closer intervals of irrigation i. e., once in 5 days with 200 l of water

suggests that this maintained optimum water potential in the effective root zone of areca palms.

The study of growth characters also evidenced that closer intervals of irrigation (once in 5 days) resulted in greater height, girth at collar, number of nodes and number of leaves than rest of the intervals. This significant increase in growth components may be attributed to the better plant-water balance and to the increased nutrient uptake by areca palms due to probable creation of optimum soil water potential by irrigating at closer interval. The higher yield obtained in the treatment receiving irrigation once in 5 days may be consequent to the better growth and vigour of the palms as evidenced in this experiment.

The economic analysis revealed that for higher returns it is imperative to irrigate arecanut palms at closer intervals. Though the cost of irrigation is more for increasing the frequency of irrigation, the ultimate cost benefit ratio is more in the palms irrigated at closer intervals (3.1). In the palms, which received irrigation once in 20 days, the amount spent on irrigation is the minimum but the cost benefit ratio is also

Table 3. Economics of irrigation in arecanut

Irrigation interval (days)	Depth of water applied/season (cm)	Yield of chali (kg / ha)	Value @ Rs 8 / kg (Rs / ha)	Total man days required for irrigation	Cost of labour for irrigation @ Rs 6/head (Rs / ha)	Total cost of cultivation (Rs / ha)	Net return (Rs / ha)
5	88.80	2425.0	19400	180	1080	4725	14675
10	44.40	2041.0	16328	90	540	4185	12143
15	29.60	1014.0	8112	60	360	4005	4107
20	23.68	589.0	4712	48	288	3933	779

Cost benefit ratio :

$$I_1 = 3.1$$

$$I_3 = 1.02$$

$$I_2 = 2.90$$

$$I_4 = 0.19$$

below one (0.19). The study also brings out that the beneficial influences of all other inputs will not be expressed if the irrigation water is limited. It is also obvious that these expressions diminish with decrease in frequency of irrigation and may also result in loss at a particular stage, as in the case of irrigation once in 20 days.

The optimum depth of planting areca seedlings was found to be 90 cm. Surface planting often results in poor root growth and more so in hard sub soil encountered in shallow laterites. The restricted root growth in the surface planted seedlings might have been the possible cause for lower yield in the palms planted at 30 and 60 cm than those planted at 90 cm depth.

The method of approach in the present study to determine the irrigation requirement of arecanut palm, though is very preliminary, it can be concluded that irrigation once in 5 days with 200 l of water per palm in each irrigation and planting seedlings at 90 cm depth is optimum for arecanut under the well drained laterite soils. The results of a subsequent and more systematic study on the above aspects are presented elsewhere in this proceedings (Yadukumar et al., 1984).

Acknowledgements

The authors are thankful to Dr. K. V. Ahamed Bavappa, Director and Shri E. V. Nelliath, Head of the Division of Agronomy, CPCRI, Kasaragod for the facilities provided for carrying out these studies and for their valuable suggestions.

References

MOHAPATRA, A. R. 1977. Soil fertility research in arecanut: A review. *Plant. Crops*. **5** (2) 114-120.

NAMBIAR, K. K. 1949. *A survey of arecanut crop in Indian Union*: Indian Central Arecanut Committee, Calicut pp. 74.

SADANANDAN, A. K. 1973. Water requirement of arecanut. *Indian J. Agric. Sci.* **43**: 483-485.

YADUKUMAR, N., KHADER, K. B. A. and BHAT, K. S. 1984. Scheduling of irrigation for arecanut with pan-evaporimeter. *Proc. SIJAR CPCRI Vittal* pp 33-36

Discussions

V Gopala Swamy:

Will the economics given by you hold good if you are not taking into consideration the water holding capacity and other soil characteristics in arriving at the water efficiency for arecanut?

K B A Khader:

Water holding capacity and other soil characteristics (chemical and physical) have been taken into consideration.

U V Sulladmath:

Irrigation scheduling should have been associated with available soil moisture levels. Why was this not done?

K B A Khader:

The first part of the experiment was to compare the farmers' practice and in the second part the ASW concept was taken into consideration.

K J Abraham:

What was the basis for fixing 200 l of water per palm per irrigation? Was it followed by soil moisture determination?

K B A Khader:

The depletion pattern of soil moisture was worked out and based on that the quantity of water was fixed.

Scheduling Irrigation for Arecanut with Pan-Evaporimeter

N. Yadukumar, K. B. A. Khader and K. Shama Bhat*

Abstract

Studies were conducted over a period of four years for scheduling irrigation in arecanut based on Cumulative Pan Evaporation (CPE). The levels of irrigation to CPE used were (1) 30mm irrigation for 30mm evaporation, (2) 30mm irrigation for 60mm evaporation, (3) 60mm irrigation for 60mm evaporation and (4) 60mm irrigation for 120mm evaporation. The field trial was laid out at CPCRI Regional Station, Vittal conforming to strip plot design with above four irrigation treatments with three depths of planting of arecanut at 30, 60 and 90cm and five replications. Significant effect on the yield of arecanut was recorded with 30mm irrigation for 30mm evaporation and this was found to be better in terms of economic returns than the other schedules. Under circumstances when water supply and energy become critical, scheduling irrigation with 30mm water for 60mm CPE was also found to be beneficial.

Introduction

Irrigation is an important component in the management of arecanut in areas where monsoon is only seasonal. In Dakshina Kannada District of Karnataka where arecanut is cultivated extensively, there is a need to irrigate the crop during the dry weather period extending from mid-November to May. Earlier studies conducted at CPCRI, Regional Station, Vittal have indicated that irrigation once in five days is optimal for higher yield of arecanut (Anonymous, 1972 and Khader et al., 1984). Additionally, planting seedlings at a depth of 90 cm was found to be better than planting at shallower depths (Sadanandan, 1973). More recent work on the irrigation scheduling for crop plants have shown that it is realistic to schedule irrigation based on evapotranspiration

than on arbitrary approach depending on frequency and quantity of water applied. Keeping this in view, an experiment was initiated during the year 1974-'75 for scheduling irrigation in arecanut based on CPE. An attempt was also made to study the depth of planting arecanut by integrating three different depths of planting along with the irrigation schedules. The studies were conducted over a period of four years and the results obtained are presented in this paper.

Materials and Methods

The experiment was laid out at CPCRI, Regional Station, Vittal during the year 1974 in an established eight year old arecanut plantation. The palms were initially planted with 3 depths of planting and were uniformly irrigated with 200 l of water every five days during December to May.

*Central Plantation Crops Research Institute, Regional Station, Vittal 574 243, Karnataka

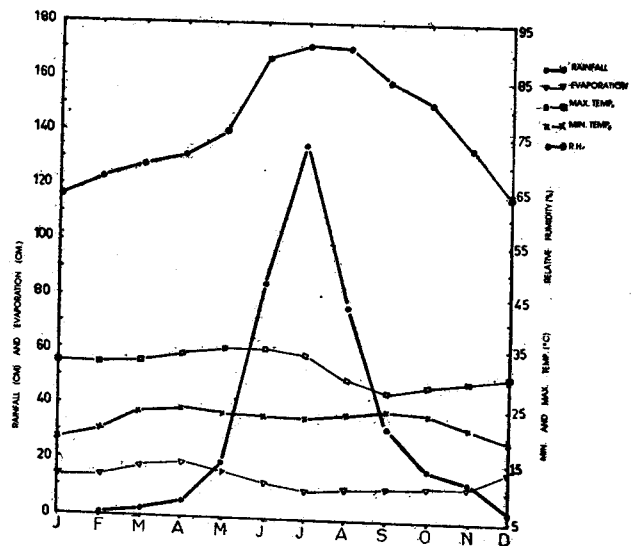
The irrigation treatments were superimposed on this by integrating the different depths of planting so as to obtain five replications for each treatment. There were four main irrigation treatments viz., (1) I_1 -irrigation 30 mm when cumulative pan evaporation reaches 30 mm; (2) I_2 -irrigation 30 mm when cumulative pan evaporation reaches 60 mm; (3) I_3 -irrigation 60 mm when cumulative pan evaporation reaches 60mm and (4) I_4 -irrigation 60 mm when cumulative pan evaporation reaches 120 mm.

The three depths of plantings were 30, 60 and 90 cm. For each treatment combination, 9 palms were available. The total plant population in the garden was 1200, out of which 540 palms were experimental. The remaining palms represent the border rows on all four sides of the plot. The palms were spaced 2.6x2.6 m apart. The layout conformed to a 4 x 3 x 5 strip plot arrangement in RB design.

The irrigation was provided through surface conveyance and water was conveyed to the plots by using syphons from a main cement lined channel. 'U' shaped syphons of 1 m length and 5 cm diameter were used and 5 such syphons could discharge 30 mm water in 15 min.

The water evaporation was monitored using an open pan evaporimeter conforming to USWB class-A specifications. The irrigation scheduling was done as detailed above. The data on maximum and minimum temperature, relative humidity, evaporation rate and rainfall were collected (Fig. 1). Irrigation was provided from second half of November to the end of May each year. There was only occasional precipitation during the irrigation period which was accounted for while scheduling the irrigation.

FIG. 1. METEOROLOGICAL DATA DURING 1974-77.



The data on nut yield in terms of number and fresh weight were collected during each harvest and pooled to obtain year-wise yield. Statistical analysis was done on pooled yield data obtained over the four year experimental period.

The soil moisture content was determined by the gravimetric method of Piper (1950) under the different irrigation treatments from 0-90 cm depth just prior to each irrigation and on the day following irrigation.

Results and Discussion

The data on number and wet weight of nuts as affected by irrigation and depth of planting (Table 1), revealed that irrigation with 30 mm water when the CPE approached 30mm (I_1) was significantly superior

to I₃ and I₄, whereas it was on par with I₂. This clearly brings out that arecanut is fairly sensitive to moisture stress and requires irrigation to be provided at more frequent intervals.

Soil moisture content ranged between 19.5 to 21.4 per cent subsequent to irrigation and reduced considerably to about 12.1 per cent within a period of 5 to 10 days before the next irrigation in treatments I₁, I₂ and I₃ irrespective of the quantity of

water used, while in I₄ the reduction (8.8%) in moisture content was even more prominent just before the next irrigation (Fig.2). Though the total quantity of water irrigated was the same for I₃ and I₁ treatments the frequency of irrigation in I₃ was only the half of that in I₁ resulting in wide fluctuations in soil water and a longer period of moisture stress thereby resulting in decreased nut yield. Such an effect of moisture stress on yield of crops has been observed by Bresler (1977).

FIG. 2. SOIL MOISTURE CONTENT UNDER DIFFERENT DEPTHS OF IRRIGATION

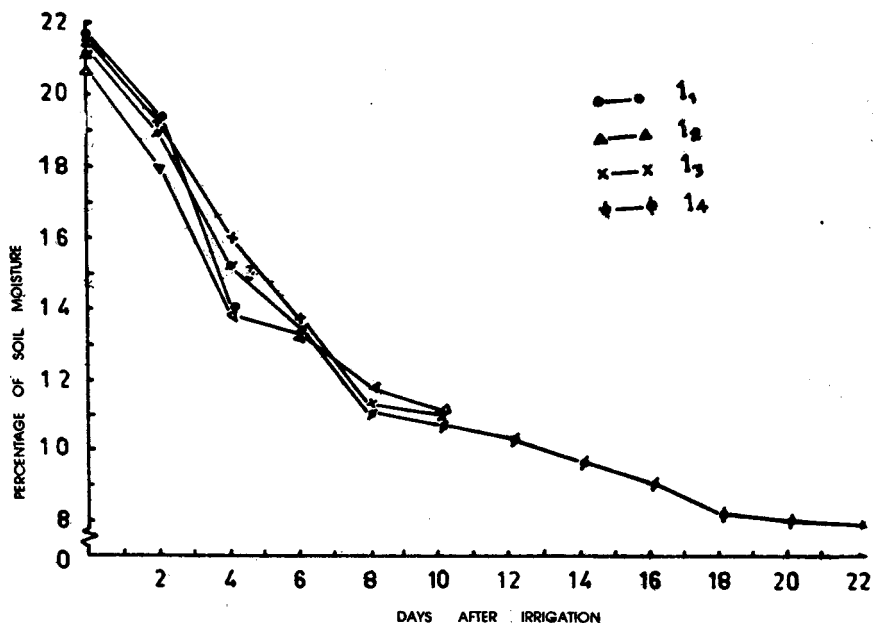


Table 1. Effect of irrigation and depths of planting on the number of nuts and weight of ripe nuts / palm

Irrigation treatments	No. of nuts / palm Depth of planting				Weight of ripe nuts (kg)/palm Depth of Planting			
	30cm	60cm	90cm	Mean	30cm	60cm	90cm	Mean
I ₁	248.38	229.55	267.11	248.34	8.59	8.60	9.56	8.91
I ₂	184.48	119.57	243.13	209.06	6.64	7.31	8.03	7.32
I ₃	147.97	221.43	195.39	188.26	4.93	7.92	7.92	6.71
I ₄	129.42	116.73	120.11	122.08	4.50	4.03	4.30	4.27
Mean	177.56	191.82	206.43	—	6.16	6.96	7.29	6.80
CD for Irrigation (P=0.05)	—	—	—	50.92	—	—	—	1.74

Though in the treatments I₂ and I₃ the frequency of irrigation was the same, I₂ had received only half the quantity of water than that of I₃. Here, again the differences in the nut yield were not significant showing that reducing the frequency of irrigation by increasing the quantum of water applied is not beneficial as the excess water supplied is not advantageous for plant use.

Economics of irrigation scheduling worked out based on the yield, volume of water required, frequency of irrigation and

the cost of irrigation (Table 2), revealed that the monetary return with I₁ was Rs. 13,000 with 34 irrigations and an application of 1020 mm of water. When only 17 irrigations were given with 510 mm of water applied, the monetary return was Rs. 10,072 (I₂). These results have clearly demonstrated that the best irrigation schedule is 30 mm water when CPE approaches 30 mm. But under situations of limitations of water and energy supply, the scheduling can be extended at 30 mm water when CPE reaches 60 mm (I₂), minimising water and energy use.

Table 2. Economics of irrigation treatments in arecanut

Treatments	No. of irrigations	Total depth of water applied during the season (mm)	Yield (kg / ha)	Value of produce @ Rs. 8/kg (Rs/ha)	Labour engaged (man days)	Cost of labour @ Rs 8/day (Rs / ha)	Total cost of cultivation (Rs / ha)	Profit (Rs / ha)
I ₁	34	1020	2545	20360	170	1360	7360	13000
I ₂	17	510	2094	16752	85	680	6680	10072
I ₃	17	1020	1922	15376	90	720	6720	8656
I ₄	8	480	1221	9768	48	384	6384	3365

References

- ANONYMOUS. 1972. Annual Report, CPCRI, Kasaragod, p.92.
- BRESLER, E. 1977. Trickle - Drip irrigation *Adv. Agron.* **29** : 344 - 395.
- KHADER, K.B.A., YADUKUMAR, N. and SHAMA BHAT, K. 1984. Irrigation requirements of arecanut (*Areca catechu L.*) Proc. SIJAR CPCRI Vittal, PP. 27-32.
- PIPER, C. S. 1950. 'Soil and Plant Analysis' Interscience Publishers, New York. 56-62.
- SADANANDAN, A. K. 1973. Water requirement of Arecanut. *Indian Agric. Sci.* **43** : 483 - 485.

Discussions

P M Gowda:

The net return from treatment I_2 may be worked out by considering the cost of providing additional 510 mm. I feel that the deep planting (90cm) with I_2 might be as efficient as I_1 at other depths. Examination of data of net returns due to interactions may be worthwhile.

N Yadu Kumar:

There was no response to depths of planting after a period of 5 years.

P Rethinam:

The experiment was continued from the earlier irrigation experiment wherein the yield potential under different treatments are highly varying. The same treatment effect will continue if the yield is recorded from 1975-'78. The pretreatment yield variance in different treatments are already very high due to previous experiment effect.

N Yadu Kumar:

Pretreatment data were taken into consideration before conclusions were drawn.

S Bhagavan:

Covariance analysis may be attempted to nullify the effect of superimposition of the treatments.

Nutritional Studies in Areca under "UPGHAT" Region

P. Bhadraiah*, H. V. Pattanshetti** and K. Krishnamurthy***

Abstract

Areca standards planted with pepper at the Agricultural Research Station, Sirsi, located at an elevation of 619m were subjected to a 3³ nutritional trial consisting of three levels of N (100, 200 and 300g/palm), three levels of P (40, 80 and 120g/palm) and three levels of K (100, 200 and 300g/palm) through a factorial design with two replications. The seedlings were planted with a spacing of 3.6m × 1.8m in a flat bed of valley. Since the pepper vines suffered high mortality due to wilt the whole experiment virtually became areca nutritional trial. The wet weight of nuts harvested was recorded palm-wise and it was found that during both years, 1979-'80 and 1980-'81, treatment N₁P₂K₃ recorded highest yields of 19.9 and 18.2 kg/palm respectively. The full details of the yield of nuts as influenced by the different treatments are dealt in the paper.

Introduction

Considerable area under arecanut in Karnataka falls in the interior regions of the State. This region can be further divided into two distinct agroclimatic zones; one consisting of heavy rainfall hill tract of *Malnad* region and the other consisting of comparatively drier tract in plains of transitional belt of Karnataka. The areca cultivation of *Malnad* zone has a unique cultural system. Areca in this zone is grown in the beds of the valleys as an entire crop but is invariably mixed with pepper, cardamom and banana and the whole garden is termed as mixed spice garden. This cropping system is very common in Sirsi area of Uttar Kannada district.

The plants in the garden are not generally applied with inorganic fertilizers. To replenish the soil with nutrients leafy twigs from the forest trees in the hillocks (*betta*) are cut and used as mulching material. This is coupled with the application of red earth collected from the neighbouring virgin soil. But with the continued cultivation of areca over a longer generation and the improper management of the *betta* land, it has become difficult to cope up with the manurial requirements in the present day. It was, therefore, considered desirable to study the effect of inorganic fertilizer on the yield of the crop and fertility of the soil.

Materials and Methods

The study was undertaken at the Agricultural Research Station, Sirsi, which is located at an elevation of 619m above MSL with a rainfall of 2600mm per annum. Areca seedlings were planted in 1964 and

*Agricultural Research Station, Sirsi, 581 401, Karnataka.

**Regional Research Station, Mudigere, 577 132, Karnataka.

***University of Agricultural Sciences, GKVK, Bangalore, 560 065.

treatments were superimposed adopting 3³ factorial design. Three levels of three major nutrients consisting of 100, 200 and 300g of N; 40, 80 and 120g of P and 100, 200 and 300g of K per palm per year were applied to the adult palms. Spacing of 3.6 × 1.8m was provided. Each treatment plot consisted of 6 palms in two rows. A common guard row was retained around the treatment plots. The treatments were replicated twice. The yield of arecanuts for individual palms was recorded for the years 1979-'80 and 1980-'81.

Results and Discussion

During 1979-'80 highest yield of 19.92 kg/palm/year of raw nuts was obtained from the treatment N₁P₂K₃ receiving 100g of N, 80g of P and 300g of K as against an average of 12.44 kg of nuts per palm per year for the entire area. Lowest yield of 5.96 kg/palm/year was recorded in treatment N₃P₁K₁ receiving 300g of N, 40g of P and 100g of K.

During 1980-'81 it was interesting to note that same treatment, N₁P₂K₃ recorded highest yield of 18.20 kg/palm/year. The treatment N₁P₁K₂ (100, 40, 200g / palm) gave the lowest yield of 5.55 kg/palm/year.

It is significant to note that the average yield for the two years mentioned above indicates the favourable and

consistent response of the palms to N₁P₂K₃ (100, 80 and 300g/palm/year). The average yield of this treatment for the two years is 19.06 kg as against a mean yield of 12.49 kg/palm/year for the experimental garden.

In perennial crops where the plant material is considerably variable in its inherent yield potential, it is generally very difficult to ascertain the consistent response of the plants to a particular dose and proportion of N, P and K. Bhat (1978) made a review of the manurial experiments in arecanut and concluded that areca palms favourably respond to 50 to 100g of N, 40g P₂O₅ and 70 to 140g of K₂O per palm per year. In the present experiment it may be noted that areca is used as a standard to pepper vine and it is very difficult to isolate the treatment effects on a particular crop. Sadanandan (1972) reported that N at 100g and K at 140g per palm individually increased the nut production and its relative weight significantly. The influence of P was not significant on any of the character except on an initial increase of height and percentage of spadices to leaf fall. In the present experiment the combination of N, P and K involving low level of N (N₁) medium level of P (P₂) and highest level of K (K₃) has given favourable response. This can be attributed to *malnad* soils which are rich in organic matter, low in P₂O₅ and medium in K₂O.

Table 1. Average yield of arecanut (kg/palm)

Sl. No.	Treatment*			yield of arecanut		Average yield
				1979-'80	1980-'81	
1.	N ₁	P ₁	K ₁	12.49	12.43	12.46
2.	N ₁	P ₁	K ₂	8.85	5.55	7.20
3.	N ₁	P ₁	K ₃	17.64	17.12	17.38
4.	N ₁	P ₂	K ₁	14.30	15.88	15.09
5.	N ₁	P ₂	K ₂	18.85	11.69	15.27

Sr. No.	Treatment*			Yield of arecanut		Average yield
				1979-'80	1980-'81	
6.	N ₁	P ₂	K ₃	19.92	18.20	19.06
7.	N ₁	P ₃	K ₁	12.32	9.57	10.94
8.	N ₁	P ₃	K ₂	15.80	8.47	11.63
9.	N ₁	P ₃	K ₃	10.68	14.08	12.38
10.	N ₂	P ₁	K ₁	8.13	14.30	11.22
11.	N ₂	P ₁	K ₂	15.23	16.03	15.63
12.	N ₂	P ₁	K ₃	10.42	12.34	11.38
13.	N ₂	P ₂	K ₁	15.00	10.40	12.70
14.	N ₂	P ₂	K ₂	10.00	10.63	10.31
15.	N ₂	P ₂	K ₃	13.10	14.38	13.74
16.	N ₂	P ₃	K ₂	6.15	9.47	7.81
17.	N ₂	P ₃	K ₂	12.12	13.47	12.84
18.	N ₂	P ₃	K ₃	12.75	13.27	13.01
19.	N ₃	P ₁	K ₁	5.96	14.19	10.07
20.	N ₃	P ₁	K ₂	15.49	16.89	16.19
21.	N ₃	P ₁	K ₃	9.58	9.00	9.29
22.	N ₃	P ₂	K ₁	13.92	11.40	12.66
23.	N ₃	P ₂	K ₂	8.35	14.92	11.63
24.	N ₃	P ₂	K ₃	9.50	14.15	11.83
25.	N ₃	P ₃	K ₁	13.38	11.73	12.55
26.	N ₃	P ₃	K ₂	13.25	10.36	11.80
27.	N ₃	P ₃	K ₃	12.74	9.33	11.03
				12.44	12.56	12.49
* g / palm:	N ₁	100	P ₁	40	K ₁	100
	N ₂	200	P ₂	80	K ₂	200
	N ₃	300	P ₃	120	K ₃	300

References

- BHAT, K. S. 1978. Agronomic research in arecanut - A review. *J. Plant. Crops* 6:67-80.
- SADANANDAN, A. K. 1972. Effect of nitrogen, phosphorus, potash and green leaves on growth, early bearing and yield of arecanut. *Proc. Third International Symposium on Sub-Tropical Horticulture, Bangalore* (Unpublished).

Discussions

M Mohan Rao:

Have you worked out the analysis of Co-variance since the population is highly heterozygous and the experiment has been superimposed on an old areca garden.

Pattanshetti:

No. This will be done after collecting data for few more years.

P Muddappa Gowda:

Since areca has responded for high levels of K application viz., 300g/palm/year it is likely that the soil is low in its K content. It may be worthwhile to find out K level of soil for justifying the results obtained.

Effects of Manuring on the Nutrients Contents of Soil and Leaf in Arecanut

A. R. Mohapatra*

Abstract

Fertility status of surface soils and nutrients content of arecanut leaf from stations, where the NPK experiments conducted, were evaluated. Organic C was optimum in soils at Vittal and Peechi due to green leaf application. Bray P-1, P was adequate in soils at Vittal, Peechi, Mohitnagar and Kahikuchi, because of P fertilization. Exchangeable K_2O was sufficient in soils at Hirehalli, Peechi, Mohitnagar and Kahikuchi as a result of addition of muriate of potash. Application of fertilizer-N increased acidity and decreased exchangeable K and Ca content of soils at Vittal, Peechi, Mohitnagar and Kahikuchi. N content of leaf appeared to be rather low, whereas K was high. Leaf-P was low in samples from Vittal and Hirehalli but satisfactory at Peechi, Mohitnagar and Kahikuchi. Ca content of leaf was above the average value in samples from all the centres except that of Peechi.

Introduction

Arecanut generally grows in acid soils of medium to low fertility. In such soils applications of organic manures and fertilizers are the common practices to increase the yield of arecanut. Prolonged use of such substances alter the soil properties ultimately affecting the nutrients content of leaf. In the present study, effects of continuous applications of green leaf and fertilizers to arecanut on the mineral nutrients content of soil and leaf were investigated in the existing NPK manurial experiments.

Materials and Methods

NPK manurial experiments were started at Vittal in 1961, at Hirehalli in 1962, at Peechi in 1961, at Mohitnagar in 1967 and at Kahikuchi in 1962. The lay out of the

experiments was 3^4 factorial with NPK and green leaf (G) as treatments at Vittal, Hirehalli, Peechi and Kahikuchi, consisting of a single replication. At Mohitnagar, the design was $3^3 \times 2$ factorial, with NPK and lime (L) treatments and 3 replications. The levels of nutrients at Vittal, Hirehalli, Peechi and Kahikuchi were 0, 50, 100 g N; 0, 40, 80 g P_2O_5 ; 0, 70, 140 g K_2O and 0, 7, 14 kg green leaf/palm/yr. The treatments were revised at Vittal in 1971 to include higher levels of nutrients. The revised levels were fixed at double the rate of the original treatments. The treatments at Mohitnagar comprised of 0, 100, 200 g N; 0, 40, 80 g P_2O_5 and 0, 140, 280 g K_2O with 0 and 1 kg lime/palm/yr.

Soil and leaf samples were collected from Vittal, Hirehalli, Peechi and Mohitnagar during October, 1976 and from Kahikuchi during September, 1977 for analyses. Soil samples were taken by

*Central Plantation Crops Research Institute, Regional Station, VITTAL 574 243, Karnataka.

tubular auger from 0 - 50 and 50 - 100 cm depths. Soil samples were air-dried, pounded in a wooden mortar and pestle and passed through a 2 mm sieve. Leaf samples were washed in distilled water, dried in oven at 70°C and ground in a mill to fineness.

Estimations of pH (H₂O), pH (1 N KCl), electrical conductivity, exchange acidity (1 N KCl), organic C (Wakley - Black), available N (alkaline KMnO₄ distillation), available P (Bray P-1) and exchangeable K, Ca (N 1 N NH₄OAc) were carried out in soil samples. P was estimated in Spectronic 20, spectrophotometer at 660 m μ , whereas K and Ca were determined in an EEL flame photometer (Subbiah and Asija, 1956; Muhr et.al., 1965; Kamprath, 1967; Jackson, 1967).

Total N in leaf samples was determined by Kjeldahl method. The leaf samples were digested in a mixture of HNO₃ and HClO₄ acids. P, in the extract, was estimated by vanadomolybdate method. K and Ca were measured in the flame photometer as that of soil extract (Jackson, 1967).

Results

Fertilizer -N at Vittal (both depths, each in original and revised schedules), Peechi (both depths), Mohitnagar (both depths) and Kahikuchi (0 - 50 cm depth) increased acidity, and decreased exchangeable K and Ca contents of soils significantly (Table 1). Application of P fertilizer raised the available P₂O₅ content of soils significantly at Vittal (both depths, both schedules), Hirehalli (both depths), Peechi (both depths), Mohitnagar and Kahikuchi; each at 0 - 50 cm depth (Table 2). Exchangeable Ca content of soils at Vittal (both

depths in original schedule and 0 - 50 cm depth in revised schedule), Peechi (both depths), Mohitnagar (both depths) and Kahikuchi (0 - 50 cm depth) significantly increased by the application of superphosphate (Table 2). Addition of muriate of potash increased significantly the available K₂O content of soils at Vittal (both depths, both schedules), Hirehalli (0 - 50 cm depth), Peechi (both depths), Mohitnagar (both depths) and Kahikuchi at 0 - 50 cm depth (Table 2). Application of green leaf significantly increased the organic C content of soils at Vittal (both depths in original schedule and 0 - 50 cm depth in revised schedule), Hirehalli and Peechi, each at 0 - 50 cm depth (Table 2). Green leaf also significantly reduced acidity in soil at Vittal (0 - 50 cm depth in original schedule and both depths in revised schedule), Hirehalli (0 - 50 cm depth), Peechi (50 - 100 cm depth) and Kahikuchi (0 - 50 cm depth).

Lime application at 1 kg/palm/yr at Mohitnagar increased the pH and exchangeable Ca and decreased the available P₂O₅ content of soil (0 - 50 cm depth) significantly.

N fertilizer at Hirehalli reduced pH (both depths) and specific conductivity of soil (0 - 50 cm depth) significantly. The specific conductivity of soil at Hirehalli was below 1 mmhos/cm which is considered as safe for the normal growth of crop plants.

Organic C content of soils (0 - 50 cm depth) was high (>0.75%) at Vittal (both schedules) and Peechi; medium (0.50 - 0.75%) at Kahikuchi and low (<0.50%) at Hirehalli as a result of green

Table 1. Effects of N levels on pH, exchange acidity, available K₂O and exchangeable Ca contents of soils
(Table of means)

Constituents	pH (H ₂ O)			pH (KCl)			Exchange acidity (meq/100g)			Available K ₂ O (ppm)			Exchangeable Ca (ppm)		
	N ₀	N ₁	N ₂	N ₀	N ₁	N ₂	N ₀	N ₁	N ₂	N ₀	N ₁	N ₂	N ₀	N ₁	N ₂
STATIONS															
Vittal	5.76	4.79	4.47	4.58	3.95	3.80	0.33	1.82	2.75	175.11	97.44	92.48	388.25	139.58	116.76
[Original levels]	[5.73]	[5.03]	[4.47]	[4.53]	[4.07]	[3.89]	[0.50]	[1.42]	[2.83]	[122.00]	[88.78]	[74.33]	[316.30]	[164.95]	[90.83]
Vittal	5.27	4.54	4.28	4.16	3.84	3.65	0.90	2.20	3.04	158.81	106.26	99.81	282.31	128.56	115.83
[Revised levels]	[5.53]	[4.72]	[4.31]	[4.40]	[3.97]	[3.75]	[0.53]	[1.98]	[3.16]	[138.89]	[97.11]	[98.00]	[314.81]	[123.19]	[88.50]
Peechi	5.75	5.27	4.85	4.66	4.22	3.81	0.10	0.32	1.18	301.74	253.67	198.07	736.65	559.77	368.73
	[5.90]	[5.41]	[4.82]	[4.76]	[4.32]	[3.81]	[0.08]	[0.30]	[1.11]	[277.33]	[246.37]	[208.81]	[699.10]	[630.84]	[389.68]
Mohitnagar	6.44	6.09	5.96	—	—	—	—	—	—	176.63	153.83	125.00	573.60	428.51	388.97
	[6.42]	[6.22]	[6.09]	—	—	—	—	—	—	[102.48]	[96.00]	[76.96]	[142.41]	[137.86]	[115.79]
Kahikuchi	4.91	4.70	4.38	4.11	3.91	3.72	0.32	0.50	0.83	450.41	332.85	359.18	549.17	435.74	357.04
	[4.93]	[4.89]	[4.77]	[4.11]	[4.16]	[4.02]	[0.20]	[0.25]	[0.32]	[376.33]	[375.00]	[348.81]	[594.26]	[559.89]	[589.44]
Vittal, OL	0.142*	—	—	0.136*	—	—	—	0.220*	—	17.93*	—	—	62.86*	—	—
LSD [P=0.05]	[0.234]*	—	—	[0.170]*	—	—	—	[0.41]*	—	[20.47]*	—	—	[55.45]*	—	—
Vittal, RL	0.138*	—	—	0.087*	—	—	—	0.218*	—	20.75*	—	—	27.95*	—	—
LSD [P=0.05]	[0.120]*	—	—	[0.11]*	—	—	—	[0.27]*	—	[23.72]*	—	—	[39.53]*	—	—
Peechi	0.12*	—	—	0.092*	—	—	—	0.124*	—	55.28*	—	—	61.08*	—	—
LSD [P=0.05]	[0.113]*	—	—	[0.099]*	—	—	—	[0.179]*	—	[24.24]*	—	—	[76.63]*	—	—
Mohitnagar	0.0058*	—	—	—	—	—	—	—	—	13.52*	—	—	31.74*	—	—
LSD [P=0.05]	[0.12]*	—	—	—	—	—	—	—	—	[11.53]*	—	—	[16.46]*	—	—
Kahikuchi	0.237*	—	—	0.190*	—	—	—	0.300*	—	83.83*	—	—	87.52*	—	—
LSD [P=0.05]	[NS]	—	—	[NS]	—	—	—	[NS]	—	[NS]	—	—	[NS]	—	—

Figures in parenthesis represent the values for 50-100 cm depth. * Significant at P=0.05; NS, Not significant

Table 2. Effects of P levels on available P₂O₅ and exchangeable Ca, K levels on available K₂O and G levels on organic C contents of soils (Table of means)

Constituents Nutrient levels	P Fertiliser						K Fertiliser						Green leaf	
	Available P ₂ O ₅ (ppm)			Exchangeable Ca (ppm)			Available K ₂ O (ppm)			Organic C (%)			G ₁	G ₂
	P ₀	P ₁	P ₂	P ₀	P ₁	P ₂	K ₀	K ₁	K ₂	G ₀	G ₁	G ₂		
STATIONS														
Vittal	2.07	57.02	188.25	171.48	220.56	252.56	58.67	138.48	167.89	0.72	0.96	1.02		
[Original levels]	[0.17]	[6.15]	[32.69]	[155.74]	[212.50]	[203.84]	[45.11]	[102.89]	[137.11]	[0.60]	[0.70]	[0.79]		
Vittal	24.57	96.39	312.85	143.43	175.42	207.87	90.15	114.52	160.22	0.85	0.95	1.10		
[Revised levels]	[2.14]	[12.75]	[28.46]	[151.11]	[190.00]	[185.40]	[70.44]	[104.33]	[159.22]	[0.62]	[0.63]	[0.67]		
Hirehalli	1.59	6.51	14.13	2950.00	2940.00	3060.00	115.89	149.67	197.55	0.46	0.49	0.51		
	[2.50]	[3.11]	[3.80]	[3020.00]	[2960.00]	[3110.00]	[118.11]	[112.04]	[120.55]	[0.42]	[0.45]	[0.45]		
Peechi	132.46	211.14	358.81	494.84	573.40	596.92	196.63	225.89	330.96	0.96	1.12	1.13		
	[67.03]	[91.20]	[117.30]	[535.80]	[559.98]	[623.82]	[176.04]	[231.81]	[324.67]	[0.68]	[0.73]	[0.74]		
Mohitnagar	33.70	67.63	97.16	436.18	460.74	494.17	63.72	157.78	233.96	—	—	—		
	[17.63]	[17.71]	[20.36]	[114.07]	[132.95]	[149.03]	[36.92]	[92.22]	[149.30]	—	—	—		
Kahikuchi	72.87	118.46	257.09	385.65	446.48	509.81	317.48	381.70	443.26	0.73	0.70	0.66		
	[39.14]	[57.62]	[71.64]	[558.13]	[594.54]	[590.92]	[351.22]	[374.89]	[374.04]	[0.40]	[0.39]	[0.36]		
Vittal, OL	30.01*				62.86*			17.93*			0.10*			
LSD [P=0.05]	[9.10]*				[55.45]*			[20.47]*			[0.13]*			
Vittal, RL	49.80*				27.95*			20.75*			0.10*			
LSD [P=0.05]	[11.19]*				[NS]			[23.72]*			[NS]			
Hirehalli	4.49*				NS			13.49*			0.03*			
LSD [P=0.05]	[0.85]*				[NS]			[NS]			[NS]			
Peechi	50.81*				61.08*			55.28*			0.11*			
LSD [P=0.05]	[23.70]*				[71.63]*			[24.24]*			[NS]			
Mohitnagar	11.51*				31.74*			13.52*			—			
LSD [P=0.05]	[NS]				[16.46]*			[11.53]*			—			
Kahikuchi	77.31*				87.52*			83.83*			NS			
LSD [P=0.05]	[NS]				[NS]			[NS]			[NS]			

Figures in parenthesis represent the values for 50-100 cm depth, * Significant at P=0.05; NS, Not significant

leaf application. At 50 - 100 cm depth it was medium at Vittal and Peechi and low at Hirehalli and Kahikuchi. The content of available N was medium (125 - 250 ppm) at Vittal (both schedules), Peechi and Kahikuchi and low (<125 ppm) at Hirehalli at 0 - 50 cm depth. Available N was medium at Peechi and Kahikuchi and low at Vittal and Hirehalli at 50 - 100 cm depth. The content of available P₂O₅ was high (>25 ppm) at Vittal, Peechi, Mohitnagar and Kahikuchi and low to medium at Hirehalli (0 - 50cm depth) due to the application of P fertilizer. Bray - 1 P was high at Peechi and Kahikuchi, medium (10 - 25ppm) at Mohitnagar and low (<10 ppm) at Hirehalli (50 - 100 cm depth). The available P₂O₅ content was high at Vittal (50-100 cm depth), when 80 g P₂O₅/palm/yr, in the original schedule and 160 g P₂O₅/palm/yr, in the revised schedule were applied. The available K₂O content of soils was high (>150 ppm) at Hirehalli, Peechi, Mohitnagar and Kahikuchi (0 - 50cm depth)

due to the application of muriate of potash. Available K₂O content was high at Vittal (0 - 50 cm depth), when K at 140 g K₂O/palm/yr, in the original schedule and 280g K₂O/palm/yr, in the revised schedule were applied. It was high at Peechi and Kahikuchi and medium (63 - 150 ppm) at Vittal (original schedule), Hirehalli and Mohitnagar (50-100 cm depth). At Vittal (revised schedule) it was high (50-100 cm depth) when K fertilizer was applied at 280g K₂O/palm/yr.

N fertilizers significantly increased the leaf - N at Hirehalli and Kahikuchi and leaf - P and K at Mohitnagar. Fertilizer - P increased the P content of leaf significantly at Vittal (both schedules) and the leaf Ca at Mohitnagar. KCl application increased significantly the leaf K at Vittal (both schedules), Hirehalli, Mohitnagar and Kahikuchi. Application of G significantly increased the leaf -N at Vittal in the revised schedule (Table 3).

Table 3. Effects of NPK fertilizers and green leaf on the N, P and K contents of arecanut leaf

(Table of means)

Treatments	N fertilizer			P fertilizer			K fertilizer			Green leaf		
Constituents	N (%)			P (%)			K (%)			N (%)		
Nutrient levels	N ₀	N ₁	N ₂	P ₀	P ₁	P ₂	K ₀	K ₁	K ₂	G ₀	G ₁	G ₂
STATIONS												
Vittal (Original levels)	2.16	2.12	2.07	0.15	0.17	0.17	0.69	0.93	0.98	2.10	2.11	2.13
Vittal (Revised levels)	2.12	2.21	2.31	0.16	0.18	0.18	0.84	0.89	1.05	2.19	2.12	2.33
Hirehalli	2.25	2.38	2.44	0.18	0.19	0.18	0.71	0.81	0.82	2.30	2.39	2.39
Peechi	2.45	2.42	2.46	0.20	0.19	0.20	0.89	0.95	0.93	2.41	2.42	2.51
Mohitnagar	2.39	2.37	2.51	0.19	0.20	0.19	0.81	1.06	1.08	—	—	—
Kahikuchi	2.55	2.71	2.69	0.20	0.20	0.21	0.96	1.03	1.12	2.64	2.69	2.62
Vittal OL (LSD,P=0.05)	NS			0.016*			0.104*			NS		
Vittal RL (LSD,P=0.05)	NS			0.014*			0.087*			0.170*		
Hirehalli (LSD,P=0.05)	0.120*			NS			0.049*			NS		
Peechi (LSD,P=0.05)	NS			NS			NS			NS		
Mohitnagar (LSD,P=0.05)	NS			NS			0.104*			—		
Kahikuchi (LSD,P=0.05)	0.099*			NS			0.050*			NS		

*Significant at P = 0.05,

NS, Not Significant.

Leaf from healthy arecanut gardens of Karnataka contained about 3% N, 0.20% P, 0.70% K and 0.50% Ca. Based on these values, the nutrients contents of leaf from Vittal, Hirehalli, Peechi, Mohitnagar and Kahikuchi were assessed (Anonymous 1975).

Discussion

Application of ammonium sulphate or urea as sources of N to arecanut for several years has increased acidity to a level that requires correction by the addition of lime. Liming is practised to neutralise the excess Al injurious to the plants. Suitable quantity of lime is applied to increase the pH (H₂O) to 5.5, beyond which adverse effects are observed on crop plants. Correction of acidity is possible in the surface soil, but relatively difficult in the subsoil horizons. In a perennial crop like arecanut the fertility and reaction of subsoil appear to be as important as that of surface soil. Therefore, source of N should be such that its prolonged application does not leave behind any residual acidity harmful for the plants (Sanchez, 1976).

Lime application at Mohitnagar has reduced the available P content of soil which is likely to occur due to the increased pH. Liming the near neutral soil of Mohitnagar (pH in H₂O, 5.71 before liming and 6.62 after liming) is unnecessary as shown by its detrimental effects on the growth and yield of arecanut (Sanchez, 1976; Anonymous, 1978).

Annual addition of forest leaf to arecanut does not serve as a good source of organic matter, particularly for subsoil. Under the tropical climatic conditions leaf decomposes rapidly leaving behind traces of humus as indicated by the low organic C and available

N contents of soils. In the alkaline soils of Hirehalli, hydrolysis of organic matter is rapid, resulting in the lower content of organic C in the soil. Under such conditions cattle manure or compost can be preferred over forest leaf (Sanchez, 1976).

The slightly acid soils of arecanut fix considerable amounts of P when applied as water-soluble phosphate. Arecanut roots are housed in one cubic metre volume of soil. Application of P above fixing capacity would enhance its downward movement in soil. This is possible when P is applied at higher rate for several years during the active growth period of the plant. When the soils are acid rock phosphate could be used satisfactorily. P nutrition of arecanut appears to be more important because of its unavailability in the soil (Sanchez, 1976).

Application of NPK fertilizers has not uniformly reflected on the nutrients status of leaf at all the centres. Similar informations are available on other plantation crops (Kamala Devi, Nelliath and Pillai, 1973; Pushpadas et al., 1973; Wahid et al., 1981). The plants also do not respond to the higher levels of fertilization, as evident from the yield of arecanut (Anonymous, 1978). It is not known, whether genetical factors of plants are responsible for such effects.

Acknowledgements

Thanks are due to the Scientists - In-Charge of the experiments at Vittal, Hirehalli, Peechi, Mohitnagar and Kahikuchi, for their co-operation, during the collection of soil and plant samples. Statistical analysis of data, carried out by Shri S. Bhagavan, Scientist, and Shri B. Pankajakshan Nair, Computer, is highly appreciated.

References

- ANONYMOUS, 1975. Annual Report, Central Plantation Crops Research Institute, Kasaragod, India. p. 103.
- ANONYMOUS, 1978. Annual Report, Central Plantation crops Research Institute, Kasaragod, India. p. 87-89.
- JACKSON, M. L. 1967. *Soil chemical analysis*. Prentice Hall of India, Pvt. Ltd., New Delhi. pp. 47, 151-153, 183-190.
- KAMALA DEVI, C. B., NELLIAT, E. V. and PILLAI, N. G. 1973. Nutritional studies on high yielding coconut genotypes. *Proc. First National Symposium on Plantation Crops* (Ed. N. M. Nayar). Indian Society for Plantation Crops, Kasaragod, India pp. 67-69.
- KAMPURATH, E. J. 1967. Soil acidity and response to liming. *International Soil Testing Tech. Bull.* 4: 1-17. North Carolina State University, Raleigh, U. S. A.
- MUHR, G. R., DATTA, N. P., SANKARASUBRAMONEY, H., LELEY, V. K. and DONAHUE, R. L. 1965. *Soil Testing in India*. 2nd ed. United States Agency for International Development Mission to India, New Delhi, pp. 39-46.
- PUSHPADAS, N. V., NARAYANAN POTTI, S., GEORGE, C. M. and KRISHNAKUMARI, M. 1973. Effect of long term application of NPK fertilizers on pH and nutrient levels of soil and leaf in *Hevea brasiliensis*. *Proc. First National Symposium on Plantation Crops* (Ed. N. M. Nayar). Indian Society for Plantation Crops, Kasaragod, India pp. 38-43.
- SANCHEZ, P. A. 1976. *Properties and management of soils in the tropics*. A Wiley - Interscience Publication, John Wiley and Sons, New York, London, Sydney and Toronto. pp. 162-183, 223-294.
- SUBBIAH, B. V. and ASIJA, G. L. 1956. A rapid procedure for the estimation of available nitrogen in soils. *Curr. Sci.* 25(8): 259-260.
- WAHID, P. A., KANNAN, K., KAMALAM, N. V. and VENUGOPAL, V. K. 1981. Genotypic and seasonal variations in the mineral nutrition of coconut palm. *J. Plant. Crops* 9(2): 105-111.

Discussions

R C Mandal:

For balancing fertilization while soil is acidic, N: K and N:Ca have to be balanced ie, 1: 1 and 1:7.5. whether such balancing is required here? If so, why lime application at Mohitnagar showed decrease in yield?

A R Mohapatra:

Acidity, intensified in soil by the prolonged use of acidifying fertilizers, requires base such as lime for amelioration. Liming near neutral soils as at Mohitnagar shows adverse effects on growth and yield of crop plants.

R C Mandal:

Whether P application is required while P content in leaf is low at Vittal and P fixation is likely to occur in acidic condition?

A R Mohapatra:

P fixation is high in acid lateritic soils. Phosphate application neither increases the yield nor the P content of leaf, probably due to genetic reasons.

S P Singh:

What is the most congenial pH of soil for growing arecanut? What is the relationship between organic matter content and soil pH?

A R Mohapatra:

pH around 5.5 is most ideal for growth of arecanut palm. Organic matter generally increases the soil pH because of which the tropical soils are neutral in reaction.

S P Singh:

With recommended doses of fertilizer for arecanut up to what extent the pH is increased and how it could be corrected?

A R Mohapatra:

The pH decreased up to 4.3 from 5.7 at Vittal when ammonium sulphate, single super phosphate and muriate of potash were the carriers of nutrients for N P and K respectively. Liming is the usual practice to correct soil acidity.

Contribution to the Micromorphology of a Lateritic Sandy Loam Soil Profile Growing Arecanut

V. Gopalaswamy and M. Subramonia Iyer

Abstract

Macro and Micromorphological investigation of a lateritic sandy loam soil profile. Nemom Village, Trivandrum District, growing arecanut has been made. These soils occur in a catenary sequence in the foot slopes with red and laterite soils in the mid and crest of the slopes respectively. The soils have reddish brown colour, Kaolinitic in nature, acidic in reaction and porous. Micromorphological features observed are weathered and pitted quartz grain set in almost opaque matrix of iron and other oxides. The transported nature of the sediment is also evident.

Introduction

Soil micromorphology covers more or less all branches of soil research. This technique of microscopic research enables to see under the microscope the various individual soil constituents and the changes they undergo in microscopic dimensions. Thin soil sections are studied to observe the soil constituents in their natural undisturbed arrangement. Observations on thin sections are always most meaningful when correlated with field observation. The elucidation of soil fabric (arrangement of particles and voids) is a major task of soil micromorphology. The present study aims to know the trend in the distribution of soil properties in the soil to judge the dependence of physico-chemical properties of soils on morphology and their interrelationship. The soil profile examined is from

Trivandrum District, Kerala State, coming under 'Karamana series'. This soil series is included as a member of Isohyperthermic family of typic Tropofluents as established by the soil survey branch of the Department of Agriculture, Kerala State (Anonymous, 1978).

Materials and Methods

The soil profile samples investigated were collected from Pappanamcode, Nemom village, Trivandrum District. Kuhina box samples representing each layer of the profile was carefully collected after examination. A record was made on the orientation of each sample as well as the location within the profile. The soil profile was examined and described according to the standard methods (Anonymous, 1951). The topography of the land is slopping. The drainage pattern of the area can be described as subparallel. The climate of the area is semi-humid, with a mean annual precipitation of about 2000 mm.

The Kuhina box samples were securely dried and a representative part was separated. This portion was cooked in Canada Balsam (R. I. 1.54) for ten minutes over a low flame so as to impregnate the material fully. After impregnation and cooling, the slice was got smooth polished by grindnig with 120 mesh carborandum powder on a thick glass slab. The polished cut surface was cemented to a flat microscopic slide with 'Lakeside 70 cement'. The protruding excess thickness of the material was removed by grinding with different grades of Carborandum powder wetted with water until a very thin section was obtained on the slide. The prepared thin section was afterwards examined under a petrological microscope and observations recorded (Fitzpatrick, 1980).

The macromorphology of the profile is presented as follows:

Location : Mangaladesam, Pappanamcode, Nemom Village, Trivandrum Dist. Kerala. Approx. 150 - 200 m East in the bank of Karamana river

Parent material: Alluvium on Charnockite

Physiography : Alluvial slope

Relief : Gentle slopping; slope: East, - West facing slope 2-3%

Elevation : Approx. 50 m

Drainage : well drained

Vegetation : Arecanut garden

Depth (cm)	Description
0-21	Dark yellowish brown (10 YR 4/4); moist, sandy loam, single grain; roots few, permeability rapid; clear wavy boundary
21-72	Strong brown (7.5 YR 4/6); sandy loam structureless, loose; roots plenty, permeability moderate; gradual wavy boundary
72-113	Brown(7.5 YR 4/4)sandy loam; structureless loose; roots few; permeability moderately slow; diffuse wavy boundary
113-150 ⁺	Strong brown (7.5 YR 5/5);sandy loam,massive, roots few; moderately slow permeability

Results and Discussion

The macromorphological observations clearly show that horizon differentiation is not well expressed. Clay illuviation shows an increasing trend at the sub-surface depths. The micromorphological observations of the thin section of samples representing the various depths of the profile studied are presented below:

0 - 21 cm depth:

The normal relation distribution pattern (NRDP) is 'Vosepic'; the plasma is brownish yellow and there is some staining with partially decomposed organic matter and silt; Plasma fabric is 'Vosepic'; locally some insepic, argilla-sepic and skelsepic fabrics are also present; large yellowish brown aggregates admixed with quartz grains occurred during transport of sediments; except the rare occurrence of chlorite no other mineral is significantly observed.

21 - 72 cm depth:

The S-matrix is similar to the overlying material; there is decrease in the amount of illuviation argillans; plasmic fabric is comparatively more clear; the yellowish brown soil aggregates noted in the overlying layer tend to be more fine and yellowish; remains of rootlets are frequent, the organic matter is more humified and more amorphous; more sedimented silt and rarely distributed fragmented quartz are present; occurrence of 'altered magnetite' is another feature.

72 - 113 cm depth:

The 'NRDP' is skelsepic; the plasma is dense and reddish yellow than the overlying; weakly oriented clay papules and plugs are sporadically distributed along the matrix; pore spaces constitute more of 'voughs' type and less channel type, these are comparatively smaller in size than the surface soil material; altered magnetite content increases.

113 - 150⁺cm depth:

S-matrix only differs slightly from the overlying; plasma is more dense and yellowish brown in colour; well oriented clay plugs are distinct; fragments of laterite materials are observed; the plasma shows slight oxic properties as indicated by the weak expression of oriented domains, microaggregation tendency and appearance of some goethite droplets.

The macro and micromorphology of the profile

The macro morphological observations indicate the structureless nature of the surface soil. The loose consistency of the surface soil is also a notable feature. The sub-surface layers become firm.

The micromorphological study by thin section mostly substantiates the macro morphological observations. It showed the granular related distribution, little plasma and equal quantity of voids and skeletal grains. All these qualify the loose nature of the material. The sub-surface layers in thin section showed more plasmified organic matter which often coats skeletal surfaces. Plasmified organic matter shows weak intergranular braces. These have a slight 'Chlamydomorphic' related distribution pattern with frequent formation of intergranular bridges. The decrease in the number of voids in the sub-surface layers is very clear in thin section which has resulted in the lowering permeability of the soil layer as indicated in macromorphological observation. The S-matrix has a compact appearance, firm to massive consistency. The chlamydomorphic related distribution pattern as seen in thin section is the result of the subsidence of argillans with organic matter. The increase in the presence of clay at the sub-surface layers and the prevalence of moderate moisture regime all along the soil depths studied has confirmed with the occurrence of clay plugs and clay papules in the thin section of the sub-surface layer samples. This facilitates an alternate wet and dry soil moisture regime at the vicinity of the flowing river.

Soil genesis

The soil is preweathered prior to deposition. It has reached slightly to oxic stage of soil formation. The presence of runi-quartz, rounded lateritic microaggregates indicate that this is transported material. It may be safe to infer that an argillic layer is developing in this weathered and transported material and that the clay illuviation is just commencing.

Soil plant relationship

The utility of micromorphological observation in assessing the soil plant relationships of crop grown in the site is a novel observation in this study. Micromorphological evidence is forthcoming very clearly in the thin sections to the effect that the profile under study is subjected to severe rainfall and stream bank erosion. This all confirm the field observation already recorded. In short, these soils can be effectively brought under profitable

arecanut cultivation by protecting from erosion and by the judicious application of organic manures and inorganic fertilizers.

Acknowledgements

The authors wish to thank the I.C.A.R. New Delhi and Dean, Faculty of Agriculture, Kerala Agricultural University for providing facilities under the I.C.A.R. Emeritus Scientists Scheme at Dept. of Soil Science and Agrl. Chemistry, College of Agriculture, Vellayani.

References

ANONYMOUS. 1951, *Soil Survey Manual, Agric. Hand Book No. 18*. Soil Conservation Service, U. S. Dept. Agri. U. S. Govt. Printing Office, Washington, DC.

ANONYMOUS. 1978, *SOILS OF KERALA*. Soil Survey Branch, Dept. of Agriculture, Kerala.

FITZPATRICK, E. A. 1980, *The Micromorphology of soils - A manual for preparation and description of thin section of soils*. Dept. of Soil Science, University of Aberdeen.

Morphology, Mineralogy and Taxonomy of some Arecanut Growing soils of Kerala

M. Subramonia Iyer and V. Gopalaswamy*

Abstract

Macromorphology of three soil series cultivated for arecanut has been investigated from three locations in Trivandrum District. Sand mineral assemblage of these soils at two depths viz., 50 cm and 100 cm has been studied. Dehydration studies and identification of the clay minerals of the soil has also been attempted. With the information obtained, an attempt is also made to classify the soil to great group level under the U. S. D. A. comprehensive system. The soils are of kaolinitic in nature and acidic in reaction. These soils come under the Inceptisol, Alfisol and Entisol as per soil taxonomy.

