Research Article

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Evaluation of coconut based high density multi-species cropping system under organic and integrated nutrient management

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Abstract

A field experiment on evaluation of coconut based high density multi-species cropping system under organic and integrated nutrient management was initiated during 2007 in coconut based cropping system at Central Plantation Crops Research Institute, Kasaragod. Three treatments *viz*., T1: 2/3rd of recommended NPK fertilizer + recycling biomass (vermicompost), T2: 1/3rd of recommended NPK fertilizer + recycling biomass (vermicompost) + bio-fertiliser + green manuring + vermiwash and T3: Fully organic with recycling biomass (vermicompost) + bio-fertiliser + green manuring + vermiwash + husk burial + mulching coconut basin were replicated seven times in RBD. The crops involved in the system were coconut, black pepper, pineapple, banana, clove, annual crops like, turmeric, ginger and vegetable crops (brinjal, pumpkin, and elephant foot yam), sweet corn and baby corn were grown in the space available during different seasons. Irrigation was provided through sprinkler system at IW/CPE=1.0. Average of five years (2007 to 2012) data on coconut yield indicated non significant difference among the treatments and it ranged between 145 to 155 nuts palm^{-1}year^{-1}. Black pepper yield also did not differ significantly among the treatments and ranged from 1.7 to 1.8 kg vine^{-1}, and banana (Njalipoovan variety) yield ranged from 6.0 to 7.2 kg bunch^{-1} and Grand naine variety yield also did not differ significantly among the treatments and it ranged from 13.7 kg to 15.5 kg bunch^{-1}. The copra and oil content of coconut did not differ significantly among the treatments and it ranged from 159.5 to 164.6 g nut^{-1} and from 65.7 to 65.8 per cent, respectively. Economics of the system indicated higher net return in T3 treatment.

Keywords: Coconut, cropping system, integrated nutrient management, organic

Introduction

Coconut (*Cocos nucifera* L.) is an important perennial oil yielding crop of humid tropics and is mainly grown in the southern states of Kerala, Karnataka, Tamil Nadu and Andhra Pradesh. Being a small holders' crop in India, when grown as a monocrop, does not provide adequate income and gainful employment to the dependent families. 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 per cent of land area, while the average air space utilization by the canopy is about 30 per cent and solar radiation interception is 45-50 per cent (Bavappa *et al.*, 1986). Thus, coconut gardens offers excellent opportunities for inclusion of compatible component crops for effective utilization of natural resources. In humid tropics, higher efficiency of utilisation of the basic resources of crop production *viz*. land, solar radiation and water can be achieved by adopting intensive cropping systems (Nelliat, 1973). Unlike in annuals, the potential for increasing productivity per unit area of land, time and inputs is considerably higher in perennial crops (Bavappa and Jacob, 1982). An agronomically desirable system should ensure that all the components of

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production are exploited at optimal level ensuring the long term production capability of the system as a whole is not affected.

The coconut based cropping systems evolved in response to the pressure of a shrinking land resource base coupled with a high population density, which necessitated a conscious attempt on the part of farmers to achieve their goals by living within biophysical, ecological, and economic constraints. High density multi-species cropping system (HDMSCS) involving several species of seasonal, annual, and perennial crops thus evolved to meet their demands and to achieve highly efficient use of resources (Bavappa *et al.*, 1986). The selection and inclusion of crop components are influenced by the climate and by household preferences, requirements, and dietary habits.

Integrated nutrient management includes the intelligent use of organic, inorganic and online biological resources so as to sustain optimum yields, improve or maintain soil chemical and physical properties and provide crop nutrition packages which are technically sound, economically attractive, practically feasible and environmentally safe (Tandon, 1990). In recent days, nutrient management through organic source of manures is gaining momentum for sustaining the productivity and conserving the natural resources. Thus such studies will address a few key aspects of nutrient management, including improving organic matter in the soil, increasing plant-available nutrients and supplying different organic manures to meet the nutrient demand. With this background, there is a gap in the research front with regard to impact of organic and integrated nutrient management practices under coconut based HDMSCS. Hence, a study was initiated to evaluate the impact of the management practices on yield and economics of the system.

