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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

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ABSTRACT

A field experiment was conducted at Kayamkulam, Kerala during 1993–2004 to study the effect of integrated management practices, like application of organic manure, recommended dose of inorganic fertilizer, *in situ* green manuring and high density multi-species cropping system in root (wilt) affected garden on resource use, recyclable biomass production and sustainable productivity of coconut (*Cocos nucifera* L.)-based cropping system. It was found that coconut had 31.32% actual air space utilization, followed by banana (*Musa* sp.) (7.32%), nutmeg (*Myristica fragrans* Houtt.) (0.67%), pineapple (*Ananas comosus* L. Merr.) (0.2%) and tuber crops, like amorphophallus (*Amorphophallus* sp.), colocasia (*Colocasia* sp.) and dioscorea (*Dioscorea* sp.) (0.38%) in the system. The system gave enormous quantity of recyclable biomass (9 110 kg/ha to 17 612 kg/ha/year) and which on conversion to vermicompost through *Eudrilus* sp. contributed 70.1 to 142.1 kg N 10.0 to 20.3 kg P and 18.0 to 36.5 kg K/year. The results also indicated that the average yield of coconut obtained during 2003–04 in the garden was 62.2 nuts/palm/year compared with the pre-experimental yield of 30 nuts/palm/year. The yield of component crops over the years was stable and the system proved to be sustainable in productivity over the years.

Key words: Biomass production, Coconut root (wilt), Resource use

The productivity of coconut (*Cocos nucifera* L.) in Kerala is as low as 7 046 nuts/ha (for 2005–06) (MOA 2006), mainly because of prevalence of root (wilt) disease, non-adoption of scientific agro-techniques coupled with crop being grown under rainfed condition. Coconut root (wilt) disease is a non-lethal, debilitating malady that affects the production potential of palm. The disease is caused by phytoplasma, a vascular limited pathogen. The most consistent and diagnostic symptom of the disease is the characteristic bending of the leaflets termed flaccidity, foliar yellowing and marginal necrosis of the older leaves (Solomon *et al.* 1983). The disease is prevalent in all districts of Kerala in varying severity, and the extent of incidence of the disease was highest in Alappuzha (48.03%), followed by Pathanamthitta (37.8%), Kottayam (36.5%), Idukki (33.56%), Ernakulam (33.0%) and Kollam (25.97%) districts. In the districts of Thrissur and Thiruvananthapuram the percentage of disease incidence was 6.19 and 2.09 respectively (GoK 1996). The disease has also has been noticed in districts of Tamil Nadu bordering Kerala and in Goa. There are no therapeutic control measures for the disease, however research efforts have resulted in evolving viable management technologies to increase the productivity of the diseased palms.

Studies have revealed that adult palm of sole crop of coconut spaced at 7.5 m×7.5 m apart effectively uses only 22.3% of land area (Kushwah *et al.* 1973, Maheswarappa *et al.* 2000), while the average air space utilization by the canopy is about 30% and solar radiation interception is 45–50% (Bavappa *et al.* 1986). Adoption of coconut-based intercropping/mixed cropping systems is one of the ways to utilize the natural resources effectively. The potential for increasing the productivity per unit area of land, time and inputs through high density multi-species cropping system is considerably higher in perennial crops (Bavappa and Jacob 1982). The negative effects of coconut monoculture system of cultivation and application of inorganic fertilizer alone without ensuring a natural organic recycling process have already shown its negative effects in progressive decrease in yield. Besides the integrated approach has the advantage towards improving nutrition, recycling the usufructs plays a major role as organic matter build up which is site of all chemical and biotic activity in the soil (Maheswarappa *et al.*

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1998, Bopaiah and Shetty 1991). With the above background, the work on effect of integrated nutrient management and high density multi-species cropping system under root (wilt) affected coconut garden is meager and hence a study was initiated at regional station CPCRI, Kayangulam, Kerala, to study the effect of integrated nutrient management and high density multi-species cropping system on the resource use, recycling the biomass and sustainable yield of the system in root (wilt) affected garden. Impact of above factors on productivity of the crops and economic viability (Maheswarappa *et al.* 2003), and on soil properties, plant nutrition and yield in root (wilt) affected coconut palms (Maheswarappa *et al.* 2005) has been reported earlier and influence of the INS and cropping system on the resource use, production and recycling of biomass and sustainable yield over the years in the system is detailed in this paper.

