Research Article

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Recycling of organic biomass from arecanut based high density multi-species cropping system models under Assam condition

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Abstract

Investigations were carried out during 2001 to 2004 to quantify the available biomass for recycling from the arecanut based high density multi-species cropping system models (arecanut, pepper, banana, clove, nutmeg, and citrus) under graded (full, 2/3rd,1/3rd of the recommended) level of fertilizers for all the crops. Results revealed that the total amount of available biomass from the system ranged from 8.76 to 10.50 t/ha/year. The highest amount of biomass for recycling was recorded from 2/3rd level of fertilizer dose (10.50 t/ha/year) under model I and the compost produced ranged from 5.4 to 8.4 t/ha/year and the highest was under 2/3rd level of fertilizer dose. The amount of nutrient contribution by recycling the compost in the garden ranged from 41.36 to 54.94 kg N, 32.69 to 42.55 kg P_2O_5 and 66.25 to 85.38 kg K_2O per ha per year. The results also indicated that there was increase in the yield of main and component crops over the years. Yield of arecanut, citrus and pepper were higher at 2/3rd recommended level of fertilizer coupled with organic biomass recycling in the form of compost. However, banana yield was higher at full dose of recommended fertilizer.

Keywords: Arecanut, biomass, compost, HDMSCS, recycling, yield

Introduction

During the last few decades heavy consumption of chemical fertilizers has caused rapid degradation of our environment, ecology, deterioration of soil health, ground water pollution, rapid depletion of fossil fuel and mineral ores, etc. In recent years, consumers are conscious about health, hygiene and quality of life which has resulted in gradual shifting from chemical to organic farming. In arecanut based high density multi-species cropping system (HDMSCS), large number of crops having different stature and rooting pattern are raised for effective utilization of solar energy, soil resources and air space (Bavappa *et al.*, 1986), which require large amount of chemical fertilizers. This has resulted in increased cost of production as the fertilizers are prohibitively costly and also leads to deterioration in soil health.

Unlike other field crops, plantation crops export nutrients to the above ground parts continuously from a limited volume of soil throughout its existence, so it is necessary to supplement the nutrients to the root zone throughout the year to realize adequate yield. Unlike chemical fertilizers, the nutrient supply from organic manure like compost is slow and steady apart from very low nutrient loss and the availability of micronutrients coupled with the added advantage of improving soil physico-chemical and biological properties. Plantation crops produce huge amount of biomass for recycling as reported by Biddappa *et al.* (1996) that the waste/usufructs from plantation crops

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account for more than 30-50 % of the produce and it is about 8.0 t/ha/year in arecanut (Nampoothiri, 2001). If the available biomass is fully utilized it can meet the requirement of a major portion of chemical fertilizers. In addition to this, huge quantity of organic materials also becomes available from intercrops/ mixed crops commonly grown in plantation crops. So it is high time for effective recycling of organic waste into suitable compost from the HDMSCS garden for sustainable agricultural production. Reports on the above aspect under Assam condition is limited and hence the present investigation was undertaken to study the biomass production in arecanut based HDMSCS and recycling through composting under various fertilizer levels.

Materials and Methods

The study was conducted during 2001 to 2004 in an existing arecanut based HDMSCS with Kahikuchi selection during 1998 in the farm of Central Plantation Crops Research Institute, Research Centre, Kahikuchi, situated at 20° 18' N latitude and 91° 78' E longitude with mean altitude of 48 m from MSL. The soil of the experimental site was texturally classified as clay loam. The average annual rainfall in the region ranges between 2500 to 3000 mm and most of the rainfall occurs during South West monsoon (June to August/September). There is a dry spell form October to March with occasional showers from March to May.

The experiment was laid out in 0.63 ha area, details of which is given in Table 1. The Arecanut based HDMSCS garden comprised of two models *viz* Model-I with pepper, banana, clove and citrus and Model-II with pepper, banana, nutmeg and citrus as component crops applied with three levels of fertilizers. Fertilizers were applied in two equal splits during March-April and September-October. Required N, P and K were applied in the form of urea, single super phosphate and muriate of potash. The garden was irrigated during non-rainy periods with sprinkler irrigation system.

