

## Performance of coconut based high density multispecies cropping system under East Godavari district of Andhra Pradesh

E. Padma<sup>1</sup>, G. Ramanandam<sup>1</sup>, K. Ravindra kumar<sup>1</sup>, N.B.V.Chalapathi Rao<sup>1</sup> and H.P. Maheswarappa<sup>2</sup>

<sup>1</sup>AICRP on Palms, Horticultural Research Station, Ambajipeta, Dr.Y.S.R. Horticultural University, Andhra Pradesh, India

<sup>2</sup>Project Co-ordinator, AICRP on Palms, CPCRI, Kasaragod, Kerala, India

Corresponding author: padma\_ed@rediffmail.com

### ABSTRACT

A trial was conducted at Horticultural Research Station, Ambajipeta during 2008-12 with cocoa, banana, pineapple, elephant foot yam and *Heliconia* as intercrops in coconut. The mean data of four years revealed that nut yield recorded in coconut under cropping system was 117.3 per palm, whereas under monocrop, it was 96.5 nuts per palm. With respect to intercrops, cocoa recorded yield of 2.0 kg dry beans/tree, banana 22.7 kg/plant, pineapple 0.9 kg/plant, elephant foot yam yielded corm of weight 2.8 kg/plant and *Heliconia* 12 spikes/plant. With respect to biomass production, a total quantity of 34.5 t/ha/year on fresh weight basis collected from the bio-system (7.6 tonnes from coconut, 15.0 tonnes from cocoa, 6.0 tonnes from banana, 3.6 tonnes from Pineapple, 1.3 tonnes from elephant foot yam and 1.0 ton from heliconia) which was used for production of vermicompost. The total quantity of vermicompost obtained was 20.11 t/ha/yr with vermicompost recovery of 58%. There was an increase in the soil organic matter content from 0.99 % to 1.2 %, soil organic carbon content from 0.5% to 0.7%, nitrogen from 288 kg/ha to 344 kg/ha, phosphorus from 20.5 kg/ha to 24.5 kg/ha and potassium from 123.76 kg/ha to 138.14 kg/ha with coconut based cropping system. The microbial population of bacteria, actinomycetes, trichoderma, phosphorus solubilising bacteria (PSB) count was high in the coconut based cropping system. The economic analysis revealed that the highest net returns were registered in coconut based cropping system compared to coconut monocrop.

**Keywords:** Coconut, cropping system, intercrops, biomass, economics, yield.

### INTRODUCTION

In India, Andhra Pradesh is one of the major coconut grown state after Kerala, Karnataka and Tamilnadu with 1.21 lakh hectares area and producing 1258 million nuts annually. Though, the state has the highest productivity of 10322 nuts per hectare (www.nhb.gov.in), the net returns per unit area are quite low and uncertain. In Andhra Pradesh, major coconut cultivation is confined to East and West Godavari districts. Though these districts stand first in production and productivity in the state, farmers in recent years experienced consistent losses in cultivation of this crop due to increase in cost of cultivation and abiotic stresses like raising temperatures, heavy gales and super cyclones. In coastal Andhra region, monocropping is predominant under irrigated conditions at spacing of 8.0 x 8.0 m, which does not fully utilize the natural resources like soil, space and solar radiation. Therefore, the remaining interspaces

could be profitably exploited for cultivation of intercrops suitable for the agro-climatic condition and there is a good scope of increasing the net returns from existing coconut plantations. Coconut being widely spaced crop provides sufficient scope for intercropping of different annual and perennial crops. Moreover, certain intercrops can successfully be grown because of their ability to tolerate coconut shade. The technique of growing intercrops in coconut garden had been standardized (Nelliath *et al.*, 1979). Studies have revealed that, adult palm of sole crop of coconut spaced at 7.5 m x 7.5 m apart effectively uses only 22.3% of land area, while the average air space utilization by the canopy is about 30 % and solar radiation interception is 45-50% (Bavappa *et al.*, 1986).

The coconut based cropping systems involving several species of seasonal, annual, and perennial crops thus evolved to meet their demands and to achieve efficient utilization of

resources. Adoption of coconut based farming systems is one among the ways to augment the productivity by improving soil characters and coconut nutrition (Maheswarappa *et al.*, 1998). The selection and inclusion of crop components are influenced by the agro ecological zone and by household preferences, requirements, and dietary habits.

Keeping in this, a trial was initiated to develop location specific coconut based cropping system (CBCS) model suitable for coastal conditions of Andhra Pradesh and to increase the net returns per unit area of coconut.

