TECHNOLOGIES FOR MINIMIZING RISK
IN
RAINFED AGRICULTURE

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Appropriate technologies for risk reduction in rainfed horticulture crops with special reference to coconut

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ABSTRACT

During the early years, the land owner did not find the tree crop investment as profitable as that in short duration field crops and livestock farming, because there was hardly any technology in horticultural tree crops. Now, it is possible to tiding over the low yielding barriers and reducing the risk in rainfed horticultural tree crops.

Considerable success has been achieved in vegetative propagation techniques and biotechnology in many of the horticultural crops. These technologies could be exploited for raising the required quantity of elite planting materials by establising the scion banks, seed gardens, nurseries and tissue culture laboratories in different regions. The technology has been evolved for minimising the risk as well as in improving the productivity of rainfed horticultural crops.

In rainfed coconut farming, the application of 100 to 200 kg tank silt per basin was found to improve the physical conditions of the soil. A technique of buying 1000 coconut husks in trenches of 40 cm deep and 150 cm width between coconut remitted in maximum soil moisture conservation. Similarly, coir dust mulching was found to reduce the water requirement by 40 to 55 per cent. Several other techniques have also been developed to step up productivity of coconut. Similar technology relevant to several other rainfed horticultural crops are given in the paper.

INTRODUCTION

The history of the traditional horticulture is as old as its homestead gardens. It is a most common sight to see people in all parts of India raising fruit trees, tubers, vegetables, spices and flowers in home compounds as a part of their living style. But the raising of horticultural crops in primitive way had resulted in poor and irregular harvests. Eventhough the field crop production in India could change to commercial agriculture some two and half decades ago, it was unfortunate that Indian horticulture remained neglected for quite long. Most land owners did not find the tree crop investment as profitable as that in short duration field crops and livestock farming. It was mainly because of the fact that there was hardly any technology worth its name in horticultural tree crops that could appeal to commercial growers for maximising the returns.

There has, however, been a marked change in the situation today. In the present juncture, horticultural tree crops show distinct economic advantages over the annual field crops by their lower energy demands both in cultivation and harvesting. It has now been realized that the intensive cultivation of field crops in relatively poor soil is not desirable because of the long-term problems of soil, water and nutrient management. With the increasing rate of complexity, the field crop production in such lands is becoming more and more energy intensive and less and less rewarding (Das, 1990).

Keeping the far reaching consequences in view, horticultural tree crop farming is considered ideal for several agro-ecological fragile zones in India. These crops have deep root systems, hence they have the ability to make use of poor soils. They also make use of ground water more efficiently and economically. Again, since they have well developed foliar canopy they provide good radiation interception ability as compared to the field crops. The shade from their canopy facilitates microbiological activity in soil. Moreover, the recycling of fallen leaves, decaying roots and twigs helps to improve the organic content of the soil. Also the presence of tree crops control soil erosion by limiting the run-off of monsoon water. The prospects for horticultural crops seem bright from other angles also. It is not that some of the viable technologies have been developed for orchard crops, but also an extremely favourable market condition for horticultural commodities are now in the offing. One could also notice a vast improvement in the transport and communication system in India. Similarly, the processing industry has progressed well. The disposable income of a large section of Indian population has also increased considerably and as a result, their standard of living in all respects has gone up. On account of these, the demand for the horticultural commodities in general, in domestic market has dramatically increased in recent years. At the same time, there has been a spurt in the demand for those produces in the overseas markets and Indian export of horticultural produces has taken a frog leap. During the year 1987-88, fruits and fruit products worth Rs. 522 million were exported from India. The sharp increase in overall demand for fruits and vegetables is clearly evident from the fact that the unit values of these articles are now much higher than that of non-horticultural commodities and they are growing faster (Das, 1990).

CONVENTIONAL PRACTICES

Some of the farmers are adopting various conventional practices to grow the horticultural crops successfully under rainfed conditions. The practices are mainly aimed at improving the soil physical properties, enhancing the nutrient status and conserving moisture through better moisture holding capacity. These practices carry special importance in coconut cultivation as the substantial area is situated in humid tropics where it is widely grown in sandy and red sandy soils.

Green leaf/Organic manuring

Farmers usually practice application of green leaves and twigs from various available sources including forests, in the crop basins. Some of the farmers also grow green manure crops and incorporate into the garden soil. It is also a common practice to apply farm yard manure to improve both the physical and chemical properties of soil. These practices carry special significance in coastal sandy soils which are highly porous, amenable to leaching and with low native fertility.

