Research Article

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Performance of black pepper in coconut based high density multi-species cropping system under different nutrient managements

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Abstract

Coconut based high density multi-species cropping system (HDMSCS) is recommended to obtain maximum income and better utilization of resources. The crops grown under HDMSCS include fruits, vegetables, spices *etc.* Black pepper (*Piper nigrum* L.), an important spice crop, is generally a component under coconut based cropping systems. In the present study, the performance of black pepper under coconut based HDMSCS (involving banana, nutmeg, cinnamon, and other annuals *viz*., turmeric, ginger and elephant foot yam as intercrops) was evaluated, in terms of yield and quality parameters. The observations, recorded for four years (2009-10 to 2012-13) under three different nutrient management practices, indicated no significant difference in yield and quality parameters of black pepper. The pooled data of four years indicated a mean pepper yield of 2.4 kg vine^{-1}, and quality parameters *viz.,* per cent of oil, oleoresin, piperine and bulk density (g L^{-1}) were 2.3, 9.8, 3.1 and 500.7, respectively. Under different nutrient management practices, the yield of both black pepper and coconut increased by 166 and 9 per cent, respectively, compared to the pre-treatment period (2005-07). The present study indicated that there was no reduction in yield of coconut when black pepper was grown in the basin and depending upon the availability of resources, farmers can follow the nutrient management practices.

Keywords: Black pepper, coconut, HDMSCS, INM, quality parameters

Introduction

Coconut (*Cocos nucifera,* L.) is one of the high value plantation crops in India. Studies have revealed that planting method and growth habit of sole coconut palms spaced at 7.5 × 7.5 m use only 22.3 per cent of land area effectively while the average air space utilization by the canopy is about 30 per cent and solar radiation interception is 45-50 per cent which make them highly adaptable for crop diversification (Nelliat *et al.,* 1974). Bavappa *et al.* (1986) reported that in the arecanut based cropping system model, the space occupied by other crops was higher than that occupied by arecanut and showed substantial increase over years primarily contributed by pepper. Coconut based high density multi species cropping system (HDMSCS) is followed to get maximum income and better utilization of resources. The crops grown under HDMSCS include vegetables, fruits and spices. Black pepper (*Piper nigrum*) is one of the most important spice crops and several studies showed that, black pepper can be grown successfully with coconut (Nagawekar *et al*., 2002; Sadanandan, 2000). High rainfall in the black pepper growing areas made the soil less productive due to leaching and erosion losses of nutrients and has effect on growth of the crop (Sadanandan, 2000). Therefore, in the present study, performance of black pepper under coconut based HDMSCS involving banana, nutmeg, cinnamon, and other

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annuals *viz*., turmeric, ginger and elephant foot yam as intercrop was evaluated, under different nutrient management systems in terms of yield and quality parameters.

Materials and methods

A study on coconut based HDMSCS involving banana, nutmeg, cinnamon and other annuals *viz*., turmeric, ginger and elephant foot yam as intercrops was done with West Coast Tall variety of coconut palm which was planted during the year 1965 at 8.0 × 8.0 m spacing. The experiment was conducted at CPCRI, Kasaragod, Kerala, situated at $12^0 30'$ N latitude and $75^0 00'$ E longitude at an elevation of 10.7 m above MSL. During the study period (2009-10 to 2012-13), the experimental area received an average annual rainfall of 3891 mm, and experienced mean maximum temperature 30.9 ^{0}C and mean minimum temperature 22.5 ^{0}C. The average relative humidity of the area is 91.4 per cent. The soil is sandy loam with field capacity of 7.4 per cent and 8.4 per cent at 0-25 cm and 25-50 cm depth, respectively. The soil nutrient status was low in available N and K and high in available P. Black pepper var. Panniyur 1 was planted during 1999. Three nutrient management 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 incorporation + mulching coconut basin were replicated seven times in RBD from 2007. Biofertilizer applied was a combination of *Bacillus* sp., and *Azospirillum* (10^7 cfu g^{-1} of carrier). The recyclable biomass from the system was converted into vermicompost in the pits made for the purpose. The vermi-wash was applied twice a year @ 10 L for coconut and two litre for black pepper after diluting to 1:10 proportion as per the treatments. All the required inorganic and organic manures were applied in two equal splits during May-June and September-October months (Table.1). Irrigation was provided during summer months using sprinkler system at IW/CPE ratio of 1.0.

