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Economic evaluation of high density multispecies cropping system in root (wilt) disease affected coconut *(Cocos nucifera)* area in Kerala

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Abstract

Root (wilt) disease, which is debilitative in nature, is one of the major constraints affecting coconut productivity in Kerala. Adoption of integrated management practices especially effective utilization of inter space in the coconut garden by inclusion of various crops shall constitute an ideal approach to improve the health and productivity of coconut palms. An experiment was undertaken at the Regional Station of Central Plantation Crops Research Institute, Kayamkulam, Kerala from 2004 to 2008 to evaluate the economics of high density multispecies cropping system (HDMSCS) model with different annual and perennial crops in an existing 39 year old West Coconut Tall (*Cocos nucifera*) garden affected by root (wilt) disease. Various crops such as elephant foot yam, pineapple, banana, black pepper and nutmeg were raised as component crops with coconut in the HDMSCS. The overall coconut yield under the system improved by around 17 % during the fourth year of experiment when compared to the initial yield of 53 nuts/palm due to the management practices including recycling of organic biomass produced through vermicomposting and basin raising and incorporation of green manure crop. In the total cost of cultivation incurred, cost of labour was the highest, ranging from 50 to 75 % during 2007-08 and 2005-06, respectively. The net return varied from Rs.15,064 to Rs.25,687 during 2005-06 and 2006-07, respectively. In the absolute monetary terms, the contribution of inter/mixed crops in the HDMSCS varied from 30 (2005-06) to 51 % (2006-06). Analysis of coconut equivalent yield showed that the overall contribution of inter/mixed crops was about 40 %, indicating the beneficial effects of the cropping system in coconut gardens, especially in areas where root(wilt) disease is a problem causing reduction in farm family income. The economic advantage of HDMSCS over mono cropping was 61 % with a BC ratio of 1.59 indicating that the coconut based high density cropping system is economically viable in root (wilt)disease affected areas provided the disease incidence is well managed by adopting integrated practices and other production and price related risks are at normal level. Analysis of root (wilt) disease incidence from the experimental field indicated significant decrease in the disease incidence due to adoption of HDMDCS in disease affected gardens.

Keywords: BC ratio, coconut, economic analysis, HDMSCS, root (wilt) disease

Introduction

Coconut (*Cocos nucifera*) plays a significant role in the overall agrarian economy of Kerala with an area of 8.2 lakh ha under cultivation and production of 5,641 million nuts (2007-08). But being a smallholder crop, it does not provide sufficient income and gainful employment opportunities to the dependent farm families. The productivity of coconut in Kerala is 15 % lower than that at national level on account of many reasons, one among them being the prevalence of Root (Wilt) Disease (RWD).This disease has been known to be present in South Kerala (India) since 1882 (Varghese,1934) and is seen in varying intensities in eight of the southern districts of the state. The disease has also

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been observed in a few districts of Tamil Nadu and Karnataka bordering Kerala. As there is no therapeutic control measure available for this disease, maintaining health of palms through various management programmes including recycling of crop residues hold an important point. If such diseased palms are not properly managed, it affects the health and productivity of palms in the long run. In many coconut growing countries, coconut as a mono crop is only marginally productive and profitable and hence, a cropping system involving inclusion of compatible crops aiming at generation of year round income is necessary. An ideal approach, under these circumstances, would be to adopt crop diversification in coconut gardens. The planting method and growth habit of coconut palms make them highly adaptable for crop diversification in the plantation. A well-spaced coconut garden provides adequate inter- and intra-row spaces where it is possible to grow a variety of useful seasonal and perennial crops. Adoption of coconut based intercropping/mixed cropping through high density multispecies cropping system(HDMSCS) is one of the means to effectively utilize the natural resources such as land, water, light and space. There are several reports to indicate the beneficial effects of such cropping systems (Bavappa and Jacob,1982; Bavappa *et al*.,1986; Maheswarappa *et al*.,2003). With these aspects under consideration, an experiment was undertaken to evaluate the economic advantage of HDMSCS in root (wilt) disease affected coconut garden.