Farmers also apply oil cakes in the crops basins as manure. Farmers use neem cake to protect the trees from common pests and diseases. The scientific studies have also corroborated the usefulness of neem cake as an insecticide besides an organic manure.

Application of tank silt/red earth

Coastal farmers usually apply 120 to 150 kg of tank silt to the tree crops specially coconut palms to improve the water holding capacity of soil as sandy soils are porous in nature. In heavy soils, red earth is applied to the palms to improve the aeration and thereby reduce the bad effects of waterlogging.

Application of common salt

The application of common salt to the coconut palm, either at base or on the crown is a time honoured agricultural practice. Some of the beneficial effects of common salts are :

i. It contains both sodium (Na) and chlorine (Cl), the two important elements connected with the water relationships of plants enabling them to conserve water during dry periods.
ii. Sodium acts as substitute for potash in soils thereby delaying the effects of potash starvation.
iii. As a dispersing agent when applied to soils it is believed to soften the hard pans and facilitate the root penetration. However, the application of common salt is not practiced in other horticultural crops.

Efficient utilization of rain water

Farmers are fully aware of the importance of soil moisture in cultivation of horticultural crops and bad effects of drought. Usually farmers follow indigenous water harvest technologies with the help of earthern pots, trays made from arecanut sheath and unserviceable tins *etc*. One or two of above mentioned containers are embedded around the trees providing small holes to it in the bottom. In certain cases, a hollow bamboo with lower end tied with plastic paper with a hole is used. This not only serves as support but also supplies water slowly for the growing seedling. These practices are even followed by some farmers after establishment of tree crops as a regular source of moisture throughout the year. This system is found to be more effective in areas enjoying rains from both south-west and north-east monsoons.

Intercultivation

In different parts of India, farmers are seen to plough the garden land in between the rows and against the slope. The value of intercultivation lies in the control of weeds and to keep land loose and friable so that the infiltration capacity of soils is improved. Where the gardens are located in light soils the farmers raise mounds in pre-monsoon season and follow subsequent levelling in post-monsoon period as this practice is believed to conserve more moisture.

NEW TECHNOLOGIES

Despite the fact that the Indian farmers are following some of the age old useful practices with their long experience these systems are not adequate to reduce the risk and increase the yield levels of horticultural crops. In view of these facts, attempts have been made to evolve appropriate technologies suited to different agro-climatic conditions. The research results advocated here are refinement in terms or method of adoption, quantity of material to be added per tree in respect of conventional practices adopted by the cultivators as highlighted in the previous section. Besides some of the new approaches evolved have been discussed here.

Contour bunding and terracing

Vijayalakshmi and Marar (1959) recommended contour bunding and terracing. Rethinam (1987) also suggested staggered trenching across the slope at short intervals besides contour bunding and terracing to intercept the run-off water and increase percolation.

In situ water harvesting

Since 10 mm rain equals 10 liters of water per m^2 area, harvesting this water from a palm spaced at 7.5 m x 7.5 m and concentrating in the basin radius of 1.8 m will provide additional water to the extent of 260 litres, if soil pores are sealed by bentonite clay or bitumen to generate cent per cent run-off. The interspaces so shaped and gradient provided will result in the concentration of run-off water into the basins.

Addition of tank silt and organic manures

Application of 100 to 200 kg of tank silt per basin found to improve the physical conditions of the soils (Vijayalakshmi and Marar, 1959; Chacko Mathew, 1979 and Rethinam, 1987). These workers also suggested addition of organic matter through raising green leaves or 50 kg cowdung in the basins to improve the water holding capacity. Joshi *et al.* (1982) suggested to incorporate organic sources blended with inorganic nutrients for improving the water holding capacity of the soil (Table 1).