Introduction

Arecanut is an important cash crop of the humid tropics. It is grown in moderately well drained soils. These soils occur in flat and gently sloping lands on the banks of rivers and tributaries and in the lateritic catenary sequences. The soils are acidic in reaction and kaolinitic in nature. So far no systematic study on the characteristics of the various arecanut growing soils in India has been made. As an initial step the morphological characteristics and mineralogy of these soils are discussed in this paper. An attempt has also been made to study their taxonomy.

Materials and Methods

Soil profiles from arecanut gardens representing three soil series established by the soil survey branch of the Department of Agriculture, Kerala State (Anonymous, 1978) were studied for their macromorphology, mineralogy and taxonomy by

the standard procedures (Anonymous, 1951; Anonymous, 1975; Kelly et al., 1936 and Black, 1965).

The morphological features of the soil series are presented below.

Results and Discussion

Morphology

In Trivandrum District, arecanut is cultivated in different soil types viz., laterite (Varkala series), red sandy loam (Vellayani series), riverine alluvium (Karamana series) etc. The Varkala series is gravelly loam to gravelly clay in texture, very deep, acidic and well drained with abundant ferruginous concretions in the subsoil.

The next group of soil in which arecanut is cultivated is the Vellayani series of the top slope of the lateritic catenary sequences. It is a sedimentary formation; sandy, very deep, excessively drained with little stratification and profile development.

*College of Agriculture, Kerala Agricultural University Vellayani 695 522, Kerala.

Macromorphology of some Arecanut Growing soil Profiles

I. Varkala series, Varkala Village Chirayinkil Taluk, Trivandrum District		II. Vellayani series, Thiruvallam Village, Neyyattinkara Taluk, Trivandrum District		III. Karamana series, Nedumangad Village, Nedumangad Taluk, Trivandrum District	
Depth (cm)	Description	Depth (cm)	Description	Depth (cm)	Description
0 - 15	Reddish brown 5YR (4 / 3); gravelly loam; coarse moderate crumb structure; roots plenty; permeability moderately rapid; clear smooth boundary	0 - 21	Dark red (2.5YR 3/6); sandy loam; medium weak granular structure; plenty of roots; rapid permeability; clear smooth boundary	0 - 21	Dark yellowish brown (10YR 4/4); sandy loam; structureless; single grain; roots plenty; permeability rapid, clear wavy boundary
15 - 45	Reddish brown 2.5YR (4 / 4); gravelly clay loam; medium weak granular structure; few roots; permeability moderately rapid; gradual wavy boundary	21 - 65	Dark reddish brown (2.5YR 3 / 4); sandy clay loam; medium weak granular structure; few roots; rapid permeability; diffuse smooth boundary	21 - 46	Strong brown (7.5YR 4 / 6); sandy loam; structureless; loose; roots plenty; permeability rapid; gradual wavy boundary
45 - 105 ⁺	Yellowish red (7.5YR 4/6); gravelly clay; medium moderate sub-angular blocky structure; roots very few; permeability moderately slow	65 - 111 ⁺	Dark red (2.5YR 3 / 6); sandy clay loam; medium weak granular; few roots, rapid permeability	46 - 73	Brown (7.5YR 4 / 4); sandy loam; structureless loose; roots few; permeability rapid; diffuse wavy boundary
Profile site	Kaithakanom	Profile site	Pachalloor	73 - 115 ⁺	Strong brown (7.5YR 5 / 5); sandy loam; massive; roots few; moderate permeability
				Profile site	Pazhakuty

The major arecanut tract is in the riverine alluvium (Karamana series). The soil is sandy loam to sandy clay loam in texture, slightly acidic to non-acidic in reaction, very deep and moderately drained. The water table rises to 0.5 - 1.0 m from surface during the rainy season resulting in water stagnation and impeded drainage. The soil is also prone to rainfall and stream bank erosion.

Sand Mineralogy

The salient findings regarding the mineralogical composition of sand fractions studied are presented in Table 1.

In general both light minerals and heavy minerals of all soil series are lesser in the lower layers than the surface layers. Iron bearing minerals (ferruginous) like limonite and magnetite are appreciably high in the Varkala series. Occurrence of limonite was a characteristic feature of the lower layer in all the three soil series. Raychaudhuri and Mukherjee (1942), Lal (1955), Durairaj (1961), Raghumohan (1962), Datta et al., (1973) and Subramonia Iyer (1979) working on laterite and lateritic profiles identified haematite and limonite as the dominating minerals. The ferromagnesium minerals were found to be in lower order of abundance in most of the red soils. Zircon was found to be appreciably high in laterite and red soils. The unstable mineral hornblende was found in Vellayani series representing unclassified crystalline rocks of South India.

It is interesting to note that in coarse sand of Varkala, 40 - 50 per cent was dominated by ferruginous gravels. The same was 20 - 25 per cent in Vellayani series and 10 - 15 per cent in Karamana series. It would be safe to infer that elevation and high rainfall in the respective series had left a remarkable influence in causing intensive laterisation consequently giving rise to the formation of ferruginous gravels (Subramonia Iyer, 1979).

All the three soil series are relatively low in easily weatherable minerals, which speaks of their low inherent fertility. Their order of inherent fertility is Varkala series < Vellayani series < Karamana series.

In studying the intensities of weathering, the resistant minerals like Zircon have been employed (Durairaj, 1961, Raghumohan, 1962, and Subramonia Iyer 1979). On the basis of the relative abundance of comparatively resistant group of minerals (Zircon) in the 50 cm and 100 cm depths, the soil

Table 1. Fine sand mineralogy of the Soils

Sample No.	Soil series	Location	Depth (cm)	Light minerals				Heavy minerals	
				Quartz group	Titanium group	Iron group	Ferro-magnesium group	Mica group	Accessory minerals (Zircon)
1.	Varkala	Kaithakanom, Varkala	0 - 50	M - L	M	M - L	—	t	M
2.	Varkala	Kaithakanom, Varkala	50 - 100	M - L	M	M - L	—	—	M - L
3.	Vellayani	Pachalloor	0 - 50	M	M - L	M - L	M - L	L	M - L
4.	Vellayani	Pachalloor	50 - 100	M - L	L	M	M	VL	L
5.	Karamana	Pazhakuty, Nedumangad	0 - 50	M - L	L	M - L	—	VL	VL
6.	Karamana	Pazhakuty, Nedumangad	50 - 100	VL	VL	L	—	t	t

Quartz group (Quartz and Feldspars)

Titanium group (Ilmenite only)

Iron group (Limonite and Haematite)

Ferromagnesium group (Hornblende and other pyroxenes)

Mica group (Muscovite and Biotite)

Index of grades

M - Medium 20 - 50% M - L Medium to Low

L - Low 10 - 20%

VL - Very low 5 - 10%

t - Traces or rare 5%

series are in the increasing order of weathering, Varkala series > Vellayani series > Karamana series.

Clay Mineralogy

The amount of water lost between intervals of temperatures, the adsorbed water, crystal lattice water and ratio between them are reported in Table 2.

Observation on clay mineral quality showed that all the three soil series investigated contained a mixture of clay minerals of which kaolinite like minerals were dominant. Presence of montmorillonite like clay mineral was also indicated in the Karamana soil series.

Soil Taxonomy

An attempt has been made to place these soils studied up to great group level in the soil taxonomy (Anonymous, 1975).

Soil series studied	Order	Sub-order	Great group
Varkala series	Inceptisols	Tropepts	Dystopepts
Vellayani series	Alfisols	Udalfs	Tropudalfs
Karamana series	Entisols	Fluents	Tropofluents

A correct understanding of the mineralogical make up, the nutrient dynamics, moisture retention and movement in the soil and arecanut physiology may throw much light in the management of arecanut growing soils. The paper provides some basic information for a detailed study.

Acknowledgements

The authors wish to record their deep sense of gratitude to Dean, Faculty of Agriculture and Professor of Soil Science and Agricultural Chemistry, College of Agriculture, Kerala Agricultural University, Vellayani for the facilities provided in the conduct of this study.

Table 2. Water lost between certain temperature intervals - Different categories of* Total water lost (water lost in terms of the percentage of total water lost per 100 g clay)**

Soil series	Below 100 C	Below 600 C	Beyond 600 C	Adsorbed water	Crystal lattice water	Total water lost / 100 g clay	Adsorbed water to Crystal water ratio
Varkala series	11.00	21.20	92.00	27.00	73.00	13.70	0.37
Vellayani series	11.10	25.50	90.10	31.37	68.63	15.30	0.46
Karamana series	13.12	30.23	88.01	36.18	63.82	17.06	0.47

* Sampling depth 0 - 50 cm.

** Different categories of total water lost calculated as per Kelly et al; 1936.

References

- ANONYMOUS. 1951. *Soil Survey Manual Agric. Handbook* No. 18. Soil Conservation Service U.S. Dept. Agric. U. S. Govt. Washington, D. C.
- ANONYMOUS. 1975. *Soil Taxonomy. A basic system of soil classification for making and interpreting soil surveys.* Agrl. Hand Book No. 436. Soil Conservation Service, USDA. Washington, DC.
- ANONYMOUS. 1978. *Soils of Kerala*, Department of Agriculture, Trivandrum, Kerala.
- BLACK, C. A. 1965. *Methods of soil analysis. Part I.* American Society of Agronomy, Inc. Publishers, Madison, Wisconsin, USA.
- DATTA, N. P., LOTSE, E. G., TOMAR, K. P. and MOTSARA, M. R. 1973. *Proc. Symp. Use of Isotopes and Radiation in Agriculture and Animal Husbandry Research*, New Delhi, pp. 370.
- DURAIRAJ, D. J. 1961. Study of the relationships between mechanical components in South Indian Soils. *J. Indian Soc. Soil Sci.* **9** : 13 - 28.
- KELLY, W. P., HANS JENNY and S. M. BROWN. 1936. Hydration of minerals and soil Colloids in relation to crystal structure. *Soil Sci.* **41**:259-271.
- LAL, A. B. 1955. A study of some of the properties of red and lateritic soils of Bihar. *Indian J. Agric. Sci.* **25** : 15.
- RAGHUMOHAN, N. G. 1962. *Contribution of mechanical fractions towards certain soil properties of four major south Indian soil types.* M.Sc. (Ag.) Thesis. Madras University.
- RAYCHAUDHURI, S. P. and MUKHERJEE, K. C. 1942. Studies on Indian Red Soils VI. Determination of mineralogical composition. *Indian J. Agric. Sci.* **12** : 323 - 335.
- SUBRAMONIA IYER, M. 1979. *Studies on the laterite and red soil association in certain locations in Kerala.* M.Sc. (Ag.) Thesis. Kerala Agricultural University, Trichur.

Biomass Productivity of Different Intercropping Systems with Arecanut[†]

A. Muralidharan* and K. Krishna Murthy**

Abstract

The biomass productivity of 12 cropping systems comprising 19 intercrops grown under arecanut is reported vis-a-vis their sole cropping systems. The productivity of all intercrops was inferior when compared to their respective sole crops. This reduction varied from 18 per cent under beans to 88 per cent under fodder sorghum. Arrow root and banana suffered less than 50 per cent reduction in their productivity as intercrops, while ginger, chilli, colocasia, paddy, turmeric, yam and Dioscorea had productivity rates ranging only between one - third to one - half of their sole crops. The remaining crops suffered severely under intercropping. Intercropping had a positive effect on the productivity of arecanut except with hybrid napier and arrow root. The biomass productivity of all the intercropping systems was greater than that of the sole cropping system of arecanut.

Introduction

Biomass productivity of crop lands is gaining importance in recent years due to the rapid growth of human population and the dwindling supply of fossil energy. Apart from providing the largest source of food, fibre, fuel and shelter plant biomass can conserve the cheapest source of renewable energy. Green plants under favourable conditions can fix two to three per cent of the solar energy into chemical energy through photosynthetic bioconversion. Since agricultural land is becoming limited due to the rapid urbanisation and improper land use it is inevitable to develop

highly productive and ecologically desirable cropping systems to harvest more from every unit of available crop land.

According to Nichiporovich (1954) the average productivity of a crop may be 80 - 150 kg/ha/day, in a period of rapid growth, but may reach as high as 500 kg/ha/day depending on the leaf area and photosynthetic efficiency. Loomis and Williams (1963) estimated a potential productivity of 77 g/m²/day at a total radiation of 550 cal/cm²/day. If the net productivity rate could be held constant at this rate for 100 days a yield of about 85 t/dry matter/ha must result. However, as reported by Loomis and Gerakis (1975), careful studies of primary productivity in agricultural fields are rare and seldom represent maximum production situations. Moss (1976) reported that the yearly biomass productivity is a function of two factors, the rate of dry matter production

[†] Part of Ph.D. thesis submitted by the first author to the University of Agricultural Sciences, Bangalore 560 065, Karnataka.

* Central Plantation Crops Research Institute, Regional Station, Kayangulam, Krishnapuram 690 533, Kerala.

** Director of Research, University of Agricultural Sciences, Bangalore 560 065, Karnataka.

and the length of the time the system functions. Nelliath et al., (1974) computed the total dry matter production of a pure stand of coconut at near optimum management as 17.1 t/ha representing hardly 6.1 per cent of the potential productivity estimate of Loomis and Williams (1963). As per the estimates of area and production by Velappan and Paulose (1974) the annual yield of arecanut is less than one t/ha but this does not account for the biomass present in other parts of the palm. Additional production through intercropping in arecanut has been reported by some workers (Abraham, 1974; Bhat, 1974; Roy, 1974 and Muralidharan and Nayar, 1979) but the information is limited to the yield of economic parts only. The present investigations were taken up to study the biomass productivity of different intercropping systems in arecanut *Vis-a-vis* their sole cropping systems.

Materials and Methods

The studies were undertaken at the Central Plantation Crops Research Institute (CPCRI), Regional Station, Vittal,

Karnataka, situated at 200 m above MSL and at 12.57°N latitude with typical monsoon climate. The field experiments comprised 12 cropping systems involving 20 crops including the main crop, arecanut as shown in Table 1, laid out in a 12×3 randomised block design.

An existing 12-year-old arecanut garden planted during 1965 with a spacing of 2.4m×2.4m was used for the intercropping experiment. Each net plot of the intercropping experiment consisted 8 palms in a gross plot size of 12m×7.2m (86.4m²) with common borders of arecanut between treatments. The sole cropping systems were tested in an adjacent but open field without arecanut. A plot size of 5.4m×2.7m was chosen for this experiment due to shortage of land. The soil of the experimental site was texturally classified as sandy clay loam (Mohapatra, 1977) of lateritic origin and was moderately deep and well drained.

The crops were raised as per the package of practices recommended by the University of Agricultural Sciences, Bangalore

Table 1. Cropping systems

Treatment	Cropping system
T ₁	Upland paddy [Apr. 15 - Aug. 15] - Finger millet [Aug. 20 - Dec. 5] - Groundnut [Dec. 15 - March 30]
T ₂	Yam [Apr. 15 - Dec. 10] - Sorghum [Dec. 15 - Mar. 30]
T ₃	Arrow root [Apr. 15 - Feb. 14] - Beans [Feb. 15 - Apr. 14]
T ₄	Dioscorea [Apr. 15 - Dec. 5] - Maize [Dec. 10 - Apr. 10]
T ₅	Ginger [Apr. 15 - Sep. 15] - Chilli [Sept. 20 - Apr. 10]
T ₆	Turmeric [Apr. 15 - Jan. 14] - Cowpea [Jan. 15 - Apr. 10]
T ₇	Colocasia [Apr. 15 - Dec. 14] - Dolichos [Dec. 15 - Apr. 10]
T ₈	Fodder Sorghum [Apr. 15 - Oct. 15] - Sweet potato [Oct. 20 - Mar. 30]
T ₉	Fodder napier [Apr. 15 - Two years]
T ₁₀	Cavendish banana [Apr. 15 - Two years]
T ₁₁	Arecanut only with frequent tillage for arecanut
T ₁₂	Arecanut only with usual tillage [control]

Note : T₁ to T₁₀ under arecanut for intercropping systems and no arecanut for sole cropping systems

(Iyer and Khan, 1975 and Iyer, 1976) for sorghum, maize, finger millet, hybrid napier, ground nut, cowpea, *Dalichos*, beans, banana and chilli; CPCRI (Pamphlet No. 2E) for arecanut and Kerala Agricultural University (Package of practices, 1976) for the remaining crops, except arrow root which was raised as per the package of practices for ginger since no separate recommendations were available for the same. The crops were irrigated during summer months (December-March). The intercropping systems were studied for two years (1977 - '79) while the sole cropping systems were studied for one year (1978 - '79).

The biological yield of all the 19 crops grown as inter and sole crops was estimated from samples of above ground portions (including tubers or rhizomes of crop like yams, ginger etc.) and dried to constant weight in hot air oven. The bioproductivity of arecanut was obtained by adding together the dry matter present in all the plant parts removed from the palm and an estimated dry matter present in the trunk formed during the experimental period using the regression equation $y = 0.01435 l + 0.3442 g - 1.0017$, where l = length of the trunk formed during the period and g = girth of the trunk (Muralidharan, 1980). The total biomass productivity of the cropping systems were worked out by summation of the productivity of the component crops under each system.

Results

Biomass productivity of intercrops

Biomass productivity of different intercrops ranged from 2.7 g/m²/day in hybrid napier to 0.16 g/m²/day in beans (Table 2). The productivity of the intercrops exceeded at

least 2 g/m²/day only in three more crops viz., arrow root (2.33 g), maize (2.21 g) and sorghum (2.10g). In the sole cropping experiment sorghum recorded the highest biomass productivity (10.85 g/m²/day) followed by maize (10.76 g/m²/day). As under intercropping, beans had the lowest productivity (0.2 g/m²/day) under the sole cropping also. The total biomass production during the year was, however, different from the daily rate of production due to the differences in duration of the crops (Table 2). Eventhough, under sole crop condition, sorghum had a higher rate of biomass production it could yield only 10,633 kg/ha as against 31,360 kg / ha under hybrid napier due to its shorter growing period. Similarly, yam and *Dioscorea* also had greater total production than sorghum and maize either as intercrop or as sole crop. The various intercrops recorded 12.2 to 80.0 per cent of their respective sole crop biomass productivity. Arrow root and beans produced more than two-thirds of their respective sole crops but the productivity of beans was equally poor under both the environments. Crops like banana, ginger, chilli, *Colocasia*, paddy, turmeric, yam and *Dioscorea* could produce at least one third of their respective sole crop biomass, while the remaining nine crops suffered severely under intercropping.

Biomass productivity of arecanut

More than half of the biomass produced in arecanut was accounted for by the leaves while the nuts had only lesser proportion of the assimilates (Table 3). The trunk had accumulated only less than 10 per cent of the total biomass produced. The cropping systems significantly influenced the productivity of arecanut which was highest

when intercropped with the crop sequence of giner followed by chilli and lowest when intercropped with arrowroot and beans.

Total biomass productivity

The cropping system consisting of arecanut with hybrid napier recorded the highest biomass productivity (22.55 t / ha / year) followed by arecanut with banana (20.64

t/ha/year) (Table 4). In all the intercropping systems arecanut remained as the major component in contributing to the total biomass productivity. However, the biomass productivity of the four sole cropping systems T₂, T₄, T₈ and T₉ exceeded the productivity of all the intercropping systems. Hybrid napier as a sole crop (T₉) recorded the highest biomass productivity (31.36 t/ha/year) followed by yam-sorghum (24.38 t/ha/year).

Table 2. Biomass productivity of different intercrops vis-a-vis their sole crops

Crop	Biomass Productivity				
	g / m ² day		Kg / ha / crop		
	Intercrop (IC) Mean of two years	Sole crop 1978-'79	Intercrop Mean	Solecrop 1978-'79	IC (%) SC 1978-'79
Paddy	1.20	3.66	1231	3691**	38.5
Fingermillet	1.11	8.52	859	6560**	16.4
Groundnut	1.37	4.55	1468	4776**	29.2
Yam	1.90	5.85	4537	13750**	36.5
Sorghum	2.10	10.85	2186	10633**	19.2
Arrowroot	2.33	3.65	6583	9852*	66.8
Beans	0.16	0.20	96	128	80.0
Dioscorea	1.53	5.21	3654	12241**	33.3
Maize	2.21	10.76	2266	10546**	25.6
Ginger	1.36	2.78	2429	5498**	47.5
Chilli	0.55	1.44	985	2281**	44.4
Turmeric	1.38	3.63	3464	8682**	38.0
Cowpea	0.92	3.53	642	2403**	29.2
Colocasia	1.06	3.51	1973	5647**	38.7
Dolichos	1.11	3.41	1162	3370**	31.9
Fodder Sorghum	0.86	6.63	1301	9616**	12.2
Sweet potato	1.48	8.77	1814	9904**	18.3
Hybrid napier	2.70	8.59	9891	31360**	30.1
Banana	1.63	2.78	5956	19137**	58.6
CD (0.05)	0.43	1.05	—	—	—

** Significant at 1 per cent

* Significant at 5 per cent only

Table 3. Biomass productivity of arecanut under different cropping systems (Mean of two years)

Cropping systems*	Biomass (kg / palm)					Total
	Nuts	Leaf	Bunch stalk	Spadix cover	Trunk (estimated)	
T ₁	2.28	4.55	0.22	0.13	0.76	7.94
T ₂	2.11	4.47	0.20	0.14	0.73	7.65
T ₃	1.47	4.32	0.19	0.12	0.66	6.76
T ₄	1.99	4.45	0.21	0.14	0.72	7.51
T ₅	2.24	5.40	0.24	0.14	0.85	8.87
T ₆	1.79	4.79	0.21	0.13	0.68	7.60
T ₇	1.80	4.80	0.22	0.13	0.75	7.70
T ₈	2.02	4.84	0.20	0.14	0.73	7.93
T ₉	1.64	4.67	0.19	0.13	0.73	7.36
T ₁₀	2.19	5.07	0.23	0.15	0.82	8.46
T ₁₁	1.82	4.54	0.20	0.13	0.64	7.33
T ₁₂	1.66	4.29	0.19	0.11	0.60	6.85
CD (0.05)	0.20	0.52	0.02	0.02	0.09	0.58
CV (%)	2.1	2.0	1.6	2.5	2.1	4.4

* Details as in Table 1.

Table 4. Biomass productivity of different cropping systems

Cropping Systems	Biomass (t / ha / yr) (Mean of 2 years)			Sole cropping
	Intercrops	Arecanut	Total	
T ₁	3.32	13.78	17.10	15.03
T ₂	6.73	13.28	20.01	24.38
T ₃	7.59	11.76	19.36	9.98
T ₄	5.92	13.11	19.03	22.79
T ₅	3.42	15.43	18.85	7.78
T ₆	4.02	13.19	17.21	11.08
T ₇	3.14	13.38	16.52	9.02
T ₈	3.12	13.76	16.88	19.52
T ₉	9.89	12.66	22.55	31.36
T ₁₀	5.96	14.68	20.64	10.14
T ₁₁	0.00	12.75	12.75	12.29
T ₁₂	0.00	11.88	11.88	10.82
CD (0.05)	—	—	—	2.59
CV (%)	—	—	—	9.95

Discussion

The results on the biomass productivity of 19 crops grown as intercrops in arecanut and as sole crops under 12 different cropping systems enabled to identify the level of productivity of each crop under normal conditions of cultivation (sole cropping) and under intercropping. Some information has been reported on the possibilities of growing certain crops like yam, arrow root, banana etc. under arecanut (Bhat, 1978; Muralidharan and Nayar, 1979). The present investigation has thrown further light on the capability of arecanut to allow a wide range of crop species which may be a cereal (C₃ or C₄), a root crop, a legume or a fodder crop to be grown in association with it.

Arecanut being widely planted to maximise economic yield may not be able to utilize the resources in all the dimensions and should spare part of its environment for other crop species. In a perennial crop like arecanut the combination of crops that may best fit into an annual sequence for intercropping deserves careful consideration. They have to be carefully fitted into a suitable rotation so that they are not only grown in ideal season but also

compete least with arecanut for growth factors and maintain soil fertility in the long run. Also the proportion of total biomass in each system that contributes to practical use either for direct human and cattle consumption, for industrial raw material or for recycling into the soil demands critical consideration.

In the present state of diminishing resources of fossil energy the world over, the concept of biomass as an alternate energy source is gaining importance, though food production will continue to be most important tasks of human society. Practically all the plant biomass produced by the farmers is a potential source of energy though crop residues may pose difficulties in their conversion to some form of transportable energy. However, until such a time the additional biomass can be put into effective use, the yield of economic parts will outweigh any other consideration to the farmer. The results of the present studies emphasised the scope offered by introducing intercropping systems not only for increasing the biomass productivity from the additional crops but also for increasing the biomass productivity of the main crop, arecanut itself.

References

- ABRAHAM, K. J. 1974. Intercropping in Arecanut helps to build up farmers' economy. *Arecanut and Spices Bull.* 5 [3] : 73-75.
- ANONYMOUS 1976. *Package of practices*. Publ. Directorate of Extension Education, Kerala Agricultural University, Mannuthy, Trichur, pp 128.
- BHAT, K. S. 1974. Intensified inter/mixed cropping in *Areca* garden - the need of the day. *Arecanut and Spices Bull.* 5 [3] : 67-69.
- IYER, A. S. 1976. *Package of practices for high yields*. Publ. Director of Extension, University of Agricultural Sciences, Bangalore, pp 188.
- IYER, A. S. and KHAN, M. M. 1975. *Cultivation practice for fruits*. Publ. Director of Extension, University of Agricultural Sciences, Bangalore, pp 88.
- LOOMIS, R. S. GERAKIS, P. A. 1975. *Productivity of agricultural ecosystems*. pp. 145 - 172. In *Photosynthesis and productivity in different environments*. [Ed. Cooper, J. P.] Cambridge University Press, Cambridge, London.

- LOOMIS, R. S. and WILLIAMS, W. A. 1963. Maximum crop productivity - an estimate. *Crop Sci.* 3 [1]: 67 - 72.
- MOHAPATRA, A. R. 1977. Soil fertility research in arecanut : a review. *J. Plant. Crops* 5 [2]: 114 - 120.
- MOSS, D.N. 1976. *Studies on increasing photosynthesis in crop plants. pp. 31 - 41. In CO₂ metabolism and plant productivity.* Eds. Burris, R. H. and Black, C. C. University Park Press, Baltimore.
- MURALIDHARAN, A. 1980. *Biomass Productivity Plant interactions and economics of intercropping in arecanut.* Ph.D. thesis Department of Agronomy, University of Agricultural Sciences, Bangalore.
- MURALIDHARAN, A. and NAYAR, T. V. R. 1979. *Intercropping in arecanut gardens. pp. 24 - 27 in Multiple Cropping in coconut and arecanut gardens.* [Eds. Nelliath, E.V. and Bhat, K. S.], Central Plantation Crops Research Institute, Kasaragod.
- NELLIATH, E. V., BAVAPPA, K. V. A. and NAIR, P. K. R. 1974. Multi-storeyed cropping - A new dimension in multiple cropping for coconut plantations. *World Crops* 26: 262 - 266.
- NICHIPOROVICH, A. A. 1954. Photosynthesis and the theory of obtaining high crop yields. *Field Crops Abst.* 1960. 13 [3]: 169 - 175.
- ROY, A. R. 1974. Intercropping in arecanut gardens of north eastern region of India. A brief review of the work done. *Arecanut and Spices Bull.* 5 (3): 70 - 72.
- VELAPPAN, E. and PAULOSE, T. T. 1974. Present position of the arecanut in India. *Arecanut and Spices Bull.* 6 [2]: 24 - 28.

Normalising Transformations for the Yield of Arecanut

S. Bhagavan*

Abstract

The yield data of arecanut was subjected to normality test. The study indicated that the distribution is non-normal and exhibits a pattern similar to poisson population. Square root transformations were attempted and found that $\sqrt{X+3/8}$ transformation for both number of nuts and wet weight of nuts would normalise the variability or distribution.

Introduction

Most of the statistical analyses are carried out with the assumption that the data follows normal distribution. But in reality all the data which we come across may not follow the normal and multivariate normal distribution. Therefore, the study on nature of distribution of the data which we deal more often and the methods of normalising transformations became necessary. Various transformations, taking into consideration the parametrical relationship between mean and variance have been suggested (Rao, 1952; Snedecor and Cochran, 1967) with illustrative examples. The present study aims at determining whether the yield data of arecanut is distributed normally or not and finding suitable normalising transformation in case of non-normality.

Materials and Methods

Ten year yield data (from 1963-'64 to 1973-'74) on number of nuts and wet

weight of nuts for 508 areca palms grown under uniform conditions at CPCRI Regional Station, Vittal were considered.

Frequency distribution, co-efficient of skewness (β_1) and kurtosis (β_2) were obtained and subjected to tests of skewness and kurtosis (Chakravarthy, et al., 1967) to study whether the data agrees or not with normal distribution.

Several normalising transformations such as \sqrt{X} , $\sqrt{X+1/2}$, $\sqrt{X+2/3}$, $\sqrt{X+3/8}$ and $\sqrt{X+3/16}$ were attempted and the transformed data were subjected to tests of skewness and kurtosis.

Results and Discussion

Co-efficient of skewness and kurtosis were worked out separately for both the yield data viz., number of nuts and wet weight of nuts for all the ten years and are presented in Table 1. These were subjected to tests of skewness and kurtosis and found that the data doesn't follow normal distribution.

* Central Plantation Crops Research Institute,
Regional Station, Vittal 574 243, Karnataka

The frequency distribution of ten years yield data do not conform to a normal distribution. The frequencies being larger in the lower and smaller in the higher classes, have characteristics of poisson distribution. When mean and variance are related as in a poisson distribution or when the variance is proportional to the mean, i. e. $\sigma^2 = K\bar{x}$ then the suitable normalising transformation is given by \sqrt{x} . The yield data under study, both in case of

number of nuts and wet weight of nuts were found to exhibit the pattern of variance being proportional to the mean and hence square root transformations such as \sqrt{x} , $\sqrt{x+1/2}$, $\sqrt{x+2/3}$, $\sqrt{x+3/8}$ and $\sqrt{x+3/16}$ were attempted.

The values of β_1 and β_2 for the three transformations (nearly suitable ones) \sqrt{x} , $\sqrt{x+2/3}$ and $\sqrt{x+3/8}$ for both the yield characters are given in Tables 2 and 3.

Table 1. Co-efficient of skewness and kurtosis for data on number and weight of nuts

Year	Number of nuts		Weight of nuts	
	β_1	β_2	β_1	β_2
1964 - 65	0.73*	3.19	0.51*	2.87
1965 - 66	1.05*	4.06*	0.50*	3.15
1966 - 67	0.84*	3.91*	0.70*	3.50*
1967 - 68	0.70*	3.82*	0.27*	2.98
1968 - 69	6.29*	11.82*	5.63*	10.44*
1969 - 70	0.57*	3.22	0.30*	2.72
1970 - 71	0.59*	3.52*	0.29*	2.94
1971 - 72	0.54*	3.47*	0.23*	2.79
1972 - 73	0.71*	3.78*	0.60*	4.03*
1973 - 74	1.09*	4.21*	0.69*	3.56*

* Significantly different from either $\beta_1=0$ or $\beta_2=3$

Table 2. Transformations, Co-efficient of skewness and kurtosis for data on number of nuts

Year	Transformations					
	\sqrt{x}		$\sqrt{x+2/3}$		$\sqrt{x+3/8}$	
	β_1	β_2	β_1	β_2	β_1	β_2
1964 - 65	0	2.39*	0	2.34*	0	2.35*
1965 - 66	0.02	2.94	0.01	2.82	0.01	2.85
1966 - 67	0.01	2.76	0	2.67	0	2.69
1967 - 68	0.15	2.67	0.10	2.58	0.11	2.60
1968 - 69	0.45*	2.80	0.67*	3.13	0.61*	3.05
1969 - 70	0.09	2.98	0.06	2.86	0.06	2.88
1970 - 71	0.18*	3.20	0.13	3.08	0.14	3.10
1971 - 72	0.22*	2.70	0.17*	2.62	0.15	2.64
1972 - 73	0.21*	3.32	0.14	3.16	0.15	3.19
1973 - 74	0.07	2.30*	0.04	2.29	0.05	2.29*

* Significantly different from either $\beta_1=0$ or $\beta_2=3$

Normalising transformation for number of nuts

The results in Table 2 indicate that $\sqrt{x+3/8}$ is the most suitable transformation. Seven out of 10 populations have shown agreement with the normal distribution. Two populations showed disagreement only with respect to kurtosis whereas the remaining population (1968 - 1969) showed skewness even after transformation.

Normalising transformation for weight of nuts

The results in Table 3 reveal that \sqrt{x} transformation is found to exhibit satisfactory agreement with normality. Even though six out of ten populations showed

disagreement with normality, the variability from normality is not very much. Since $\sqrt{x+3/8}$ transformation has already been found as the most suitable one in the case of number of nuts, the same transformation may be preferred in the case of weight of nuts too.

Finally, it may now be concluded that $\sqrt{x+3/8}$ transformation approximates the given data on both number of nuts and weight of nuts to a normally distributed one.

Acknowledgement

The author expresses his deep sense of gratitude to Mr. K. Shama Bhat, Scientist S-3, CPCRI Regional Station, Vittal for providing facilities and encouragement.

Table 3. Transformations, Co-efficient of skewness and kurtosis for data on weight of nuts

Years	Transformations					
	\sqrt{x}		$\sqrt{x+2/3}$		$\sqrt{x+3/8}$	
	β_1	β_2	β_1	β_2	β_1	β_2
1964 - 65	0.02	2.45*	0	2.20*	0	2.22*
1965 - 66	0.12	2.88	0	2.46*	0.01	2.51*
1966 - 67	0.01	2.65	0.01	2.42*	0	2.44*
1967 - 68	0.30*	2.62	0.06	2.27*	0.10	2.32*
1968 - 69	0.40*	2.68	1.53*	4.34*	1.24*	3.91*
1969 - 70	0.08	3.08	0.04	2.56	0.07	2.64
1970 - 71	0.34*	3.38	0.09	2.79	0.13	2.88
1971 - 72	0.36*	2.68	0.11	2.32*	0.15	2.38*
1972 - 73	0.12	3.43	0.04	2.86	0.07	2.93
1973 - 74	0.15	2.26*	0	2.21*	0.02	2.20*

* Significantly different from either $\beta_1=0$ or $\beta_2=3$

References

CHAKRAVARTHI, I.M., LAHA, R. G. and ROY, J. 1967. *Hand Book of Methods of applied Statistics*. John Wiley & Sons, New York PP 460.

RAO, C. R. 1952. *Advanced Statistical Methods in Biometric Research*. John Wiley & Sons, New York PP 390.

SNEDECOR, G. W. and COCHRAN, W. G. 1967. *Statistical methods*. Oxford & IBH Publishing Co., Calcutta PP 594.

Effect of Intercultivation on Production of Arecanut *Areca catechu* L.

A. K. Sadanandan*, C. K. George**, A. Muralidharan***
and K. J. Abraham****

Abstract

Effect of intercultivation in areca garden (digging with mammutty once in a year, digging with mammutty twice a year, digging with mammutty once in two years and no digging) was studied for six years (1969-1975) in the alluvial soils of CPCRI Research Centre, Peechi on the productivity of arecanut. Pooled data for six years showed that intercultivation in areca garden did not significantly increase the production of fruit or fruit weight.

Introduction

Cultural practices are adopted invariably in all the areca gardens but differ from tract to tract. After a survey of the arecanut growing tracts, Nambiar(1949) reported that intercultivation increased the production of arecanut by 10 - 20 per cent. However, information on the requirement of optimum cultural practices in areca garden for augmenting yield was not available. This information will help to reduce the cost of cultivation as intercultivation operations are labour intensive and the cost of labour is increasing steadily. An attempt has therefore been made to investigate the effect of different intervals of intercultivation on the productivity of areca palms in

central Kerala which is an important tract for this crop. The area receives an annual rainfall of 2592 mm distributed over 123 days. The minimum and maximum temperatures were 17.5°C (December) and 39.5°C (April) respectively.

Materials and Methods

A field experiment was conducted for six years (1969 - '75) in the alluvial sandy loam soil (pH 5.4, 0.53% C, 0.09% N, 12 ppm of Bray P and 125 ppm K) of the erstwhile Regional Arecanut Research Station, Peechi (Central Kerala) presently Research Centre of CPCRI. The treatments were (1) no intercultivation, (2) digging with spade once a year, (3) digging with spade twice a year and (4) digging with spade once in two years.

The weed growth in the control plot was regulated by scything grass at ground level and spreading over the plot. Other plots were dug to a depth of 15 - 20 cm with the use of spade during October and April

*Central Plantation Crops Research Institute, Regional Station, Calicut 673 012, Kerala.

**Directorate of Cocoa, Arecanut and Spices Development, Calicut 673 005, Kerala.

***CPCRI Regional Station, Kayangulam, Krishnapuram 690 533, Kerala.

****CPCRI Research Centre, Palode, Pacha 695 562, Trivandrum District, Kerala.

depending upon the treatments. The number and weight of arecanuts harvested per palm were recorded. The data for six years were pooled and subjected to statistical analysis.

Results and Discussion

The results showed no significant difference between the treatments in the production of arecanut (Table 1). The number of nuts per palm averaged over the years ranged from 321 (digging once/twice in a year) to 374 (no intercultivation). Likewise the weight of nuts per palm averaged over the years ranged from 8.5 kg (digging once/twice a year) to 9.8 kg

(no intercultivation). These findings are contrary to that of Krishna Marar et al., (1959) in coconut and Sannamarappa et al., (1976) in arecanut. Under Karnataka conditions digging arecanut garden twice a year (June and December) gave the highest yield. The reasons for no response for intercultivation in the present study may be attributed to the better fertility status and the improved structural condition of the alluvial soil.

Acknowledgement

The authors thank Dr. K. V. Ahamed Bavappa, Director of the Institute for the encouragement and facilities given for the studies.

Table 1. Effect of intercultivation on production of arecanut palm (pooled analysis 1969 - '75)

Treatment	Year												Mean	
	1969 - '70		1970 - '71		1971 - '72		1972 - '73		1973 - '74		1974 - '75		No.	Wt.
	No.	Wt. (kg)	No.	Wt. (kg)	No.	Wt. (kg)	No.	Wt. (kg)	No.	Wt. (kg)	No.	Wt. (kg)	No.	Wt. (kg)
No intercultivation	287	7.4	396	9.4	477	13.0	366	10.1	373	9.8	344	8.9	374	9.8
Digging once a year	224	6.1	289	7.2	419	11.4	329	9.6	330	9.2	337	7.7	321	8.5
Digging twice a yr	240	6.5	271	6.8	420	11.4	333	8.6	359	9.7	301	8.2	321	8.5
Digging once in 2 years	249	6.7	330	8.6	320	13.0	320	9.2	428	11.9	278	7.9	321	9.6
Mean	250	6.7	322	8.0	409	12.2	337	9.4	372	10.2	315	8.2	334	9.1
						No.	Wt.							
						SE for treatment	33.6	0.81						
						SE for year	14.2	1.09						
						SE for interaction	28.2	0.79						

References

KRISHNA MARAR, M. M. and PANDALAI, K. M. 1959. Observations from some long term experimental plots of the coconuts. *Indian Coconut Journal*, 13(1) : 1 - 24.

NAMBIAR, K.K. 1949. *A survey of arecanut crop in Indian Union*. Indian Central Arecanut Committee, Calicut, PP. 76.

SANNAMARAPPA, M., KUMAR, S. N. S. and NAGARAJ, B. 1976. Effect of tillage operation in arecanut gardens of maidan part of Karnataka on the productivity of palm. *J. Plant. Crops* 4 : 58 - 59.

Evaluation of Banana Varieties for Intercropping in Arecanut Gardens

T. V. Ramakrishnan Nayar*, A. Muralidharan** and
K. Shama Bhat***

Abstract

Field experiments were conducted at the Central Plantation Crops Research Institute (CPCRI), Research Centre, Kannara, during the period 1975 to 1981 to identify banana varieties suitable for intercropping in arecanut gardens and to study the effects of intercropping with banana on the yield of arecanut palms. Among the banana varieties tried, 'Robusta', 'Mysore Poovan', 'Red banana' and 'Karpuravally' were found suitable for intercropping in arecanut gardens. The variety 'Red banana' gave maximum net returns under intercropping in arecanut gardens. There was no adverse effect on the yield of arecanut palms due to intercropping with banana.

Introduction

Banana is usually grown as a nurse crop in arecanut gardens during the initial three or four years with the main objective of providing shade to the growing arecanut seedlings. The advantages of growing banana as an intercrop in arecanut gardens were reported by Khader and Antony (1968), Bhat and Khader (1970) and Bhandary (1974). The effects of intercropping with banana for different durations and intensities in arecanut gardens were studied at CPCRI, Regional Station, Vittal (Bhat, 1978). But no information on the suitability of different banana varieties / cultivars for intercropping in

arecanut gardens was available. So field experiments were taken up at CPCRI Research Centre, Kannara, to evaluate some banana varieties for intercropping in arecanut garden and to study the effect of intercropping with them on the productivity of arecanut palms.

Materials and Methods

The field experiment was conducted in a seventeen year old arecanut garden having lateritic soil overlaid with river alluvium. Arecanut palms were planted in the garden with a spacing of 2.7×2.7m. The experiment was laid out in randomised block design with eight treatments and five replications. The treatments consisted of intercropping with seven banana varieties and a control plot with no banana. The banana varieties tried during 1975-'78 were 'Peyan', 'Karpuravally', 'Dwarf Cavendish', 'Red banana', 'Mysore poovan', 'Kunnan' and 'Nendran'. Since the quality

*Present address : Central Tuber Crops Research Institute, Trivandrum 695 017, Kerala.

**Central Plantation Crops Research Institute, Regional Station, Kayangulam, Krishnapuram 690 533, Kerala.

***Central Plantation Crops Research Institute, Regional Station, Vittal 574 243, Karnataka.

of the 'Peyan' fruits was not acceptable to the market and the yield of 'Kunnan' was very poor, these varieties were replaced with 'Robusta' and 'Poovan' respectively and the experiment was repeated during the period 1978 - '81 in the same area.

The banana suckers were planted in the middle of arecanut rows adopting a spacing of 5.4×2.7m. In each plot there were sixteen arecanut palms and eight banana plants. The recommended package of practices for both arecanut palms and banana were carried out. During summer months arecanut palms and banana plants were irrigated at weekly intervals. In the case of banana the weight of bunches from the plant crop and the following two ratoon crops were recorded. Observation on the number and fresh weight of the nuts were recorded in the case of arecanut palms and the data were statistically analysed.

Results and Discussion

Performance of banana varieties:

The data on mean yield of banana varieties grown as intercrop in arecanut

garden during 1975 - '78 and 1978 - '81 are provided in Table 1. The variety 'Mysore Poovan' gave the highest yield with a mean bunch weight of 15.3 kg / plant during 1975 - '78. During the period 1978 - '81 also the yield from 'Mysore Poovan' was the highest with a mean bunch weight of 12.3 kg/plant. The varieties Karpuravally and Robusta ranked as second and third respectively in mean bunch yield. The yields from 'Kunnan', 'Poovan' and 'Nendran' were not satisfactory. The performance of Dwarf Cavendish was very poor due to severe incidence of 'Kokkan' disease. The variety Karpuravally was free from incidence of bunchy top disease. In the case of other varieties also the incidence of bunchy top was negligible.

Economics of intercropping with different banana varieties:

The average yield of banana varieties grown during 1978 - '81, cost of cultivation, value of the bunches and the net profit per hectare due to intercropping with banana in arecanut garden are

**Table 1. Yield of banana varieties as intercrop in arecanut garden
Weight of bunch / plant (kg)**

	1975 - 1978				1978 - 1981			
	Plant crop	Ratoon			Plant crop	Ratoon		
		I	II	Mean		I	II	Mean
Peyan / Robusta*	10.4	9.9	9.8	10.0	14.2	13.5	8.4	12.0
Karpuravally	14.6	13.9	13.5	14.0	11.3	12.0	10.0	11.1
Dwarf cavendish	8.8	8.3	7.9	8.3	10.7	9.0	7.0	8.9
Red banana	9.0	9.3	9.4	9.2	11.8	10.5	8.0	10.1
Mysore Poovan	15.7	15.2	14.9	15.3	10.1	14.3	12.5	12.3
Kunnan / Poovan*	4.3	4.1	4.2	4.2	7.0	6.0	5.3	6.1
Nendran	6.4	5.2	5.5	5.7	6.0	5.4	4.1	5.2

*Peyan, Kunnan - 1975 to 1978

Robusta, Poovan - 1978 to 1981

presented in Table 2. Intercropping with all the banana varieties tried except Poovan was profitable. The variety 'Red banana' though ranked as fourth in per hectare yield gave maximum net profit/ha due to the higher market rate obtained for the produce. Net returns to the tune of Rs. 5190 / ha could be obtained from intercropping with 'Red banana' in arecanut gardens. This is in addition to the returns obtained from the main crop arecanut. 'Red banana' which is commonly known as 'Kappapazham' is a well appreciated dessert fruit, especially in Southern Kerala where the cost ranges from Rs. 4 to Rs. 5 per kg. Though there is not much difference in per hectare yield between the varieties 'Robusta' and 'Mysore Poovan' the former gave higher net profit. Next to Mysore

Poovan, the bunchy top disease tolerant variety 'Karpuravally' stood with a net profit of Rs. 2166/ha.

Effect of intercropping with banana on the productivity of arecanut palms:

The data on mean number of nuts/palm and weight of fresh nuts/palm for the period 1976 - '77 to 1979 - '80 are given in Table 3. The above yield attributes of arecanut palms were not significantly influenced by intercropping with banana. This finding is in confirmation with the earlier reports by Roy (1974), Nagaraj (1974), and Bhat (1978). The different banana varieties grown also had no adverse effect on the productivity of arecanut palms.

Table 2. Economics of intercropping with banana varieties in arecanut garden

Banana varieties	Cost of cultivation Rs. / ha	Yield of banana bunches (kg / ha)	Market rate Rs. / kg	Gross value Rs. / ha	Net profit from the intercrop Rs. / ha
Robusta	3900	7200	1.00	7200	3300
Karpuravally	3828	6660	0.90	5994	2166
Dwarf cavendish	3900	5340	1.00	5340	1440
Red banana	3900	6060	1.50	9090	5190
Mysore Poovan	3766	7380	0.90	6642	2876
Poovan	3828	3660	1.00	3660	-168
Nendran	3900	3096	1.50	4644	744

Table 3. Effect of intercropping with banana varieties on the yield of arecanut palms

Treatments	Yield of arecanut palm (mean of 4 years)	
	No. of Nuts / palm	Fresh weight of nuts kg / palm
Arecanut alone (Control)	375	11.2
Peyan / Robusta	387	11.6
Karpuravally	403	12.7
Dwarf cavendish	379	11.3
Red banana	378	11.7
Mysore Poovan	307	9.1
Kunnan / Poovan	317	9.6
Nendran	363	11.1
CD	NS	NS

References

- BHANDARY, K. D. 1974. Study of inter and associated crops in areca gardens of the 'Malnad' tract of Karnataka. *Areca nut and Spices Bull.* **5** : 76 - 77.
- BHAT, K. S. and KHADER, K. B. A. 1970. Inter and mixed cropping in areca nut gardens. *Indian Fmg.* **18** (4) : 19 - 20.
- BHAT, K. S. 1978. Agronomic research in areca nut - A review. *J. Plant. Crops* **6** : 67 - 80.
- KHADER, K. B. A. and ANTONY, K. J. 1968. Intercropping - A paying proposition for areca growers. *Indian Fmg.* **18** (4) : 14 - 15.
- NAGARAJ, B. 1974. Intercropping in areca nut gardens of 'Maidan' areas of Karnataka. *Areca nut and Spices Bull.* **5** : 78 - 79.
- ROY, A.R. 1974. Intercropping in areca nut gardens of North Eastern India : A brief review of work done. *Areca nut and Spices Bull.* **5** : 82 - 85.

Beneficial Micro-organisms in the Root Region of Arecanut Palm

B. M. Bopaiah*

Abstract

The micro-organisms inhabiting in the root region of arecanut palms are enumerated. The occurrence of asymbiotic nitrogen fixers, phosphate solubilizers and cellulolytic micro-organisms were recorded. The antagonistic Streptomyces sp. and Actinomyces sp. were found to be associated in the root regions. The influence of intercropping on the population of asymbiotic nitrogen fixers was studied. Among the asymbiotic nitrogen fixers Beijerinckia sp., Derxia sp. and Azotobacter sp. were present. Aspergillus sp., Penicillium sp. and Pseudomonas sp. being the phosphate solubilizers were also detected in the root region. Indole producing bacteria were isolated from the rhizosphere of arecanut palms. The micro-organisms capable of utilizing cellulose, hemicellulose, starch and pectin are discussed.

Introduction

Arecanut cultivation is restricted mainly to the high rainfall belts. Being a perennial crop, the palm continues to yield for 35-50 years. Root region is the active zone for the proliferation of several micro-organisms. The rhizosphere activities depend on root spread, exudation and respiration of the roots. In arecanut 60-80 per cent of the roots are confined to 50 cm radius from base to a depth of 50 cm. The other soil characteristics like soil moisture, pH, temperature, the age and also the conditions of the palms are known to influence the microflora and microbiological activities in the root region. The micro-organisms are beneficial in increasing the soil fertility and plant growth as they are involved in several important biochemical transformations and mineralisation activities in soil.

In the present investigation, the enumeration and occurrence of beneficial micro-organisms in the root region of arecanut palms are discussed. The influence of intercropping on the population of asymbiotic N₂ fixers are also studied.

Materials and Methods

The arecanut rhizosphere samples were collected from the experimental plot of the institute. The samples were collected from the base of arecanut palms between 30-60 cm lateral distance and at 0-30 cm depth. The sampling was done from three palms. The non-rhizosphere samples were collected to enumerate the micro-organisms with a view to find out the rhizosphere and non-rhizosphere ratio (R:S ratio). The bacterial, fungal and actinomycetes flora were enumerated quantitatively using soil extract agar, Martin's rose bengal agar and Kustar's agar medium, respectively (Dilution plating

* Central Plantation Crops Research Institute, Regional Station, Vittal 574 243. Karnataka

method, Jenson, et al., 1959). The representative colonies of bacteria, fungi and actinomycetes were isolated, purified and maintained on Nutrient Agar (NA), Potato Dextrose Agar (PDA) and Kustar's agar (KA) respectively for identification and for the studies on the utilization of different components of organic matter.

The enumeration of *Azotobacter*, *Beijerinckia* and *Derxia* (asymbiotic nitrogen fixers) were carried out using specific medium viz. Jensen's medium (Jensen, 1942), Beeking medium (Beeking, 1959) and medium of Campelo and Dobereiner (1969) respectively for each of them. Both dilution plating technique and spread plate technique (0.1 g soil) were employed to enumerate the different asymbiotic nitrogen fixers. The phosphate solubilizing organisms were counted using Katznelson and Bose (1959) and Pikovskaya's medium and the plates were incubated at room temperature for 7 days. A clear zone develops around the colonies of those capable of solubilizing phosphate.

The micro-organisms capable of utilizing the different components were studied by inoculating the different isolates of bacteria, fungi and actinomycetes. Cellulose, hemicellulose, pectin and starch were used as source of carbon in the medium and the growth of micro-organisms were recorded. The cellulose decomposing ability was found out in Omeliansky's medium using filter paper strips in the test tube and cellulose decomposers were recorded after 15 days of incubation.

Enumeration of asymbiotic nitrogen-fixers in arecanut intercrops:

The rhizosphere samples were collected from the intercrops of cowpea, arrow root, elephant foot yam, sweet potato, ginger,

ragi, *Dioscorea*, banana and Napier grass (NB-21) for the enumeration of *Azotobacter* (Waksman medium No. 77) and *Beijerinckia* (Beeking medium) population. The control soil, where there was no intercrop was used for comparison.

The bacterial isolates were grown for 48 hr in test tube broth containing Tryptophane and Voges-Proskauer test (V-P test) was conducted for the production of indole.

Results and Discussion

The occurrence of bacteria, fungi and actinomycetes flora in the rhizosphere region of arecanut and non-rhizosphere soils were studied and indicated that large number of bacteria, fungi and actinomycetes were observed in the rhizosphere soils (153.3×10^4 , 37.3×10^3 and 10.7×10^4) as compared to non-rhizosphere (47.0×10^4 , 4.3×10^3 and 7.3×10^4) respectively. The rhizosphere effect indicates the overall influence of plant roots on soil micro-organisms. The R:S ratio for bacteria (3.6) and actinomycetes (1.5) is narrow because the population difference between root region and non-rhizosphere is not much, mainly due to the acidic nature of the soil (pH 5.2-5.8).

The enumeration of asymbiotic nitrogen fixers indicated the occurrence of *Azotobacter* sp., *Beijerinckia* sp. and *Derxia* sp. on different medium. The colonies of asymbiotic nitrogen fixers were small and not well developed in the dilution plating method, whereas sprinkling of soil (0.1 g) and spread plate method on the medium produced slow growing as well as fast growing well developed colonies. This indicates that these organisms require some growth promoting compounds in the

medium. In general, *Beijerinckia* sp. and *Derxia* sp. were more compared to *Azotobacter* sp.

The intercropping in areca garden in general has increased the population of asymbiotic nitrogen fixers, in addition to the increase in the total microflora i.e., bacteria, fungi and actinomycetes (Muralidharan-personal communication). Similarly the mixed cropping trials with cowpea, Guinea grass and Napier grass (NB-21) in arecanut has increased the asymbiotic N₂ fixers (*Azotobacter* and *Beijerinckia*) and phosphate solubilizing micro-organisms (Rawther, et al., 1979). This indicates that several intercrops could be grown in areca gardens so as to increase the productivity per unit area through nitrogen fixers and P solubilization mechanisms.

The population of phosphate solubilizing micro-organisms was in the range of 5-10⁴ × 10⁴/g of soil. *Aspergillus* sp., *Penicillium* sp. and *Pseudomonas* sp. were the phosphate solubilizers observed in the root region.

The genera of micro-organisms isolated from the rhizosphere of arecanut palms capable of utilizing different components of organic matter are given in Table 1. The studies on the micro-organisms capable of decomposing cellulose and hemicellulose indicated that they were in abundant number in the root region of areca palms. The starch hydrolising and pectin degrading micro-organisms were also recorded. The green leaf and farm yard manure (FYM) application is the common practice by growers every year in the month of September - October. Therefore, the cellulose, hemicellulose, lignin and pectin degrading micro-organisms are important in the decomposition of organic matter (green

leaf and FYM), The degradation of organic matter by the activities of root-region microflora releases the nutrients and makes it available to the plant for the uptake slowly. Variety of organic substances available at the root region by way of exudates from roots directly or indirectly influence the quantity and quality of micro-organisms in the root region.