Observations on yield and yield attributing characters were recorded from the vines from 2009-10 to 2012-13. Yield parameters were recorded in one meter column of vine at one meter above the ground. The harvested spikes were threshed and dried in open sun and dry weight was taken as yield per vine. Quality parameters such as essential oil and oleoresin were estimated by ASTA (1968) method, while piperine was estimated by HPLC method (Wood *et al*., 1988). The bulk density, which is the ratio of the mass to volume, was determined using the standard method by filling a measuring cylinder of 500 mL with the berries from a constant height (Balasubramanian and Visvanathan, 2011). Coconut yield per palm was collected from July to June of each agricultural year. Number of nuts obtained for the years 2005 to 2007 was taken as the pre treatment yield. Nut analysis (copra and oil content) was carried out after each harvest and mean of 2009-10 to 2012-13 was statistically analyzed. Soil samples collected during May 2012, air dried in shade, ground to pass through 2 mm sieve and analyzed for organic carbon, total N, available P, and K from two depths 0-25 cm and 25-50 cm. Organic carbon content of the soil was analysed by Walkley and Black (1934) wet oxidation method. Soil samples were analysed for total nitrogen by macro Kjeldahl method, the available phosphorus was estimated (Bray-1) following the procedure outlined by Jackson (1973) and available potassium was determined in the 1N NH_4OAC flame photometrically. The leaf samples were collected from index leaf (14th leaf) of the palm by cutting four to five leaflets from middle of the frond on both the sides. The leaf samples were washed with distilled water, air dried and then oven dried at 65 ^{0}C until the weight was constant. The dry leaves were powdered and digested in diacid mixture (HNO_3: $HClO_4$) and analysed for phosphorus by vanado-molybdate method and potassium

Table 1. Sources of nutrients for coconut and black pepper

Crop	2/3rd rec. NPK (g palm^{-1})	1/3rd rec. NPK (g palm^{-1})	Vermicompost (kg plant^{-1})	Bio-fertilizer (g plant^{-1})	Vermiwash (L plant^{-1})
Coconut	333:213:800	167:107:400	30	200	10
Black pepper	33:33:100	17:17:50	3	50	6

content by flame photometry method (Jackson, 1973). The nitrogen content in plant samples was estimated according to micro Kjheldahl procedure as described by Jackson (1973). The input cost mentioned includes labour (imputed and actual), fertilizer, plant protection measures, irrigation and other miscellaneous overhead charges. The returns were computed by combining the weighted average yield of various years under consideration with weighted average market prices which prevailed during respective years. Data were analysed using using standard analysis of variance (ANOVA) technique.

Results and discussion

Performance of black pepper

The effect of different nutrient management practices on pepper yield and quality parameters is presented in Table 2. The pertinent four years mean data on pepper yield, yield and quality parameters revealed that, there was no significant difference among the nutrient management practices. Number of spikes ranged from 188 to 212, length of the spike 15.3 cm to 16 cm, number of berries per spike 84 to 85, and the pepper yield ranged from 2.38 to 2.45 kg vine^{-1}. Black pepper yield increased by 166 per cent when compared to the pre-treatment period (2005-07). Evaluation of black pepper varieties carried out by earlier workers (Potty *et al*., 1979; Mathew *et al*., 1993; Sadanandan *et al.,* 1993) in the multi-storeyed cropping system and mixed cropping system indicated better performance of Panniyur-1 variety. As there was no difference among the different nutrient management practices, farmers can also grow pepper organically by recycling biomass generated in the system, avoiding dependence on costly chemical fertilizers which will ensure the soil health and sustainability. The study also corroborates the findings of earlier works on black pepper nutrition. Sadanandan and Hamza (1995) reported that fertility and productivity can be improved by judicious use of organic manures.

