Research Article

doi: 10.25081/jpc.2024.v52.i2.9622
Journal of Plantation Crops, 2024, 52 (2) : Page 55-61

Comparative study of different arecanut-based cropping system models under sub Himalayan terai region

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(Manuscript Received: 10.06.2024, Revised: 18.09.2024, Accepted: 29.01.2025)

Abstract

There is ample scope for intercropping in arecanut plantations for better utilisation of natural resources like land and sunlight. An experiment was conducted at CPCRI, Research Centre, Mohitnagar, with different crop combinations to establish a model for increased system productivity and better livelihood. Five arecanut-based cropping system models comprising different crop combinations were compared with the monocropping system of arecanut. The total system productivity ranged from 31.5 q/ha (control) to 131.1 q/ha across different models. Model II (arecanut + black pepper + acid lime + turmeric) emerged as the most productive, demonstrating superior total system productivity. This model resulted in notable increase in arecanut challi yield. Particularly noteworthy was the contribution of black pepper, which accounted for over 50% of the total system productivity. It is concluded that the arecanut-based cropping system is more advantageous than the monocropping of arecanut. Arecanut based cropping system has the potential to double the farmers's income as the total system productivity has increased many folds over control. Among the different models studied, Model II with a crop combination of arecanut, black pepper, acid lime, and turmeric performed better withhigher returns. It is also suggested to the arecanut growers to adopt arecanut-based cropping system for their better livelihood.

Keywords: Arecanut, Black pepper, Turmeric, Intercropping, Total system Productivity, Dry kernel Yield

Introduction

Arecanut, or betel nut (*Areca catechu* L., Arecaceae), is a crop of the warm, humid tropics. It is mainly grown in Asian countries like India, Sri Lanka, Nepal, Bangladesh, Bhutan, Myanmar, China, Malaysia, and Indonesia. It is also grown in a few African countries, including Kenya, Madagascar, and the betel nuts are mostly used for chewing. The Middle East and the far East have the highest consumption rates. India exports these nuts not only to SAARC countries but also to Middle Eastern countries and other places where Asian people live to meet their needs. Apart from that, it is also used for religious purposes. To some extent, it is also used for medicinal purposes in some south-eastern countries. The world production of areca nut is 8.54 lakh metric tonnes, covering an area of 7.03 lakh hectares. India is positioned first in the world, accounting for 578 thousand metric tonnes of arecanut production with a share of 54% of global production. Its economic importance is witnessed by the 6.25 million people who make their livelihood through the areca industry in India. Areca nuts provide income and livelihood security to more than three crores of people. The areca nut plant is spaced at a distance of 2.7 m x 2.7 m for its proper growth and yield over a longer period of time.

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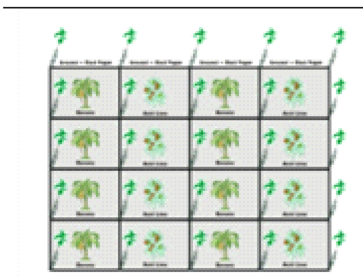
Researchers have documented that about 75% land and 55% penetrated light are available in the system, which can provide ample scope for growing different intercrops and mixed crops to increase the system productivity and provide a better livelihood to the arecanut growers. Different mixed crops like black pepper, betel leaf, dioscoria, and intercrops like cassava, ginger, turmeric, and different vegetables were tried from time to time by many researchers (Abraham, 1974; Muralidharan, 1980; Sujatha *et al.*, 2006). Intercropping in arecanut plantations with different horticultural crops has been well documented by Thomas *et al.* (2011). Das (1990) reported that the adoption of a plantation-based farming system would provide economic stability to the farming community against production and price risks. Different workers had tried with different annuals and perennial crops as inter- or mixed crops under arecanut plantations. However, intercroppingannual crops is labour-consuming, hence, it provides a ample scope on employment generation. Based on the report on intercropping and mixed cropping systems, different models with different crop combinations were established at the research centre to find out the increase in system productivity over the monocropping system and to provide a recommendation to the farming community for more income generation.

