

Performance of areca-based high-density multispecies cropping system under different levels of fertilizer

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An arecanut (*Areca catechu* Linn.) based high-density multispecies cropping system (HDMSCS) model was studied under three levels of fertilizer management, i.e., full, two-thirds, and one-third dose of recommended fertilizers for productivity. The component crops included in the system were pepper (cv. Panniyur) trained on arecanut palms, banana (cv. Cheni Champa) in a triangular system (5.4 m × 2.7 m), turmeric (cv. Kasturi) spaced 30 cm × 30 cm, and pineapple (cv. Queen) in two rows spaced 60 cm × 30 cm between two palms of arecanut. Nine years of mean economic yield revealed that the full dose of recommended fertilizer application resulted in higher production with arecanut chali yield of 2405 kg ha⁻¹, dry pepper yield of 1252 kg ha⁻¹, pineapple fruit yield of 988 kg ha⁻¹, and turmeric yield of 2127 kg ha⁻¹. However, the banana yield did not vary much between the full and two-thirds dose of fertilizers (6331 kg to 6313 kg ha⁻¹). Under one-third dose of fertilizers, all the crops realized the lowest yields with arecanut chali yield of 1975 kg ha⁻¹; pepper, 1051 kg ha⁻¹; banana, 5165 kg ha⁻¹; pineapple, 543 kg ha⁻¹; and turmeric, 1801 kg ha⁻¹. The net returns under graded levels of fertilizers for the mean of nine years data revealed that application of full dose of fertilizers resulted in higher net returns of Rs 324 548 (U.S. \$6801.00) ha⁻¹ yr⁻¹. The major share was derived from the main crop of arecanut (48%) followed by the component crop of pepper (43%). Other crops contributed the remaining 8.9%. The pineapple cultivation was found to be uneconomical as a component crop in the areca-based HDMSCS model.

Keywords: Arecanut; HDMSCS; Cropping systems; Fertilizers; Economic returns

Arecanut (*Areca catechu* Linn.) is extensively cultivated in Assam and is one of the important cash crops in that area. Although its cultivation is mainly under homestead conditions, large-scale commercial cultivations are also common. The long pre-bearing stage of arecanut and the limited availability of arable land has led to farmers growing different annual and perennial crops in the interspace of the arecanut plantations in order to generate additional income per unit area.

Mixed cropping of pepper, banana, and cocoa were found to be economical in arecanut gardens (Muralidharan, 1980; Nair, 1982; Shama Bhat, 1988; Khader *et al.*, 1992). Growing a single crop as a mixed crop in an arecanut garden would not maximise resources use such as land, sunshine, and moisture. This has led to the concept of high-density multispecies cropping system (HDMSCS), where more than one crop are grown as mixed crops (Bavappa *et al.*, 1986). Growing more crops in a unit land area would add biomass to the soil in the form of leaf sheddings and prunings and indirectly add nutrients to the system. Hence, this study was initiated to evaluate the areca-based HDMSCS under different levels of fertilizers, for productivity and economic viability.

Materials and Methods

Between 1985 and 1986, an arecanut-based HDMSCS model was laid out in a 26-year-old arecanut plantation of 0.285 ha comprising 432 arecanut palms in a spacing of 2.7 m × 2.7 m at CPCRI Research Centre, Kahikuchi, Assam. The experimental site is situated at 20°18' N latitude and 91°78' E longitude with an altitude of 60 m above mean sea level. The average annual rainfall is about 3000 mm, of which the major portion is received between June and September. There is a dry spell from October to March with occasional showers from March to May. The soil of the experimental site is mainly alluvium with lower laterite strata having a pH of 4.4 to 5.6. Four different crops, viz., pepper, banana, pineapple, and turmeric were grown as intercrops in areca garden. The crop varieties and their spacings are given in Table 1.

During 1986–87, the plot was sub-divided into three different blocks and introduced to three levels of fertilizers, viz., full, two-thirds, and one-third dose of recommended fertilizers of arecanut and the other component crops. The recommended dose of NPK fertilizers for the crops is as shown in Table 2.

