Effects of Manuring on the Nutrients Contents of Soil and Leaf in Arecanut

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Abstract

Fertility status of surface soils and nutrients content of arecanut leaf from stations, where the NPK experiments conducted, were evaluated. Organic C was optimum in soils at Vittal and Peechi due to green leaf application. Bray P-1, P was adequate in soils at Vittal, Peechi, Mohitnagar and Kahikuchi, because of P fertilization. Exchangeable K_2O was sufficient in soils at Hirehalli, Peechi, Mohitnagar and Kahikuchi as a result of addition of muriate of potash. Application of fertilizer-N increased acidity and decreased exchangeable K and Ca content of soils at Vittal, Peechi, Mohitnagar and Kahikuchi. N content of leaf appeared to be rather low, whereas K was high. Leaf-P was low in samples from Vittal and Hirehalli but satisfactory at Peechi, Mohitnagar and Kahikuchi. Ca content of leaf was above the average value in samples from all the centres except that of Peechi.

Introduction

Arecanut generally grows in acid soils of medium to low fertility. In such soils applications of organic manures and fertilizers are the common practices to increase the yield of arecanut. Prolonged use of such substances alter the soil properties ultimately affecting the nutrients content of leaf. In the present study, effects of continuous applications of green leaf and fertilizers to arecanut on the mineral nutrients content of soil and leaf were investigated in the existing NPK manurial experiments.

Materials and Methods

NPK manurial experiments were started at Vittal in 1961, at Hirehalli in 1962, at Peechi in 1961, at Mohitnagar in 1967 and at Kahikuchi in 1962. The lay out of the experiments was 3^4 factorial with NPK and green leaf (G) as treatments at Vittal, Hirehalli, Peechi and Kahikuchi, consisting of a single replication. At Mohitnagar, the design was $3^3 \times 2$ factorial, with NPK and lime (L) treatments and 3 replications. The levels of nutrients at Vittal, Hirehalli, Peechi and Kahikuchi were 0, 50, 100 g N; 0, 40, 80 g P_2O_5; 0, 70, 140 g K_2O and 0, 7, 14 kg green leaf/palm/yr. The treatments were revised at Vittal in 1971 to include higher levels of nutrients. The revised levels were fixed at double the rate of the original treatments. The treatments at Mohitnagar comprised of 0, 100, 200 g N; 0, 40, 80 g P_2O_5 and 0, 140, 280 g K_2O with 0 and 1 kg lime/palm/yr.

Soil and leaf samples were collected from Vittal, Hirehalli, Peechi and Mohitnagar during October, 1976 and from Kahikuchi during September, 1977 for analyses. Soil samples were taken by

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tubular auger from 0 - 50 and 50 - 100 cm depths. Soil samples were air - dried, pounded in a wooden mortar and pestle and passed through a 2 mm sieve. Leaf samples were washed in distilled water, dried in oven at 70°C and ground in a mill to fineness.

Estimations of pH (H_2O), pH (1 *N* KCl), electrical conductivity, exchange acidity (1 *N* KCl), organic C (Wakley - Black), available N (alkaline $KMnO_4$ distillation), available P (Bray P-1) and exchangeable K, Ca (N 1 *N* NH_4OAc) were carried out in soil samples. P was estimated in Spectronic 20, spectrophotometer at 660 mμ, whereas K and Ca were determined in an EEL flame photometer (Subbiah and Asija, 1956; Muhr et.al.,1965; Kamprath, 1967; Jackson, 1967).

Total N in leaf samples was determined by Kjeldahl method. The leaf samples were digested in a mixture of HNO_3 and $HClO_4$ acids. P, in the extract, was estimated by vanadomolybdate method. K and Ca were measured in the flame photometer as that of soil extract (Jackson, 1967).

Results

Fertilizer -N at Vittal (both depths, each in original and revised schedules), Peechi (both depths), Mohitnagar (both depths) and Kahikuchi (0 - 50 cm depth) increased acidity, and decreased exchangeable K and Ca contents of soils significantly (Table 1). Application of P fertilizer raised the available P_2O_5 content of soils significantly at Vittal (both depths, both schedules), Hirehalli (both depths), Peechi (both depths), Mohitnagar and Kahikuchi; each at 0 - 50 cm depth (Table 2). Exchangeable Ca content of soils at Vittal (both depths in original schedule and 0 - 50 cm depth in revised schedule), Peechi (both depths), Mohitnagar (both depths) and Kahikuchi (0 - 50 cm depth) significantly increased by the application of superphosphate (Table 2). Addition of muriate of potash increased significantly the available K_2O content of soils at Vittal (both depths,both schedules),Hirehalli (0 - 50 cm depth), Peechi (both depths), Mohitnagar (both depths) and Kahikuchi at 0 - 50 cm depth (Table 2). Application of green leaf significantly increased the organic C content of soils at Vittal (both depths in original schedule and 0 - 50 cm depth in revised schedule), Hirehalli and Peechi, each at 0 - 50 cm depth (Table 2). Green leaf also significantly reduced acidity in soil at Vittal (0 - 50 cm depth in original schedule and both depths in revised schedule), Hirehalli (0 - 50 cm depth), Peechi (50 - 100 cm depth) and Kahikuchi (0 - 50 cm depth).