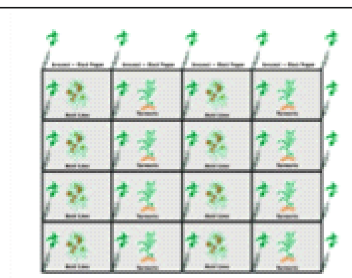
Materials and Methods

An experiment was conducted from 2015 to 2020 at the ICAR-CPCRI Research Centre Mohitnagar in an existing arecanut (var. Mohitnagar, aged 40 years) plantation spaced at 2.7 m X 2.7 m. The experimental site was located at 26^0 N latitude and 88^0E longitude with an altitude of 93 m MSL. The maximum temperature varies from 22^0C to 37^0C whereas the minimum temperature ranges from 8^0C to 24^0C. The average rainfall received in the area is 3200 mm. Ninety percent of rainfall is received during the rainy season, i.e., June–September, and the rest, ten percent, received during other months of the year. Relative humidity varied from 70 to 98%. The site was predominantly alluvium soil with a pH range of 5.0 to 5.8.

Arecanut palms were spaced at a distance of 2.7 m x 2.7 m. Different crop combinations (Listed below) were considered to develop the models.

Cropping model	Crop combination details	Plant population/ha
I	Arecanut+ Black pepper+ Banana + Acid lime	(1370+1370+ 606+606) nos.
II	Arecanut + Blackpepper+ Acid lime + Turmeric	(1370+1370+ 606+5880) nos.
III	Arecanut + Black pepper + acid lime	(1370+1370+ 606) nos.
IV	Arecanut + Black pepper + Banana	(1370+1370+ 606) nos.
V	Arecanut + Black pepper + Acid lime + Jute	(1370+1370+ 606+2200) nos.
VI (control)	Arecanut as sole crop (Control)	1370 nos.


Model I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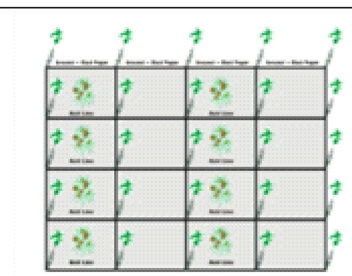
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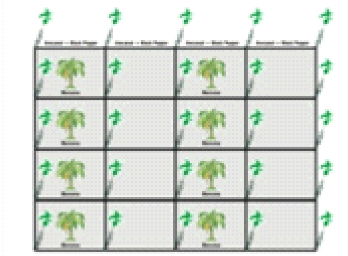
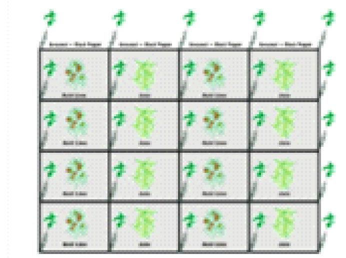
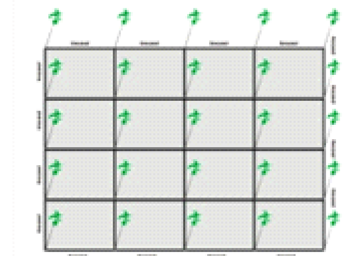


Model IV



Model V



Model VI (Control)

Different varieties of crops, like Mohitnagar for arecanut, Panniyur 1 for black pepper, Malbhog for banana, Gandharaj for acid lime, Suguna for turmeric, and JRO-420 for jute, were established. Banana and acid lime were planted in the middle of four areca nut palms in an alternate row, whereas turmeric and jute were planted in a raised bed (1.2 m wide) in between two areca nut lines, leaving a basin area of 0.75 m. Recommended agronomic practices were followed for all the crops. Irrigation was provided as and when required. Each model was established in an area of 1110 square meters, with three replications having a palm population of 152. Betel nut fruits were dried after the harvesting of mature, ripe nuts and the dry kernel yield was recorded. The dry weight of black pepper was recorded after processing. A fresh weight was recorded for bananas. In the case of acid lime, yield was calculated as the number of fruits per plant. In the case of jute, fibre was extracted after retting and weighed. Yield was recorded plot-wise and converted to hectare yield. The yield of all the intercrops was converted to dry kernel equivalent yield with the following formula to make the comparison among different models. The data was analyzed using standard statistical analysis procedure (Panse and Sukhatme, R 3.2 software