MATERIALS AND METHODS

The experiment was carried out at Regional Station, Central Plantation Crops Research Institute, Kayamkulam, Kerala, which is situated at 9° 8' N latitude and 76°31' E longitude at an elevation of 3.05 m above mean sea level. The annual rainfall of 2 580 mm with the mean maximum temperature ranges between 29 and 32.9°C and mean minimum temperature of 20.6 to 24.9°C. The soil is loamy sand with low fertility and acidic in nature (*p*H 5.5) and with a mechanical composition of 69% fine sand, 18.9% coarse sand, 8.9% clay and 3.2% silt.

High density multi-species model with different crops was initiated in an area of 1.0 ha of coconut root (wilt) affected garden during 1993–94 in a coconut garden planted during 1965 at a spacing of 7.5 m×7.5 m. The crops with variety, their population and planting period is presented in Table 1 and the plan and layout of different crops is given in Fig 1. The coconut palms were of different age group; 10–20 years: 46 palms, >20 years: 79 palms were constituted the experimental area. The disease advanced palms yielding less than 10 nuts/palm/year were removed. Under planting with seedlings was carried out in between the palms within the row during 1995–96. Tuber crops such as dioscorea, colocasia were discontinued from the system from 2002 to 03 and amorphophallus also discontinued from 2003 to 04 onwards due to development of under planted coconut and other mixed crops in the system. Component crops were managed with the package of practices recommended as per the Kerala Agricultural University recommendations (KAU 2002).

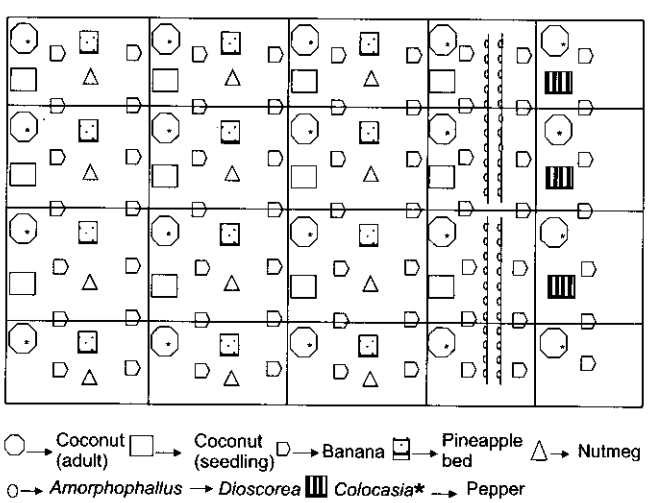

Fig 1 Plan and layout of coconut-based high density multi-species cropping system

Table 1 Crops with their population and planting year in HDMSCS plot in root (wilt) affected coconut garden (1 ha area)

Crops/spacing	Population	Year of planting
Coconut: adults: (7.5 m×7.5 m)	125 (1995–98) 112 (1998–2002) 98 (2002–04)	1965
Seedlings (underplanted) (7.5 m × 7.5 m)	152	1995–96
Nutmeg (local) (7.5 m × 7.5 m)	45	1993–94
Pepper (karimunda) (trained on coconut)	30	1993–94
Banana: ('Poovan', 'Njalipoovan', 'Robusta', 'Nendran', 'Palayankodan' 'Karpooravalli'): (2.5 m spacing between plants)	500	1993–94 and replanted once in 3 years
Pineapple (kew) (60×45 cm)	3 600 (1993–99) 1 920 (2000–04)	1993–94 and replanted once in 3 years
Tuber crops (1 m×1 m)		
Amorphophallus (local):	100	Annual crops planted during pre-monsoon period of every year
Colocasia (local):	100	
Dioscorea (local):	100	