Lime application at 1 kg/palm/yr at Mohitnagar increased the pH and exchangeable Ca and decreased the available P_2O_5 content of soil (0 - 50 cm depth) significantly.

N fertilizer at Hirehalli reduced pH (both depths) and specific conductivity of soil (0 - 50 cm depth) significantly. The specific conductivity of soil at Hirehalli was below 1 mmhos / cm which is considered as safe for the normal growth of crop plants.

Organic C content of soils (0 - 50 cm depth) was high (>0.75%) at Vittal (both schedules) and Peechi; medium (0.50 - 0.75%) at Kahikuchi and low (<0.50%) at Hirehalli as a result of green

Table 1. Effects of N levels on pH, exchange acidity, available K_2O and exchangeable Ca contents of soils

(Table of means)

Constituents	pH (H_2O)			pH (KCl)			Exchange acidity (meq/100g)			Availabe K_2O (ppm)			Exchangeable Ca (ppm)		
N. Levels	N_0	N_1	N_2	N_0	N_1	N_2	N_0	N_1	N_2	N_0	N_1	N_2	N_0	N_1	2
STATIONS															
Vittal	5.76	4.79	4.47	4.58	3.95	3.80	0.33	1.82	2.75	175.11	97.44	92.48	388.25	139.58	116.76
[Original levels]	[5.73]	[5.03]	[4.47]	[4.53]	[4.07]	[3.89]	[0.50]	[1.42]	[2.83]	[122.00]	[88.78]	[74.33]	[316.30]	[164.95]	[90.83]
Vittal	5.27	4.54	4.28	4.16	3.84	3.65	0.90	2.20	3.04	158.81	106.26	99.81	282.31	128.56	115.83
[Revised levels]	[5.53]	[4.72]	[4.31]	[4.40]	[3.97]	[3.75]	[0.53]	[1.98]	[3.16]	[138.89]	[97.11]	[98.00]	[314.81]	[123.19]	[88.50]
Peechi	5.75	5.27	4.85	4.66	4.22	3.81	0.10	0.32	1.18	301.74	253.67	198.07	736.65	559.77	368.73
	[5.90]	[5.41]	[4.82]	[4.76]	[4.32]	[3.81]	[0.08]	[0.30]	[1.11]	[277.33]	[246.37]	[208.81]	[699.10]	[630.84]	[389.68]
Mohitnagar	6.44	6.09	5.96	—	—	—	—	—	—	176.63	153.83	125.00	573.60	428.51	388.97
	[6.42]	[6.22]	[6.09]	—	—	—	—	—	—	[102.48]	[96.00]	[76.96]	[142.41]	[137.86]	[115.79]
Kahikuchi	4.91	4.70	4.38	4.11	3.91	3.72	0.32	0.50	0.83	450.41	332.85	359.18	549.17	435.74	357.04
	[4.93]	[4.89]	[4.77]	[4.11]	[4.16]	[4.02]	[0.20]	[0.25]	[0.32]	[376.33]	[375.00]	[348.81]	[594.26]	[559.89]	589.44]
Vittal, OL		0.142*			0.136*			0.220*			17.93*			62.86*	
LSD [P=0.05]		[0.234]*			[0.170]*			[0.41]*			[20.47]*			[55.45]*	
Vittal, RL		0.138*			0.087*			0.218*			20.75*			27.95*	
LSD [P=0.05]		[0.120]*			[0.11]*			[0.27]*			[23.72]*			[39.53]*	
Peechi		0.12*			0.092*			0.124*			55.28*			61.08*	
LSD [P=0.05]		[0.113]*			[0.099]*			[0.179]*			[24.24]*			[76.63]*	
Mohitnagar		0.0058*			—			—			13.52*			31.74*	
LSD [P=0.05]		[0.12]*			—			—			[11.53]*			[16.46]*	
Kahikuchi		0.237*			0.190*			0.300*			83.83*			87.52*	
LSD [P=0.05]		[NS]			[NS]			[NS]			[NS]			[NS]	

