

NPK NUTRITION OF COCONUT PALM—A REVIEW

E. V. NELLIAT

Central Plantation Crops Research Institute, Kasaragod, Kerala

ABSTRACT

The available information on NPK nutrition of the coconut palm has been reviewed.

To produce seedlings with favourable nutrient status and facilitate their quicker growth and early bearing, it was found necessary to manure the coconut nursery adequately. NPK fertilisation has been found essential even during the prebearing stage, since the damages caused by deficiency in the early years persisted and were not rectified fully by later ameliorative measures. The first dose of fertilisers may be applied three months after transplanting in the main field at 1/10th the adult palm dosage. The young palms may be fertilised with 1/3 and 2/3 the adult palm dose during the first and second year respectively and the full dose from the third year. Based on the nutrients removal by the crop and field experimental evidences, the general dose of fertilisers for palms yielding about 50 nuts per annum had been found to be 500 g N, 320 g P₂O₅ and 1200 g K₂O per palm, per year. Palms with higher yield potential may be given 1.0 kg N, 0.5 kg P₂O₅ and 2.0 kg K₂O per palm, per year.

Application of the annual dose of fertilisers in two or more splits had been found highly beneficial in increasing the yield and quality of nut. Also to obtain higher efficiency in the uptake of applied nutrients, fertilisers are to be applied in circular basins 20 to 25 cm deep and 1.5 to 1.8 m radius, round the base of palms.

Nitrogen increased trunk height and production of leaves, bunches and female flowers, but adversely affected the nut characters. K improved the leaf area, leaf colour, setting of female flowers, size of nut and weight of nut. Although the effect of P as such was negligible, it had proved beneficial in the presence of N or K.

The critical levels of nutrients in the leaves had been determined as 1.8 to 2.0% nitrogen, 0.12 to 0.14% P and 0.8 to 1.0% K on dry matter basis. However, the organic anion concentration in the leaves may be a more valid index of the optimal nutritional status of the palm.

INTRODUCTION

RATIONAL manuring is one of the most important means for obtaining higher and stabilised yields from the coconut palm. The quantity and proportion of nutrients supplied through fertilisers should meet the requirements of the palm and should be determined on the basis of soil fertility and productivity of the plantation. The data and information to be collected in perfecting fertilisation schedule should, therefore, answer not only the nutritional requirements at different stages of growth such as nursery, prebearing and adult bearing stages, but also the quantity, time and method of application of fertilisers at each of these stages. In order to seek answers to the above questions, the available information has been reviewed and presented in this paper.

NUTRIENT REMOVAL

Nathaniel (1969) elaborated the conceptual basis to assess the nutrient requirement of the coconut palm by the equation $F = R - S + L$, where F is the quantity of fertiliser nutrient, R is the quantity of the nutrient required by the crop for unrestricted growth, S is the quantity of the nutrient supplied by the soil and L is that portion of the fertiliser nutrient not utilised by the crop plant. He calculated the annual removal of the major nutrients by a middle aged palm of the ordinary tall variety as 0.59 Kg N, 0.26 Kg P₂O₅ and 0.86 Kg K₂O, when the yield is about 40 nuts per year. If the mean yield is around 60 nuts, he calculated the nutrient removal at 0.72 Kg N, 0.33 Kg P₂O₅ and 1.08 Kg K₂O per palm, per year.

A number of workers have estimated the removal of nutrients by middle aged bearing palms and have obtained widely varying values. This is probably because of the variations in agro-climatic conditions, management practices and the plant material itself. Some of the available data are furnished in Table I.

unmanured palms. Foale (1968) from Australia reported that the nutrient contribution by the endosperm to the growing seedling decreased from the fourth month after germination. This implies that the young seedlings are actually in short supply of nutrients for a major part of their one year growth in the

