10. ROLE OF NUTRIENT MANAGEMENT IN COCONUT BASED CROPPING SYSTEM FOR SUSTAINABLE PRODUCTIVITY

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Introduction

Coconut (*Cocos nucifera* L.), is an important perennial crop of humid tropics. In general, coconut is grown on variety of soils like lateritic and laterite, littoral coastal sand, red sandy loams, alluviums, coral, peaty and black soils. The ideal coconut growing soils are well drained and aerated with a minimum depth of 80 to 100 cm, pH range between 5 to near neutral, adequate nutrient availability and water holding capacity. The major coconut growing soils are laterite, lateritic, coastal sand and alluvial. Except alluvial soils, all the other soil types have low native soil fertility and poor physical properties. In South India, where majority of the area under coconut in India is existing, coconut suffers from prolonged spell of high temperature and high rainfall which leads to the leaching losses of silica and bases from parent material with concurrent accumulation of oxides of Fe and Al resulting in the formation of laterites, a dominant soil group under plantation crops and various studies have long established that the soils are acidic in reaction with poor native fertility, low CEC, a characteristic of Kaolinite as dominant clay minerals and have high presence of sesquioxides.

Coconut flowers and fruits through out the year. Therefore, supply of the required water and nutrients should be maintained year around. The quantitative order of requirement of the major nutrients for adult bearing palms is K>N>Ca>Mg>P. The study conducted by Pillai and Davis (1963) on the removal of nutrients by West Coast Tall palms in India.

Table 1. Annual removal of nutrients (kg/ha) by the coconut palm

Basis	Nutrients					References
	N	P	K	Ca	Mg	
173 palms/ha 40 nuts/palm	56	11.9	70	33.9	12.5	Pillai & Davis, 1963
173 palms/ha 40 nuts/palm	96	20.8	120	61.8	21.9	Ramadasan & Lal, 1966

Annual removal/ha (1.5 t copra/ha)	95	9.0	117	65.0	-	Ouvrier & Ochs, 1978
Annual removal/ha (6.7t copra/ha	174	20.0	249	70.0	39.0	Manciot *et al.*. 1979 a

The percentage removal of nutrients through different parts of the Tall palm is presented and for a comparative assessment, the percentage removal of nutrients for the development of bunches with nuts and for the growth of stem and leaves is computed and presented.

Table 2. Percentage removal of nutrients by different parts of WCT palm (Pillai and Davis, 1963)

Parts of the palm	N	P	K	Ca	Mg
Nuts	43.0	40.0	63.0	15.3	25.0
Peduncles	4.2	7.0	12.1	3.3	11.4
Spathe	3.5	2.9	2.7	4.5	4.9
Leaf with stipules	41.2	45.1	12.4	73.8	56.5
Stem	8.1	5.0	9.8	3.1	2.2
Total	100	100	100	100	100

Table 3. Percentage removal of nutrients for the yield of nuts and for the growth and development of stem and leaves by West Coast Tall (Pillai & Davis, 1963)

		N	P	K	Ca	Mg
West Coast Tall	Stem + leaves	49	50	22	77	59
	Yield of nuts	51	50	78	23	41

Nutrient management for coconut

General requirement of fertilizer elements for palms yielding an average of 50 nuts palm^{-1} year^{-1} could be 500g N, 320 g P_2O_5 and 1200 g K_2O palm/year. The nutrients should be applied in the form of urea, rock phosphate and muriate of potash in acid soils and urea, single super phosphate and muriate of potash in neutral to alkaline soils. Adequate quantity of bulky organic manures (50 kg/palm) if possible should also be applied. This not only provides some of the micronutrients needed by the palms but also improves the soil physical conditions including water holding capacity. General Fertilizer recommendation for coconut is given in table 8.

