24

Comparative Evaluation of Soil Health and Fertility Under Organic, Inorganic and Integrated Nutrient Management in Coconut Based Mixed Farming System

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INTRODUCTION

Soil is the fundamental resource for the agriculture, being the medium for the crop growth. Soil functions to soil productivity, maintain environmental quality and provide plant human and animal health. Soil health is defined as the continued capacity of soil to function as a vital living system, by recognizing that it contains biological elements that are key to ecosystem function within land-use boundaries. These functions are able to sustain biological productivity of soil, maintain the quality of surrounding air and water environments, as well as promote plant, animal, and human health (Doran and Zeiss, 2000; Karlen *et al.*, 2001).

The intensive use of chemical fertilizers during the green revolution era led to the degradation of the soil health under agricultural land use system resulted with increasing input requirement with low factor productivity and environmental problems. The alternative farming system to improve and sustain the soil fertility, productivity and soil ecology for the long-term is the need of the hour, and one of the ways is organic farming.

Organic farming is agricultural production without the use of synthetic fertilizers, chemicals and growth regulators (USDA, 1980). Organic agriculture is a holistic way of farming, besides producing high quality produce it aims the conservation of the natural resources fertile soil, clean water and rich biodiversity. It is more helpful to view the soil

fertility as an ecosystem concept integrating the diverse soil functions, including nutrient supply, which promote plant production (Swift and Palm, 2000). Hence, the organic farming which recognizes the complex relationships that exist between different system components and that the sustainability of the system is dependent upon the functioning of a whole integrated and inter-related system (Atkinson and Watson, 2000) is very appropriate for the soil fertility management. The important aspect of organic farming is that it promises the sustainability of soil health and environmental safety.

Organic farming includes different concepts to ensure the soil health like crop rotation, green manure, cover cropping, application of compost, mulching etc. Being perennial in nature the most promising organic farming concept can that be followed in plantation crops is inter-cropping/mixed farming. In plantation crops where the crop rotation is restricted, the mixed farming system comprising the dairy, poultry, fish components along with main and intercrops enables the system to self-sustain in nutrient supply under organic farming through following practices like addition of organic manures from animal component, recycling of organic wastes through composting, green manures and biological inputs like vermi-composts and bio-fertilizers, etc. Apart from supplying the nutrients in a balanced way the organics plays major role in soil health through improving the physical properties by increasing soil aggregation, water holding capacity, etc., and biological properties like increasing the beneficial micro and macro fauna by serving as a medium.

The effects of different farming and fertility management practices like monocropping of coconut and inter-cropping coconut with grass, application of nutrients through organic manures, through inorganic fertilizers as well as their combination on soil health and crop productivity were studied at the Central Plantation Crops Research Institute, Kasaragod, Kerala. The cropping system and nutrient management practices include:

T1– monocropping of coconut with recommended fertilizer as inorganics,

T2 – Coconut based mixed farming system comprising Coconut, Hybrid Bajra napier grass, pepper, dairy, poultry and pisiculture components (pepper intercropped in the basins and Hybrid Bajra Napier Grass (Co 3) in the inter spaces of coconut palms) along with application of 50% of the recommended nutrients (on available Potassium basis) as vermi-compost produced from the wastes from crop and animal components of the coconut based mixed farming system,

T3 – Coconut based mixed farming system with application of 100% of the recommended nutrient as vermi-compost obtained from waste recycling of the mixed farming system, T4 – Coconut based mixed farming system with application of 100% of the recommended nutrient as inorganic fertilizer.

Soil samples were analysed for organic carbon, total N, available P, K, Ca, Mg and micro-nutrient contents. Analysis of plant samples were done for macro and micro-nutrient contents. Physical (bulk density, hydraulic conductivity and water holding capacity) and

biological properties (population level of bacteria, fungi and actinomycetes) of soil were also determined from the production system.