Table 1. Crops with varieties, population and treatment details

Model	Crop and variety	Population (No. of plants)	Treatment	Plot size (ha)
M1	Arecanut (Kahikuchi selection)	432	Full level of recommended dose (M1T1)	0.105
	Pepper: Karimunda	432		
	Banana: Chenichampa	135	2/3rd level of recommended dose (M1T2)	0.105
	Clove: Local	72		
	Citrus: Assam lemon	138	1/3rd level of recommended dose (M1T3)	0.105
M2	Arecanut (Kahikuchi selection)	432	Full level of recommended dose (M2T1)	0.105
	Pepper: Panniyur 1	432		
	Banana: Chenichampa	135	2/3rd level of recommended dose (M2T2)	0.105
	Nutmeg: grafts (Local)	72		
	Citrus: Gandhraj lemon	138	1/3rd level of recommended dose (M2T3)	0.105

Methods of sampling

a) Areca biomass

Dried leaves: The total leaves in the crown were counted and the first fully opened leaf was marked in 10 palms/ treatment (sixty palms). The number of dried leaves fallen on the ground were counted annually and the samples were collected at three months intervals from 2001 up to 2004 (March, June, Sept. Dec.). The leaves were separated into petiole and leaflets and then weighed. Sub samples of each of these were oven dried and dry weight was estimated.

Inflorescences: Dry weight of spathe and bunch waste was estimated in a similar manner as mentioned above.

b) Banana biomass

Six plants per treatment (total thirty six 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.

c) Pepper biomass

Thirty six vines (six per treatment) were marked and the fallen leaves were collected at monthly interval for dry matter estimation.

d) Clove, nutmeg and citrus biomass

Thirty six plants (six per treatment) were marked and the fallen leaves were collected at fortnightly interval for dry matter estimation.

Composting

The biomass collected were chopped into pieces, weighed and put into pits of size 4.5 m X 1.5 m X 0.9 m by spreading them in a thin layer. Fresh cowdung @ 10 % of the weight of biomass was later spread over it. When the pit was filled to a height of 45-60 cm above ground level, the surface was covered with dried leaves. During non-rainy periods pits were sprinkled with water to maintain the moisture and were allowed to undergo decomposition and compost became ready in about 95 to 100 days.

After completion of the composting process, it was mixed thoroughly and weighed. Samples were taken from compost pits of each treatment for chemical analysis. The recovery percentage was worked out on dry matter basis by using oven dry technique. The nutrient content, organic carbon content and pH of compost was determined following the procedure adopted by Jackson (1967). The yield of different crops was recorded in each year and the average of four years (2001 to 2004) is presented in this paper.

Results and Discussion

Amount of available biomass for recycling

Two-third and full doses of recommended level of fertilizers recorded higher amount of available biomass and the lowest was recorded in the one-third dose of recommended level of fertilizers in both the models (Table 2). In general, model-1 produced slightly higher amount of available biomass than model-2. The average biomass from arecanut in the form of leaves and inflorescence waste ranged from 5.08 to 6.28 t/ha/year. The treatment 2/3rd dose of fertilizer recorded the highest biomass of 6.13 t/ha/year in model-2 and in model-1 it was 6.28 t/ha/year. The treatment with 1/3rd of recommended fertilizer recorded the lowest biomass of 5.08 t/ha/year in model-2 and 5.38 t/ha/year in molel-1 respectively.