Integrated nutrient management system involves: growing green manure crop, cowpea [*Vigna unguiculata* (L.) Walp.] in the coconut basin during April–May and incorporating in the basin when it attains maximum growth during September–October. Application of 50 kg composted coir pith during September–October (up to 2000). From 2001 onwards, vermicompost which was obtained from the biomass of the system was applied. Application of inorganic fertilizer: N:P:K @ 500:300:1 000 g/palm/year applied in 2 splits in the form of urea, rajphos and muriate of potash (1/3 during May–June and 2/3 during September–October) along with $MgSO_4$–1.0 g/palm/annum. Need-based plant protection measures, particularly for leaf rot control was carried out as per the recommendation. Leaf rot affected

portions of the spindle leaf only was cut and removed. A 300 ml of fungicidal solution containing 2 ml of contaf 5% EC or 3 g mancozeb was poured around the spindle leaf during April–May and October–November. Mulching of coconut basin with coconut leaves during November–May.

Irrigation was provided with hose irrigation during initial years and later perfo irrigation was adopted from 2000 and water to a depth of 20 mm was provided at the IW/CPE ratio of 1.0.

Observations on canopy spread of the crops was estimated during February 2004 and Actual Air Space Utilization of the canopies were calculated using the appropriate geometrical formulae (Jamaluddeen and Jacob 1983) according to the shape of the crop canopy:

For coconut, nutmeg, banana : Frustrum of cone
For pepper : Cylinder
For pineapple, tuber crops : Rectangle

The dried fallen leaves (after removing petiole), spathe and bunch wastes (after harvesting the nuts) of coconuts were collected separately as and when fallen and dry weight was estimated. The total biomass obtained from 175 palms was calculated year wise from 2001 to 2004 and expressed in Mg/ha/year (on dry weight basis).

Banana plants were removed at the ground level at the time of harvest and the biomass was estimated. The plants were separated into leaves and pseudostem. Each part was weighed separately and sub-samples were taken, oven-dried and the percentage of dry matter as well as the total dry weight of the plant was estimated. The banana plants were replanted during 2001–04 and biomass of all the plants was taken during those periods.

The crown parts of pineapple after harvesting fruit and the whole plant with roots (during replanting) were collected and dry weight was taken. The pineapple plants were replanted during 2001–04 and biomass of all the plants was taken during those periods.

In nutmeg, dry weight of leaves fallen at the base of trees was recorded at monthly interval by collecting by spreading nylon sheet and average was worked out for the year. The leaves were incorporated at the base of the tree during fertilizer application.

The weed biomass was estimated at monthly interval before slashing in 1 m^2 area and estimation was carried out for 1 ha garden. Then the weeds were slashed and left as such in the garden.

The recyclable biomass of coconut (leaflets, spathe and bunch wastes), banana and pineapple were put into vermicompost pits made in the garden and converted into suitable vermicompost with the help of *Eudrilus* sp. of earthworm as prescribed by Prabhu *et al.* (1998) and was recycled in the garden every year.

Nut yield of adult palms was recorded palm-wise regularly and mean was worked out. Yield of component corps was recorded as and when harvesting was carried out.

RESULTS AND DISCUSSION

Actual air space utilization

Actual Air Space Utilization (AASU) for each crop in the cropping system involving coconut, banana, nutmeg, pineapple and tuber crops was calculated using the appropriate geometrical formulae. It was found that the per cent actual air space utilization for each crop in the system was: coconut had 31.32%, AASU, followed by banana (7.32%), nutmeg (0.67%), pineapple (0.2%) and tuber crops (0.38%). Bavappa *et al.* (1986) also reported that the average air space utilization by the coconut canopy is about 30% under high density multi-species cropping system.

