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Performance of coconut based cropping systems for sustainable productivity under Coastal Ecosystem of Andhra Pradesh

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Abstract

Two coconut based multispecies cropping systems consisting of Model-I (Coconut + Cinnamon + Pepper + Cocoa + Banana + Pineapple + E.F.Yam + Colocasia + Turmeric) and Model-II (Coconut + Pepper + Banana + Pineapple + E.F.Yam + colocasia + Turmeric) were evaluated comparing with coconut monocropping system (Model-III) for coconut yield, nut quality and sustained productivity and economic viability for four consecutive years (1999-2003) at ARS, Ambajipeta.

Data on mean nut yield/palm/year revealed that the highest yields were registered by the palms of Model-I (102.7 nuts/palm/year) followed by Model-II (96.47 nuts/palm/year) compared to only 71.14 nuts/palm/year in Model-III (monocropping) accounting for an yield increase of 35.60 to 44.36 per cent. Data on annual nut yield exhibited a gradual increase year after year from 1999-2000 up to 2002-03 indicating the sustainability of the cropping system. The nut yield increased by 27.04 per cent in Model-I and 18.47 per cent in Model-II compared to only 3.63 per cent in Model-III prior to the experimental values. The economic analysis and employment generation studies revealed that the maximum returns and maximum number of mandays/ha/year were obtained from Model-I (Rs.47,589 and 680 mandays) followed by Model-II (Rs. 39,496 and 569 mandays) with Model-III putting up the lowest returns and mandays (Rs. 9,477 and 166 mandays). Considering the monetary returns and sustainability of the coconut yields, cropping system Model-I followed by Model-II were found suitable and these models may be recommended to the coastal ecosystem of AP.

Key words: Coconut based cropping systems, Sustainability, Cocoa, Banana, Employment, Economic analysis

Introduction

Andhra Pradesh is one of the major coconut growing states in the country commanding an area of one lakh hectares. Within the state, half of the area is confined to the coastal region comprising the East and West Godavari districts. Though these districts stand first in production and productivity in the state, the farmers in recent years experienced major monetary losses in coconut cultivation due to the cyclone during 1996 and monocropping with coconut aggravated the losses. The farmers in the coastal district follow monocropping of coconut mainly under irrigated condition at the recommended spacing of 9 x 9 m, which does not fully utilize the available soil, space and incident solar radiation. Therefore, the remaining interspaces could be profitably exploited for raising certain intercrops. Since the agroclimate facilitates the cultivation of a variety of intercrops in the coconut plantations, there seems to be a good scope of increasing the productivity and net returns from coconut plantations by raising compatible intercrops. The research work conducted in the Southern states led to the development of many intensive crop combinations involving different annuals, biennials and perennials. In Andhra Pradesh, research work on coconut based cropping systems was initiated only recently. Hence, two coconut based cropping system models were evaluated for four years for coconut yields, nut quality, monetary gains and results were reported.

Materials and Methods

Studies were under taken at ARS, Ambajipeta during 1999-2000 to 2002-2003. The experimental plot is situated at 14.05 m altitude in the Central Delta of river Godavari in East Godavari district and the soils are of coastal alluvial type.

Two high density multispecies cropping systems were established in 0.54 ha of 20 years old East Coast Tall plantation spaced at 9 x 9 m by inter planting various intercrops, such as perennial, biennials and annuals. The two cropping system models *i.e.*, Model-I and Model-II were established in 0.18 ha each along with the solo coconut as control. The details of main and intercrop population of two cropping system and monocrop (coconut) are furnished below.

Crops	Variety	No. of Plants		
		Model-I	Model-II	Model-III
Coconut	ECT	28	28	28
Cocoa	Forastero	54	—	—
Cinnamon	Local species	48	—	—
Pepper	Panniyur	28	28	—
Pineapple	Kew	864	864	—
Banana	TC Keli	144	144	—
E.F.Yam	Gajendra	144	144	—
Colocasia	Sathamuki	144	144	—
Turmeric	PCT-13	144	144	—

In Model-I, a single row of cocoa was planted at a distance of 3.5 m, between two rows of coconut palms, two plants of cinnamon were accommodated at 3.5 m in between two coconut palms. Banana was planted on either side of cinnamon row at 2 m spacing. Likewise colocasia was planted in double row with 30 cm spacing in between the cocoa plants. The E.F.Yam, turmeric and pineapple were planted on raised beds adopting spacings of 100 x 75 cm, 45 x 22.5 cm and 60 x 60 cm respectively. Pepper vines were trailed on each coconut palm. In Model-II, banana was planted @ 3 plants in between two coconut trees adopting 2.5 m spacing. In between the row of coconut, turmeric, colocasia, E.F.Yam and pineapple were planted on the raised beds adopting spacings of 45 x 22.5 cm, 100 x 75 cm and 60 x 60 cm respectively. All the crops were maintained with recommended doses of fertilizers applied in split doses during June-July and September-October along with normal basin irrigations. The biomass from main and component crops were subjected to vermicoposting through *Eisenia foetida* and *Eudrilus* spp. The vermicompost obtained was recycled back into the three cropping systems. Coconut palms were manured with 25 kg of composted biomass + ½ kg urea + 1 kg super phosphate + 1.25 kg muriate of potash /palm/year and basin irrigation was provided.