Figures in parenthesis represent the values for 50-100 cm depth. * Significant at P=0.05; NS, Not significant

Table 2. Effects of P levels on available P_2O_5 and exchangeable Ca, K levels on available K_2O and G levels on organic C contents of soils

(Table of means)

Constituents / Nutrient levels	P Fertiliser						K Fertiliser			Green leaf		
	Available P_2O_5 (ppm)			Exchangeable Ca (ppm)			Available K_2O (ppm)			Organic C (%)		
	P_0	P_1	P_2	P_0	P_1	P_2	K_0	K_1	K_2	G_0	G_1	G_2
STATIONS												
Vittal	2.07	57·02	188.25	171.48	220.56	252.56	58.67	138.48	167.89	0.72	0.96	1.02
[Original levels]	[0.17]	[6.15]	[32.69]	[155.74]	[212.50]	[203.84]	[45.11]	[102.89]	[137.11]	[0.60]	[0.70]	[0.79]
Vittal	24.57	96.39	312.85	143.43	175.42	207.87	90.15	114.52	160.22	0.85	0.95	1.10
[Revised levels]	[2.14]	[12.75]	[28.46]	[151.11]	[190.00]	[185.40]	[70.44]	[104.33]	[159.22]	[0.62]	[0.63]	[0.67]
Hirehalli	1.59	6.51	14.13	2950.00	2940.00	3060.00	115.89	149.67	197.55	0.46	0.49	0.51
	[2.50]	[3.11]	[3.80]	[3020.00]	[2960.00]	[3110.00]	[118.11]	[112.04]	[120.55]	[0.42]	[0.45]	[0.45]
Peechi	132.46	211.14	358.81	494.84	573.40	596.92	196.63	225.89	330.96	0.96	1.12	1.13
	[67.03]	[91.20]	[117.30]	[535.80]	[559.98]	[623.82]	[176.04]	[231.81]	[324.67]	[0.68]	[0.73]	[0.74]
Mohitnagar	33.70	67.63	97.16	436.18	460.74	494.17	63.72	157.78	233.96	—	—	—
	[17.63]	[17.71]	[20.36]	[114.07]	[132.95]	[149.03]	[36.92]	[92.22]	[149.30]	—	—	—
Kahikuchi	72.87	118.46	257.09	385.65	446.48	509.81	317.48	381.70	443.26	0.73	0.70	0.66
	[39.14]	[57.62]	[71.64]	[558.13]	[594.54]	[590.92]	[351.22]	[374.89]	[374.04]	[0.40]	[0.39]	[0.36]
Vittal, OL		30.01*			62.86*			17.93*			0.10*	
LSD [P=0.05]		[9.10]*			[55.45]*			[20.47]*			[0.13]*	
Vittal, RL		49.80*			27.95*			20.75*			0.10*	
LSD [P=0.05]		[11.19]*			[NS]			[23.72]*			[NS]	
Hirehalli		4.49*			NS			13.49*			0.03*	
LSD [P=0.05]		[0.85]*			[NS]			[NS]			[NS]	
Peechi		50.81*			61.08*			55.28*			0.11*	
LSD [P=0.05]		[23.70]*			[71.63]*			[24.24]*			[NS]	
Mohitnagar		11.51*			31.74*			13.52*			—	
LSD [P=0.05]		[NS]			[16.46]*			[11.53]*			—	
Kahikuchi		77.31*			87.52*			83.83*			NS	
LSD [P=0.05]		[NS]			[NS]			[NS]			[NS]	

Figures in parenthesis represent the values for 50-100 cm depth. * Significant at P=0.05; NS, Not significant

leaf application. At 50 - 100 cm depth it was medium at Vittal and Peechi and low at Hirehalli and Kahikuchi. The content of available N was medium (125 - 250 ppm) at Vittal (both schedules), Peechi and Kahikuchi and low (<125 ppm) at Hirehalli at 0 - 50 cm depth. Available N was medium at Peechi and Kahikuchi and low at Vittal and Hirehalli at 50 - 100 cm depth. The content of available P_2O_5 was high (>25 ppm) at Vittal, Peechi, Mohitnagar and Kahikuchi and low to medium at Hirehalli (0 - 50cm depth) due to the application of P fertilizer. Bray - 1 P was high at Peechi and Kahikuchi,medium (10 - 25ppm) at Mohitnagar and low (<10 ppm) at Hirehalli (50 - 100 cm depth). The available P_2O_5 content was high at Vittal (50-100 cm depth), when 80 g P_2O_5/palm/yr, in the original schedule and 160 g P_2O_5/palm/yr, in the revised schedule were applied. The available K_2O content of soils was high (>150 ppm) at Hirehalli, Peechi, Mohitnagar and Kahikuchi (0 - 50cm depth) due to the application of muriate of potash. Available K_2O content was high at Vittal (0 - 50 cm depth), when K at 140 g K_2O/palm/yr, in the original schedule and 280g K_2O/palm/yr, in the revised schedule were applied. It was high at Peechi and Kahikuchi and medium (63 - 150 ppm) at Vittal (original schedule), Hirehalli and Mohitnagar (50-100 cm depth). At Vittal (revised schedule) it was high (50-100 cm depth) when K fertilizer was applied at 280g K_2O/palm/yr.