The treatments which received organic manures showed reduction in bulk density than the other treatments where the entire requirement of nutrients was met only through inorganic fertilizers (Table 24.1). This reduction in the bulk density is due to the application of vermi-compost which increased the soil aggregation and pore space, whereas the treatments where only the inorganic fertilizers are applied the bulk density was very high due to natural compaction of the red sandy loam soil. This particular limitation of the red soil is very well managed when the organic farming practices are followed. Similarly due to the reduced bulk density with high micro pores in the favorable soil structure developed by the application of vermi-compost, the water holding capacity of the soil is also increased (Logsdon and Linden, 1992). It was the highest in the treatment where 100 % organic nutrient sources are applied followed by the 50% organic and inorganic sources are integrated and it was the lowest in the 100% inorganic application. The hydraulic conductivity of soil was the highest where entire nutrients were supplied through inorganic source, but it was less in the treatment of 100% organic nutrient source application. Hydraulic conductivity was very low in monocropping of coconut than in the treatments were the grass was intercropped.

Table 24.1. Effect of organic cultivation on soil physical properties

Treatments	*Water holding capacity (%)*	*Bulk Density (g cm^{-3})*	*Hydraulic conductivity (mm $second^{-1}$)*
Monocrop + Recommended fertilizer	19	1.56	0.0037
Mixed farming + 50% Organic + 50% inorganic	19	1.23	0.0064
Mixed farming + 100% organic	21	1.41	0.0044
Mixed farming +100% Inorganic	18	1.56	0.0105

The plant macro and secondary nutrient status of the main crop coconut and intercrop grass showed positive influence of organic nutrient application. Leaf N content was high (2.17%) when 100% nutrient recommendation was supplied through the organic source under mixed farming practices followed by full fertilizer application or integrated application when compared to monocropping. The high nitrogen content in coconut leaves grown under organic farming is due to the reduced leaching loss attained by the slow release of nitrogen from the vermi-compost than the inorganic nitrogen fertilizer. Similar kind of results were obtained by Lampkin (1990), who reported that there is some evidence to suggest that nitrate leaching may be less under organic than under conventional systems and nitrate leached below the root zone is effectively lost from the system.

The leaf P and K contents were high in the treatment where 50% inorganic and 50% organic sources of nutrients were applied than the rest of the treatments (Table 24.2) due to the readily available inorganic source and the availability of these inorganic sources were

enhanced by the organic sources through its role on reducing the fixation loss of applied inorganic P and K. In the same way the Ca content of the was leaf also influenced by the application of 100% organic source resulting in the highest value among the treatments but Mg was found to be high in the treatment where 100% nutrient recommendation was applied through organics, which might be due to the slow release of nutrients in organic farming which reduced the very high leaching loss of the Mg when applied as inorganic fertilizer. The Mg content was high in the organic matter applied treatments and found very low in the inorganic fertilizer alone applied treatments due to the leaching loss of inorganic Mg source. The coconut leaf nutrient content was found to be low in the monocropping compared to the mixed cropping.

Table 24.2. Effect of organic cultivation on plant macro and secondary nutrient status

Treatments	*N (%)*	*P_2O_5 (%)*	*K_2O(%)*	*Ca (%)*	*Mg(%)*
Monocrop + Recommended fertilizer	1.83	0.12	1.01	0.394	0.187
Mixed farming + 50% Organic + 50% inorganic	1.97	0.14	1.14	0.519	0.199
Mixed farming + 100% organic	2.17	0.12	1.04	0.488	0.214
Mixed farming +100% inorganic	1.92	0.13	1.01	0.498	0.189
Grass	1.36	0.21	1.45	0.361	0.336

The content of Zn in coconut leaves was very high in the organic farming treatment (13.65ppm) than the other treatments (Table 24.3). Apart from Zn, the other micro-nutrients like Fe, Cu and Mn were found to be numerically low in the organic farming treatment than in the nutrient management using inorganic fertilizers. Except Zn, all the other micronutrients were high in 100 % inorganic source applied treatments (T1 and T4) followed by T2.