Materials and Methods

Performance of coconut based high density multi-species cropping system with integrated and organic nutrient management practices was conducted at Central Plantation Crops Research Institute (CPCRI), Kasaragod during 2007 to 2012 in 42 years old coconut (WCT) garden spaced at 8 m x 8 m. CPCRI is situated at 12° 30' N latitude and 75° 00" E longitude at an elevation of 10.7 m above mean sea level. The mean annual rainfall during 2007 to 2012 was 3683 mm. Three treatments *viz.*, T1: 2/3rd of recommended NPK fertilizer + recycling biomass (vermicompost), T2: 1/3rd of recommended NPK fertilizer + recycling biomass (vermicompost) + bio-fertiliser + green manuring + vermiwash and T3: Fully organic with recycling biomass (vermicompost) + bio-fertiliser + green manuring + vermiwash + husk burial + mulching coconut basin were replicated seven times in RBD. The crops involved in the system were coconut, black pepper (Panniyur 1), pineapple (Mauritius), banana (Njalipoovan and during 2009, Grand naine variety was also planted) and clove. The banana crop was replanted after 3 years of planting. Clove crop was removed from the system during 2009 and in the same place nutmeg has been planted. In between coconut palms, cinnamon has been planted during 2010. The annual crops like, turmeric, ginger and vegetable crops (brinjal, pumpkin, and elephant foot yam), sweet corn and baby corn were grown in the space available during different seasons during 2010-11 and 2011-12. Schematic presentation of different crops arrangement is given in Fig. 1.

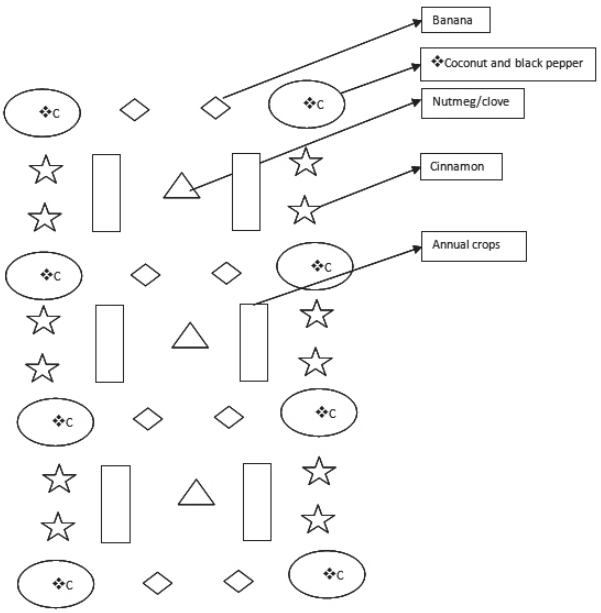

Fig. 1. Schematic representation of different crops in the HDMSCS

The quantity of different fertilizers and manures applied for different crops is given in the Table 1 and for annuals, the package of practice of KAU was adopted for applying organic manure and major nutrients. Bio-fertiliser applied was a combination of *Bacillus* sp. and Azospirillum (10^7 cfu g^{-1} of carrier). Cowpea was grown as green manure crop in the basins of coconut, banana and nutmeg crops in the system and was incorporated during September-October months. Quantity of green manure obtained and its nutrient composition was documented every year. Quantity of recyclable biomass from the system was converted into vermi-compost in the pits made for the purpose. The vermin-wash was applied after diluting to 1:10 proportion as per the treatments to different crops. All the required inorganic and organic manures were applied in two equal splits during May-June and September-October months. During summer months irrigation was provided with perfo system at IW/ CPE ratio of 1.0. As crops vary in their growth habit, the harvesting period also varied. The economic products were harvested as and when ready and quantified per hectare of coconut garden. Nut analysis (copra and oil content) was carried out after each harvest and mean of 2010 to 2012 was statistically analysed.

The input cost mentioned includes labour (imputed and actual), fertilizer, plant protection measures, irrigation and other miscellaneous overhead charges. The returns were computed in rupee terms by combining the weighted average yield of various years under consideration with weighed average market prices prevailed during respective years.

Results and discussion

Yield of different crops

Coconut

The coconut nut yield realised in the coconut based high density multispecies cropping system is presented in Table 2. It is evident from the data that, the nut yield did not differ significantly among the treatments during the study period. During 2008-09, the nut yield ranged between 163 nuts to 172 nuts $palm^{-1}year^{-1}$. Mean of five year period data indicated that, the nut yield recorded under T3 treatment was numerically higher than the other treatments from 2008-09 to 2011-12 even though it was statistically on par. The mean data for 2007 to 2012 was in the range of 145 to 155 nuts $palm^{-1}year^{-1}$. Thus, the nut yield has clearly indicated that, over the years, there was marginal increase in the yield under all the treatments compared to pre-experimental yield of 2005 to 2007. Increase in coconut yield due to application of inorganic fertilizer combined with organic manure has been reported by many workers (Palaniswami *et al*., 2007; Upadhyaay *et al*., 2009; Krishna Kumar and Maheswarappa, 2010; Maheswarappa *et al*., 2011).