Urea, single-super phosphate, and muriate of potash were used as the source of NPK fertilizers. Cultivation operations and plant protection measures were carried out when necessary and

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Table 1 Layout of the arecanut-based cropping system

Crop	Variety	Spacing	Bed size	Population
Arecanut	Local	2.7 m × 2.7 m	—	432 plants
Pepper	Panniyur	2.7 m × 2.7 m	Trailed on arecanut palm	432 plants
Banana	Cheni Champa	5.4 m × 2.7 m	—	196 plants
Pineapple	Queen	60 cm × 30 cm	1 m × 1 m ¹	414 beds
Turmeric	Kasturi	20 cm × 30 cm	2.5 m × 1 m ²	195 beds

¹8 Suckers bed⁻¹²36 Rhizomes**Table 2** Fertilizer levels used in the arecanut and other component crops

Crop	Unit	n	P ₂ O ₅	K ₂ O	Method of application
Arecanut	g palm ⁻¹	100	40	140	In split dose (June and September)
Pepper	g vine ⁻¹	100	40	140	In split dose (June and September)
Banana	g plant ⁻¹	160	160	320	In split dose (June and September)
Pineapple	g bed ⁻¹	64	32	64	In split dose (June and September)
Turmeric	g bed ⁻¹	7.5	5	5	As basal dose

1% Bordeaux mixture was sprayed onto the arecanut during the pre- and post-monsoon periods as a prophylactic measure against *Phytophthora* diseases. Irrigation was provided at regular intervals during dry months through sprinklers.

Banana and pineapple were replanted once during 1992–93. Turmeric cultivation was not taken up during 1991–92, 1992–93, and 1993–94. Yield data of each crop were recorded separately from 1987–88 onwards. Considering the prevailing market prices of produce, the economics was determined for the mean yield of nine years.

Results and Discussion

Yield response of fertilizers

Arecanut yield was higher with the full dose of fertilizer application in all years except 1988–89, 1993–94, and 1994–95 compared to two-thirds dose of fertilizer application (Table 3). In 1988–89, 1993–94, and 1994–95, the two-thirds dose of fertilizer treatment maintained a higher chali yield of 2864 kg, 2138 kg, and 2485 kg ha⁻¹, respectively. One-third dose of fertilizer treatment recorded the lowest chali yield in all years compared to the other two fertilizer treatments (1453 kg chali and 2653 kg chali ha⁻¹). The mean yield indicated that the full fertilizer dose gave a higher chali yield of 2405 kg ha⁻¹, followed by the two-thirds dosage (2388 kg ha⁻¹) and one-third dose (1975 kg ha⁻¹).

Pepper started producing yields from the fourth year of planting. Application of full dose of recommended fertilizers gave higher dry pepper yield compared to the lower levels of fertilizer treatments. The mean yield also revealed

that the full dose of fertilizer gave a higher yield (1252 kg dry pepper ha⁻¹), followed by the two-thirds dose (1128 kg ha⁻¹) and the one-third dose (1051 kg ha⁻¹).

Banana began to produce yields in the second year of planting and gave higher yields under full and two-thirds dose of recommended fertilizers in most of the years compared to the one-third dose. Between the full and two-thirds doses, the yield did not vary much. However, the one-third dose recorded the lowest yield in most of the years. The mean yield was 6313 kg bunches ha⁻¹ with full dose, 6331 kg bunches ha⁻¹ with two-thirds dose, and 5165 kg bunches ha⁻¹ with one-third dose. In general, the banana yield realized in this model was higher compared to the yield levels reported by Khader *et al.* (1992) and Sannamarappa (1993) (both in Karnataka) under arecanut-based HDMSCS models.

The pineapple yield was lowest with two-thirds and one-third dose of fertilizer application in all years compared to the full dose. The lowest mean fruit yield was recorded with one-third dose of fertilizer application (543 kg ha⁻¹) compared to the two-thirds (733 kg ha⁻¹) and the full dose (988 kg ha⁻¹). Khader *et al.* (1992) reported that although in the beginning, pineapple yield was higher (1263 kg ha⁻¹) in the arecanut-based HDMSCS model, in the subsequent years, it had declined and the system realized lower yields even with the full dose of recommended fertilizers.