The crowded plate technique using Potato Dextrose Agar (PDA) and Nutrient Agar (NA) has yielded several actinomycetes antagonistic to bacteria. The antagonistic actinomycetes belong to the genera of *Streptomyces* sp. and *Actinomyces* sp. Root region may also provide a food base for the growth of the pathogenic micro-organisms in soil. The indole producing bacteria isolated from the rhizosphere of arecanut belong to *Pseudomonas* sp.

Table 1. Genera of micro-organisms isolated from the root region of areca palms capable of utilizing different components of organic matter

Cellulose	F: <i>Aspergillus, Chaetomium, Fusarium, Penicillium, Rhizoctonia, Rhizopus, Trichoderma, Alternaria.</i> B: <i>Bacillus, Pseudomonas.</i> A: <i>Micromonospora, Nocardia, Streptomyces.</i>
Hemicellulose	F: <i>Aspergillus, Rhizopus, Fusarium, Chaetomium, Penicillium, Alternaria.</i> B: <i>Bacillus, Pseudomonas.</i> A: <i>Streptomyces.</i>
Starch	F: <i>Aspergillus, Fusarium, Rhizopus.</i> B: <i>Bacillus.</i> A: <i>Micromonospora, Nocardia, Streptomyces.</i>
Pectins	F: <i>Fusarium.</i> B: <i>Bacillus, Pseudomonas.</i>

F = Fungi B = Bacteria A = Actinomycetes

Several micro-organisms were found inhabiting in the root region of areca palms. The micro-organisms are responsible for ammonification, nitrification, denitrification, carbohydrate utilization, cellulose decomposition and nitrogen fixation. In general, the greater rhizosphere effect is seen with bacteria (R:S ratio ranging from 10 to 20 or more) but it is not so with the rhizosphere of arecanut palm, may be due to the acidic nature of the soil and soil

type (laterite soils). From the agronomic point of view, the abundance of nitrogen fixing and phosphate solubilizing micro-organisms in the rhizosphere assumes a natural significance.

Acknowledgement

The author is thankful to Senior Scientist-in-charge, CPCRI Regional Station, Vittal for the encouragement.

References

- BEEKING, J. H. 1959. Nitrogen fixing bacteria of the genus *Beijerinckia* in South African Soils. *Plant and Soil* 11: 193-206.
- BOPALAH, B. M. and KOTI REDDY 1982. Distribution of microflora population in the rhizosphere of arecanut. *J. Plant. Crops* 10: 127-128.
- CAMPELO, A. B. and DOBEREINER, J. 1969. Soil biology, *Int. news Bull*-11: 40-44.
- JENSEN, H. L. 1942. Nitrogen fixation in leguminous plants II. Is Symbiotic nitrogen fixation influenced by *Azotobacter*? *Proc. Linn. Soc. N. S. W.* 57: 205-212.
- JENSONS, L. F., CURL, E. A., BOND, J. H. and FRIBOURG, H. A. 1959. *Methods for studying soil microflora plant disease relationships*. Burgess Publishing Co. Minneapolis, Minn. U. S. A.
- KATZNELSON, H. and BOSE, B. 1969. Metabolic activity and phosphate dissolving capability of bacterial isolates from wheat roots, rhizosphere and nonrhizosphere soil. *Can. J. Microbiol.* 5: 79-85.
- RAWTHER, T. S. S., ABRAHAM, K. J., ACHUTHAN NAIR M. and JAYASANKAR N. P. 1979. Microbial profiles of arecanut soils under mixed cropping with special reference to arecanut yellow leaf disease PP. 71 - 75 In *PROC. PLACROSYM - II. ed. VENKATARAM, C. S.* Indian Society for Plantation Crops, Kasaragod, India.

Standardization of Leaf Sampling Technique in Arecanut Palm

A. R. Mohapatra and N. T. Bhat*

Abstract

In perennial crops with extensive root system soil sampling and analysis for predicting plant nutrient supply are problems. In such cases leaf analysis is adopted as one of the alternative methods for diagnosing the nutrient requirement. Proper selection of leaf is of utmost importance. A method for selecting leaf part for analysis of arecanut is discussed.

Introduction

It is well established that the composition of a particular plant species is profoundly influenced by the composition of the soil. In perennial crops where extensive root systems mine the plant nutrients from large soil mass, soil sampling is a problem. If tissue analysis is standardised on a well laid out field trial this would compliment soil analysis for computing the nutrient status and nutrient requirement. In tissue analysis a well defined plant part, time of sampling and age of the tissue should be fixed. Leaf analysis has distinct advantages over soil analysis in perennial crops for diagnostic purpose. Meaningful soil samples are difficult to take in situations where manures/fertilisers were applied in narrow bands around the trees. Yadava et al., (1971) studied the leaf sampling technique in arecanut palm. They have suggested the collection of leaflets from different leaf numbers for different nutrient element and second leaf for composite analysis.

Because of certain limitations in the suggested sampling procedure a reexamination was done.

Materials and Methods

The treatment $N_2P_2K_2G_2$ * from the NPK Experiment laid out at CPCRI Regional Station, Vittal was selected. Thirteen palms were used for sampling. The samples were collected in the month of February.

In the present study the leaves were numbered serially from top to bottom. The latest fully opened leaf is taken as leaf number one and counted down in the sequence of maturity. For analysis purpose leaflets were collected from each leaf from three positions i.e., base, middle and top. From each side of main rachis leaflets were collected on either side. From each position two to three leaves were adequate to give enough samples for

* N_2 - Nitrogen, 100 g / palm / year
 P_2 - Phosphoric acid, 80 g / palm / year
 K_2 - Potash, 140 g / palm / year
 G_2 - Green leaf, 14 kg / palm / year

*Central Plantation Crops Research Institute, Regional Station, Vittal 574 243, Karnataka

analysis. Immediately after field collection the samples were washed in tap water, rinsed with distilled water and processed as per the standard methods.

The following procedures were adopted for laboratory analysis

Nitrogen : Kjeldhal method (Jackson, 1967).

Phosphorus : Vanado - molybdo phosphorie yellow colour method using Klett summerson colorimeter (Jackson, 1967)

Potassium : Flame photometer (Jackson, 1967).

Calcium and

Magnesium : E. D. T. A. titration. (Heald, 1965).

Phosphorus, potassium, calcium and magnesium were estimated from the aliquot obtained by wet digestion of plant sample using nitric and perchloric acid. From the data the coefficient of variations and table of rank for cv(%) have been computed for selecting the leaf position for sampling purpose.

Results and Discussion

From the result, it is evident that the fourth leaf has the lowest rank sum for N,P,K. The sixth leaf has the lowest rank sum for Ca, Mg. This shows that for

NPK analysis, leaf number 4 is suitable and for Ca and Mg, leaf number 6 is suitable. Similarly co-efficient of variations were ranked for leaflet position for all the leaves. The table of ranks is given in Table 1a and 1b.

The rank sum figures show that the lowest value is for leaflets collected from the top portion of leaf number 6 and leaflets collected from the bottom portion of leaf number 8. The next higher figures is for top portion leaflets in leaf number 4.

The fourth leaf was found suitable for sampling in the earlier conclusion. The difference in rank sum is negligible. Hence it can be concluded that leaflets collected from the top portion of leaf number 4 are suitable for NPK analysis.

The rank sum figures for Ca and Mg values show the lowest in bottom leaflets of leaf number 4. The next higher value is obtained for leaflets collected from all the three position of leaf number 6. So it can be concluded that for Ca, Mg analysis it is desirable to collect separate sample either from the bottom leaflets of leaf number 4 or leaflets at any position in leaf number 6.

Acknowledgement

The authors are thankful to Shri K. Shama Bhat, Agronomist. who kindly permitted to use the palms in the NPK experiment for this study. Our sincere thanks are due to Shri S. Bhagavan and Shri B. P. Nair who assisted in statistical interpretation.

Table 1a. The rank and rank sum for N,P,K in different leaves.

Leaf No.	1	2	3	4	5	6	7	8
Constituent								
N	8	3	1	5	2	6	7	4
P	8	6	3	1	7	2	4	5
K	5	4	8	3	7	6	1	2
Rank sum	21	13	12	9	16	14	12	11

Table 1b. The rank and rank sum for Ca and Mg in different leaves.

Leaf No.	1	2	3	4	5	6	7	8
Constituent								
Ca	4	6	8	3	7	1	2	5
Mg	3	7	5	4	6	2	8	1
Rank sum	7	13	13	7	13	3	10	6

References

HEALD, W.R. 1965. *Calcium and Magnesium In Methods of Soil analysis Part 2. Agronomy Monograph No. 9.* Amer. Soc. of Agron. Madison, Wisconsin USA. P 999 - 1010.

JACKSON, M. L. 1967. *Soil chemical analysis.* Prentice Hall of India. Pvt. Ltd. New Delhi. 187 - 190.

YADAVA, R. B. R., MATHAI, C. K. and VELLAICHAMI, K. 1971. Leaf sampling techniques in arecanut palm for nutrient analysis. *The Andhra Agric. J.* 18 : 149 - 152.

Session 3

Plant Protection

Plant Pathology

Chairman : P V Rai

**Rapporteurs : R Radhakrishnan Nair
R Chandramohan**

On the Mechanism of Spore Dispersal in *Phytophthora arecae*, the causal organism of 'Koleroga' of Arecanut

M. Anandaraj*

Abstract

The fruit rot or Koleroga caused by Phytophthora arecae occurs in epidemic proportions during south west monsoon season. The secondary spread of the pathogen is by sporangia produced abundantly on the infected fruits. To study the dispersal of sporangia, Hirst volumetric spore trap, bidirectional and multidirectional splash traps were used. The sporangia were liberated and spread mainly by rain splashes.

Introduction

Fruit rot of arecanut commonly known as *Koleroga* or *Mahali* caused by the fungus *Phytophthora arecae* (Coleman) Pethybridge occurs as an epidemic during the south west monsoon from June to September in southern India. The secondary spread of the epidemic is by sporangia which are produced abundantly on the infected fruit surface. The mechanism of sporangial dispersal is passive and appears to be dependent on rain drops. The present studies were undertaken to get an understanding on the mechanism of spore dispersal and spread of the disease.

Materials and Methods

The studies were carried out in an unsprayed areca plot situated in the midst of CPCRI farm at Vittal, Dakshina Kannada by using spore traps. The splash borne nature of the sporangia was studied in the laboratory by allowing water droplets to

fall from a height of 7.5m on infected sporulating areca fruits and the resultant splashed droplets collected on slides and observed for the presence of sporangia. Hirst volumetric spore trap (24 h recorder) was set up at a height of 7.5m at the crown level to collect the air spores. Splash traps were made out of galvanised iron sheets based on J. M. Waller's Model (Waller, 1972; Rajasab et al., 1979). Two types of splash traps viz., multidirectional and bidirectional were used. The multidirectional traps are cylindrical in structure with a diameter of 12 cm and length of 15.5 cm with a roof to prevent the direct falling of rain water. This was supported by a funnel which drains water from the cylinder into a collection tube. The entire structure was fixed to the areca palm. The bidirectional trap is a rectangular plate of 15cm × 10cm with a narrow strip of galvanised iron sheet at the sides which drains into a collection tube. These were fixed to wooden poles and installed at 3m, 4.5m and 6m height in the field. The multidirectional traps were fixed at 7.5 m adjacent to the crown of the palm. The water

* Central Plantation Crops Research Institute, Regional Station, Vittal 574 243, Karnataka

collected in the tubes was centrifuged at 1200 rpm for 5 min, the supernatant discarded, the sediment with 1 ml of water was obtained and observed for the presence of sporangia. The number of sporangia present was quantified using a haemocytometer. The slides collected from the Hirst volumetric spore traps were examined for the presence of *Phytophthora* sporangia.

Results and Discussion

In the laboratory studies on the splash dispersal it was observed that the water droplet falling on the sporulating fruit surface, after the impact, breaks into smaller droplets and splashes. During this process it liberates and carries the sporangia present on the fruit surface. These droplets were collected on slides and the number of sporangia present was counted (Table 1). The first droplet did not liberate any sporangia, but the subsequent droplets carried the sporangia. The number of sporangia liberated reduced gradually after 11th droplet.

Splash water collected from all the splash traps were examined for the presence of sporangia. There were no sporangia from

Table 1. Number of sporangia liberated through water droplet (mean of 4 observations)

Droplet No.	No. of sporangia	Droplet No.	No. of sporangia
1	—	9	20
2	11	10	12
3	29	11	12
4	26	12	11
5	23	13	9
6	20	14	9
7	20	15	4
8	21		

the water collected from splash traps installed at 3m and 4.5m. Sporangia were observed in the splash water collected from the bidirectional splash trap installed at 7.5m. The number of sporangia caught on these traps, collected during first day to fifth day of August, 1981 are presented in Table 2. During this period there was maximum incidence of the disease. There was no sporangia in the slides obtained from the Hirst volumetric spore trap. This indicates that the sporangia are liberated and dispersed mainly through rain water.

Table 2. Number of sporangia caught in the splash traps

Splash Trap No.*	Ht. of observation (m)	Qty. of water collected (ml)	Sporangia present/mm ³
1	6	50	20
2	6	45	10
3	6	60	30
4	7.5	55	70
5	7.5	50	200
6	7.5	75	150
7	7.5	45	120
8	7.5	50	160
9	7.5	40	110
10	7.5	35	170

* 1-3 bidirectional splash traps

4-10 multi-directional splash traps

The disease is reported to spread rapidly during the period of alternate sunshine and rain (Coleman, 1910; Nambiar, 1956). Since the fungus requires sunlight for the production of sporangia, a short period of bright sunlight would induce sporulation and the subsequent rains help in spreading the sporangia which results in the rapid spread of the disease. Thus the fungus requires the help of falling rain water for the liberation and dispersal of the sporangia.

References

- COLEMAN, L. C. 1910. Disease of areca palm, *Areca catechu* L. I. *Koleroga* or rot disease. *Ann. Myc.* 8 : 591 - 626.
- NAMBIAR, K. K. 1956. *Areca nut cultivation in India*. ICAR Farm Bull. No. 14. pp. 32.
- RAJASAB, A. H., SHENOI, M. M. and RAMALINGAM, A. 1979. Epidemiology of Sorghum downy mildew III. Dispersal of inoculum by air and water. *Kavaka*. 7 : 63 - 67.
- WALLER, J. M. 1972. Waterborne spore dispersal in coffee berry disease and its relation to control. *Ann. App. Biol.* 71 (1) : 1 - 18.

Discussions

PM Gowda:

Is there any radial dispersal of sporangia of *P. arecae* when there is no rainfall?

M Anandaraj:

There is no radial spread when there is no rainfall.

RN Brahma:

Could you collect sporangia from the dew drops which may also have role in dispersal?

M Anandaraj:

During south west monsoon season it rains throughout the season. There is no dew formation. When there is dew formation in November - December there is no incidence of the disease.

Abi Cheeran:

Having deciduous sporangia there is a possibility for dispersal of sporangia by air current and this cannot be ruled out. Please clarify the point.

M Anandaraj:

The Hirst volumetric spore trap was installed at a height of 7.5 m in an unsprayed garden and there was incidence of disease in this garden. The absence of sporangia in the slides of Hirst trap and its presence in splash trap indicates the dependence on rain water for dispersal.

Control of 'Koleroga' of Arecanut

M. N. L. Sastry and R. K. Hegde*

Abstract

Experiments were conducted during 1979 and 1980 to find out the best control measure against Koleroga of arecanut caused by *Phytophthora meadii*, in the gardens of Sirsi, Uttara Kannada. The treatments included the covering of arecanut bunches with suitable covers and spraying of chemicals. Among these, good control of Koleroga with high field applicability was obtained when the arecanut bunches were covered with polythene covers (200 gauge). Bordeaux mixture (1 per cent) did not give perfect control of the disease even after three repeated applications. Although, the systemic chemicals viz., Aliette and metalaxyl had some curative effect on the infected arecanuts, their efficacy did not last longer.

Introduction

Among several diseases that affect arecanut (*Areca catechu* L.), Koleroga or fruit rot caused by *Phytophthora meadii* McRae (earlier known to be caused by *P. arecae* (Coleman) Pethybridge is a major problem in the plantations of Uttara Kannada. The disease occurs after the onset of the monsoon and results in heavy dropping of arecanuts from the bunches and death of the palm itself in advanced stages (Coleman 1910; Mundkur, 1961 and Sastry, 1982). The measures that were suggested by the earlier workers to control the disease comprised of either providing covers to arecanut bunches made of arecanut leaf sheaths (*Kotte*) or dried grass (*Karada*) or spraying Bordeaux mixture (1 per cent) to the bunches 2-3 times (Coleman, 1910, 1915; Narasimhan, 1922 and Venkata Rao, 1925). The following are the drawbacks in these measures. The covers either will be knocked off and broken by heavy winds or

rot during the rains in the monsoon and in such cases they will be more harmful, as they allow the rain water to enter into the bunches and provide favourable condition for the *Phytophthora* infection. In case of Bordeaux mixture sprays, the necessity of its repeated application causes a heavy labour cost and application problems during the rains and it is unable to check the internal infection of the kernel. Therefore, the present investigations were taken up to find out the best protective and curative measure to check the onslaught of the disease.

Materials and Methods

Selection of site

Gardens selected at Sirsi area for the experiments were situated in valleys with thick perennial trees on both sides. The humidity during the rainy season was almost 100 per cent and the gardens were regularly affected by *Koleroga* in the previous years.

* Department of Plant Pathology, University of Agricultural Sciences, Bangalore 560 024

Experiments during the year 1979

During the monsoon of 1979, a field experiment was laid out at Bhairumbe, Sirsi to find out the best protective and therapeutic (curative) measures in keeping the disease under check. Under protective measures, polythene coverings, *Kotte* and *Karada* were used while for prophylactic sprays systemic chemicals like Aliette (aluminium tris (ethyl phosphonate)) and metalaxyl (methyl D, L-N - (2, 6 - dimethylphenyl) - N - (2¹ methoxyacetyl) - alaninate) and Bordeaux mixture (1 per cent) were used. The design followed for the experiment was randomized block method with five replications.

Preparation of *Kotte*, *Karada* and Polythene covers

Kotte and *Karada* were prepared as described by Coleman (1910). Polythene covers of 200 gauge thickness and of size 75 cm length × 62.5 cm breadth with two ends (one lengthwise and one breadthwise) sealed, were obtained and covered on to the bunches (the sealed portion facing the front portion and the unsealed portion facing the stem) like a cap. The corner ends of the covers were tied firmly to the stem. The bottom portion of the covers were kept open to facilitate proper aeration to the bunches.

Schedule of operation

The mechanical coverings with *Kotte*, *Karada* and polythene coverings were done just before the onset of the monsoon. In case of prophylactic sprays, Bordeaux mixture (1 per cent), Aliette and metalaxyl (both at 0.1 per cent) were sprayed, once just before the onset and twice at monthly intervals after the onset of monsoon. One therapeutic spray with the three chemicals

was tried at various stages of *Koleroga* incidence on the arecanut bunches. Aliette was tried at 0.1 and 0.5 per cent, while metalaxyl and Bordeaux mixture were tried at 0.1 per cent and 1 per cent respectively for therapeutic sprays.

Observations

Observations were recorded at regular intervals of 15 days up to the harvest of bunches with regard to the incidence of the disease, growth performance of bunches and nuts and condition of bunch covers.

In case of therapeutic sprays the disease grades on the bunches were recorded before and after the completion of the sprays. The disease grades followed (based on the nut fall from the bunches) were as follows: grade 1 (1 - 10% nut fall from bunches), grade 2 (11 - 25% nut drop), grade 3 (26 - 50% nut drop), grade 4 (51 - 75% nut drop + spread of the disease to bunch stalk), grade 5 (76 - 100% nut drop + spread of the disease to the main stalk of the bunch) and grade 6 (crown death).

Experiment during the year 1980

The treatments which were found successful in controlling *Koleroga* during 1979 were tried on a large scale in the gardens selected from four different villages of Sirsi, viz., Bhairumbe, Hakkimane, Koppalotota and Kesinamane. At each locality 60 palms were employed for each treatment. The percentage disease incidence in each treatment and at each locality was recorded and tabulated.

Results

Experiment during 1979

a) Prophylactic method

Among the prophylactic chemical spray treatments, all the three chemicals gave adequate control of the disease. Among

the mechanical methods, covering the bunches with polythene covers gave 100 per cent control of the disease. In the case of *Kotte* and *Karada*, disease incidence was recorded in the later months of monsoon and these coverings were found rotted at the end of the monsoon (Table 1).

Table 1. Control of *Koleroga* of arecanut in the garden at Sirsi during 1979 (Prophylactic methods)

Sl. No.	Method	Disease incidence (%)
1.	Chemical sprays	
	i) Bordeaux mixture (1%)	0.00
	ii) Aliette (0.1%)	0.00
	iii) Metalaxyl (0.1%)	0.00
2.	Mechanical methods with	
	i) Polythene cover	0.00
	ii) <i>Kotte</i> cover	14.00
	iii) <i>Karada</i> cover	5.00
3.	Chemical + Mechanical methods	
	i) Bordeaux mixture (BM) spray (1%) + <i>Karada</i> cover	0.00
	ii) BM spray (1%) + <i>Kotte</i> cover	0.00
	iii) BM spray (1%) + Polythene cover	0.00
	iv) Aliette spray (0.1%) + <i>Karada</i> cover	0.00
	v) Aliette spray (0.1%) + <i>Kotte</i> cover	15.00
	vi) Aliette spray (0.1%) + Polythene cover	0.00
	vii) Metalaxyl spray (0.1%) + <i>Karada</i> cover	12.00
	viii) Metalaxyl spray (0.1%) + <i>Kotte</i> cover	0.00
	ix) Metalaxyl spray (0.1%) + Polythene cover	0.00

b) Therapeutic sprays

The systemic chemicals, Aliette (0.1 and 0.5 per cent) and metalaxyl (0.1 per cent) arrested the nut drop 3 - 10 days after their application to the bunches.

Further, they also exhibited the curative effect on the nuts and bunch stalks. The treated nuts did not yield any fungus when isolations were attempted. In case of Bordeaux mixture (1 per cent), there was no reduction in disease and hence more nut drop. The isolation of *Phytophthora* from Bordeaux mixture treated nuts was always positive (Table 2).

Experiments during 1980

As good control of *Koleroga* was obtained by covering the bunches with polythene covers and by spraying Bordeaux mixture, Aliette and metalaxyl, experiments using these treatments were taken up in four gardens in four different villages of Sirsi during 1980. The percentage disease incidence recorded in case of each treatment and in each locality are presented in Table 3. The data clearly revealed that covering of bunches with or without the presprays was effective in protecting the bunches against *Koleroga* in all the four locations.

Table 2. Control of *Koleroga* of arecanut in the garden at Sirsi during 1979 (Therapeutic sprays)

Sl. No.	Fungicide	Plant number	Disease grade before the application of fungicide	Disease grade after 15 days
1.	Bordeaux mixture, 1.0%	i	1	3
		ii	2	5
		iii	3	5
		iv	4	5
2.	Aliette, 0.1%	i	3	4
		ii	2	2
		iii	3	3
3.	Aliette, 0.5%	i	2	2
		ii	4	4
		iii	3	3
4.	Metalaxyl, 0.1%	i	1	1
		ii	2	2
		iii	4	4

In very few instances, the disease incidence in the bunches covered with polythene covers was observed particularly when dislocation of covers on the bunches due to some reason (like wind) was observed.

None of the chemicals gave perfect control of the disease. More disease incidence was noticed in case of bunches sprayed with Aliette or metalaxyl (both at 0.1 and 0.2 per cent) than in case of bunches sprayed with Bordeaux mixture (1 per cent) in all the four locations. But when they were sprayed at 0.5 per cent concentration the disease incidence was comparatively less than that noticed in Bordeaux sprayed palms.

Loss due to *Koleroga* in arecanut gardens sprayed with Bordeaux mixture (1 per cent)

As Bordeaux mixture (1 per cent) did not give good control of the disease in 1980, it was planned to estimate the loss caused by the disease. Data revealed maximum yield loss of 350 kg of arecanut amounting to Rs. 4117 and death of 50 palms per 0.4 ha (1 acre) in a garden at Hakkimane (Table 4). Minimum yield loss of 72 kg of arecanut amounting to Rs. 847 and death of 9 palms per 0.4 ha were recorded in a garden at Arsapur. On an average yield loss of 167 kg of arecanut amounting to Rs. 1967 and death of 21 palms per 0.4 ha were recorded due to *Koleroga* in the five

Table 3. Control of *Koleroga* of arecanut in the gardens at four different locations of Sirsi, during 1980

Sl. No.	Treatment	Percentage of disease incidence at various locations*				
		I	II	III	IV	Mean
A. Chemical sprays⁺						
1.	Bordeaux mixture (1%)	10.00	16.61	7.57	7.01	10.29
2.	Aliette (0.1%)	28.30	NT	10.93	NT	19.61
3.	Aliette (0.2%)	NT	18.46	NT	9.75	14.10
4.	Aliette (0.5%)	NT	8.57	NT	NT	8.57
5.	Metalaxyl (0.1%)	16.60	NT	11.66	NT	14.13
6.	Metalaxyl (0.2%)	NT	21.43	NT	6.85	14.14
7.	Metalaxyl (0.5%)	NT	8.57	NT	NT	8.57
B. Mechanical coverings⁺⁺						
8.	Polythene	0.00	0.00	0.00	0.00	0.00
9.	Bordeaux mixture (1%) spray before covering the bunches with polythene	0.00	4.00**	0.00	0.00	1.00
10.	Aliette (0.1%) spray before covering the bunches with polythene	0.00	0.00	0.00	0.00	0.00
11.	Metalaxyl (0.1%) spray before covering the bunches with polythene	0.00	0.00	0.00	0.00	0.00

* Based on the observations on 60 arecanut palms under each treatment. NT Not tried at that location

** There was dislocation of polythene covers.

+ One spray before monsoon and two sprays after outbreak of monsoon at an interval of 20 days for treatments 1-7.

++ Covering done just before monsoon for treatments 8-11.

gardens at Sirsi in spite of providing three regular spraying of Bordeaux mixture.

Table 4. Loss due to *Koleroga* of arecanut in five gardens sprayed with Bordeaux mixture (1%)

Sl. No	Location of garden	Loss of yield		Palms died due to disease (No.)
		Quantity (kg/0.4ha)	Value (Rs./0.4ha)	
1.	Arsapur	72	847	9
2.	Bhairumbe	114	1341	14
3.	Bhairumbe	100	1176	20
4.	Hakkimane	350	4117	50
5.	Kibballi	200	2352	12
	Average	167	1967	21

Comparative cost analysis between polythene coverings and Bordeaux mixture sprays

As covering of arecanut bunches with polythene covers gave an excellent protection against *Koleroga*, a study was conducted in a garden at Bhairumbe (Sirsi) on the cost involved for this operation in comparison with three rounds of Bordeaux mixture (1 per cent) spraying. The cost incurred on polythene coverings to cover the arecanut bunches (Table 5) of 0.4 ha was Rs. 1362, as against Rs. 476 incurred for three sprays with Bordeaux mixture (1 per cent) per 0.4 ha.

Table 5. Comparison of cost of polythene covering vs Bordeaux mixture (1%) spraying (3 rounds)

Sl. No.	Particulars	Polythene covering (Rs)	Bordeaux mixture (Rs)
1.	Material	1068	152
2.	Labour	294	324
	Total	1362	476

Discussion

As *P. meadii* causing *Koleroga* in arecanut was found surviving on infected arecanut palm tops, nuts and bunches and as

free moisture was found to be essential for the initiation and spread of the disease (Sastry, 1982), the control experiments were aimed at eradicating the previously infected host materials and to protect the palms from fresh attack by the fungus, or to create an unfavourable condition to the pathogen by keeping off the collection of rain drops on the bunches by covering them with suitable covers. Spraying systemic chemicals was also included as a curative measure. The experiments during 1979 and 1980 monsoons revealed the excellent control of *Koleroga* in the palms where the bunches were covered with polythene covers (200 gauge) before monsoon. The polythene covers prevented the rain drops reaching the nuts, which would otherwise help in liberating the zoospores. The polythene covers did not have any adverse effect on the development of nuts. Though, *Kotte* and *Karada* gave initial protection to bunches against the disease, they could not prevent the disease development in the later part as they rotted in the middle of the monsoon and lost their effectiveness. Regarding Bordeaux mixture sprays, even repeated application did not afford a satisfactory control of the disease. This might be due to the slow washing of the chemical during the heavy rains and its inability to kill the deep seated fungus in the tissues. The disease could not be brought under control even after three sprays with the fungicide in the five gardens.

The studies on the economics of using polythene cover in comparison with three sprays of Bordeaux mixture (1 per cent) showed that the cost involved in covering the bunches per 0.4 ha was Rs. 1362 while the cost for three sprays of Bordeaux

mixture (1 per cent) was Rs. 476. The arecanut loss that happened by way of improper control by Bordeaux mixture sprays was Rs. 1967 in addition to the death of palms (21 no. / 0.4 ha) as against almost no loss either due to diseased nuts or death of palms in polythene cover treatment. Thus, it is worthwhile to cover the bunches with polythene covers, as there will be a net profit of Rs. 980 over the Bordeaux mixture sprays. Again, as most of the polythene covers can be reused for one or two seasons, the cost of its

operation can be minimised in subsequent seasons. Besides, it saves labour charges as the covering operation can be performed well in advance of the monsoon. Also, covering of polythene to the bunches appears to be a suitable alternative to Bordeaux mixture, as the spraying of the latter cannot be taken up timely, during the continuous rains of monsoon and thus the disease cannot be brought under control. More than this, there is a distinct possibility of eliminating the pathogen from the gardens within a few years.

References

- COLEMAN, L. C. 1910. Diseases of the areca palm (*Areca catechu*) I. *Koleroga* or rot disease *Dept. Agr. Mysore Mycol. ser. Bull.* 2 : 92.
- COLEMAN, L. C. 1915. The control of *Koleroga* of areca palm, a disease caused by *Phytophthora omnivora* var. *arecae*. *Agric. J. India.* 10 : 129 - 136
- SASTRY, M. N. L. 1982. Studies on the species of *Phytophthora* affecting plantation crops in Karnataka with special reference to *Koleroga* of arecanut and wilt of black pepper. (Unpublished) Ph. D. Thesis, University of Agricultural Sciences, Bangalore, pp. 188.
- MUNDKUR, B.B. 1961. *Fungi and Plant Diseases*. Macmillan and Co. Ltd., New York, pp. 246.
- NARASIMHAN, M. J. 1922. The areca *Koleroga* work during 1921. *Mysore agric. Col.* pp. 4-8.
- VENKATA RAO, M.K. 1925. Report of work done in the Mycological section during 1923-'24. *Ann. Rept. Mysore Agric. Dept.* for the year 1923-'24 pp. 7-10.

Discussions

KKN Nambiar:

Is there any rise in temperature inside the polythene cover? Will water accumulate inside the cover and increase relative humidity?

MNL Sastry:

As there is an opening at the bottom of the bunch cover there will be no rise in

temperature and relative humidity inside the bunch cover.

Abi Cheeran:

What is the labour requirement for spreading and tying the polythene sheets?

MNL Sastry:

Six skilled labourers were required to tie the sheets in 0.4 ha areca garden.

Taxonomic Identity of Arecanut *Phytophthora* Isolates from the Gardens of Sirsi, Uttara Kannada

M. N. L. Sastry and R. K. Hegde*

Abstract

The *Phytophthora* isolates obtained from the arecanut gardens of Sirsi, (Uttara Kannada) were identified as *Phytophthora meadii* McRae, based on the sporangial morphology. This differs from the earlier identification of the fungus as *P. arecae* (Coleman) Pethybridge. Only A¹ mating type was recorded among the isolates collected from different localities of Uttara Kannada.

Introduction

Fruit rot or *Koleroga* of arecanut is one of the major diseases responsible for heavy loss of yield in the plantations of Uttara Kannada district. The pathogen was first named as *Phytophthora omnivora* De Bary by Sydow and Butler (1906, 1907). Coleman (1910) described it as *P. omnivora* var. *arecae* Coleman. Pethybridge (1913) considered the fungus as *P. arecae* (Coleman) Pethybridge and observed it to be quite different from *P. omnivora*. Tucker (1931) reported that *P. arecae* is a synonym of *P. palmivora* (Butler) which attacks many plants belonging to palmae, whereas Waterhouse (1963, 1970) and Newhook et al., (1978) recognised it as a distinct species. Thus, controversy and confusion existed for decades regarding the taxonomic identity and nomenclature of *Phytophthora* isolate, pathogenic on arecanut. Therefore, in the present investigation detailed taxonomic studies of *Phytophthora* isolates obtained from *Koleroga*

affected arecanuts of different localities were undertaken to establish the exact identity of the same.

Materials and Methods

Isolates of *Phytophthora* on arecanut were collected from nine different villages of Sirsi, Siddapur and Yellapur taluks of Uttara Kannada viz., Bhairumbe (PM 1), Hakkamane (PM 3), Kalve (PM 4), Tattikai (PM 6), Nirannahalli (PM 7), Hosmane (PM 9), Ashisara (PM 10), Balesara (PM 6) and Kodsara (PM 20). Single hyphal tip isolations of all these isolates were made and maintained on oat meal agar.

The morphology of the isolates with reference to mycelial characters, sporangial stalk type and stalk length, sporangial characters like shape, length, breadth, papilla, proliferation and caducous or persistent nature, presence or absence of chlamyospore, antheridial and oogonial characters and production of oospores (homothallic or heterothallic) were studied.

* Department of Plant Pathology, University of Agricultural Sciences, Bangalore 560 024

The sporangial and chlamydospore characters of the isolates were studied on carrot agar. The carrot agar plates (100 mm diameter) were inoculated with seven mm diameter inoculum discs and incubated at $25 \pm 1^\circ\text{C}$ in dark for three days, after which the cultures were exposed to continuous cool light of fluorescent lamp for two days. The cultures were then examined for sporangial production under a microscope. For the production of chlamydospores, the carrot agar cultures were incubated in darkness for one month and then observed.

The isolates were grown either singly or in combination with compatible mating types on Ribeiro's synthetic medium with β - Sitosterol (Ribeiro et al., 1975) in order to obtain reproductive structures. The mating types of the isolates were determined using A¹ and A² types. A culture was considered as A¹ mating type when it produced oospores with A² but not with A¹ and *vice versa*. The characters observed were compared with the descriptions given for different *Phytophthora* spp. in the tabular key (Newhook et al., 1978).

Results and Discussion

The study of hyphal, sporangial and chlamydospore characters of the nine isolates revealed that in all the cases the hyphae were of uniform diameter (6 μm), smooth without hyphal swellings and copiously branched. Sporangia developed on carrot agar in 3 - 5 days, but many more developed in water, obpyriform, base

rounded, papilla hemispherical, 25 - 70 (48) \times 15 - 40 (25) μm , length - breadth ratio 1.3:1 and caducous with a slender stalk, 11 - 16 μm long, chlamydospores absent.

The isolates were found to be heterothallic and produced oospores in dual cultures with the compatible mating type (A²). Antheridia - amphigynous and 12 \times 13 μm . Oogonia - spherical to pyriform and 26 - 45 μm . Oospores aplerotic, 15 - 34 μm and wall 2 - 4 μm .

The above descriptions of sporangia, chlamydospores and oospores of *Phytophthora* isolates of arecanut resembled the descriptions given for *P. meadii* McRae in the tabular key (Newhook et al., 1978). The identification of the isolates was further confirmed with Commonwealth Mycological Institute, Kew, Surrey, England, which also identified arecanut *Phytophthora* isolates as *P. meadii*. One of the arecanut *Phytophthora* isolates (PM 1) has been deposited at CMI (Herb. IMI 255066).

The present identification of *Koleroga* fungus from arecanut as *P. meadii* differs from its earlier identification as *P. arecae*. Ribeiro (1978) distinguished *P. meadii* from *P. arecae* using length - breadth ratio as a criterion (1.2:1 up to 1.4:1 and 1.5:1 respectively). In the present study also, the length - breadth ratio of sporangia of arecanut isolates agreed with the length - breadth ratio of sporangia of *P. meadii* but not of *P. arecae*.

References

- COLEMAN, C. C. 1910. Diseases of the areca palm (*Areca catechu*). I. *Koleroga* or rot disease. *Dept. Agr. Mysore Mycol. Ser. Bull.*, 2: 92.
- NEWHOOK, F. J., WATERHOUSE, C. M. and STAMPS, D. J. 1978. *Tabular key to the species of Phytophthora De Bary*. Mycological Paper No. 143. Commonwealth Mycological Institute, Kew, Surrey, England. pp. 20.
- PETHYBRIDGE, G. H. 1913. On the rotting of the potato tubers by a new species of *Phytophthora* having a method of sexual reproduction hitherto undescribed. *Sci. Proc. Royal Dublin Soc. NS* 13: 529 - 565.
- RIBEIRO, O. K. 1978. *A source book of the genus Phytophthora*. Publisher J. Cramer and FL-9490 Vaduz. pp. 417.
- RIBEIRO, O. K., ERWIN, D. C. and ZENTMYER, G. A., 1975. An improved synthetic medium for oospore production and germination of several *Phytophthora* species. *Mycologia*, 67 : 1012 - 1019.
- SYDOW, H. and BUTLER, E. J. 1906. *Fungi Indiae orientalis* Part. I. *Ann. Mycol.* 5 : 485-515.
- SYDOW, H. and BUTLER, E. J. 1907. *Fungi Indiae orientalis*, Part. II. *Ann. Mycol.* 5: 485-515.
- TUCKER, C. M. 1931. *Taxonomy of the genus Phytophthora De Bary*. *Res. Bull. Agric. Exp. Stn., University of Missouri*. pp. 208.
- WATERHOUSE, G. M. 1963. *Key to the Species of Phytophthora*. Mycological paper 92. Commonwealth Mycological Institute, Kew, Surrey, England pp. 22.
- WATERHOUSE, G. M. 1970. *The genus Phytophthora De Bary*. Mycological Paper No. 122. Commonwealth Mycological Institute, Kew, Surrey, England, pp. 22.

Disease Surveillance on 'Koleroga' of Arecanut caused by *Phytophthora arecae*

M. Anandaraj and N. Saraswathy*

Abstract

'Koleroga' of arecanut occurs during south west monsoon in all the areca growing areas where there is heavy rainfall, high humidity and a temperature range of 22-29°C. To study the correlation between the climatic factors and occurrence of the disease in different areas a proforma was evolved and the information was collected. The disease appeared 12-20 days after the onset of monsoon in different areas under favourable conditions. There was no indication to show that the disease spreads from one area to another.

Introduction

Fruit rot or *Mahali* or *Koleroga*, a serious disease of arecanut caused by the fungus *Phytophthora arecae* (Coleman) Pethybridge, occurs during the south west monsoon season. The disease occurs in all high rainfall areas of the areca growing tracts and is more severe in plantations situated in valleys and those surrounded by thick vegetation (Kamat, 1953) or in plantations densely planted with intercrops. The present study was undertaken to find out the correlation between the onset of the monsoon and the occurrence of the disease and also to study the pattern of spread of the disease from one region to another so as to develop a forecasting system.

Materials and Methods

The study was undertaken during 1981 and 1982. A proforma was evolved to elicit information on the weather conditions such as the date of onset of monsoon,

number of rainy days, maximum and minimum temperature, relative humidity, date of occurrence of the disease etc. and was sent to the District Agricultural Officers. This proforma in turn was sent to the officers at taluk levels. The weather data for these regions were also obtained from the Indian Institute of Tropical Meteorology, Poona. The data obtained for two years were tabulated and analysed.

Results and Discussion

The south west monsoon sets in Kerala and coastal Karnataka during 1 - 10 June (communication from I.I.T.M., Poona). The information collected from different locations indicated that the disease developed within 12 - 20 days after the onset of monsoon (Table 1). But in extreme cases, the interval between first monsoon shower and first incidence of disease varied from 24 to 56 days. This can be attributed to irregular rains and the wide gap between first shower and actual monsoon and also due to less rainfall. The disease occurred in

* Central Plantation crops Research Institute, Regional Station, Vittal 574 243, Karnataka

isolated locations and there was no regular pattern in the spread of the disease. During the south west monsoon period the relative humidity was more than 95 per cent and temperature ranged from 22 - 29°C which is congenial for the development of the disease. (Koti Reddy and Anandaraj, 1980). The simultaneous occurrence of the disease in several places indicates that the inoculum does not move from one region to another but may be present in the areca growing areas endemically.

The present study shows that the disease develops within 15 - 20 days under favourable conditions after the onset of south west monsoon and there was no regular pattern in the spread of the disease.

Acknowledgement

The authors wish to express their thanks to the Director, I. I. T. M., Poona for the weather data.

Table 1. Incidence of *Koleroga* in different locations

State	District	Location	Date of 1st rain	Date of occurrence of disease	Period between 1st rain & disease occurrence (days)	
Kerala	Ernakulam	Vengola	30-5-1981	14-6-1981	15	
		Kuthiathode	16-5-1982	28-5-1982	12	
		Valakam	30-5-1982	15-6-1982	16	
		Trichur	Kodungalloor	1-6-1982	12-6-1982	12
		Idukki	Udumbanoor	22-4-1981	12-5-1981	20
Karnataka	Dakshina Kannada	Mangalore	1-6-1981	18-6-1981	18	
		Sāmpaje	1-5-1981*	25-6-1981	56	
		Vittal	28-5-1981**	27-6-1981	30	
		Vittal	17-5-1982**	10-6-1982	24	

* Number of rainy days only 10 and was scattered

** Number of rainy days 10 and 11 respectively in 1981 and 1982

References

- COLEMAN, L. C. 1910. Diseases of areca palm (*Areca catechu* L.) I. *Koleroga* or rot disease. *Ann. Myc.* 8 : 591 - 626.
- KAMAT, M. N. 1953. *Practical Plant Pathology*. Prakash Publishing House, Poona, India. pp. 200.
- KOTI REDDY, M. and ANANDARAJ, M. 1980. *Koleroga* of arecanut. pp. 71 - 79. In *PROC. Workshop on Phytophthora diseases of Tropical Cultivated Plants*. Central Plantation Crops Research Institute, Kasaragod, India.

Changes in Foliar Pigments in Yellow Leaf Disease of Arecanut

N. Srinivasan*

Abstract

Yellow leaf disease remains as a serious disease of arecanut in Kerala and Karnataka. The precise etiology of the disease is unknown. Serious alterations in foliar pigments were noticed and the content of chlorophyll declined significantly depending upon severity of the disease. Pigments, carotene and xanthophyll seem to superimpose the yellowing of foliage in affected palms. The significance of changes in major plant pigments has been discussed.

Introduction

Arecanut (*Areca catechu* L.) popularly known as betel nut is an important plantation crop of India. Yellow leaf disease (YLD) threatens the arecanut cultivation in Kerala and Karnataka where the crop is cultivated extensively. The yield of arecanut palm is affected drastically due to YLD. The precise cause of disease is yet unknown.

Foliar yellowing is the most conspicuous symptom of YLD. As the etiology of the disease is not known conclusively it is believed that an understanding of pathophysiology of the foliar yellowing would be helpful in the diagnosis of YLD. In many plant diseases, the degree of pigment changes has been correlated with intensity of tissue damage and expression of disease syndromes (Takahashi, 1971; Haspel-Horvatovic and Horickova, 1975; Farkas, 1978). Therefore, an attempt has been

made to relate the changes in major plant pigments with expression of YLD and its early diagnosis.

Materials and Methods

Healthy and YLD affected palms in early, middle, and advanced stages of foliar syndromes were selected for the study. Leaves at lower, middle and upper positions of the crown from selected palms were subjected to analysis of total chlorophyll, carotene and xanthophyll pigments. The total chlorophyll was estimated by the modified method of Smith and Benitez (1955) and the other pigments by following the method of Snell and Snell (1937). Three palms were analysed independently under each category and the contents of the pigments were calculated (mg/g of leaf sample).

Results and Discussion

The contents of foliar pigments in healthy and YLD affected areca palms are presented in Table 1. In healthy palms,

* Central Plantation Crops Research Institute, Regional Station, Kayangulam, Krishnapuram 690 533, Kerala

chlorophyll, carotene and xanthophyll contents were maximum in lower leaves. The quantity of chlorophyll was several fold higher than other pigments. In YLD affected palms, deviations in contents of these pigments were observed depending upon severity of yellow leaf syndromes.

Changes in early stage of foliar symptom

In lower leaves of affected palms, chlorophyll was significantly reduced. But in younger leaves the pigment content generally remained unchanged. Contents of carotene and xanthophyll increased in lower (older) leaves of the diseased palm as compared to younger ones and also the corresponding healthy leaves in control palms. It reveals that in early phase of foliar syndromes the pigment changes occur particularly in lower fronds and the palm loses an average of 12 per cent chlorophyll with an increase in carotene (9 per cent) and xanthophyll (27.50 per cent) levels.

Changes in advanced stage of foliar symptom

Chlorophyll was found to be reduced drastically in leaves at all positions of the affected palm. The change was maximum in lower fronds followed by younger ones. Contents of carotene and xanthophyll enhanced, on the other hand, in all leaves of the YLD palm. However, these pigments were generally higher in other fronds. Palms expressing severe foliar syndromes retained 16.48 per cent of chlorophyll only revealing a major derangement in chlorophyll system of affected palms.

The results showed that changes occurred in foliar pigments in arecanut, from early to advanced stages of the disease. Decreased level of chlorophyll has been observed as a distinct feature of the disease. In YLD affected palms chlorophyll derangement may be due to direct pathological causes.

Table 1. Contents of pigments in leaves of healthy and yellow leaf disease affected arecanut palms*

Nature of palm	Leaf position in crown	Pigments (mg / g)			Diseased / Healthy (%)		
		Total chlorophyll	Carotene	Xanthophyll	Total chlorophyll	Carotene	Xanthophyll
Healthy	Lower	2.85	0.23	0.10			
	Middle	2.70	0.19	0.08			
	Upper	1.67	0.22	0.04			
	Mean	2.41	0.21	0.07			
Early YLD syndrome	Lower	1.92	0.28	0.17	67.37	121.74	170.00
	Middle	2.68	0.20	0.09	99.26	105.26	112.50
	Upper	1.65	0.22	0.04	98.80	100.00	100.00
	Mean	2.09	0.23	0.10	88.48	109.00	127.50
Middle YLD syndrome	Lower	1.02	0.33	0.22	35.79	143.48	220.00
	Middle	1.80	0.24	0.15	66.67	126.32	187.50
	Upper	1.62	0.23	0.06	97.01	104.55	150.00
	Mean	1.48	0.27	0.14	66.49	124.78	185.83
Advanced YLD syndrome	Lower	0.33	0.39	0.28	11.58	169.57	200.00
	Middle	0.44	0.31	0.21	16.30	163.16	262.50
	Upper	0.36	0.23	0.11	21.56	104.55	275.00
	Mean	0.38	0.31	0.20	16.48	145.76	245.83

*Average of 3 samples / treatment

Enhanced levels of carotene and xanthophyll in diseased palm is believed to be a result rather than a cause for foliar syndromes. In healthy leaf, chlorophyll level outweighed carotene and xanthophyll levels. Under diseased state the chlorophyll level was outweighed by yellow pigments resulting in foliar yellowing. The degree of alteration in pigments is dependent on the disease intensity or the stages of the

disease in affected palms. This is supported by the fact that early chlorosis appears in affected palm at its older leaves and symptom spreads to younger leaves systematically (George et al., 1980; Seliskar and Wilson, 1981). The observation of early changes in pigments in older leaves may be considered as a criterion for early diagnosis of YLD.

References

FARKAS, G. L. 1978. Senescence and Plant Disease. In *Plant Disease, an Advanced Treatise*. Eds, J. G. Horsfall and E. B. Cowling, Academic Press, London, pp. 391 - 412.

GEORGE, M.V., JACOB MATHEW and NAGARAJ, B. 1980. Indexing the yellow leaf disease of arecanut, *J. Plant. Crops*. **8** : 82 - 85.

HASPEL - HORVATOVIC, E. and HORICKOVA, B. 1975. Changes of the assimilatory pigments indicating the degree of damaging of plants. *Phytopath. Z.* **81** : 5 - 17.

SELISKAR, C. E. and WILSON, C.L. 1981. Yellows diseases of Trees. In : *Mycoplasma Diseases of*

Trees and Shrubs. Eds, K. Maramorosch and S. P. Raychaudhuri, Academic Press, New York, pp. 35 - 95.

SMITH, J. H. C. and BENITEZ, A. 1955. Chlorophylls: Analysis in Plant Materials. *Modern Methods of Plant Analysis*. **4** : 142 - 196.

SNELL, F. D. and SNELL, C. T. 1937. *Colorimetric Methods of Analysis II. Organic and Biological*. Chapman and Hall Ltd., London. pp. 815.

TAKAHASHI, T. 1971. Studies on viral Pathogenesis in plant hosts. I. Relation between host leaf age and the formation of systemic symptoms induced by tobacco mosaic virus. *Phytopath. Z.* **71** : 275 - 284.

Discussions

Abi Cheeran:

It is not necessary for root disease that the pathogen should be a parasite. Therefore the role of population dynamics of the microbes in rhizosphere and rhizoplane should be studied well.

N Srinivasan:

YLD is considered as a complex disease. The bacteriological studies require intensive approach. Of course, the population in rhizoplane and rhizosphere of the roots would supplement additional information.

Yellow Leaf Disease of Arecanut. III-Root Region Microflora and Involvement of Toxin

B. M. Bopaiah*

Abstract

The root region microflora of disease early, disease advanced and apparently healthy palms from yellow leaf disease affected areas and healthy palms from disease free areas of Chikmagalur, Shimoga and Dakshina Kannada districts of Karnataka State were enumerated. The bacterial population was more in the disease affected area as compared to healthy area. But the fungal flora were less in the disease affected area of Aranthodu (Sullia) and Sagar (Shimoga) as compared to the disease free area. Qualitatively the microflora did not differ much in the healthy and disease affected palms and no selective proliferation of micro-organisms occurred in either healthy or disease affected palms. The study has indicated the possible involvement of a phytotoxin in the disease.

Introduction

Yellow leaf disease (YLD) of arecanut is prevalent in Kerala, Karnataka, Tamil Nadu and parts of Maharashtra. In Kerala State the disease is prevalent in 35 - 40 per cent of the area under arecanut. The disease is present in parts of Chikmagalur, Shimoga and Dakshina Kannada districts of Karnataka State. Though research on this disease was initiated in 1959, the etiology of the disease is not clearly understood. (Rawther, 1976; Nayar, 1976; Koshy et al., 1976; Mohapatra et al., 1976 and Mathai, 1976). In the present study, the rhizosphere microflora of yellow leaf disease affected and healthy palms were enumerated with a view to investigate the proliferation or inhibition of specific micro-organisms in the root region of YLD affected palms.

Materials and Methods

Sampling of rhizosphere soil

The samples were collected from the basin of areca palms at a distance of 30 - 60 cm from the bole and at 0 - 30 cm depth, according to the procedure of Bopaiah and Koti Reddy, (1982). Rhizosphere samples were collected from the disease affected areas of Koppa - Sringeri (Chikmagalur), Sagar (Shimoga) and Aranthodu-Sullia (Dakshina Kannada). Sampling was done from 3 palms each of 3 different groups of palms based on the disease intensity, viz., apparently healthy, disease early stage and disease advanced stage. The samples representing the healthy palms were collected from Vittal (Dakshina Kannada) and Tirthahalli (Shimoga) for comparison. The above studies were carried out during 1979 and 1980.

Dilution plating technique was employed for the enumeration of microflora (Allen,

* Central Plantation Crops Research Institute,
Regional Station, Vittal 574 243, Karnataka

1957). The population of bacteria, fungi and actinomycetes were counted using Nutrient Agar (NA), Martin's Rose Bengal Agar (MRBA) and Kustar's Agar (KA) respectively. The Warcup soil plate method was followed to enumerate the mycelial form of fungi in the root region (Warcup, 1950). The fungi isolated were identified by microscopic examination and bacterial and actinomycetes isolates were identified up to generic level following colony morphology, cultural, physiological and biochemical tests (Buchanan and Gibbons, 1974).

Roots from yellow leaf disease affected and healthy palms were collected for toxin extraction and they were chilled under deep freeze to facilitate maceration of the tissue. The crude toxin was extracted following method of Rai and Strobel (1969). Biological assay for the crude toxin was conducted by treating tomato leaves (7.5 cm trifoliate leaves) with 0.5 mg/ml concentration of compound as described by Strobel (1967).

Results and Discussion

The bacterial population in the root region of YLD affected and healthy palms are presented in Table 1. There was a

significant difference in the bacterial counts between disease affected and healthy palms. However, within the diseased area the bacterial flora of apparently healthy palms and palms showing different intensities of disease (early to advanced YLD) did not vary much. Qualitatively bacteria did not differ much between the healthy and YLD affected palms. The bacteria inhabiting the root region of healthy and YLD affected palms are *Bacillus* sp., *Arthrobacter* sp., *Micrococcus* sp. and *Pseudomonas* sp.

The fungal flora was considerably less in Sullia and Sagar area (diseased) as compared to healthy areas of Vittal and Tirthahalli (Table 2). No difference in the fungal population was observed among the apparently healthy and diseased palms. Though severe root rotting of diseased palms was reported from Kerala (Rawther, 1976) such root rotting was not observed in Sullia and Sagar area. The dilution plating method yielded *Trichoderma harzianum*, *T. viride*, *Aspergillus niger*, *A. sydowi*, *A. fumigatus* and *A. tamari* in larger proportion. The other genera of fungi recorded were *Penicillium*, *Mucor*, *Rhizopus*, *Fusarium*, *Alternaria* and *Cylindrocarpum* species in both diseased and healthy palms. *Trichoderma harzianum*, *T. viride*, *Curvularia* sp., *Fusarium* sp. and *Cladosporium* sp. were observed in Warcup plates also.

Table 1. Bacterial population in the root region of yellow leaf disease affected and healthy areca palms [10^5]

Location	Healthy	Apparently healthy	Initial stage of YLD	Advanced stage of YLD
Sullia*	—	17.12	17.20	14.96
Koppa - Sringeri*	—	23.23	21.40	21.26
Sagar*	—	27.40	28.50	28.00
Vittal**	13.50	—	—	—
Tirthahalli**	10.40	—	—	—

Not much variation was noticed in the actinomycetes population in the sample collected from different areas except the rhizosphere samples of Vittal (Table 3). The actinomycetes belonged to the genera *Streptomyces*, *Nocardia*, *Micromonospora* and *Actinomyces*.

The soil pH, root exudate, soil organic matter and season are some of the factors which influence the microflora in the root region. The enumeration of the micro-organisms in the root zone of arecanut palms at Palode (South Kerala) revealed a higher level in the disease as compared to healthy palms (Anonymous, 1964). In the present investigation, the difference was observed in the quantitative bacterial population. No difference in the qualitative micro-flora was noticed in the YLD affected root regions.