## MATERIALS AND METHODS

A field trial was conducted at Horticultural Research Station, Ambajipeta, East Godavari district of Andhra Pradesh during 2008-12. The soils are coastal alluvial type with impeded drainage. The average annual rainfall during experimental period was 1207 mm and mean temperature ranged from minimum of 26.7 °C to maximum of 30.7 °C. The average relative humidity varied between 65.7 and 87.2%. The trial was initiated in 20 years old healthy Godavari Ganga (ECT x GBGD) coconut plantation with the following intercrops like cocoa, banana, pineapple, elephant foot yam and heliconia.

The geometric spacing of intercrops, variety and recommended dose of fertilizers are given below.

Standard package of practices were adapted for coconut and intercrops. Initial and final soil nutrient analysis was carried out. Organic carbon content of the soil was analyzed by Walkley and Black's Wet oxidation method (Walkley and Black, 1934) available nitrogen by alkaline permanganate method (Subbiah and Asija, 1956) the available phosphorus by Olsen's method (Olsen *et al.*, 1954) and available potassium was determined photometrically using neutral Ammonium acetate method (Jackson, 1958). The microbial population *viz* bacteria, actinomycetes, trichoderma, PSB count was done in CBCS plot and monocrop coconut plot by dilution, plating and culturing methods (Rifai, 1969). Growth observations and yield parameters of coconut and component crops were recorded, computed the mean values and 't' test was done for comparing the yield of coconut in CBCS and as monocrop. Biomass yield and vermicompost recovery was calculated and finally the economics of coconut based cropping system was worked out considering the cost of cultivation which includes labour, inputs, irrigation costs etc., and returns were computed in terms of rupees based on prevailed market price of the produce during the respective years.

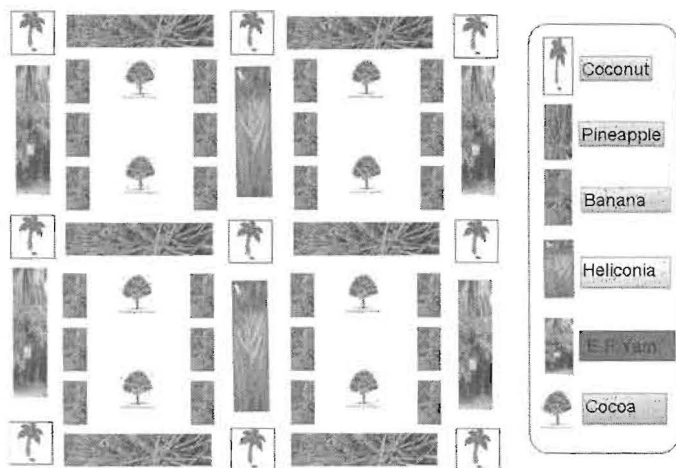


Fig. 1 : Schematic representation of different crops in CBCS

## RESULTS AND DISCUSSION

### Growth and Yield of Crops

The data pertaining to growth and yield of coconut was furnished in Table 1. The total number of leaves on crown did not differ significantly in the initial years but significant differences were observed during 2010-11 and 2011-12 and the total number of leaves produced per palm per year showed significant differences during 2008-09 and 2009-10 and non significant differences during 2010-11 and 2011-12. Mean number of leaves on crown and total number of leaves produced per palm per year are more in CBCS (32.9 & 12.9 respectively) compared to monocrop (31.0 & 12.1 respectively). Number of bunches produced per year showed significant difference between CBCS (11.9) and

Main crop/Inter Crop	Variety/Hybrid	Spacing	No. of Plants	Recommended dose of Fertilizer as per DrYSRHU
Coconut	Godavari ganga(ECT x GBGD)	8.0 x 8.0 m	90 palms	500:320:1000g NPK/palm
Cocoa	Forestero	2.75m x 2.75 m	108 plants	100:40:140g NPK/plant
Banana	T C keli	1.5 x 1.5 m	324 plants	200:50:200g NPK/plant
Pineapple	Kew	0.45 x 0.45 m	72 beds/ 12 plants per bed (864 plants)	8:4:8 g NPK/plant
Elephant foot yam	Gajendra	0.60 x 0.60 m	27 beds/18 plants per bed (486 plants)	9:3:9 g NPK/plant
Heliconia	Golden Torch	0.45 x 0.45 m	27 beds/ 18 plants per bed (486 plants)	20:20:20 g NPK/plant