TABLE I
*Nutrients removed annually by the coconut palm**

Sl. No.	Authority	Location	Basis	In kg per hectare		
				N	P	K
1.	Pillai, 1919	India	5000 nuts per hectare per year	20.26	5.68	92.50
2.	Jacob and Coyle, 1927	..	From one hectare per year	64.0	29.16	95.38
3.	Copeland, 1972	East Africa	7000 nuts per hectare per year	91.92	41.51	136.65
4.	Georgi and Teik, 1932	Malaysia	Soil rich in plant nutrients	73.88	30.15	137.89
5.	Patel, 1938	India	..	26.93	13.34	67.21
6.	Carvalho, 1947	..	156 mature palms per hectare	90.69	30.15	121.08
7.	Cook, 1950	Sri Lanka	150 palms per hectare with 25 nuts each per annum	29.16	8.90	26.93
8.	Pillai and Davis, 1963	India	..	54.86	26.93	84.02
9.	Ramadasan and Lal, 1966	India	175 palms per year	97.30	48.13	145.95

* Nos. 1 to 7 after Menon and Pandalai (1958).

From Table I, it is seen that there are broad similarities in the quantity and proportion of nutrients among the estimates listed as 3, 4, 6 and 9. These may, therefore, provide useful guidelines for approximating the quantity of each of these nutrients and the proportion in which they are to be applied.

FIELD EXPERIMENTS

Earliest manuring experiments on coconut were reported to have been carried out in Sri Lanka as early as 1900 (Telwes, 1962), when trials with fertilisers were indicated.

(a) Seedlings at Nursery Stage

In Sri Lanka (Annual Report, 1941) application of potash to the seedbeds produced remarkable effect on the growth of the seedlings in the nursery. In Ivory Coast (Annual Report, 1956) seedlings, produced from nuts obtained from palms manured with K, displayed better growth than those obtained from

nursery. Ziller and Fremond (1961) were of the opinion that N, P, K, Ca and Mg manuring in the nursery was essential to produce young palms with a satisfactory nutrient status. Fremond *et al.* (1966) recommended heavy organic and inorganic fertilisation of the nursery to produce healthy and vigorous seedlings. They suggested that a basal application of 6 tons of well-rotted cattle manure combined with 400 kg each of ammonium sulphate, superphosphate and muriate of potash per hectare would be beneficial.

These results indicate the need to change the concept that there is sufficient stored food inside the seednuts. It is, therefore, necessary to apply NPK fertilisers in the nursery to produce seedlings with favourable nutrient status so as to facilitate better establishment, faster growth and earlier bearing in the main fields. It is reasonable to suggest application of fertilisers to nursery in the months of December, February and April to supply 40 Kg N + 20 Kg P₂O₅ + 40 Kg K₂O per application.

(b) *Young Palms (Prebearing Stage)*

In New Guinea, Charles (1968) made an interesting study on the uptake of nutrients from applied fertilisers by newly planted seedlings. He applied fertilisers at planting, and after one month, two months and three months of planting. The absorption of nutrients from the applied fertilisers was determined by foliar analysis. He found that there was definite absorption of nutrients even from the fertilisers applied at the time of planting, although the efficiency of uptake of nutrients was greater in the case of later applications.

Systematic fertilisation of young palms is essential not only for faster and vigorous growth but also for reducing the prebearing age (Smith, 1968 and 1969). At Veppankulam, Tamil Nadu (Annual Report, 1971) application of graded dose of fertilisers—the adult palm dosage being 0.34 Kg N, 0.23 Kg P_2O_5 and 0.45 Kg K_2O , induced flowering one year ahead of the control—no fertiliser plots. When double the above dosage was applied, the prebearing period was further reduced by four months.

Salgado (1952) reported that in the palms receiving K, the first fruits were observed in 5 years after planting, while it took 8 years for the unmanured palms to fruit. Fremont and Ouvrier (1971) stressed the importance of balanced NPK nutrition to the young palms from the time of planting in the field as they found that the damage caused by K deficiency in the early stages was not entirely repaired by later dressings. Although the later application of K enabled re-establishment of good physiological

functioning, the palms which suffered from K deficiency during the prebearing stage remained on an average 15% less productive than those that never suffered.