Materials and Methods

The experiment was undertaken at the Regional Station of Central Plantation Crops Research Institute, Kayamkulam, Kerala, which is situated at 9° 8' N latitude and 76° 31' E longitude with an elevation of 3.05 m above MSL. During the study period (2004-08), the experimental area received an average annual rainfall of 2,350 mm, with the mean maximum temperature ranging between 30.0° C to 33.5° C and the mean minimum temperature of 20.3° C to 24.4° C. The soil of the experimental field is sandy loam with total N-340 ppm; av.P 40 ppm; av. K 90 ppm; org.carbon 0.25% and acidic in nature (pH 5.5). The study was conducted for four years (2004 to 2008) in a coconut garden with West Coast Tall variety of palms planted at 7.5 x 7.5 m during 1965. High density multispecies cropping system (HDMSCS) model with different annual and perennial crops was initiated in this coconut field affected by RWD. The details of crops grown with their mean population level over the experimental period are given in Table 1.

Table 1. Mean plant density of main and component crops under HDMSCS (2004 to 2008)

Crop	Plant density (mean)
Main crop	
Coconut (West Coast Tall)	91
Intercrops	
Banana (different varieties such as Njalipoovan, Nendran, Robusta, Red Banana, Palayankodan)	310
Elephant foot yam (Gajendra)	900*
Mixed crops	
Nut meg(Local)	70
Black pepper (Karimuda trained on coconut palms)	60
Pine apple(Kew)	550

Spacing adopted for different crops

Coconut: 7.5 x 7.5 m; Nutmeg: 7.5 x 7.5 m (in the centre of four coconut palms)
Pine apple: 60 x 45 cm (in raised beds along the border);
Banana: 2.5 m in between coconut palms leaving about 2 m from coconut basin; *Elephant foot yam: 90 x 90 cm (planted in between coconut palms after removal of banana during 2007)

Coconut palms in one-half of the experimental area were applied with recommended dose of fertilizers (500:300:1000 g NPK/palm/year) and the other half with an integrated nutrient supply including 50 % fertilizers and organic manures. Fertilizers were applied in two split doses (one-third during May-June and two-third during August-September) every year. For the supply of organic manures, green manure cowpea (*Vigna unguiculata)* seeds @ 100 g/palm was sown in basins during May and incorporated once they attained maximum vegetative growth. The total crop residues / recyclable bio mass of coconut (leaves after removing petiole portion; spathe and bunch waste), banana (leaves and pseudostem after harvest of bunch), pine apple (crown of pine apple after harvest of fruit and whole plant while uprooting) was collected during different years, vermicomposted in the field itself using *Eudrilus* sp. of earthworm and applied to coconut palms. Dry leaves from nutmeg plants and weed materials (obtained while slash weeding) were used as mulch. Package of practices for various inter/mixed crops were followed as per recommendations of Kerala Agricultural University (KAU,2002). Perfo irrigation at IW/CPE ratio of 1.0 was given to coconut and other component crops from December to May during each year.

Economic analysis of HDMSCS

Information on various inputs such as manures and fertilizers, cost of planting materials, plant protection chemicals, labour (both contract and farm) etc. were collected during each year. Data on output of the cropping system (individual palm-wise coconut yield during each

harvest and that of component crops as and when they were harvested) was also recorded during each year. The market rates of various inputs and outputs (coconut and other crop produces) during different years were considered to work out the economics.

In the present study, the standard method of economic analysis of perennial crops was used. The interventions were carried out in an existing coconut garden of 39 years and hence, the establishment costs were imputed on the basis of simulation study of a new coconut garden. The total investment (pre-bearing establishment cost) and the interest thereon were reduced to an annuity bearing 10 percent interest. The annuity is calculated using the formula given below.

$$\sum_{i=1}^{n} B_n / (1+i)^n / \sum_{i=1}^{n} C_n (1+i)^n$$ where,

B_n = benefit in each year

C_n = costs in each year

n = number of years

i = discount rate

Since the data from beginning was not available, we had to compute the BCR under certain assumptions. Here we have considered that, the coconut garden is about 39 years old and the intercropping was done subsequently. Further assumption is that the cash flow would be generated from the system for at least next 14 years.