The rhizome yield of turmeric was higher with the full dose of fertilizer application in most years compared to the other two levels of fertilizers. The mean yield also indicated that the rhizome yield was higher with the full fertilizer dose (2127 kg ha⁻¹), closely followed by the two-thirds dose (1973 kg ha⁻¹) and the one-third dose (1801 kg ha⁻¹). Turmeric being

Table 3 Yield response of different crops under different levels of fertilizers in arecanut-based high-density multispecies cropping system (1987–88 to 1995–96)

Crop	Treatment	1987–88	1988–89	1989–90	1990–91	1991–92	1992–93	1993–94	1994–95	1995–96	Mean
Arecanut (kg chali ha ⁻¹)	Full dose	3038	2379	2053	2560	2263	2643	2078	2253	2381	2405
	2/3 dose	3022	2864	2042	2066	2089	2443	2138	2485	2339	2388
	1/3 dose	2653	2211	1453	1664	1895	2317	1663	1969	1954	1975
Pepper (dry) (kg ha ⁻¹)	Full dose	—	—	—	410	1627	1669	1074	1411	1320	1252
	2/3 dose	—	—	—	432	1463	1622	1032	1032	1188	1128
	1/3 dose	—	—	—	410	2000	1374	853	800	867	1051
Banana (kg bunch ha ⁻¹)	Full dose	7139	5812	6222	6339	7423	—	5328	6476	5766	6313
	2/3 dose	7623	5222	5559	8845	7092	—	4659	5592	6053	6331
	1/3 dose	5296	3769	4674	7897	6044	—	4443	4380	4820	5165
Pineapple (kg ha ⁻¹)	Full dose	—	948	947	421	422	—	—	2348	839	988
	2/3 dose	—	284	758	368	316	—	—	2011	662	733
	1/3 dose	—	294	589	316	210	—	—	1358	492	543
Turmeric (kg ha ⁻¹)	Full dose	2511	2253	2516	2074	—	—	—	1663	1744	2127
	2/3 dose	2590	1884	2284	2010	—	—	—	1432	1640	1973
	1/3 dose	2948	1853	1816	1263	—	—	—	1243	1685	1801

a nutrient-exhaustive crop, showed decline in yield from the second year particularly under the reduced dose of recommended fertilizer treatments. Hence, turmeric cultivation was discontinued for three years during 1991–94 to allow the fertility of the soil to recover.

Economics

The profit:loss was determined for the mean yield of nine years in arecanut and other component crops under different levels of fertilization considering the prevailing market prices for the produce (Table 4). The cost of cultivation was maximum at Rs 45 504 (U.S. \$953.50) ha⁻¹ model yr⁻¹ with the full dose of recommended fertilizer application. This was reduced to Rs 41 330 (U.S. \$866.00) ha⁻¹ yr⁻¹ with reduction in fertilizer dose to two-thirds of the recommended dose and to Rs 36 135 (U.S. \$757.20) ha⁻¹ yr⁻¹ with reduction in fertilizer dose to one-third of recommended dose. Among the individual crops, the maximum cost of cultivation at Rs 12 280 (U.S. \$257.30) ha⁻¹ yr⁻¹ was for arecanut under full dose of recommended fertilizers. This was followed by pepper at Rs 10 200 (U.S. \$213.70) ha⁻¹ yr⁻¹ and turmeric at Rs 10 000 (U.S. \$209.50) ha⁻¹ yr⁻¹. The lowest cost of cultivation was recorded for pineapple at Rs 3720 (U.S. \$77.90) ha⁻¹ yr⁻¹ under the full dose of recommended fertilizers. With reduction in fertilizer dose, the cost of cultivation was reduced in all crops. However, the trend in contribution of individual crops towards the total cost of cultivation in two-thirds and one-third dose of fertilizers followed a similar trend as the full dose of fertilizers. The gross returns from the model was maximum under full dose of fertilizers at Rs 370 052 (U.S. \$7754.60) ha⁻¹ yr⁻¹ compared to Rs 351 239 (U.S. \$7360.40) ha⁻¹ yr⁻¹ with two-thirds and Rs 305 755 (U.S.

\$6407.20) ha⁻¹ yr⁻¹ with one-third dose of recommended fertilizers. Subsequently, the net returns from the model was higher at Rs 324 548 (U.S. \$6801.00) ha⁻¹ yr⁻¹ with the full dose of recommended fertilizers. This was closely followed by the two-thirds dose of recommended fertilizers with Rs 309 909 (U.S. \$6494.30) ha⁻¹ yr⁻¹. However, under the one-third dose of fertilizers, the net returns per hectare per year were reduced substantially [Rs 269 620 (U.S. \$5650.00) ha⁻¹ yr⁻¹]. This indicates that for sustained production and higher returns, the model needs to be fertilized with full dose of recommended fertilizers for the respective crops individually. Similarly, higher gross returns of Rs 176 757 (U.S. \$3704.00) ha⁻¹ were recorded by the eighth year of planting from the arecanut-based HDMSCS model in maidan parts of Karnataka with the full dose of recommended fertilizer application (Sannamarappa, 1993).