Field experiments conducted at CPCRI, Kasaragod, in the littoral sandy soil (Annual Report, 1971) showed that NPK fertilisation is necessary for obtaining satisfactory growth in the early years. The data on the vegetative characters as observed by the author three years after planting are presented in Table II. In an NPK factorial experiment on young palms of the Tall variety in sandy loam soil (Annual Report, 1972) the main effect of nitrogen was significant in respect of leaf production and length of leaf-blade and leaflet. P significantly increased leaf production. NP and NK interactions were also significant in increasing leaf production. The palms to flower first were those that received 1 Kg N + 1.5 Kg P_2O_5 + 1.5 Kg K_2O per palm, per year. In the fertiliser experiment on the young palms of high yielding hybrids and varieties Nelliatt and Muliyyar (1971), found that the application of fertilisers resulted in highly significant increase in all the growth characters studied and that among the 54 palms that flowered by the 6th year, none was from the plots that did not receive fertilisers. Mathew and Ramadasan (1964) reported that P application increased the girth at collar and number of leaves of the seedlings. Soon and Wat (1971) reported that in the coastal clay soils of Malaysia application of nitrogen significantly increased the length and weight of frond.

These studies indicate the need for NPK fertilisation of young palms right from the time

TABLE II

Growth characters of three year old palms of the ordinary Tall variety as influenced by fertilisation at CPCRI, Kasaragod

Growth characters	Treatments				
	Control	N_1	N_2	$N_1P_1K_1$	$N_2P_2K_2$
Height (cm)	250.5	260.7	264.3	305.9	323.2
Girth (cm)	42.3	41.3	43.1	55.5	55.8
No. of leaves produced	21.8	22.2	22.6	23.6	24.0

where $N_1 = 0.5$ kg Nitrogen, $N_2 = 1.0$ kg Nitrogen, $P_1 = 0.25$ kg P_2O_5 , $P_2 = 0.5$ kg P_2O_5 , $K_1 = 0.75$ kg K_2O and $K_2 = 1.50$ kg K_2O per adult palm, per year.

of planting in the main field. Since palms of the Tall variety come to fruiting in about five years and as the response to fertilisers in terms of yield of nuts is obtained only two years after application, the adult palm dosage should be given from the third year onwards. It is, therefore, appropriate that one-third and two-thirds the above fertiliser dosage should be applied during the first and second year, respectively. About three months after planting one-tenth the adult palm dosage may be applied.

(c) Adult Palms

(i) *Yield and yield components.* Smith (1969) expressed the view that the number of nuts per bunch was the most variable component of yield of coconut and that it was also the one that was most easily influenced by fertiliser treatments. Marked increases in the yield of coconut due to NPK fertiliser application have been obtained in most of the coconut growing countries.

In the fertiliser demonstration trials conducted all over the West Coast of India, John and Jacob (1959) found that the application of 0.34 Kg N, 0.34 Kg P₂O₅ and 0.68 Kg K₂O per palm, per year, resulted in an increase of 35% in the nut production and 44% in copra production over the cultivators' practice. Where they failed to obtain response to the above dosage, significant yield increases were recorded when the K₂O dosage was raised to 0.90 Kg per palm, per year. Increasing the dosage to 0.90 Kg N, 1.135 Kg P₂O₅ and 1.135 Kg K₂O caused a further increase in yield. Prevot and Fremont (1961) found a substantial effect of K manuring on the production of nut in Dahomey. Ziller and Fremont (1962) reported that a dressing of 1.5 Kg muriate of potash resulted in 62% increased yield of nuts and 23% increased copra content per nut, i.e., a gross increase of 1.1 to 1.2 tonnes of copra per hectare.

