



# Performance of coconut-based high density multispecies cropping system under East Godavari Dist. of Andhra Pradesh

E. PADMA<sup>a1\*</sup>, G. RAMANANDAM<sup>a2</sup>, K. RAVINDRA KUMAR<sup>a3</sup>, N.B.V. CHALAPATHI RAO<sup>a4</sup>  
and H.P. MAHESWARAPPA<sup>b5</sup>

<sup>a</sup> AICRP on Palms, Horticultural Research Station, Ambajipeta – 533 214 (Andhra Pradesh)

<sup>b</sup> AICRP on Palms, ICAR-Central Plantation Crops Research Institute, Kasaragod – 671 124 (Kerala)

Received : 29 June 2016 ; Revised accepted : 9 November 2016

## 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. Earthworm count and soil moisture were also higher in coconut based cropping system whereas soil temperatures were found lower in coconut based cropping system compared to monocrop. The economic analysis revealed that the highest net returns were registered in coconut based cropping system compared to coconut monocrop.

**Key words :** Biomass, CBCS, Coconut, Cropping system, Economics, Intercrops, Vermicompost, Yield attributes.

## 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](http://www.nhb.gov.in)), the net returns per unit area are quite low and uncertain. In Andhra Pradesh, major coconut cultivation 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. 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. The technique

of growing intercrops in coconut garden had been standardized (Nelli et al., 1979).

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 Res. Station, Ambajipeta, East Godavari (Andhra Pradesh) during 2008-12.

<sup>1,3</sup> Scientist \*([padma.edee@gmail.com](mailto:padma.edee@gmail.com)), <sup>2</sup> Principal Scientist  
<sup>4</sup> Senior Scientist, <sup>5</sup> Project Co-ordinator

The geometric spacing of intercrops, variety and recommended dose of fertilizers in the experiment

Main crop/ Inter crop	Variety/Hybrid	Spacing	No. of plants	Recommended dose of fertilizer as per Dr. YSRHU
Coconut	Godavari Ganga (ECT x GBGD)	8.0 x 8.0 m	90 palms	500:320:1500g NPK/palm
Cocoa	Forestero	2.75m x 2.75 m	108 plants	100:40:140g NPK/plant
Banana	Grand Naine	2.0 x 2.0 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

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 43°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 intercrops like cocoa, banana, pineapple, elephant foot yam and heliconia.

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 (1934) wet oxidation method 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. Earthworm count was taken at three different depths 10, 20 and 30 cm. Soil temperatures were measured using soil thermometers at 15 cm and 30 cm depth of soil. Soil moisture content was

measured by calculating the difference between the weights of the wet and oven dry samples. (Black, 1965) Biomass yield and vermicompost recovery was calculated and finally the economics of coconut-based cropping system was worked out considering the cost of cultivation and returns were computed in terms of rupees based on prevailed market price of the produce during the respective years.

## 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 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.

**Table 1.** Effect of coconut based cropping system (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

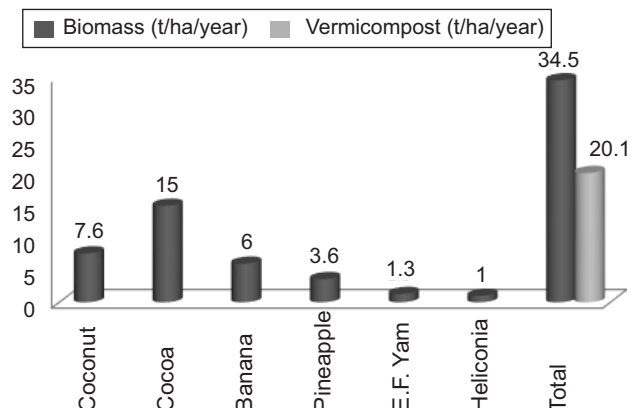
Regarding nut yield per palm per year, non significant differences were observed between CBCS and monocrop in the initial three years but in 2011-12 significant differences were observed between CBCS (138.5 nuts/palm/year) and monocrop (104.1 nuts/palm/year). By growing intercrops, CBCS realized average 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

**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



**Fig. 1.** Mean biomass yield in different crops (Av. of 4 yr.)

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. 1). 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 & 18.0 to 36.5 kg K/year.