**Table 1:** Effect of CBCS on growth and yield of coconut

Year	Treatment	No. of leaves on crown	No. of leaves produced/year	No. of bunches /Year	No. of buttons / bunch	Nut yield / palm/ year	Copra content (g/nut)	Oil (%)
2008-09	CBCS	31.1	12.2	11.9	21.0	108.6	155.4	68.1
	Monocrop	30.2	11.1	10.8	19.8	91.2	152.6	68.0
	T value	0.9	2.7*	2.4*	1.1	1.8	0.7	0.1
2009-10	CBCS	32.1	12.5	12.4	22.0	110.5	156.5	68.5
	Monocrop	31.5	11.6	11.8	21.0	95.7	154.4	68.2
	T value	0.7	2.7*	1.6	0.9	1.5	0.6	0.5
2010-11	CBCS	32.8	13.1	12.3	22.2	111.5	160.0	69.0
	Monocrop	30.4	12.8	12.0	22.0	94.2	158.0	68.0
	T value	3.0*	0.8	0.7	0.1	1.8	0.6	1.9
2011-12	CBCS	33.0	13.6	13.1	23.1	138.5	162.3	68.4
	Monocrop	32.0	12.2	12.8	22.4	104.1	159.6	68.1
	T value	2.7*	1.82	0.9	0.7	4.5*	1.2	0.5
Mean of 4 years	CBCS	32.8	12.9	12.5	22.1	117.3	158.5	68.5
	Monocrop	31.0	12.1	11.8	21.3	96.5	156.1	68.0

\*Indicates significance

monocrop (10.8) in 2008-09 and non significant difference in the later years with mean value of 12.5 in CBCS compared to monocrop (11.8). Number of buttons per bunch showed non significant differences between CBCS and monocrop during 2008-12.

Regarding nut yield per palm per year, non significant differences were observed between CBCS and monocrop in the initial three years but in 2011-12 significant differences were observed between CBCS (138.5 nuts/palm/year) and monocrop (104.1 nuts/palm/year). By growing intercrops, CBCS realized average nut yield (4 years) of 117.3 nuts/palm/year compared to monocrop (96.54 nuts/palm/year). The increase in nut yield over the years suggest that the intercrops have not competed with the main crop and instead contributed synergistically which may be due to additional input the coconut has received in terms of additional biomass, irrigation, fertilizer, weed control, *etc.* Similar increase in nut yield in WCT and Laccadive ordinary when grown in mixed farming system was also reported by Maheswarappa *et al.* (2001). Probable reasons for increase in nut yield were due to the overall influence of integrated management practices for coconut and changes in microclimate due to mixed cropping (Bavappa *et al.*, 1986). Addition of organic manure, in situ green manuring in the coconut basins, resulted in improvement in the retention of soil moisture, available nutrients, buildup of organic carbon in the soil, which enhanced the uptake of nutrients and resulted in improvement in health of palms. The overall improvement of the palms health had positive influence on productivity of coconut (Maheswarappa

*et al.*, 2005). The copra content and oil content also did not differ significantly among CBCS and monocrop during 2008-12. However, mean copra content and oil content recorded in CBCS was 158.5 g/nut and 68.5% respectively than in monocrop (156 g/nut and 68.0% respectively).

### Yield of Intercrops

In addition to coconut produce, the intercrops *viz* cocoa recorded dry bean yield of 2.0 kg /tree, banana bunch of 22.7 kg/tree, pineapple fruit weight of 0.9 kg /plant elephant foot yam corm yield of 2.8 kg and Heliconia 12 spikes/plant (Table 2). Rahim *et al.* (2007) evaluated coconut based multistoried cropping system and found that indigenous vegetables like aroids, brinjal and medicinal plants grow very well as compared to sole cropping. Girija Devi *et al.* (2011) reported that banana, elephant foot yam, ginger, turmeric, cassava and vegetable cowpea can be grown as suitable intercrops in coconut garden in different combination and yields are on par with their sole crops in coconut garden.

**Table 2:** Yield of intercrops in CBCS.

Crops	2008-09	2009-10	2010-11	2011-12	Mean
Cocoa Dry beans (kg/tree)	pre-bearing	pre-bearing	pre-bearing	2.0	2.0
Banana (kg/ plant)	25.4	20.5	21.5	23.4	22.7
Pineapple (g/plant)	850.4	875.2	975.2	1050	937.7
E.F.Yam (kg/plant)	2.56	3.15	2.9	2.75	2.8
Heliconia (Spikes/Plant)	10.0	11.0	12.0	15.0	12.0