Table 24.3. Effect of organic cultivation on plant micro nutrient status

Treatments	*Fe(ppm)*	*Cu(ppm)*	*Zn(ppm)*	*Mn(ppm)*
Monocrop + Recommended fertilizer	172.85	7.00	7.30	357.50
Mixed farming + 50% Organic + 50% inorganic	151.20	8.00	9.45	235.50
Mixed farming + 100% organic	138.80	6.35	13.65	156.75
Mixed farming +100% inorganic	170.85	7.10	11.50	292.50
Grass	147.70	17.40	24.00	334.00

The microbial distribution in the coconut basin and the interspaces in the coconut garden showed that population of bacteria, fungi and actinomycetes were found to be very high in the 100 % organic farming treatment where vermi-compost was applied followed by the 50 % organic substituted treatment and the population was low in inorganic fertilizer alone applied plots (Table 24.4). The organic manure vermi-compost served as a good medium for the microbial growth due to growth promoting substances and enzymes present in it. Microbial population was comparatively high in the interspaces where grass was

grown than the coconut basin due to high root biomass available in the grass cropped area, ultimately the root turn over in the rhizosphere and root exudates contributing highly conducive environment for the microbial population to multiply (Gunadi *et al.*, 1999 and Masciandaro *et al.*, 2000).

Table 24.4. Microbial distribution in coconut based cropping system

Treatments	Bacteria (10^6 cfu/g soil)		Fungi (10^3 cfu/g soil)		Actinomycetes (10^5 cfu/g soil)	
	Coconut basin	Inter-space	Coconut	Inter-space	Coconut	Inter-space
Monocrop + Recommended fertilizer	13.45	10	6.86	4.16	9.62	6.16
Mixed farming + 50% Organic + 50% inorganic	18.22	21.64	6.6	7.23	7.83	8.35
Mixed farming + 100% organic	23.17	29.22	18.16	19.31	11.33	14.26
Mixed farming +100% inorganic	11.76	14.66	7.12	8.35	7	12.94

When the inorganic monocropping and the organic farming under mixed farming system were compared on the available nutrient content of soil (Table 24.5), the inorganic monocropping showed high nutrient content than the mixed under organic nutrient management due to the high uptake of nutrients in the mixed farming system. Especially the K content was very low in the mixed farming because the rigorous potassium uptake nature of both coconut and grass components.

Table 24.5. Impact of organic farming on available nutrient content in soil

System	Depth (cm)	Available nutrients (kg/ha)			Org. C (%)
		N	P_2O_5	K_2O	
Inorganic Monocrop	0-25	271.49	223.14	422.35	0.43
	25-50	189.88	89.28	293.82	0.28
	50-100	159.78	26.26	426.96	0.25
Organically managed Coconut basin (mixed farming)	0-25	229.88	189.64	197.40	0.41
	25-50	181.80	108.98	192.96	0.27
	50-100	178.16	52.08	211.18	0.27

The present results showed that the organic farming practices under mixed farming system has a positive impact on soil health by improving the physical, chemical and biological properties when compared to the inorganic nutrient management practices under mixed farming system. The coconut based mixed farming system is highly sustainable in maintaining soil health than the monocropping of coconut combined with inorganic nutrient management apart from high economic return from mixed farming system.

The findings also suggested that organic managed soils could be considered as more conservative systems which is in line with the comparative study of organic, conventional and integrated apple production systems in Washington State, which found that organic and integrated systems had higher soil quality and potentially lower negative environmental impact than the conventional system. The data indicated that the organic system ranked first in environmental and economic sustainability, the integrated system second and the conventional system last (Reganold *et al.,* 2001). The organic farming practices in the coconut based mixed farming system promises to sustain the soil health through *in situ* nutrient management in an eco friendly manner.

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