**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

**Table 3.** Soil fertility parameters as influenced by intercropping in CBCS

Treatments	Total organic matter content (%)	Organic carbon (%)	Nutrients (kg/ha)		
			N	P	K
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 ( <i>Trichoderma</i> specific media) ( $\times 10^3$ cfu/g)	9.35	9.0

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.

**Soil moisture and soil temperature :** The soil moisture (%) measured during summer months *i.e.*, March, April, May and June are presented in **Table 5**. There is increasing trend in soil moisture (%) both in CBCS and monocrop compared to initial years. In both CBCS and monocrop, soil moisture values are less in 0-30 cm depth, high in 30-60 cm depth, still high in 60-90 cm depth. The mean moisture values are more in CBCS (17.31%) compared to monocrop coconut (15.52%). In the 2nd generation HDMSCS model of coconut-clove-banana, at 1.5 m and 2.0 m distance from coconut and clove, top soil moisture was low compared to sub soil moisture (Palaniswami *et al.*, 2010).

**Table 5.** Effect of coconut-based cropping system on soil moisture (%)

Summer month and Depth of soil	2008-09		2009-10		2010-11		2011-12		Mean	
	CBCS	Monocrop	CBCS	Monocrop	CBCS	Monocrop	CBCS	Monocrop	CBCS	Monocrop
March										
0-30 cm	13.54	12.48	15.04	14.50	15.6	15.0	15.8	15.3	15.0	14.3
30-60 cm	18.96	16.45	20.64	18.85	21.64	19.58	22.48	20.85	21.0	18.9
60-90 cm	21.39	18.85	23.77	21.0	24.00	21.5	24.50	22.0	23.4	20.8
April										
0-30 cm	11.88	10.65	13.20	11.50	14.10	12.00	14.34	12.45	13.4	11.6
30-60 cm	16.63	15.50	18.34	16.50	18.48	17.0	19.45	17.50	18.2	16.6
60-90 cm	18.77	16.55	20.85	18.65	21.0	19.00	21.58	19.54	20.5	18.4
May										
0-30 cm	10.44	9.50	11.60	10.50	12.00	11.0	12.82	11.45	11.7	10.6
30-60 cm	14.62	13.25	16.24	15.00	16.80	15.50	17.50	16.95	16.3	15.1
60-90 cm	16.50	14.00	17.48	15.85	18.33	16.85	18.60	17.0	17.7	15.9
June										
0-30 cm	11.50	9.50	12.78	10.68	13.0	11.0	13.20	11.50	12.6	10.6
30-60 cm	16.10	14.45	17.89	15.45	17.94	15.85	18.42	16.00	17.5	15.4
60-90 cm	18.17	16.14	20.19	18.51	20.84	18.85	22.4	19.0	20.5	18.1
Mean	15.70	13.94	17.33	15.58	17.81	16.09	18.42	16.62	17.31	15.52

**Table 6.** Effect of coconut-based cropping system on soil temperature ( $^{\circ}$ C)

Depth of soil	2008-09		2009-10		2010-11		2011-12		Mean	
	CBCS	Monocrop	CBCS	Monocrop	CBCS	Monocrop	CBCS	Monocrop	CBCS	Monocrop
15 cm	24.25	25.20	23.58	24.89	21.45	22.67	23.40	24.85	23.1	24.4
30 cm	22.15	23.10	22.48	23.56	20.14	21.87	21.25	22.58	21.5	22.7

The soil temperatures were high at 15 cm depth compared to 30 cm both in CBCS and monocrop. However CBCS recorded lesser mean temperatures (23.1 and 21 $^{\circ}$ C) compared to monocrop coconut (24.4 and 22.7  $^{\circ}$ C) respectively at 15 cm and 30 cm depth (**Table 6**).