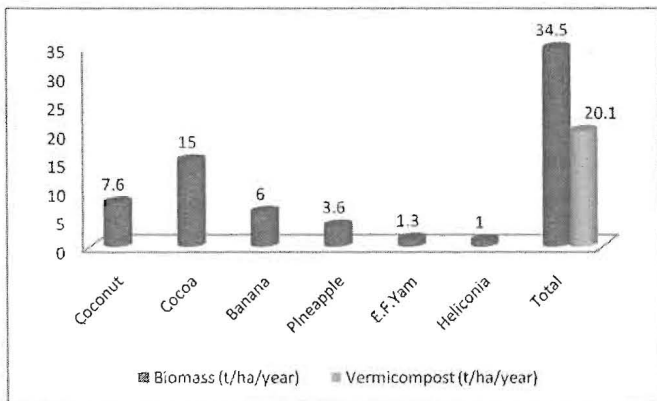


Fig. 2: Mean Biomass yield in different crops (Average of 4 years)

### Biomass and Vermicompost

In the coconut based cropping system, the total biomass obtained from all the crops was to the tune of 34.5 tonnes/ha/year (7.6 tonnes from coconut, 15.0 tonnes from cocoa, 6.0 tonnes from banana, 3.6 tonnes from pineapple, 1.3 tonnes from elephant foot yam and 1.0 ton from heliconia). The recyclable biomass was converted to vermicompost by using *Eudrilus* sp. About 20.11 tonnes of vermicompost was generated from the collected biomass from one hectare area with a recovery of 58.1% (Fig. 2). These results are in accordance with Maheswarappa (2008) where in coconut based cropping system with coconut, banana, pineapple and tuber crops gave enormous quantity of recyclable biomass (9110 kg/ha to 17612 kg/ha/year) and which on conversion to vermicompost through *Eudrilus* sp. contributed to 70.1 to 142.1 kg N, 10.0 to 20.3 kg P and 18.0 to 36.5 kg K /year.

Table 3: Soil fertility parameters as influenced by intercropping in CBCS

Treatments	Total Organic matter content (%)	Organic carbon (%)	Nitrogen (kg/ha)	Phosphorus(kg/ha)	Potassium(kg/ha)
Before experiment(2008)	0.99	0.58	288	20.5	123.76
After experiment (2012)	1.20	0.70	348	24.5	138.14

Table 4: Effect of coconut based cropping system on soil microbial population (4 years average)

Soil microbial population	Mean values	
	CBCS	Monocrop
Bacteria (Nutrient Agar medium) ( $\times 10^5$ cfu/g)	6.70	6.2
Actinomycetes (Starch-Casein Agar medium) ( $\times 10^5$ cfu/g)	8.37	7.91
PSB ( $\times 10^4$ cfu/g)	2.51	2.32
Trichoderma (Trichoderma specific media) ( $\times 10^3$ cfu/g)	9.35	9.0

Table 5: Economics of coconut based cropping system (4 years average)

S.No	Component	Gross Returns( Rs/ha/year)	Cost of cultivation( Rs/ha/year)	Net Returns( Rs/ha/year)	B:C ratio
1.	CBCS	417955	240475	177480	1.73
2.	Monocrop coconut	73493	54238	19255	1.35

### Soil Nutrient Status and Microbial Population

The results pertaining to influence of intercrops on soil fertility is furnished in Table 3. There was increase in the total organic matter content of the soil from 0.99 to 1.2%. It is evident from the results that there was also increase in the soil organic carbon from 0.5% to 0.7%, nitrogen from 288 kg/ha to 344 kg/ha, phosphorus from 20.5 kg/ha to 24.5 kg/ha and potassium from 123.76 kg/ha to 138.14 kg/ha with cropping system which could be attributed to increased root activity and biomass addition to the soil that might have favored carbon mineralization through increased population of soil micro organisms. The mean of four years revealed that the population of Bacteria, Actinomycetes, Trichoderma, PSB count was more in CBCS compared to monocrop (Table 4). Due to addition of organic matter in soil being the chief source of energy and food for most of the soil organisms, it has great influence on the microbial population. Bopaiah *et al.*, (1991) studied on soil microflora and biological-activities in the rhizospheres and root regions of coconut-based multistoried cropping and coconut monocropping systems and reported that the organic C, total N, P and K were higher in the root region soils of multistoried cropping system than in the coconut monocropping system.

### Economics of CBCS

The economics of coconut based cropping system was worked out based on prevailing market prices and is furnished in Table 5. The gross returns obtained from one hectare of CBCS was Rs 4,17,955 /ha/year whereas it was Rs 73,493

/ha/year under monocrop. The cost of cultivation in CBCS was Rs 2,40,475 /ha/year and it was Rs 54,238 /ha/year under monocrop. The net return and B:C ratio of CBCS was Rs.177480/ha/year and 1.73 under CBCs whereas it was Rs.19255 and 1.35 under monocrop. By following this cropping system in coconut ,there exists an advantage of increase in yield, additional income and hence resulted in higher income, as reported by earlier workers (Maheswarappa *et al.*, 2013; Palaniswami *et al.*, 2007).