Table 4. Fertilizer recommendation (g/tree)

Year	May-June			September-October		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O
First year	--	--	--	50	40	135
Second year	50	40	135	110	80	270
Third year	110	80	270	220	160	540
Fourth year onwards	170	120	400	330	200	800

Fertilizer application is usually recommended in two splits a year, one third of the recommended dose must be spread around the palms within a radius of 1.8 m and forked in immediately after the pre monsoon showers. Remaining two third fertilizer doses should be applied in September when the monsoon rains recedes.

Based on experiments conducted nationally and internationally, it has been well accepted that soils with 1% organic C status was ideal for coconut cultivation. Further, long-term observations led to conclude that 70 to 80 ppm of mineralizable nitrogen in soil and 10 to 12 ppm Bray extractable 'P' can sustain sufficient levels in coconut. Further work at CPCRI revealed that if soil available P is less than 10 ppm, full recommended dose of 320g P_2O_5/palm/year may be applied and for a soil test value of 10 to 20 ppm, 50 per cent of the same may be applied. For soil test values of more than 20 ppm, P application can be skipped.

Boron deficiency causes characteristic malformation of leaves like hook leaves, nut cracking, drying of the female flowers etc. Soil application of Borax @ 50 g/tree twice at monthly intervals after appearance of the first symptom corrects the deficiency. In the root (wilt) disease affected area, it has been recommended to apply Borax @ 300 g/seedling and Borax @ 500 g/ adult tree. Application of magnesium @ 500 g MgO per palm is advantageous for the management of root (wilt) diseased palms to restore palm vigour and sustain the productivity.

Nutrient management through leaf nutrient analysis

In tree crops like coconut, the plant diagnostic methods give more reliable information on the nutritional status of plants in relation to soil fertility potential. The methods involve both qualitative and quantitative procedures which are designed to correlate plant status with productivity. The most important and the most widely practiced plant diagnostic method in coconut is the critical concentration approach based on plant analysis, known as foliar diagnosis. The practicability of using specific nutrient levels in the plant as indicators of the uptake pattern of nutrients and their consequential effects on growth and yield has been widely established, and has been found highly useful for studying the nutrient requirements and fertilizer responses of perennial crops. The method depends on the determination of critical nutrient levels from the relationship between nutrient concentrations in standard plant parts and the corresponding growth/yield response curves derived mainly from field fertilizer experiments using different nutrient levels of nutrients. The foliar levels are then compared with the critical levels for assessing the nutrient needs of the palm. The critical level is defined as the concentration of the nutrient in the standard plant part below which the addition of that particular nutrient has every chance of giving an economic increase in yield.

Table 5. Leaf critical levels for bearing coconut palms suggested by different workers (frond 14)

Nutrient	Critical levels
N (%)	1.8-2.0
P_2O_5 (%)	0.11-0.12
K_2O (%)	0.8-1.0
Ca (%)	0.3
Mg (%)	0.2
S (%)	0.15 -20

Cu (ppm)	5-7
Fe (ppm)	50
Mn (ppm)	60
Zn (ppm)	10-15
B (ppm)	9-11

Nutrient exhaust in cropping system

Nutrient exhaust from one hectare of coconut ranged from 92 to 149 kg N, 12 to 20 kg P and 119 to 183 kg K. The nutrient exhaust that K and N are required in higher quantities for coconut production. Integrated nutrient management includes the intelligent use of organic, inorganic and biological resources (BNF) so as to sustain optimum yields improve or maintain soil's chemical and physical properties and provide crop nutrition packages which are technically sound, economically attractive, practically feasible and environmentally safe. INM optimizes all aspects of nutrient cycling — supply, uptake, and loss to the environment — to improve food production. The interventions address a few key aspects of nutrient management, including improving organic matter in the soil, increasing plant-available nutrients and supplying both organic and chemical fertilizers. These interventions have the potential to increase and sustain production levels, increase the economic potential of a production system, and counteract and minimize environmental pollution.