The black pepper quality parameters *viz*., per cent of oil, oleoresin, piperine and bulk density (g L^{-1}) plays a very important role for getting quality processed product from black pepper. The alkaloid, piperine, is the major contributor for pungency whereas essential oil constituents *viz*., α- and β-pinene, limonene, myrcene, linalool, α-phellandrene, sabinene, β-caryophyllene, germacrene-D, *etc*., are the major aroma and flavor compounds of pepper (Jirovetz *et al*., 2002; Jagella and Grosch, 1999). In the present study, the black pepper quality parameters *viz*., per cent of oil, oleoresin, piperine and bulk density were not affected by different nutrient management practices (2.3, 9.8, 3.1, and 500.7, respectively). Sruti *et al*., (2013) reported that, black pepper bulk density ranges from 460.6 to 608.7 g L^{-1}. Bulk density is the major physical property and it influences directly the market price of black pepper (Lam *et al.,* 2008). It is also having impact on storage requirements, the sizing of the material handling system and how the material behaves during subsequent thermo-chemical and biological processes (Mc Kendry, 2002).

Performance of coconut

Coconut yield recorded during the observation period indicated no significant difference among the treatments. However, there was an improvement in the nut yield by 9 per cent compared to pre treatment period (2005-07). This clearly indicated that growing of black pepper in the basin of coconut palm had complementary effect on coconut yield.

Table 2. Yield, yield parameters and quality parameters of black pepper under coconut based HDMSCS (Mean of 4 years 2009-10 to 2012-13)

Treatment	Yield (kg vine-^{1})	Yield parameters			Quality parameters			
		No. of spikes per column	Length of the spike (cm)	No. of berries	Oil (%)	Oleoresin (%)	Piperine (%)	BD (g L^{-1})
T1	2.5	188	15.3	84.0	2.3	9.7	3.2	502.7
T2	2.4	212	16.0	84.2	2.2	9.4	3.1	501.2
T3	2.4	192	15.4	84.8	2.3	10.5	3.1	498.3
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS

Table 3. Coconut yield, copra weight and kernel thickness under coconut based HDMSCS (Mean of 4 years 2009-10 to 2012-13)

Treatment	Nut yield (No. palm^{-1} year^{-1})	Copra dry weight (g nut^{-1})	Kernel thickness (cm)
T1	151.4	182.2	1.36
T2	165.3	180.2	1.39
T3	163.1	189.6	1.44
Monocrop	130.1	180.4	1.36
CD (P= 0.05)	7.29	NS	NS

Four year mean yield of coconut also indicated improvement in the yield (160 nuts palm^{-1} year^{-1}). The same effect was observed for copra dry weight and kernel thickness. Copra dry weight recorded 184 g with kernel thickness of 1.4 cm. Several studies (Maheswarappa and Anithakumari; 2005; Palaniswami *et al*., 2007; Krishnakumar *et al.,* 2010) reported that, under high density multi-species cropping system, black pepper provided additional yield and there was improvement in the yield of coconut. There was a significant increase in the coconut yield (160 nuts palm^{-1}) with intercropping when compared to monocropping (130 nuts palm^{-1}).

Leaf nutrient status of coconut and pepper

Soil and leaf nutrient status of coconut and black pepper is presented in Table 4. The soil nutrient status indicates that, there was no significant difference among the treatments with reference to organic carbon, nitrogen and phosphorous under both depths. However, significant difference was observed between different nutrient management practices on available K. T1 recorded significantly higher K content at 0-25 and 25-50 cm (246.4 and 257.9 ppm, respectively) compared to others and T3 recorded the lowest (127.1 and 135.7 ppm, respectively). This clearly showed that potassium level was depleted at a higher rate when no inorganic sources were applied. This necessitates the substitution of required quantity of potash through organic resources when organic nutrient management was adopted. At surface soil (0-25 cm) organic carbon content (0.61) was more in T3 compared to T1 (0.57) and T2 (0.41). This was mainly due to high amount of organic matter addition by recycling the biomass in T3 treatment. T1 recorded significantly higher potassium content (246.4 ppm) compared to T2 and T3 (186.4 and 127.1 respectively). Nutrient status in the leaf indicated that, there was not much variation in composition of N, P, K nutrients in the leaf tissues of coconut and pepper grown in HDMSCS for all the three nutrient management treatments.

