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Sustainable productivity and economics of arecanut based high density multi-species cropping system under Brahmaputra valley region of Assam

M. Hussain, A.K. Ray, H.P. Maheswarappa[1], P. Subramanian[2], Ravi Bhat[3], V. Krishnakumar[4] and G.C. Acharya

Central Plantation Crops Research Institute, Research Centre, Kahikuchi, Guwahati-781 017, Assam

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Abstract

Field investigations were carried out on arecanut based high density multi-species cropping system at Central Plantation Crops Research Institute, Research Centre, Kahikuchi, Guwahati from 1998 to 2008 to find out productivity and economics of the system. Arecanut, banana, citrus and black pepper crops were tried in two models with full, 2/3rd and 1/3rd of recommended fertilizer levels along with recycling organic biomass in the form of compost. The results on yield of different crops indicated that there was increase in the yield of main crop and component crops over the years. Yield of arecanut, citrus, pepper were higher at 2/3rd of recommended level of fertilizer coupled with organic biomass recycling in the form of compost. Banana yield was higher at full dose of recommended fertilizer. The major share of the production cost was towards labour (55 to 65 %) followed by fertilizers (30 to 40 %). The employment generated in the system was 450-475 man days compared to 250-275 man days in arecanut monocrop. The net income and B:C ratio were higher under 2/3rd of recommended fertiliser level compared to full dose and 1/3rd of recommended level of fertiliser.

Keywords: Arecanut, cropping system, economics, sustainability, yield

Introduction

Arecanut (*Areca catechu* L.) is a commercially important plantation crop predominantly grown in humid tropics of West Coast and North East regions of India. About 90% of total arecanut production in India is mainly contributed by Karnataka, Kerala and Assam and small and marginal holdings of less than one hectare dominate in arecanut tract. The income generated from these holdings is insufficient to sustain the needs of farmers. Besides, arecanut farmers face recurrent problems due to price fluctuations, pests and diseases, water logging and drought resulting in considerable yield losses. In Assam, arecanut cultivation is confined within the homestead garden and it is commonly called as "Bari system" of planting. Although grown in all districts of Assam, about 65 % of the total cultivation and 52 % of the total production is mainly confined to the undivided Kamrup, Sibsagar and Cacher districts of Assam. In these districts, most of the raw nuts are consumed for chewing purposes, and however, fully ripened arecanut are also used for preparation of chali (dried supari).

Arecanut as a sole crop does not fully utilize the natural resources such as soil, space, and light. The compact nature of arecanut crown, raised well above the ground (10 to 15 m), allows more sunlight to pass down to ground and maintain high humidity which in turn favors excellent growth of shade loving crops. Studies at Central Plantation Crops Research Institute have revealed that orientation and structure of arecanut canopy permits 32 to 48 % of incident radiation to penetrate down depending on the time of the day (Muralidharan, 1980). Normally in an areca garden spaced at 2.7 m x

[1 & 2]*Central Plantation Crops Research Institute, Kasaragod-671 124, Kerala, maheshcpcri@gmail.com*
[3]*Central Plantation Crops Research Institute,Regional Station, Vittal*
[4]*Central Plantation Crops Research Institute,Regional Station, Kayamkulam*

2.7 m, the light energy reaches the ground and get wasted. Rooting pattern revealed that arecanut palms planted at 2.7 m x 2.7 m spacing could use effectively only 30 % of the land area (Sharma Bhat and Leela, 1969). The normal cultural operations are also confined within about 75-80 cm radius from the base. Thus the areca palm exploits 2.27 Sq.m (r = 0.85m) area of soil out of 7.29 Sq.m (2.7 m x 2.7 m).

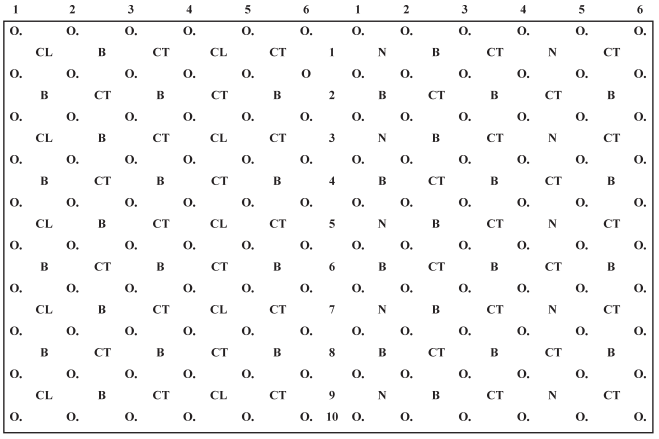
In order to utilize the natural resources to the maximum extent, growing different crops as inter/mixed crops is a common practice. Concept of high density multi-species cropping system (HDMSCS) involving compatible crops in arecanut garden was conceived by Bavappa *et al.* (1986) and the results indicated the advantages with the increase in yield of arecanut and additional income (Bhat *et al.*, 1999). With the above background, the study on impact of different levels of fertilizers coupled with recycling available biomass in arecanut based HDMSCS models was initiated at CPCRI,RC, Kahikuchi to know the productivity and economics of the system over a period of time.