Experiments conducted in Sri Lanka have shown (Salgado, 1964) that nitrogen caused 8% and potash 39% increases in the yield of copra over no fertiliser. The results thus far obtained from fertiliser experiments conducted in Sri Lanka (Annual Report, 1969) showed that the main effects of N, P and K were significant. The yields of copra obtained in the above experiment (Annual Report, 1970) are furnished in Table III.

Muliyar and Nelliatt (1971) obtained response to the application of nitrogen in terms of yield from the third year onwards in a 3rd

TABLE III

Effect of N, P and K fertilization on the production of copra

(From the report of the Acting Soil Chemist, Coconut Research Institute, Sri Lanka)

Nutrient	Dosage (per palm) Kg	Mean copra yield (per ha) kg	% increase
N	0	1465	100.0
	0.227	1626	110.0
	0.454	1594	108.8
	0.681	1532	105.7
P ₂ O ₅	0	1376	100.0
	0.227	1572	113.1
	0.454	1514	110.1
	0.681	1772	128.7
K ₂ O	0	1317	100.0
	0.227	1537	116.8
	0.454	1670	126.9
	0.681	1698	129.0

NPK experiment conducted at CPCRI, Kasaragod, on sandy loam soil and the mean increase in nut production was 16.9%. There was practically no response to phosphoric acid for the first 8 years; but from the 9th year onwards significant increase in nut production was obtained due to P application. Potash gave significant response from the fifth year of commencement of the treatment. In the NPK factorial experiment initiated in 1935 in Sri Lanka, significant response to P application was obtained in the yield of nuts in the 26th year at Bandripuwa (Annual Report, 1962). According to Smith (1969) there would be a greater delay in the response to NPK nutrition in N deficient soil than in K deficient soil. Von Uex Kull (1971) found that palm suffering from slight K deficiency responded quickly to applied K, while severe and prolonged K deficiency affected palms took two-three years to show response. Salgado (1948) found that 0.34 Kg K₂O applied once in two years gave response in the fifth year; while double the above dose gave response in the third year.

The results from the long duration NPK fertiliser experiment conducted in Sri Lanka (Annual Report, 1969) showed that NP, NK and PK interactions were significant in respect of

the yield of nuts. Fremond (1966) also obtained a beneficial effect of P in the presence of K, in terms of yield of nuts (19%). From a fertiliser trial having two levels each of N, P and K, viz., 0 and 0.45 Kg N; 0 and 0.227 Kg P₂O₅ and 0 and 0.454 Kg K₂O, Marar and Pandalai (1961) concluded that the effect of N and K to be equal and additive. They quantitatively fixed the effect of N at 10.7 nuts, K at 11.8 nuts and NK at 20.8 nuts per palm, per year. However, from Jamaica (Annual Report, 1969), it has been reported that high nitrogen treatments induced K deficiency. Spencer (1963) found that there was no beneficial effect to P application in the absence of N and K.

Salgado (1948), summarising the data from his fertiliser experiments, found that female flower production increased by 15% from N application. The setting percentage increased by 35% in the 0.68 Kg K₂O treatment over K₀ treatment of the same experiment. The NP interaction had a positive effect on the number of bunches and female flowers per bunch.

Studies conducted in Jamaica (Annual Report, 1969) showed that nitrogen increased the trunk height, female flower production and number of nuts. Increasing rates of N application resulted in corresponding increases in the frond production right upto the highest level tried, viz., 3.63 Kg ammonium sulphate per palm, per year. It was also reported from Jamaica (Annual Report, 1967) that the beneficial effect of nitrogen was due to the increased production of bunches ranging from 11.7 to 12.8% and female flowers ranging from 20 to 40%, although there was reduction in setting. The trunk height and frond production also increased. Telwes* (1962) felt that an over-dose P resulted in a tendency for excessive bud formation. Von Uex Kull (1971) reporting his observation from Philippines noted that the beneficial effect of potash dressing was due to the increased leaf area and improved leaf angle and leaf colour which resulted in better utilisation of sun light and ultimately caused increased number of fronds, inflorescences, female flowers and nuts set and weight of nuts.