**Earthworm count :** The population of earthworms was less at 10 cm depth of soil compared to 20cm and 30 cm depth of soil both in CBCS and monocrop. CBCS recorded more number of earthworms/m<sup>2</sup> (12.5) compared to monocrop (11.0) (**Table 7**). The population of earthworms in CBCS (16.66) and monocrop (14.66) during 2011-12 was high compared to earthworm population in CBCS (9.0) and monocrop (7.0) in 2008-09. The key indicator of soil quality is earthworm activity, which is important for improving and maintaining soil fertility, soil structure and aggregate stability. (Edwards and Lofty, 1977; Clements *et al.*, 1991) Organic cropping systems have shown higher earthworm biomass and density than conventional systems (Mader *et al.*, 2002).

**Economics of CBCS :** The economics of coconut based cropping system was worked out based on prevailing market prices and is furnished in **Table 8**. The gross returns obtained from one hectare of CBCS was ₹ 4,17,955 /ha/year whereas it was ₹ 73,493 /ha/year under monocrop. The cost of cultivation in CBCS was ₹ 2,40,475 /ha/year and it was ₹ 54,238 /ha/year under monocrop. The net return and B:C ratio of CBCS was ₹ 177480/ha/year and 1.73 under CBCs whereas it was ₹ 19255 and 1.35 under monocrop. By following this cropping system in coconut, there exists an advantage of increase in yield,

**Table 7.** Influence of coconut-based cropping system on earthworm population (no.)

Depth (Population in sq.m. soil)	2008-09		2009-10		2010-11		2011-12		Mean	
	CBCS	Monocrop	CBCS	Monocrop	CBCS	Monocrop	CBCS	Monocrop	CBCS	Monocrop
10 cm	8	6	10	9	11	10	15	13	11	9.5
20 cm	9	7	11	10	12	11	17	15	12.25	10.75
30 cm	10	8	14	13	15	14	18	16	14.25	12.75
Mean	9	7	11.66	10.66	12.66	11.66	16.66	14.66	12.5	11.0

**Table 8.** Economics of CBCS (4 years average)

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

,additional income and hence resulted in higher income, as reported by earlier workers (Maheswarappa *et al.*, 2013; Palaniswami *et al.*, 2007).

## CONCLUSION

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 HH, 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 Plantation Crops*. **14** (2): 74-87.
- Black C.A. 1965. *Methods of Soil Analysis* : Part I Physical and mineralogical properties. *American Society of Agronomy*, Madison, Wisconsin, USA.
- 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.
- Clements R O, Murray P J, Sturdy RG 1991. The impact of 20 years absence of earthworms and three levels of N fertilizer on a grassland soil environment. *Agric. Ecosyst. Environ.* **36** : 75-85
- Edwards C A and Lofty J R. 1977. *Biology of Earthworms*, 2<sup>nd</sup> ed. Chapman and Hall, London. pp.309
- 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 1958. *Soil Chemical Analysis*. Prentice-Hall Inc., Englewood Cliffs, New Jersey. pp. 498.
- Mader P, Fliessbach A, Dubois D, Gunst L, Fried P and Niggli U. 2002. Soil fertility and bio-diversity in organic farming. *Science*. **296** : 1694-1697.
- 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 J. of Agricultural Sciences*. **78** : 924-928.
- Maheswarappa H P, AnithaKumari P, Kamalakshamma 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 J. of Agronomy*. **46** (1) : 56-63.
- Maheswarappa H P, Hegde M R, Dhanpal R and Bidappa CC. 1998. Mixed farming in coconut garden : Its impact on soil physical, chemical properties, coconut nutrition and yield. *Journal of Plantation 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, 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. pp. 24.
- Palaniswami C, George V Thomas, Dhanpal R, Subramanian P and Maheswarappa H P. 2010. Nutrient management in coconut based high density multi species cropping system. *Technical Bulletin Coconut based cropping /farming systems* Central Plantation Crops Res. Inst., Kasaragod. pp. 80-96.
- 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, Surrey, England.
- Subbiah B V and Asija G L. 1956. A rapid procedure for determination of available nitrogen in soils. *Curr. Sci*. **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 Sci*. **37** : 29-38.