Materials and methods

The study was conducted at Central Plantation Crops Research Institute, Research centre, Kahikuchi, which is situated at 20° 18' N latitude and 91° 78' E longitude with mean altitude of 48 m from MSL. The soil of the experimental site is clay loam. The average annual rainfall in the region ranges between 2500 to 3000 mm and most of the rainfall occurs during South-West monsoon (June to August/September). There is a dry spell form October to March with occasional showers from March to May. In the region, mean maximum temperature during March to October was 31.4° C and the mean minimum temperature was 23.4° C and the relative humidity was 75.5 % (forenoon) and 72.7 % (afternoon). The mean maximum temperature during November to February months was 24.8° C and the mean minimum temperature was 13.9° C with the relative humidity of 84.3 % (forenoon) and 72.7 % (afternoon).

HDMSCS Model

The field experiment on arecanut based HDMSCS with levels of fertilisers was conducted in a 39 years old arecanut (Kahikuchi selection) garden during 1998. The experiment was laid out in 0.63 ha area and the detail of crops, varieties with their population is given in Table 1 and field layout in Fig. 1. The Arecanut based HDMSCS garden comprised of two models *viz* Model-I with black pepper (Karimunda variety), banana, clove and citrus (Assam lemon variety) and Model-II with black pepper (Panniyur 1 variety), banana, nutmeg and citrus (Gandhraj lemon variety) as component crops. Both the models were sub divided into three treatments with three levels of fertilizers (Table 1). Inorganic fertilizers were applied in two equal splits *i.e.* one during March-April and the other during September-October. The recyclable biomass obtained in the system was converted into compost and applied uniformly to all the crops during Sept-October every year. The collected biomass of different crops were chopped into pieces, weighed and put into pits of size 4.5 m x 1.5 m x 0.9 m by spreading the biomass in a thin layer and sprinkled with fresh cow dung @ 10% of the fresh weight of biomass. When the pit was filled to a height of 45-60 cm above ground level, the surface was plastered with 45-60 cm layer of mixture of mud and cow dung. During non-rainy periods pits were sprinkled with water to maintain the moisture and were allowed to undergo decomposition and compost became ready in about 95 to 100 days. The amount of N, P and K contribution by recycling the compost in the garden ranged from 41.36 to 54.94 kg N, 32.69 to 42.55 kg P_2O_5 and 66.25 to 85.38 kg K_2O per ha per year (Hussain *et al.*, 2008).



MODEL I LAYOUT PLAN OF TREATMENT **MODEL I** LAYOUT PLAN OF TREATMENT

"O':- **ARECANUT & BLACK PEPPER: 2.7m x 2.7m = 144 Nos/Tr. x 3 = 432 Nos/ M**
"CL":- **CLOVE : 5.4m x 8.1m = 24 Nos/Tr. x 3 = 72 Nos./M**
"N":- **NUTMEG : 5.4m x 8.1m = 24 Nos./Tr x 3 = 72 Nos./M**
"B":- **BANANA : 2.7m x 5.4m (Triangular)=45 Nos/Tr x 3 = 135 Nos./M**
"CT":- **CITRUS : 2.7m x 5.4m (--do--) = 46 Nos/Tr x 3 = 138 Nos/M**

Fig. 1. Field lay out of arecanut based HDMSCS model at CPCRI Research Centre, Kahikuchi

Inputs and Outputs

The inputs such as fertilizers, plant protection chemicals, labour used for establishing and sustaining the model was maintained. The recommended dose of fertilizer for arecanut was 100:40:140, black pepper: 100:40:140, banana: 160:160:320,clove:300:250:750, citrus: 450:300: 430 and nutmeg : 300:250:750 g NPK/

plant/year. Required N, P and K were applied in the form of urea, single super phosphate and muriate of potash. The garden was irrigated during non-rainy periods with sprinkler irrigation system based IW/CPE ratio of 1.0. Need based plant protection measures were undertaken as and when required for all the crops in the system. Harvesting of the economic produce was done at appropriate stages and the yield recorded from the experimental plot and was converted into 1.0 ha area. The market price for both inputs and outputs for the corresponding years were considered to workout the economics of the system for one hectare area.