Data on the effect of two cropping systems on coconut yields, yield attributes, nut quality and yields of components crops were collected. The net monetary returns, employment generation in the cropping systems models were estimated and the results are reported in Table 1, 2 & 3.

Results and Discussion

Evaluation of coconut based cropping systems under coastal ecosystem for four consecutive years (1999-2000 to 2002-03) revealed that the highest nut yield/palm/year (102.7) was recorded by Model-I followed by Model-II (96.47) as against 71.12 nuts in monocropping *i.e.*, Model-III, accounting to yield increases of 44.36 and 35.60 per cent compared to Model-III (Table 1a). The nut yield in general gradually increased year after year from 1999 in Model-I and Model-II indicating that the cropping systems became sustainable. When, the cumulative nut yield/palm after experimentation was compared with the figures prior to experimentation (Table 1b), the results exhibited 27.04 per cent increase in

Table 1a. Yields, yield attributes and nut quality in different coconut based cropping systems

Cropping systems	Number of of leaves on crown	No. of leaves produced/ palm/year	Mean No. on spadices/ plam/year	No. of female flowers/ palm/year	Mean nut yield/ palm/year	Nut quality copra content (g/nut)	Copra wt (kg/palm/ year)
Model-I	34.84	13.35	12.12	257.70	102.70	164.30	19.70
Model-II	33.19	12.69	11.68	234.42	96.47	152.40	17.20
Model-III	31.90	11.33	9.60	196.05	71.14	116.68	11.28

Table 1b. Cumulative and mean nut yield of coconut before and after experimentation in different cropping systems

Cropping systems	Cumulative nut yield prior to experimentation (1993-99)	Mean nut yield	Cumulative nut yield after experimentation (1999-03)	Mean	% increase over mean prior to experimentation	% increase in nut yield over Model-III
Model-I	323.36	80.84	410.80	102.70	27.04	44.36
Model-II	326.56	81.64	385.88	96.47	18.17	35.60
Model-III	274.56	68.64	284.56	71.14	3.63	—

Model-I followed by 18.17 per cent increase in Model-II compared to only 3.63 per cent in Model-III. A similar report was made by Nambiar *et.al.*, (1988), who reported increase in nut yields of coconut, which ranged from 92 to 98 nuts/palm/year under the crop combination of coconut + cocoa + pineapple + pepper. The increase in yield of coconut by 176 per cent as compared to the pre-experimental yield could be due to the practice of high density multispecies cropping system (Anon, 1995).

Observations on yield attributes indicated that the rate of production of leaves, spadices and female flowers were the highest in palms of Model-I followed by Model-II compared to the monocropped palms in Model-III. Data on quality in terms of copra content/nut (Table-1a) revealed that in general, the copra content showed an increase in palms of Model-I and Model-II compared to monocropping (Model-III).

The percentage area covered by the main and component crops in the three cropping systems were compared and expressed as cropping intensity. It was found that the intensity of cropping was the highest in case of Model-I (240.19%) followed by Model-II (166.40) compared to the minimum area recorded by coconut monocropping *i.e.*, Model-III (45.26%) (Table 2a).

A perusal of data on certain physiological parameters *viz.*, PAR transpiration rate, stomatal conductance, stomatal resistance and photosynthetic rate (1977), who reported that the shading and reduced air temperature in coconut crop combination cause considerable reduction in the rate of evaporation in the ecoclimate of multispecies crop combination. The cropping systems also enhance the population of beneficial bacteria and fungi in the rhizosphere of coconut including phosphate solubilising bacteria and *Trichoderma viride*, a bioagent against basal stem rot (Table-2c). Thus the soil fertility in cropping systems created a more favorable environment for sustained crop production within the cropping system.

Table 2b. Physiological parameters of coconut in different cropping systems

Cropping systems	PAR ($mmol/m^2s$)	Transpira-tion rate ($mmol/m^2s$)	Stomatal conductance (mol/m^2s)	Stomatal resistance (m^2s/mol)	Photosyn-thetic rate ($mmol/m^2s$)
Model-I	1207.84	2.010	0.070	18.290	6.350
Model-II	1237.09	2.430	0.070	16.520	6.810
Model-III	1336.50	3.110	0.180	13.940	5.590

Table 2c. Microflora and beneficial microorganisms in coconut based cropping systems

Cropping system	Bacteria ($x10^5$)	Fungi ($x10^5$)	N.fixers ($x10^5$)	P.solubili-zing bacteria ($x10^5$)	Tricho-derma ($x10^5$)
Model-I	23.8	31.6	11.2	8.1	116.0
Model-II	18.3	26.7	12.0	5.0	123.0
Model-III	6.3	13.0	5.9	3.2	10.0

Recycling of biomass and increased biomass production enhanced microbial activity in the rhizosphere