Table 1. Effect of application of different organic sources alongwith inorganic sources on some physical properties of soil in coconut garden

Treatment	Water holding capacity (% by wt.)	Bulk density (g/cc)	Saturated hydraulic conductivity (cm/hr)
Coir dust	33.8	1.37	181.2
Coconut sheddings	27.1	1.48	194.8
Forest leaves	27.2	1.50	175.8
Cattle manure	26.5	1.57	150.7
Control (NPK alone)	23.4	1.60	133.3

Mulching

Mulching coconut basins with coconut husks, leaves and coir dust has been reported to reduce the soil temperature and conserve soil moisture and influence coconut production (Vijayalakshmi and Marar, 1959; Chacko Mathew, 1979; Rethinam, 1987; and Balasubramanian *et al.* 1985). Shantaamllaiah *et al.* (1978) reported that coir dust mulching reduced the water requirement by 40 to 50 per cent. At Veppankulam (Tamil Nadu). Balasubramanian *et al.* (1985) recorded the maximum available moisture and cumulative yield of coconut (265 nuts/palm) for four years in plot mulched with coconut husk at *1000 state*/basin as against 177 nuts/palm without mulching.

Nambair and Sasidharan (1988) reported increased yield as compared to 38.0 nuts/palm/year with no mulch of 69.6 nuts/palm/ year in mulched plots. Coconut husk has been reported to absorb 3 to 6 times more moisture to its weight (Chacko Mathew, 1979). Marar and Kunhiraman (1957) reported that the first improvement due to husk burial was changed in colour of leaves from pale to dark green followed by increase in functional leaves which resulted in increased yields of palms. During fourth year, the productivity of palms increased by 22 nuts/palm/year over the control. Thereafter the yield declined and the palms reverted back to original position by 10th year of husk application. The effect of husk persisted for about six years only.

Interculture and weed management

Substantial increase in coconut yield has been reported due to interculture and weed management practices at Agricultural Research Station, Kumarakom (Kerala). The study indicated that surface removal of weeds produced more nuts (Table 2).

Table 2. Effect of cultural practices on yield of coconut (nuts/palm)

Treatment	Pre-treatment (1959-62)	Post treatment 1965	1966	1967	1968	1969	Mean
Two diggings August/September and December/January	37.2	37.0	52.8	40.8	37.2	36.8	40.9
Clean surface removal of grass	35.2	48.7	55.6	43.0	35.3	33.6	43.3
Leguminous cover	28.9	38.9	49.4	42.0	32.4	30.3	38.6
Control	32.7	32.7	35.3	27.7	24.0	25.0	28.9

Optimum plant spacing

High density of coconut per unit area is one of the factors for low productivity of the palms especially under rainfed conditions. Experimental evidences have shown that palms optimally spaced come early to bearing and yield higher than unevenly spaced and thickly populated situations. Nambair and Sasidharan (1988) concluded from experiments in progress since 1964 at Coconut Research Station, Balaramapuram that wider spacing led to marked increase in yield per palm under rainfed condition (Table 3).

Table 3. Cumulative nut yield /palm as influenced by spacing and manuring (1976-1985)

Spacing (m)	Levels of NPK (g/palm) 0-0-0	340-225-450	680-950-900	Mean
5.0 x 5.0	13.9	149.1	156.6	106.5
7.5 x 7.5	121.9	501.9	629.3	417.7
10.0 x 10.0	187.6	596.5	764.3	516.1
Mean	107.5	415.8	516.7	
CD (0.05) 73.6				

Judicious fertilizer application

The study conducted at CPCRI, Kasaragod revealed that West Coast Tall respond to highest dose of fertilizer levels, where as the hybrids responded only up to medium fertility levels (Table 4). This clearly indicates that hybrids are efficient converters of nutrients. It could thus be inferred that hybrids can be adopted under rainfed condition with medium level of fertilizers. Nelliat *et al.* (1982) recorded more than double the yield obtained under farmer's practice with fertilizer application (Table 5). This study demonstrated that palms in neglected gardens can be improved by application of double the recommended dose in first year and thereafter full dose of recommended fertilizers.

Table 4. Effect of fertilizer levels on yield of three coconut genotypes (nuts/palm/year)

Genotypes	M0	M1	M2
WCT	30	59	73
COD x WCT	39	85	86
WCT x COD	22	70	67

M0 : no manuring

M1 : 500 g N + 500g P_2O_5 + 1000g K_2O/palm/year

M2 : 1000 g N + 1000g P_2O_5 + 2000g K_2O/palm/year

Table 5. Effect of fertilizer application on nut yield

Treatment	Cumulative nut yield/palm (1974-75 to 1978-79)	Per cent increase over no manuring
Farmer's practice No manuring	100.8	-
1/3 dose in first year, 2/3 dose in second year and full dose from third year onwards	178.9	77.4
1/2 dose in first year and full dose from second year onwards	230.1	128.2
Full dose from first year onwards	220.9	119.1
Double dose in first year and full dose from second year onwards	265.3	163.1
Double dose in first and second year and full dose from third year onwards	259.4	157.3

Proper management of coconut gardens

In a long term management trial at CPCRI, Kasaragod, marked effect of management has been noticed on the yield of nuts. In neglected plot even after 18 years of planting only one palm out of twelve has flowered and yielded only 3 nuts so far.