$$\textbf{Kernel equivalent yield of intercrops} = \frac{\text{Yield of intercrop (q ha}^{-1}\text{) x Price of intercrop (Rs. q}^{-1}\text{)}}{\text{Price of arecanut kernel (Rs. q}^{-1}\text{)}} \text{ (q ha}^{-1}\text{)}$$

Result and Discussion

Different parameters, like the dry kernel yield of arecanuts and the dry yield of black pepper, banana, citrus, jute, and turmeric, were recorded and depicted in the tables 1 through 3.

Yield of arecanut

The areca nut yield (Table 1) was either decreasing or stable with the advancement of the experiment. This may be due to the age of the arecanut palm. It was found that the five-year average arecanut yield was significantly different among different models. The Dry kernel yield of arecanut in models I, II, and IV was on par with the Dry kernel yield of arecanut under control. However, Dry kernel yield was recorded at its maximum in models II (33.0 q/ha) and V (36.9 q/ha) and was significantly different from the other models. The Dry kernel yield in these two models may be due to better management practices for annual intercrops grown within the system

Table 1. Year wise arecanut (Dry kernel) yield (q/ha) at different models

Crop Model	2015-16	2016-17	2017-18	2018-19	2019-20	Average
I	36.36	33.98	34.52	30.69	28.5	32.8
II	34.94	39.59	37.63	32.58	30.33	35.0
III	34.54	36.51	34.58	32.14	27.4	33.0
IV	38.16	33.97	32.88	31.15	23.85	32.0
V	39.05	40.19	41.65	31.81	31.89	36.9
VI	35.83	33.43	33.98	30.14	23.89	31.5
Sem	0.39	0.32	0.70	0.57	0.44	0.76
CD	1.52	1.25	2.72	2.22	1.71	3.58

Yield of black pepper

The yield of black pepper was recorded in all the models except the control, where arecanut was grown as the sole crop. The data has been depicted in Table 2. The yield data indicated that black pepperis alternate-bearing in nature. Krishnamurthy *et al.* (2013) also reported the alternate bearing of the black pepper variety Panniyur 1. The dry yield of black pepper cv. Panniyur 1 in different years and at different models varied significantly. Maximum black pepper yield was recorded in Model II throughout the experimental year. However, in the first year, it was significantly different with Models I, III, and IV. In the second year, it varied significantly with Model IV, and it was on par with the other models. Black pepper yield was almost on par in all the models except model V in the third year of the experiment. In the fourth year, the yield of black pepper in all the models was recorded higher than in the other years of experimentation due to favorable weather condition (rainfall occurs during the flowering period). The black pepper yield was on par in models II and III, and these two were significantly different from the black pepper yields of other models. In the last year of experimentation (2019-20), black pepper yield was drastically reduced but the yield of black pepper in Model II was increased and deferred significantly compared to the yield of black pepper in other models. Five-year average data on dry black pepper yield from different models indicated that model II had a higher yield of dry black pepper (21.2 q/ha), followed by other models that were statistically on par. This may be due to more crop intensification within the system which facilitated better growth environment.

Table 2. Year wise dry black pepper yield (q/ha) at different models

Crop Model	2015-16	2016-17	2017-18	2018-19	2019-20	Average
I	17.95	22.61	17.13	23.98	13.7	19.1
II	21.71	23.98	18.5	26.72	15.07	21.2
III	18.5	23.02	17.4	25.35	13.7	19.6
IV	18.91	21.24	17.54	23.98	12.33	18.8
V	20.76	23.15	15.76	22.61	13.02	19.1
SEM	0.63	0.78	0.68	0.38	0.38	
CD	1.79	1.99	1.86	1.39	1.39	NS

Total system productivity (TSP)