The crude toxin obtained from the roots of yellow leaf affected palms resulted in reversible wilting of tomato leaves. The roots of healthy palms though yielded small quantity of toxin precipitate did not show any wilting. The tomato cuttings were treated with an aqueous solution (0.5 mg/ml) of toxin and the wilting was recorded when the margin of leaves become flaccid. Wilting symptom was observed in 2 min. This shows that in yellow leaf disease affected palms there is an accumulation of toxin like substances. Further investigations are needed to characterise the toxin principle.

Acknowledgement

The author is grateful to Director, CPCRI, Kasaragod and Shri K. Shama Bhat, Senior Scientist-in-charge, Regional Station, Vittal, for the encouragement.

Table 2. Fungal population in the root region of yellow leaf disease affected and healthy areca palms [10^3]

Location	Healthy	Apparently healthy	Initial stage of YLD	Advanced stage of YLD
Sullia*	—	10.67	16.83	15.00
Koppa - Sringeri*	—	20.33	15.40	23.50
Sagar*	—	8.50	12.16	10.16
Vittal**	25.33	—	—	—
Tirthahalli**	24.00	—	—	—

*Yellow leaf disease area **Healthy area

Table 3. Actinomycetes population in the root region of yellow leaf disease affected and healthy areca palm [10^4]

Location	Healthy	Apparently healthy	Initial stage of YLD	Advanced stage of YLD
Sullia*	—	4.00	4.06	3.00
Koppa - Sringeri*	—	3.33	1.00	1.00
Sagar*	—	3.75	2.00	2.20
Vittal**	10.33	—	—	—
Tirthahalli**	2.70	—	—	—

References

- ALLEN, O. N. 1957. *Experiments in soil bacteriology*. 3rd Ed. Burgess Publ. Co. Minneapolis, Minn. USA. pp. 278.
- ANONYMOUS. 1964. Annual Report of the Regional Arecanut Research Station, Palode for 1963 - '64, Indian Central Arecanut Committee, Calicut. pp. 7 - 8.
- BOPAIAH, B. M. and KOTI REDDY, M. 1982. Distribution of microflora population in the rhizosphere of arecanut. *J. Plant. Crops*. **10** : 127 - 128.
- BUCHANAN, R. E. and GIBBONS, N. E. 1974. *Bergey's Manual of Determinative Bacteriology*. Eighth Ed. William and Wilkins, Baltimore. pp. 1268.
- KOSHY, P. K., SOSAMMA, V. K. and SUNDARARAJU, P. 1976. Yellow Leaf Disease : Nematological studies. *Arecanut and Spices Bull.* **8** (2) : 37 - 41.
- MATHAI, C. K. 1976. Yellow Leaf Disease of Arecanut : Physiological studies. *Arecanut and Spices Bull.* **8** (2) : 33 - 36.
- MOHAPATRA, A. R., BHAT, N. T. and HARISHU KUMAR, P. 1976. Yellow Leaf Disease of arecanut in soil fertility studies. *Arecanut and Spices Bull.* **8** (2) : 27 - 31.
- NAYAR, R. 1976. Yellow Leaf Disease of Arecanut : Virus Pathological studies. *Arecanut and Spices Bull.* **8** (2) : 25 - 26.
- RAI, P. V. and STROBEL, G. A. 1969. Phytotoxic glycopeptides produced by *Corynebacterium michiganense*. II. Biological properties. *Phytopath.* **59** : 53 - 57.
- RAWTHER, T. S. S. 1976. Yellow Leaf Disease of Arecanut : Symptomatology, Bacterial and Pathological studies. *Arecanut and Spices Bull.* **8** (2) : 22 - 24.
- STROBEL, G. A. 1967. Purification and properties of Phytotoxic polysaccharide produced by *Corynebacterium sepedonicum*. *Plant Physiol.* **42** : 1433 - 1441.
- WARCUP, J. H. 1950. The soil plate method for isolation of fungi from soil. *Nature (Lond.)* **166** : 177.

Discussions

Abi Cheeran:

How did you separate the toxin from plant sample?

B M Bopaiah:

Toxin is precipitated using ethanol as solvent and centrifuged. The precipitate is passed through Dowex column to get the crude toxin.

Frequency of Occurrence and Intensity of Yellow Leaf Disease of Arecanut (*Areca catechu* L.) in Relation to Water Table

R. Chandra Mohanan and B. P. Nair*

Abstract

Among the diseases affecting areca palm (Areca catechu L.), yellow leaf disease is one of the most important diseases based on the nature of the disease and extent of damage. Its etiology is unknown.

During the present survey, 18 per cent of the palms in Trichur district (Kerala State) were found to be affected by the disease. The severity of the disease varied. In areas where the water table was above 1.5m, the disease was noticed in 20 per cent of the palms. In areas where the water table was 1.5 to 3m below ground level the disease was observed in 20 per cent of the palms and only in 12 per cent of the palms where the water table was below 3 m. Log-likelihood ratio test conducted to examine the relationship between water table and disease incidence showed that the disease incidence was not independent of water table.

Introduction

Yellow leaf disease (YLD) was first reported from Moovattupuzha and Meenachal taluks of Kerala State in 1914 (Nambiar, 1949). Since then it has been recorded from different parts of Kerala, coastal regions of Maharashtra, parts of Karnataka and Tamil Nadu. The etiology of the disease is yet to be established. Detailed studies on the role of fungi, bacteria, nematodes, virus, mycoplasma-like-organisms and nutritional disorders did not give any clear indication on the etiology of the disease. The probable role of water logging, acidity and nutritional disorders in the disease incidence has been reported by many workers

(Dastagir, 1963; Velappan, 1969 and Mohapatra et al., 1976). Though intensity of this disease was noticed to be more in low lying areas, detailed studies have not been conducted to find out the relationship between water table and disease incidence. This study was aimed at understanding this relationship.

Materials and Methods

The study was taken up during 1976. To estimate the intensity and spread of YLD in Trichur district, Kerala State a survey was conducted during October-November during which time the symptoms become distinct. A total of 42 villages belonging to Trichur, Thalappally and Mukundapuram taluks were surveyed. From each village five survey numbers where arecanut was cultivated were selected at random. Data pertaining to

* Central Plantation Crops Research Institute, Regional Station, Vittal 574 243, Karnataka

water table, total number of healthy and diseased palms and intensity of the disease were recorded from the selected plots. The water table of each garden was recorded by measuring the water level in the well in each garden. The disease index was determined. The palms in each garden were grouped into healthy, diseased early, diseased middle and diseased severe based on visual scoring. The palms observed were further grouped depending on depth of water table viz., above 1.5 m, 1.5 - 3.0m and below 3.0m water table.

The palms observed in each village were considered on hectare basis per village for statistical analysis, with a view to finding out the dependency of intensity of disease incidence on water table. Log-likelihood ratio test was carried out using the following expression (Zar, 1974).

$$G = 2 \left[\sum \sum_{i,j} f_{ij} \log_e f_{ij} - \sum R_i \log_e R_i - \sum C_j \log_e C_j + n \log_e n \right]$$

Where: f_{ij} = Palms in the i th row and j th column

R_i = total palms in the i th row

C_j = total palms in the j th column

n = total number of palms

(G is distributed approximately to χ^2 with $(r-1)(C-1)$ d.f.)

Results and Discussion

The occurrence of YLD of arecanut was observed to be of varying intensities in Trichur, Mukundapuram and Thalapally taluks in Trichur district. Over 50 per cent of the total villages were found to be affected. A total of 40,061 palms were observed during this survey. Eighteen per cent of the observed palms were found

to be affected. The occurrence and intensity of the disease in relation to water table are given in Table 1. In areas, where the water table was above 1.5m the disease was noticed in 20 per cent of the palms with 11 per cent in the early, 7 per cent in the middle and 2 per cent in the severe stage of intensity. The disease incidence in areas where the water table was 1.5 - 3.0m below ground level, was also 20 per cent with 10, 8 and 2 per cent of the palms in diseased early, middle and severe stage of intensity, respectively. But only 12 per cent of the palms were found to be affected in localities with water table below 3.0m.

Log - likelihood ratio test showed a significant relationship between water table and disease incidence ($G=19.9^{**}$ at $P=0.05$). Thus, it has been found that the incidence of YLD is not independent of water table and incidence was more in areas of high water table. Water logging was considered as one of the pre-disposing factors in the incidence of the disease (Pal et al., 1960). Mathai (1976) has also observed that waterlogging in affected gardens were generally high with 10 - 20cm standing water during the period of

Table 1. Percentage of yellow leaf disease affected palms under different water table and intensity

Disease severity	%of palms			
	Water table (from ground level)			
	upto 1.5m	1.5 - 3.0m	Below 3.0m	
Healthy	80	80	88	
Diseased early	11	10	6	
Diseased middle	7	8	5	
Diseased severe	2	2	1	
	} 20		} 12	

symptom appearance. Mohapatra et al., (1976) observed that water table in affected gardens was within the root zone of areca palms and in Karnataka state, yellow leaf disease was generally seen in areas of high water table. The present studies

also showed that the incidence was more in areas with high water table. Therefore, water table may be considered as one of the important factors while investigating the predisposing factors in the occurrence of yellow leaf disease.

References

DASTAGIR, A. A. 1963. A note on the preliminary investigations of Yellow Leaf Disease of arecanut palms in Mysore state. *Arecanut J.* 14 : 62 - 63.

MATHAI, C.K. 1976. Yellow Leaf Disease of arecanut : physiological studies. *Arecanut and spices Bull.* 8 (2) : 33 - 36.

MOHAPATRA, A. R., BHAT, N. T. and HARISHU KUMAR, P. 1976. Yellow Leaf Disease of arecanut in soil fertility studies. *Arecanut and spices Bull.* 8 (2) : 27 - 31.

NAMBIAR, K. K. 1949. *A survey of arecanut crop in Indian Union.* Indian Central Arecanut Committee. Calicut. pp. 74.

PAL, N. L., DAVIS, T.A., JOSHI, S.G., SUBRAHMANIAN, C. K. and RADHA MENON. 1960. *Report of the sub-committee to recommend detailed investigations regarding micronutritional aspects of arecanut and coconut palms* (unpublished).

VELAPPAN, E. 1969. *Investigations on the possible relationship between the nutritional status of soils and the incidence of yellow leaf disease of arecanut palm (Areca catechu Linn).* M.Sc. Thesis, University of Kerala, Trivandrum, India. pp. 75.

ZAR, J. H. 1974. *Biostatistical Analysis.* Prentice-Hall Inc., Englewood Cliffs, N. Jersey. pp. 620.

A Comparative Study of the Rhizosphere Microflora of Healthy and Diseased Arecanut Palms affected by Yellow Leaf Disease

K. J. Alice*, S. Balakrishnan* and P. Karunakaran**

Abstract

Arecanut palms affected by yellow leaf disease support a higher microbial population than healthy ones in the rhizosphere. The rhizosphere microbial count in healthy roots ranged from 19.3m to 24.0m while it ranged from 19.5m to 28.0m in the diseased roots. The microbial count in the non rhizosphere soil ranged from 4.7m to 6.5m. This increased population is attributed to the presence of root exudates and sloughed off tissues in the rhizosphere. The studies also revealed that soil environment itself will be having some influence on the rhizosphere population during different seasons of the year. There were variations in the microbial populations in different regions of the root. Young and growing regions of the roots were found to harbour more micro-organisms which is believed to be due to various root secretions.

Introduction

Yellow leaf disease (YLD) of arecanut (*Areca catechu* L.) is a serious disease affecting arecanut palms in Kerala and in some areas of Karnáataka. This is a disease of uncertain etiology. Srivastava et al., (1970) reported that the roots of YLD affected arecanut palms showed bacterial streaming and the associated bacterium was identified as *Pseudomonas* sp.

Bopaiah (1979) found that the counts of gram positive bacteria were more in the rhizosphere of healthy arecanut palms. Fungi such as *Phytophthora* sp. and *Pythium* sp. have also been isolated from roots of diseased arecanut palms (Radhakrishnan, personal communication).

The rhizosphere microflora of plants are known to be influenced by the physiological conditions of the plants. Therefore, the altered metabolism as a result of disease also may possibly affect the rhizosphere microbial population. Hence, a comparative study of the bacteria, fungi and actinomycetes present in the rhizosphere of the healthy as well as YLD affected arecanut palms was conducted.

Materials and Methods

Samples of arecanut roots and soil were collected from diseased and apparently healthy arecanut palms from Vithura, Trivandrum District, Kerala State which is known to be a disease affected area. Samples were taken from tip and basal portions of both young and old roots. The estimation of rhizosphere microflora was done by adopting the soil dilution and plate count method (Timonin, 1940).

* College of Agriculture, Vellayani - 695 522, Kerala

** Cardamom Research Station, Pampadumpara, Idukki District, Kerala

The root samples were cut and taken in 250 ml Erlenmeyer flasks containing 100 ml sterile distilled water. The flasks were then shaken for 30 min in a mechanical shaker. Serial dilutions were prepared from these suspensions to get a final dilution of one in a million. One ml each of the diluted suspension was plated in sterilized petridishes containing 15 ml of the respective media for the isolation of different types of micro-organisms. The media used for the isolation of bacteria, fungi and actinomycetes were soil extract agar, peptone dextrose agar with rose bengal and streptomycin and Kenknights agar respectively. The number of colonies of different micro-organisms was recorded and expressed in millions per gram of soil on dry weight basis.

Results and Discussion

The results are presented in Tables 1 to 4. The data revealed that the YLD affected palms harboured a higher bacterial, fungal and actinomycetes population in the rhizosphere as compared to that of healthy palms. Rhizosphere of diseased palms harboured a total microbial population of 3469.3 m as against 3142.1 m for healthy palms (Table 4). This increase was more prominent in the case of bacteria and actinomycetes. The population of bacteria, fungi and actinomycetes in diseased palms were 2572.9m, 291.7m and 604.7m respectively and those of apparently healthy palms were 2335.0m, 286.3m and 520.8m respectively.

Diseased crop plants were reported to support a higher rhizosphere microbial population than healthy plants by earlier workers also (Lakshmikumari, 1960; Kanakambaran, 1974 and Balakrishnan and Sam

Raj, 1970). The rhizosphere bacterial population in YLD affected palms ranged from 8.4m to 86.4m with an average of 53.6m whereas in apparently healthy palms it ranged from 11.9m to 74.3m with an average of 48.6m. The counts from non-rhizosphere soil were 9.3 and 7.7 respectively for apparently healthy and diseased. (Table 1). The corresponding fungal populations in diseased palms ranged from 1.4m to 14.5m with an average of 6.1m and in apparently healthy palms it ranged from 1.7m to 15.5m with an average of 5.9m. The counts for non-rhizosphere soil were 5.3 and 2.8 respectively for apparently healthy and diseased. (Table 2). Similarly actinomycetes population in diseased palms ranged from 5.3m to 23.1m with an average of 12.6m and in apparently healthy palms it ranged from 4.1 to 22.4m and had an average of 10.9m. The counts for non-rhizosphere soil were 5.3 and 3.8 respectively for apparently healthy and diseased (Table 3). As the disease advances, its effect is reflected on the rhizosphere microflora also on account of the physiological changes brought about by the pathogens on the host. The increase in the microbial population in the rhizosphere of YLD affected palms may be due to the favourable environmental conditions provided by the host roots because of the possible alterations in the root exudates.

In the present studies it was noticed that the total microbial population in the rhizosphere was much higher in diseased soil than that of the corresponding control soil. The increase in population is attributed to the presence of root exudates and sloughed off tissues in the rhizosphere which stimulates the growth and multiplication of the micro-organisms (Balakrishnan and Sam Raj, 1970).

Table 1. Bacterial population in the rhizosphere of diseased and healthy arecanut palms
(Population 10^6 / g of dry soil)

Condition of palm / Region of root	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total	Average
HEALTHY PALM														
Young root tip	66.3	61.1	41.2	14.6	32.0	44.6	63.3	60.4	54.8	49.3	37.2	66.9	591.7	49.3
Young root base	54.5	57.3	33.9	11.9	30.0	57.6	43.7	68.3	55.4	57.2	50.4	51.0	571.2	47.6
Old root tip	59.2	65.2	49.6	18.7	33.8	39.5	63.0	74.3	68.4	68.5	38.9	72.9	652.0	54.3
Old root base	66.7	45.0	41.4	12.6	25.3	46.5	53.6	52.5	56.3	39.0	32.9	48.3	520.1	43.3
														48.6
DISEASED PALM														
Young root tip	71.2	73.4	86.4	17.8	36.5	51.0	64.2	64.3	75.3	67.0	43.9	73.2	724.2	60.4
Young root base	67.8	76.6	67.7	24.3	37.4	55.7	66.6	75.7	66.5	58.0	53.6	66.3	716.2	59.7
Old root tip	64.8	60.1	65.7	12.5	33.8	45.9	59.5	62.9	72.5	46.0	46.7	56.2	626.6	52.2
Old root base	53.3	41.6	35.7	12.7	35.4	51.4	58.2	69.5	8.4	55.0	41.8	42.9	505.9	42.2
Healthy soil	8.5	7.2	8.9	2.4	4.4	9.3	9.3	17.3	6.5	4.8	22.2	7.6	108.4	9.3
Diseased soil	6.7	6.9	9.3	2.8	6.3	14.1	6.1	11.2	5.3	5.3	9.8	8.0	91.8	7.7
Average	51.9	49.4	43.9	13.9	27.5	41.6	48.8	55.6	46.9	45.0	37.7	49.3	—	—
														53.6

Table 2. Fungal population in the rhizosphere of diseased and healthy arecanut palms
(Population 10^6 / g of dry soil)

Condition of palm / Region of root	Jan.	Feb.	Mar.	Apr.	May	June	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total	Average
HEALTHY PALM														
Young root tip	9.8	9.3	6.3	5.8	6.5	11.2	11.3	9.0	9.5	15.5	4.2	8.0	106.4	8.9
Young root base	5.5	6.0	4.0	2.2	4.4	7.5	4.7	3.8	4.6	7.2	4.0	5.6	59.5	4.9
Old root tip	3.9	7.3	7.4	4.9	7.3	5.0	6.6	5.4	10.8	4.5	1.7	6.0	70.8	5.9
Old root base	4.9	4.2	5.5	3.1	4.4	3.4	3.3	3.6	4.7	2.5	5.0	2.0	49.6	4.1
DISEASED PALM														
Young root tip	8.6	2.8	5.8	4.2	8.9	4.9	4.9	10.5	14.5	12.5	6.8	13.3	94.7	7.9
Young root base	6.0	3.5	4.3	5.0	5.0	5.0	6.1	6.5	2.5	-9.4	7.8	3.2	64.3	5.4
Old root tip	5.7	6.2	4.9	4.5	5.7	3.4	3.6	1.4	7.5	4.8	4.5	4.6	56.8	4.7
Old root base	8.1	7.2	2.9	3.5	5.2	6.1	5.5	6.5	13.6	6.5	7.8	3.0	75.9	6.3
Healthy soil	5.9	1.8	2.2	3.0	2.4	3.6	3.3	13.5	12.6	9.2	1.8	4.8	64.1	5.3
Diseased soil	3.3	9.1	1.4	1.8	2.7	3.8	1.8	2.3	2.2	1.4	1.8	1.8	33.4	2.8
Average	6.2	5.7	4.5	3.8	5.3	5.4	5.1	6.6	8.3	7.4	4.5	4.3	—	—

Table 3. Actinomycetes population in the rhizosphere of diseased and healthy arecanut palms
(Population 10^6 / g of dry soil)

Condition of palm / Region of root	Jan.	Feb.	Mar.	Apr.	May	June	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total	Average
HEALTHY PALM														
Young root tip	20.8	14.3	22.4	10.3	12.0	7.9	13.3	7.7	12.5	19.5	9.2	14.5	164.4	13.7
Young root base	11.0	8.5	7.7	7.2	10.7	11.2	6.2	5.5	9.6	6.0	4.1	4.1	91.8	7.7
Old root tip	11.5	13.6	13.3	9.7	11.7	9.1	9.7	14.6	11.6	14.5	10.8	10.8	140.9	11.7
Old root base	13.4	10.4	13.5	11.1	11.2	12.7	6.4	5.7	7.5	17.6	7.1	7.1	123.7	10.3
DISEASED PALM														
Young root tip	15.1	21.2	21.5	9.9	11.4	10.7	12.7	15.3	16.8	20.4	17.1	15.4	187.5	15.6
Young root base	23.1	14.3	14.8	8.2	11.2	13.6	13.5	18.8	9.4	15.6	8.4	18.9	169.8	14.2
Old root tip	14.4	13.1	19.0	9.1	8.0	9.1	6.7	5.3	10.5	9.4	9.8	13.1	127.5	10.6
Old root base	10.8	8.8	8.7	6.5	9.3	7.5	9.4	11.9	12.6	19.0	6.8	8.6	119.9	10.0
Healthy soil	26.5	2.8	4.5	6.1	3.1	4.7	2.7	2.9	1.5	1.9	4.3	2.3	63.3	5.3
Diseased soil	4.6	2.7	5.5	2.6	3.5	4.2	3.9	4.3	2.3	2.8	3.8	4.4	44.6	3.8
Average	15.1	10.9	13.1	8.1	9.2	9.1	8.5	9.2	9.4	12.7	8.1	9.9	—	—

Seasonal Variation

The seasonal variation as presented in Tables 1 to 3 shows that the bacterial population was high during the month of August, followed by January (55.6m and 51.9m). Fungal population was high during September and October (8.3 and 7.4m). Actinomycetes population was high during January (15.1m). The rhizosphere population was least during April for bacteria, fungi and actinomycetes. There was a gradual decrease for bacterial and fungal population from January to April. A gradual increase was noticed from April to August for bacterial population and for fungal population from April to September. There was no such gradual increase or decrease of population for actinomycetes.

Effect of different regions of root

There were variations in the microbial populations even in the different regions of the same root (Table 4). Young and growing regions of the roots were found to harbour more micro-organisms than the

matured and basal portions. Rangaswami and Vasantharajan (1962) found that in perennials, the growing roots harboured a much greater number of bacterial population as compared to the non-growing roots. In the case of bacteria the counts were 59.7m and 60.4m for diseased young root base and tip respectively and 42.2m and 52.2m respectively for diseased old root base and tip.

For fungi the counts for healthy palms were 4.9m and 8.9m respectively for young root base and root tip and 4.1m and 5.9m respectively for old root base and tip. For diseased palms it was 5.4 m and 7.9m for young root base and tip respectively. The presence of higher fungal population at the basal region of the diseased old roots (6.3m for root base and 4.7m for root tip) may be due to the presence of sloughed off tissues in the basal region which may be more favourable for the multiplication of fungi, than that of other micro-organisms.

Table 4. Microbial population in the rhizosphere of different regions of root of healthy and diseased arecanut palms

	Bacteria	Fungi	Actinomycetes	Total	Average
HEALTHY PALM					
Young root tip	591.7	106.4	164.4	862.5	23.9
Young root base	571.2	59.5	91.8	722.5	20.1
Old root tip	652.0	70.8	140.9	863.7	24.0
Old root base	520.1	49.6	123.7	693.4	19.3
Total	2335.0	286.3	520.8	3142.1	—
DISEASED PALM					
Young root tip	724.2	94.7	187.5	1006.4	28.0
Young root base	716.2	64.3	169.8	950.3	26.4
Old root tip	626.6	56.8	127.5	810.9	22.5
Old root base	505.9	75.9	119.9	701.8	19.5
Total	2572.9	291.7	604.7	3469.3	—
Total rhizosphere flora	4907.9	565.6	1125.5	6599.0	22.9
Healthy soil flora	108.4	64.1	63.3	235.8	6.5
Diseased soil flora	91.8	33.4	44.6	169.8	4.7

In the case of actinomycetes, the counts of rhizosphere microflora for healthy palms were 7.7m and 13.7m for young root base and tip respectively. For old root it was 10.3m and 11.7m for base and tip respectively. In diseased palms it was 14.2 m and 15.6 m for young root base and tip respectively and 10.0m and 10.6 m for old roots base and tip respectively.

The increased activity of micro-organisms at the growing young root tips than dead or non-growing roots is believed to be due to various root secretions such as amino acids, vitamins and sugars. Miller (1938) found that growing roots liberate more root exudates as compared to the non growing or old roots. The basal region of the roots in the diseased palms usually showed a certain amount of decay and it may account for reduced microbial populations.

References

- BALAKRISHNAN, S. and SAM RAJ, J. 1970. Effect of TMV and certain chemicals in the rhizosphere of tobacco. *Agric. Res. J. Kerala*. **8** : 114-120.
- BOPAI AH, B. M, 1979. The studies on root region microflora of arecanut. pp. 89 - 92. In *Proc. PLACROSYM II*, ed. Venkataram, C. S, Indian Society for Plantation Crops, Kasaragod, India.
- KANAKAMBARAN, P. N. 1974. Effects of collar rot and ring barking on the rhizosphere microflora and certain chemical constituents of sword bean plants. *Agric. Res. J. Kerala*. **12** (1) 56-63.
- LAKSHMIKUMARI, M. 1960. Rhizosphere in relation to virus infection *Mem. Indian Bot. Sci.* **3** : 160.
- MILLER, E. C. 1938. *Plant physiology*. McGraw Hill Book Co. New York, USA, pp. 1201.
- RANGASWAMY, G. and VASANTHARAJAN, V.N. 1962. Studies on the rhizosphere microflora of citrus trees. II. Qualitative distribution of bacterial flora. *Canad. J. Microbiol.* **8** : 479-484.
- SRIVASTAVA, D. N., RAO, Y. P. and MOHAN, S. K. 1970. Note on the bacterial association with roots of arecanut palms infected with yellow leaf disease. *Indian J. Agric. Sci.* **40** : 1021-1022.
- TIMONIN, I. 1940. The interaction of higher plants and soil micro-organisms. I. Microbial populations of rhizosphere of seedlings of certain cultivated plants. *Canad. J. Research C.* **18** : 307 - 317.

Survey of 'Anabe' (Foot Rot) and 'Band' Diseases of Arecanut (*Areca catechu* L.)

M. J. Salvi*, S. P. Singh** and S. B. Deshpande**

Abstract

In order to find out the extent of incidence of Anabe (foot rot) and Band diseases of arecanut in Diveagar village, a survey was conducted in one hundred areca gardens selected at random.

The percentage of Anabe affected areca palms ranged from 0 - 11.72 with an average of 2.20 per cent. The disease was severe in gardens which were not being properly managed, ill-drained, crowded and unsystematically planted.

The percentage of Band affected areca palms ranged from 0-16.66 with an average of 2.59 per cent. There were 83 per cent areca gardens affected with Band disease. The incidence of the disease was higher in areas having prolonged water stagnation, hard pan below the root zone, poor crop management and gardens situated on flat land and close to the sea.

Introduction

Arecanut (*Areca catechu* L.) is affected by a number of diseases and in Maharashtra the *Band* disease is one of the serious diseases in the Konkan region. In recent years the incidence of *Anabe* (foot rot) disease caused by *Ganoderma lucidum* (Leys) Karst. is being noticed increasingly and is particularly severe in Diveagar village, Shrivardhan Taluk of Raigad Dist. Both the diseases cause substantial crop loss. With a view to estimating the loss, a survey was undertaken in the above village.

Methods

In the village Diveagar, most of the cultivators are having small land holding. One hundred cultivators were selected

randomly for the survey. The number of areca palms affected by the two diseases were recorded based on visual observation

Results and Discussion

Incidence of *Anabe* (foot rot) disease:

An extent of 11.72 per cent incidence of *Anabe* disease with an average of 2.20 per cent was revealed in the survey. The survey indicated that there were 89 per cent areca gardens infected with the disease. The disease was severe in gardens which were not properly managed, having poor drainage system and irregular planting. Most of the cultivators do not adopt phytosanitary measures by removing boles of dead palms from the garden. However, some farmers removed and destroyed fruiting bodies of the fungus. In many gardens, some alternate host plants were commonly grown with areca palms.

* Department of Horticulture, College of Agriculture, Konkan Krishi Vidyapeeth, Dapoli, Maharashtra.

** Arecanut Research Station, Shrivardhan 402 110, Maharashtra

Incidence of *Band* disease:

Out of one hundred gardens surveyed, seventeen gardens had no incidence of *Band* disease. The percentage of areca palms affected by the disease ranged from 0-16.66 with an average of 2.59 per cent.

During the survey, it was observed that the incidence of *Band* disease was more in gardens having hard pan below the root zone of areca palm and no provision of draining excess water during rain, gardens which are poorly managed and situated on flat land near the sea.

Most of the cultivators do not use fertilizers but use only organic manures like cow dung and compost. Thus the nutrient

requirement of areca palms are not fully met. Clean cultivation practices are not followed. Heavy irrigations are given at short intervals in most of the gardens. Planting is done in pits without taking into consideration the water table or the hard pan beneath. Many cultivators do not provide proper drainage for excess rain water.

Acknowledgement

The authors are grateful to the Konkan Krishi Vidyapeeth, Dapoli, for providing facilities. Thanks are due to Shri S. G. Abhyankar, the then Head, Department of Plant Pathology, College of Agriculture, Dapoli, for guidance.

Epidemiological Studies on Inflorescence Dieback of Arecanut caused by *Colletotrichum gloeosporioides*

R. Chandra Mohanan* and K. M. Kaveriappa**

Abstract

The inflorescence dieback of areca palm occurs mainly during the months of March - May. Areca inflorescences immediately after shedding of male flowers are highly susceptible to the disease. The infection usually starts from the tip of inflorescences and spreads towards the base leading to shedding of female flowers. The scars left by the male flowers at the time of shedding and the dew water deposits during night are believed to be the favourable factors for the germination, penetration and infection by the fungus on the rachille of inflorescences. It has been observed that the areca fruits which are resistant when green become susceptible when they ripen.

*The epidemiological studies have shown that the incidence of the disease becomes higher and higher during February-March, reaches a peak during April-May and subsequently becomes insignificant during July-January. The high relative humidity (86-99%) and low temperature (18-29°C) in the early hours of the morning (2.00 hr to 8.00 hr) followed by high temperature (28-34.5°C) and low RH (30-70%) in the afternoon (12.00 hr to 16.00 hr) and the availability of inflorescences of the susceptible stage appear to favour disease development during March-May. The relationship between per cent inflorescence produced and disease incidence was found to be highly significant ($r=0.65^{**}$).*

Introduction

Areca palm (*Areca catechu* L.) is affected by a number of fungal diseases such as *Koleroga* or fruit rot caused by *Phytophthora arecae* (Coleman) Pethybridge, *anabe roga* or foot rot caused by *Ganoderma lucidum* (Leys.) Karst. and inflorescence die back caused by *Colletotrichum gloeosporioides* Penz. (stonem) spauld and schrenk (Reddy et al., 1978). Inflorescence dieback has been reported

to be wide spread in Kerala and Karnataka which are the major areca growing states in India (Saraswathy et al., 1977). Though the incidence of the disease is high during the dry weather, epidemiological factors which influence disease development and severity are not worked out in detail and hence the present studies were undertaken.

Materials and Methods

Susceptibility of inflorescence to infection

The susceptibility has been studied on inflorescences at three stages of maturity viz., (1) before shedding of male flowers; (2) after shedding of all the male flowers

* Central Plantation Crops Research Institute, Regional Station, Vittal 574 243, Karnataka

** Department of Bio-Sciences, Mangalore University, Mangalagangotri, Konaje, Mangalore, Karnataka

and (3) after fruit set. In the field the inflorescences at these stages of maturity were inoculated by spraying a suspension of conidia and mycelia of the fungus in sterile water and covered with polythene bags for 72 hr. They were kept under constant observation.

Disease Incidence

The incidence of inflorescence dieback on 75 palms in three replications in a cacao-areca mixed garden was recorded at monthly intervals during 1980 - '81. The per cent inflorescences produced and disease index were calculated as follows:

$$\text{Inflorescence produced (\%)} = \frac{\text{Total inflorescence produced}}{\text{Total trees observed}} \times 100$$

The severity of the disease was rated visually on a 5 point scale; 0=no infection, 1=1-25%, 2=25-50%, 3=50-75% and 4=75-100% infection based on the area of the inflorescence affected.

The disease index of each plot was calculated by following Mckinney's equation (Mckinney, 1923).

$$\text{Disease index (\%)} = \frac{\text{Sum of all numerical ratings}}{\text{Total no. of plants observed} \times \text{Maximum rating value (4)}} \times 100$$

The mean of three replications was taken as the monthly disease index.

The R H and temperature in the cacao-areca mixed garden were recorded continuously with a thermohygrograph during critical period of disease incidence.

Results and Discussion

Susceptibility of inflorescence to *C. gloeosporioides* infection

From the constant observations on the initial stage of infection of the inflorescences under natural condition, the most

susceptible stage of infection was found to be immediately after shedding of all the male flowers. The scars left after shedding of male flowers were found to be the main foci of infection. The infection spreads from the tip of the inflorescences to the base and causes the shedding of female flowers. The inflorescences were found to be partially or completely infected. The infection was rarely initiated at the basal portion of the inflorescence or through the female flowers. The green fruits were resistant in the beginning and they became susceptible only when they turned yellowish-red during ripening.

Though detailed studies were not conducted earlier on the initial foci of infection, Saraswathy et al., (1977) reported that in nature the pathogen may gain entry into the inflorescence through the scars left after the shedding of male flowers or through the stigma of the opened female flowers. The present observations also confirm the earlier finding. It is quite possible that the scars left on the rachille by the male flowers and collection of water due to dew formation in night favour the entire process of infection.

From artificial inoculation experiments, it was found that the inflorescences soon after shedding of male flowers became more easily infected than other stages. This confirms the observation that infection mostly takes place on inflorescences soon after shedding of male flowers under natural conditions.

Disease Incidence

Monthly observations on the disease incidence showed that inflorescence dieback is present throughout the year. The incidence of the disease became higher

during February - March, reached a peak during April-May and subsequently became low and insignificant during July - January (Table 1)

The R H and temperature recorded from the garden during March to May are given in Table 2. Though the mean R H during 1980-1981 was 76.13 to 82.08 per cent the highest was 99% and lowest was 45% during March-May. The highest temperature, (28°C to 34.5°C) was recorded from 12.00 hr to 16.00 hr and the lowest (18°C to 29°C) from 2.00 hr to 8.00 hr during March to May.

The maximum number of inflorescences of the susceptible stage (75-80%) was observed from January to May. In general the disease appeared to be closely related to the production of inflorescences.

The high humidity and low temperature prevailing during the months March-May in the early hours of morning followed by high temperature in the afternoon and the availability of inflorescences of susceptible stage during this period appear to favour disease development. The relationship between inflorescence produced and disease incidence was found to be highly

Table 1. Incidence of inflorescence die back of Arecanut*

Months	1980		1981	
	Inflorescence produced (%)	Disease index (%)	Inflorescence produced (%)	Disease index (%)
January	64.84 [81.93]	18.41 [9.98]	66.20 [83.71]	15.99 [7.58]
February	77.51 [95.33]	25.09 [17.98]	83.10 [98.56]	24.54 [17.25]
March	75.25 [93.52]	30.11 [25.17]	73.10 [91.55]	24.75 [17.53]
April	68.11 [86.11]	39.36 [40.22]	83.10 [98.56]	38.55 [38.84]
May	60.45 [75.67]	42.80 [46.16]	63.10 [79.53]	41.74 [44.32]
June	51.33 [60.96]	22.82 [15.05]	45.00 [50.00]	24.54 [17.25]
July	28.10 [22.19]	17.94 [9.48]	40.00 [41.32]	10.68 [3.43]
August	21.02 [12.86]	12.70 [4.84]	16.90 [8.45]	11.73 [4.13]
September	21.44 [13.36]	10.85 [3.55]	30.00 [25.00]	10.30 [3.20]
October	33.47 [30.42]	12.39 [4.60]	32.59 [29.01]	13.70 [5.61]
November	39.35 [40.19]	12.83 [4.93]	40.00 [41.32]	12.85 [4.94]
December	56.00 [68.73]	14.49 [6.26]	47.41 [54.21]	11.73 [4.13]
CD [P = 0.05]	19.42	10.28	15.83	18.10

significant ($r=0.65^{**}$). The regression equation to determine the disease index from per cent inflorescence produced is $y=1.625+0.305x^{**}$.

During the south-west monsoon period (June-September) the inflorescences were very rarely produced and hence the disease

incidence in the garden was also very low.

Thus the abundance of inflorescence of susceptible stage and the prevailing climatic conditions during April-May are the favourable factors in the epidemiology of the inflorescence dieback of arecanut in this region.

Table 2. Temperature and RH in cacao - areca mixed garden during the peak incidence of inflorescence die back

Month	TEMPERATURE °C				RELATIVE HUMIDITY	
	Minimum		Maximum		Mean	Range
	Mean	Range	Mean	Range		
1980						
March	21.96	18.0 - 24.0	32.00	30.5 - 34.5	80.50	50-99
April	22.30	19.0 - 25.0	32.87	28.9 - 34.5	82.08	64-98
May	24.88	22.0 - 27.5	35.68	29.5 - 33.5	79.88	59-99
1981						
March	21.26	18.0 - 23.0	31.85	30.0 - 33.5	76.13	20-96
April	23.97	22.5 - 25.5	33.50	31.5 - 36.0	81.06	50-99
May	25.18	24.0 - 27.0	37.86	35.0 - 42.0	78.70	45-97

References

- MCKINNEY, 1923, Influence of soil temperature and moisture on infection of wheat seedlings by *Helminthosporium sativum*. *J. Agric. Res.* **26** : 195-217.
- REDDY, M. K., SARASWATHY, N. and CHANDRA MOHANAN, R., 1978, Diseases of arecanut in India- A review and further considerations. *J. Plant. Crops.* **6** : 28-48.
- SARASWATHY, N., REDDY, M. K. and NAIR, R. R. 1977. *Colletotrichum gloeosporioides* causing inflorescence dieback, button shedding and nut rot of betel nut palm. *Plant Dis. Repr.* **61** : 172-174.

Epidemiology of Bacterial Leaf Stripe Disease of Arecanut Palm (*Areca catechu* L.) caused by *Xanthomonas campestris* pv *arecae*

I. EFFECT OF AGE OF PALM AND AGE OF THE LEAF ON DISEASE MANIFESTATION

S. N. Sampath Kumar*

Abstract

Bacterial leaf stripe disease infection on arecanut palms caused by Xanthomonas campestris pv arecae showed variation not only with the age of the palm, but also with age of the leaves. Palms of younger age groups from 3 to 5 years showed a pattern of high degree of susceptibility to the disease indicated by rapid rate of lesion expansion as also the total lesion length recorded. Palms beyond 5 years age showed reduced susceptibility indicated by decreased lesion length. The lesion length decreased gradually with age and comparatively less in higher age groups. The leaf susceptibility character also showed a similar trend. Leaves that are of similar type and physiological age but produced at different periods in the life of the palm behaved differently to infection by the pathogen.

Introduction

Arecanut palms (*Areca catechu* L.) were found to be affected by a bacterial disease in the inland plains of Karnataka State. The pathogen was identified as *Xanthomonas campestris* pv *arecae* (Rao et al., 1970). There is no evidence of the occurrence of this disease on arecanut in the earlier years. Since then it has been reported to occur in epiphytotic form regularly in many plantations of the area. The disease can cause economic loss up to 35 per cent (Sampath Kumar, 1981).

In this paper the observations on the relative virulence and infection of the pathogen on arecanut palms of different age groups and leaves of different maturity are reported.

Materials and Methods

Bacterial isolation

Fresh isolations were made by subjecting the lesion from the infected leaves to ooze test initially by cutting through the lesions with a sharp razor blade and observing under the microscope the cut ends in a few drops of water on a slide. Pure culture was grown on nutrient

* Central Plantation Crops Research Institute, Research Centre, Hirehalli, Tumkur District, Karnataka

dextrose agar (Bacto peptone 10g; dextrose 5g; agar 20g; distilled water 1000ml; pH adjusted to 7.0).

Field inoculation tests:

The field studies were carried out at the Central Plantation Crops Research Institute, Research Centre, Hirehalli in Tumkur District of Karnataka State. The inoculation tests were carried out on three to ten years old arecanut palms from July to October using fronds of different maturity. The leaves were examined eight to ten days after inoculation when the disease symptoms started appearing. The observations were recorded on their relative susceptibility during active disease season.

Preparation of the inoculum

The inoculum was prepared by suspending the bacteria in sterile distilled water to an absorbance of 1.0 O.D. (about 10^8 colony forming units (CFU) per ml at 600nm as determined by Bausch and Lomb

spectronic - 20 colorimeter. The bacterial suspension was rubbed on to the under surface of the selected leaflets after making pinpricks. Symptoms were recorded eight to ten days after inoculation.

Results

When arecanut palms of different age groups were inoculated, palms of younger age groups from three to five years exhibited high degree of susceptibility to the disease, indicated by rapid rate of lesion expansion recorded during the period of study. Palms beyond five years age were less susceptible as shown by decreased rate of lesion length on the final day of observation. The lesion length decreased gradually with the age and was comparatively less in older age groups (Table 1). The correlation coefficient worked out between age and disease development (total lesion length) and between days and disease development is found to be significant.

Table 1. Susceptibility of Arecanut palms of different ages to *Xanthomonas campestris* pv *arecae* (Average of five lesion lengths in cm)

Days	Lesion lengths (cm) in different ages of palms (years)							
	3	4	5	6	7	8	9	10
5	1.2	1.0	2.4	3.0	3.0	2.6	3.2	—
7	2.4	2.0	2.8	3.2	3.2	4.0	3.8	2.0
10	5.9	4.2	6.3	4.4	4.2	7.0	4.4	3.8
15	15.6	8.2	11.2	7.8	5.6	9.8	5.8	6.8
20	21.8	13.5	14.5	12.6	6.2	10.0	6.2	9.8
30	26.0	21.6	18.6	15.0	9.2	11.4	8.8	10.6
50	27.5	22.8	20.2	16.8	11.8	12.2	10.6	10.6
75	30.0	23.0	21.2	17.2	12.6	14.4	11.6	13.0
100	30.5	25.0	23.6	19.2	16.0	16.0	13.2	13.2

Age and total lesion length:

$$r = 0.9642$$

$$y = 35.54 - 2.45 \times$$

Days and Av. lesion length:

$$r = 0.8209$$

$$y = 4.51 + 0.2236 \times$$

The leaf susceptibility character also showed a similar variation. The tender leaves, particularly the first, second and third leaf (from the spindle) picked up the infection earlier than other older leaves in the whorl. The lesion expansion rate also varied considerably. The first leaf showed rapid rate of lesion expansion with maximum lesion length on the final day of count, whereas the oldest leaf on the crown (seventh) had the lesion length at its minimum. (Table 2). The calculated values for age as well as for leaves does not reveal any significant variation, so also the interaction between them.

Discussion

Plants like animals vary in susceptibility to disease with age. Tissue susceptibility in relation to age decreased with obligate parasites and increased with saprophytes (Yarwood, 1934). In bacterial leaf stripe disease the susceptibility character varied not only with the age of the palm but with the plant part too, particularly in the leaves that were examined for infection studies. Leaves that are of the same type but, produced at different times in the life of the palm behaved differently to infection. Patel and walker (1963) showed that although the bean plant is susceptible at

Table 2. Lesion development in the leaves of different ages

Age & leaf No.	Days							
	10	15	20	30	40	50	75	100
3 yr								
I	1.2	5.5	23.6	25.0	29.5	31.0	32.5	37.5
II	1.0	9.0	17.0	21.0	21.1	21.2	21.2	21.3
5 yr								
I	2.7	10.5	14.5	16.0	16.0	16.0	16.0	16.5
II	0.4	2.0	2.5	2.6	4.4	4.4	4.6	4.8
III	0.6	5.0	5.5	6.5	7.0	7.0	7.0	7.5
6 yr								
I	3.2	5.5	5.8	7.3	7.5	7.5	7.5	7.5
IV	1.2	2.8	4.5	4.5	4.5	4.5	4.7	4.7
VII	0.2	0.5	1.6	1.7	1.7	1.7	3.7	3.7
7 yr								
I	3.0	5.2	12.0	14.0	14.5	14.7	14.8	14.8
IV	4.3	5.2	6.5	7.0	7.1	7.3	7.3	7.5
VII	4.0	5.0	8.4	9.2	11.5	15.0	15.0	15.0
8 yr								
I	9.5	9.7	10.3	10.3	10.3	13.2	15.3	15.3
IV	7.5	7.6	7.7	7.9	8.0	10.0	10.1	10.1
VII	3.2	4.5	4.6	4.7	4.8	4.8	7.5	7.8
9 yr								
I	5.3	5.4	6.4	8.9	10.2	10.2	10.2	10.2
IV	1.2	1.4	1.5	4.3	7.3	9.8	12.7	12.7
VII	3.5	5.5	5.8	6.3	7.9	8.0	8.3	8.3
10 yr								
I	6.2	9.5	10.5	12.5	13.7	13.7	13.7	13.7
IV	13.5	13.5	14.5	15.0	15.7	15.7	15.7	15.7
VII	7.5	9.5	9.9	10.3	10.8	10.8	10.8	10.8

all stages of its growth, the younger leaves are more susceptible than older ones from common and fuscous blight infection. This decrease in susceptibility with plant age called 'adult plant resistance' has been well noticed in rubber affected by species of *Oidium*, *Helminthosporium*, *Gloeosporium* and

Dothidella (Populer, 1972). The need for such studies cannot be over emphasized. For, as the plant becomes older and it produces successive leaves, the lower leaves are affected by different environmental conditions due to shading by their own whorls.

References

PATEL, P. N. and WALKER, J. C. 1963. Relation of air, temperature, age, and nutrition of the host to the development of halo and common bacterial blights of bean. *Phytopathology*. **53** : 407 - 411.

POPULER, C. 1972. Epidemics of powdery mildew of rubber and phenology of its host in the world. *Publ. Inst. Natl. Etude Agron. Congo, Ser Sci.* **115**.

RAO, Y. P. and MOHAN, S. K. 1970. A new bacterial leaf stripe disease of arecanut (*Areca catechu*) in Mysore state. *Indian Phytopath.* **23** (4); 702 - 704.

SAMPATH KUMAR, S. N. 1981. Bacterial leaf stripe disease of Arecanut caused by *Xanthomonas campestris* pv. *arecae*. Ph.D. thesis submitted to the Indian Institute of Science, Bangalore, PP - 190.

YARWOOD, C. E. 1934. The comparative behaviour of four clover leaf parasites on excised leaves. *Phytopathology* **24** : 797-806.

Epidemiology of Bacterial Leaf Stripe Disease of Arecanut palm (*Areca catechu* L.) caused by *Xanthomonas campestris* pv *arecae*

II. INFLUENCE OF MANAGEMENT PRACTICES ON THE DISEASE INCIDENCE

S. N. Sampath Kumar

Abstract

Bacterial leaf stripe of arecanut caused by X. campestris pv. arecae is a serious disease found affecting arecanut palms in the inland plains of Karnataka. For ensuring infection by the pathogen temperature, humidity and nutrients seem to have an important role. Certain specific cultural practices adopted in plantations were also found to be congenial for disease development and spread. Frequent irrigations (once in 5 to 10 days interval) was found to aggravate the disease. Higher levels of nitrogen and green matter were found to favour disease development. Phosphorus and potash did not seem to have any influence. Intercropping with banana was found to enhance disease intensity.

Introduction

Bacterial leaf stripe of arecanut (*Areca catechu* L.) caused by *Xanthomonas campestris* pv *arecae* is a serious malady prevalent in the *Maidan* parts of Karnataka state. The disease causes heavy loss to the crop in this area. Environmental factors like temperature, humidity etc., which govern the incidence of epiphytotics have been studied earlier (Sampath Kumar, 1981). The agronomic practices recommended may alter directly or indirectly the micro-climate affecting the pathogen and the host. In the present studies, certain specific practices that favoured disease incidence are reported.

* Central Plantation Crops Research Institute, Research Centre, Hirehalli - 572 168, Karnataka

Materials and Methods

These investigations were conducted during 1974-'76 at the Central Plantation Crops Research Institute, Research Centre, Hirehalli, Tumkur District, Karnataka State in the existing agronomic field layouts. The soil is clayey to clayey loam with a pH 6.8. The recommended agronomic practices were adopted in all experiments unless otherwise stated.

Effect of irrigation on disease incidence

This main field experiment was to find out the optimum depth of planting and suitable intervals of irrigation to be adopted. The irrigation done during summer months involved four treatments.

The experiment was laid out in a 4x3x5 split plot design with four levels of irrigation based on cumulative pan evaporimeter readings as detailed below:

- 30mm when CPE = 30mm irrigation (I₁)
- 30mm when CPE = 60mm irrigation (I₂)
- 60mm when CPE = 60mm irrigation (I₃)
- 60mm when CPE = 120mm irrigation (I₄)

Effect of fertilization

The layout of this experiment was on a 3⁴ factorial confounded design with nine plot blocks with a single replication to find out the optimum levels of NPK and green leaf (G) to be given to arecanut palms. The effect of fertilization on disease incidence and severity were recorded during the years 1974 - '76. The different levels of NPKG applied are as follows:

	Levels (in gm palm/yr)		
	0	1	2
Nitrogen (N) in the form of Am. Sulphate	0	100	200
Phosphorus (P) in the form of Superphosphate	0	40	80
Potash (K) in the form of Muriate of potash	0	140	280
Green leaf (G) in the form of Glyricidia/Pongamia	0	12kg	24kg

Effect of Intercropping

The different intercrops comprising banana, tapioca, pineapple and betelvine were planted and cultural practices were adopted as per the recommended package of practices. This experiment was laid out on a randomised block design with four replications.

Method of scoring disease severity

Disease incidence was measured as the number of palms affected in different field layouts. Individual leaflets were rated for the disease intensity. The data gathered

represented the proportion of leaflets infected in a frond and the number of palms affected by the disease in each of the field experiments. The data obtained were analysed using appropriate statistical methods.

Results

Effect of irrigation on disease incidence

Data showed that frequent irrigation at shorter intervals encouraged disease development and spread. Palms receiving irrigation once in five days (30mm CPE) showed higher percentage of incidence and spread (Table 1) as compared to other intervals studied. Though the intervals of irrigation was significant, between years there was no significance.

Table 1. Effect of Intervals of Irrigation on the percentage of disease incidence due to *Xanthomonas campestris* pv *arecae*.

Year	5 days	10 days	15 days	20 days
1974	13.5	8.6	10.7	6.4
1975	20.6	12.0	7.0	7.4
1976	15.0	10.0	8.0	7.0

S. E. 2.21

C. D. for Int. of Irrigation 4.41

Effect of fertilization on disease incidence

Palms receiving higher dose of nitrogenous fertilizers and green leaf showed higher percentage of disease as compared to palms not receiving any nitrogen or green manure. Phosphorus and potash had no significant influence except for slight reduction of disease incidence at higher levels (Table 2). The difference between treatments and their interaction has been found to be significant.

Effect of intercropping

The effect of intercropping and the change in environment as a result of intercropping and response of intercrops on the disease status revealed that, plots intercropped with banana had higher percentage of disease incidence than other intercrops tested (Table 3). Betelvine showed next higher incidence, whereas, tapioca and pineapple did not have much influence on the disease status. Though there is significance between intercrops, between years there was no significance.

Discussion

Changes in land use patterns and management practices influence disease incidence in every crop either positively or negatively.

This has to be understood clearly so that sustained disease free crop could be raised. Among the physical environmental factors, moisture is essential for plant growth and development of disease causing agents. Soil moisture in the form of irrigation and rain could influence the host and the pathogen. The variation in soil moisture and humidity play an important role in the development and conversely the control of soil borne and aerial pathogens (Zentmyer and Bald, 1978). Alternate drying and irrigation could cause disease build up in bacterial blight of rice due to *X. campestris* pv *oryzae* (Dath and Padmanabhan, 1976). Several diseases are controlled by maintaining a flooded soil for varying periods of time (Newhall, 1955).

Table 2. Effect of different levels of fertilizers on disease incidence (%) due to *Xanthomonas campestris* pv *arecae*.

LEVELS	1974			1975			1976		
	0	1	2	0	1	2	0	1	2
Nitrogen (N)	16.0	26.0	35.5	15.0	25.0	34.0	20.0	26.6	36.0
Phosphorus (P)	20.0	19.0	20.0	24.0	29.0	26.3	30.0	23.0	23.0
Potash (K)	30.0	22.0	22.0	29.6	24.0	25.0	26.0	23.0	23.0
Green leaf (G)	23.0	32.0	34.0	20.0	30.0	30.0	23.0	33.0	26.0
Control	18.0	21.0	18.0	16.0	20.0	20.0	18.0	20.0	19.0

SE for Main treatments 1.717

SE for sub - treatments 0.7658

Table 3. Effect of intercropping on the disease incidence (%) due to *Xanthomonas campestris* pv *arecae*.

Crop	1974	1975	1976	Mean
Betelvine	6.50	5.50	5.75	5.92
Banana	7.75	8.00	8.00	7.92
Tapioca	5.00	3.50	4.00	4.17
Pineapple	5.25	3.75	4.25	4.42
Control	6.00	4.25	3.75	4.67

Changes in host nutrition cannot be explained clearly as it is a complex one. The increase in disease incidence at higher levels of N and G in bacterial leaf stripe disease may be due to good growth which is favourable for dissemination of the pathogen there by influencing disease incidence under field conditions. Also, increased supply of N can increase the innate susceptibility of plants (Segall et al., 1977). Different levels of N and unsuitable combinations of N, P and K and their influence on bacterial diseases has been extensively reviewed (Yamanaka et al., 1952; Kondo and Kamura, 1953; Suliman and Ahmed, 1965; Ten Have and Kauffman, 1972; Bartz et al., 1979).

The philosophy of intercropping or multiple cropping is maximum crop per unit area and time with least soil deterioration. This practice helps to tide over the risk of poor yields from main crop due to unfavourable weather conditions, ravages of pest and disease. As a result of intercropping the environment within the plantation is considerably altered which indirectly influences the soil moisture relations. Moreover, it reduces radiation from the foliage and soil, temperature difference between air and soil. The higher incidence of disease in plots intercropped with banana may be due to one of these factors or a combination of these factors.

References

- BARTZ, J.A., G.M. GERALDSON and CRILL, J.P. 1979. Nitrogen nutrition of tomato plants and susceptibility of the fruit to bacterial soft rot. *Phytopathology*. **69** : 162
- DATH, A.P. and PADMANABHAN, S.Y. 1976. Effect of Wetting and drying of soils on the lesion length produced by *X. campestris* pv *oryzae*. *Curr. Sci.* **54** : 231
- KONDO, G. and KAMURA, T. 1953. Effect of fertilizers on the severity of bacterial leaf blight of rice. *Bull. Aicai. Expt. Sta.* **8** : 35
- NEWHALL, A.G. 1985. Disinfection of soil by heat, flooding and fumigation. *Bot. Rev.* **21** : 189
- SAMPATH KUMAR, S.N. 1981. Bacterial leaf stripe disease of Arecanut caused by *Xanthomonas Campestris* pv *arecae*. Ph.D. thesis submitted to the Indian Institute of Science, Bangalore, pp 190.
- SEGALL, R.T., A.T. DOW and G.M. GERALDSON. 1977. The Effect of fertilizer components on yield, ripening and susceptibility of tomato fruit to post harvest rot. *Proc. Fla. Stat Horticult Soc.* **90** : 393.
- SULIMAN, M. and AHAMED, L. 1965. Controlling bacterial blight of paddy in Maharashtra. *Indian farmg.* **15** : 27
- TEN HAVE, H. and KAUFFMAN, H.E. 1972. Effect of Nitrogen and spacing on bacterial leaf blight of rice. *Indian farmg.* **21** : 8
- YAMANAKA, T., K. NAKAYA, T. TOMINAGA and K. UCHIDA, 1952. Effect of environments on the occurrence of bacterial leaf blight disease of rice. *Ann. Phytopath. Soc. Japan* **16** : 191
- ZENTMYER, G.A. and BALD J.G. 1978. 'Management of Environment'. In 'Plant Disease' Ed. J.G. Horsfall and E.B. Cowling. Academic press, London pp. 410.