Table 1. NPK, vermicompost, bio-fertiliser and vermiwash doses for different crops

Crop	2/3rd of Rec. NPK (g $plant^{-1}$)	1/3rd of Rec. fert. (g $plant^{-1}$)	Vermicompost (kg $plant^{-1}$)	Bio-fertiliser (g $plant^{-1}$)	Vermiwash (l $plant^{-1}$)
Coconut	N: 333 P: 213 K: 800	N: 167 P: 107 K: 400	30 (15+15)	200 (100+100)	10 (5+5)
Clove	N:200 P:167 K:500	N:100 P:83 K:250	25 (12.5+12.5)	100 (50+50)	6 (3+3)
Banana	N:133 P:133 K:267	N:67 P:67 K:133	6 (3+3)	50 (25+25)	4 (2+2)
Pineapple	N:5 P:3 K:5	N:3 P:1 K:3	50 g $plant^{-1}$ (25 +25)	50 (25+25)	8 lit bed^{-1} (4+4)
Black pepper	N:33 P:33 K:100	N:17 P:17 K:50	3 (1.5+1.5)	50 g bed^{-1} (25+25)	2 (1+1)

(Vermicompost, bio-fertiliser and vermiwash : applied twice a year)

The copra content and oil content also did not differ significantly among the treatments (Table 2). However, the copra content during the study period was higher (159.5 to 164.6 g nut^{-1}) compared to the pre-experimental period copra content (150.8 to 152.1 g nut^{-1}). Thus the impact of organic and integrated nutrient management had positive effect on copra content compared to pre-experimental data.

Black pepper

Black pepper yield recorded in different treatments is presented in Table 3 and it indicated the non-significant difference among the treatments. During 2010-11, the yield recorded was higher among the years studied and it ranged from 2.3 kg to 2.9 kg $vine^{-1}$. The mean data of 2007-2012 also indicated non-significant difference among the treatments and it ranged from 1.7 kg to 1.8 kg $vine^{-1}$. As early as 1971-72, Panniyur-1 variety of pepper planted as mixed crop and trailed on palms aged over 60 years in one ha plot at CPCRI, Kasaragod yielded a mean of 2.0 kg dry pepper $vine^{-1}year^{-1}$ (CPCRI, 1977). While evaluating the performance of six varieties of pepper in the multi-storied cropping system, Potty *et al*. (1979) suggested that Karimunda and Panniyur-1 varieties perform better under mixed cropping situations. Research findings have indicated that under coconut based HDMSCS and mixed farming systems, pepper variety Panniyur -1 has performed better and yielded 1.2 to 1.7 kg $vine^{-1}$ $year^{-1}$ and the yield was higher under $2/3^{rd}$ recommended fertilizer dose (1.7 kg $vine^{-1}$) (Palaniswami *et al.,* 2007). While evaluating the performance of different verities and hybrids, Maheswarappa *et al*. (2012) have reported better performance of Panniyur-1 in coconut based mixed cropping system.

Banana

There was increase in the yield of banana (Njalipoovan variety) over the years (Table 3). During 2010-11, treatment T3 recorded significantly higher yield (10 kg $bunch^{-1}$) compared to other treatments. The mean data for 2007-2012 indicated non-significant difference among the treatments and it ranged from 6.0 kg to 7.2 kg $bunch^{-1}$. The Grand naine variety yield also did not differ significantly among the treatments and it ranged from 13.7 kg $bunch^{-1}$ to 15.5 kg $bunch^{-1}$ (Mean of 2010 to 2012) (Table 3). Under HDMSCS at Kasaragod, banana (variety Njalipoovan) and pineapple (variety Mauritius) yield was highest under full dose of NPK and recycling of organic manure treatment (Palaniswami *et al.,* 2007).

Other crops

Clove and pineapple yield also did not differ significantly among the treatments (Table 3). The clove yield ranged between 0.82 kg to 1.1 kg $tree^{-1}$ and pineapple yield ranged between 0.79 kg to 1.1 kg $fruit^{-1}$. Ginger and turmeric yield was comparatively higher under T3 treatment compared to other treatments (Table 4). In baby corn, sweet corn, brinjal and pumpkin crops, there was not much

Table 2. Yield, copra and oil content of coconut under different treatments in coconut based HDMSCS

Treatment	Yield (nuts $palm^{-1}$ $year^{-1}$)		Copra content (g nut^{-1})		Oil content (%)	
	Pre-treatment (2005-07)	Mean (2007-12)	Pre- treatment (2005-07)	Mean (2009-11)	Pre- treatment (2005-07)	Mean (2009-11)
T1: 2/3rd recommended NPK fertilizer + recycling biomass (Vermicompost)	141.9	144.8	151.2	159.5	65.0	65.7
T2: 1/3rd recommended NPK fertilizer + recycling biomass (Vermicompost) + bio-fertiliser + green manuring + vermiwash	146.4	151.6	150.8	160.0	65.8	65.5
T3: Fully organic with recycling biomass (Vermicompost) + bio-fertiliser + green manuring + vermiwash + husk burial + mulching	151.6	154.7	152.1	164.6	66.1	65.8
CD (P=0.05)	NS	NS	NS	NS	NS	NS