Economics

Economic analysis is depicted in Fig. 1. The average cost of production for four years was higher in T3 (₹ 55,688 and 17,888 ha^{-1} yr^{-1}) for coconut and pepper respectively followed by T2 (₹ 52,146 and 17,413 ha^{-1} yr^{-1}) and T1 (₹ 48,566 and 16,595 ha^{-1} yr^{-1}). The net return was high in T1 (₹ 97,715 and ₹ 1,47,067) for both coconut and pepper respectively. This implies that, there is an advantage of yield increase, additional income and hence resulted in higher income. Nagawekar *et al.* (2002) reported that, there was an increase of 37 per cent of average net profit from coconut + pepper model when compared to coconut monocrop. Though there was no significant difference observed for the yield of black pepper and coconut, the net returns were higher in inorganically managed treatments because of higher cost of production. This necessitates the

Table 4. Nutrient composition of soil in coconut basin and leaf of coconut and black pepper

	Soil							Leaf					
		0-25 cm			25-50 cm			Coconut			Black Pepper		
	OC (%)	N (ppm)	P (ppm)	K (ppm)	OC (%)	N (ppm)	K (ppm)	N (%)	P (%)	K (%)	N (%)	P (%)	K (%)
T1	0.57	832	91.38	246.4	0.41	528	257.9	1.85	0.12	1.12	2.48	0.36	1.83
T2	0.41	736	83.34	186.4	0.42	552	202.9	1.88	0.11	1.32	2.40	0.40	1.93
T3	0.61	976	92.25	127.1	0.37	492	135.7	1.87	0.13	1.28	2.44	0.37	1.65
CD (P= 0.05)	NS	NS	NS	31.26	NS	NS	17.18	NS	NS	NS	NS	NS	NS

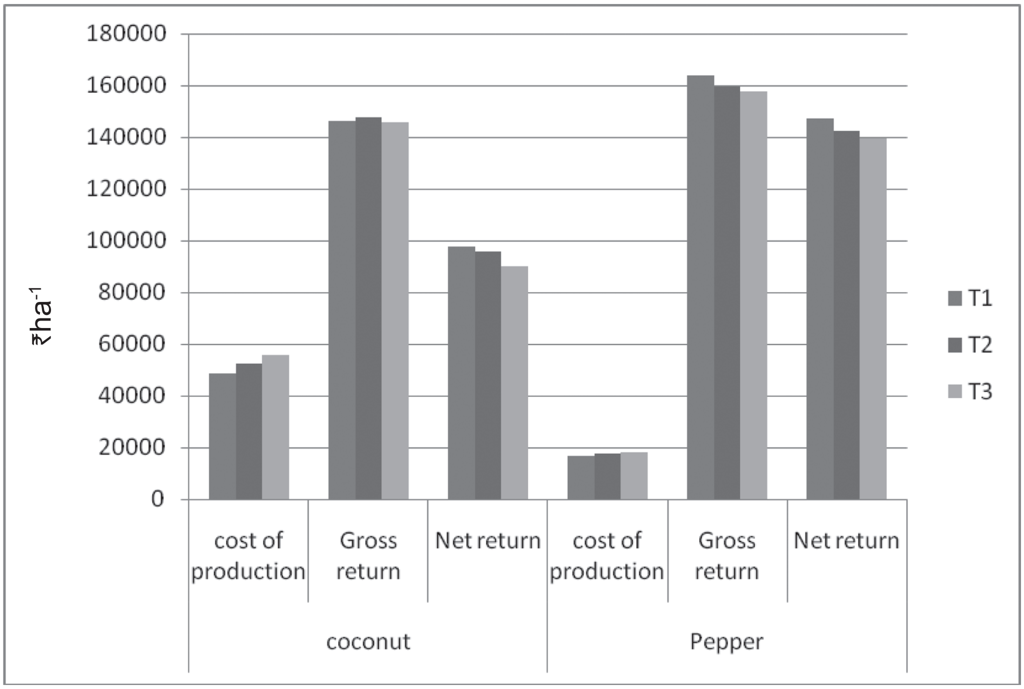

Fig. 1. Economic analysis of coconut and black pepper

requirement of premium price for the organically produced black pepper and coconut.

Conclusion

The present study indicated that there was no reduction in yield of coconut when black pepper was grown in the basin. The black pepper yield and quality parameters did not differ significantly among different nutrient management treatments. Hence, depending on the availability of resources, farmers can follow either integrated or organic nutrient management practices. The high demand for organic pepper in the market can be achieved easily as the coconut based HDMSCS provides sufficient organic biomass to recycle and produce the crop organically.

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