Table 2a. Cropping intensity in different cropping systems

Crop	Model-I		Model-II		Model-III	
	No. of plants	% area covered	No. of plants	% area covered	No. of plants	% area covered
Coconut	28	47.87	28	45.96	28	45.26
Cocoa	51	40.96	—	—	—	—
Cinnamon	72	55.81	—	—	—	—
Banana	144	54.99	144	71.88	—	—
Pineapple	288	18.61	384	24.99	—	—
E.F.Yam	—	8.09	—	8.71	—	—
Colocasia	—	6.44	—	7.15	—	—
Turmeric	—	7.42	—	7.71	—	—
Total		**240.19**		**166.40**		**45.26**

in the three cropping systems (Table-2b) revealed that PAR values, transpiration rate and stomatal conductance in Model-III were the highest indicating the rapid loss of water vapour from palms compared to Model-I & II. The photosynethetic rate was also found to be the highest in Model-II & Model-I compared to monocropping *i.e.*, Model-III. These results indicate that the photosynthetic efficiency of palms was increased by the cropping systems thereby exhibiting a favourable influence on nut yield, nut quality and yield attributes of palms. A similar trend was observed by Nair and Balakrishna favourable microclimate and an increase in photosynthetic efficiency and enhanced vegetative vigour may be attributed in the enhancement of nut yield and quality of coconut in Model-I and Model-II compared to the palms of monocropped coconut in Model-III. The performance of component crops revealed that the cocoa, banana and E.F.Yam were productive and more remunerative than the others.

The studies on monetary returns and employment generation of the three cropping systems (Table 3) revealed that the highest net returns/ha/year were

registered by Model-I (Rs. 47,589) followed by Model-II (Rs. 39,496) as against the lowest in monocropping of coconut *i.e.*, Model-III at Rs. 9,477. These treatments also recorded the highest benefit cost ratio at 1.70 and 1.67 respectively compared to the lowest ratio in Model-III (1.30). Similar findings were also reported by Das (1991) revealing that the benefit cost ratio of multistoreyed cropping system was 1.76 and the internal rate of return was higher than 20%. It was also clear from the data on employment generation in the models that (Table 3) the Model-I recorded the highest number of mandays/ha/year (680) closely followed by Model-II (569) and the lowest value was observed in Model-III (166). The results were in tune with the findings of Rethinam (2001), who reported that coconut based systems generate additional employment.

Table 3. Economics and employment generation of coconut based cropping systems

Cropping systems	Cost of cultivation Rs/ha/year	Gross returns Rs/ha/ year	Net returns Rs/ha/ year	Cost benefit ratios	Total mandays / ha/year
Model-I	67,985	1,15,575	47,589	1.70	680
Model-II	58,453	97,950	39,496	1.67	569
Model-III	30,950	40,428	9,477	1.30	166

In this investigation, two cropping system models were compared with a control *i.e.*, monocropping with coconut. Subsequent to cyclone hit in 1996 to the coconut plantations in Andhra Pradesh, the coconut industry was confronted with several problems. One of the easy approaches to make the cultivation more competitive is the adoption of cropping system approach to increase the per palm productivity and productivity of unit holding. A series of filed experiments conducted at CPCRI, Kasaragod during sixties to nineties had already established the suitability of many crops as remunerative intercrops involving coconut as a base (Nelliat and Bavappa, 1974; Nelliat, 1979; Gopalasundaram and Nelliat, 1979; Srinivasa Reddy *et.al.*, 2002). The researches revealed that in coconut the effective root zone of the adult bearing palm is confined laterally to only 2 m around the base of the palm (Kushwah *et.al.*, 1973) and only 50% of the solar radiation being intercepted by coconut canopy projecting the scope for use of under utilized soil space and solar radiation (Nair, 1979). The experiments conducted during seventies and eighties on mixed cropping revealed that cocoa would be suitable while among multi-storeyed crops, banana, pepper, pineapple, clove, nutmeg and breadfruit were suggested under West Coast conditions. (Nelliat, 1979). Gopalasundaram and Nelliat (1979) evaluated several intercrops and reported yam, banana, spices, pineapple, banana, tapioca as suitable crops. Subsequent studies were pursued with High Density multi-species and crops *viz.*, cocoa, papaya, yam and pineapple were reported to be suitable (Bavappa *et.al.*, 1986). Recent experiments at the Institute included evaluation of certain INM treatments under high density multi-species cropping systems and certain interesting findings were reported *viz.*, registration of higher yields of main as well as intercrops even with only 2/3 of the full doses of fertilizers with substantiate income from the systems (Srinivasa Reddy *et.al.*, 2002). The present findings of this investigation are in line with those of earlier reports establishing the possibility for introducing certain high density multi-species cropping models in coconut plantations of Andhra Pradesh.

The experimental results revealed that cropping systems Model-I & Model-II enhanced the soil fertility promoted the microbial activity favourable microclimate and photosynthetic efficiency of coconut palms, which ultimately resulted in sustained productivity and quality of nuts. Cocoa, banana, E.F.yam, pineapple, colocasia and turmeric were found to be productive and remunerative components crop suitable to the coastal ecosystem of AP. Keeping in view of the above said benefits, the cropping system Model-I followed by Model-II could be recommended to the coastal ecosystem of the existing practice of monocropping.

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