Within the fertilizer dose, the major contribution towards the total net returns was from the main crop of arecanut (48%) and equal contribution from the component crop of pepper (43.1%) with the full dose of recommended fertilizers. The profitability of growing pepper with areca was also reported earlier by Singh *et al.* (1982) and Khader *et al.* (1992). The remaining 8.9% returns were contributed by banana (4.9%), turmeric (3.5%), and pineapple (0.4%). In the lower levels of recommended fertilizers, the contribution from the main crop of arecanut increased with two-thirds (50.4%) and with one-third (48.8%) dose and the component crops decreased. This further indicates that the component crops needed a full dose of the recommended fertilizers for higher production and returns. The lowest contributor towards total net returns was pineapple contributing only 0.4% to negative returns under different doses of recommended fertilizers. This could be attributed to

Table 4 Economics of arecanut-based high-density multispecies cropping system model for the mean yield of nine years (1985-96)

Crops	Yield	Full dose			Two-thirds dose			One-third dose				
		Cost of production (Rs ha ⁻¹)	Gross returns (Rs ha ⁻¹)	Net returns (Rs ha ⁻¹)	Yield	Cost of production (Rs ha ⁻¹)	Gross returns (Rs ha ⁻¹)	Net returns (Rs ha ⁻¹)	Yield	Cost of production (Rs ha ⁻¹)	Gross returns (Rs ha ⁻¹)	Net returns (Rs ha ⁻¹)
Arecanut (kg chali ha ⁻¹)	2405	12280 (257.3) ¹	168350 (3527.8)	156070 (3270.5)	2388	10828 (226.9)	167160 (3502.9)	156332 (3276.0)	1975	9354 (196.0)	138250 (2897.1)	128896 (2701.0)
Pepper (dry) (kg ha ⁻¹)	1252	10200 (213.7)	150240 (3148.3)	140040 (2934.6)	1128	8849 (185.4)	135360 (2836.5)	126511 (2651.1)	1051	7462 (156.3)	126120 (2642.9)	118658 (2486.5)
Banana (kg bunch ha ⁻¹)	6313	9304 (194.9)	25252 (529.1)	15948 (334.20)	6331	8740 (183.1)	25324 (530.6)	16584 (347.5)	5165	7716 (161.6)	20660 (432.9)	12944 (271.2)
Pineapple (kg ha ⁻¹)	988	3720 (77.9)	4940 (103.5)	1220 (25.5)	733	3563 (74.6)	3665 (76.8)	102 (2.1)	543	3353 (70.2)	2715 (56.8)	-638 (-13.3)
Turmeric (kg ha ⁻¹)	2127	10000 (209.5)	21270 (445.7)	11270 (236.1)	1973	9350 (195.9)	19730 (413.4)	10380 (217.5)	1801	8250 (172.8)	18010 (377.4)	9760 (204.5)
Total		45504 (953.5)	370052 (7754.6)	324548 (6801.0)		41330 (866.0)	351239 (7360.4)	309909 (6494.3)		36135 (757.2)	305755 (6407.2)	269620 (5650.0)

¹Values in parentheses are U.S. \$ equivalent (U.S. \$1.00 = Rs 47.72)

the low production of fruits in pineapple due to higher shade. Singh *et al.* (1982) and Khader *et al.* (1992) also reported uneconomical returns from pineapple under arecanut-based HDMSCS models.

The findings of this study clearly revealed that of the four crops tried as component crops in the HDMSCS, productivity was higher in three crops (pepper, banana, and turmeric) and showed enhanced returns per unit area under full dose of recommended fertilizers. Pineapple did not perform well and was found to be uneconomical as a component crop in the areca-based HDMSCS model. Although the returns were predominantly from areca and pepper due to their high price, in the event of reduction in price of areca and pepper, banana and turmeric may play a vital role in sustaining returns.

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