Control of 'Band' Disease of Arecanut (*Areca catechu* L.)

M. J. Salvi*, S. P. Singh** and S. B. Deshpande**

Abstract

Studies in Band disease of arecanut were undertaken at Arecanut Research Station, Shrivardhan. Field experiments showed that application of lime, nitrogen and provision of drainage independently had given significantly more recovery percentage of Band affected palms over the control treatment. However, lime application along with nitrogen or with drainage or with nitrogen + drainage could not show significant effect. Application of nitrogen at 0.15 kg + provision of drainage proved to be the best treatment in respect to percentage of recovery of Band affected palms.

Introduction

Among the various diseases of areca palm, *Areca catechu* L. 'Band' disease is a serious one, particularly in parts of South Maharashtra and North Kanara in Karnataka. 'Band' disease was first recorded during 1889-1890 (Joshi and Joshi, 1952). The major symptom of the affected palm is reduction in size of the leaves with characteristic dark green colour compared to normal leaves. Leaves are erect and wrinkled and leaflets are thick, brittle and leathery. In later stage, the crown exhibits a small tuft. The internodal distance reduces, stem becomes tapered and constricted at the top and roots get poorly developed. Ultimately, affected palm stops bearing fruits and subsequently it dies. (Reddy et al., 1978)

* Arecanut Research Station, Shrivardhan 402 110 Maharashtra.

** Department of Horticulture, College of Agriculture, Konkan Krishi Vidyapeeth, Dapoli Maharashtra.

Previous workers have reported the possible causes of 'Band' disease as poor drainage and low soil fertility (Gokhale et al., 1916; Daji, 1948; Nambiar, 1951) and hard pan formation in the subsoil (Patel and Rao, 1958). It is not caused by fungus, virus or insect (Anon. 1951). Hence, it was thought to study precisely the effect of drainage and application of fertilizers on the recovery of 'Band' affected areca palms.

Materials and Methods

The experiment was laid out in the year 1968-'69 following randomised block design with fourteen replications. The replications were later on reduced to nine. There were eight treatments viz., (1) control, (2) application of lime at 1.0 kg/palm/year, (3) application of nitrogen at 0.15 kg/palm/year, (4) provision of drainage, (5) lime + nitrogen, (6) lime + drainage, (7) nitrogen + drainage and (8) nitrogen + drainage + lime.

Each experimental plot was of 144 sq.m with initial number of 'Band' affected palms varying from 1 to 10. The open drains were dug to a depth of 75 cm and width of 60 cm before commencement of monsoon. Nitrogen at 0.15 kg/palm/year was applied in three equal split doses in the month of September, November and January. Lime at 1.0 kg/palm/year was applied in the first week of June. The observations on the disease condition of experimental palms were recorded initially and later after every three months.

Results and Discussion

The final data recorded on percentage of recovery of 'Band' affected palms at the termination of experiment during 1975-'76 are presented in Table 1. A perusal of data indicates that application of lime, nitrogen and provision of drainage either independently or in combination has given significantly more recovery percentage of 'Band' affected palms over the control treatment. However lime could not show significant difference either from nitrogen or drainage treatment or both. The best treatment proved to be an application of nitrogen at

0.15 kg + provision of drainage as indicated by the percentage of recovery of 'Band' affected palms.

From the above studies it becomes very clear that improved cultural techniques help to a great extent in avoiding the incidence of 'Band' disease in arecanut. Factors which cause impairment of root activities may cause symptoms like 'Band' disease. Water stagnation on the surface of soil or in the root zone reduces the activities of roots. The average value of leaf nitrogen of healthy palms was higher than that of diseased palms throughout the year. Therefore, it appears that the uptake of nitrogen reduces due to incidence of disease (Anon, 1973 - '74). The effect of water stagnation has further been proved from the survey conducted in the districts of Ratnagiri and Raigad (then Kolaba). Most of the affected palms were located in gardens of flat land near the sea shore (poor drainage with high water table) while gardens in the hill slopes were almost free from the disease.

Prolonged stagnation of water not only enhances loss of nutrients due to leaching but also create anaerobic conditions in the root zone. Further, the continuous and heavy rainfall accelerates loss of nutrients through run-off, causes low level of soil fertility which in turn may favour incidence of 'Band' disease (Nambiar, 1951).

It has been observed that in hill slopes where there is no problem of water stagnation a few palms may be seen showing 'Band' like symptoms. In hill slopes if there is a hard pan below the root zone, it restricts proper growth and development of roots and in turn, palms show 'Band' like symptoms. Hard pan has also been attributed as one of the causes of 'Band' disease (Patel and Nagaraja Rao, 1958).

Table 1. Effect of lime, nitrogen and drainage on percentage recovery of 'Band' affected areca palms

Treatments	% recovery
1. Control	19.55
2. Lime	43.50
3. Nitrogen	48.12
4. Drainage	55.52
5. Lime + Nitrogen	45.23
6. Lime + Drainage	58.31
7. Nitrogen + Drainage	69.58
8. Nitrogen + Drainage + Lime	68.29
SE + 6.07	
CD 5% 16.85	

When affected palms were given sufficient NPK manures and fertilizers they showed improvement which indicate that poor nutritional status increases this malady (Anon., 1962).

Acknowledgement

The authors are grateful to the Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri, for providing facilities. Thanks are due to all the workers who devoted their time in these studies.

References

- ANONYMOUS, 1951. Scheme for investigation of the stem breaking disease of arecanuts. *Proc. Second-Ann. Gen. Meeting, Special Meeting and Third ordinary Meeting*. Indian Central Arecanut Committee, Kozhikode, pp. 266.
- ANONYMOUS, 1962. *Annual Progress report CARS, Vittal for 1959 - 1960*. pp. 92.
- ANONYMOUS, 1973-74. *Annual Progress report Arecanut Research Station, Shriwardhan*, p. 3.
- DAJI, J. A. 1948. Manganese toxicity as a probable cause for band disease of areca palm. *Curr. Sci.* 4: 77-82.
- GOKHALE, G. P., KASARAGODA, R. S. and AYREKAR, S. L. 1916. The Band disease of betelnut palm in Konkan. *Poona Agril. College Mag.* 8: 49-53.
- JOSHI, N. V. and JOSHI, S. G. 1952. The Band disease of areca palm. *ICAC Month. Bull.* 11: 91-96.
- KOTI REDDY, M., SARASWATHY, N. and CHANDRA MOHANAN, R. 1978. Diseases of arecanut in India: A review and further consideration. *J. Plant. Crops.* 6 (1): 33-34.
- NAMBIAR, K. K. 1951. Cultivation of arecanut in Mysore State. *ICAC Month. Bull.* 1: 1-6.
- PATEL, G. I. and NAGARAJA RAO, K. S. 1958. Important diseases and pests of arecanut and their control. *Arecanut J.* 9: 89-96.

Session 3

Plant Protection

Entomology

Chairman : M R G K Nair

Rapporteurs : C P R Nair

S Devasahayam

Seasonal Fluctuations in Population of the Spindle Bug *Carvalhoia arecae* M. and C. (Heteroptera : Miridae)

B. Sathiamma,* K. M. Abdulla Koya,** V. A. Abraham*,
T. S. S. Rawther* and Chandy Kurian*

Abstract

The spindle bug Carvalhoia arecae is one of the major pests of arecanut palm. The bugs suck sap from the tender tissues of the spindle leaf and cause necrotic lesions. Seasonal fluctuation in population of the spindle bug studied at three locations revealed that the pest occurred throughout the year. The peak period of the pest abundance was found to vary at different centres. The peak period of occurrence was in January and November at Krishnapuram, in July at Palode and in February at Sullia. High pest population was noted at Krishnapuram and Palode whereas it was quite low at Sullia. Among the weather factors, positive correlation was observed with rainfall and pest population.

Introduction

The spindle bug *Carvalhoia arecae* Miller and China is the most serious and widely distributed pest of arecanut palm occurring all along the west coast of Kerala, Karnataka and in certain parts of Tamil Nadu. *C. arecae* was first recorded as a major pest of areca palm in Dakshina Kannada, Karnataka by Khandige (1955). Miller and China (1957) recorded this as a new genus and species from *Areca catechu*.

Nymphs and adults of *C. arecae* live in colonies in the innermost leaf axils surrounding the unopened spindle and

suck the sap from the tender tissues. Characteristic linear dark brown lesions appear in the infested area and the damaged tissues gradually dry up and drop off leaving shot holes in the opened leaf. Badly damaged spindle never unfolds fully and in many cases it dries up. Severe infestation results in tapering of crown, reduction in number and size of leaves, loss of vigour of the palm and the consequent reduced yield. Nair (1964) estimated that more than 80% of the arecanut gardens in southern Kerala are infested by this pest, with nearly 25% loss in yields.

A thorough knowledge of the seasonal fluctuations in population density is imperative for evolving effective control schedules against the pest. Nair (1964) observed that it occurs in abundance during June to October with maximum populations in August and September in southern

* Central Plantation Crops Research Institute,
Regional Station, Kayangulam, Krishnapuram
690 533, Kerala.

Central Plantation Crops Research Institute,
Regional Station, Marikunnu, Calicut 673 012,
Kerala.

Kerala. However, information on the population density of the pest in other tracts is lacking. The present paper summarises the results of studies on the population fluctuation of the pest carried out during 1976 - 1978 at Krishnapuram and Palode (Kerala) and Sullia (Karnataka).

Materials and Methods

Observations were recorded from three locations viz., Krishnapuram (Alleppey district, Kerala), Palode (Trivandrum district, Kerala) and Sullia (Dakshina Kannada district, Karnataka). Data on the population density of the nymphs and adults of the bug were recorded at monthly intervals from fifty palms of uniform age at each location. Weather data such as

temperature, relative humidity and rainfall were recorded at Krishnapuram and temperature and rainfall were recorded at Palode. They were correlated with the fluctuations in pest population.

Results and Discussion

C. arecae occurred at all three locations almost throughout the year. The intensity of pest population varied at different locations. Pest population was high at Krishnapuram and Palode and low at Sullia (Fig. 1).

At Krishnapuram, pest abundance was observed from September to January. Maximum population of the bug was recorded in January and November. Pest population remained at a significantly

lower level during the period from February to August. Minimum pest population was observed in March and April. At Palode pest incidence occurred at its peak in July. A decline in pest population was observed during August - September. But the population remained at a high level during February and October. Pest population was low in March and April, the lowest level being in March. However, no significant difference in the level of population was seen during the different months of the year at Sullia. As compared to Krishnapuram and Palode the intensity of spindle bug population was quite low at Sullia. Maximum population at Sullia was recorded during July and February and minimum during August.

No significant correlation was observed between temperature, relative humidity and pest population. However, a positive correlation was noticed between rainfall and population of *C. arecae* (Table 1; Figs. 2 and 3)

FIG. 1 SEASONAL FLUCTUATIONS IN POPULATION OF *C. ARECAE* AT KRISHNAPURAM, PALODE AND SULLIA.

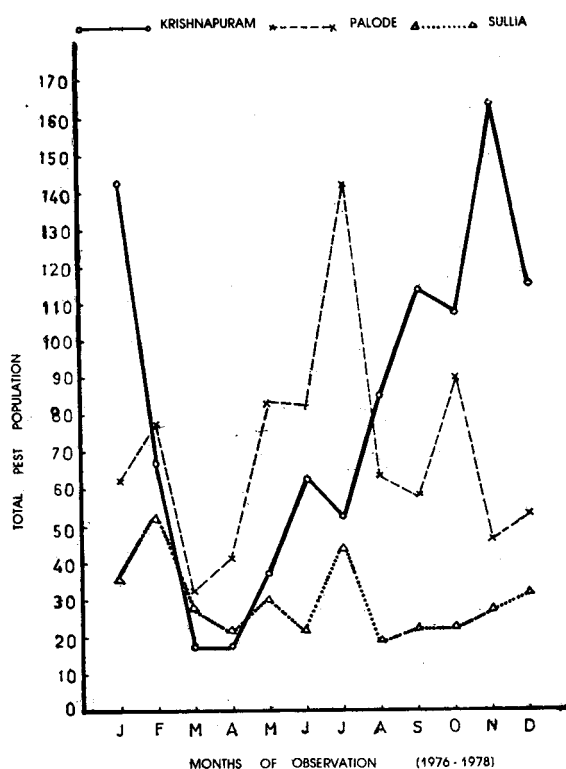


FIG.2 SEASONAL FLUCTUATIONS IN POPULATION OF C. ARECAE
IN CORRELATION WITH RAINFALL AT KRISHNAPURAM.

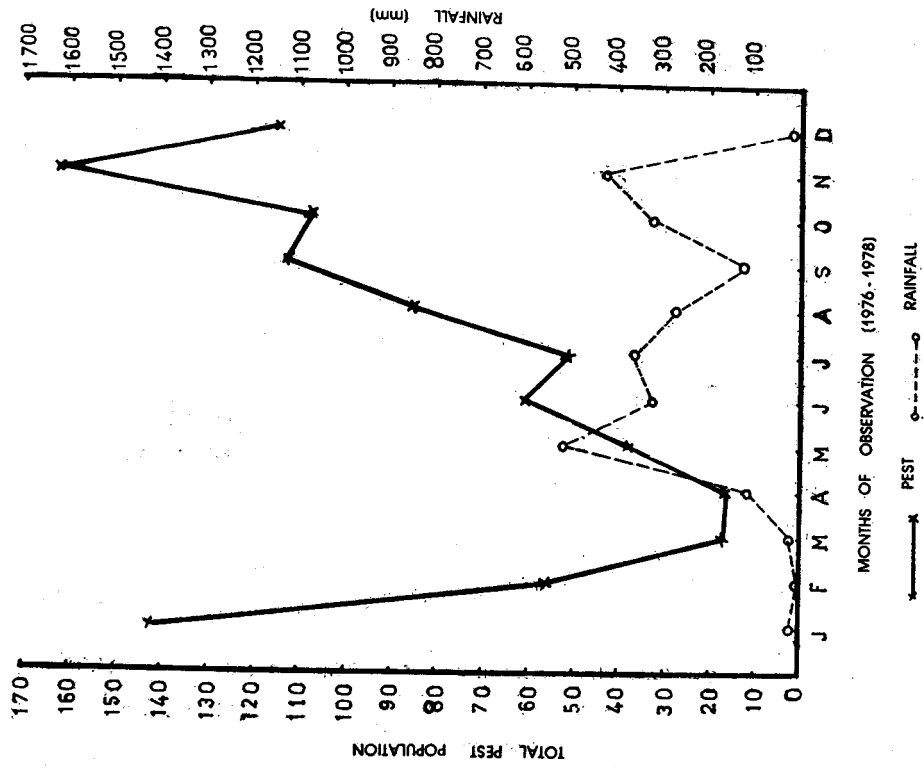
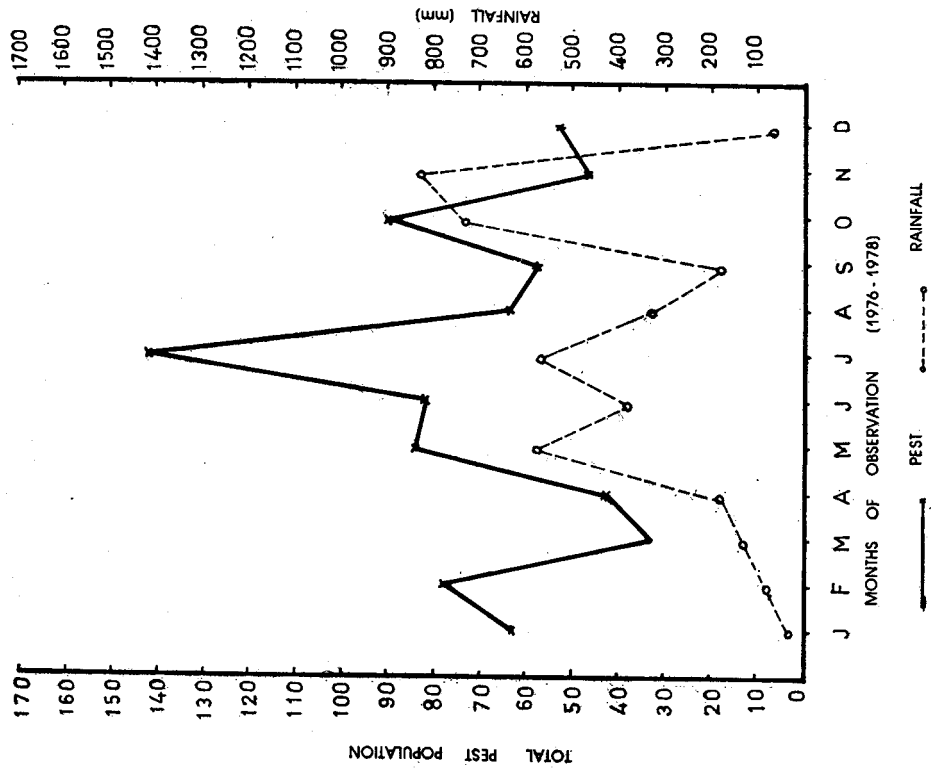


FIG.3 SEASONAL FLUCTUATIONS IN POPULATION OF C. ARECAE
IN CORRELATION WITH RAINFALL AT PALODE.



Acknowledgements

The authors are thankful to Shri Jose Abraham, Scientist, CPCRI, Regional Station, Kayangulam for the analysis of

the data. Thanks are due to all our colleagues who helped in recording the data and to the cultivators for their co-operation in the conduct of the experiment in their garden.

Table 1. Correlations between population of *C. arecae* and meteorological factors

Year / Factors	PALODE			KRISHNAPURAM				
	Temperature Max. °C	Rainfall (mm)	R ²	Temperature °C		Relative humidity (%)	Rain- fall (mm)	R ²
				Max.	Min.			
1976	-0.5797*	0.0596	48.77	-0.3721	-0.2964	0.1267	0.3135	60.58
1977	-0.3227	0.5031	25.85	-0.3740	-0.4401	0.0008	0.0038	47.86
1978	-0.2718	0.4484	24.84	-0.6825*	-0.7079	-0.1227	-0.2523	80.84
Overall	-0.5553	0.3452	32.87	-0.6022*	-0.2704	0.2963	0.0188	67.52

* Significant

References

- KHANDIGE, S. B. 1955. A capsid bug on areca. *Arecanut Bull.* 6 : 120-121.
- MILLER, N. C. E. and CHINA, W. E. 1957. A new genus and species of Miridae from *Areca catechu* in South India (Hemiptera: Heteroptera). *Bull. Ent. Res.* 47 : 429-431.
- NAIR, R. B. 1964. *Carvalhoia arecae* Miller and China - A major pest of *Areca catechu*. *Arecanut J.* 15: 57-61.

Control of Arecanut Spindle Bug *Carvalhoia arecae* M. and C. using Granular Insecticides in the Field

B. Sathiamma*, K. M. Abdulla Koya**, T. S. S. Rawther* and Chandy Kurian*

Abstract

Granular formulations of phorate, lindane and quinalphos were tested under field conditions in demonstration cum trial plots at CPCRI, Research Centre, Palode during 1977-1980. Trials proved that granular formulations of lindane and phorate, applied to the innermost two or three leaf axils @ 10 g per palm at quarterly intervals, in March, June, September and December effected significant control of the spindle bug population in the field. The cost of the insecticide granule+labour for treatment of 100 palms worked out to Rs. 30/- for lindane and Rs. 38/- for phorate.

Introduction

The spindle bug *Carvalhoia arecae* Miller and China (Heteroptera: Miridae) is one of the major pests of arecanut palm, infesting nearly 80% of areca gardens in the west coast of Kerala. It causes about 25% loss in yields. The nymphs and adults of the bug congregate in the leaf axils surrounding the spindle and suck the sap from the tender leaf tissues. The infested patches develop dark brown necrotic lesions which later dry up leaving shot holes on the opened leaves. Severely damaged spindle fails to open fully and usually gets dried up.

Wettable and granular formulations of different insecticides were recommended for the control of *C. arecae*. Spraying BHC at 0.25% or endrin at 0.125% concentration was recommended for the control of spindle bug on infested palms (Nair and Das, 1962; Nair, 1964). Leaf axil filling with granular formulations of endrin 2 G, heptachlor 3 G and lindane 6 G could be effectively employed in the control of the bugs (Abraham et al., 1972). Abraham et al., (1976) observed that phorate 10G thiodemeton 5G and carbaryl 4 G applied @ 10g per palm, at quarterly intervals, could bring down the pest below the economic injury level. Subsequent trials revealed that quinalphos 5 G, mephosfolan 10G, thiodemeton 5G, lindane 6G, lindane+carbaryl 4:4 G and carbaryl 4 G applied @ 10 g per palm, at quarterly intervals, effected significant control of the pest (Abdulla Koya et al., 1979). Small scale tests with phorate 10G, lindane 6G and

* Central Plantation Crops Research Institute, Regional Station, Kayangulam, Krishnapuram 690 533, Kerala.

** Central Plantation Crops Research Institute, Regional Station, Marikunnu, Calicut 673 012, Kerala.

quinalphos 5 G proved to be very effective and best suited for the control of the arecanut spindle bug. These formulations were further tested in demonstration *cum* trial plots during the period 1977 - 1980 and the results are presented in this paper.

Materials and Methods

The trial was conducted in the farm of Central Plantation Crops Research Institute, Research Centre, Palode, Trivandrum district, Kerala. One hundred and twenty five areca palms per treatment were selected for the experiment. Twenty per cent of palms were marked as sample palms for periodic observations. A control plot was also maintained with equal number of palms. Observations were made on the total number of leaves and infested leaves at half yearly intervals. Phorate 10G, lindane 6G and quinalphos 5G were applied @ 10g per palm, at quarterly intervals, by filling the innermost two or three leaf axils surrounding the spindle. Observations on nymph and adult populations were recorded at quarterly intervals in March, June, September and December prior to insecticide application. Data were analysed statistically and the results are presented in Table 1.

Results and Discussion

The granular formulations of phorate, lindane and quinalphos effected significant control of the pest as compared to the untreated control. Significant difference in the total pest population was observed between treatments. The difference between treatments was highly significant in the case of leaf infestation and fresh incidence. Leaf damage was comparatively less in lindane treatment (27%), whereas it was more in quinalphos (38.8%) and control (41.9%). Minimum pest population was recorded in the phorate and lindane treatments (9.8 and 11.4 respectively). Quinalphos treated palms showed high population of the pest (47.5), which was higher than that of the untreated control (33.9). Taking into account the fresh incidence of the bug on newly emerged spindle leaf, lindane followed by phorate treated palms showed the minimum incidence (3.6 and 4.2 respectively). Phorate and lindane were observed to be superior to quinalphos.

For treatment of 100 palms lindane costs Rs. 10/- and phorate Rs. 18/-. The total cost including insecticide and labour requirement for treatment of 100 palms at a time works out to Rs. 30/- and Rs. 38/- for lindane and phorate respectively.

Table 1. Summary of observations on demonstration *cum* trial for the control of *Carvalhoia arecae* (Data for the period 1977-1980)

Observations	Treatments				CD (P= 0.05)
	Quinalphos 5G	Phorate 10G	Lindane 6G	Untreated control	
Leaf infestation (%)	38.8	29.5	27.0	41.9	7.8* ^c
Total pest population	47.5	9.8	11.4	33.9	26.7*
Fresh incidence	8.5	4.2	3.6	10.5	3.4**

Considering the efficacy and cost, lindane 6G or phorate IOG is recommended for the control of *C. arecae* in the field.

Wettable formulations such as BHC 0.25% and endrin 0.125% were hitherto recommended for the control of the spindle bug in the field. They have to be sprayed at 30-35 days interval for effecting satisfactory control of the pest and protecting the newly emerging spindle leaf from pest infestation. The pest normally occurs in abundance during the rainy seasons and in high rainfall tracts. The insecticide spray gets washed away during the rains and quite often the spraying treatment leads to unsatisfactory control of the pest. Tests proved that the granular insecticides could maintain the palms free of infestation for

more than three months. The treatment by way of filling the innermost leaf axils surrounding the spindle, need be done only at quarterly intervals in March, June, September and December synchronising with the abundance of the spindle bug population.

The present finding of leaf axil filling with granular insecticides overcomes the difficulties in the control of the pest.

Acknowledgements

Authors are thankful to Shri P. T. N. Nambiar, Statistician, Central Plantation Crops Research Institute, Kasaragod, for the analysis of the data and to all our colleagues who helped in the conduct of this field study.

References

- ABDULLA KOYA, K. M., RAWTHER, T. S. S., SATHIAMMA, B. and KURIAN, C. 1979, Evaluation of six granular insecticides for the control of arecanut spindle bug *Carvalhoia arecae* Miller and China in the field. *Pesticides* **13** (8): 50-51.
- ABRAHAM, V. A., SATHIAMMA, B. and ABRAHAM, K. J. 1972. In Central Plantation Crops Research Institute Annual Report for 1971. Kasaragod, India. p. 185.
- ABRAHAM, V. A., SATHIAMMA, B., ABRAHAM, K. J. and KURIAN, C. 1976. Control of arecanut spindle bug (*Carvalhoia arecae* Miller and China) using granular insecticides. *J. Plant. Crops* **4** : 24 - 25.
- NAIR, R. B. 1964, *Carvalhoia arecae* Miller and China - a major pest of Arecanut (*Areca catechu* L.). *Arecanut J.* **15** : 57 - 61.
- NAIR, M. R. G. K. and DAS, N. M. 1962. On the biology and control of *Carvalhoia arecae* Miller and China as a pest of arecanut palm in Kerala. *Indian J. Ent.* **24**: 86-93.

Chemical Control of Palm Mite *Raoiella indica* Hirst on Arecanut

S. Devasahayam and C. P. Radhakrishnan Nair*

Abstract

The palm mite, Raoiella indica Hirst is a common and widespread pest of arecanut in India attaining serious proportions especially during the hot summer months. A field trial was conducted at Central Plantation Crops Research Institute, Regional Station, Vittal, Karnataka to evaluate the efficacy of four pesticides viz., dicofol, dimethoate, formothion and phosphamidon at 0.05% and 0.025% concentration in controlling the population of the pest. It was found that dicofol 0.05%, dimethoate 0.05% and 0.025%, formothion 0.05% and phosphamidon 0.05% gave significant control of the mite population.

Introduction

The palm mite, *Raoiella indica* Hirst (Acarina: Tenuipalpidae) is a common and widespread pest of arecanut in India. The mite is found in colonies on the lower surface of the leaves. As a result of the feeding activity of the mites, the leaves become yellow and bronzed in appearance and ultimately wilt and wither away. Young seedlings when severely affected often die. The mite infestation reaches its peak during summer months and decreases with the onset of monsoon.

The pesticides earlier reported effective against the mites include, dicofol, carbophenion, chlorobenzilate (Rajamani and Nambiar, 1970), formothion, dimethoate (Saradamma, 1972) and dinobuton (Anonymous, 1981). In the present study

the relative efficacy of four pesticides in controlling the mite was tested in a field experiment.

Materials and Methods

The experiment was conducted at the farm of the Central Plantation Crops Research Institute, Regional Station, Vittal, Karnataka during April-May 1981 on young areca palms. Each treatment plot consisted of a single palm and was replicated thrice. The treatments included dicofol, dimethoate, formothion and phosphamidon, each at 0.05% and 0.025% concentrations. Two controls, one with water spray and the other without spray were also maintained. The chemicals were applied with a manually operated knapsack sprayer taking care to avoid drift. The effects of the treatments were assessed by taking counts of the mite population prior to treatment and also on the 7th, 15th and 30th day after treatment. Counts were taken of eggs, nymphs and adults in three 1cm² unit area on a

* Central Plantation Crops Research Institute,
Regional Station,
Vittal 574 243, Karnataka

Table 1. Effect of different pesticide sprays on the control of *R. indica* on arecanut

Pesticide and concentration	Percentage reduction in population over pretreatment during different periods*					
	7th day		15th day		30th day	
	Nymphs and Adult	±Eggs	Nymphs and Adults	Eggs	Nymphs and Adults	Eggs
Dicofol 0.05%	87.22 [99.76]	90.00 [100.00]	58.32 [72.42]	90.00 [100.00]	80.00 [96.98]	88.27 [99.91]
Dicofol 0.025%	88.73 [99.95]	90.00 [100.00]	77.92 [95.62]	72.34 [90.80]	49.94 [58.58]	55.00 [67.12]
Dimethoate 0.05%	86.66 [99.66]	90.00 [100.00]	77.90 [95.61]	88.81 [99.95]	75.72 [93.92]	85.80 [99.46]
Dimethoate 0.025%	85.21 [99.30]	90.00 [100.00]	81.13 [97.63]	90.00 [100.00]	69.72 [87.99]	84.28 [99.01]
Formothion 0.05%	90.00 [100.00]	90.00 [100.00]	73.24 [95.85]	90.00 [100.00]	82.94 [98.49]	90.00 [100.00]
Formothion 0.025%	72.22 [90.67]	90.00 [100.00]	74.28 [92.67]	88.39 [99.92]	44.81 [49.67]	66.97 [84.70]
Phosphamidon 0.05%	85.04 [99.25]	90.00 [100.00]	83.47 [98.71]	85.09 [99.27]	68.22 [86.23]	77.69 [95.45]
Fhosphamidon 0.025%	74.00 [92.40]	87.30 [99.78]	69.70 [87.96]	82.12 [98.12]	43.07 [46.63]	52.97 [63.73]
Control [water spray]	17.19 [8.73]	49.38 [57.61]	26.71 [20.22]	53.53 [67.67]	9.20 [2.56]	39.03 [39.66]
Control [no treatment]	0 [0]	43.37 [47.16]	8.51 [2.19]	31.78 [27.74]	0 [0]	40.38 [41.97]
CD [P = 0.05]	14.59	26.58	40.08	23.42	16.91	22.30

* Mean values after areasin transformation
 Figures in parentheses indicate retransformed mean values

leaflet distributed at the base, middle and tip portions of the leaflet in each replication.

Results and Discussion

The percentage reduction in the number of eggs, nymphs and adults present under different treatments over pretreatment at different intervals is furnished in Table 1. The results show that all the pesticides under test gave significant control of the mites at one or other or both the concentrations, as compared to that in untreated control. The pesticides remained effective up to the 30th day after application and the loss of toxicity from the 15th day to the 30th day of treatment was not significant

with any of the pesticides. Based on the sustained effect in controlling the mite population, dicofol 0.05%, dimethoate 0.05% and 0.025%, formothion 0.05% and phosphamidon 0.05% were found to be the most effective treatments and superior over the others significantly and were on par among themselves.

Acknowledgements

The authors are grateful to Dr. M.R.G.K. Nair, Retired Professor of Entomology, Kerala Agricultural University for his valuable suggestions and for critically going through the manuscript and to Shri B. P. Nair, CPCRI, Regional Station, Vittal for statistical analysis of the data.

References

- ANONYMOUS, 1981. Annual Report for 1978. Central Plantation Crops Research Institute, Kasaragod, India. p. 104.
- RAJAMANI, S. and NAMBIAR, K.K.N. 1970. Pests of arecanut palm, *Indian Fmg.* **20** (8) : 23.
- SARADAMMA, K. 1973. Evaluation of the toxicity of some pesticides to the red mite on coconut, *Raoiella indica* Hirst (Phytoptipalpidae). *Agric Res. J. Kerala.* **10** (1) 61 - 62.

Distribution of Phytoparasitic Nematodes on Arecanut in South India

P. Sundararaju and P. K. Koshy*

Abstract

Extensive surveys of arecanut growing areas of Kerala, Karnataka and Tamil Nadu were conducted during 1976 to 1980. A total of 822 each of soil and root samples were collected from healthy and Yellow Leaf Disease affected arecanut gardens. Twenty eight genera of plant parasitic nematodes were isolated from the root zone of arecanut. The burrowing nematode, *Radopholus similis* was obtained from maximum number of root samples. *Rotylenchulus reniformis*, *Helicotylenchus dihystra*, *Hemicriconemoides mangiferae*, *Caloosia longicaudata* and *Hoplolaimus seinhorsti* were the most widely distributed ectoparasitic forms in the soil samples of arecanut growing areas in South India.

Introduction

In India, arecanut (*Areca catechu L.*) is grown in about 1.8 lakh ha and 63 per cent of the total area under cultivation is in Kerala and Karnataka. The Yellow Leaf Disease (YLD) remains today as the most serious problem facing arecanut growers. The malady is prevalent in different intensities in Kerala and Karnataka states. The association of nematodes with arecanut was first reported by Nair in 1964. Later Weischer (1967) and Kumar et al., (1971) recorded the presence of seven and five genera of plant parasitic nematodes from soil samples of arecanut palms. Koshy et al., (1976 and 1978) recorded the wide spread occurrence of *Radopholus similis* (Cobb, 1893) Thorne, 1949 in South India. Results of an attempt made to study

the distribution of phytoparasitic nematodes in soil samples collected during a survey are reported herein.

Materials and Methods

The route of survey was mostly along the main roads and samples were collected from nearby gardens after every 10 km. A total of 822 each of soil and root samples were collected from healthy and YLD affected arecanut gardens in Kerala Karnataka and Tamil Nadu. Soil samples were collected 75 cm away from the bole of the palm at a depth of 10 - 50 cm with a soil augur. Three such samples were taken within the basin at 120° to each other, mixed well and an aliquot of 250 ml sample was drawn. The extraction was done by Cobb's modified sieving and decanting technique. Nematodes of each sample were killed and preserved in 2 per. cent formaldehyde.

* Central Plantation Crops Research Institute, Regional Station, Kayangulam, Krishnapuram 690 533, Kerala.

Table 1. Distribution and frequency of occurrence (%) of phytonematodes recovered from soil samples

Sl. No.	Genera / species	Kerala	Karnataka	Tamil Nadu
1.	<i>Aphelenchoides</i> sp.	13	3	7
2.	<i>Aphelenchus</i> (<i>Anaphelenchus</i>) <i>isomerus</i> (Anderson & Hooper, 1980)	13	4	—
3.	<i>Boleodorus</i> sp.	∠ 1	—	—
4.	<i>Brachydorus swarupi</i> (Koshy, Raski & Sosamma, 1981)	1	—	—
5.	<i>Caloosia longicaudata</i> (Loos, 1948; Siddiqi & Goodey, 1964)	22	20	20
6.	<i>Criconemoides</i> sp.	8	∠ 1	—
7.	<i>Ditylenchus</i> sp.	2	—	—
8.	<i>Ecphyadophora teres</i> (Raski, Koshy & Sosamma, 1982)	3	2	7
9.	<i>Epicharinema keralensis</i> (Raski, Maggenti, Koshy & Sosamma, 1980)	5	—	—
10.	<i>Helicotylenchus dihystra</i> (Cobb, 1893; Sher, 1961)	53	40	53
11.	<i>Hemicriconemoides mangiferae</i> (Siddiqi, 1961)	20	31	27
12.	<i>Hoplolaimus seinhorsti</i> (Luc, 1958)	22	19	33
13.	<i>Longidorus saginus</i> (Khan, Seshadri, Weischer and Mathen, 1971)	3	3	—
14.	<i>Malenchus</i> sp.	∠ 1	—	—
15.	<i>Meloidogyne</i> sp.	19	21	13
16.	<i>Paralongidorus</i> sp.	∠ 1	—	—
17.	<i>Paratylenchus</i> sp.	5	9	7
18.	<i>Pratylenchus</i> sp.	3	2	13
19.	<i>Psilenchus</i> sp.	∠ 1	—	—
20.	<i>Radopholus similis</i> (Cobb, 1893; Thorne, 1949)	40	21	20
21.	<i>Rotylenchulus reniformis</i> (Linford & Oliveria, 1940)	59	49	33
22.	<i>Rotylenchus</i> sp.	∠ 1	—	—
23.	<i>Scutellonema</i> sp.	∠ 1	—	—
24.	<i>Trichodotus</i> sp.	8	3	—
25.	<i>Trophurus</i> sp.	∠ 1	2	—
26.	<i>Tylenchothynchus coffeae</i> (Siddiqi & Basir, 1959)	28	11	7
27.	<i>Tylenchus</i> sp.	5	15	13
28.	<i>Xiphinema inaequale</i> (Khan & Ahmed, 1976) (Syn. <i>X. neoamericanum</i> Khan & Ahmed, 1975)	19	5	—

Nematode populations were assessed in 435 out of 822 soil samples collected during the survey.

Results and Discussion

Of a total of 435 soil samples assessed, 314 were from Kerala, 106 from Karnataka and 15 from Tamil Nadu. Twenty eight genera of plant parasitic nematodes were recorded. The frequency of occurrence of plant parasitic nematodes is given in Table 1. *Rotylenchulus reniformis* was obtained with largest number (4800/250 ml) in 66 per cent of samples analysed. It is seen from Table 1 that the following phytone-matodes viz., *R. reniformis*, *H. dihystra*, *R. similis*, *H. mangiferae*, *C. longicaudata* and

H. seinhorsti were recorded from maximum number of soil samples from all the three states. The frequency of occurrence of these nematodes in the root zone of healthy and YLD affected arecanut gardens is given in Table 2.

Amongst the nematode fauna isolated from diseased as well as healthy palms *R. similis* was given the major attention because of the well known role of this nematode in other crop diseases, particularly in citrus and banana (O'Bannon, 1977).

The pathogenicity studies conducted earlier with *R. similis* recorded as high as 52 per cent reduction in plant growth over a period of three years under pot conditions (Koshy and Sundararaju, 1981) which has convincingly proved the pathogenicity of the nematode on arecanut palms. However, its exact role, if any, in the Yellow Leaf Disease complex remains still to be resolved. This brings out the need of studying the role of nematodes in association with other micro-organisms.

Acknowledgement

The authors are grateful to Dr. M. R. Siddiqi, Principal Nematologist, C. I. H., 103, St. Peters Street, St. Albans, Herts, England for identification of the nematodes to species level.

Table 2. Frequency of occurrence of various nematodes in root zone of areca palms.

Nematode species	Frequency of occurrence	
	Healthy gardens*	Diseased gardens**
<i>Rotylenchulus reniformis</i>	63	189
<i>Helicotylenchus dihystra</i>	58	189
<i>Hemicriconemoides mangiferae</i>	21	80
<i>Caloosia longicaudata</i>	25	68
<i>Hoplolaimus seinhorsti</i>	23	62
<i>Radopholus similis</i>	34	157

* Total no. of Samples - 120

** Total no. of Samples - 315

References

- KOSHY, P. K., SOSAMMA, V. K. and SUNDARARAJU, P. 1976. Yellow leaf disease : Nematological studies. *Areca nut and Spices Bull.* **8** : 37-41.
- KOSHY, P. K., SUNDARARAJU, P. and SOSAMMA, V. K. 1978. Occurrence and distribution of *Radopholus similis* (Cobb, 1893) Thorne. 1949 in South India. *Indian J. Nematol.* **8** : 49-58.
- KOSHY, P. K. and SUNDARARAJU, P. 1981. Pathogenicity of *Radopholus similis* on *Areca catechu* L. In Abstracts (P - 22 - 23) of Paper presented in *Third International Symposium on Plant Pathology*. New Delhi, Dec. 14-18. pp. 271.
- KUMAR, A. C., KASI VISWANATHAN, P. R. and D'SOUZA, G. I. 1971. A study on plant parasitic nematodes of certain commercial crops in coffee tracts of South India. *Indian Coffee* **36**: 1 - 3.
- NAIR, R. B. 1964. Nematodes of areca nut soils. *Areca nut J.* **15**: 87 - 88.
- O'BANNON, J. H. 1977. World wide dissemination of *Radopholus similis* and its importance in crop production. *J. Nematol.* **9**: 16 - 25.
- WEISCHER, B. 1967. Plant parasitic Nematodes. Report to Govt of India. UNDP, FAO, No. 2332, T. A. of the United Nations, Rome.

Discussions

Abi Cheeran:

What is the population of the burrowing nematode in healthy and diseased area?

P Sundararaju:

The burrowing nematode was obtained as high as 440/g of root of YLD affected gardens against 48/g of root from healthy gardens.

Abi Cheeran:

How does *R. similis* affect the areca palm?

P Sundararaju:

R. similis feeding results in formation of small, elongate cortical lesions on young roots. The lesions later coalesce and cause extensive root rotting and blackening of root tip.

Bioecology and Management of White Grubs on Arecanut

G. K. Veeresh*, M. Vijayendra, N. Vijayamohan Reddy,
C. Rajanna and P. S. Rai**

Abstract

Bioecology of three species of Leucopholis viz., L. lepidophora, L. coneophora and L. burmeisteri attacking areca palm have been studied. An integrated approach for the management of areca root grubs has been suggested. This consists of a sequence of operations like application of insecticides at the time of egg laying during May - June, adult collection at the time of emergence, intercropping with tapioca or sweet potato as trap crop to attract the grubs around them and destruction of grubs by digging out the trap crops during August - September.

Introduction

White grubs form an important group of insect pests affecting areca palms in India. Three species of white grubs viz., *Leucopholis coneophora* Burm. *L. lepidophora* Blanch and *L. burmeisteri* Brenske are commonly found damaging areca palms in Karnataka and Kerala (Beeson, 1919; Nirula et. al., 1952; Anonymous, 1961; Rajamani and Nambiar, 1970 and Veeresh et. al., 1982). They are well adapted to heavy rain fall areas with laterite soil and have assumed the status of major pests of the crop. Salient findings of extensive field and laboratory studies on their bioecology carried out in the arecanut growing areas of Karnataka are given in the present paper.

Materials and Methods

Field observations were recorded on the ecological and biological aspects of the

* Department of Entomology, University of Agricultural Sciences, Hebbal, Bangalore 560 024.

** Present Address: Department of Entomology, College of Agriculture, Dharwar.

pest from three locations in Shimoga and Dakshina Kannada Districts. Rearing of the grubs was carried out in cement pots (60 × 30 × 30 cm) planted with arecanut seedlings. Adult beetles were maintained in cages of 30 cm³ with 10 cm soil at bottom. Incubation studies were carried out in plastic containers using a mixture of 1:1:1 red soil, sand and farm yard manure. Grubs were reared individually in plastic containers with soil. Potato slices were used as food for the developing grubs. Pupating grubs were kept in earthen pots filled with soil and the pots were maintained inside a wire mesh cage. The date of emergence of adults was recorded.

Results and Discussion

Adult activity

In contrast to other chafer beetles, adults of *Leucopholis* emerge after a couple of rains in May-June. The grubs of *Leucopholis* pupate 60-70 cm deep in soil. So substantial rainfall was found to be necessary to

trigger emergence. The adults were found emerging around 18.00 hr on cloudy evenings in May-June. None of the three species reported here was seen flying in the laboratory, although they were found flying in the field after emergence.

Adults were not observed feeding either in the field or in the laboratory. Feeding trials with various host plants did not show any positive results. The adults were not attracted to light.

The adult females protrude their heads outside the emergence hole and the males locate them. Then the male and female crawl for some distance on the ground and mate. Longevity of adult beetles varied from 20 to 45 days.

Life Cycle

- Eggs were laid singly 5 cm deep in the soil. Though gravid females contained 40 to 50 well developed eggs, on an average 20 eggs only were laid by a female.
- Eggs were pearly white when laid and 4 to 5 mm in size. They turned creamy white and round after two days. Incubation period varied from 12 to 15 days.

The first instar grub, though found feeding occasionally on small roots of grass and weeds mainly feed on organic matter in the soil. The second and third instar grubs fed on roots of areca and other alternate hosts like coconut, sugarcane tapioca and other tuber crops. In some of the fields, the grub activity was observed upto April-May.

The prepupal stage was 25 to 30 days. Pupation occurred at a depth of 45 to 50 cm in soil under laboratory conditions. Pupal

period ranged from 10 to 12 days in the laboratory. Grubs of *L. lepidophora* were found to pupate till the last week of June and adults emerged during early first week of July.

Management of grubs in the field

It is very difficult to notice the symptoms of white grub infestation in the beginning. Heavily infested palms show narrowing of the crown, yellowing of leaves and reduction in yield. Indications for the presence of grubs in the field are wilting and death of intercrops. The affected palms become unstable indicating the loss of anchorage roots.

Field management of white grubs requires careful planning and it involves elimination of grubs step by step. Though effective chemical control measures have been suggested by various workers, insecticidal application alone will not give satisfactory control and it is not long lasting. The insecticidal control is successful if it is properly done. The method and time of application are very important factors determining the success of the insecticidal control programme. The best time for application of chemicals would be after a couple of rains and before the onset of monsoon. Drenching the whole area of the infested garden with chlordane EC or Aldrin EC at the rate of 5 l/ha in 1000 l water, after weeding is found effective in controlling the pest.

Adult collection, if carefully done during the adult emergence can give complete control. Adults can be located by their buzzing sound during the period of emergence in May-June or even sometimes during July.

The intercrops like tapioca, sweet potato and other tuber crops attract adults for egg laying. The grubs concentrate around the

root zone of these crops. During August-September they can be dug out and destroyed easily.

References

ANONYMOUS, 1961. Advances in farm research. *Indian Fmg.*, **11** : 29.

BEESON, C. F. C. 1919. Report of the imperial entomologist. *Scient. Rep., Agric. Res. Inst., Pusa*, 1918, pp. 89 - 116.

NIRULA, K. K., ANTONY, J. and MENON, K.P.V. 1952. A new pest of coconut palm in India. *Indian Coconut J.* **5** : 137 - 140.

RAJAMANI, S. and NAMBIAR, K. K. N. 1970. Pests of arecanut palm. *Indian Fmg.*, **20** : 23.

VEERESH, G. K., VIJAYENDRA, M., VIJAYAMOHAN REDDY, N. and RAJANNA, C. 1982. Bioecology and management of areca white grubs *Leucopholis* spp. (Coleoptera : Scarabaeidae : Melolonthinae). *J. Soil. Biol. Ecol.* **2** : 78 - 86,

Session 4

**Technology, Biochemistry
And
Pharmacology**

Chairman : G S Pendse

Rapporteurs : B Chempakam

S J K Annamalai

The use of Arecanut Husk Fibre for Fibre Reinforced Plastic Product

C. R. Debnath*

Abstract

Randomised fibrous webs were made from arecanut husk fibre, woolenised jute, goat hair, goat hair-woollenised jute (1:1) and coir fibre waste-woollenised jute (4:1) blends on Callaghan Non-woven Fabric Machine (UK), employing an-air laying technique. Attempt was made to produce fibre reinforced plastic sheet out of these fibrous webs. The study showed that interfibre cohesiveness of arecanut husk fibre in fibrous web was very poor in comparison with that of other fibres. But the physical properties of different fibre reinforced plastic sheets were comparable.

Introduction

Arecanut is cultivated in Assam, Karnataka, Kerala, Tamil Nadu and West Bengal on an extensive scale. Arecanut husk fibre, a by-product in arecanut production, was used for the manufacture of fibre reinforced plastic sheet. Goat hair, woolenised jute, goat hair-woollenised jute (1:1) and coir fibre waste-woollenised jute (4:1) blends were also used similarly. Their physical properties like weight, thickness, density, surface appearance and suitability for partition board were compared.

Materials and Methods

The arecanut husk fibre and goat hair were received from Central Plantation Crops Research Institute, Regional Station, Vittal, Karnataka and Tansi Wool Processing Centre, Vinnamangalam, Minnur, Tamil Nadu, respectively. Coir fibre waste

was collected from M/s. Hasting Jute Co., Coir and Felt Division, West Bengal and woollenised jute was prepared in this laboratory.

Fibre properties

The length of the arecanut fibre, goat hair, coir fibre and woollenised jute was measured by length distribution method. The fineness of the fibre/hair was examined by the method where 2mm length fibre/hair was weighed after necessary stapling. The tensile strength (tenacity) and extension at break of all the fibre/hair were measured on an Instron Tensile strength Tester operated at a constant rate of traverse of 0.5 cm/min with 1 cm test length.

The Callaghan Non-Woven Fabric Machine based on a system of air-laying of short fibres used in the study has three main stages viz., hopper feeder, pre opener and randomiser for opening, blending, randomising and laying of fibres/hairs into web by pneumatic action through

* Non-Woven Technology Division,
Jute Technological Research Laboratories [I.C.A.R.]
Calcutta 700 040

perforation cages covered by phosphor-bronze wire mesh. This process sequence is preceded by a Midhurst Opener (UK) to open the fibre suitable for air-laying.

Dimensional characteristics

The mass per unit area was obtained from the weight of 10 specimens, 40 × 40 cm, cut from different parts of the material using a template. The same specimens were placed between anvils of area 25 cm² under a compressive stress of 5 g/cm² and measured for thickness and on the basis of 20 readings the average thickness was obtained. The fibrous webs were treated with polyester resin followed by gel coating.

The same fibre/hair reinforced plastic samples were dipped in water for 20 days and the materials were reweighed to examine the change of weight of the material with water treatment.

Results and Discussion

The results given in Table 1 indicated that arecanut husk fibre was generally longer than woolenised jute, goat hair or coir fibre. About 50 per cent of arecanut husk fibre was finer than other fibres and the remaining 50 per cent of fibre was coarser than those fibres. The tenacity value of arecanut husk fibre was comparable with that of goat hair and woolenised jute.

Web weight of arecanut husk fibre was comparable with that of other fibres. The weight and thickness of all fibre reinforced plastic sheets were comparable. The proportion of fibre in the fibre reinforced plastic sheets varied between 7.6 and 9.9 per cent. The proportion of arecanut husk fibre was higher (9.12 per cent) in comparison with that of glass fibre (7.9 per cent), though the thickness and water swelling ie, increase

Table 1. Comparison of physical properties of arecanut husk fibre, goat hair, woolenised jute and coir fibre waste, fibrous webs and fibre reinforced plastic sheets

Fibre	Fibre properties			Tensile Properties			Fibrous Web Properties		FRP Sheet Properties			
	Fibre length Min. (cm)	Fibre length Max. (cm)	Fibre length Av. (cm)	Fibre Fineness (Tex.)	Break- ing Load(g)	Tenacity (g tex)	Exten- sion at break (%)	Web weight (g/m ²)	Thick- ness (cm)	Weight (g/m ²)	Thick- ness (cm)	Water swelling (increase in wt. by 20 days) (%)
Arecanut husk fibre	2.4	5.0	1.10			16.0	15.0	540	0.15	5920	0.45	5-6
Goat hair (GH)	0.5	6.0	1.99	3.72	692	18.6	44.7	424	0.10	5520	0.41	5-6
Woolenised jute (WJ)			1.15	1.55		25.0	6.0	332	0.07	4400	0.35	5-6
Coir fibre waste (CFW)	1.0	16.0	2.40	14.00	428	30.6	55.8					
WJ:CFW Blend 1 : 4								512	0.08	5200	0.42	5-6
WJ : GH Blend 1 : 1								424	0.05	5280	0.41	5-6
Glass fibre Matt.								496	0.12	6320	0.45	5-6

in weight of the sheets by immersion in water for 20 days, values were same,) as shown in Table 1.

The results of the above studies indicated that arecanut husk fibre/goat hair/woollenised jute reinforced plastic products may be considered as a substitute of conventional glass fibre reinforced plastic products in some cases.

Acknowledgement

The author is thankful to Shri K.N. Murthy, Joint Director, Central Plantation

Crops Research Institute (ICAR), Regional Station, Vittal, Karnataka for supplying the arecanut husk fibre, Shri T. D. Bahety, Works Manager, Coir and Felt Division, M/s. Hastings Jute Co., West Bengal for supplying the coir fibre waste and to Dr. A. C. Chakravarthy, Director, Jute Technological Research Laboratories (ICAR), Calcutta, for facilities rendered to carry out these investigations and for permission to publish the results.

Discussions

RT Patil:

What is the process employed to extract the fibre from husk? Is it similar to coir extraction by retting?

CR Debnath:

Manually operated Midhurst operator. Not similar to coir extraction process.

RT Patil:

What are the economic uses for this product?

CR Debnath:

False ceiling, corrugated sheets as roof, partition board, insulation board etc.

RT Patil:

What is the cost of the board?

CR Debnath:

Rs. 60 - 70 / m².

Use of Areca leaf Sheaths for Making Plyboard and Packaging Materials⁺

S. J. K. Annamalai* and N. M. Nayar**

Abstract

Arecanut leaf sheath was found suitable for making plyboards. Two plies of processed arecanut leaf sheaths in combination with an ordinary wood veneer as core glued with urea formaldehyde resin are used for making the plyboards. These boards may be used for making packing cases like tea chests, suitcases etc. The process of making the plyboards and the properties of the boards as a packaging material are reported.

Introduction

Arecanut palm (*Areca catechu* L.) is grown extensively in India. In the regular system of planting the population of 1300 palms/ha is common. Each palm sheds about five leaves in an year and thus about 1100 million leaf sheaths are shed annually from an area of about 1,80,000 ha. The stalks of the areca leaves are flat and somewhat cylindrical in shape, measure 60-100 cm long and 30-45 cm broad and possess a waxy water repelling surface. These are not put to any use presently. They are used to a limited extent for making caps for agricultural workers, containers for toddy, packing sheets for fish and also as an inferior fuel. When computed for their total availability, they provide a total flat surface of about 120 million m². Since it was felt that leaf sheaths could be used as atleast a partial

replacement for wood veneer, work was taken up in the institute to develop some economic uses for the same, particularly its suitability for making ply boards.

In India about 13 million m² of tea chest plywood is produced annually. About three-fourths of this is produced by small scale and cottage industries (Dokania, 1974). Plywood industry in India is faced with an increasing scarcity of soft wood required for plywood making as a result of dwindling resources of timber (Gupta and Singh, 1978). Hence if even a part of the requirements of plywood can be met for tea chests by arecanut leaf sheath (ALS ply boards), it could result in much saving of the timber resources. Further, this can fetch an additional income to the arecanut farmers. The process for making ALS ply boards and their various properties are discussed in this paper.

* Central Plantation Crops Research Institute, Kasaragod 670 124, Kerala

+ CPCRI Kasaragod Publication No. 239.