The amount of recyclable biomass from pepper in the form of leaves was the highest under 2/3rd level of fertilizer dose (0.90 and 0.93 t/ha/year under model-2 and model-1, respectively) and it gradually decreased at lower level of fertilizer dose. The average biomass from banana in the form of leaves and pseudostem ranged from 1.50 to 2.48 t/ha/year. The highest biomass production was from full dose of fertilizer in both the models and gradually decreased with reduction in the level of fertilizer dose. Subramanian *et al*. (2005) have also reported that the available biomass from banana was in the range of 503 to 1295 kg/ha/year under coconut based high density multi-species cropping system. The contribution of clove and nutmeg towards the recyclable biomass in the form of fallen leaves was less which ranged from 0.53 to 0.78 t/ha/year for model-1 and model-2 respectively. The recyclable biomass in the form of fallen leaves for citrus ranged from 0.63 to 0.71 t/ha/year. The amount of recyclable biomass from citrus in the form of leaves was the highest under 2/3rd level of fertilizer dose in both the models and it gradually decreased at lower level of fertilizer dose. In an experiment on crop waste recycling, it was found that an arecanut based system, in which cocoa, clove, banana, pepper and coffee were grown as mixed crops, produced about 9.0 t/ha of recyclable waste in Karnataka (Bhat and Sujatha, 2004). Subramanian *et al*. (2005) also have reported higher amount of recyclable biomass under 2/3rd level of fertilizers in coconut based HDMSCS involving coconut, banana, pineapple and clove in Kerala. Under coconut based high density multi-species cropping system in root (wilt) affected garden (Kerala), Maheswarappa and Anitha Kumari (2005) have reported that the total biomass generated from coconut, banana, nutmeg and weeds was about 14.46 t/ha/year.

Table 2. Available biomass (t/ha) from 1.0 ha of arecanut based HDMSCS (Average of 4 years)

Model & Treatment	Available biomass(t/ha) of different crops						Total
	Arecanut	Pepper	Banana	Clove	Nutmeg	Citrus	
M1T1	5.75	0.89	2.48	0.56	-	0.67	10.35
M1T2	6.28	0.93	2.08	0.58	-	0.71	10.58
M1T3	5.38	0.86	1.50	0.53	-	0.64	8.91
M2T1	5.58	0.88	2.30	-	0.74	0.65	10.15
M2T2	6.13	0.90	1.83	-	0.78	0.69	10.33
M2T3	5.08	0.85	1.50	-	0.70	0.63	8.76

Compost

The amount of compost produced from different treatments during different years is presented in Fig. 1. It ranged from 5.4 to 8.4 t/ha/year and it was the highest under 2/3rd level of fertilizer dose (8.4 t/ha/year) during 2004. The recovery of the compost ranged from 66.51 to 74.52 % and it was higher during later years of the experiment i.e. 2003 and 2004 (72.36 to 74.52 %) compared to the initial two years, which might be due to build-up of microbial population in subsequent years in the compost pit.

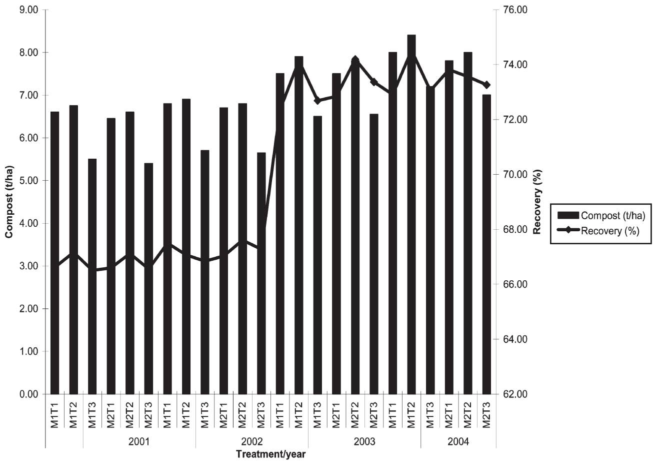

Fig.1. Production and recovery of compost

The data on chemical properties of the compost (Table 3) indicated that the pH ranged from 6.3 to 6.78, organic carbon from 6.77 to 7.58 %, and C:N ratio from 10.1:1 to 10.5:1, which indicate its suitability as organic manure. The available N, P and K were in the range of 0.67-0.73 %, 0.53–0.57 % and 1.07-1.14 %, respectively. The N, P and K content was higher during later years compared to initial years of composting. The amount of N, P and K contribution by recycling the compost in the garden ranged from 41.36 to 54.94 kg N, 32.69 to 42.55 kg P_2O_5 and 66.25 to 85.38 kg K_2O per ha per year.