Total system productivity was expressed as quintal dry kernel per hectare. The yields of other inter and mixed crops were converted to dry kernel equivalent yield, added together with arecanut dry kernel yields, and analyzed. The total system productivity of all the models in the year 2015-16 was statistically significant over control (Model VI). And among the different model it ranged between 114.7 q/ha (Model III) to 130.91 q/ha(Model II) and model II was significantly different than the other models in terms of TSP. The second year (2016-17) results showed that models II and V were on par but significantly different from the other models. In the third (2017-18), fourth (2018-19), and fifth years (2019-20) of experimentation, similar results were obtained, where the maximum TSP was recorded in Model II and was statistically significant compared to the other models. The TSP was minimum in all the models in the years 2019–20 and that is because of the lower black pepper yield in this year. Five-year experimental data was averaged and analyzed. Significant difference in all the models was observed. It was found that model II, where arecanut, black pepper, acid lime, and turmeric were the crop combinations, had the maximum TSP (131.1 q/ha) compared to the other models and it was significantly different with the other models.The average system productivity ranged from 31.5 q/ha (control) to 131.1 q/ha (Model II).Error box plot (Fig. 2) indicates that all the models are significantly different over control on total system productivity. Though maximum system productivity was obtained in Model II but it is not significantly different with model I. This is due to the same crop combinations except one component crop. Total system productivity of model III, IV and V was on par.

The percent contribution of different crops to total system productivity (TSP) has been presented in Table 4 and Fig. 1. The average yield of arecanut and other mixed and

Table 3. Total system productivity (q/ha) at different year of different models

Crop Model	2015-16	2016-17	2017-18	2018-19	2019-20	Average
I	116.13	127.76	116.992	134.41	98.55	118.8
II	130.91	134.07	128.74	148.53	113.01	131.1
III	114.7	125.05	112.10	135.58	91.21	115.7
IV	119.59	123.68	112.20	135.66	88.47	115.9
V	121.96	131.52	110.20	131.11	96.39	118.2
VI	35.83	33.43	33.98	30.14	23.89	31.5
SEM	1.71	2.34	2.44	0.41	0.81	0.38
CD	2.95	3.45	3.53	1.44	2.03	1.81

Figure 1. Percent contribution of different component crops on total system productivity