** Present Address: Director, Central Potato Research Institute, Simla - 171 001, Himachal Pradesh,

Materials and Methods

1. Processing of leaf sheaths

Leaf sheaths obtained from the farm are highly heterogenous having variations in structure, shape and thickness. The rear

end is thicker and the two edges are thinner. The thickness at the centre ranges from 3.0-8.5 mm (average 5.0 mm). A comparatively homogenous piece of fairly uniform thickness and size 50-65 x 20-25 cm can be obtained if a piece of about 10 cm length from either sides along the grain direction, 5 cm from the distal and 10-15 cm from the end across the grain direction are trimmed out from the sheath. Further, to get a flat sheath of uniform thickness and to remove the bucklings or folds, the sheath is flattened under pressure and heat. For this, the sheaths are soaked in water to about 75 per cent moisture and then pressed for 30 min in a hot Platten press at 4 kg/cm² pressure and 110°C temperature. This process gives flat sheaths of 1.0-1.5 mm thickness with about 12 per cent moisture.)

Table 1 shows the reduction in thickness at various points of the sheath profile after processing.

(To prevent fungal growth on the sheath surface, it can be soaked in 1 per cent copper sulphate solution for 24 hr before pressing. The pressed sheaths are then air dried for one hour or longer.)

2. Preparation of ply boards

Studies on glue adhesion properties have revealed that the ALS plyboards made with two veneers of areca sheaths as the faces and one veneer of even an ordinary wood species like Mango (*Mangifera indica* L.) as core ply and bonded with Urea formaldehyde (UF) resin make commercially acceptable boards with average dry and wet glue shear strengths of 50 kg and 12 kg respectively (Annamalai et al., 1982). They have been found to be superior to locally purchased non-ISI grade tea chest plywood, in wet glue shear strength, which was less than 6 kg.

Table 1. Reduction in thickness of areca leaf sheath profile upon processing

Distance across profile (cm)		Thickness in mm									
		Stem end			Distance from stem end in cm						Leaf end
		0	10	20	30	40	50	60	70	80	
0	Before Processing	—	1.40	1.20	1.20	1.20	1.15	1.49	—	—	
	After Processing	—	1.10	1.08	1.08	1.08	1.08	1.20	—	—	
5	Before	1.95	1.48	1.31	1.30	1.28	1.47	1.75	2.03	—	
	After	1.10	1.09	1.10	1.10	1.10	1.15	1.16	1.18	—	
10	Before	4.88	2.56	2.15	1.85	1.92	2.12	2.46	3.15	4.40	
	After	1.26	1.25	1.21	1.20	1.13	1.18	1.21	1.31	1.41	
15	Before	6.76	3.99	3.50	3.09	2.83	2.75	3.40	4.80	6.61	
	After	1.35	1.39	1.25	1.21	1.17	1.25	1.33	1.60	1.71	
20	Before	3.44	2.90	2.41	1.97	2.42	2.83	2.76	3.05	4.40	
	After	1.25	1.20	1.18	1.17	1.17	1.15	1.21	1.30	1.45	
25	Before	1.64	1.49	1.70	1.91	2.32	2.15	2.15	2.32	2.52	
	After	1.18	1.15	1.08	1.10	1.10	1.08	1.10	1.11	1.15	
30	Before	—	1.35	1.30	1.30	1.39	1.61	1.69	1.76	—	
	After	—	1.14	1.08	1.08	1.08	1.15	1.16	1.21	—	
35	Before	—	1.20	1.24	1.25	1.30	1.36	1.60	—	—	
	After	—	1.08	1.08	1.08	1.08	1.10	1.10	—	—	

Three ply boards using 1.5 mm thick Vellapine (*Vateria indica* L.) wood veneer as the core ply and UF resin by either cold setting at 4 kg/cm² pressure for 16 hr or by hot pressing at 95-100°C temperature and 14 kg / cm² specific pressure for 7 - 10 min were used in the present study.

3. Testing of the ply boards

The boards were tested for their various properties (Annamalai et al., 1982) as per the Indian Standard Specifications at the Western India Plywood Ltd., Baliapatam, Kerala and Indian Institute of packaging, Bombay. The details are listed in Table 2.

The wet tensile strength and wet bursting strength properties were determined after soaking the samples in water at 27°C for 4 hr.

For the transport container tests, tea chests of sizes 40×40×50 cm were prepared out of ALS ply boards as per the Indian Standard Specifications for plywood tea chests (I. S. 10, 1976). Each tea chest

was filled with 30 kg net weight of sand-saw dust mixture and the gross weight of each tea chest box was 33.5 kg. These tea chests were subjected to drop test, stack test and compression test (IS : 7028, 1973).

Results and Discussion

1. Weight and thickness

The weight/m² of the ALS plyboards are given in Table 3. The weight of ALS plyboards was about 80 per cent of that of conventional 3 - plywood boards. The thickness of the boards was about 3.8 - 4.3 mm.

2. Tensile strength

Details on the tensile strength of the boards are given in Table 3. Three ply (ALS) boards had about 30 per cent strength of 4.6 mm ISI grade 3 ply wood board and 50 per cent strength of locally purchased non-ISI grade 4 mm tea chest plywood board along the grain direction and it showed about 70 per cent strength

Table 2. Tests with areca leaf sheath (ALS) ply boards

Sl. No.	Name of the test	I. S. Test Code
1.	Tensile strength	IS : 1734 [1972] 10 and IS : 1060 [1966]
2.	Wet tensile strength	IS : 1060 [1966]
3.	Static bending strength	IS : 1734 [1972]
4.	Impact strength	IS : 303 [1975]
5.	Mandrel bending strength	IS : 4859 [1968]
6.	Bursting strength	IS : 1060 [1966]
7.	Wet bursting strength	IS : 1060 [1966]
8.	Puncture resistance	IS : 4006 [1966]
9.	Water Proofness - Cobb 30 min.	IS : 1060 [1966]
10.	Drop test	IS : 7028 [1973] Part I & IV
11.	Stack load test	IS : 7028 [1973] Part I & IV
12.	Compression Test	IS : 7028 [1973] Part IV

of ISI grade 3 plywood board and about three times more strength than the 3 - ply non - ISI grade tea chest plywood board across the grain direction. With regard to wet tensile strength, the boards showed about 45 per cent strength along the grain direction and about 1.8 times more strength across the grain direction with reference to 3 - ply non - ISI tea chest plywood.

3. Static bending strength

The static bending strength of the boards ranged from 144.0 - 171.9 kg / cm² (Table 3).

4. Impact strength and Mandrel bending strength

The impact strength and mandrel bending strength of areca leaf sheath plyboards are given in Table 4. The 3 - ply areca leaf

sheath boards showed slightly higher impact strength than 3 - ply ISI grade plywood boards. The areca leaf sheath (ALS) plyboards could be bent to a minimum diameter of 17.5 cm while the 3 - plywood boards could be bent up to a diameter of 35 cm only. This shows that ALS ply boards have double the flexibility of plywood boards.

5. Bursting strength

Details on the bursting strength of the boards is given in Table 5. The average bursting strength of ALS plyboards was approximately equal to the bursting strength of about 44 km/cm² of 5 mm cardboard and higher than that of a 9 ply 100 gsm corrugated fibre board which is about 25 kg/cm² (Anonymous, 1974).

Table 3. Weight, Tensile and Static bending strength of arecanut leaf sheath boards/ plywood boards

Sl. No.	Items	Along the grain direction			Across the grain direction			Remarks IS : test code
		Mean	Std. deviation	Range	Mean	Std. deviation	Range	
I Weight - gm/m²								
1.	3-ply arecanut leaf sheath board	2250	—	—	—	—	—	
2.	3-ply 4 mm plywood	2800						
II A. Tensile strength kg/cm²								
1.	3-ply arecanut leaf sheath board	157.36	—	—	276.50	31.00	235.3-316.7	IS: 1734 (1972) & IS: 1060 (1966)
2.	3-ply ISI grade plywood	530.80	52.7	475.5-615.3	376.10	42.41	313.9-412.9	IS: 1734 (1972)
3.	3-ply ISI grade tea chest plywood-4 mm	344.2	—	—	73.14	—	—	IS: 1060 (Part I) (1966)
B. Wet Tensile strength kg / cm²								
1.	3-ply arecanut leaf sheath boards	102.21	—	—	157.14	—	—	IS: 1060 (Part I) (1966)
2.	3-ply non ISI grade tea-chest plywood 4 mm	230.62	—	—	87.30	—	—	IS: 1060 (Part I) (1966)
III Static Bending Strength kg/cm²								
1.	3-ply arecanut leaf Sheath board	160.60	8.91	144.0-171.9	—	—	—	IS: 1734 (1972)
2.	3-ply ISI grade plywood	578.70	30.07	535.8-618.1	—	—	—	IS: 1734 (1972)

6. Puncture resistance

Table 5 gives details on the puncture resistance of ALS ply boards. The average values for the areca boards were about 45 per cent higher than that for 5 - ply 150 gsm corrugated fibre board.

7. Water proofness

The cobb test for 30 min duration showed that ALS plywood absorbed 18.5 g of water/m² (Table 5) while the areca leaf sheath absorbed 121 g/m². Thus

water absorption capacity of the sheaths was considerably reduced when they were made into plyboards.

8. Transport container tests

In the drop test, the tea chests were given 10 sequential drops from a height of 75 cm, first on one corner, followed by drops on the three edges around (or touching) the corner and then dropped once each on all the faces. Neither damage or deformation to the tea chests nor seepage of sand - saw dust mixture was observed.

Table 4. Impact strength and Mandrel (Drum) bending strength of ALS boards and plywood boards

Sl. No.	Items	3 - ply ALS plyboard	3 - ply ISI grade plywood [4 mm]	Remarks IS: Test Code
I.	Impact strength - KgM / cm ²			
1.	Mean	0.4129	0.3983	IS : 303 [1975]
2.	Standard deviation	0.0266	0.0114	
3.	Range	0.3472-0.4345	0.3819-0.4172	
II.	Mandrel [Drum] bending strength Minimum bending: Diameter [cm]	17.5	35.0	IS : 4859 [1968]

Table 5. Properties of arecanut leaf sheath plyboards

Sl. No.	Items	ALS Boards		Corrugated fibre boards	Remarks IS: Test Code
		Mean	Range		
1.	Bursting strength Kg / cm ²	43.97	39.90-53.20	25.00 [9 ply 100 gsm]	IS : 1060 Part - I [1966]
2.	Wet bursting strength [kg / cm ²]	34.55	27.30-45.50	—	IS : 1060 Part - II [1966]
3.	Puncture resistance- Oz. inch / tear inch kg cm/tear cm]	494.00 [13.823	300.00-625.00	340.00 [5 ply-150 gsm]	IS : 4006 Part - II [1972]
4.	Water proofness - Cobb [30 min.] g / m ²				
	3 - Ply ALS Board	18.47	17.26-19.92	—	IS : 1060 Part - II [1966]
	Areca leaf sheath	121.0	—	—	S : 1060 Part - II [1966]

In the stack load test, the tea chests were superimposed with 450 kg weight for 24 hr. The tea chests made from ALS plyboards did not show neither deformation or damage nor seepage of sand-saw dust mixture.

Tea chests made of ALS plyboards when subjected to a compression load applied to the top side face exhibited average compression strength of 4295 kg while the tea chests made from locally purchased non ISI grade plywood showed a compression strength of 4338 kg.

The properties of the ALS plyboards developed as per the process described above indicate their possible applications in packaging. ALS plyboards showed 30-50 per cent strength of plywood boards with respect to tensile and static bending strengths. In certain cases of packaging like that of pharmaceuticals high strength properties as possessed by plywood are not required. But in the absence of a

material of lower strength properties, plywoods are employed. The transport container tests have shown that tea chests made of ALS plyboards performed almost equally well as the tea chests made of non ISI grade conventional plywood in their mechanical strength properties. These tea chests are suitable for movement of tea within the country. Two thirds of the total annual tea production of about 571 million kg (Anonymous, 1979) is consumed within the country itself and tea chest made from ALS plyboards can be used for this purpose. This will have several advantages. For instance, this will help the areca farmer for an additional income of about Rs. 1000/ha annually by sale of areca leaf sheaths. It will promote additional rural employment in the setting up of ALS plyboards manufacturing industry. Thirdly it will help to save soft wood which is becoming scarce in the country. The improved higher impact strength of the boards and their ability to bend short curvatures are very desirable properties for making briefcases, suitcases, tubular packages, etc.

Table 6. Results of Transport Container tests

Sl. No.	Items	Observation on ALS Plyboard boxes	Observation on non - ISI grade tea chest plywood boxes	IS Test code
1.	Drop test : 75 cm height. 10 sequential drops	Neither damage or deformation to the boxes nor seepage of contents was observed	Neither damage or deformation to the boxes nor seepage of contents was observed	IS : 7028 [1973] Part I & IV
2.	Stack Load test : 450 kg weight for 24 hr	Neither damage or deformation to the boxes nor seepage of contents was observed	Neither damage or deformation to the boxes nor seepage of contents was observed	IS : 7028 [1973] Part I & IV
3.	Compression test : Average compression strength	4295 kg	4338 kg	IS : 7028 Part IV [1973]

Acknowledgement

We gratefully acknowledge the facilities and assistance rendered by M/s. Western India Plywood Limited, Baliapatam, Kerala and particularly Dr. R. N. Kumar, Technical Manager for the advice given. We thank

Mr. V. Rangunathan, Deputy Director, Indian Institute of Packaging, Bombay and his colleagues for their help. The work on areca leaf sheath plyboards was initiated under the aegis of late S. R. K. Menon, N. Parur, Kerala.

References

- ANONYMOUS, 1974. *Corrugated and solid fibre boards in packaging*. Indian Institute of Packaging, Bombay. pp. 108.
- ANONYMOUS, 1975. *Ann. Rept.* Central Plantation Crops Research Institute, Kasaragod, for 1974. p. 101.
- ANONYMOUS, 1976. *Ann. Rept.* Central Plantation Crops Research Institute, Kasaragod, for 1975. p. 99.
- ANONYMOUS, 1977. *Ann. Rept.* Central Plantation Crops Research Institute, Kasaragod, for 1976. p. 136.
- ANONYMOUS, 1978. *Ann. Rept.* Central Plantation Crops Research Institute, Kasaragod, for 1977. p. 94.
- ANONYMOUS, 1979. *Tea Statistics 1978-79*. Tea Board of India.
- ANNAMALAI, S.J.K., MENON, S.R.K. and NAYAR, N.M. 1982. Glue adhesive properties of arecanut leaf sheath plyboards. *Proceedings of the Third Annual Symposium on Plantation Crops (PLACROSYM-III)* 1980. Indian Society for Plantation Crops, Kasaragod 670124, Kerala. pp. 432.
- ANNAMALAI, S.J.K. and NAYAR, N.M. 1982. Mechanical properties of arecanut leaf sheath plyboards. *Paper (No. APF/82-412) Presented at XIX Annual Convention of Indian Society of Agricultural Engineers*, 15-17 February, Udaipur.
- DOKANIA, L. N. 1974. Progress and Problems of Plywood and Panel Industry, *IPIRI J.* 4 [3] : 97-99.
- GUPTA, R. C. and SINGH, S. P. 1978. Panel products Industry in India. *IPIRI J.* 8 [1]: 38-42. IS : 1734 [1972]. *Indian Standard Method of tests for plywood* [General]. Indian Standards Institution, New Delhi.
- IS: 1060 [1966]. *Indian Standard Methods of tests for paper and allied products-part I and II*. Indian Standards Institution, New Delhi.
- IS: 303 [1975]. *Indian Standard Specifications for plywood for general purposes*. Indian Standards Institution, New Delhi.
- IS: 4859 [1968]. *Indian Standards Specifications for High Strength Aircraft Plywood*. Indian Standards Institution, New Delhi.
- IS: 4006 [1972]. *Indian Standard Methods of tests for paper and pulp based packaging materials-Part II*. Indian Standards Institution, New Delhi.
- IS: 7028 [1973]. *Indian Standard performance tests for Complete field transport packages-Parts I and IV*. Indian Standards Institution, New Delhi.
- IS: 10 [1976]. *Indian Standard Specifications for Plywood Tea chests*. Indian Standards Institution, New Delhi.
- MENON, S.R.K., ANNAMALAI, S.J.K. and NAYAR, N.M. 1982. Arecanut leaf sheath-Raw material for product development. *Proceedings of the Third Annual Symposium on Plantation Crops (PLACROSYM-III)*, 1980. Indian Society for Plantation Crops, Kasaragod 670124, Kerala. pp. 432.

Biochemical Changes During Storage of Arecanut (*Areca catechu* L.)

B. Chempakam and N. Saraswathy*

Abstract

Changes in biochemical constituents during storage of arecanuts were studied. Protein, fat, phenols, sugars and arecoline contents decreased significantly during storage. When whole dried nuts with husk were stored for one year, the contents of protein, fat, total phenols, reducing sugars and total sugars decreased to a lesser extent while a slight increase in ortho dihydroxy phenols and alkaloids was noticed as compared to dehusked nuts similarly stored.

Introduction

Arecanut is one of the most important commercial crops of India. The edible endosperm of areca fruit is widely used as a masticatory in India and south East Asia either alone or as a constituent of the quid along with betel leaves, lime and tobacco. It is consumed either raw or after processing. After harvesting, the whole ripe nuts are sun-dried by spreading them in a single layer for 35-40 days. Subsequently they are stored in gunny bags or wooden boxes either as whole nuts or in the dehusked form, until sold (Mathew et al., 1963). Improper storage leads to spoilage and a reduction in the market value and render it unsuitable as a masticatory (Nambiar et al., 1972; Koti Reddy and Nambiar, 1979).

Shivasankar and Govindarajan (1963) and Virakthamath (1963) had carried out studies on the humidity - moisture relationships in processed arecanuts, but have not

studied the biochemical changes during storage. In the present study, the changes in some biochemical constituents during storage spread over an year were studied.

Materials and Methods

Arecanuts which were sun-dried and stored for one year were used along with freshly harvested and dried nuts in these studies. The following biochemical constituents viz., total protein, fat, total phenols, ortho dihydroxy phenols, total sugars, reducing sugars and alkaloids, mainly arecoline were studied for their changes during storage. The experiment was replicated thrice and the data were statistically analysed using the completely randomised design.

Estimation of protein

The nuts were ground to a fine powder and 100mg samples were digested with concentrated H_2SO_4 and the total nitrogen was estimated using microkjeldahl digestion method. The crude protein content was calculated using the conversion factor 6.25 (Anonymous, 1975.)

* Central Plantation Crops Research Institute
Regional Station, Vittal 574 243
Karnataka

Estimation of fat

Samples weighing 5g each were defatted using chloroform in a soxhlet extractor for 14 hr. The solvent was evaporated and the residual weight represented the total fat content.

Estimation of total phenols and ortho dihydroxy phenols

Five hundred mg powdered sample was repeatedly washed with hot 80 per cent alcohol and made up to 100 ml. Aliquots were taken from this alcohol extract for the determination of total phenols using Folin-ciocattan reagent (Bray et al., 1954) and ortho dihydroxy phenols by the method described by Mahadevan (1966).

Estimation of total sugars and reducing sugars

Five ml of the alcohol extract was evaporated and dissolved in 2 ml distilled water. Aliquots were taken for the estimation of total sugars by the phenol-sulphuric acid method (Dubois et al., 1956) and reducing sugars by the copper-reduction method (Nelson, 1944). Prior to this, the extract was clarified free of phenols using lead acetate and potassium oxalate

as described by Peech et al., (1955), since tests showed that phenols interfered with the estimation of sugars.

Estimation of arecoline

Since the major alkaloid present in arecanut is arecoline, the same was estimated by the rapid distillation method described by Nambudiri (1968). The powdered sample (2.5g) was steam-distilled along with 5 ml 0.3 N NaOH and the distillate was collected in a receiver containing 0.02 N H₂SO₄. This was then titrated against 0.02 N NaOH using methyl red as indicator. One ml of 0.02 N NaOH is equivalent to 0.003108g of arecoline.

Isolation of fungi

For the isolation of the fungi, potato dextrose agar medium was used. Nuts showing different degrees of discolouration were selected for isolation.

Results and Discussion

Data given in Table 1 show that in stored nuts, there was a significant decrease in all the constituents studied as compared to fresh nuts. The total protein content decreased by 22.19 and 30.27 per cent in

Table 1. Biochemical constituents in stored areca nuts

Constituents	Fresh Nuts	Stored nuts with husk	Stored nuts without husk	Percentage decrease / increase			C. D. (P=0.05)
				Col. 1 & 2	Col. 1 & 3	Col. 2 & 3	
	(1)	(2)	(3)				
Protein	7.50	5.83	5.23	22.19	30.27	10.38	0.6020
Phenols	7.63	5.86	5.01	23.20	34.34	14.51	0.3597
O. D. phenols	1.09	0.61	0.73	44.34	32.94	+20.49	0.0799
Total sugars	4.99	3.64	2.46	24.01	50.70	32.42	0.4195
Reducing sugars	0.97	0.81	0.62	16.32	35.93	23.44	0.0813
Arecoline	0.43	0.22	0.26	47.86	39.91	+15.39	0.0507
Total fat	17.06	12.79	9.08	25.02	46.74	28.96	1.6149

Results expressed as g / 100 g dry weight

+ . Per cent increase

stored nuts with and without husk respectively. A reduction of 10.38 per cent in protein content occurred when the nuts were dehusked as compared to whole nuts.

Phenol content decreased significantly by 23.20 and 34.34 per cent in stored nuts with and without husk respectively. Comparing nuts with and without husk, a decrease of 14.5 per cent in phenols was observed in the latter during storage. Though ortho dihydroxy phenols registered a significant decrease of 44.34 per cent and 32.94 per cent respectively in stored nuts with and without husk there was an increase of 20.49 per cent in dehusked nuts as compared to whole dried nuts.

The total sugars showed a reduction of 24.01 per cent and 50.7 per cent respectively in nuts with and without husk, during storage. A reduction of 32.42 per cent more was observed in dehusked nuts. Storage of nuts caused a decrease of 16.32 per cent and 35.32 per cent respectively in nuts with and without husk with regard to reducing sugars. Here a reduction of 23.44 per cent was observed in dehusked nuts as compared to whole dried nuts.

Eventhough there was a reduction in the arecoline content to the extent of 47.86 per cent and 39.91 per cent in stored nuts, an increase of 15.39 per cent was observed in dehusked nuts as compared to whole nuts during storage. Total fat also registered a significant decrease of 25.02 per cent and 46.74 per cent during storage. However, the fat content was more in nuts stored with husk as compared to dehusked ones, the decrease in latter being 28.96 per cent.)

The storage of areca render them susceptible to attack by fungi. The predominant fungi isolated were *Aspergillus niger*, *A. flavus*, *A. terreus*, *A. fumigatus*, *Chaetomium* sp. and *Botryodiplodia* sp. The reduction in the various constituents may be due to the fungal activity or due to the normal biochemical changes taking place in nuts during storage. The reduction in the fat content is possibly due to the auto-oxidation of lipids with passage of time. During storage, the oxidative enzymes may become active causing a reduction in the phenol content, thereby making it more susceptible to attack by fungi. However, lesser decrease was noticed in nuts stored with husk, except in the case of other dihydroxy phenols and arecoline. Hence it is certain that the quality can be better maintained by storing the nuts with the husk intact.

References

- ANONYMOUS, 1975. *Official Methods of Analysis*, 12th Edn. Washington DC. Association of official Analytical Chemists.
- BRAY, A.G. and THORPE, W.Y. 1954. Analysis of phenolic compounds of interest in metabolism. *In: Methods in biochemical analysis*. Inter Science Publ. Inc, New York, Glick, D. Vol. I. 27-32.
- DUBOIS, M., GILLES, K., HAMLTON, J. K., REBERS, P. A. and SMITH, F. D. 1956. *In: Methods in Enzymology*. Academic Press, New York, London. Colowick, S. P. Kaplan [Eds], Vol. 8. pp. 93-95.
- KOTI REDDY, M. and NAMBIAR, K.K.N. 1979. Fungal Infection in stored arecanut. *J. Plant.Crops*. 7 [1]: 50-53.

- MAHADEVAN, A. 1966. Biochemistry of infection and resistance. In: *Methods in Physiological Plant Pathology*, Sivakami Publications, Madras, p. 64-65.
- MATHEW, A. G., VENKATARAMAN, S. D., JALEEL, S.A., GOVINDARAJAN, V.S. and SUBRAMONIYAN, V. 1963. Storage of arecanut fruit: I - Preservative Steeping Storage. *Arecanut J.* 14 [2]: 51-62.
- NAMBIAR, K.K.N., EDISON, S. and RADHAKRISHNAN NAIR, R. 1972. Fungal infection of processed arecanuts. *The Andhra Agric. J.* 18 [1]: 1-7.
- NAMBUDIRI, E. S. 1968, Estimation of arecoline. A rapid distillation method. *J Assoc. Off. Anal. Chem.* 51 : 799-802.
- NELSON, N. 1944. A photometric adaptation of the Somogyi method for the determination of glucose. *J. Biol. Chem.* 153 : 375 - 380.
- PEECH, K. and TRACEY, M.V. 1955. Elimination of interfering substances from plant tissue extracts. In : *Modern methods of plant Analysis*. Springer-Verlag, Ed. p. 4 - 5.
- SHIVASANKAR, S. and GOVINDARAJAN, V. S. 1963. Equilibrium relative humidity [ERH] relationships of processed arecanut and whole dried ripe arecanuts. *Food Sci.* 12 [11]: 317 - 321.
- VIRAKTAMATH, C. S. 1963. Packing and storage studies on scented supari (Processed arecanuts) *Food Sci.* 12 (11) : 322-325.

Discussion

S Shivashankar:

What is the initial moisture content of the nuts? At what stage it got fungal infection?

B Chempakam:

The initial moisture content comes up to 8.1 to 8.4 per cent. The stages of infection by the fungi was not studied.

Abi Cheeran:

What is the basis for per cent calculation of different contents?

B Chempakam:

The data were calculated on dry weight basis.

Mutagenicity and Tumorigenicity of Arecanut Extracts and its Constituent Alkaloids

S. V. Bhide*

Abstract

*Water extract and polyphenolic extracts of arecanut were administered daily by subcutaneous and intraperitoneal injections and by gavage feeding to Swiss mice, from the age of 8-10 weeks till death. It was observed that mice treated with subcutaneous injections developed 60 and 80 per cent tumors respectively at the site of injection within a period of 10-12 months. However, I.P. administration failed to produce any tumors in treated mice. Gavage feeding of water extract of arecanut induced systemic tumors while polyphenolic fraction had no effect in treated mice. Gavage feeding of arecoline, an important alkaloid of arecanut, also induced lung and stomach tumors. Using histidine deficient mutants of *S. typhimurium* strains it was observed that water extract of arecanut, betelquid, betel quid + tobacco and arecoline are mutagenic in strain TA 100.*

Introduction

Chewing arecanut alone or as an ingredient of betel quid is an age old habit in Indian population. Arecanut is known to have many medicinal properties (Chopra, et al., 1956). It is also known to stimulate the central nervous system (Sirsi, M. 1967). Long term effects of arecanut extracts and betel quid extracts on animal tissues have been studied in our laboratory (Bhide et al., 1979 and Shivapurkar et al., 1980). The present paper deals with the salient observations on mutagenicity and carcinogenicity of arecanut and betel quid extracts.

Materials and Methods

Water extract of arecanut (AN)

Water extract of arecanut was prepared by shaking 100g of arecanut powder with

100 ml of distilled water on an automatic shaker and then lyophilized to dry residue. The dry residue was then dissolved in 10 ml of distilled water so that 0.1 ml of the extract contained 1.5 mg of arecoline.

Water extract of betel quid (BQ)

Thirty grams of betel leaf, 20g of arecanut, 1 g of lime and 1 g of catechu were ground in 100 ml of distilled water. The extract was then lyophilized to dry residue and redissolved in 35 ml of distilled water so that 0.1 ml contained 1.0 mg of arecoline.

Water extract of betel quid + tobacco (BQT)

Four grams of tobacco was added to the mixture used for making the betel quid extract and ground in 100 ml distilled water. The extract was then lyophilized and redissolved in 10 ml distilled water, so that 0.1 ml of extract contained 0.9 mg of arecoline.

* Carcinogenesis Division, Cancer Research Institute, Tata Memorial Centre, Parel, Bombay 400 012

Tannin fraction of arecanut (ANT)

This was prepared by shaking 100g of arecanut powder with 150 ml of ethyl acetate containing 8 ml of ethanol for 4 hr, in an automatic shaker. The extraction was repeated several times and the combined extracts were treated with 0.1 N HCl to remove any alkaloid impurities. The purified fraction was lyophilized and the dry residue was dissolved in 10 ml of distilled water so that the amount of total tannins measured as tannic acid was 1.9 mg of tannic acid in 0.1 ml of diluted extract.

NADP, glucose - 6 - phosphate and arecoline were purchased from Sigma Chemical Co. and nutrient broth and agar were purchased from Difco Products, U.S.A. Rest of the chemicals were of analytical grade and purchased either from E. Merks or B. D. H. India.

Six to eight weeks old male mice were obtained from the animal colony of Cancer Research Institute, Bombay. These animals were administered AN and ANT by subcutaneous and ip injections and also by gavage feeding whereas BQ, BQT and arecoline were administered by gavage feeding. The treated animals received 0.1 ml of AN and BQ so that they received 1.5 mg and 1.0 mg of arecoline respectively. Mice treated with ANT received 1.9 mg of tannic acid either by gavage feeding or by ip injections.

BQT and arecoline were administered only by gavage feeding. Six to eight weeks old mice received 1.5 mg and 1.0 mg of arecoline respectively per day and five times a week. Mice receiving equivalent volume of distilled water by gavage feeding served as controls. Both treated and control mice were kept under observation and killed only when moribund. Mice

were killed by cervical dislocation and carefully dissected to observe any gross abnormality. Liver and lung tissues were fixed along with other normal tissues in 10 per cent formalin and processed by routine histological procedures. Six μ m thick paraffin sections were stained by haematoxylin and eosin.

For studies on mutagenicity AN, BQ, BQT extracts of arecanut and arecoline were used. Ames test using histidine deficient mutants of *Salmonella typhimurium* was carried out according to procedure of Ames et al., (1978). Mutagenicity was measured in number of histidine independent revertants per plate.

Results

Table 1 gives data on tumorigenicity of AN and ANT in Swiss mice treated by subcutaneous injection. Mice treated with these extracts by ip injection did not develop any tumors. It may be observed that 60 per cent injected subcutaneously with AN and 80 per cent of ANT group developed tumors at the site of injection. All the tumors observed were fibrosarcomas. None of the distilled water injected mice developed any tumors.

Table 1. Tumor incidence in Swiss mice injected subcutaneously with AN and ANT

Group	Age (in months)		Total incidence
	5-8	9-12	
Untreated	0-10	0-10	0%
AN	1/6	11/14	12/20 (60%)
ANT	0/0	16/20	16/20 (80%)

Of the 19 Swiss mice fed with AN, 4 mice developed either hepatocellular carcinomas or haemangiomas. Five other mice developed tumors at other sites, 2 being lung

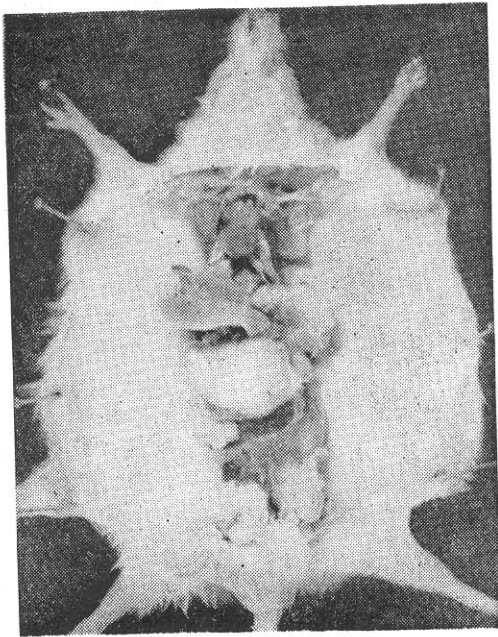


Fig. 1. A Swiss mice bearing Lung Tumour adenocarcinomas (Fig. 1, 2) squamous cell carcinoma, one adenocarcinoma of the stomach (Fig. 3) and one leukemia.

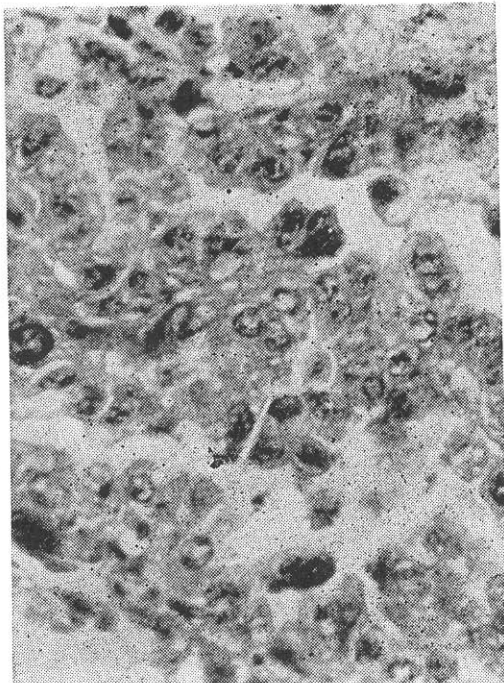


Fig. 2. Photomicrograph of lung adenocarcinoma

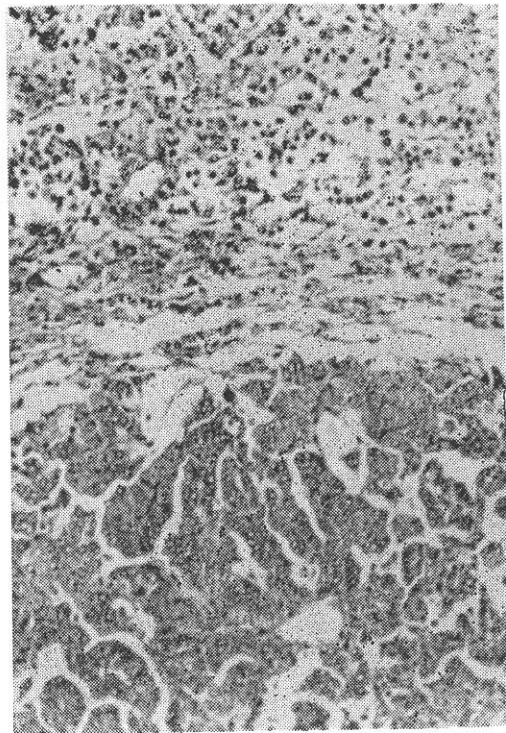


Fig. 3. Photomicrograph of stomach adenocarcinoma
Twenty six per cent of mice fed with BQ developed tumors of the lung or hepatocellular carcinomas and 22 per cent of BQT treated Swiss mice developed lung adenocarcinomas, whereas 43 per cent arecoline treated Swiss mice developed tumors majority of which were lung adenocarcinomas and only few were stomach tumors Table 3.

Subsequently, mutagenicity of BQ, BQT, AN and arecoline was tested in all four tester strains of *Salmonella typhimurium*, viz., TA 100, TA 1535, TA 98 and TA 1538, in presence and absence of S9 mixture consisting of microsomes NADP, G-6-P and MgSo₄ (Table 2). The extracts were lyophilised to dry residue and redissolved in DMSO so as to give concentrations of 20 µg/ml to 200 µg/ml. It was observed that BQ, BQT and BN were mutagenic only in strain TA 100 with or without S9 mixture. Arecoline was mutagenic in all

the four strains again with and without S9 mixture. However, it was more mutagenic in presence of S9 mixture. Since, strain TA 100 showed mutagenicity with respect to all the compounds, a dose response curve was studied in presence of S9 mixture.

Table 3 shows that all the substances show a dose dependent increase in the number of revertants. It is also evident that BQT is more mutagenic than BQ at very low concentration.

Table 3. Tumorigenicity of Betel quid and its constituents in Swiss mice treated by gavage feeding

Group	Months		Cumulative incidence	
	16-19	19-24		
AN	3/6	6/13	9/19	[47%]
BL	0/6	0/8	0/14	0
AN + BL	1/3	5/13	6/16	[38%]
BQ	2/6	2/9	4/15	[26%]
BQT	—	4/18	4/18	[22%]
Arecoline	5/15	8/15	13/30	[43%]
Untreated	0/6	2/14	2/20	[10%]

Discussion

Above data clearly show that AN is mutagenic in Ames test and also tumorigenic in mice when administered by both

the routes. Similarly arecoline is mutagenic and also tumorigenic when fed by gavage. Since arecoline is the major alkaloid in arecanut it is conveyable that it has both the properties. However, this correlation is not so clear in case of BQ and BQT. The tumor incidence in BQ and BQT treated group is not significantly higher than that observed in untreated group. However, both the extracts are mutagenic in strain TA 100 which indicates that the mutagenic effect is at the base-pair substitution level. Lack of tumorigenicity in BQ and BQT suggests that there is some anticarcinogenic agent present in the quid. Khanolkar (1944) had proposed that probably betel leaf has some protective action. Our earlier data has also shown that betel leaf is neither mutagenic nor tumorigenic (Shirname et al., 1983). Furthermore, we have observed that when AN+BL is administered no tumors were observed in treated mice.

Another interesting observation from the above data is that ANT or tannin fraction of arecanut is carcinogenic when injected subcutaneously and this observation is supported in literature (Korpassy, 1961). However, when the same fraction is fed by gavage no tumors were observed. This

Table 2. Mutagenicity of BQ, BQT, AN, BL, Arecoline and Arecaidine in strain TA 100 in presence of S9

Substance	Concentration μg / plate						
	1	5	10	20	50	100	200
BQ	—	—	9	10	360	410	460
BQT	9	130	210	330	350	370	410
AN	—	—	21	32	109	256	342
BL	—	—	0	—	4	—	0
Arecoline	—	—	242	294	532	576	613
Arecaidine	—	—	67	94	127	159	160
B (a) P	490	—	—	—	—	—	—

Values expressed as revertants/plate are mean of 4 plates for each dose. The spontaneous revertants (SR) has been subtracted from each value. SR for TA 100 + S9 = 140.

indicates that either tannins are not observed in the gastrointestinal tract or they are rapidly detoxified. Since arecanut is consumed by oral route, this observation is very important and it appears that only the alkaloid from betel nut are mutagenic and carcinogenic. There is no epidemiological data available on the people consuming betel nut alone and hence it is not possible to extrapolate the above observations and to decide if arecanut is carcinogenic to man or otherwise. Detailed epidemiological studies are necessary to resolve this question.

Acknowledgements

The author expresses sincere thanks to Dr. N. M. Nayar, then Director, Central Plantation Crops Research Institute, Kasaragod, Kerala for his encouragement and help in the project as well as Indian Council of Agricultural Research New Delhi and Karnataka State Marketing Board, Mysore for the financial support to this scheme and Mr. S. V. Waghchoure, Mr. R. S. Dolas and Mr. N. A. Dhonde for their excellent technical help.

References

- AMES, B. N., MCKANN, J. and YAMASAKI, E. 1978. Methods for detecting carcinogens and mutagens with the salmonella mammalian microsome mutagenicity test. *Mutat. Res.* **31**, pp 347-364.
- BHIDE, S. V., SHIVAPURKAR, N. M., GOTHOSKAR, S. V. and RANADIVE, K. J. 1979. Carcinogenicity of betel-quid ingredients : Feeding mice with aqueous extract and the polyphenol fraction of betel nut. *Br. J. Cancer.*, **40**, 422-426.
- CHOPRA, R. N., CHOPRA, C L., HANDA, K. L. and KAPUR, L. D. 1956. *Areca Catechu* Linn. In "Indegenous drugs of India". pp. 280-283.
- KHANOLKAR, V. R. 1944. Oral cancer in Bombay, India. A review of 1000 consecutive cases. *Cancer Res.* **4**, 313-319.
- KORPASSY, B. 1961. Tannins and hepatic carcinogens. *Prog. Exp. Tumor Res.* [ed] Krager Basel/New York. pp. 245-290.
- SIRSI, M. 1967. The effect of arecoline and some CNS drugs on motor learning in rats. *Current Science*, **36**, 234-235.
- SHIVAPURKAR, N.M., RANADIVE, S.N., GOTHOSKAR, S. V., BHIDE, S. V. and RANADIVE, K. J. 1980. Tumorigenic effect of aqueous and polyphenolic fractions of betel nut in Swiss mice. *Ind. J. Exp. Biol.* **18**, 1159 - 1161.
- SHIRNAME, L. P., MENON, M.M. and BHIDE, S.V. 1983. Correlation of mutagenicity and carcinogenicity of betel quid and its ingredients. *Nutr. and Cancer*, **5**, 87-91.

Discussion

G K Veeresh:

What is the effect of saliva on arecoline?

S V Bhide:

The enzymes in saliva may metabolise arecoline.

A M Majumdar:

Role of immunosuppressive effect of arecoline in carcinogenicity?

S V Bhide:

As other carcinogens arecoline may affect the system.

Miotic Activity of Arecanut

A. M. Mujumdar, A. H. Kapadi and G. S. Pendse*

Abstract

The ethanol extract of defatted arecanut was divided into alkaloidal and non-alkaloidal fractions by acid extraction. The non-alkaloidal fraction showed significant miotic activity on rabbit's eye at one per cent concentration. It is also observed that non-alkaloidal fraction had higher miotic potency than arecoline and both compounds have no action on the light, corneal and conjunctival reflexes of rabbit's eye. By repeated preparative TLC of the active fraction, on silica gel a white crystalline solid in trace amount was isolated which showed miotic activity. In addition to miotic activity, the non-alkaloidal fraction showed potentiation of pentobarbitone sleeping time, and was ineffective on blood sugar level of rabbit.

Introduction

Arecoline is a pharmacologically active alkaloid present in *Areca catechu* Linn having a content of 0.07 to 0.1 per cent (Watt, 1889). Chief pharmacological actions of arecoline are due to its cholinergic nature as can be seen from its effect on central nervous system (Leelie, 1965), cardiovascular system (Heymans, 1922), antihelmintic (Barker, 1966) and miotic activity (Young, 1933). In addition to these actions, other actions are antimicrobial (Lalitha Kumari et al., 1965), antifertility (Garg and Garg, 1971) and hypoglycemic (Lang and Rigo, 1928). Most of the pharmacological work so far is done on arecoline; very little work is done on the other alkaloids, tannins and polyphenols. In the present investigation, work was undertaken to locate some pharmacological actions in non-alkaloidal fraction.

Materials and Methods

The ripe arecanut (chali and processed) was supplied by the Central Plantation Crops Research Institute, Regional Station Vittal, Karnataka State. The arecanut was coarsely powdered and was extracted by cold percolation method using petroleum ether at 40° - 60°C and subsequently with ethanol for 72 hr twice. The ethanol extract was concentrated under reduced pressure to yield a syrup. The concentrated extract was made alkaline (pH 8.5 to 9.0) by dilute ammonia and diluted with water and was extracted with chloroform repeatedly. The aqueous layer was acidified to pH 2.0 to 2.5 with dilute sulphuric acid and was again extracted with chloroform repeatedly. All chloroform extracts were combined and extracted with 2 per cent sulphuric acid to remove arecoline. The chloroform layer remaining after extraction was dried over anhydrous sodium sulphate, filtered and the solvent was removed under reduced pressure to yield the non-alkaloidal fraction. This fraction was used to study the following pharmacological properties.

* Indian Drugs Research Laboratory
561-B, Shivajinagar,
Pune 411 005

The non-alkaloidal fraction thus obtained was partially soluble in water, hence emulsion was prepared using Tween 80. For control Tween 80 was prepared without non - alkaloidal fraction.

Acute toxicity

The acute toxicity study was carried out in mice, by oral and I/p routes. For each dose 10 mice were used.

Effect on pentobarbitone sleeping time

Twenty mice were divided in 2 groups of 10 mice each. Half an hour after drug and control treatments to these groups, pentobarbitone was injected I/p 40 mg/kg. The sleeping time was noted as time interval between loss and regain of lighting reflex.

Effect on blood sugar level

This study was performed in rabbits. Eight rabbits were divided in two groups, four for control and four for non-alkaloidal fraction treatment. Initially and subsequently two and four hours after drug treatment blood was taken out from ear vein and blood sugar level was stimatede.

Effect of non-alkaloidal fraction on rabbit's eye

In this study at a time three rabbits were employed. For installation 1 per cent non-alkaloidal fraction emulsion was prepared in Tween 80 and control was Tween 80 without drug in water. Simultaneously, the drug and control were instilled into left and right eye respectively. Light, corneal and conjunctival reflexes in addition to the pupillary diameter in mm were recorded every five min after instillation of drug and control.

Miotic activity of sub - fractions of non-alkaloidal fraction on rabbit's eye

Non - alkaloid fraction was separated into individual components by TLC using chloroform as a developing solvent and visualised by iodine vapours. There were six distinct spots (Fig. 1). The non-alkaloidal fraction wss further fractionated into sub fraction A and sub fraction B on silica gel G layers with chloroform and chloroform:methanol mixture (80:20). TLC of the sub fractions A and B showed two spots and four spots respectively (Fig. 1). These fractions were subjected for miotic effect using 1 per cent sub-fraction B in Tween - 80 as described earlier.

The sub-fraction B was further fractionated by preparative TLC and three fractions were obtained with 3 spots, 2 spots and 1 spot respectively (Fig. 2). All these fractions were subjected to the testing on rabbit's eye.

Results

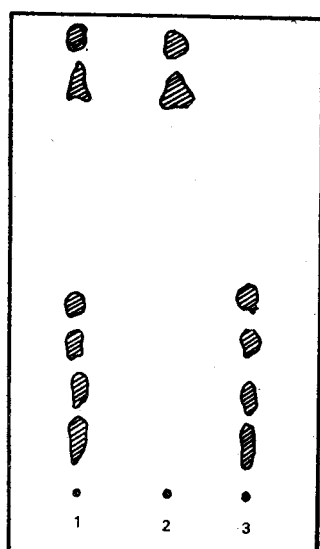
The contents of fat, arecoline and non-alkaloidal fraction in chali and processed arecanut are given in Table 1. It can be seen from the table that there was no appreciable difference in the content of non-alkaloidal fraction in both types of arecanut.

Table 1. Biochemical constituents in arecanut

Constituent	Chali	Processed
Fat	10.5 - 11.9%	8.66 - 9.30%
Arecoline	0.05 - 0.10%	0.12 - 0.17%
Non-alkaloide	0.87 - 1.54%	0.85 - 1.16%

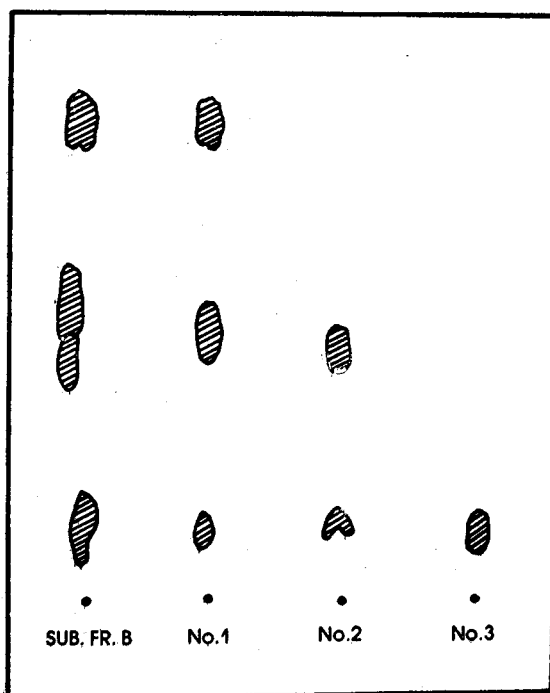
In the acute toxicity study even at a dose of 2g / kg by oral route, there was no mortality. In I / p group maximum dose

FIG. 1 FRACTIONATION OF NON-ALKALOIDAL FRACTION OF ARECA NUT



1 - NON-ALKALOIDAL FR.
2 - SUB-FRACTION A
3 - SUB-FRACTION B

FIG. 2 FRACTION OF SUB-FRACTION B



that could be given was 2.1 g/kg which resulted in 40 per cent mortality. In latter group, mice were showing over all depression.

Effect on pentobarbitone sleeping time is as given in Table-2. Non-alkaloid fraction had significant effect on pentobarbitone sleeping time in mice.

Table 2. Effect of non-alkaloidal fraction on pentobarbitone sleeping time in mice

Group	No. of mice used	Sleeping time (in min) \pm SE
Control	10	82.3 \pm 13.3
Non-alkaloidal fraction	10	141.0* \pm 13.1

P = (0.05)

Studies on the effect of non-alkaloidal fraction on the blood sugar level showed that it had no effect on the blood sugar level of rabbits as seen from Table - 3.

Table 3. Effect of non-alkaloidal fraction on rabbit's blood sugar level

Group	Mean blood sugar level 0h	Mean blood sugar level 2h	mg % at 4h
Control	105.9	108.1	97.8
Non-alkaloidal fraction	103.7	101.2	100.8

Studies on the effect of non-alkaloidal fraction on rabbit's eye showed that it had no effect on light, corneal and conjunctival reflexes whereas it has significantly affected the pupillary diameter (Table 4).

Table 4. Miotic effect of non-alkaloidal fraction on rabbit's eye

Effect at	Pupillary diameter (mm) Control	1% non-alkaloid
Initial	8	8
Onset	8	6 [5 min]
Peak	8	3 [20-45 min]
Recovery	8	8 [75 min]

Studies on the miotic activity of sub-fractions of non-alkaloidal fraction on rabbit's eye showed that sub-fraction B has significant miotic activity (Table 5), but this activity lasts for lesser period as compared to the total non-alkaloidal fraction. There was no effect on light, corneal and conjunctival reflexes. Sub-fraction A was inactive on rabbit's eye.

Table 5. Miotic activity of sub-fractions of non-alkaloidal fraction on rabbit's eye

Effect at	Mean pupillary diameter [mm]			
	Control	Sub-fraction A	Control	Subfraction B
Initial	7	7	7	7
Onset	7	7	7	6 [5 min]
Peak	7	7	7	3 [15-40 min.]
Recovery	7	7	7	7 [60min]

Fractions of the sub-fraction B were subjected to the testing on rabbit's eye. Out of these fractions only No. 3 fraction, a white crystalline solid was active at 5 per cent concentration and rest were inactive. The results are shown in Table 6.

Table 6. Miotic activity of fraction No. 3 of sub-fraction B on rabbit's eye

Effect at	Mean pupillary diameter [mm]	
	Control	5% fraction No.3
Initial	8	8
Onset	8	5 [5 min]
Peak	8	3 [10-35 min]
Recovery	8	8 [45 min]

As compared to non-alkaloid and sub-fraction B, the fraction No. 3 is less potent. In order to get results 5 per cent solution was required and the effect lasted for lesser period.

The fraction No. 3 when subjected for testing after 24 h was still less than earlier. This observation was consistent in subsequent experiments also.

Discussion

Arecoline is pharmacologically the most active alkaloid in arecanut. The non-alkaloidal fraction is safer, as was much less toxic.

In general behavioural observation in animals shows overall depression. The potentiation of pentobarbitone sleeping time in mice substantiate the general behavioural observation. The arecoline is showing depressant and stimulant activity (Pradhan and Dutta, 1970; Schweitzer and Wright, 1937). From behavioural observation and potentiation of pentobarbitone sleeping time, it is likely that only depressant component might be present in non-alkaloidal fraction. The arecoline shows biphasic action on blood sugar level hypo and hyper-glycemia at low and higher doses (Lang and Rigo, 1928). At the dose used the non-alkaloidal fraction has no effect on blood sugar level, which needs further work at various dose levels to arrive at conclusion.

The non-alkaloidal fraction is showing miotic activity on rabbit's eye. This fraction on further fractionation and refraction showed miotic activity with less potency. The fraction No. 3 obtained is showing much less potency (duration and dose) as compared to the parent material.

It may be possible that more than one constituent is required to show the mitotic activity i.e., the activity is attributed to synergistic action of two or more constituents and hence pure constituent shows lower potency. The other possibility is due to an oxidation or some change that may be taking place during purification. It would be advisable to use crude non-alkaloidal fraction as a total drug.

Acknowledgement

The authors are highly thankful to Dr. N. M. Nayar, Ex-Director, Central Plantation Crops Research Institute, Kasaragod, for time to time suggestions and financial support. We also acknowledge with thanks, the active help given by Shri Shama Bhat and Shri K. N. Murthy.

References

- BARKER, L. R. 1966. The possible role of acetylcholine in *Schistosoma monsonii*. *Brit. Z. Pharmacol. Chemotherapy* 26 : 656-665.
- GARG, S. K. and GARG, G. P. 1971. Antifertility screening of plants VII. Effect of five indigenous plants on early pregnancy in albino rats. *Indian J. Med. Res.* 59 : 302-306.
- HAWK. 1965. *physiological chemistry* Ed. B. L. Oser 14th edition. Tata McGraw Hill publishing Company Ltd., Bombay, New Delhi, 1054-1055
- HEYMANS, C. 1922. Action of arecoline on the sinus auricles and ventricles of the frog heart. *Compt. Rend. Soc. Biol.* 87 : 1062-1064.
- LALITHA KUMARI, H., SIRSI, M. and GOVINDA RAJAN, V. S. 1965. Antibacterial and antifungal activities of *Areca catechu* Linn. *Indian J. Exp. Biol.* 3 : 66-67.
- LANG, S. and RIGO, L. 1928. Influence of parasympathetic poisons on blood sugar concentrations. *Biochem. Zeitch.* 192 : 172-175.
- LESLIE, G. H. 1965. Central stimulant properties of compounds with peripheral muscarinic properties. *Nature* 208 : 1291-1293.
- PRADHAN, S. N. and DUTTA, S. N. 1970. Behavioural effects of arecoline in rats. *Psychopharmacologia* 17 : 49 - 58.
- SCHWEITZER, A. and WRIGHT, S. 1937. The action of eserine and related compounds and of acetylcholine on CNS. *J. Physiol.* 89 : 165 - 197.
- WATT, G. 1889. A Dictionary of Economic products of India. Vol. I, Ed. I, Reprinted by Periodical experts, Delhi.
- YOUNG, J. Z. 1933. Comparative studies on the physiology of the iris II. Uranoscopius and Iophius. *Proc. Roy. Soc. B* 112 : 242-249.

✓ Polyphenols of Arecanut

A. G. Mathew*

Abstract

Polyphenols of arecanut have been found to be composed entirely of flavourols. The monomeric flavour 3-ols are present as (+) catechin and (-) epicatechin which are present to the level of 10 per cent and 2.5 per cent respectively of the total phenols. Flavan 3-4 diols are represented by (+) leucocyanidin (12 per cent) and another isomer of the same (1.3 per cent).

The complex polyphenols of different degrees of polymerisation present are found to have predominantly leucocyanidin and traces of catechin and leucopelargonidin.

The polyphenols on autoxidation under alkaline condition get converted into coloured o-quinones which take part in secondary reactions. Spectral studies indicate similar changes when arecanut is chewed with slaked lime. Some taste characteristics of the polyphenols present in arecanut also have been studied.