The Coconut Equivalent Yield (CEY) was calculated for the inter/mixed crops for various years as follows:

$$CEY = \frac{\text{Yield of inter crop (kg/ha) X cost of inter crop/ unit (Rs./kg)}}{\text{Cost of coconut (Rs. /nut)}}$$

Results and Discussion

Yield of different crops

Details of yield from coconut (pooled yield from both the plots) and other component crops are provided in Table 2. A gradual increase in nut yield per palm was observed over the years registering an increase of 17 % (from initial 53 to 62 nuts per palm), during fourth year of the study. The impact of any agro management practice including nutrient management through recycling of biomass will become visible for coconut only from the fourth year onwards.

Among the intercrops, some of the old banana plants available in the field were replanted during 2004 and hence, there was low economic yield during the second year. There was steady increase in the yield of pine apple during the first three years, which started senescence during the fourth year, showing reduction in yield. Crop rotation was adopted during the fourth year and elephant foot yam (Gajendra variety) was introduced and it also contributed to the overall yield of the cropping system. Though yield of other crops viz., nutmeg and black pepper, differed during the study period, they also added to the overall productivity of the HDMSCS.

Table 2.Yield of coconut and component crops under HDMSCS during different years

Year	Crop						
	Coconut (nuts/year)	Banana (kg)	Pineapple (kg)	Black pepper(kg)	Nutmeg (kg)	Mace (kg)	Elephant foot yam (kg)
2004-05	5,092	1,619	114	23	12.7	5.2	-
2005-06	5,428	750	260	29	8.0	1.3	-
2006-07	5,108	1,170	515	21	20.0	7.2	-
2007-08	5,560	75*	393	18	9.3	1.4	1485**

* From banana plants available in the border ** Elephant foot yam

Availability of recyclable biomass from HDMSCS

Availability of bio mass from the system ranged from 9.10 t during 2007-08 to 18.87 t during 2004-05. The biomass production was low during 2007-08 mainly because of removal of banana plants from the field during the previous years and inclusion of elephant foot yam as intercrop, whose contribution towards bio mass is very much limited. Availability of bio mass from coconut based HDMSCS under Kasaragod condition free from root (wilt) disease condition ranged from 12.7 to 18.5 t/ha/year (Subramanian *et al*., 2005). The biomass obtained excluding nutmeg leaves, weeds (which were used for mulching plant basins) was vermicomposted and its recovery ranged from 65 to 70 %. The nutrient content of compost produced during each year was analysed and on an average it contained 1.413 % N, 0.112 % P and 0.304 % K and thus the total nutrient contribution from recycling of biomass through vermicomposting ranged from 86.7 to 180.0 kg N, 6.9 to 14.3 kg P and 18.7 to 38.7 kg K during different years. Krishnakumar *et al*. (2007) reported the contribution of vermicompost produced from homestead farms adopting cropping system towards major nutrients to be 35 to 60 kg N, 3.5 to 6.0 kg P and 6.5 to 12.0 kg K. The recycling of biomass by vermicomposting and field application will reduce the chemical fertilizer requirement of coconut. Integrated nutrient management by using 2/3 recommended fertilizer dose along with recycling biomass by vermicomposting gave the best benefit of coconut based high density multispecies cropping at Kasaragod (Kerala) (Palaniswami *et al*., 2007).

Soil nutrient status in basins of coconut and component crops

The overall soil nutrient status in the basins of coconut palms (Table 3) indicated a decline in nutrient content with soil depth. Organic carbon and total N were found to be higher in basins of palms under root (wilt) disease middle 1 and 2 categories than in the disease early category. The results are in conformity with the findings of Pillai *et al*. (1975).