Even if farmer applies fertilizer and forks the basins, he can realise good yield (Table 6). Nambair *et al.* (1983) reported that addition of blended organic sources particularly forest leaves and cattle manure markedly enhanced the growth and vigour of coconut palms as compared to palms treated with NPK fertilizer alone.

Cover Cropping

In sole coconut gardens, growing of cover crops is beneficial. It conserves soil, smothers the weed growth and reduces ground temperature. At CPCRI Regional Station, Kayangulam, tropical Kudzu *(Pueraria phaseoloides)* reduced soil temperature by 10 to 20°C compared to adjacent bare land.

Table 6. Effect of management practices on coconut yield

Treatment	Palms in bearing (%)	Nut yield Total since bearing	Mean/palm (1986 to 1990)
Cultivation + organic and inorganic manuring	100	842	102.5
Cultivation + inorganic manuring	100	743	85.9
Fertilizer application + forking basins	100	644	83.2
Cultivation alone	88	189	28.4
Weed control through herbicides	25	76	10.9
No cultivation and no manuring	8	3	0.4

Cultivation - ploughing in August and October Organic - 30 kg green leaves/palm,
Inorganic - 550 g N + 320g P_2O_5 + 1200 g K_2O/palm/year

Thomas and Shantaram (1984) tested the ability of growth and establishment of nine species of green manure legumes. *Pureria phaseoloides, Mimosa invisa* and *Calapogonium mucunoidia* yielded 19.43, 17.00 and 14.71 kg green matter/basin (Table 7). Green manuring at 20 kg/palm induced high level of Zymogenic response by microorganisms in the coconut rhizosphere. Thomas and George (1990) have revealed that basin management using green manure legumes in the root (wilt) affected coconut gardens has restricted the further deterioration in disease condition.

Intercropping

About 90 per cent of the coconut holdings are below 1 ha. The small size of the holdings makes it uneconomical to the owners to invest large amount on irrigation and land development. As a result, most of the coconut holdings are rainfed. Intercropping not only meets varied food requirements of the farmers but also acts as insurance against crop failures and price fluctuations. Various tuber crops like tapioca, elephant-foot-yam, colocasia, yam and lesser yam, oilseed crops like groundnut and castor and vegetables can be successfully grown in interspaces of coconut.

Table 7. Green matter yield and nutrient addition by green manure crops in coconut basins

Legume species	Fresh weight (kg/basin)	Total N added (g/basin)
Calopogonium mucunoides	14.71	102.61
Macrotyloma axillaire	0.95	6.67
Mimosa invisa	17.00	153.19
Pueraria phaseoloides	19.43	121.29
Leucaena leucocephala	2.95	16.55
Sesbania aegiptica	1.30	6.98
Macroptilium atropurpureum	9.10	66.64
Glycine wightii	2.35	19.20
Stylosanthes guianensis	3.50	12.70
CD at 5%	7.59	53.24

Studies conducted at CPCRI, Kasaragod revealed that raising tuber crops had no adverse effect on coconut provided the same intercrop was not grown in the same plot every year and that both the crops were manured adequately and separately (Table 8). The economic potential in terms of net profit in coconut + elephant foot yam system was Rs.18,550/ha/year. In coconut + ginger system, the same was Rs.14,350/ha/year (Das, 1989). Coconut sole under similar situation gave a net return of Rs.5,150/ha/year only (Table 9).