Murray and Smith (1952) reported from Trinidad that the response to N was inversely

of the palm—the poor bearers showing greater response to the application of N. The palms giving an annual yield of about 100 nuts showed no improvement in productivity due to

fertilisation. Mulyar and Nelliatt (1971) also obtained similar results. They also found that, for palms yielding less than 60 nuts annually, the optimum dose of N ranged between 0.40 and 0.65 Kg with a mean of 0.48 Kg and that of potash ranged between 0.89 and 1.21 Kg per year per palm.

(ii) *Foliar nutrient content.* Foliar analysis for diagnostic purposes are particularly useful for perennial crops, since they are relatively slow growing. Fremond *et al.* (1968) suggested the 14th leaf from the top in adult palms as the standard leaf, as it fitted best in the notion of physiological maturity and had not yet entered the phase of senescence. According to Ziller and Prevot (1962) the N content increased upto the sixth leaf and then it decreased. The P and K content decreased with the age of leaf. They further reported that the foliar level of K was highest during the rainy season and lowest during the dry season. Fremond *et al.* (1966) found that the nutrient content varied widely depending on the age of the leaf sampled. The data are presented in Table IV.

TABLE IV

Nutrient content of coconut leaf (per cent on dry matter basis)

(after Fremond *et al.*, 1966)

Nutrient element	Leaf number from the last emerged one				
	1	6	11	16	21
N	1.7	2.5	2.4	2.1	1.9
P	0.17	0.16	0.14	0.12	0.11
K	1.7	1.3	0.8	0.6	0.5

Prevot and Ollagnier (1963) suggested the critical levels of 1.8% N, 0.1% P and 0.45% K in the 14th leaf of coconut.

Work done in Sri Lanka (Annual Report, 1969) showed that the 14th leaf of adult palms contained 1.98% N, 0.13% P and 0.87% K. The foliar nutrient status of young palms obtained under N P K fertiliser experiment at CPCRI, Kasaragod. (Annual Report, 1969)

TABLE V

Foliar nutrient content of young palms under NPK fertiliser experiment at CPCRI, Kasaragod (1972)

(per cent/dry matter)

Treatment	% Content N	Treatment	% Content P	Treatment	% Content K
0.5 kg N	1.60	0.5 kg P ₂ O ₅	0.10	0.75 kg K ₂ O	0.55
0.75 kg N	1.70	1.0 kg P ₂ O ₅	0.11	1.50 kg K ₂ O	0.80
1.00 kg N	1.80	1.5 kg P ₂ O ₅	0.13	2.25 kg K ₂ O	0.90

Under irrigated conditions at CPCRI, Kasaragod N and K content in the leaves increased while the P content decreased. In Philippines Von Uex Kull (1971) estimated that the foliar nutrient levels of palms yielding over 100 nuts per year were N 1.96%, P 0.1% and K 1.26%. Fremont *et al.* (1966) determined that the 14th leaf had 1.8 to 2.00% N, 0.12% P and 0.8 to 1.0% K on dry matter basis. Pillai and Davis (1963) found that foliar nutrient content of a healthy palm to be 1.4% N, 0.16% P, and 1.00% K. Brunin (1968) determined the critical level of P in leaves to be 0.12%. But Kanapatty (1971) could not establish any relationship between yield and leaf nutrient status based on his study on palms belonging to different yield groups of the Tall, Semi Tall and Dwarf varieties. His data are presented in Table VI. At the same time, he suggested the optimum levels of 1.8% N, 0.12% P, and 0.8% to 1.11% K for the Tall variety, 1.8% to 2.0% N, 0.12% P and 0.8% to 0.9% K for the Semi Tall variety and 1.9 to 2.0% N, 0.12% P and 0.75 to 1.0% K for the Dwarf variety.