Growing of inter/ mixed crops in coconut garden will not only increase the utilisation of unexploited natural resources, but will also have a beneficial effect on the farm economics. High density multi species cropping system (HDMSCS), is one of the mixed cropping systems, where a number of compatible crops are grown in a unit area to meet the diverse needs of the farmers such as food, fuel, timber, fodder and cash and are ideally suited for smaller units of land and aim maximum production both temporally and spatially. This also leads to control of weeds, soil and water conservation, regulated temperature and favourable microbial activity in the soil.

Nutrient management in Coconut based HDMSCS would be a complex task as this will involve the interplay of various factors viz. nutrient recycling, fertilizer additions, differential crop responses, nutrient uptake and soil environment. Thus, there is a need to consider the system as a unit. It has been rightly summarised that in intensive cropping system with tree crops, the application of fertilizers according to the estimated requirement for each crop is certainly not the most efficient and economic way of utilizing the native and applied nutrients. It has been well established in several coconuts growing countries that coconut as a monocrop is only, marginally productive and profitable. The interplay of various factors viz. limited size of holdings, number of trees, needs of the family, labour requirement for crop, fluctuating returns to farm families and easiness of marketing are some of the considerations for the grower to diversify his farm operations for higher returns by adopting intercropping, mixed cropping or introducing other enterprises like dairy, poultry etc. in the system. Moreover, under coconut based cropping system, the same land can be put to use to produce other crops so that the productivity of the land is increased. This wisdom has led the farmers to evolve through their innovative efforts very successful models, which have come to stay in different countries. Nevertheless, the traditional method of distribution of crops in a coconut garden is not scientific to utilize natural resources efficiently.

Nutrient management in cropping/ farming system is difficult as it involves interplay of various factors like crop requirements, differential crop responses, crop residue additions, management practices suiting crop needs, water requirement and soil environment. It is therefore imperative that whole system must be considered as one unit. Experience in coconut based cropping system suggests that it is necessary to fertilize coconut and component crops according to the nutrient requirement of individual crops to make the system more productive and competitive.

Coconut based cropping system

a) Component crops

An experiment was conducted in an existing 35 year old coconut garden intercropped with clove, banana and pineapple in the research farm of Central Plantation Crops Research Institute, Kasaragod, Kerala, India. The coconut palms are spaced 8 m apart and arranged in square system of planting. Clove, banana, black pepper and pineapple were grown as intercrops (Table 1). The experiment was laid out in 1.2 ha area and the planting pattern is given in figure 1. The soil is red sandy loam (*Arenic Paleustult*). The soil had pH 5.3, clay 22 %, 0.48 % organic carbon and CEC 4.7 cmol kg^{-1} soil. Initially (1983), the experimental plot had three treatments *i.e.* full, two-third and one-third of the recommended fertilizer dose. Later, based on the results of ten years wherein one-third was found sufficient for maintaining the optimum crop nutrition, the experiment was modified by including three more additional treatments from the year 1994. The experiment is divided into six blocks with an area of 2048 m^2 comprising of 32 coconut palms, 32 black pepper, 21 clove, 84 banana and 21 pineapple beds.

b) Integrated nutrient management

i) Fertiliser dose

The quantity of nutrient applied for crops in the system is given in the Table 2. The N, P and K were applied in the form of urea, mussoorie-phos and muriate of potash respectively, in two splits *viz.* one-third (33 %) in May-June (beginning of monsoon) and two-third (66 %) in September- October (receding monsoon).

ii) Crop residue availability and recycling

Biomass production

The total biomass from the system was estimated on yearly basis. Highest coconut biomass was obtained at full dose treatment (23.51 t/ha), and it was 19 t/ha in the control treatment (Table 3). Major contribution of biomass is from coconut (Fig.2).