Introduction

The most important constituents of arecanut are polyphenols which constitute about 15 to 20 per cent of a dry ripe arecanut. In very young stages polyphenols account for as much as 40 to 50 per cent of the dry nut. This progressive decrease in concentration with maturity is due to dilution by the rapid and substantial synthesis of constituents like fat, polysaccharides and fibre and thereby increasing the bulk (Mathew et al., 1964). However, viewed on the basis of weight per nut, the polyphenols continue to be synthesised during the entire maturation. The increase is less evident during the last stage of ripening

Identity of polyphenols

Both (+) catechin and leucocyanidin have been reported by a number of workers

(Govindarajan and Mathew, 1963). Most of the polyphenols are found to be present in the form of polymers. These polymers were found to be predominantly leucocyanidin with traces of (+) catechin and leucopelargonidin. The pattern of changes with maturation and ripening is mainly insolubilisation of higher polymers together with formation of fresh monomers and intermediate polymers (Mathew and Govindarajan, 1964). Leucocyanidins extractable as cyanidin in cold dilute hydrochloric acid increased significantly during maturation. Also insoluble leucocyanidin in fibrous residue yielded cyanidin in greater amounts.

Table 1 shows the identity and proportion of the various polyphenolic constituents present in ripe arecanut. The monomeric compounds detected include (+) catechin, (-) epicatechin and 2 isomers of leucocyanidin (Mathew et al., 1969). The polymeric fractions were found to be

* Regional Research Laboratory (CSIR)
Trivandrum 695 019

Table 1. Chromatographic Characteristics and analysis of Areca Polyphenols

Spot No.	R _f in BAW	R _f in 2% acetic acid	Leucoantho- cyanidin test	Chemical Nature	% of the total Folin-Denis
1	0.00	0.00	+ve	Very highly polymerized proanthocyanidin	14.70
2	0.10 - 0.23	0.00	+ve	Highly polymerized proanthocyanidins	3.46
3	0.00 - 0.10	0.05 - 0.38	+ve		27.98
4	0.11 - 0.22	0.07 - 0.58	+ve		17.68
5	0.25 - 0.35	0.20 - 0.62	+ve	Low polymer proantho- cyanidin	8.13
6	0.50	0.56	+ve	Monomer (+) leucocyanidin	12.06
7	0.45	0.68	+ve	Isomer of 6	1.26
8	0.59	0.34	-ve	(-) Epicatechin	2.57
9	0.72	0.34	-ve	+ Catechin	10.27
10, 11, 12	—	—	—	Minor spots	2.00

Table 2. Organoleptic Qualities of Areca Polyphenolic Fractions

	Catechin (monomer)	Leucocya- nidin (monomer)	Oligomeric fraction	Polymeric fraction
Astringency (score)	Intense (10)	Intense (10)	Good (8)	Fairly good (7)
Colour	Reddish	Yellowish	Yellowish	Yellowish
Odour	Earthy	—	—	—

predominantly leucocyanidin but traces of (+) catechin and leucopelargonidin have also been detected.

Taste characteristics

The main taste sensation on taking polyphenolic materials in the mouth is what is termed as astringency. It differs from the true taste, in that the astringency is felt as a diffuse stimulus not confined to any specialised nerve ending in the tongue. It is sometime described as a "contracting drying taste" or "puckeriness" and can be called a sensoric factor.

Areca polyphenols on fractionation into (+) catechin, monomer leucocyanidin, oligomeric fractions which has some mobility on paper and polymeric fraction, were tested for organoleptic qualities (Table 2). It can be seen that simple monomeric compounds were very astringent which was felt immediately with the usual drying sensation in the mouth and a feeling of choking in the throat (Mathew, 1967). The astringency appeared to be reduced

with polymerization as shown by oligomeric and polymeric fractions. There was a feeling that astringency was felt after a little delay in the case of polymers.

All fractions showed a faint flavour associated with arecanut, but catechin, in addition, had a peculiar odour that is associated with raw plant roots. The faint bitterness associated with astringency appeared to be slightly more evident in the case of catechin than leucoanthocyanidin. The colour of aqueous solution was more reddish in the case of catechin compared to yellowish of leucocyanidin.

Red colour formation of arecanut on chewing

Of all the ingredients used in a chew, it was found that arecanut and lime are required to get the characteristic red colour. Betel leaf contributes only a pleasant burning flavour caused by the essential oil rich in phenolic terpenes. Measurement of pH of a number of samples showed that the normal pH of the chew is between 8 and 9. It is not essential that the alkali should be calcium hydroxide as in slaked lime, but even sodium hydroxide or any other alkali gives the colour at appropriate pH. Extracted polyphenols also gave colour with alkali showing that the colour formation during chewing is due to change to polyphenols in arecanut in alkaline pH (Mathew, 1971).

Catechin was found to turn brilliant yellow red immediately after addition of alkali (pH 10) and on standing gradually turned reddish brown after 2 hr and remained nearly so after 24hr. Under similar conditions leucocyanidin was dark red initially but turned dull brown in about 2

hr and pale brown on keeping over night. The polymeric proanthocyanidin which contain mostly leucoanthocyanidin behaved similarly to leucoanthocyanidin. The total polyphenolic extract which contained 85 per cent proanthocyanidins also showed a similar pattern of colour change. The colour change of all the compounds at pH 8 was basically similar, but the rate of change was slower.

Purified (+) catechin and leucocyanidin after keeping for 15 min in alkaline pH gave a prominent peak at 500-510 nm and an inflection at 430 nm. On keeping both catechin and leucocyanidin lost the flavour characteristics like 280 nm absorption and reaction with valillin sulphuric acid. The loss of reactivity was faster in the case of leucoanthocyanidins.

Catechin and catechol when oxidised by o-dihydroxy specific polyphenol oxidase also showed similar pattern of change. This showed that under alkaline oxidation also, catechin and leucocyanidin get converted to o-quinone. In more alkaline condition, the colour became more intense.

In the arecanut chew containing slaked lime, the dark red of o-quinone formed from leucoanthocyanidin, which is present in larger amounts especially in polymeric form, will dominate. It is however a transient stage represented by the first 2 to 3 hr at pH between 8 and 10 when o-quinones will be formed in substantial quantity and some of them are being converted into complex polymerized end products of the second stage.

A chewer generally keeps the chew in the mouth for a period of less than half an hr and rarely over an hr. Therefore under

the mild alkaline condition prevalent at pH of about 8, there is scope for formation of o-quinones which will be dark red in alkaline medium. The mouth of a regular chewer and the expectorated material on long keeping, assume a dull red colour

due to secondary reaction products that appear with time. No enzymatic reaction takes place during chewing since a previously blanched arecanut also produce the same colour change as seen during normal chewing.

References

- GOVINDARAJAN, V.S. and MATHEW, A.G. 1963. Polyphenolic substances of arecanut. I. Chromatographic analysis of fresh mature nut. *Phytochemistry* 2 : 321 - 326.
- MATHEW, A. G. 1967. Chemical studies of astringency in plant products with special reference to polyphenols. Ph.D. thesis. University of Kerala.
- MATHEW, A. G. 1971. Formation of red colour on chewing arecanut with slaked lime. *J. Food Sci. Technol.*, 8 : 140-142.
- MATHEW, A.G. and GOVINDARAJAN, V.S. 1964. Polyphenolic substances of arecanut II Changes during maturation and ripening. *Phytochemistry* 3 : 657 - 665.
- MATHEW, A.G., PARPIA, H. A.B. and GOVINDARAJAN, V. S. 1969. Nature of complex proanthocyanidins. *Phytochemistry*, 8 : 1543 - 1547.
- MATHEW, A. G., VENKATARAMU, S. D. and GOVINDARAJAN, V. S. 1964. Studies on arecanut: Part I - Changes with composition and physical characteristics of nuts with maturity. *Indian J. Technol.*, 2 (3), 90 - 96.

✓ Technological Aspects of Arecanut

S. Shivashankar and E. S. Nambudiri*

Abstract

Development of a mixed preservative solution for preserving fresh ripe arecanut and a drier for producing Kottapak and Kalipak are discussed. Chemical composition of fresh ripe arecanut, processed varieties, adulterants and standards for prevention of adulteration are also presented. Diverified uses of arecanut are enumerated.

Introduction

India is the largest producer of arecanut (*Areca catechu* Linn.). The habit of 'paan-supari' chewing finds a unique place in the habits of millions of people. Chewing of 'paan-supari' is known to aid digestion by increasing the production of saliva and gastric juice. It helps in improving the odour of the mouth and also beautifies the mouth. Arecanut is consumed both in raw stage and after processing. Ripe arecanut is the chewers' favourite in Assam, Kerala and northern parts of West Bengal. 'Chali' and its half-cut form 'parcha' are extensively used in western and northern parts of India. Processed green nut 'Kalipak' is most popular in Karnataka, Kerala and Tamil Nadu. Chemical composition of green and ripe arecanut is presented in Table 1.

Processing of Arecanut

Fresh ripe arecanut is used for chewing in Assam and Kerala. The edible nut is so much liked by the people, that they have evolved rather crude methods of storing,

Table 1. Range of variation of chemical constituents of green and ripe arecanuts

Constituents*	Green (Kalipak stage)	Ripe
Moisture content	69.4-74.1	38.9-56.7
Total water extractives	32.9-56.5	23.3-29.8
Polyphenols	17.2-29.8	11.1-17.8
Arecoline (Extraction method)	0.11-0.14	0.12-0.24
Fat	8.1-12.0	9.5-15.1
Crude Fibre	8.2-9.8	11.4-15.4
Total Polysaccharides	17.3-23.0	17.8-25.7
Crude Protein	6.7-9.4	6.2-7.5
Ash	1.2-2.5	1.1-1.5

* Constituents expressed as percentage values (except moisture) calculated on dry basis

for use during the off-season. In Kerala the fresh ripe fruits are stored in water and are known as 'neetadaka'. The nut contains mainly polyphenols, polysaccharides, fibre and fat (Mathew et al., 1964). The husk contains easily fermentable substances such as sugars and pectins. These are easily attacked by bacteria when stored in water. The husk is loosened and the bright orange colour is lost. Because of fermentation foul smell is produced which penetrates

* Central Food Technological Research Institute, Mysore 570 013, Karnataka

into the edible nut. In Assam fresh ripe arecanuts are stored in pits. The husk gets attacked by fungus and the fat and polysaccharides core is eaten away by bacteria. The nut is thus rendered unsuitable for consumption.

The problem of preserving fresh ripe arecanut in garden fresh condition was tackled by the C.F.T.R.I. and a method of preserving fresh ripe arecanuts by steeping in mixed preservative solution has been developed (Mathew et al., 1963). The method is very simple. It consists of washing freshly harvested areca fruits in chlorinated water (100 ppm) to remove the adhering dirt. The fruits are then blanched in boiling 0.2 per cent calcium chloride solution. This treatment is known to reduce the microbial load, destroys the enzymes and preserves the firmness of the husk. The fruits are then kept immersed in a solution containing 0.1 per cent sodium benzoate and 0.2 per cent potassium metabisulphite acidified to a pH of 3.5 to 4.0 using hydrochloric acid.)

Physical and chemical analysis of preserved arecanuts have indicated that the fruits can be preserved in fresh ripe condition for 10-12 months (Mathew et al., 1963). Fresh bright colour and firmness of the skin are maintained. Stored fruits will be free from foul smell without any significant changes in the constituents.)

Dried ripe nuts

Fresh ripe areca fruits are dried in the sun by spreading in single layers for 35-40 days. The fruits are turned over at regular intervals to ensure uniform drying. To facilitate uniform drying some times the

outer skin is peeled off. Later on they are de-husked and sent to market. Whole dry nuts are known as 'Chali' or 'Kottapak'. The well known grades of 'chali' in descending order of size are 'moti', 'Srivardhan', 'Jamnagar' and 'Jini' (Anonymous, 1961). Other characteristics which are valued are uniformity in size, absence of immature nuts, surface cracking, husk sticking, fungus and insect attack and good cutting feel, inside structure and taste (Dhanaraj, et al., 1970).

Lack of attention during drying and unexpected rains and unsuitable wet drying yards contribute to onset of fungal infection and result in a poor quality final product. In Kerala and Assam harvesting season coincides with the monsoon and sun drying is difficult. The main areas producing 'chali' nuts are Karnataka, Kerala and Assam. Bangla Desh, Malaysia and Sri Lanka also produce 'chali' nuts.

To facilitate drying areca fruits are cut longitudinally into two halves and then dried in the sun with the husk. Later they are scooped out and sent to market. This half-cut form is known as 'parcha'. It is produced mainly in Kerala and Karnataka. In Karnataka its production is concentrated in South Kanara, Sirsi and Kumta area. In Kerala its production is confined to Kasaragod, Nedumangad and Kottayam areas. Small quantities of this type are produced in Assam, Maharashtra and West Bengal. In West Bengal they are processed in parts of Cooch - Bihar and Jalpaiguri districts.

C.F.T.R.I. has developed a mechanical through-flow-drier for making 'chali' and 'parcha' (Nambudiri, et al., 1963). Drying can be completed in about 60-70 hr spread

over 7-8 days at progressively increasing temperatures between 45-70°C. The drying schedule consists of successive 8 hr. drying period followed by 16 hr equilibration outside the drier. The capacity of the drier is 4000-5000 big sized fruits. The parts of the drier are a drying chamber with four perforated trays, a heat exchanger, fuel furnace and a centrifugal blower. 'Kalipaks' can be conveniently dried using this drier.

Kalipak

Areca fruits of 6-7 months maturity are used for making this important class of processed arecanut. The main processing centres are Karnataka and Kerala. The outer skin of the husk will be green in colour and the immature nut will be soft. The processing consists of dehusking, cutting the soft nut into pieces, boiling the cut pieces with water or a thin extract from a previous boiling, 'Kali' coating and drying. Depending upon the number of cuts, different types representing pieces of various sizes and shapes are recognised. 'Api' or 'unde' is the type which is processed without any cutting. 'Batlu' or 'Ottavettu' is cut transversely into two halves. 'Choor' is produced after several longitudinal cuttings. It is further divided into sub-groups namely 'mukkachoor', 'edachoor', 'pettichoor' etc. in the descending order of thickness. 'Podi' is produced by cutting the nuts both transversely and longitudinally 3 to 4 times. 'Erazel' and 'Chalakudi' are thin slices produced by slicing the nuts transversely or longitudinally.

During the boiling operation, the same water is used for boiling 2 or 3 batches of arecanuts. The extract so obtained is concentrated to get 'Kali'. After boiling, the pieces are coated with 'kali'

which imparts a good glossy appearance. In interior Karnataka the boiling and 'kali' coating operations are combined into single operation. The cut nuts are boiled in a thicker extract called 'Chogaru'.

Both sun drying and oven drying are practiced by 'Kalipak' processors. A well dried product with a dark brown colour is preferred. Other desirable qualities in 'Kalipak' are crisp chewing feel, glossy appearance, a well toned astringency and absence of overmature nuts.

Sagopalm nut is used for adulterating 'Kalipak' samples. The cut pieces have a similar cut surface and are coated with 'kali'. The chemical analysis (Table 2) will reveal that sagopalm nuts have lower polyphenol and fat contents but have higher polysaccharides and fibre contents. Other adulterants used after 'kali' coating are sweet potato and tapioca and they are comparatively easier to identify.

Table 2. Analysis of arecanut and sagopalm

Constituents (%)	Arecanut (dried-green)	Sagopalm (dried)
Moisture	12.04	14.50
Tannins	33.90	7.51
Total water extractives	52.73	13.69
Fat	8.70	0.32
Crude fibre	7.32	23.63
Arecoline	0.28	0.04
Ash	2.51	1.21

'Iylon' is an unboiled variety made from green arecanuts. The nuts are cut into 5 or 6 discs transversely and dried without kali coating. The nuts will be slightly more

mature than those used for 'kalipak'. Tamil Nadu and Andhra Pradesh are important consuming areas. The grades in increasing maturity and therefore decreasing grade are 'Chittanum', 'Virivu' and 'Kora'. 'Nayampak' is also unboiled type and is made from immature arecanuts after cutting once transversely and drying.

The range of variation in physical and chemical constituents of important processed varieties are given in Tables 3 and 4 (Shivashankar et al., 1969).

Scented Supari

There are many varieties of scented suparis. The processing consists of breaking the dried nuts into bits, blending with flavour mixture and packaging. Roasting of bits in oil or ghee is also practised. Batlu adike is mainly used for making scented supari. In North India scented supari is made from 'Chali' nuts in addition to those made from 'Kalipaks'. The flavouring varies depending on the region and it is a closely guarded secret. Rose essence

is used in most of the cases. Coconut grating which were used in earlier days are now avoided as they get fungal infection.)

Chemical Constituents

Polyphenols are the most important constituents of arecanuts and constitute about 20% of the dried nut. These polyphenols are shown to be entirely flavenols by paper chromatography supplemented by reaction with specific reagents. The monomeric components include about 10% of (+) catechin, 2.5% of (-) epicatechin, 12% of (+) leucocyanidin and 1.3% of another isomer of leucocyanidin out of the total polyphenols (Mathew et al., 1969). The remaining are made up of complex flavonoids of varying degree of polymerisation. Acid hydrolysis and study of the reaction products have shown them to be predominantly leucocyanidins and traces of catechin and leucopelargonidin.

Astringency, the characteristic taste of arecanut is contributed by polyphenols. By a study of organoleptic properties of

Table 3. Range of variation of Physical characteristics

Types/Trade name	No. of samples analysed	Limits - Range of variation						
		Length		Diameter		Nuts/ pieces/ kg	Volume/ nut/piece (in cc)	% Floating
		Measurements (in cm)	Standard deviation	Measurement	Standard deviation			
1. Chali	68	0.9-3.3	0.19-0.37	0.8-3.4	0.02-0.33	92-840	1.1-12.0	0-75
2. Parcha	19	1.1-3.0	0.15-0.30	1.3-3.1	0.14-0.31	220-522	1.7-4.5	0-58
3. Iylon	26	—	—	0.9-3.0	0.09-0.36	800-2832	0.4-1.3	0-33
4. Api	54	0.6-2.9	0.02-0.30	0.7-3.6	0.03-0.40	158-1054	1.1-6.5	0-90
5. Batlu	31	—	—	1.0-2.9	0.02-0.27	452-1712	0.7-27	0-53
6. Choor	34	1.0-3.5	0.15-0.40	0.1-2.7	0.03-0.45	912-1626	0.1-1.1	0-71
7. Erazel	9	—	—	—	—	—	—	—
8. Chalakudi	3	—	—	1.5-3.0	0.25-0.30	1144-1332	0.8-0.9	0
9. Nuli	5	—	—	—	—	1296-3012	0.4-0.8	5-23

Table 4. Range of variation in chemical constituents

Types/Trade names	No. of samples analysed	Moisture (%)	Total water extractives (%)	Polyphenols (%)	Arecoline % steam-distillation method	Fat (%)	Range of variation				Total polysaccharide (%)	Ash (%)	Acid insoluble ash (%)
							F. F. A. on fat (%)	Crude fibre (%)	F. F. A. on fat (%)	F. F. A. on fat (%)			
1. Chali	65	5.46-12.23	19.63-39.19	7.32-34.93	0.11-0.72	4.87-24.35	0.74-74.09	7.09-17.42	14.29-26.25	1.18-2.54	Nil-0.28		
2. Purcha	18	6.15-14.28	28.37-36.43	11.73-24.99	0.12-0.54	12.29-18.14	1.98-22.94	7.96-14.25	13.02-27.30	1.34-2.08	Nil-0.088		
3. Iyfon	25	7.80-10.86	28.67-60.54	19.59-45.94	0.14-0.69	6.80-18.11	2.65-47.63	5.38-13.30	13.54-28.19	1.35-2.65	Nil-0.16		
4. Api	54	7.40-11.00	23.03-53.28	15.19-41.25	0.15-0.90	5.32-18.52	0.65-45.65	5.38-18.50	9.22-28.24	1.01-2.53	Nil-0.19		
5. Batlu	31	7.89-13.38	28.28-69.61	22.42-55.21	0.10-0.88	4.33-17.89	0.51-57.25	3.14-12.30	14.20-26.99	1.48-2.37	Nil-0.10		
6. Choor	33	5.20-11.63	32.43-66.03	24.92-43.69	0.14-0.87	5.91-17.78	0.93-20.11	5.10-15.15	11.13-28.08	1.19-3.32	Nil-0.153		
7. Erazel	9	7.67-11.64	29.85-57.42	16.87-38.01	0.21-0.75	5.48-12.25	2.08-75.97	5.87-8.72	13.14-26.58	1.48-4.97	Nil-1.17		
8. Chalakudi	3	9.16-10.15	49.78-56.99	31.95-39.29	0.35-0.93	7.05-10.48	2.76-33.17	5.32-14.87	22.08-26.94	2.34-3.61	Nil-0.08		
9. Nuli	6	9.17-10.58	53.01-72.44	38.98-47.92	0.63-0.01	3.66-13.78	0.97-5.07	3.75-6.00	16.43-22.68	2.13-3.24	0.002-0.16		

various fractions, catechin and leucocyanidin have been found to be very astringent as compared with the astringency of polymeric fractions (Mathew, 1967). Pure catechin is reddish as compared to the yellowish colour of leucocyanidin fractions.

These polyphenols get converted to coloured O-quinones when treated with alkali which on further oxidation slowly becomes dull brown. The colour and spectral characteristics of the chew containing arecanut and slaked lime is similar to the latter (Mathew, 1971). Leucocyanidins are therefore considered mainly responsible for the colour of the chew. Abundant quantities of leucocyanidins are present in arecanut, both in monomeric and polymeric forms.

The most important alkaloid of arecanut is arecoline. A method for the estimation of arecoline in arecanut has been standardi-

sed (Nambudiri, 1968). Arecoline has a parasympathetic stimulant action. It induces intestinal peristalsis and is poisonous to round worm. In veterinary preparation arecoline and its hydrobromide are used as a vermifuge. As it is toxic in higher dosages it is not administered to human beings.

The percentage of fat in dry ripe arecanut ranges between 9 to 15 per cent. The fat has a melting point of 80°C, saponification value of 236.1 and iodine value of 59.0 (Mathew, et al., 1974). In physical appearance it resembles vanaspathi. Other major constituents of the nut are polysaccharides and fibre which are higher in mature stages.

Because of increased production the price of arecanut has fallen considerably. Efforts were made to find out diversified use. But cost-wise it remains a costly raw material for extraction of either polyphenols or fat for industrial use.

References

- ANONYMOUS, 1961. Directorate of Marketing and Inspection, Nagpur. Report of Marketing of Betelnuts.
- DHANARAJ, S., SANKARAN, A. N. and MATHEW, A. G. 1970. Quality and Market Evaluation of Processed Arecanuts. *J. Food Sci. Technol.* **7** : 123-126.
- MATHEW, A. G., VENKATARAMU, S. D., JALEEL, S. A., GOVINDARAJAN, V. S. and SUBRAHMANYAN, V. 1963. Storage of Areca Fruit: 1. Preservative Steeping Storage. *Arecanut J.* **14** : 51-62.
- MATHEW, A. G., VENKATARAMU, S. D. and GOVINDARAJAN, V. S. 1964. Studies on Arecanut: Part I-Changes in Chemical Composition and Physical Characteristics of Nuts with Maturity. *Indian J. Technol.* **2** : 90-96.
- MATHEW, A. G. 1967. Chemical Studies of Astringency in Plant Products with special reference to Polyphenols. Ph.D. Thesis, University of Kerala, Trivandrum.
- MATHEW, A. G., PARPIA, H. A. B. and GOVINDARAJAN, V. S. 1969. The Nature of the Complex Proanthocyanidins. *Phytochemistry*. **8**:1543-1547.

MATHEW, A. G. 1971. Formation of red colour on chewing arecanut with slaked lime. *J. Food Sci. Technol.* 8 : 140-142.

✓ MATHEW, A.G., SHIVASHANKAR, S., FAZLULLA KHAN and NATARAJAN, C. P. 1974. Extraction of Fat from Arecanut. *Arecanut Spices Bull.* 6 : 31.

NAMBUDIRI, E. S., GOVINDARAJAN, V. S. and SUBRAHMANYAN, V. 1963. Mechanical Drying of Arecanuts: 1. Making of Ripe Dry Nuts. *Arecanut J.* 14 : 95.

✓ NAMBUDIRI, E. S., 1698[?] Estimation of Arecoline: A Rapid Distillation Method. *J.A.O.A.C.* 51 [4]: 799-802.

✓ SHIVASHANKAR, S., DHANARAJ, S., MATHEW, A. G., SREENIVASA MURTHY, S., VYAS MURTHY, M. N. and GOVINDARAJAN, V. S. 1969. Physical and Chemical Characteristics of Processed Arecanuts. *J. Food Sci. Technol.* 6 : 113.

Xylose and Activated Charcoal from Arecanut Husk

A. H. Kapadi, Vandana Deshpande, A. M. Mujumdar and G. S. Pendse

Abstract

The processing of arecanut husk, the waste product of arecanut industry, for the recovery of Xylose and high quality activated charcoal has been described. Arecanut husk, coarsely disintegrated, is digested with ten-fold excess of 8 per cent sulphuric acid for 3 hr. The acidic extract yields 9-11 per cent crude xylose and 2-3 per cent pure xylose. The digested, recovered husk is mixed with 25 per cent zinc chloride and heated to 800°C for 2 hr in a closed container. The crude charcoal thus obtained is processed to yield high quality (I. P. 1966 standard) activated carbon with good yield (25-28%). The zinc chloride catalyst is recovered and recycled so that the process could be adopted for commercial utilisation.

Introduction

Areca catechu Linn., commonly known as arecanut is extensively used in this country as a masticatory. Arecanut husk is largely used as a domestic fuel. Some efforts have been made to extend the use of this large quantity of waste material available in our country. Thus, Singh (1956) has obtained 5.5 per cent furfural from arecanut husk by an acid catalysed high temperature and high pressure process. The waste residue left in the production of furfural, can be used as fillers for phenolic plastics (Narayana-murti and Singh, 1955). Ali and Khundkar (1954) obtained the nitrated product of lignin from arecanut husk in 30 per cent yield. Some attempts have been made to produce pulp and paper from arecanut husk

(Singh and Guha, 1960 and Subramanyam et al., 1963). Guha et al., (1963) have described a pilot plant for the production of low strength brown wrapping paper using 60 per cent arecanut husk pulp and 40 per cent bamboo pulp.

The need for better utilisation of arecanut husk is clearly evident from the foregoing discussion. In the present communication the processing of arecanut husk to obtain xylose and activated charcoal has been reported for the first time. Xylitol, which can be obtained by one step synthesis from xylose, is gaining importance as a sugar substitute in diabetic food and low-calorie diets for controlling obesity. The activated charcoal thus obtained from arecanut husk has excellent decolourising properties.

* Indian Drugs Research Laboratory 561-B, Shivajinagar, Pune 411 005

Materials and Methods

Arecanut husk is supplied by Central plantation Crops Research Institute. It is used in the process after coarse disintegration. Analytical Reagent grade Xylose and activated charcoal were obtained from E. Merck for use as authentic samples. Indian pharmacopoea specifications are used for testing activated charcoal.

The acid hydrolysis of arecanut husk for optimising the reaction conditions for best yield of xylose was monitored by thin layer chromatography using acetone: methanol: chloroform: water (125:75:15:75) solvent system. The coarsely disintegrated arecanut husk was digested with a ten-fold quantity of different concentrations (6 to 12 per cent) of sulphuric acid, for different time intervals (3 and 6 hr). The residue obtained after filtering the reaction mixture is washed with equal volume of water and processed for activated charcoal.

The xylose from combined filtrates and washings is recovered as follows. The filtrate is neutralised with slight excess of calcium carbonate, and filtered to remove precipitated calcium sulphate. Excess calcium in solution is precipitated by adding a few drops of phosphoric acid and by heating with active charcoal (1 per cent of the filtrate). The colourless solution is concentrated under vacuum to a syrupy consistency and poured into ethanol to precipitate crude xylose (9 to 11 per cent yield). The crude product is an amorphous light brown solid. It is crystallised from methanol to yield cream coloured xylose crystals with a m.p. of 142°. The xylose thus obtained is comparable with authentic xylose with respect to its m.p. and tlc behaviour. The yield of pure xylose is 2-3 per cent.

The residue left after acid hydrolysis is mixed with zinc chloride (25 per cent w/w of residue) while the residue is still wet and allowed to dry in oven. The dry mass is heated in a closed container at about 800° for two hr. The charcoal product is moistened with HCl and washed with deionised water till free from chloride ions. The zinc chloride is recovered to the extent of 90 per cent from the washing by concentration and reused for treating next batch. The crude charcoal is dried (105°/5 hr), powdered and analysed. The yield is 25-28 per cent.

Results and Discussion

The optimum conditions required for the best yield of xylose from arecanut husk by hydrolysis are 8 per cent sulphuric acid and the time of digestion is 3 hours (Table 1). Higher concentrations of sulphuric acid for hydrolysis cause degradation of xylose, which is also true for longer period of digestion.

Table 1. Hydrolysis of arecanut husk

Ex. No.	Arecanut husk quantity	% H ₂ SO ₄	Yield of crude xylose (%)		Purity
			3 hr	6 hr	
1.	100g	6%	6	8	Mostly impure
2.	100g	8%	11	9	Mostly pure
3.	100g	10%	9	7	Impure
4.	100g	12%	8	6	Impure

The yield of crude xylose is 9-11 per cent. The product appears to be fairly pure by tlc. However, the pure product could be obtained only to the extent of 2-3 per cent. This is possibly due to contamination of the product with furfural, a degradation

product of xylose. It may be said at this juncture, that the economic feasibility of the process of obtaining xylose alone from arecanut husk appears to be unpromising.

The process of preparing activated charcoal from arecanut husk is encouraging as the yield is good (25 - 28 per cent) and the quality of the product is high and compares well with the authentic sample of activated charcoal (Table 2). The present study is restricted to explore the possibility of getting xylose and active carbon from husk and the economic feasibility of the process cannot be worked out unless the process is improved and scaled up to a pilot plant size. However, considering the low costs of input of chemicals, cheap availability of raw materials and demand for the end products, a small scale plant for getting active carbon from arecanut husk may be economically feasible, if set up at

a place with abundant and round-the-year supply of this cheap raw material.

Conclusion

Arecanut husk could be processed to yield xylose and activated carbon of good quality. Crude xylose is obtained to an extent of 9-11 per cent while pure xylose is obtained to an extent of 2-3 per cent. A process has been developed to yield active carbon of standard quality in good yields (25-28 per cent) which could be economically feasible.

Acknowledgement

The authors gratefully acknowledge the active help, financial support and encouragement from Dr. N. M. Nayar, Ex. Director, Central Plantation Crops Research Institute, Kasaragod, Kerala. Our sincere thanks are also due to Shri K. Shama Bhat and Shri K. N. Murthy of the above institute for helpful cooperation.

Table 2. Comparison of arecanut husk charcoal with Merck charcoal (as per I. P. 1966 specifications)

Test	Charcoal Arecanut husk	E. Merck
1. Sub-soluble in water	Complies	Complies
2. Sub-soluble in HCl	Complies	Complies
3. Chlorides	Complies	Complies
4. Sulphates	Complies	Complies
5. Iron	Complies	Complies
6. Incomplete combustion	Passes test	Passes test
7. Heavy metals (Pb)	Complies	Complies
8. Methylene blue titre	10.5 ml	12 ml
9. Loss on drying	Nil	10%
10. Residue on ignition	3.48%	5.00%
11. Chloroform adsorption	25%	34.06%

References

- ✓ ALI, M. E. and KHUNDKAR, M. H. 1954. Rice husk, betelnut husk and bamboo lignins. II. *J. Ind. Chem. Soc.* **31** : 471-474.
- GUHA, S.R.D., MATHUR, G. M., MATHUR, B. C. and SINGH, M. M. 1963. Pilot plant production of brown wrapping papers from arecanut husks. *Indian Pulp and Paper.* **17** : 433-435.
- NARAYANAMURTI, D. and SINGH, H. 1955. The use of indigenous agricultural, lignocellulosic wastes and acid-hydrolysed materials as fillers for phenolic plastics. *Composite Wood.* **2** : 87-91.
- ✓ SINGH, H. 1956. Production of furfural from coconut shells and arecanut husk. *Composite Wood.* **3** : 47-50.
- SINGH, J. and GUHA, S.R.D. 1960. Brown wrapping papers from arecanut. *Res. and Ind.* **5** : 169-170.
- SUBRAHMANYAM, V., SIDDAPPA, G. S., GOVINDARAJAN, V. S. and IYENGAR, V. N. R. 1963. Utilisation of cullulosic agricultural wastes. *Indian Pulp Paper.* **17** : 535-536.

Session 5

Marketing and Extension

Chairman : V Rajagopal

Rapporteurs : M S Lakshmanachar

R K Singh

Arecanut Situation in India⁺ (An Economic Analysis)

Prafulla K. Das*

Abstract

The index of arecanut production in India has moved from 153 in 1970-'71 (Triennium ending 1961-'62=100) to 208 in 1980-'81. The compound growth rates of area, production and yield of arecanut in the country are estimated at 0.32 per cent, 3.05 per cent and 2.69 per cent respectively, per annum for the period 1970-'71 to 1979-'80. India was turned to a net exporter of arecanut from the net importer from 1967 through her R & D efforts. The exports however, constitutes mere 0.15 per cent to 0.37 per cent of India's production. During the 1970s, the export growth rates have been very much spectacular, the annual compound rates for the quantity exported, export earnings and unit values being 12.07 per cent, 17.86 per cent and 5.17 per cent, respectively. The wholesale price index for different types of arecanut in 1980 have gone up by three to four times over 1959-'62.

Arecanut enterprise today is found to be highly paying due to both the attractive price incentives and the adoption of high density cropping systems in areca gardens by raising cacao, banana, cardamom, pepper, pineapple and several economically important crop species as inter/mixed crops. The outlook seems to be bright as the processing industry has been able to develop a few value added products that find ready acceptance among the non-traditional consumers.

Introduction

India is the largest producer and consumer of arecanut in the world. As far as the production is concerned, it constitutes nearly 88 per cent of the world production of arecanut. The economic importance of the arecanut sector can be realised from the fact that nearly 56 million people in this country are either directly or indirectly connected with it. This paper discusses the trends in the area, production and

yield; import - export position; price behaviour and outlook in respect of arecanut in India.

Materials and Methods

The area, production and yield data used for this analysis are the estimated figures of the Directorate of Economics and Statistics, Ministry of Agriculture, Government of India. The import/export particulars are the official figures of the Directorate General of the Commercial Intelligence and Statistics, Government of India. The wholesale prices for different grades of arecanut are the compiled figures of the Directorate

* Central Plantation Crops Research Institute
Kasaragod 670 124, Kerala

+ CPCRI Contribution No. 227

of Cocoa, Arecanut and Spices Development, Government of India. The published documents, reports and periodicals which were used as the secondary sources for some of the data have been shown in the references.

Results and Discussions

Trends in Arecanut Area

The area under arecanut in India in the year 1950-'51 was of the order of 105,000 ha. This area was increased to 113,000 ha in 1960-'61, to 167,000 ha in 1970-'71 and to 185,000 ha in 1980-'81. This shows that the area under this crop has gone up by 76 per cent over a period of 30 years amounting to an annual growth rate of around 2.5 per cent. The estimated compound growth rate of arecanut area in India for the period 1960-'61 to 1969-'70 comes to 4.26 per cent per annum and for the period 1970-'71 to 1979-'80 it comes to 0.32 per cent per annum. During the 1960s the expansion of area was one of the important strategies to achieve self sufficiency in arecanut production and India could achieve this goal towards the mid 60s. Anticipating the problem of excess supply of the commodity over the demand, the strategy for area expansion was withdrawn in the 70s. For these reasons we could see such spectacular difference in growth rates between the 60s and the 70s.

Trends in Arecanut Production

Arecanut production in India was 73,000 tonnes in the year 1950-'51. The same was raised to 96,000 tonnes in 1960-'61, to 141,000 tonnes in 1970-'71 and to 191,000 tonnes in 1980-'81. In other words, the production of arecanut in India

has registered a rise of 162 per cent over a period of 30 years resulting to an annual growth rate of 5.4 per cent. The estimated compound growth rate of arecanut production in India for the period 1960-'61 to 1969-'70 comes to 5.00 per cent per annum and for the period 1970-'71 to 1979-'80 it comes to 3.05 per cent per annum. The index of arecanut production has moved from 153 in 1970-'71 to 208 in 1980-'81 considering the triennium ending 1961-'62 as the base (Table 1).

Trends in Productivity

During the year 1950-'51 the average productivity of arecanut in India was 695 kg/ha. The trend in productivity rose slowly with some fluctuations and attained the level of 844 kg/ha in the year 1960-'61. Then it had a declining trend for three years followed by an increasing trend for four years and reached the level of 918 kg/ha in 1967-'68. Thereafter the yield fell till it reached 843 kg/ha in 1970-'71. The productivity of this crop again showed an increasing trend in the 70s and stood at 1037 kg/ha in the year 1980-'81. The estimated compound growth rate of the productivity of arecanut in India for the period 1960-'61 to 1969-'70 comes to 0.85 per cent per annum and for the period 1970-'71 to 1979-'80 it comes to 2.69 per cent per annum. The Index Numbers drawn in respect of the yield of arecanut clearly illustrate the variations in the productivity of the two periods namely the 60s and the 70s (Table 1).

Influenced by the productivity the growth in the level of production was more proportionate than the growth in area during the last decade. The relatively high growth rate in productivity during the late 70s is largely due to the creation of a

stabilised market for arecanut which ensured an attractive price to the areca growers of the major producing areas namely Kerala and Karnataka.

Import Situation

With the partition of the country in 1947, nearly 50 per cent of the total area under arecanut in undivided India fell in the hands of erstwhile East Pakistan, presently Bangladesh. Consequent upon this changed situation, India had no option other than resorting to import of arecanut from Sri Lanka, Malaysia and other producing countries to meet the internal demand for the commodity. In the year 1950-'51 India's arecanut import was of the order of 45,000 tonnes valued at Rs. 34.3 million and during the following year the volume of import touched the all time record high of 51,000 tonnes valued at Rs. 55.7 million. The imports in such large volumes had an obvious adverse effect on the economy of India in general through the drain in foreign exchange and arecanut production sector in particular through internal price depression.

To overcome these problems the Government of India in 1953 fixed ceilings on the volume of imports as well as on the import values alongwith the levy of import duty on all varieties of arecanut imported into India. Simultaneously, efforts were made to raise production within the country. All *these measures yielded desirable results* and imports were gradually reduced. During 1960-'61 to 1962-'63, the volume of import averaged to 10,000 tonnes and in the subsequent three years the annual imports further came down to 3,000 tonnes. Finally, in 1967-'68, the imports reached the rock bottom of 136 tonnes valued at

Rs. 0.1 million (Anonymous, 1973). Since then there is no more large scale imports into India.

Export Situation

As regards exports, India was seen to export between 100 to 350 tonnes of arecanut annually till 1972-'73. With the birth of CAMPCO (Central Arecanut Marketing and Processing Cooperative Ltd.) the exports from India increased to 410 tonnes valued at Rs. 3.4 million in 1973-'74. During 1979-'80 the volume of export stood at 619 tonnes valued at Rs. 8.2 million. Index Numbers of the volumes of exports, export earnings and unit value reveal that the trend in export earnings is rising more than proportionately with the trend in volume of exports due to positive growth in unit value (Table 2).

The estimated compound growth rates of exports, export earnings and unit value of arecanut in India for the period 1970-'71 to 1979-'80 come to 12.07 per cent, 17.86 per cent and 5.17 per cent, respectively. However, the export of arecanut as percentage of its production in India between 1960-'61 and 1979-'80 comes to mere 0.15 to 0.37. India exports arecanut mostly to Nepal and under the existing situation, there is not much export potential for this commodity.

Trend in Wholesale Prices

The wholesale price of 'Mangalore Supari' (fully matured sundried husked arecanut) in Mangalore market was Rs. 2600/tonne in the year 1950. In the following year the price came down to Rs. 2450 due to the increase in imports by nearly 6000 tonnes and another increase in production by nearly 1000 tonnes. The

**Table 1. Index Numbers of Area, Production and yield of Arecanut in India
(Base : Triennium ending 1961-'62 = 100)**

Year	Area	Production	Yield	Year	Area	Production	Yield
1962-63	108	108	100	1972-73	163	161	99
1963-64	113	108	96	1973-74	170	182	108
1964-65	120	123	103	1974-75	173	179	104
1965-66	127	130	104	1975-76	163	174	108
1966-67	130	141	109	1976-77	157	179	116
1967-68	135	147	110	1977-78	157	190	122
1968-69	144	148	106	1978-79	164	198	121
1969-70	148	150	102	1979-80	168	207	124
1970-71	153	153	101	1980-81	170	208	124
1971-72	160	160	100				

**Table 2. Index Numbers of Exports, Export values and unit values of Arecanut in India
(Base : Triennium ending 1961-'62 = 100)**

Year	Quantity Exported	Export Earnings	Unit value	Year	Quantity Exported	Export earnings	Unit value
1962-63	68	83	120	1972-73	137	187	134
1963-64	60	70	116	1973-74	255	325	126
1964-65	134	143	106	1974-75	326	513	155
1965-66	219	274	123	1975-76	348	518	147
1966-67	137	187	135	1976-77	375	642	169
1967-68	163	219	132	1977-78	324	659	200
1968-69	210	295	139	1978-79	381	784	203
1969-70	140	200	141	1979-80	384	797	205
1970-71	157	232	146				
1971-72	181	263	143				

restricted import policy helped the price to rise by which the wholesale price was raised to Rs. 4600/tonne in 1960. With the absence of imports the prices further moved upwards and registered at Rs. 6600/tonnes in 1970. The prices again started declining from 1971 and became Rs. 4250/tonne in 1973. The factors such as increased supply and trade manipulations are attributed to the fall in the prices of arecanut in the early 70s. Towards the

middle of 1973, an organised marketing infrastructure was created under the co-operative sector for the main producing tracts of Kerala and Karnataka and with this the prices of arecanut started peaking up very fast such that in 1974 the price rise was 57 per cent over 1973 price. In 1980 the average wholesale price was Rs. 15087/tonne. Index Numbers of wholesale prices of processed arecanut show a uniform trend for different varieties

**Table 3. Index Number of Wholesale Prices of different varieties of Dried and Processed Arecanuts in wholesale markets
(Base : Triennium ending 1961 = 100)**

Year	Mangalore Supari	Sirsi Rashi	Shimoga Deshawaram	Trichur Choor	Trichur lylon
1962	102	112	110	115	119
1963	104	119	129	116	117
1964	116	92	106	111	116
1965	128	118	131	156	171
1966	126	147	161	158	156
1967	123	152	165	177	200
1968	138	123	156	163	166
1969	134	133	146	167	170
1970	138	157	176	207	188
1971	123	170	193	174	213
1972	94	100	132	140	162
1973	89	89	148	171	139
1974	139	129	141	179	187
1975	145	174	160	189	170
1976	157	171	192	216	173
1977	148	174	222	230	209
1978	162	171	237	250	207
1979	218	239	245	280	282
1980	269	334	—	321	279
1981	322	404	—	348	319

(Table 3). The Table indicates that the wholesale prices of arecanut in 1981 have gone up by three to four times over 1959-'62. The present level of arecanut price can be considered as quite remunerative.

Outlook

In India, arecanut is consumed as a masticatory and outside India it has almost no demand. Even within India the habit of chewing is slowly declining. However, the future of arecanut does not appear to be alarming as the industry is able to create

a market for the value added products, such as 'scented supari', and pan masala. Many attempts are being made to find out the alternate uses for arecanut and its by-products. Though this crop is raised in small homestead gardens, it provides enormous opportunity for maximising the farm income through high density cropping systems. Areca growers of 'Maidan' and 'Malnad' areas of Karnataka and 'Malabar' area of Kerala today find the mixed cropping of areca with banana, cardamom, pepper, cacao etc as one of the most paying concern particularly when the

cultivation of some of the traditional crops such as paddy and sugarcane is found to be uneconomic under the existing situation.

The production of arecanut in India by 2000 AD has been projected to be 3,50,000 tonnes based on the assumption that the compound growth rate of production for 70's would continue. In other words, one can anticipate a rise in production by 54 per cent from the present level of 1,91,000 tonnes within a period of 20 years. However, the constraint of the availability of suitable land for arecanut cultivation will not result in such a high

level of production as projected through the conventional model, but adequate planning as well as strategy are needed to create new demands for the product so that the supply does not dampen the arecanut market.

Acknowledgements

The author is grateful to Dr KV Ahamed Bavappa, Director, CPCRI and Dr EVV Bhaskara Rao, Scientist, Plant Breeding and Genetics, CPCRI, Kasaragod for their encouragement during the preparation of this paper.

References

ANONYMOUS, 1973. Report of the Committee constituted by the State Govt. of Mysore to study the Price Structure of Arecanut and other Allied Matters, Govt. of Mysore, Agri. and Forest Department, Bangalore, pp. 66.

ANONYMOUS, 1980. *Estimates of Area and Production of Principal Crops in India*, Directorate of Economics & Statistics, Ministry of Agriculture, Govt. of India, New Delhi, p 109.

ANONYMOUS, 1980. *Cocoa, Arecanut and Spices Statistics for 1969-80*, Directorate of Cocoa, Arecanut & Spices Development, Ministry of Agriculture, Govt. of India, Calicut, pp 7-16.

LAKSHMANACHAR, M. S., 1969. Sample Surveys and Its Role in the collection of Arecanut and Spices Statistics, *Arecanut and Spices Bull.* 1 (4), pp. 8-16.

An Analysis of Production and Productivity Trends of Arecanut in Different States in India

R. K. Sikka*

Abstract

A considerable increase has taken place in the area, production and productivity of arecanut in the country during the last two decades. The expansion of area was largely responsible for the increase in production during the sixties. In seventies production increased mainly due to improvement in productivity. Among the leading producing states, Karnataka and Assam showed a notable increase in area between 1967-'68 and 1980-'81, with impressive increase in area in the case of the latter. But in Kerala the area declined markedly. The study revealed an improvement in productivity in Kerala and Karnataka but a fall in the case of Assam. This is due to the reason that in Assam a large area has been brought under the crop during the last seven years.

Introduction

The importance of arecanut as a masticatory with or without betel leaves or as scented 'supari' hardly needs any emphasis. Present area under the crop in India is 1.84 lakh ha producing 1.91 lakh tonnes of arecanut. The crop plays an important role in the agricultural economy of the country. The production of arecanut in the country had an impressive pace during the last two decades. This was due to increase in area and productivity. The growth rate in production however, has not been uniform in the States.

Growth pattern - All India

Arecanut registered a compound growth rate of 4.3 per cent, 5.0 per cent and 0.1

per cent per annum in respect of area, production and productivity during the period 1961-'62 to 1970-'71 while the corresponding figures for the period 1971-'72 to 1980-'81 were 0.4 per cent, 2.9 per cent and 2.7 per cent. The increase in production during 1961-'71 was mainly due to area expansion while during 1971-'81 improvement in productivity was largely responsible for this.

The comparison of the growth pattern during the plan periods from 1956-'61 revealed that the area, production and productivity increased almost steadily. It was due to the concerted efforts made by the Government to augment the production that the acreage and productivity registered a higher rate of increase during the Third Plan period and afterwards. The increase in area, production and productivity during different plan periods is given in Table 1.

* Directorate of Cocoa, Arecanut and Spices Development, Calicut 673 005, Kerala

Table 1. Area, production and productivity of Arecanut in India during plans

Plan period/ Year	Area		Production		Productivity	
	'00oha	Percentage in- crease over the base period	'000 tonnes	percentage in- crease over the base period	Kg/ha	Percentage in- crease over the base period
II Plan						
1956 - 57 (base)	94.8	—	74.7	—	789	—
1960 - 61	113.0	—	95.5	—	844	—
1956 - 61	99.9	5.4	82.2	10.4	822	4.0
III Plan						
1961 - 62	115.9	—	97.1	—	838	—
1965 - 66	137.0	—	119.0	—	868	—
1961 - 66	125.1	32.0	105.3	41.1	841	6.6
Annual plan						
1966 - 67	142.1	—	130.1	—	915	—
1967 - 68	147.4	—	135.4	—	918	—
1968 - 69	157.0	—	139.7	—	890	—
1966 - 69	148.8	57.2	135.1	80.8	908	15.1
IV Plan						
1969 - 70	160.7	—	137.7	—	853	—
1973 - 74	184.4	—	167.4	—	907	—
1969 - 74	172.9	82.3	148.2	98.7	856	8.5
V Plan						
1974 - 75	189.2	—	164.7	—	870	—
1978 - 79	179.2	—	181.9	—	1015	—
1974 - 79	177.5	87.2	169.4	126.8	956	21.0
VI Plan						
1980 - 81	184.5	94.6	191.4	156.2	1037	31.4

Table 2. Change in the share of the Major arecanut producing states in the All India Area and Production

State	Percentage share in area		Percentage share in Production		Yield / ha (Kg)	
	1967 - '68	1980 - '81	1967 - '68	1980 - '81	1967 - '68	1980 - '81
	Kerala	51.6	33.0	30.5	27.8	543
Karnataka	23.7	29.4	40.0	41.4	1533	1459
Assam	17.9	27.5	19.5	26.0	1000	980
All India	100.0	100.0	100.0	100.0	918	1037

While the area under arecanut increased by 94.6 per cent since the beginning of the IIInd plan, the production went up by 156.2 per cent and the productivity increased by 31.4 per cent.

Growth Pattern in the States

Much of the contribution to the increase in output in the country was accounted for by two of the leading arecanut producing states of Karnataka and Assam. Between 1967-'68 and 1980-'81 arecanut production in Karnataka went up from 54,200 to 79,200 tonnes and in Assam from 26,400 to 49,800 tonnes. In Kerala, the other important arecanut producing state, the production which increased from 47,300 tonnes in 1967-'68 to 57,200 tonnes in 1974-'75 declined to 53,200 tonnes in 1980-'81. The compound growth rates of area, production and productivity of arecanut in the three states during the period 1967-'68 to 1980-'81 revealed that Assam had the highest growth rate of production (6.5 per cent) followed by Karnataka (4.7 per cent). The traditional arecanut producing state, Kerala had a growth rate of only 0.7 per cent per annum. The growth rate of area was also higher in Assam. The area in this State increased by 8.1 per cent per annum against 3.3 per cent in Karnataka. Area expansion was mainly responsible for the increase in production in Karnataka and Assam. In Assam the productivity fell by 0.7 per cent per annum. Poor performance in Kerala State with regard to output was due to fall in area. The productivity on the other hand improved by 3 per cent per annum which is an encouraging feature.

The data presented in Table 2 confirmed the mixed trend in area, production and productivity of arecanut in the states. The

share of Karnataka in All India output was 40.0 per cent during the year 1967-'68 and the share increased to 41.4 per cent during the year 1980-'81. Likewise the relative share of Assam went up from 19.5 to 26.0 per cent but that of Kerala reduced from 30.5 to 27.8 per cent. It would be seen from the table that there is a wide difference in respect of productivity (yield/ha) in the states. Average productivity during the year 1980-'81 was highest in Karnataka (1,459 kg/ha) followed by Assam (980 kg/ha) and Kerala (874 kg/ha). Lower productivity in Kerala is mainly due to the traditional management practices followed and the high incidence of Yellow Leaf-Disease.

Performance-Districtwise

It would perhaps be worthwhile to compare the performance of districts within each major arecanut producing state. The comparison of the data pertaining to various districts of the States at the end of last two plan periods viz., 1973-'74 and 1978-'79 showed that the area, production and productivity registered significant changes during this period.

Area

At the State level the area under arecanut during the period 1973-'79 recorded an increase of 52 per cent in Assam and 12 per cent in Karnataka. Eight out of 10 districts in Assam and 12 out of 16 districts in Karnataka registered a positive change. A relatively higher increase was indicated in Kamrup, Dibrugarh, Nowgong and Darrang districts in Assam, the extent varying from 46 to 128 per cent. South Kanara district which is the largest arecanut producing district in Karnataka registered an increase of 30 per cent. In Kerala state,

however, the area under the crop came down by nearly 31 per cent and all the districts contributed to its fall, the extent varying from 5 to 50 per cent.

Production

Pattern of change in production was more or less corresponding with the pattern of change in area. Assam, however, did exceptionally well. The state registered 42 per cent increase in production during the period 1973-'79 and 5 out of 10 districts contributed to the increase. Maximum increase was in Kamrup district where the production went up by 280 per cent. In Karnataka production improved in 8 out of 14 districts sharing the increase. However, in Kerala, 7 out of 11 districts contributed to the fall in the State's production. Maximum fall was in Quilon followed by Alleppey, Trivandrum and Kottayam.

Productivity:

Kerala State registered 32 per cent increase in productivity during the period 1973-'79. Seven out of 11 districts viz. Ernakulam, Trichur, Kozhikode, Cannanore, Malappuram, Palghat and Kottayam marked an increase. However, Kozhikode was the only district yielding above the All India average during the year 1978-'79. In both Karnataka and Assam the productivity recorded a marginal fall of about 6 per cent during the period. While in Karnataka 12 out of 14 districts were yielding more than the All India average, in Assam it was only in 2 out of 11 districts.

Due to considerable increase in arecanut production, the country has reached almost a level of self-sufficiency. Efforts therefore need be directed towards intensive cultivation only. There is scope for increasing productivity especially in Kerala and Assam as most of the districts in these States are yielding below the All India average.

A Study of Marketing of Arecanut in Jalpaiguri District of West Bengal

R. K. Singh* and M. M. Bhalerao**

Abstract

The study indicated that marketed surplus in arecanut accounted for about 96 per cent of the total production. It exhibited negative relation with the size of farm. Further, the arecanut producers received only 61 per cent of the price paid by the consumers while the price spread was 39 per cent of the consumers price. Items included in the price spread were commission, octroi, market fee, weighing and handling charges, storage charges, processing charges, transport charges, village traders' margin, wholesaler's margin and retailer's margin.

Introduction

India is the largest producer of arecanut in the world, with 1.83 lakh hectares of area and employing about 4 million persons in its production, processing and marketing. Until recently, India used to import large quantities of arecanut, such imports amounting to Rs. 26 crores during the period 1951-'60. However, India became self-sufficient in arecanut during the 70s. Marketing of arecanut in India suffers from a number of imperfections. It is, therefore, necessary to conduct micro-studies in various aspects of marketing of arecanut in India. The present study is an attempt in this direction.

Main objectives of the study are to analyse the pattern of disposal and marketed surplus of arecanut and to find out the price spread in arecanut for the sample

farmers. The details about the sample farmers and the period of study are given in the paper "Profitability of arecanut cultivation in Jalpaiguri areas" by the authors.

Results and Analysis

Disposal of arecanut

The study reveals that marketed surplus accounted for about 95 per cent of the total production of arecanut in the sample holdings and it exhibited positive relation with the size of farm. Around 52 per cent of the produce was sold in the village and this percentage declined with the increase in the farm size. Nearly 43 per cent of the produce was sold in the market, this percentage registering increase with the size of farm (Table 1).