According to Smith (1969) the critical level of K operated only when the N level was satisfactory. He suggested an N/K ratio of 2.25 where the N level was less than 1.8%. The ratio was not applicable where N was greater than 1.8%. Grunder (1960) and Bachy (1963) were of the opinion that for optimal growth and yield, the sum of K, Ca, and Mg should be 2.7% of the dry weight of leaf and 67 to 70% of this should be K. This works out at 1.7 to 1.9% K on dry matter basis.

A given species of plant regulated the organic salt content within a narrow range of values at optimal growth rates (Watanabe *et al.*, 1971),

TABLE VI

Foliar nutrient level (per cent dry matter) (after Kanapatty, 1971)

Yield group	N	P	K	Varieties
150 nuts	1.72	0.123	0.95	Tall
101-150	1.74	0.126	0.86	
51-100	1.69	0.124	0.89	
10-50	1.74	0.125	0.87	
150 nuts	1.89	0.145	0.84	Semi Tall
101-150	1.88	0.144	0.80	
51-100	1.88	0.143	0.81	
10-50	1.89	0.144	0.81	
150 nuts	1.95	0.138	0.74	Dwarf
101-150	1.88	0.135	0.76	
51-100	1.87	0.138	0.78	
10-50	1.80	0.138	0.85	

This is estimated as the difference between the concentration of cations (K + Na + Ca + Mg) and the concentration of inorganic anions (Cl + NO₃ + PO₄ + SO₄). Perhaps, the organic salt content of the tissues (leaves) might be a more valid index of the nutritional status of the coconut palm and may explain why Kanapatty could find little difference in the foliar NPK content, although yield was varying widely.

(iii) *Quality of nuts.* Muliyar and Nelliath (1971) reported that nitrogen adversely affected all the nuts character studied, *viz.*, weight of whole nut, weight of husked nut, volume of whole nut, volume of husked nut, and copra weight per nut. These characters were highly improved by K nutrition while P had negligible effect. Although N application increased nut production by 16%, the copra outturn increased only 6%. With K, the nut production increased by 12% while the copra outturn increased by 22%. Nelliath *et al.* (unpublished) found that the weight of husk decreased with increase in N level while P did not have any effect. The mean weight of husk per nut increased with increase in K fertiliser level. As regards the volume of husk, there was significant reduction due to nitrogen application, while it was nearly static with P application. However, highly significant increase in the volume of husk was obtained at the higher level of K application (Table VII). However, Smith (1969) stated that neither N or K influenced nut size, though P did influence.

TABLE VII

Effect of NPK fertilisers on the weight and volume of husk at CPCRI, Kasaragod
(after Nelliati *et al.*, Unpublished data)

Treatments	Mean weight of husk g				Mean volume of husk cc			
	1961	1962	1963	Mean	1961	1962	1963	Mean
No nitrogen	441	439	502	461	1932	2031	2032	1998
0.34 kg N	444	435	588	489	1878	1990	2029	1632
0.68 kg N	437	419	502	453	1844	1859	1986	1896
No phosphoric acid	432	427	535	465	1891	1979	2020	1963
0.34 kg P ₂ O ₅	422	429	507	453	1885	1998	2024	1969
0.68 kg P ₂ O ₅	441	431	520	464	1877	1902	2003	1927
No potash	415	392	501	436	1696	1733	1834	1754
0.34 kg K ₂ O	441	438	525	468	1936	2007	2086	2008
0.68 Kg K ₂ O	440	458	536	478	2028	2139	2128	2098

Von Uex Kull (1971) from his studies in the Philippines found that nut size decreased rapidly in the absence of K. With an annual dressing of 0.5 Kg K₂O per palm, it remained unaffected; when 1.0 Kg K₂O was applied the nut size improved. He estimated that the increased copra outturn due to K fertilisation could be apportioned as 30% to the increase in the number of nuts and 70% to the increase in size.

(a) *Effect on soil nutrient status*

Most of the coconut soils are low in major nutrients. It has been found that continued application of fertilisers to the young palms had improved the available nutrient status of the top 50 cm soil, the higher level having superior effect (Annual Report, 1972).