Table 3. Yield of black pepper, banana (Njalipoovan and Grand naine), pineapple and clove under different treatments in coconut based HDMSCS

Treatment	Black pepper (kg vine^{-1})		Njalipoovan (kg bunch^{-1})		Grand naine (kg bunch^{-1})		Pineapple (kg plant^{-1})		Clove (kg tree^{-1})	
	Pre-treatment (2005-07)	Mean (2007-12)	Pre-treatment (2005-07)	Mean (2007-12)	2010-11	Mean (2010-12)	2007-08	2009-10	2007-08	2008-09
T1	0.87	1.8	6.2	6.9	16.4	15.5	1.0	0.9	1.0	0.9
T2	0.90	1.7	6.3	6.0	14.3	13.1	0.9	1.1	0.9	1.1
T3	0.85	1.7	5.9	7.2	14.8	13.7	0.9	1.0	0.9	1.0
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

T1: 2/3rd of recommended NPK fertilizer + recycling biomass (Vermicompost), T2: 1/3rd of recommended NPK fertilizer + recycling biomass (Vermicompost) + bio-fertiliser + green manuring + vermiwash, T3: Fully organic with recycling biomass (Vermicompost) + bio-fertiliser + green manuring+ vermi-wash + husk burial + mulching

Table 4. Yield of other crops under different treatments in coconut based HDMSCS (kg ha^{-1})

Treatment	Ginger*		Turmeric*		Baby corn	Sweet corn	Brinjal*	Elephant foot yam*	Pumpkin*
	2010-11	2011-12	2010-11	2011-12	2010-11	2010-11	2010-11	2010-11	2010-11
T1	569	462	503	616	1542	467	938	3973	1255
T2	658	708	688	755	1928	517	900	2741	1348
T3	745	862	835	955	1854	650	865	3080	1288
CD (P=0.05)	-	-	-	-	215.5	129.8	-	-	-

(*Mean of three replications) T1: 2/3rd of recommended NPK fertilizer + recycling biomass (Vermicompost), T2: 1/3rd of recommended NPK fertilizer + recycling biomass (Vermicompost) + bio-fertiliser + green manuring + vermiwash, T3: Fully organic with recycling biomass (Vermicompost) + bio-fertiliser + green manuring+ vermi-wash + husk burial + mulching

yield difference among the treatments. In elephant foot yam, the highest yield was obtained under T1 treatment (3973 kg ha^{-1} of coconut garden) compared to other treatments.

Economics

The cost of production was higher in T3 treatment during both the years (₹ 1,03,800 ha^{-1} during 2010-11 and ₹ 1,12,450 ha^{-1} during 2011-12) (Fig. 2). The net return was also the highest under T3 treatment (₹ 2,17,595 ha^{-1} during 2010-11 and ₹ 1,77,825 ha^{-1} during 2011-12) followed by other treatments. Higher net return during 2010-11 was mainly attributed to higher price for coconut and during 2011-12 there was higher price for black pepper and hence the net return was higher. By following this cropping system in coconut, there exists a advantage of increase in yield, additional income and hence resulted in higher income, as reported by earlier workers (Maheswarappa *et al.*, 2003; Palaniswami *et al.*, 2007).

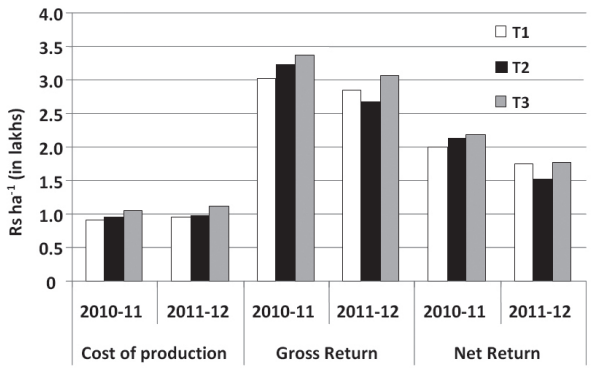

Fig. 2. Economics of coconut based HDMSCS under different treatments (₹ ha^{-1})

The present study has indicated non-significant difference among integrated and organic nutrient treatments under coconut based HDMSCS and there is a trend of positive influence of organic treatment in sustaining the productivity in the system. Further, it needs to be studied for some more years to arrive at exact impact of the treatments in the system.

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