N fertilizers significantly increased the leaf - N at Hirehalli and Kahikuchi and leaf - P and K at Mohitnagar. Fertilizer - P increased the P content of leaf significantly at Vittal (both schedules) and the leaf Ca at Mohitnagar. KCl application increased significantly the leaf K at Vittal (both schedules), Hirehalli, Mohitnagar and Kahikuchi. Application of G significantly increased the leaf -N at Vittal in the revised schedule (Table 3).

Table 3. Effects of NPK fertilizers and green leaf on the N, P and K contents of arecanut leaf

(Table of means)

Treatments	N fertilizer			P fertilizer			K fertilizer			Grean leaf		
Constituents	N (%)			P (%)			K (%)			N (%)		
Nutrient levels	N_0	N_1	N_2	P_0	P_1	P_2	K_0	K_1	K_2	G_0	G_1	G_2
STATIONS												
Vittal (Original levels)	2.16	2.12	2.07	0.15	0.17	0.17	0.69	0.93	0.98	2.10	2.11	2.13
Vittal (Revised levels)	2.12	2.21	2.31	0.16	0.18	0.18	0.84	0.89	1.05	2.19	2.12	2.33
Hirehalli	2.25	2.38	2.44	0.18	0.19	0.18	0.71	0.81	0.82	2.30	2.39	2.39
Peechi	2.45	2.42	2.46	0.20	0.19	0.20	0.89	0.95	0.93	2.41	2.42	2.51
Mohitnagar	2.39	2.37	2.51	0.19	0.20	0.19	0.81	1.06	1.08	—	—	—
Kahikuchi	2.55	2.71	2.69	0.20	0.20	0.21	0.96	1.03	1.12	2.64	2.69	2.62
Vittal OL (LSD,P=0.05)		NS			0.016*			0.104*			NS	
Vittal RL (LSD,P=0.05)		NS			0.014*			0.087*			0.170*	
Hirehalli (LSD,P=0.05)		0.120*			NS			0.049*			NS	
Peechi (LSD,P=0.05)		NS			NS			NS			NS	
Mohitnagar (LSD,P=0.05)		NS			NS			0.104*			—	
Kahikuchi (LSD,P=0.05)		0.099*			NS			0.050*			NS	

*Significant at P = 0.05, NS, Not Significant.

Leaf from healthy arecanut gardens of Karnataka contained about 3% N, 0.20%P, 0.70% K and 0.50% Ca. Based on these values, the nutrients contents of leaf from Vittal, Hirehalli, Peechi, Mohitnagar and Kahikuchi were assessed (Anonymous 1975).

Discussion

Application of ammonium sulphate or urea as sources of N to arecanut for several years has increased acidity to a level that requires correction by the addition of lime. Liming is practised to neutralise the excess Al injurious to the plants. Suitable quantity of lime is applied to increase the pH (H_2O) to 5.5, beyond which adverse effects are observed on crop plants. Correction of acidity is possible in the surface soil, but relatively difficult in the subsoil horizons. In a perennial crop like arecanut the fertility and reaction of subsoil appear to be as important as that of surface soil. Therefore, source of N should be such that its prolonged application does not leave behind any residual acidity harmful for the plants (Sanchez, 1976).

Lime application at Mohitnagar has reduced the available P content of soil which is likely to occur due to the increased pH. Liming the near neutral soil of Mohitnagar (pH in H_2O, 5.71 before liming and 6.62 after liming) is unnecessary as shown by its detrimental effects on the growth and yield of arecanut (Sanchez, 1976; Anonymous, 1978).

Annual addition of forest leaf to arecanut does not serve as a good source of organic matter, particularly for subsoil. Under the tropical climatic conditions leaf decomposes rapidly leaving behind traces of humus as indicated by the low organic C and available N contents of soils. In the alkaline soils of Hirehalli, hydrolysis of organic matter is rapid, resulting in the lower content of organic C in the soil. Under such conditions cattle manure or compost can be preferred over forest leaf (Sanchez, 1976).