Nethsinghe (1961) from a study of the soil samples collected from fertiliser experiment found that six months after application of

TABLE VIII

The nutrient status of soil—0 to 50 cm depth—as influenced by fertiliser application at different levels at CPCRI, Kasaragod

(after Nelliati *et al.*, 1972)

Treatment	pH	Org. carbon (%)	Available nutrient (ppm)		
			N	P	K
No fertiliser	5.6	0.20	103	12	86
N ₁ + P ₁ + K ₁ (0.5 kg + 0.5 kg + 1.0 kg)	5.2	0.21	104	104	115
N ₂ + P ₂ + K ₂ (1.0 kg + 1.0 kg + 2.0 kg)	5.1	0.21	111	251	246

TABLE IX

Results of fertiliser placement trial using ^{32}P

Distance	Dry season				Wet season			
	Counts per minute per mg P				Count per minute per g of dry matter			
	10th day	23rd day	30th day	40th day	10th day	23rd day	30th day	40th day
<i>Lateral</i>								
0.5 m	2.30	4.88	6.34	7.41	34.15	96.36	176.85	242.61
1.0 m	2.41	4.37	5.32	7.38	35.32	100.93	181.90	249.38
2.0 m	1.34	2.48	2.91	3.55	11.96	36.07	62.38	90.52
3.0 m	0.61	1.20	1.40	1.67	5.68	16.90	29.31	44.27
<i>Vertical</i>								
10 cm	3.82	4.27	4.54	4.54	51.95	125.86	206.59	301.54
30 cm	1.55	3.95	5.18	6.12	17.32	60.45	119.07	155.13
45 cm	1.01	3.58	4.69	6.87	11.20	40.48	82.37	114.82
60 cm	0.30	1.14	1.57	2.58	7.64	23.47	41.58	55.28

fertilisers, there was little difference in the available N and K contents of samples collected from control and fertilised plots. Nelliath *et al.* (1972) reported that the continued application of fertilisers had little effect on soil organic C and available N. But there was considerable build up of available P and K in the soil. The data obtained are given in Table VIII.

It could be summarised from the above studies that nitrogen is actually in short supply for a major part of the year and that the coconut palm experiences N stress.

METHOD OF APPLICATION

Nethsinghe (1966) concluded from his studies on fertiliser placement using radioisotopes that for maximum efficiency in the uptake of nutrients by bearing coconut palms, fertilisers should be applied round the palm in the entire area upto a distance of 150 cm from the bole. According to him efficiency in fertiliser utilisation may be governed by two factors, *viz.* (1) extent of root surface available for absorbing nutrients and (2) the concentration of the nutrients in the soil solution. From the studies carried out in Sri Lanka using ^{32}P with 16 placement treatments at

various lateral and vertical distances, the uptake was found to be greatest at a distance of 0.5 m and depth of 10 cm during the early period. But after 30 days uptake was more from placements at depths of 30 and 45 cm than from 10 cm depth. The data obtained are presented in Table IX.

On grouping the distance and depth, it was found that for about 10 days the uptake from shallow placement—whether near or distant—was better than from deeper placements. With time, the uptake from deep near reached the same level as shallow near. With distant placements, whether shallow or deep, the uptake was lower than near placement.

Work done in Jamaica (Annual Report, 1969) showed better responses from broadcast application in wide circle than using the same quantity close to the bole. De Silva (1968) estimated that fertiliser application in the entire area round upto a distance of 150 cm can lead to an uptake efficiency as high as 100% more than either application in centres of squares or 90 cm wide circular strip 90 cm from the bole. Nethsinghe (1967) found that application of fertilisers in alternate half circles each year was 40% less effective than application in full circles.