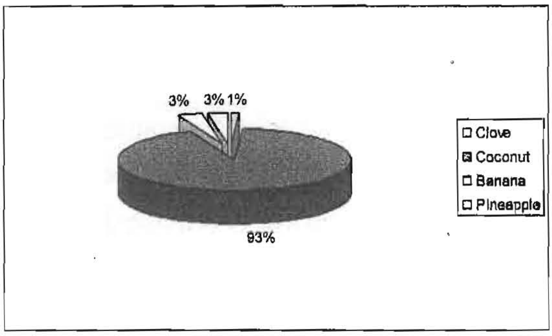

Fig. 2. Biomass contribution from the component crops

Nutrient recycling

The total nutrient exhaust in the cropping system ranged from 130.45, 18.29 and 172.64 kg of N, P and K respectively per ha in the full dose to 97.11, 13.06 and 125.45 kg of N, P and K respectively per ha in the no fertilizer treatment plot. The extent of nutrient recycling ranged from 90 to 130 kg N/ha, 5.4 to 8.5 kg P/ha and 87 to 121 kg K/ha.

Vermicomposting

The weathered wastes obtained during rainy seasons may be preferred for vermicomposting. This waste can be used without chopping, thus saving a lot of labour.

These organic wastes are to be treated with cow dung at the rate of 10 percent by weight in the form of slurry and must be allowed to undergo a preliminary decomposition for about 2 –3 weeks. The earthworms at the rate of 1000 worms per tonne of wastes are to be introduced. The compost bed should be mulched properly using any locally available plant material or gunny bags and has to be protected from direct sun light. Watering is to be done to maintain enough moisture. As full leaves are used for composting, compact mass is not formed, thus allowing free movement of air in the bed. In about 60- 75 days compost will be ready. On an average, 70 per cent recovery of vermicompost was obtained. The same technology for vermicomposting was also tested in large pits taken in the inter spaces of four coconut palms in sandy loam and coastal sandy soils and was found to work well. The average nutrient composition of the vermicompost recovered was: N % (1.8), P % (0.216), K % (0.16), Organic carbon % (17.84), and C/N (9.95). Total microbial counts and beneficial microbial population were also more in the compost compared to the base material. The C/N ratio of the organic matter ingested by the earthworm decreases and bound nutrients are converted into easily available forms.

Effect of INM on crop production

a) Effect on yield

In the coconut based high density multi species cropping system, the coconut yield (mean of six years) ranged from 127 nuts/palm/year under no fertilizer control treatment to 147 nuts/palm/year at two third and one third of the recommended fertilizer dose. The productivity of the palm declined with the reduction in the fertilizer levels beyond $1/3^{rd}$ of the recommended fertilizer treatment. The yield of the clove tree varied with the fertilizer treatments. The clove yield ranged from 0.246 kg/tree/year under no fertilizer control treatment to 1.44 kg/tree/year at full dose of the recommended fertilizer dose. The average weight of banana bunch was highest in the full recommended dose treatment (6.20 kg/bunch). The average weight of pineapple fruit was highest in the full recommended fertilizer dose treatment (890 g). The black pepper yield was highest in the $2/3^{rd}$ recommended fertilizer dose (1.66 kg/bush/year).

Yield relationship function of coconut

The quadratic response fitted showed significant correlation coefficient (Figure 4). The optimum fertilizer requirement worked out to be 359 g N, 229 g P_2O_5 and 860 g K_2O per palm per year, which gave the nut yield of 151.77 nuts/year.

The total cost involved in maintaining the system under various fertilizer doses ranged from Rs 48,983 (No fertilizer dose) to 56,973 (Full dose). The net returns were highest in the treatment, two third of the recommended fertilizer dose (Rs 63,579/-) with a cost benefit ratio of 1: 2.18.

Conclusion

Integrated nutrient management by using 2/3 recommended fertiliser dose along with recycling of biomass by vermicomposting gives the best economic benefit in a sustainable manner. INM on coconut based cropping system demonstrated model to the farmer for integrated nutrient management in a cropping system. The system is more sustainable and production and productivity will increase without affecting the ecosystem. There is a positive impact through improvement of soil health by recycling of waste products in the system as organic manures. Further it will be eco-friendly with nature which will enable to increase the production and productivity of the system.