Recyclable biomass production

The recyclable biomass from different crops from the system is presented in Table 2. It shows quantity of recyclable biomass being generated in the system ranging from 9 110 kg (during 2002) to 17 612 kg (during 2004)/ha/year. The biomass generation was higher during 2001 and 2004 due to replanting of banana and pineapple. Subramanian *et al.* (2005) also reported the quantity of biomass available for recycling under coconut-based multi-species cropping system in root (wilt)-free tract of Kasaragod ranged from 12.7 to 18.5 tonnes/ha/year. The biomass of coconut (leaflets, spathe and bunch wastes), banana (leaves, pseudostem, bunch wastes) and pineapple (crown and whole plant) were converted into vermicompost and recycled in the garden every year. The recovery of the vermicompost was ranged between 70 and 72%. The major nutrient content of the vermicompost obtained was N: 1.4%, P: 0.20% and K: 0.36%. Thus on an average the amount of N, P and K recycled in the system through vermicompost was 70.1 to 142.1 kg N, 10.0 to 20.3 kg P and 18.0 to 36.5 kg K/year during different years when the recovery of vermicompost was 70%. The nutmeg leaves were left in the basin of nutmeg plant and weeds were slashed periodically in the garden and left in the same place.

Table 2 Recyclable biomass (dry weight basis) from different crops and weeds in coconut-based HDMSCS garden

Crops	2001	2002	2003	2004	Pooled mean
Coconut (kg/ha)	4 080	4 385	5 100	5 515	4 770.00
Banana (kg/ha)	5 760	930	1 010	6 849	3 637.25
Pineapple (kg)	2 725	1 835	1 652	2 139	2 087.75
Nutmeg (kg)	42	48	49	63	50.50
Weed biomass (kg/ha)	2 732	1 912	2 816	3 046	2626.50
Total	15 339	9 110	10 627	17 612	13 172.00

Sustainable yield of the system

Coconut yield: The yield of main crop and component crops from the system over the years is presented in Table 3.

Table 3 Yield of coconut and component crops in HDMSCS from 1.0 ha area over the years

Year	Coconut (Nuts/year)	Banana (kg)	Pepper (kg)	Pineapple (kg)	Nutmeg (kg)		Amorphophallus (kg)	Dioscorea (kg)	Colocasia (kg)
					Mace	Nutmeg			
1993–94	6 149	975					280	310	205
1994–95	6 225	823		280			310	285	235
1995–96	6 115	912	25	385			230	260	
1996–97	6 364	876	26	288			390	237	230
1997–98	6 053	660	28	320	5	8	350	260	
1998–99	4 848	1 339	32	298	8	13	360	289	187
1999–00	6 042	1 102	28	315	12	20	355	305	
2000–01	8 486	1 030	26	268	14	23	302	387	
2001–02	6 946	1 792	35		10	25	204	222	568
2002–03	5 942	1 752	20	87	6	18	146		
2003–04	6 092	1 619	23	114	7	19			

There was an increase in the nut yield of coconut over the years. The average yield obtained during 2003–04 in the garden was 62.2 nuts/palm/year compared to pre-experimental yield of 30 nuts/palm/year. 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 available nutrients, build-up 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).

Yield of component crops

Average yield of different crops grown in the system is given in Table 3. Among banana varieties studied 'Palayankodan' and 'Karpooravalli' gave highest/plant yield (20–24 kg/bunch, 22–25 kg/bunch respectively). The average yield of pepper was 1.0 to 1.2 kg dry pepper/vine. Pineapple crop also gave on an average 1.2 to 2..0 kg fruit/plant. Tuber crops, such as amorphophallus, dioscorea and colocasia also preformed very well in the system and provided additional yield. Nutmeg also started yielding and the yield was very good in the system yielding on an average 200 to 750 fruits/tree/year. The economic advantages and employment potential of the above cropping system with above crops in coconut garden for the farming family has been already studied and reported by Maheswarappa *et al.* (2003). Bavappa *et al.* (1986) reported the advantages of high density multi-species cropping system involving compatible crops in coconut with the increase in yield of coconut by 175% and additional income under red sandy foam soil in a root (wilt) disease-free tract under perfo system of irrigation.

Thus it can be concluded that under coconut root (wilt)-affected tract of Kerala, for sustainable productivity of the garden one has to integrate the management practices along with growing suitable crops in coconut garden and recycling the biomass in the garden for higher yield.

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