Table 8. Yield of coconut palm during pre-experimental and experimental periods as influenced by intercropping

Intercrop	Mean yield of nuts/ palm/year Pre-experimental	Experimental	Per cent increase (+) or decrease (-)
Control	48.2	45.2	- 6.2
Tapioca (every year)	54.8	51.2	- 6.6
Elephant yam (every year)	68.3	59.3	- 13.2
Tapioca and elephant yam in alternate years	73.0	68.2	- 6.6
Elephant yam and tapioca in alternate years	66.6	62.4	- 6.3
Tapioca, elephant yam, sweet potato, ginger and turmeric in 5 years rotation	49.7	52.1	+ 4.8
Yam, lesseryam, colocasia and coleus in rotation	60.8	69.8	+ 14.8

In preliminary studies at CPCRI, Kasaragod, rainy season vegetable crops as intercrops in coconut also showed promise. However, the crops chosen should be able to tolerate shade, dripping of water from leaves and leaf nut fall damage. Vegetables like amaranthus, brinjal, coccinia, snakegourd and cowpea can be successfully grown in association with coconut as intercrops.

In locations of acute moisture stress in summer months, care should be taken to restrict the cultivation of intercrops within the period of optimum moisture regime so that the competition between the main and intercrops for scarce resource could be avoided.

Though these studies have direct bearing to coconut crop, the approaches discussed is this paper are relevant to most of the horticultural tree crops management.

NEW THRUST AREAS

There is considerable scope in horticultural crops to tide over the present low yielding barriers and reducing the risk in the rainfed situation. The technologies have to be refined in such a way that even the small holders can adopt it. Some of the thrust areas have been highlighted here.

Table 9. Economics of rainfed coconut based mixed cropping system with annual crops in marginal land (Rs./ha)

Particulars	Coconut	Coconut+ Cassava	Coconut+ EF Yam	Coconut+ ginger
Cost				
Labour wages @ Rs 28/-day	3350	7000	7030	17340
Planting materials	-	250	4500	6500
Organic manure @ Rs 10.0/t	450	1700	1100	3450
Fertilizers :				
Urea @ Rs 2.40/kg	460	840	700	850
Superphosphate @ Rs 1/kg	350	800	500	660
Muriate of Potash @ Rs 1.40/kg	490	660	620	600
Plant protection	450	600	600	1000
Contingencies	450	650	550	1000
Total variable cost	5950	12500	15600	31400
Annuity value @ 14%	1 0800	10800	10800	10800
Gross cost	16750	23300	26400	42200
Returns				
Coconut @ Rs 2.50/nut	21000	23450	23450	23450
Byproducts	900	1400	900	900
Cassava @ Rs 1/kg	-	9600	-	-
EF Yam @ Rs 2/kg intercrops	-	-	20600	-
Ginger @ Rs 7/kg	-	-	-	32200
Gross return	21900	34450	44950	56550
Net return	5150	11150	18550	14350

Horticultural crops are mostly grown under rainfed situations. Therefore the breeding programme has to be oriented towards evolving drought resistant varieties specific to varied agroclimatic zones. Stress also has to be laid on the selection of shade tolerant varieties of fruits, vegetables, spices and rhizomatous crops so that these may find suitable place in cropping systems. Use of insecticides and pesticides is not desirable in horticultural crops due to the health hazards. Therefore emphasis has to be laid on the breeding for disease and pest resistant varieties besides evolving the biological means of pest and disease control.

There is also an urgent need to make available the quality planting material in these crops. Hence considerable success has been achieved in standardizing vegetative propagation techniques in most of the horticultural crops. These methods have to be commercially exploited through the establishment of scion banks and nurseries to multiply quality planting materials. Considerable success has been achieved in large scale multiplication of elite planting materials through the tissue culture and other biotechnological means in some of the horticultural crops such as banana and cardamom. However, such programmes have to be diversified into other crops by developing and standardizing the techniques to cater to the needs of the planting materials.

The horticultural crops are grown as rainfed. It is therefore necessary to standardize agro-techniques so as to realise high yields under limited moisture situations. There is awareness among the farmers for the use of organic manures hence efforts must be made to evolve techniques involving judicious management of nutrients through organic and inorganic combinations. Most of the horticultural gardens are low yielders because of uneven spacing, use of unsuitable varieties and non-practice of recommended production practices. Hence attempts have to be made to rejuvenate the unproductive gardens through systematic replanting and rejuvenating programmes.

There is also an urgent need to bring awareness among cultivators about the worthiness of the improved package of practices in horticultural crops through demonstration programmes. However, the national demonstration programmes in horticulture have to be suitably designed keeping in view the special characteristics of these crops having long gestation, juvenile and productive periods.

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