Table 3. Soil nutrient status in coconut basins

Depth of soil (cm)	Nutrient status in coconut basin					
	Organic Carbon (%)	Total N (ppm)	Av.P (ppm)	Av.K (ppm)	Av.Ca (ppm)	Av.Mg (ppm)
0-25	0.340	375	39.8	96.8	80.6	48.9
25-50	0.287	360	35.5	89.3	80.5	45.1

Soil nutrient status in the basins of component crops (Table 4) showed an improvement in the status of organic carbon, total N as well as available P and K in the HDMSCS during the post-experiment period. This could be made possible by the recycling of crop residues into the system. The beneficial interactions of inter/mixed cropping of coconut with different crops in improving soil nutrient status of the system has been reported by Maheswarappa *et al*. (2005). The improved soil nutrient status in the basins of coconut as well as other component crops will be beneficial for their better performance.

Table 4. Soil nutrient status in basins of component crops

Crop	Org. C(%)		Total N(ppm)		Av.P (ppm)		Av.K (ppm)		Av.Ca (ppm)		Av.Mg (ppm)	
	Pre*	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Banana												
1	0.30	0.31	337	350	85	86.2	137	139	95	99	40	46
2	0.23	0.28	280	295	76	76.4	129	129	88	92	36	39
Nutmeg												
1	0.29	0.32	410	420	83	86.5	114	124	104	112	39	43
2	0.18	0.29	300	315	75	79.2	128	129	89	97	36	38
Pineapple												
1	0.29	0.45	270	277	118	115.2	97	101	83	89	41	45

(* Maheswarappa *et al*., 2005) Soil depth 1= 0-25 cm 2= 25-50 cm

Economics of HDMSCS

The net returns obtained from coconut based high density multispecies cropping system is given in Table 5. It could be observed that the net returns from one hectare of coconut garden with varying levels of RWD adopting HDMSCS has been ranging from Rs. 15,064 to Rs.25, 687 during the period of 2004-05 to 2007-08. The average net return during this four year period was estimated at Rs. 21, 625.

To make the analysis more comprehensive, we require to estimate the additional returns generated by the cropping system over the coconut mono crop from a unit area of land (here it is hectare). The additional income generated from the system would reflect the economic advantage of coconut based high density multi species cropping system over the coconut mono crop. Table 6 provides the additional returns generated from the system as well as the BCR of HDMSCS vis-a-vis coconut mono crop.

Table 5. Net returns of coconut based high density multi species cropping system (Rs/ha)

Year	Cost	Benefit	Net return
2004-05	33,910	58,978	25,068
2005-06	31,680	46,744	15,064
2006-07	24,670	50,357	25,687
2007-08	27,145	47,826	20,681
Average	29,351	50,976	21,625

Table 6. Economic advantage of high density multi species cropping system

Average net return of coconut mono crop (Rs/ha)	13,468
Average net return from cropping system (Rs/ha)	21,625
Advantage of system over mono crop (Rs/ha)	8,157
B:C Ratio of coconut mono crop	1.09
B:C Ratio of HDMSCS	1.59

The additional income generated from the system over coconut mono crop was found to be Rs. 8,157 per ha, which could be further enhanced by including low volume high value crops. While comparing the BCR of the HDMSCS with coconut mono crop, we found that the capital productivity of the system (BCR 1.59) is much better than that of coconut mono crop (BCR 1.09) which in turn directly reflects the profitability of the coconut based HDMS cropping system.