Table 3. Chemical properties, nutrient content and contribution of compost (Average of 4 years)

Model & Treatment	pH	O.C. (%)	N (%)	P (%)	K (%)	C:N ratio	N (kg/ha)	P_2O_5 (kg/ha)	K_2O (kg/ha)
M1T1	6.53	7.06	0.69	0.54	1.09	10.3:1	49.78	39.13	78.74
M1T2	6.78	7.58	0.73	0.57	1.14	10.4:1	54.94	42.55	85.38
M1T3	6.35	6.78	0.67	0.53	1.07	10.1:1	42.00	33.26	67.23
M2T1	6.48	6.95	0.69	0.54	1.08	10.1:1	48.82	38.13	77.17
M2T2	6.75	7.46	0.71	0.55	1.12	10.5:1	52.10	40.42	81.88
M2T3	6.30	6.77	0.67	0.53	1.07	10.1:1	41.36	32.69	66.25

Yield of crops

The average yield of arecanut as influenced by different treatments is presented in Table 4. In general the areca chali yield was higher in model-I compared to model-2 and over the years there was increase in the yield of areca. Among the treatments, application of 2/3rd level of recommended fertilizer recorded higher yield in both the models followed by full dose of recommended fertilizer. The areca yield was the lowest in the 1/3rd of recommended fertilizer treatment in both the models. Higher yield under 2/3rd level of recommended fertilizer application along with recycling available biomass in the form of compost might be due to improvement in soil physico-chemical properties, which had positive effect on growth and yield. In coconut based HDMSCS at CPCRI, Kasaragod also it has been reported that application of 2/3rd level of recommended fertilizer recorded higher yield (CPCRI, 2002). It is evident from the yield data that, there was no reduction in the yield of arecanut due to growing different mixed crops over the years rather there was increase in the arecanut yield. Similar results were also reported by Bhat *et al.* (1999) from coastal Karnataka in areca based cropping system.

Table 4. Yield of component crops under HDMSCS (Average of 2001-2004)

Model & Treatment	Yield (per ha) of component crops under HDMSCS			
	Arecanut (chali,kg)	Banana fruits (kg)	Citrus fruit (numbers)	Pepper (dry,kg)
M1T1	2125.5	8022.7	8928	1034.7
M1T2	2446.5	7836.2	10135	1333.7
M1T3	1996.5	7583.5	8417	596.7
M2T1	2001.2	8107.7	7464	958.0
M2T2	2189.7	7191.2	8732	1125.0
M2T3	1810.0	5885.2	6856	620.7

Yield of banana was higher under full dose of recommended fertilizer in both the models followed by 2/3rd of recommended fertilizer application. The yield of banana was the lowest in 1/3rd of recommended fertilizer treatment. This indicates that banana crop is an exhaustive nutrient exporter and responds well to applied nutrients. The per plant yield ranged from 22 kg to 23 kg fruit under full dose of fertilizer treatments, 20 to 21 kg fruit under 2/3rd dose of fertilizer treatment, whereas it was 15 to 17 kg fruit under 1/3rd of recommended dose. Citrus fruit yield was higher at 2/3rd level of fertilizer followed by full dose of fertilizer and 1/3rd level of recommended fertilizer. Among the varieties, Assam lemon has performed well yielding 20 to 24 fruits per plant compared to Gandhraj lemon (15 to 20 fruits per plant). Black pepper yield was higher under 2/3rd level of recommended fertilizer treatment followed by full dose and the yield was very low under 1/3rd level of fertilizer treatment. Among the varieties, Karimunda performed better than Panniyur-1. Clove and nutmeg plants were planted during 1998 and only 33.3 % of the clove plants started flowering and only 10 % of the nutmeg plants started yielding.

Conclusions

From the above investigations, it can be concluded that under arecanut based HDMSCS, large quantity of biomass is available for efficient recycling. The amount of available biomass reduced considerably in all the crops except banana when fertilizer dose was reduced below two-third level of recommended dose. In the case of banana, higher amount of biomass was obtained under full dose of recommended level and thereafter it reduced gradually. The highest amount and per cent recovery of compost was obtained from the system when two-third level of recommended dose of fertilizers were applied. The amount of N, P and K contribution by recycling the compost in the garden ranged from 41.36 to 54.94 kg N, 32.69 to 42.55 kg P_2O_5 and 66.25 to 85.38 kg K_2O per ha per year. It is evident from the above study that application of 2/3rd of recommended level of fertilizers coupled with recycling available biomass in the form of compost in arecanut based HDMSCS is beneficial with respect to sustainable yield of different crops.

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