Kushwah *et al.* (1973) studied the rooting pattern of coconut palm. In a regularly

TABLE X

Effect of annual, biennial and split application of fertilisers on production of nuts at CPCRI, Kasaragod

(Annual Report, 1971)

Treatment	Pretreatment Mean of 4 years (1963-66)	Mean yield of nuts/ palm			Copra content per nut (g)
		1969	1970	Mean	
No fertiliser	63.4	60.0	70.2	65.1	139
Annual single application	63.6	75.2	75.5	75.4	148
Annual application in two splits	64.0	78.7	84.1	81.4	152
Biennial single application	62.2	65.9	72.4	69.2	149
Biennial application in two splits	62.8	70.4	72.1	72.3	138

Fertiliser dose: 0.9 kg N+0.25 kg P₂O₅+1.00 kg K₂O per palm, per year.

cultivated and manured plot 74% of the emerging roots did not extend beyond 2 metres and few roots were met within the first 30 cm layer of soil. About 82% of the roots were confined to 31 cm to 120 cm depth of soil.

FREQUENCY OF APPLICATION

In the fertiliser quantity-cum-frequency experiment conducted in Sri Lanka (Annual Report, 1970), biennial application was found to be definitely inferior to annual application.

Field experiments conducted at CPCRI, Kasaragod (Table X), also showed that split application of the annual dose of fertiliser resulted in significantly higher production of nuts compared to annual or biennial or biennial-split applications. The copra content per nut was also much higher in split application.

On the coastal marine sandy soil in Sri Lanka, where the annual application produced poor crops (Annual Report, 1968) quarterly application of fertilizers—the total dose per year, being the same—raised the yield of nuts 241 to 500% thereby indicating that the nutrient availability in the light textured soils could be considerably enhanced by resorting to frequent applications.

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DISCUSSION

VENKATESWARAN: 1. What is the basis for the three year schedule for coconut?

2. Would you suggest that hybrid palms should be given the full manurial dose much earlier?

NELLIAT: 1. West Coast Tall palms begin bearing about 5 years after planting.

2. Yes.

VERGHESE: Potash improves quality. What are these quality factors?

NELLIAT: Volume of nuts, weight of nuts, weight of copra, etc.

MOHANKUMAR: Would you agree or disagree with the view that "damages caused by K-deficiency in the early years persist and are not rectified fully by K dressings"?

NELLIAT: The vigour and productivity can be restored, but not fully.

PUSHPADAS: 1. The fertilizer trials conducted earlier in coconuts were all with NPK fertilizers. Heavy

application of fertilizers is likely to create Mg deficiency. So can you preclude the possibility that the deficiency of Mg may be a factor in not getting any response to P since Mg is associated with the mobility of P within the plants?

2. Is it not desirable to include Mg also in the fertilizer schedules for coconut?

NELLIAT: 1. No.

2. Experiments are now in progress with Ca and Mg included in the schedules.

SANKARA SUBRAMONEY: Since there is no response to P, why not reduce the content of this costly element from the fertilizer recommendations?

NELLIAT: Interaction of P with N and K are beneficial.

BALASUBRAMANIAN: The author mentioned about foliar diagnosis and said that the 14th leaf indicate the NPK status on a percentage dry matter basis. Now, shouldn't it differ for different age groups of palms and also for different types of soils as the uptake of nutrients from soil varies with the soil type?

NELLIAT:

Now, the use of soil testing in coconut gardens is very much limited. In the case of perennial crops, there are lot of limitations to the use of soil testing. If there are 100 trees in a garden anything about 60-70 trees may be good and the rest alone may need special treatment. Soil testing, except that it may give us a general indication of pH, N, P, K, Ca, and Mg status, may not help us to formulate a general recommendation applicable to all the trees. Each tree is a variant and a type by itself. Hence leaf analysis assumes paramount importance. The CPCRI, Kasaragod, should start this work for different soil types and arrive at a crop log whereby any tree which needs improvement can be tackled. Reliable, easy, and quick methods of foliar analysis to indicate N, P, K, Ca, and Mg should be formulated and standards fixed for different age groups of trees.

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