Price spread for arecanut

Price spread (Table 2) refers to the difference between the price received by the producer and that paid by the consumer. It includes the cost of transport, storage,

* CPCRI Research Centre, Mohitnagar, West Bengal

** Institute of Agricultural Sciences, Banaras Hindu University, Varanasi

Table 1. Consumption and disposal of arecanut by sample farmers (Quintals per farm)

Sl. No.	Particulars	Size group			All farms
		Small	Medium	Large	
1.	H	0.34 (8.02)	0.43 (6.39)	0.37 (3.23)	0.35 (4.13)
2.	V	2.70 (63.68)	3.85 (57.21)	6.30 (54.92)	4.49 (52.95)
3.	M	1.20 (28.30)	2.45 (36.40)	4.80 (41.85)	3.64 (42.93)
4.	TP	4.24 (100.0)	6.73 (100.0)	11.47 (100)	8.48 (100.0)

H = Home Consumption V = Sold in Village
M = Sold in Market TP = Total Production
(Figures in parentheses indicate percentage to total production)

Table 2. Price spread in arecanut

Sl. No.	Particulars	Rs./quintal	Percentage
1.	Producer's price	800.00	61.07
2.	Commission	19.50	1.49
3.	Octroi	3.25	0.25
4.	Market fee	19.75	1.50
5.	Weighing and handling charges	6.50	0.50
6.	Storage charges	18.00	1.37
7.	Processing charges	65.00	4.96
8.	Transport charges	36.00	2.75
9.	Village trader's margin	115.00	8.78
10.	Wholesaler's margin	105.00	8.02
11.	Retailer's margin	122.00	9.31
12.	Consumer's price	1310.00	100.00

processing, handling and weighing commission, octroi, market fee, margins of the village trader, wholesaler and retailer. The arecanut producers in the area under this study received only 61 per cent of the price paid by the consumers, while the remaining 39 per cent of the consumers' price was spread over the marketing charges, commission and the related costs.

Conclusion

The above analysis reveals that the producer's share in the consumer's rupee for arecanut is quite low and there is considerable scope for increasing this share in favour of the areca growers. For this, cooperativisation of storage, transport, processing and marketing of arecanut needs to be done progressively as found in Karnataka and Kerala.

Arecanut Development in Karnataka State

G. N. Appaiah*

Abstract

The various development programmes undertaken by the Department of Horticulture in Karnataka have been discussed in the paper. Details on the adaptive research and development programmes carried out by the department are also given.

Introduction

Arecanut is one of the important commercial crops of Karnataka. The area under arecanut in the State is distributed over all the three regions, namely, coastal region, 'Malnad' region and 'Maidan' region. The major areca growing districts in the State are Dakshina Kannada, Tumkur, Shimoga, Uttara Kannada, Chikmagalur and Chitradurga, contributing to 75 per cent of the total area under the crop in the State. To some extent, it is also being grown in Hassan, Kodagu, Bangalore, Mysore, Dharwar and Mandya. Majority of the areca gardens in the state is holdings of less than one hectare.

Areca Development in the State

Prior to reorganisation of State, in Coorg at Ponnampet, an arecanut nursery was established with the main idea of supplying the quality planting materials to the growers. In the year 1958, at the assistance of the 'Indian Central Arecanut Committee', arecanut nursery scheme was started in the state of Karnataka and areca nurseries were established in all the important growing districts. During third

Five Year Plan period, a comprehensive scheme for arecanut development in the State was sanctioned with the objective of enhancing production and to increase the area by supplying quality seedlings, advocating application of fertilizers and adoption of plant protection measures and rendering technical know-how to the growers regarding improved package of practices. After the creation of new major department of Horticulture in the State during the year 1963, arecanut crop was given due importance and more intensive approach for the development was taken up.

Considering the financial requirement for establishing the areca plantation and also the long gestation period, a special areca development scheme with the financial assistance of ARDC was introduced in the State during the year 1966, covering all the major areca growing districts. Under this programme, a sum of Rs. 5,000/acre was given as long term loan. This has helped particularly small and marginal farmers to take up areca cultivation in a scientific manner. It was envisaged to develop 2000 acres under this scheme and an area of 2151 acres was

* Department of Horticulture, Lalbagh, Bangalore, Karnataka.

covered by way of sanctioning loan and development by the end of 1973.

During the winter of 1970, cold wave damaged the areca gardens in different districts of the State. The damage was very severe and nearly 30 per cent of the crop was affected. The Department took up immediate effective measures to revive the affected areca palms, by launching intensive extension work. As a result, most of the damaged gardens were recovered remarkably without much loss in production. Due to various development programmes taken up in the State, the production of arecanut was considerably increased and the country which was importing arecanut, became self-sufficient.

As a policy of Government of India not to encourage any fresh planting of areca, the State has discontinued the special areca development scheme for financing fresh areca cultivation and also discontinued the large scale nursery programme. To take up gap filling in the old gardens, one lakh of seedlings are being raised every year.

In order to avoid the crisis caused due to sudden fall in price of areca during 1970-'71, the Department took immediate measures through its extension wing to create confidence among the growers by introducing intercrop cultivation in areca gardens with cacao, pepper, betelvine, etc. A number of demonstrations were laid out in growers field. ARDC Schemes for financing inter crops like cacao and pepper were introduced and they became very popular. Further, the terms and conditions of financing short term credit for the purchase of inputs to areca was liberalised. All these measures helped the growers for proper maintenance of their gardens.

Disease management

Yellow Leaf Disease

A survey was conducted by the Department of Horticulture and an area of 160

acres was estimated to have been affected. A project proposed for Research on the above disease has been sent to Government for approval. The University of Agricultural Sciences, Bangalore has prepared a technical programme for the operational research on the above problem at Koppa, Sringeri and N.R. Pura in Chikmagalur district to identify the cause of the disease. Treatments have been started since 1981 and are being continued.

A New Disease on Areca

Arecanut palms in Sagar taluk of Shimoga district are found to be affected by a new disease. This disease is causing a quick decline of productive palms. The exact cause of the disease is yet to be identified. An expert committee consisting of Scientists of UAS and officers of the Department of Horticulture, has been formulated to study the problem. A field trial had been initiated for disease control in a few gardens and the results are awaited.

Marketing

The important marketing centres in the State are Sirsi, Mangalore, Shimoga, Sagar, Siddapur, Kumta and Tumkur. These have been brought under regulated market perview. During 1970, when there was a sudden fall in price of arecanut, it made the Government to think seriously to organise a marketing federation to help the growers in marketing their produce and to help them to come out of the clutches of the middlemen. Accordingly, Kerala and Karnataka State Governments jointly sponsored the co-operative Federation known as CAMPCO. This venture has resulted in a great success in maintaining a proper market for arecanut.

A Study on the Progress of CAMPCO and its Impact on Arecanut Sector in Karnataka and Kerala⁺

Prafulla K. Das*

Abstract

The main objective of CAMPCO is to improve the economic condition of the arecanut farmers by correcting market disabilities. The analysis of the price per unit of arecanut realised by the farmers in the pre-CAMPCO and post-CAMPCO periods depicts that the co-operative marketing channels have offered better price to the arecanut growers. CAMPCO provides many facilities to the arecanut growers of Karnataka and Kerala. These facilities are found to motivate the producers for adoption of certain scientific crop management practices. As a result of this, the average yield of arecanut per hectare tends to increase in the areas served by CAMPCO. Both the physical and financial growth of CAMPCO reveal that this organisation has induced significant desirable changes in arecanut programmes in the region.

Introduction

Arecanut is a small holder crop and it holds a unique place in the rural economy of Karnataka and Kerala. During the mid 50s and '60s an intensive drive was made by the Government agencies through the R & D support, to increase arecanut production with a view to achieve self sufficiency in the commodity. Consequently, the trend in arecanut production started steadily rising and almost doubled in 1970-'71 over the 1956-'57 level. However, due to lack of adequate attention on marketing aspects, arecanut price fluctuated significantly over the years and then began to decline persistently from 1971. The decline came to as much as 36 per cent in mid-1973 from

the 1970 price level as there was no effective organisation to protect the farmers from the exploitation of the middlemen.

The Government of Karnataka constituted a Committee in September 1972 under the Chairmanship of Sri T. T. Paulose to examine the problems of arecanut cultivation and marketing and suggest ways and means to have agency for marketing of the commodity. The Committee submitted its report to the Government in March 1973 recommending the formation of a central organisation to procure, process and market arecanut. In the meantime, a large number of growers and co-operators came forward with the proposal to organise a central agency for marketing in co-operative sector. This was accepted by the Governments of Karnataka and Kerala and

* Central Plantation Crops Research Institute,
Kasaragod 670 124, Kerala

+ CPCRI Contribution No. 228

accordingly the Central Arecanut Marketing and Processing Co-operative Limited (CAMPCO) was registered in July 1973 under section 7 of the Karnataka Co-operative Societies Act of 1959 read with section 4 (2) of the Multi - Unit Co-operative Societies Act of 1942.

An attempt has been made by the researcher to review the progress of CAMPCO to assess its economic impact in arecanut sector of Karnataka and Kerala States.

Materials and Methods

The data on the memberships, shares, share capital of CAMPCO, maximum credit limit, profits and procurement of arecanut concerning to CAMPCO were collected from the Head office of CAMPCO. The wholesale prices of arecanut were collected from the Agricultural Produce Market Committees of Karnataka while the farm prices of arecanut for Kerala was obtained from the Directorate of Economics and Statistics, Kerala. The productivity of arecanut for different states was computed from the published data of the Directorate of Economics and Statistics, Ministry of Agriculture, Government of India.

The scope of the paper is limited to the impact at the macro level.

Results and Discussion

Growth in the membership and shares of CAMPCO

CAMPCO has four classes of membership.¹

As regards the growth in the membership in the CAMPCO, 'A' class membership has gone up from 251 to 396, 'B' class

from 3 to 9 and 'C' class from 3264 to 13446 between 1973-'74 and 1980-'81. In other words there is an annual growth at the rate of 8 per cent in case of 'A' class, 30 per cent in case of 'B' class and 45 per cent in case of 'C' class membership of this Co-operative Organisation. The growth in all the three categories is more pronounced in Kerala as compared to Karnataka. (The reduction in growth rate of 'A' class membership of Karnataka was due to the amalgamation of the Societies). This could suggest that Kerala has been able to derive larger benefits from the CAMPCO than that of Karnataka.

The study further shows that the growth in the shares of all the four categories including the 'D' class is more than the growth in the membership. Between 1973-'74 and 1980-'81 the 'A' class share increased by 409 per cent, 'B' class by 578 per cent, 'C' class by 435 per cent and 'D' class by 178 per cent. However, the increase in 'A', 'C' and 'D' class shares were proportionately more in Kerala than that of Karnataka. The classwise distribution of average number of shares per member reveals the overall trend of the Organisation (Table 1).

- ¹ i) 'A' class: Open to Agricultural Produce Co-operative Marketing Societies and Agricultural Co-operative Credit Societies in the areca growing areas of the two States. (One 'A' class share Rs. 1000/-)
- ii) 'B' class: Open to commercial and Co-operative Banks operating in the two States (One 'B' class share Rs. 1000/-)
- iii) 'C' class: Open to individual growers of arecanut in the two States (One 'C' class share Rs. 100/-)
- iv) 'D' class: Open to State Governments of Karnataka and Kerala (One 'D' class share Rs. 1000/-)

Table 1. Trend in Average Number of Shares Per Member in CAMPCO

Year	KARNATAKA				KERALA				TOTAL			
	A	B	C	D	A	B	C	D	A	B	C	D
1973-74	5.3	50.5	2.0	3750	2.1	25.0	1.3	3750	4.8	42.0	1.9	7500
1974-75	6.4	50.5	1.9	3750	1.9	25.0	1.3	3750	5.4	42.0	1.8	7500
1975-76	9.8	50.5	1.9	5750	1.9	25.0	1.3	3750	7.9	42.0	1.8	9500
1976-77	11.9	106.5	1.9	7350	2.1	22.5	1.3	4250	9.4	64.5	1.8	11600
1977-78	12.0	145.2	1.9	7950	1.8	39.0	1.3	4250	7.7	98.0	1.8	12200
1978-79	17.8	145.2	1.9	7950	2.5	36.8	1.3	4700	10.8	97.0	1.8	12650
1979-80	17.9	145.2	2.0	7950	2.6	34.5	1.5	7700	10.8	96.4	1.9	15650
1980-81	25.5	145.2	2.7	9879	3.9	32.3	2.1	11000	15.4	95.0	2.4	20879

Table 2. Yearwise Profits of CAMPCO (Million Rs)

Year	Gross Profit	% change	Cumulative G.P.	Net Profit	% change	Cumulative N. P.
1973-74	0.732	—	0.732	0.101	—	0.101
1974-75	2.622	258.0	3.354	0.203	100.1	0.304
1975-76	5.514	110.2	8.868	1.193	487.7	1.497
1976-77	8.512	54.3	17.380	0.252	(—) 78.9	1.749
1977-78	5.610	(—) 34.1	22.990	(—) 3.037	(—) 1105.2	(—) 1.288
1978-79	13.047	132.5	36.037	5.338	175.8	4.050
1979-80	16.381	25.5	52.418	4.106	(—) 23.1	8.156
1980-81	22.074	34.7	74.492	4.140	0.8	12.296

The growth patterns under the study reveal that not only the areca growers of the twin CAMPCO states but also both the state governments, financial institutions and the village societies in the region have bestowed tremendous faith and confidence in the affairs of CAMPCO.

Growth in the credit worthiness of CAMPCO

Another way of critically evaluating the performance of a commercial institution is in terms of the growth in the bankability of an organisation as an indicator of its soundness of the economic health. In this respect, the maximum credit limit of CAMPCO is found to be increasing from Rs. 12.5 million in 1973-'74 to Rs. 125 million in 1981-'82. This trend could suggest that CAMPCO's performance is on sound footing since the investment in the

arecanut trade is increasing year after year to cope up with the expectations of the areca growers in the participating states.

Growth in the profits of CAMPCO

Unlike many of the co-operative organisations CAMPCO has been able to make a sizeable net profit after fulfilling its desired objectives. In its history of eight years, only in one year (1977-'78) CAMPCO incurred a loss to the tune of Rs. 3 million. In the following successive years the net profit ranged between Rs. 4.1 million to Rs. 5.3 million. The cumulative net profit at the end of 1980-'81 stood at Rs. 12.3 million (Table 2). Being set up in the co-operative sector CAMPCO is not expected to make a huge profit as its ultimate goal is to render the services to the areca growers for improving their lot.

Keeping this in mind one can feel highly satisfied with the business record of CAMPCO.

Growth in the procurement of arecanut by CAMPCO

The CAMPCO attempts to stabilise the arecanut price by manipulating the procurement operations. When the price starts declining due to excess supply, CAMPCO increases its procurement and holds the stock in order to cut down the supply. Similarly, when the price starts rising in a big way due to short supply, CAMPCO reduces its procurement and simultaneously releases the stock to enhance the availability of the commodity in the open market. However, CAMPCO always influences the arecanut market in such a way that the price of this commodity moves along with the general trend with a view to maintaining parity with the other essential commodities.

In the first year of its establishment, the procurement of arecanut by CAMPCO over a period of seven months was of the order of 5000 tonnes. In the year 1980-'81 it was 24,000 tonnes - a rise by 380 per cent in a small period of seven years. By any standards, this performance is commendable. The cumulative volume of procurement of arecanut by CAMPCO for seven and a half years comes to nearly 1,27,000 tonnes (Table 3).

Assuming a marketed surplus of arecanut at the rates of 87 per cent and 92 per cent for Karnataka and Kerala, respectively, the total marketed surplus for these two states were estimated from the total production figures and the shares of the CAMPCO in the procurement of the commodity for

different years were worked out. According to this exercise, the procurement of arecanut by CAMPCO as percentage of the marketed surplus in CAMPCO States has gone up from 4.4 in 1973-'74 to 20.3 in 1980-'81 (Table 4).

Trends in Arecanut prices

For studying the arecanut price situation in the post CAMPCO period, the Index Numbers of the wholesale prices of some of the important varieties of arecanut of this region were constructed taking 1972-'73 as the base year. It is interesting to observe that in the case of 'Mangalore Choll' (old stock) as well as 'new', 'Sagar red' as well as 'white', and 'Shimoga Bette' varieties the price trends were uniform and stable. The rise in the prices of these varieties was between 323 to 360 per cent in 1980-'81 from the 1972-'73 level (Table 5).

Similarly, the farm gate price of arecanut in Kerala rose steadily from 1973-'74 and became 212 per cent higher in 1980-'81 over the 1972-'73 farm price level (Table 5). A comparison between the price trends in the pre and post CAMPCO periods would clearly indicate that the setting up of CAMPCO has resulted in an effective stabilisation of arecanut market and has offered the most reasonable price incentive to the areca growers of the region.

Trends in the productivity

Index numbers on the productivity of arecanut were computed simultaneously for the CAMPCO States and non-CAMPCO States taking triennium ending 1973-'74 as the base (Though the CAMPCO came into the existence during 1973-'74 its developmental activities concerning the

Table 3. Procurement of Arecanut by CAMPCO

Year	Procurement Qty. ('000Tonnes)	% change	Cumulative Qty. ('000Tonnes)	Procurement value (million Rs.)	Cumulative value (million Rs.)	Unit value	% change
1973-74	5.0	—	5.0	35.9	35.9	7180.00	—
1974-75	8.1	61.2	13.1	56.7	92.6	7090.00	(—) 2.5
1975-76	11.2	37.5	24.3	79.1	172.4	7125.00	1.8
1976-77	17.7	58.3	42.0	133.9	306.3	7564.97	6.2
1977-78	19.4	9.6	61.4	145.7	452.0	7510.31	(—) 0.7
1978-79	19.0	(—) 1.7	80.4	192.2	644.2	10115.79	34.7
1979-80	22.5	17.8	102.9	275.0	919.2	12222.22	20.8
1980-81	24.0	6.5	126.9	379.6	1298.8	15816.67	29.4

Table 4. Procurement of Arecanut by CAMPCO as percentage of the Estimated marketed surplus in Karnataka and Kerala

Year	Marketed Surplus* ('000 Tonnes)	Procurement by CAMPCO ('000 Tonnes)	Col. 3 as % of Col. 2
(1)	(2)	(3)	(4)
1973-74	114.4	5.0	4.4
1974-75	110.0	8.1	7.4
1975-76	104.3	11.2	10.7
1976-77	105.2	17.7	16.8
1977-78	109.7	19.4	19.8
1978-79	113.3	19.1	16.8
1979-80	113.5	22.5	19.8
1980-81	117.8	24.0	20.3

* Assumption. For Karnataka 87% and Kerala 92% of total production of nuts.

productivity of the crop obviously began from 1974-'75. Thus, the first year of the CAMPCO was included in the base period in order to assess the post CAMPCO situation on the yield of arecanut).

The analysis reveals that in the case of CAMPCO States there were rising trends in the productivity during the post CAMPCO years, Karnataka having a marginal rise whereas Kerala having a significant increase. But in the non-CAMPCO States, barring Tamil Nadu where the increase was very substantial at the same time highly

fluctuating, in Andhra Pradesh and West Bengal there was no change in the productivity, in Assam there was some decline, in Maharashtra there was slight increase for a few years and there was sudden decrease in the productivity (Table 6). In other words, the promotional activities of CAMPCO such as the supply of fertilisers and pesticides besides assured and better price for the produce, has motivated the arecanut growers of Karnataka and Kerala to modernise their farming. The neighbouring State of Tamil Nadu had the benefit of the spread effect and thus it is the only

Table 5. Index Numbers of the wholesale prices of Arecanut in Karnataka Markets and Farm Prices of Kerala State. (Base year : 1972-'73 = 100)

Year	Index Numbers of Wholesale Prices					Index Numbers of Farm Prices in Kerala
	Mangalore		Sagar		Shimoga	
	Choll	New	Red	White	Bette	
1973-74	151	158	142	173	146	127
1974-75	181	170	200	176	196	140
1975-76	185	186	197	189	223	158
1976-77	199	190	208	203	220	185
1977-78	193	208	218	215	210	170
1978-79	255	275	293	311	296	221
1979-80	323	326	353	352	331	253
1980-81	425	423	446	460	449	312

Table 6. Trends in the Productivity of Arecanut in Major Arecanut Growing States (Base : Triennium ending 1973-'74)

Year	Karnataka	Kerala	Tamil Nadu	Andhra Pradesh	West Bengal	Assam	Maharashtra	All India
1974-75	100	100	183	100	100	96	108	101
1975-76	104	101	172	100	100	89	102	105
1976-77	106	113	125	100	100	98	106	112
1977-78	106	133	148	100	100	95	108	119
1978-79	107	132	144	100	100	89	93	118
1979-80	107	135	146	100	100	89	97	120
1980-81	107	142	146	100	100	91	93	120

Table 7. Estimated Average Productivity of Arecanut in Major Arecanut Growing States in two periods (kg/ha)

States	Average for 1969-'70 to 1973-'74	Average for 1974-'75 to 1978-'79	% change
Karnataka	1323	1424	7.6
Kerala	617	713	15.6
Tamil Nadu	564	739	31.0
Andhra Pradesh	1000	1000	0.0
West Bengal	258	258	0.0
Assam	1085	1010	(-) 7.0
Maharashtra	1313	1330	(-) 1.2
India	856	955	16.3

non - CAMPCO State which could achieve the increase in the productivity during the recent years.

Similar trends were noticed when the five yearly average yields for the pre and post CAMPCO periods for different States were worked out and compared (Table 7). However, this Table indicates that the yield level in the case of Karnataka was more than double the yield levels of Kerala and Tamil Nadu during the pre - CAMPCO period. This explains the relatively smaller rise in the productivity of Karnataka as compared to Kerala and Tamil Nadu in recent years. The creation of the organised market infrastructure for arecanut through CAMPCO has contributed maximum to the higher rate of growth in the productivity of arecanut in Kerala, though its average productivity is still much lower than Karnataka even today. In Kerala, the market conditions were worse than Karnataka in the pre - CAMPCO years. 'Chalissery' variety of arecanut which was usually fetching earlier 25 per cent less price than Mangalore supari, after the formation of CAMPCO, could fetch almost the same price as that of the latter. This price incentive coupled with the other favourable factors encouraged the arecanut growers of Palghat, Malappuram and Trichur Districts of Kerala to undertake crop improvement programmes in the post-CAMPCO period. As a result of the

favourable trade climate and economic gains, new plantations started coming up. For example, Idikki District in Kerala has turned out to be a major arecanut growing area in the last few years with a lot of new plantations. Even in some parts of Cannanore District a substantial area has been covered by new arecanut gardens, which promise higher productivity during the years to come.

The study shows that remarkable progress has been made by CAMPCO in stabilising the arecanut market in Karnataka and Kerala. Besides arecanut, CAMPCO has undertaken the procurement of cocoa since late 1980 with a view to avoiding a big crisis in cocoa sector. CAMPCO is making vigorous efforts to manufacture cocoa powder, cocoa butter, cocoa mass, cocoa liquor, enrobed chocolates, instant cocoa and other confectionery items in its proposed plant at Puttur near Mangalore in order to offer better price to the cocoa growers who generally grow cocoa as a mixed crop with arecanut and coconut.

Acknowledgements

The author expresses his thanks to Dr KV Ahamed Bavappa, Director, CPCRI, Dr RD Iyer, Head, Division of Genetics, CPCRI, Kasaragod and Shri Varanashi Subraya Bhat, Chairman, CAMPCO, Mangalore for their encouragements during the preparation of this paper.

References Consulted

ANONYMOUS, 1973. *Bye Laws*, The Central Arecanut Marketing and Processing Co-operative Limited (CAMPCO), Mangalore

ANONYMOUS, 1971-'81. *Annual Reports*, The Central Arecanut Marketing and Processing Co-operative Limited (CAMPCO), Mangalore

ANONYMOUS, 1982. *Project Report for the year 1982-'83*, The Central Arecanut Marketing and Processing Co-operative Limited (CAMPCO), Mangalore

Discussions:

C K George:

The aim of CAMPCO is to assure a reasonable price to the grower. To achieve this goal to what extent it should go on increasing the purchase?

P K Das:

The procurement by CAMPCO of the order of 25 to 30 per cent will stabilise the price. It is always desirable to allow healthy competition by the private traders.

Profitability of Arecanut Cultivation in Jalpaiguri Area of West Bengal - A Sample Study

M. M. Bhalerao* and R. K. Singh**

Abstract

The profitability of arecanut cultivation in Jalpaiguri was evaluated with the help of four techniques widely used in project evaluation. The study revealed that arecanut cultivation was profitable in the region and there was no need to replant any of the gardens from the samples. Among the three size groups of arecanut gardens, the large size-group i. e., with an area of 0.69 ha under arecanut was the most profitable size of arecanut garden in the region.

Introduction

Investigations into the productivity or cost and returns in arecanut in India, conducted by various agencies, have been based mostly on the traditional concepts and techniques without considering the time element, which must be taken into consideration in view of the longer gestation period required by arecanut. The present study was planned with an objective to analyse the profitability of arecanut cultivation, to determine the replacement time of arecanut palms and the most profitable size of arecanut garden.

Materials and Methods

The study is based on the data collected from a stratified random sample of 190 arecanut growers-50 small (2 ha and below), 67 medium (above 2 ha to 4 ha) and 73

large (above 4 ha) - selected from thirty seven panchayats of seven blocks in Jalpaiguri district, West Bengal. Data were collected by survey method for a period of two years, 1978-'79 and '1979-'80.

The time element in the calculation of cost and returns has been taken care of by evaluating the profitability of arecanut gardens with the help of the four major techniques widely used in the project evaluations.

Pay Back Period (PBP)

$$t^* \sum_{t=1}^{t^*} Ct < \sum_{t=1}^{t^*} Rt$$

Where:
Rt = Return in period t
Ct = Cost in period t

Net Present Value (NPV)

$$NPV = \sum_{t=1}^T \frac{Rt - Ct}{[1+i]^t}$$

Where
i = discount rate
T = number of years

Internal Rate of Return (IRR)

$$\sum_{t=1}^T \frac{Rt - Ct}{[1+r]^t} = 0$$

* Institute of Agricultural Sciences, Banaras Hindu University, Varanasi

** CPCRI, Research Centre, Mohitnagar, West Bengal

Benefit Cost Ratio (BCR)

$$BCR = \frac{\sum_{t=1}^T \frac{R_t}{[1+i]^t}}{\sum_{t=1}^T \frac{C_t}{[1+i]^t}}$$

Results and Analysis

(1) Pay Back Period (PBP)

The PBP ranged from 8.7 years to 9.5 years which was less than the maximum

pay back period (10 to 12 years) desired by the sample growers. Hence, according to the criterion of PBP, arecanut cultivation was profitable (Table 1).

(2) Net Present Value (NPV)

The NPV at 10 per cent discount rate ranged from Rs. 47,874 for medium farmers to Rs. 54,420 for large farmers. Even at higher discount rate of 12 per cent, NPV ranged from Rs. 32,507 for medium farmers to Rs. 35,052 for large farmers. These values of NPV were positive and

Table 1. Measures of profitability (investment worth) in arecanut (n=4)

Sl. No.	Particulars	Size group			All farms	
		Small	Medium	Large		
1.	Pay back period [Years]	8.7 [I]	9.5 [III]	9.20 [II]	9.3	
2.	Net Present Value [NPV] Rs.	10%	50876 [II]	32507 [III]	54420 [I]	21253
		12%	34956 [II]	32507 [III]	35052 [I]	34599
3.	Internal Rate of Return [IRR] %	24.8 [I]	24.4 [II]	24.6 [II]	24.74	
4.	Benefit Cost Ratio [BCR] at	10%	2.4 [II]	2.3 [III]	2.5 [I]	2.411
		12%	2.2 [I]	2.0 [III]	2.1 [II]	2.1

Figures in parentheses indicate ranks

Table 2. Average annual returns for arecanut (Rs. / ha)

Sl. No.	Particulars	Size group			All farms	
		Small	Medium	Large		
1.	Net Present Value	A ₁ at 10%	50786	47874	54420	51253
		A ₂ at 12%	34956	32507	35052	34576
		2.	Present value of annuity of rupee one for 40 years	B at 10%	9.779	9.779
C at 12%	8.244	8.244		8.244	8.244	
3.	Average Annual Return	i] at 10%		$\frac{50786}{9.779}$	$\frac{47974}{9.779}$	$\frac{54420}{9.779}$
		A ₁ / B =	5193.374	4895.592	5564.986	5241.128
		ii] at 12%	$\frac{34956}{8.244}$	$\frac{32507}{8.244}$	$\frac{35052}{8.244}$	$\frac{34576}{8.244}$
		A ₂ / C =	4240	3943	4252	4198

quite high. Hence, according to this criterion, arecanut cultivation was profitable (Table 2).

(3) Internal Rate of Return (IRR)

The IRR ranged from 24.4 per cent for medium farmers to 24.8 per cent for small farmers. It was much greater than the cost of borrowing capital, which ranged from 9 per cent to 14 per cent, for borrowings from co-operatives and commercial banks in the region. Thus, according to this criterion, arecanut cultivation was profitable (Table 1).

(4) Benefit Cost Ratio (BCR)

The BCR at 10 per cent discount rate ranged from 2.3 for medium farmers to 2.5 for large farmers. Even at higher rate of discount of 12 per cent, it ranged from 2.0 for medium farmers to 2.2 for small farmers. In all the size groups, it was greater than unity. Hence, according to this criterion also, arecanut cultivation was profitable (Table 1).

Replacement period

The average annual returns (AAR) help us in determining the replacement period of arecanut palms. AAR is Computed as follows:

$$\text{AAR} = \frac{\text{NPV}}{\text{Present value of annuity of Re. 1 for n years}}$$

In the case of arecanut 'n' is taken as 40 years.

The AARs computed at 10 per cent and 12 per cent discount rate indicate that so long as net returns (revenue - cost) per ha are greater than Rs. 4240 for small farmers, Rs. 3943 for medium farmers and Rs. 4252 for large farmers, the arecanut gardens do not require replacement. Thus, on this basis, no arecanut garden of the sample farmers need to be replanted at this stage since none of the sample gardens reported net returns (up to 40 years of age) below the AARs computed above (Table 2).

Most profitable size of arecanut garden

From all the measures of profitability given in Table 1, it is clear that the large size gardens rank first, followed by small size and medium size gardens. The average size for small farmers was 1.34 ha, for medium farmers 2.97 ha and for large farmers 6.65 ha, whereas the average size of arecanut garden for small farmers was 0.22 ha, for medium farmers 0.36 ha and for large farmers 0.69 ha. Thus among these three size groups of arecanut gardens, the large size group, i.e., with an average area of 0.69 ha under arecanut, was the most profitable size of arecanut garden in the region.

Conclusion

The above analysis reveals that the profitability of arecanut cultivation in the Jalpaiguri region is quite high.

Profitability of Arecanut Cultivation in Dakshina Kannada District (Karnataka)

R. K. Singh*, K. S. Bhat** and M. Vijayarajan

Abstract

The analysis revealed that arecanut cultivation was highly profitable in the region. Replanting need be done only after the age of twenty one years. Capital invested in arecanut cultivation took only seven years to recover from its return.

Introduction

The purpose of this paper was to analyse the profitability of arecanut cultivation and to determine the replanting time of arecanut gardens in the region.

Materials and Methods

The data for the present study were obtained from Central Plantation Crops Research Institute, Regional Station, Vittal, Dakshina Kannada, Karnataka for the period 1957-'58 to 1977-'78 (i. e., 1st year of plantation to 21st year). Universally used standard techniques of project evaluation such as PBP, NPV, IRR and BCR were applied in the analysis of data.

The agewise cost and return data presented in Table 1 were used to compute the various measures of investment worth. The results are given in Table 2. Since the

net present value and the benefit cost ratio are functions of the discount rate and are negatively related to discount rate, these measures were obtained separately for two discount rates viz., 10 per cent and 12 per cent as the opportunity cost of capital could vary from 8 to 15 per cent in India (Gittinger, 1976).

Results and Discussion

Pay Back Period (PBP)

Since no information is available on the maximum Pay Back Period desired, not much can be said about the worthwhileness or otherwise of arecanut cultivation on the basis of the criterion of the Pay Back Period. It can be only said that Pay Back Period obtained in this situation (7 years) was not more and arecanut cultivation was highly profitable.

Net Present Value (NPV)

The net present value obtained at 10 and 12 per cent discount rates were Rs. 38,924 and Rs. 29,771 / ha, respectively. These values of NPV were positive and quite

* Central Plantation Crops Research Institute
Research Centre, Mohitnagar 735 101 West
Bengal

** Central Plantation Crops Research Institute,
Regional Station, Vittal 574 243, Karnataka

Table 1. Costs and Returns of Arecanut (Rs / ha)

Age in years	Undiscounted			Discount Factor		Discounted			
	Costs [C]	Returns [R]	Cash flow [R-C]	10%	12%	Costs		Returns	
						10%	12%	10%	12%
1	3205	—	[—] 3205	.909	.893	2913	2862	—	—
2	3521	—	[—] 3521	.826	.797	2908	2806	—	—
3	2958	—	[—] 2958	.751	.712	2221	2106	—	—
4	3665	—	[—] 3665	.683	.636	2503	2331	—	—
5	3096	—	[—] 3096	.621	.567	1923	1755	—	—
6	4122	8899	4777	.564	.507	2293	2090	5019	4512
7	3615	17645	14030	.513	.452	1854	1634	9052	7976
8	5493	17817	12324	.467	.404	2565	2219	8321	7189
9	4458	17494	13036	.424	.361	1890	1609	7417	6315
10	5162	15609	10447	.386	.322	1993	1662	5978	5026
11	4471	13648	8877	.350	.287	1670	1369	4777	3917
12	5044	14059	9015	.319	.257	1609	1296	4485	3613
13	6102	15802	9700	.290	.229	1770	1397	4583	3619
14	6180	16594	10404	.263	.205	1628	1269	4364	3402
15	7320	14217	6897	.239	.183	1749	1340	3398	2602
16	7088	16920	9832	.218	.163	1545	1155	3689	2758
17	6635	17021	10386	.198	.146	1314	969	3370	2485
18	6394	20501	14107	.180	.130	1151	831	3690	2665
19	6093	14404	8311	.164	.116	1018	707	2362	1671
20	8492	21960	13468	.149	.104	1265	883	3272	2284
21	7900	29600	21700	.135	.093	1067	735	3996	2753
Total	111324	272190	160866			38849	33025	77773	62796

Table 2. Measures of Profitability (Investment worth) in Arecanut (n=21)

Sl. No.	Particulars	Results
1.	Pay Back Periods [years]	7
2.	Net Present Value [NPV] at 10%	38924
	[Rs/ha] at 12%	29771
3.	Internal Rate of Return [IRR]	29.32
4.	Benefit Cost Ratio [BCR] at 10%	2.001
	at 12%	1.901

Table 3. Average Annual Returns for Arecanut (n=21) (Rs/ha)

Sl. No.	Particulars		
1.	Net Present Value [NPV]	A ₁ — at 10%	38,924
		A ₂ — at 12%	29,771
2.	Present value of annuity of rupee one for 21 years	B — at 10%	8.65
		C — at 12%	7.56
3.	Average Annual Return	[i] at 10% $A_1/B = \frac{38924}{8.65} =$	4500
		[ii] at 12% $A_2/C = \frac{29771}{7.56} =$	3937

high. Hence, according to criterion of NPV arecanut cultivation was profitable in the region.

Internal Rate of Return (IRR)

The internal rate of return was found to be 29.32 per cent. It was much greater than cost of borrowing the capital which ranged from 10 to 18 per cent. Thus according to the criterion of IRR arecanut cultivation was highly profitable.

Benefit Cost Ratio (BCR)

The benefit cost ratio at 12 per cent discount rate was 1.9. It was greater than unity and hence according to the criterion of BCR also arecanut cultivation was profitable in the region.

Replacement period

The average annual return (AAR) helps us in determining the replacement period of arecanut palms. It can be computed by

dividing the NPV by the present value of an annuity of rupee one over the life of the project. At a discount rate of 10 per cent, the present value of rupee one received at the end of each period of 21 years is Rs. 8.65 and at 12 per cent discount rate it is Rs. 7.56. The study reveals that so long as net return is greater than Rs. 3,937/ha, the garden should not be replanted. In other words, old arecanut palms should not be replaced by new seedlings until net returns do not fall below Rs. 3,937/ha (Table 3).

In the absence of studies on alternative uses of land and other resources, not much can be said about the comparative advantage of arecanut cultivation. All that can be said is that so long as the alternative uses do not fetch as much NPV, IRR or/and benefit-cost ratio as promised by arecanut cultivation, arecanut cultivation is relatively profitable.

References

GITTINGER, J. B. 1976. Economic Analysis of Agricultural Projects, EDI, I. R. B. D. reprinted by A. R. D. C., Bombay. pp. 66-68.

GITTINGER, J. P. 1976. Compounding and Discounting Tables for Project Evaluation, I. B. R. D. pp. 20-25.

An Evaluation of Investment in Areca Gardens in Dakshina Kannada District, Karnataka⁺

E. Krishnaraja and J. V. Venkataram*

Abstract

The small, medium and large areca growers required Rs. 30,505, Rs. 30,085 and Rs. 28,864 per hectare respectively to establish areca gardens. The total cost of maintenance till the bearing age of areca (7th year) was Rs. 17,203, Rs. 14,912 and Rs. 13,642 per hectare in small, medium and large gardens, respectively. The per hectare annual operational cost of bearing areca gardens was Rs. 7,485, Rs. 7,031 and Rs. 7,710 for small, medium and large farmers respectively. The annual net returns per hectare were Rs. 16,436 in small, Rs. 18,370 in medium and Rs. 21,975 in large gardens.

The evaluation of investment in areca gardens at fifteen per cent discount rate indicated a per hectare net present worth of Rs. 18,164 in small, Rs. 22,157 in medium and Rs. 25,999 in large gardens. The discounted benefit cost ratios were 1.43, 1.57 and 1.66; while the internal rate of returns were 26.28, 26.68 and 27.53 per cent for small, medium and large areca gardens respectively. The results also showed that the investment in areca gardens could be recovered in about 11 years.

Introduction

Arecanut (*Areca catechu* Linn) is an important commercial crop which occupies a special position in the cultural and social life of the people of India. India ranks first in the world as a producer of arecanut followed by Sri Lanka and Bangladesh. The major arecanut growing states in India are Karnataka, Kerala and Assam with a production of 61,457, 51,061 and 44,467 tonnes, respectively, during 1978-'79 and accounted for 93 per cent of total production in India. In Karnataka, the cultivation of

arecanut is concentrated in heavy rainfall districts of Dakshina Kannada, Shimoga, Uttar Kannada and Chikkamagalur. The revenue in the form of sales tax from this crop is estimated to be Rs. 1.22 crores annually in Karnataka. Arecanut is a perennial crop with about fifty years of economic life period and requires huge investment both in terms of establishment and maintenance expenditure. Naturally, there is a need for evaluating the investment in order to avoid risks if any in investment of funds.

Data and Methodology

The data were collected from a total of 60 areca farmers who were selected at random at the rate of 20 each in small, medium and large farmers, from a random sample of five villages of Puttur taluk which has the

* Department of Agricultural Economics, University of Agricultural Sciences, G. K. V. K. Campus, Bangalore 560065

+ M.Sc. (Agri) thesis submitted to University of Agricultural Sciences, Bangalore

highest acreage and production of areca in Dakshina Kannada District. The data pertains to agricultural year 1979-'80. The areca farmers having areca area up to one standard hectare, 1.01 to 2 standard hectare and above 2 standard hectare were grouped into small, medium and large farmer category respectively. The standardisation was done on the basis that two hectare of dry/garden land is equal to one standard or irrigated hectare.

The net present value, benefit cost ratios and internal rate of returns criteria were employed to assess the economic feasibility and financial soundness of investment in areca gardens. In doing so the following assumptions were made:

1. The economic life period of the areca gardens was assumed to be 50 years.

2. The investment made in the first seven years i.e., till the crop comes to bearing was considered as establishment cost. The costs incurred from eighth year onwards were considered as operating costs.

3. The data from sample areca farmers were spread over 40 years of the gardens with some years gap. The age of the garden upto the 40th year was classified into eight groups of 5 years each and the actual averages of costs and returns were taken to arrive at the costs and return in each year. Further, it was assumed that the costs remaining the same, the returns decreased by 15 per cent during 41st to 45th year and by 30 per cent from 46th to 50th year of a garden. This is based on the idea that as the garden becomes aged its yielding capacity decreases.

4. The life span of the fixed investments on pumpsets was considered to be 20 years and the apportioned costs of these items were added to the costs during the 1st, 21st, and 41st years. The life span of the sprayers was taken as 20 years and this cost was included in the 7th, 28th and 48th years. The life span of wells/ponds was assumed to be the same as that of the areca garden. The salvage value of the fixed investments on pumpsets and sprayers was added to the returns at the end of plant life period if and only if it has not completed the full life span.

5. The returns generated in the gardens over years from areca as well as pepper/banana intercrop were recorded in monetary terms and these constituted the cash inflow in the areca gardens. A discount rate of 15 per cent was assumed to be the opportunity cost of capital and the stream of cash inflows and outflows were discounted at this rate.

Results and Discussion

The average size of areca gardens was 0.56 ha in small, 1.28 ha in medium and 2.29 ha in large categories. The results show that Rs. 66,097.33 (Rs. 28,864.22 per ha), Rs. 38,509.51 (Rs. 30,085 per ha) and Rs. 17,141.09 (Rs. 30,505.09 per ha) were needed to establish large, medium and small areca gardens, respectively (Table 1). The costs and returns are presented per technical unit (per hectare) of an area to have better understanding and interpretation. The total establishment cost per hectare during the first year of areca garden which included the labour, material, investment on permanent items such as wells, ponds, pumpsets and other machinery as well as cost of planting an intercrop worked out to

Table 1. Establishment cost of Areca Gardens in Dakshina Kannada District (in rupees)

Sl. No.	Particulars	Small garden		Medium garden		Large garden	
		Per garden	Per hectare	Per garden	Per hectare	Per garden	Per hectare
1.	Total labour cost in the first year	1786.07	3189.41	3857.61	3013.76	8720.73	3808.19
2.	Total labour cost in the remaining years	6335.17	11315.38	12181.54	9516.22	18930.01	8266.39
3.	Total labour cost	8120.24	14504.79	16039.15	12529.98	27650.74	12074.58
4.	Total material cost in the first year	1218.78	2175.53	3833.69	2995.08	7375.54	3221.48
5.	Total material cost in the remaining years	3297.04	5887.21	6906.17	5395.49	12311.03	5376.01
6.	Total material cost	4575.82	8062.74	10739.86	8390.57	19686.57	8597.49
7.	Investment on permanent items	4241.28	7573.74	11477.26	8966.61	16784.16	7329.33
8.	Cost incurred for banana	203.74	363.82	253.24	197.84	1975.86	862.82
9.	Total establishment cost in the first year [1 + 4 + 7 + 8]	7449.78	13302.50	19421.80	15173.29	34856.29	14791.73
10.	Maintenance cost in the remaining years (2 + 5)	9632.21	17202.59	19087.71	14911.71	31241.04	13642.40
11.	Total establishment costs (9 + 10)	17141.09	30505.09	38505.51	30085.00	66097.33	28864.22
12.	Average size (ha)	0.56	—	1.28	—	2.29	—

Rs. 13,302 for small, Rs. 15,173 for medium and Rs. 14,792 for large farmers. The total cost of maintenance per hectare from 2nd year onwards till the bearing stage (7th year) of areca gardens amounted to Rs 17,202 in small, Rs 14,912 in medium and Rs 13,642 in large gardens (Table 1).

The per hectare annual operational cost of bearing areca gardens was Rs 7482, Rs 7031 and Rs 7710 for small, medium and large farmers, respectively (Table 2). The average yield of arecanut per hectare was 1970 kg for small, 2002 kg for medium and 2082 kg for large areca farmers.

The net returns per hectare were higher for large farmers than medium and small and they were Rs 21,975, Rs 18,364 and Rs 16,436, respectively (Table 2). Pepper as an inter crop provided an additional per hectare net return of Rs. 865 for small, Rs. 844 for medium and Rs. 1065 for large farmers with an additional per hectare cost of Rs. 84, Rs. 71 and Rs. 70 respectively.

The labour employment in mandays was 452, 366 and 490 per hectare in small, medium and large areca gardens and this reflects the employment generation potential in areca gardens.

Table 2. Costs and returns in areca gardens

	Small garden		Medium garden		Large garden	
	Per garden	Per hectare	Per garden	Per hectare	Per garden	Per hectare
1. Labour cost	2271.92	4057.03	4506.38	3520.59	9194.10	4014.89
2. Material cost	1388.08	2478.73	2980.31	2328.37	5223.99	2281.22
3. Other expenses	529.83	946.12	1512.91	1181.96	3236.95	1413.51
Total cost(1 + 2 + 3)	4189.83	7481.88	8999.60	7030.92	17655.04	7709.62
4. Yield						
(dried kernels in kg)	1103.28	1970.14	2562.53	2001.98	4768.07	2082.13
Value of yield	13304.30	23757.68	32350.29	25274.24	67754.81	29588.75
Value of quantity used for house consumption	90.00	160.72	154.56	120.67	219.22	95.73
5. Total returns (Rs.)	13394.30	23918.40	32504.75	25394.91	67974.03	29684.48
6. Net returns (Rs.)	9204.47	16436.52	23505.15	18363.99	50318.99	21974.86

The evaluation of investment in areca gardens at 15 per cent discount rate indicated a per hectare net present worth of Rs 18,164 in small, Rs 22,157 in medium and Rs 25,999 in large areca gardens. The discounted benefit cost ratios were 1.43, 1.57 and 1.66, while the internal rate of returns were 26.28, 26.68 and 27.53 per cent for small, medium and large areca gardens, respectively. The results also showed that the investment in areca gardens could be recovered in about 11 years.

Thus, the investment in all the three size groups of areca gardens was found economically feasible and financially sound.

However, the return per rupee of investment as well as employment generation was highest in large areca gardens than medium and small.

The sensitivity analysis at 10 per cent variation in cost (increase) and returns (decrease) clearly indicate that even if there is escalation in costs and or decrease in returns by 10 per cent in the years to come, still the investment in areca gardens would be economically feasible and financially sound proposition besides creating employment opportunities throughout the year.

On the Significance of Environmental Resources in Sustaining the Productivity of Arecanut Gardens of Uttara Kannada

V. S. Hegde, D. M. Bhat, K. M. Hegde*, S. N. Prasad and Madhav Gadgil**

Abstract

The plantations in Yellapur, Sirsi and Siddapur, Uttara Kannada District are generally surrounded by natural forests. The forest is rich in deciduous-semi ever green plants viz; *Terminalia tomentosa*, *T. paniculata*, *Xylia xylocarpa*, *Pterocarpus marsupium*, *Careya arborea*, *Dillenia pentagyna*, *Strychnos nux-vomica* and *Themeda Spp.* These plants provide green/dry leaves for manuring the arecanut based gardens and grazing for live-stock. Thus, this self sustaining agro-forestry system helps in maintaining good ecological balance with lesser dependence on expensive chemical inputs.

Introduction

Most human populations ultimately depend on land-based plant production for their sustenance. The production fulfils their requirements of food, fuel, fodder, manure and structural material which is in degree by cultivating different types of plants. A very interesting example of such traditional balanced agro-forestry system of Uttara Kannada district with arecanut as main crop is discussed in this paper.

Discussion

In the three taluks taken for studies, the lower reaches of valleys are put under paddy and sugarcane (for production of jaggery for household purposes), the upper reaches

of valleys under a multistoreyed garden of arecanut (600 trees per ha), pepper (600 vines per ha), cardamom (600 per ha) and plantain (125 per ha) or more recently cocoa (125 per ha). These gardens are fringed by coconut, mango and jack trees. The hilly lands are either converted to grass covered grazing or 'bena' lands or natural forests used as a source of leaf manure and other produce, the *soppin betta* lands. The bena lands are covered primarily by coarse grasses belonging to the genus *Themeda* and the betta lands by a moist deciduous-semievergreen forest with the following major species: *Aporosa melanoxyton*, *Syzygium corymbosa*, *S. cuminii*, *Terminalia bellerica*, *T. tomentosa*, *T. paniculata*, *Mesua ferrea*, *Mimusops elengi*, *Pterocarpus marsupium*, *Dalbergia latifolia*, *Xylia xylocarpa*, *Careya arborea*, *Lagerstroemia. Sp.*, *Dillenia pentagyna*, *Strychnos nux-vomica* and *Carallia integerrima*. The natural resources available from such a system and crop

* The Hulgol Group Villages Service Co-operative Society Limited, Bhairumbe, Karnataka

** Centre for Theoretical Studies, Indian Institute of Science, Bangalore, Karnataka

yields are given in Table 1. These environmental inputs render the gardens of Yellapur-Sirsi-Siddapur taluks more productive than those in areas where such inputs from betta and bena lands are not available (Table 1).

An average family of 7 individuals in this tract holds about 1.2 ha of paddy land, 0.8 ha of orchard, 1.2 ha of bena land, about 7.2 ha of betta land. The orchard also houses about 11 labourers. The average farmer keeps 7-12 cattle.

The total system is then made up of seven components, viz., the farmer's household, labourers, livestock, paddy fields, orchard, bena and betta lands. There is an intricate pattern of interdependence amongst these components. Table 2 makes a preliminary attempt at depicting some of these interconnections in the form of output of materials from one component to the other.

Apart from the material inputs of leaves, wood etc., the betta lands also serve the important function of maintenance of the microclimate. In particular, the protection they afford to the areca palms from the scorching effect of the evening sun rays from December to March from the south-western direction is of much value in maintaining their productivity.

The traditional integrated land use system is at least several centuries old which has tended to break down in recent years. To avoid this adverse effect on the horticulture a group of farmers of the Hulgol Group villages Co-operative Service Society in Sirsi Taluk have launched a project for more efficient management and restocking of the betta lands. The emphasis in restocking is on indigenous and exotic species suitable for green leaf manure, fodder and fuel.

Table 1. Annual resources required from forest area and crop yields.

Resources from forests (tonnes/ha)		Yield as crops/annum		
		With betta land		Without betta land
Dry leaves for mulching	30-37.5	1. Arecanut	3000 kg/ha	2400 kg/ha
Leaves for green manure	20-25.0	2. Pepper	750 kg/ha	300 kg/ha
		3. Cardamom	75 kg/ha	24 kg/ha
		4. Cocoa	300 kg/ha	—
Green leaves for compost	80-85.0	5. Coconuts	60 nuts/palm	18 nuts/palm
Wood for fuel	30-35.0	6. Banana	37,000 no/ha	32,000 no/ha

Table 2. Annual fluxes of material within different components of the system

Outputs from	Inputs to	Farmer's household (5 members) [1]	Labourers (11 members) [2]	Livestock (12 animals) [3]	Paddy fields (1.2 ha) [4]	Orchard (0.8 ha) [5]	Bena lands (1.2 ha) [6]	Betta lands (7.2 ha) [7]	Outside markets [8]
Farmer's household (5 members)		—	—	—	—	—	—	—	—
Labourers (11 members)		—	—	—	—	—	—	—	—
Livestock (12 animals)	800 litres of milk	—	400 litres of milk	—	Some farm-yard manure	33 tonnes of farm yard manure	Some dung while grazing	—	—
Paddy fields (1.2 ha)	2 tonnes of paddy + jagger	—	4 tonnes of paddy	Some paddy straw	—	—	—	—	—
Orchard (0.8 ha)	Some fuel especially from coconut fronds	—	—	—	—	—	—	—	2.4 tonnes areca, 0.6 t pepper, 60 kg cardamom, 28000 bananas, 0.25 tonnes cocoa, 500 coconuts
Bena lands (1.2 ha)	—	—	—	10 tonnes of grass	—	—	—	—	—
Betta lands [7.2 ha]	20 tonnes fuel	—	15 tonnes fuel	1.5 tonnes grass + 80 tonnes of green leaves for bedding and composting	0.5 tonnes for implements and fencing + 2.5 t fuel wood	18 tonnes green leaves + 25 tonnes dry leaves + 25 tonnes fuel wood	—	—	—
Outside markets	Some domestic requirements like cloth, oil, tobacco, etc.	—	Domestic requirements like cloth, oil, tobacco, etc.	Some concentrate rates	Some fertilizer, pesticides	86 kg N, 60 kg P + 145 kg K + pesticides	—	—	—

AUTHOR INDEX

<i>Author</i>	<i>Page</i>	<i>Author</i>	<i>Page</i>
Abdul Khader, JBM.Md.	13	Kapadi, A. H.	172, 188
Abdul Khader, K. B.	27, 33	Karunakaran, P.	107
Abdulla Koya, K. M.	133, 137	Kaveriappa, K. M.	116
Abraham, K. J.	68	Krishnamurthy, K.	7, 38, 58
Abraham, V. A.	133	Krishnaraja, E.	223
Alice, K. J.	107	Koshy, P. K.	143
Anandaraj, M.	83, 95	Madhav Gadgil	227
Annamalai, S. J. K.	156	Mathew, A. G.	177
Appaiah, G. N.	207	Mohapatra A. R.	41, 78
Balakrishnan, S.	107	Mujumdar, A. M.	172, 188
Bhadraiah, P.	7, 38	Muralidharan, A.	58, 68, 70
Bhagavan, S.	3, 65	Muthukrishnan, C. R.	13
Bhalerao, M. M.	205, 217	Muthuswamy, S.	13
Bhat, D. M.	227	Nair, B. P.	104
Bhat, N. T.	78	Nambudiri, E. S.	181
Bhide, S. V.	167	Nayar, N. M.	156
Bopaiah, B. M.	74, 100	Pattanshetti, H. V.	7, 38
Chandra Mohanan, R.	104, 116	Pendse, G. S.	172, 188
Chandy Kurian,	133, 137	Prafulla K. Das	195, 209
Chempakam, B.	163	Prasad, S. N.	227
Chenchu Subbaiah, C.	19	Radhakrishnan Nair, C. P.	140
Debnath, C. R.	153	Rai, P. S.	147
Deshpande, S. B.	10, 22, 114, 128	Rajanna, C.	147
Devasahayam, S.	140	Ramakrishnan Nayar, T.V.	70
George, C. K.	68	Rawther, T. S. S.	133, 137
Gopaldaswamy, V.	49, 53	Sadanandan, A. K.	68
Hegde, K. M.	227	Salvi, M. J.	10, 22, 114, 128
Hegde, R. K.	86, 92	Sampath Kumar, S. N.	120, 124
Hegde, V. S.	227	Saraswathy, N.	95, 163

<i>Author</i>	<i>Page</i>	<i>Author</i>	<i>Page</i>
Sastry, M. N. L.	86, 92	Thangaraj, T.	13
Sathiamma, B.	133, 137	Vandana Deshpande,	188
Shama Bhat, K.	27, 33, 70, 220	Veeresh, G. K.	147
Shivashankar, S.	181	Venkataram, J. V.	223
Sikka, R. K.	201	Vijayamohan Reddy, N.	147
Singh, R. K.	205, 217, 220	Vijayarajan, M.	220
Singh, S. P.	10, 22, 114, 128	Vijayendra, M.	147
Srinivasan, N.	97	Yadava, R. B. R.	17
Subramonia Iyer, M.	49, 53	Yadukumar, N.	27, 33
Sundararaju, P.	143		