Market price of output

Crops	2001	2002	2003	2004	2005	2006	2007	2008
Arecanut Chali (Rs/kg)	35	35	37	37	40	40	40	40
Banana Fruits (Rs/kg)	2	2	3	3	4	4	4	4
Citrus (Rs/fruit)	0.5	0.5	0.75	0.75	1	1	1	1
Black pepper (Rs/kg dry)	75	75	77	77	80	80	80	80

Table 1. Crops with varieties, population and treatment details

Model	Crop/Variety	Population	Treatment	Plot size (ha)
M1	Arecanut (Kahikuchi local selection)	432	Full level of recommended dose (M1T1)	0.105
	Black pepper: Karimunda	432		
	Banana: Chenichampa	135		
	Clove: Local variety	72	2/3rd level of recommended dose (M1T2)	
	Citrus: Assam lemon	138		
			1/3rd level of recommended dose (M1T3)	
M2	Arecanut (Kahikuchi local selection)	432	Full level of recommended dose (M2T1)	0.105
	Black pepper: Panniyur 1	432	2/3rd level of recommended dose (M2T2)	
	Banana: Chenichampa	135		
	Nutmeg grafts	72		
	Citrus: Gandhraj lemon	138	1/3rd level of recommended dose (M2T3)	

Results and Discussion

Yield of different crops

Mean yield of different crops for 8 years is presented in Table 2.

Arecanut: The yield of arecanut over the years as influenced by different treatments is presented in Fig 2. In general the arecanut chali yield was higher in Model I compared to Model II and over the years there was increase in the yield of arecanut. Among the treatments, application of 2/3rd level of recommended fertilizer recorded higher yield in both the models followed by full dose of recommended fertilizer. The areca yield was lowest in the 1/3rd of recommended fertilizer level treatment in both the models. Higher yield under 2/3rd level of recommended fertilizer application along with recycling available biomass in the form of compost might be due to improvement in soil physico-chemical properties, which had positive effect on growth and yield. In coconut based HDMSCS at CPCRI, Kasaragod, it has been reported that application of 2/3rd level of recommended fertilizer along with recycling biomass in the form of vermicompost recorded higher yield of coconut over a period of long time (Palaniswami *et al*., 2007). It is evident from the yield data that, there was no reduction in the yield of arecanut due to growing different mixed crops over the years rather, there was increase in the arecanut yield was noticed (Fig. 2). Similar results were also reported by Bhat *et al.* (1999) from coastal Karnataka in areca based cropping system. Bhat *et al*. (2001) also have studied the effect of mixed cropping of cocoa, clove on arecanut yield in Karnataka and reported that growing of cocoa and clove as mixed crops individually or in combination did not show any adverse effect on arecanut yield, rather there was slight increase in the yield.

Table. 2. Yield of different crops as influenced by HDMSCS and nutrient management (Average of 2001 to 2008)

Model/ Treatments	Arecanut (Chali) (kg/ha)	Banana (kg/ha)	Citrus (Nos./ha)	Black pepper (dry in kg/ha)
M1T1	2155.9	8180.7	8961	1911.4
M1T2	2579.5	8118.0	10345	2321.5
M1T3	2025.7	6867.2	7541	636.0
M2T1	2032.4	8272.1	7660	1630.8
M2T2	2212.1	7401.5	8899	1925.9
M2T3	1827.7	5559.4	6286	652.5

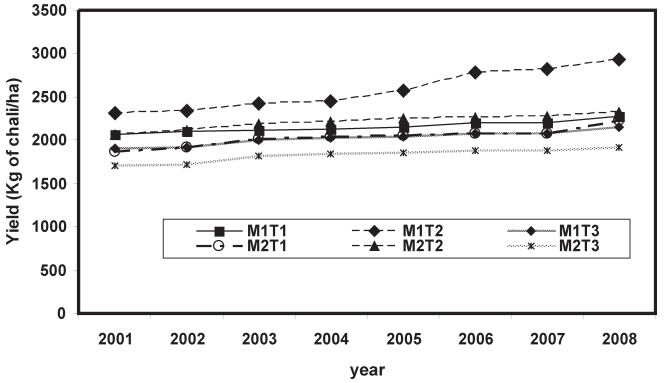


Fig. 2. Yield of arecanut over the years as influenced by HDMSCS models and nutrient management

Performance of component crops

Banana: Mean yield of banana over 8 years indicated that, the higher yield under full dose of recommended fertilizer in both the models followed by 2/3rd of

recommended fertilizer application (Table 2) and the yield was lowest in 1/3rd of recommended fertilizer treatment. This indicates that banana crop is an exhaustive nutrient exporter and responds well to applied nutrients. The per plant yield ranged from 22 kg to 23 kg fruit under full dose of fertilizer treatments, 20 to 21 kg fruit under 2/3rd dose of fertilizer treatment, whereas it was 15 to 17 kg fruit under 1/3rd of recommended dose.