## CONCLUSION

From the present study it can be concluded that cropping systems through raising compatible intercrops augment soil health along with increased productivity and net returns. However, selection of suitable crop species together with adoption of recommended package of practices are of prime importance for harnessing the full potential of the system. Based on the results, coconut based cropping system with intercrops *viz* cocoa, banana, pineapple, elephant foot yam, heliconia adjudged as best cropping system and can be recommended for coastal districts of Andhra Pradesh.

## REFERENCES

- Bavappa, K.V.A., Abdul Khader , K .B.,Biddappa, C.C., Khan, H.H., Kasturi Bai, K. V., Ramadasan. A., Sundararaju, P., Bopaiah. B.M., Thomas, G. V., Misra, L.,P., Balasimha, D., Bhat. N.T.and Sham Bhat, K.1986. Coconut and arecanut based high density multi- species cropping systems. *Journal of Planation Crops*, **14** (2):74-87.
- Bopaiah, B. M. and Shetty, H. 1991 .Soil microflora and Biological-activities in the rhizospheres and root regions of coconut-based multistoried cropping and coconut monocropping systems. *Soil biology & biochemistry*, **23**(1): 89-94.
- Girija devi. L., Gladis, R. and Biju, J. 2011. Performance studies of various crops in coconut based cropping system compared to sole cropping. *Journal of Progressive Agriculture*, **2**: 47-50.
- Jackson, M.L. 195. *Soil Chemical Analysis*. Prentice-Hall Inc., Englewood cliffs, New Jersey. pp. 498.
- Maheswarappa, H.P., Dhanpal, R., Subramanian, P. and Palaniswami, C. 2013. Evaluation of coconut based high density multi-species cropping system under organic and integrated nutrient management. *Journal of Plantation Crops*, **41**(2):130-135.
- Maheswarappa, H.P. 2008 .*In situ* Waste Management in Integrated Nutrient Management System under Coconut (*Cocos nucifera*)- Based High Density Multi-species Cropping System in Tropical Soils of India. *Indian Journal of Agricultural Sciences*, **78**: 924-928.
- Maheswarappa, H.P., Anitha Kumari,P., Kamalakshyamma,P.G and Shanavasa,M. 2005. Influence of integrated nutrient management and high density multi species cropping system on soil properties ,plant nutrition and yield in root wilt affected coconut palms. *Cord*, **21**(2): 18-29.
- Maheswarappa, H.P., Hegde, M.R., Dhanpal.R., Sairam. C.V. and Vidhan Singh,T. 2001. Impact of integrated mixed farming system in coconut (*Cocos nucifera* ) garden on coconut yield and economic analysis . *Indian Journal of Agronomy*, **46**(1): 56-63.
- Maheswarappa, H.P., Hegde, M.R., Dhanpal, R. and Bidappa C,C.1998. Mixed farming in coconut garden:Its impact on soil physical,chemical properties, coconut nutrition and yield. *Journal of Planation Crops*, **26**(2): 139-143.
- Nelliat, E.V. 1979. Prospects of multiple cropping in coconut based farming system -The Indian Experience. *Indian Coconut Journal*, **32**: 3-11.
- Olsen,S.R *et al.*, 1954. Estimation of available phosphorus in soils by extraction with sodium bicarbonate.U.S.Dep.Agric., Washington, D.C. Circ.939
- Palaniswami,C.,George V.Thomas, Dhanpal,R., Subramanian, P., Maheswarappa, H.P. and Upadhyay, A.K. 2007. Integrated nutrient management in coconut based cropping system.Technical Bulletin No.49. Central Plantation Crops Research Institute, Kasaragod. 24p.
- Rahim, M.A., Bari M., S., Islam, F. and Naher, N. 2007 Multistoried Cropping System-a New Room for Indigenous Vegetables and Medicinal Plants. *Acta Horticulturae*, **751**:493-497.
- Rifai, M,A.1969. A revision of the genus *Trichoderma*. Mycological papers,no.116, Common Wealth Mycological Inst., Asso. of applied biologists, Kew, Survey,England.
- Subbiah,B.V and Asija G.L.1956. A rapid procedure for the determination of available nitrogen in soils. *Current Science*, **25**:259-260.
- Walkley, A. and Black, C.A.1934. An estimation of Degtjareff methods for determining soil organic matter and a proposed modifications of the chromic acid titration method. *Soil Science*, **37**: 29-38.