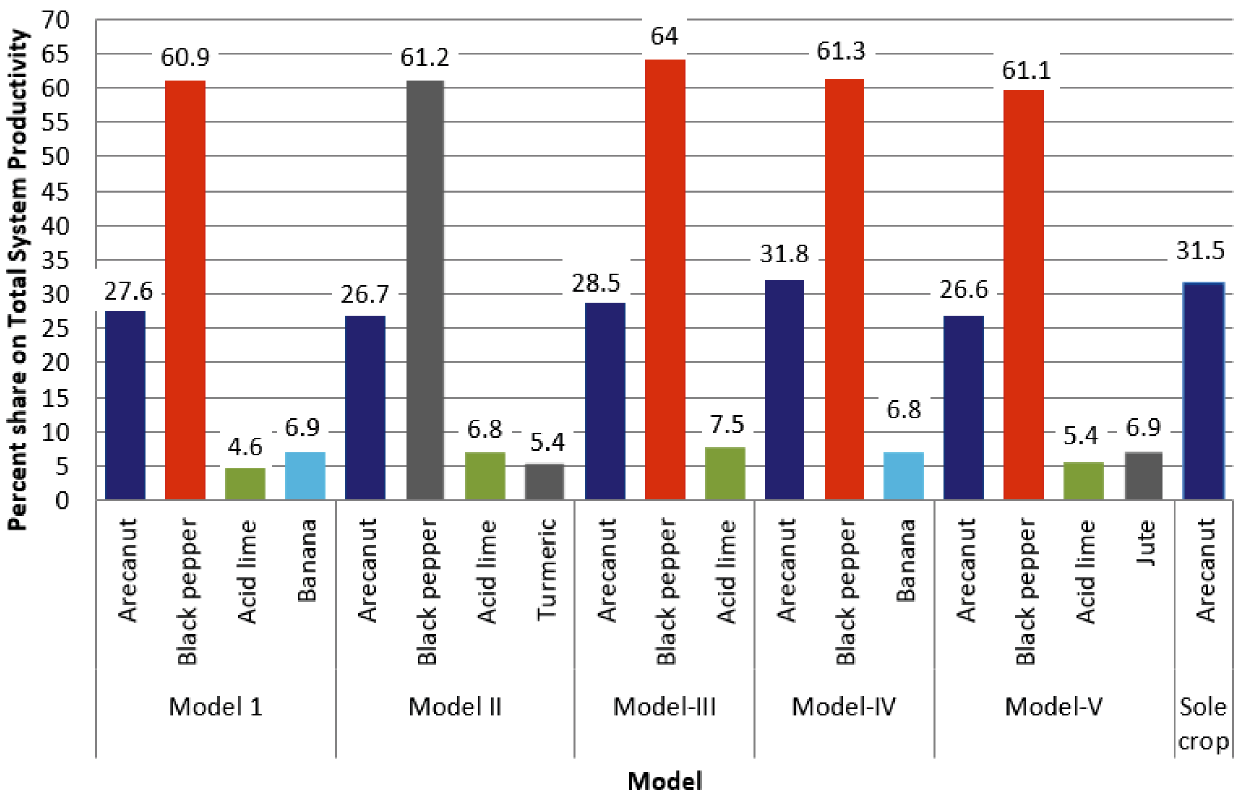


Figure 2. Box plot analysis of total system productivity

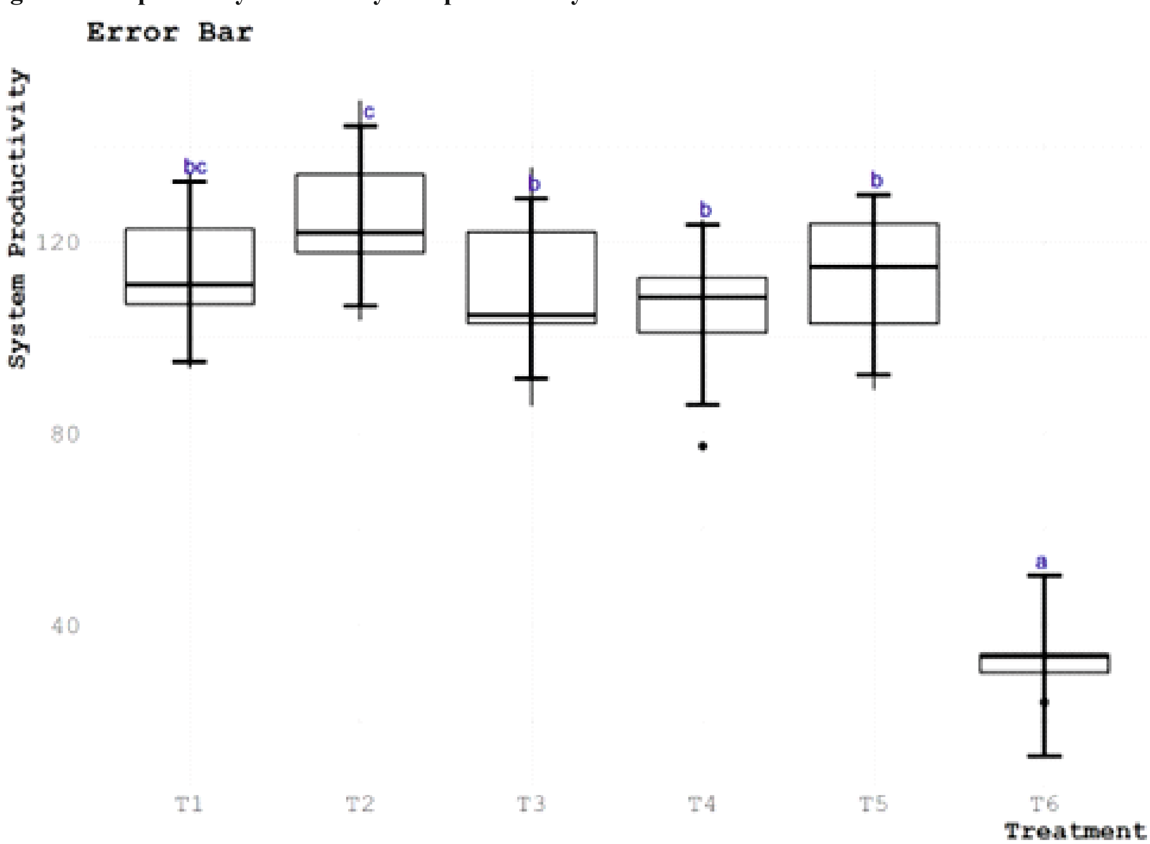


Table 4. Plant population and yield of different crops in different models

Crop Model	Crop combination	Plant population/ ha n	Crop yield (q or no./ha	Arecanut equivalent Yield (q/ha	Total system productivity (q/ha)	% share of individual crop over total system productivity	% Increase over control	BC Ratio
1	Arecanut	1370	32.8	-	118.8	27.6	377	3.46
	Black Pepper	1370	19.1	72.3	-	60.9	-	-
	Acid lime	606	50904 nos	5.49	-	4.6	-	-
	Banana	606	93.22	8.17	-	6.9	-	-
II	Arecanut	1370	35.0	-	131.1	26.7	416	3.86
	Black Pepper	1370	21.2	80.2	-	61.2	-	-
	Acid lime	606	85063 nos.	8.85	-	6.8	-	-
	turmeric 5880	63.54	7.02	-	5.4	-	-	
III	Arecanut	1370	33.0	-	115.7	28.5	367	3.72
	Black Pepper	1370	19.6	74.1	-	64.0	-	-
	Acid lime	606	84132 nos.	8.63	-	7.5	-	-
IV	Arecanut	1370	36.9	-	115.91	31.8	368	3.67
	Black Pepper	1370	18.8	71.1	-	61.3	-	-
	Banana	606	90.75	7.91	-	6.8	-	-
V	Arecanut	1370	31.5	-	118.23	26.6	375	3.53
	Black Pepper	1370	19.1	72.2	-	61.1	-	-
	Acid lime	606	60140 nos.	6.33	-	5.4	-	-
	Jute	2200	3.16	8.2	-	6.9	-	-
Control	Arecanut	1370	31.5	-	31.5	-	-	1.32
CD	-	-	-	-	1.81	-	-	0.24

intercrops of different models for five years has also been depicted in Table 4. The arecanut Dry kernel equivalent yield (q/ha) has been calculated for all the crops considering the five-year average data. It was found that out of different crop components, black pepper contributed the most to total system productivity (60.9% in Model-I to 64% in Model-III), followed by arecanut (26.6% in Model V to 31.8% in Model IV). Though the other component crops had the minimum contribution to the TSP, they helped to increase the TSP. The result showed that black pepper is an important component crop of arecanut-based cropping systems, not only for increased TSP but also because it can increase the livelihood of farming communities. Different models had better advantages than the control. There was a 367–417% increase in TSP over the control. A higher system productivity value was reported by Sujatha *et al.* (2010) in arecanut and medicinal plant combinations. BC ratio was calculated considering fixed costs and variable costs like cost of cultivation of arecanut, intercrops including costs of planting material of annual crops, harvesting cost, processing and post harvest handling costs of all the components. The BC ratio was ranged between 1.32 (arecanut as mono crop) to 3.86 (arecanut+ black pepper +acid lime + turmeric) and its were significantly different over the control. Maximum BC ratio (3.86) was obtained from Model II followed by Model III (3.72) and Model IV (3.67)

Based on the study, it is concluded that the arecanut-based cropping system is more advantageous than the monocropping of arecanuts. Out of different models, Model II with a crop combination of arecanut, black pepper, acid lime, and turmeric can give more return than the other crop combinations. It is also suggested to the arecanut growers to adopt arecanut-based cropping system for their better livelihood.

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