Citrus: Citrus fruit yield was higher at 2/3rd level of fertilizer followed by full dose of fertilizer and 1/3rd level of recommended fertilizer (Table 2). Among the varieties, Assam lemon has performed well yielding 20 to 24 fruits per plant compared to Gandhraj lemon (15 to 20 fruits per plant).

Black pepper: Dry berry yield was higher under 2/3rd level of recommended fertilizer treatment followed by full dose and the yield was very low under 1/3rd level of fertilizer treatment (Table 2). In the present system, among the varieties, Karimunda performed better than Panniyur-1.

Clove and nutmeg plants were planted during 1998 and only 33.3 % of the clove plants started flowering and only 10 % of the nutmeg plants started yielding.

Increase in the yield over the years of different crops in the system indicated overall mutual benefit of the different crops in the garden. This might be due to favourable microclimate creation, improvement in soil physico-chemical and biological properties of the high density multi-species cropping system garden along with recycling the biomass in the form of compost. The results are in conformity with the work of many workers in arecanut and coconut based cropping system gardens (Bavappa *et al.*, 1986, Bhat *et al.*, 1999, Maheswarappa *et al*., 2005).

Economics

Economics of the system for different years was worked out based on prevailing market prices and is presented in Fig. 3 and 4. The data indicated that the cost of production of the system over the years was increased. The cost of production was higher under full dose of fertilizer treatment (Rs. 49,217/- to Rs. 61,603/- per ha) and the major share of the production was towards labour (55 to 65 %) followed by fertilizers (30 to 40 %) and plant protection (5 to 8 %) (Fig. 3). Thus it indicated that, high density multi-species cropping system required higher labour and generated additional employment for the farming family. The employment generated in the system was 450-475 man days compared to 250-275 man days in arecanut monocrop.

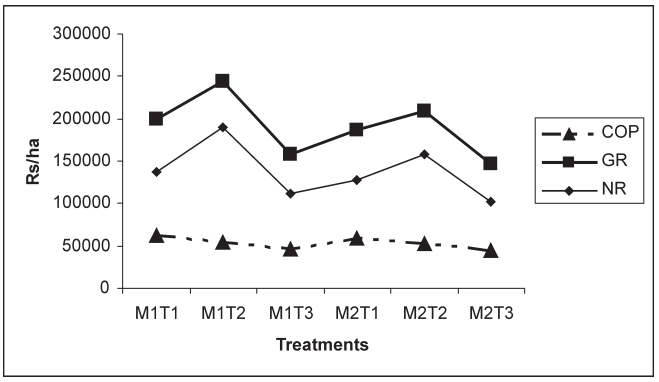


Fig. 3. Economics of arecanut based high density multispecies cropping system (COP: Cost of production, GR: Gross return, NR: Net return)

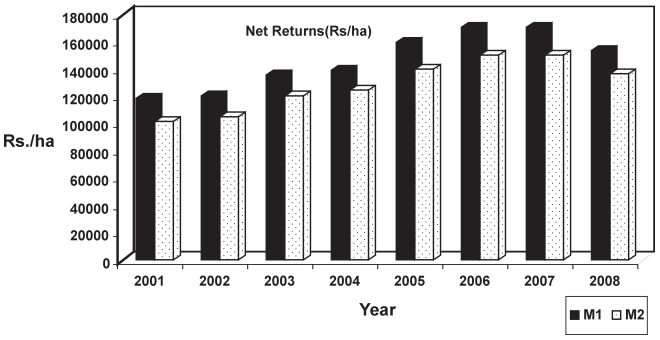


Fig. 4. Net returns (Rs./ha) as influenced by HDMSCS models and nutrient management over the years from 2001 to 2008

The net return was highest in Model I during different years compared to Model II mainly due to the higher yield of component crops varieties like Assam lemon and Karimunda black pepper (Fig. 4). The major contribution towards gross return was from the main crop arecanut (40 to 52 %) and black pepper (31 to 47 %) during different years. Among the fertilizer treatments, the net return was higher with 2/3rd of recommended fertilizer level and B:C ratio (4.57) was also higher followed by 1/3rd and full dose of recommended fertiliser. Bhat *et al*. (1999) also reported higher returns and employment under arecanut based high density multi-species cropping system.

Conclusions

It is evident from the above study that application of 2/3rd of recommended levels of fertilizers coupled with recycling of available biomass in the form of compost in arecanut based HDMSCS was beneficial with respect to sustainable yield of different crops except banana which requires recommended dose of fertilizer. The major share of the production was towards labour (55 to 65 %) followed by fertilizers (30 to 40 %), indicating higher employment generated in the system.

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