The slightly acid soils of arecanut fix considerable amounts of P when applied as water-soluble phosphate. Arecanut roots are housed in one cubic metre volume of soil. Application of P above fixing capacity would enhance its downward movement in soil. This is possible when P is applied at higher rate for several years during the active growth period of the plant. When the soils are acid rock phosphate could be used satisfactorily. P nutrition of arecanut appears to be more important because of its unavailability in the soil (Sanchez, 1976).

Application of NPK fertilizers has not uniformly reflected on the nutrients status of leaf at all the centres. Similar informations are available on other plantation crops (Kamala Devi, Nelliat and Pillai, 1973; Pushpadas et al., 1973; Wahid et al., 1981). The plants also do not respond to the higher levels of fertilization, as evident from the yield of arecanut (Anonymous, 1978). It is not known, whether genetical factors of plants are responsible for such effects.

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References

ANONYMOUS, 1975. Annual Report, Central Plantation Crops Research Institute, Kasaragod, India. p. 103.

ANONYMOUS, 1978. Annual Report, Central Plantation crops Research Institute, Kasaragod, India. p. 87-89.

JACKSON, M. L. 1967. *Soil chemical analysis*. Prentice Hall of India, Pvt. Ltd., New Delhi. pp. 47, 151-153, 183-190.

KAMALA DEVI, C. B., NELLIAT, E. V. and PILLAI, N. G. 1973. Nutritional studies on high yielding coconut genotypes. *Proc. First National Symposium on Plantation Crops* (Ed. N. M. Nayar). Indian Society for Plantation Crops, Kasaragod, India pp. 67-69.

KAMPRATH, E. J. 1967. Soil acidity and response to liming. *International Soil Testing Tech. Bull.* **4**: 1-17. North Carolina State University, Raleigh, U. S. A.

MUHR, G. R., DATTA, N. P., SANKARA-SUBRAMONEY, H., LELEY, V. K. and DONAHUE, R. L. 1965. *Soil Testing in India.* 2nd ed. United States Agency for International Development Mission to India, New Delhi, pp. 39-46.

PUSHPADAS, N. V., NARAYANAN POTTI, S., GEORGE, C. M. and KRISHNAKUMARI, M. 1973. Effect of long term application of NPK fertilizers on pH and nutrient levels of soil and leaf in *Hevea brasiliensis*. *Proc. First National Symposium on Plantation Crops* (Ed. N. M. Nayar). Indian Society for Plantation Crops, Kasaragod, India pp. 38-43.

SANCHEZ, P. A. 1976. *Properties and management of soils in the tropics*. A Wiley - Interscience Publication, John Wiley and Sons, New York, London, Sydney and Toronto. pp. 162-183, 223-294.

SUBBIAH, B. V. and ASIJA, G. L. 1956. A rapid procedure for the estimation of available nitrogen in soils. *Curr. Sci.* **25**(8): 259-260.

WAHID, P. A., KANNAN, K., KAMALAM, N. V. and VENUGOPAL, V. K. 1981. Genotypic and seasonal variations in the mineral nutrition of coconut palm. *J. Plant. Crops* **9**(2): 105-111.

Discussions

R C Mandal:

For balancing fertilization while soil is acidic, N: K and N:Ca have to be balanced ie, 1: 1 and 1:7.5. whether such balancing is required here? If so, why lime application at Mohitnagar showed decrease in yield?

A R Mohapatra:

Acidity, intensified in soil by the prolonged use of acidifying fertilizers, requires base such as lime for amelioration. Liming near neutral soils as at Mohitnagar shows adverse effects on growth and yield of crop plants.

R C Mandal:

Whether P application is required while P content in leaf is low at Vittal and P fixation is likely to occur in acidic condition?

A R Mohapatra:

P fixation is high in acid lateritic soils. Phosphate application neither increases the yield nor the P content of leaf, probably due to genetic reasons.

S P Singh:

What is the most congenial pH of soil for growing arecanut? What is the relationship between organic matter content and soil pH?

A R Mohapatra:

pH around 5.5 is most ideal for growth of arecanut palm. Organic matter generally increases the soil pH because of which the tropical soils are neutral in reaction.

S P Singh:

With recommended doses of fertilizer for arecanut up to what extent the pH is increased and how it could be corrected?

A R Mohapatra:

The pH decreased up to 4.3 from 5.7 at Vittal when ammonium sulphate, single super phosphate and muriate of potash were the carriers of nutrients for N P and K respectively. Liming is the usual practice to correct soil acidity.