A further analysis indicated that in the total cost incurred for the HDMSCS, cost of labour was the highest, ranging from 50 % during 2007-08 to 75 % during 2005-06. Requirement of labour for undertaking various agro management practices including harvest of main and component crops, planting and replating *etc*. will always be high under a HDMSCS (Sairam *et al*., 2004). In the present system, pine apple required more labour input on account of periodical weeding *etc.*

The share of main crop of coconut in the gross return for different years varied between 49 to 70 %, the highest being during the second year and the lowest during third year, because of lower price per coconut obtained during that year. The contribution of inter/mixed crop in the HDMSCS varied from 30 % during 2005-06 to 51 % during 2006-07 indicating that any fall in price of main crop (coconut) could be compensated to a great

extent by other crops of the system. These results showed that crop diversification could help the farmers to realize better returns even if the price of one commodity gets reduced in any year. Girijadevi and Muraleedharan Nair (2003) obtained higher net income by intercropping various combinations of component crops such as banana, ginger, turmeric, elephant foot yam and vegetable cowpea in coconut garden. Elephant foot yam and banana were found to ideal as companion crops for coconut (Raveendran, 1997).

Coconut Equivalent Yield (CEY) of the system was worked out and is presented in Table 7. It was found that CEY ranged from 2,294 (2005-06) to 4,466 (2004-05). Banana gave the highest average CEY (2,012) followed by elephant foot yam (514), nutmeg and mace (408), pepper (303) and pineapple (282). The total yield of the system, based on CEY, ranged from 7,722 (2205-06) to 9,558 (2004-05) due to the higher contribution of banana during that year. The results also indicated that the contribution of inter/mixed crop towards the average total yield of the HDMSCS was about 40 %, indicating the beneficial effects of the cropping system in coconut gardens, especially in areas where the RWD is a problem causing reduction in farm family income. Anithakumari (2007) noticed improvement in income from coconut based homesteads by adopting intercrops in RWD affected areas.

Table 7. Coconut equivalent yield (CYE) of high density multi species cropping system

Year/ Crop of	Banana	Pine apple	Pepper	Nutmeg & mace	Elephant foot yam	*Total CYE of inter crops	Yield of coconut (no. of nuts)	Total yield the system
2004-05	3,526	103	230	607	--	4,466	5,092	9,558
2005-06	1,546	223	299	226	--	2,294	5,428	7,722
2006-07	2,848	522	426	584	--	4,380	5,108	9,488
2007-08	129	281	257	213	2,055	2,936	5,560	8,496
Average	2,012	282	303	408	514	3,519	5,297	8,816

***No. of coconuts**

Average price of coconut for 2004-05 was Rs.5.51/nut, for 2005-06 was Rs.5.82/nut, for 2006-07 was Rs.4.93/nut and for 2007-08 was Rs.7.00/nut.
Average price of banana for different years was Rs.12/kg.
Average price of pine apple, nut meg, mace, elephant foot yam and were Rs.5, Rs.100, Rs.400 and Rs.10 /kg, respectively.
Average price of black pepper for 2004-05 was Rs.55, for 2005-06 was Rs.60 and for 2006- 08 was Rs.100/kg.

Results of the analysis of RWD incidence from the experimental field (Krishnakumar and Maheswarappa, 2010) indicated that there was no increase in the occurrence of disease and in fact there was significant decrease in the disease incidence which is a positive indication of the beneficial effects of adoption of HDMDCS in RWD affected gardens.

Conclusion

The overall yield of root (wilt) disease affected coconut palms improved by around 17 % during the fourth year of experiment when compared to the initial yield of 53 nuts/palm due adoption of High Density Multispecies Cropping System. The net return from system varied from Rs.15,064 to Rs.25,687 during 2005-06 and 2006-07, respectively. Contribution of inter/mixed crops in the HDMSCS varied from 30 (2005-06) to 51 % (2006-07). Analysis of coconut equivalent yield showed that the overall contribution of inter/mixed crops was about 40 %, indicating the beneficial effects of the cropping system in coconut gardens, especially in areas where root(wilt) disease is a problem causing reduction in farm family income. The economic advantage of HDMSCS over mono cropping was found to be 61 % with a BC ratio of 1.59 indicating that the coconut based high density multispecies cropping system is economically viable in root (wilt)disease affected areas provided the disease incidence is well managed by adopting integrated practices and other production and price related risks are at normal level.

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