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Effect of NPK fertilization on the mineral nutrition and yield of three coconut genotypes

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Abstract. Annual application of NPK fertilizers over a 18 year period to coconut on red sandy loam soils resulted in a minimal increase in mineralisable N, but in a marked increase in available P and K. Plant N levels, however, reflected the improved N nutrition but did not reach sufficiency levels found elsewhere. An available P status of 15 ppm in the control plots kept leaf P at sufficiency levels. P fertilizers did not increase the P content of leaves. K fertilizers raised the K leaf content to sufficiency levels. Doubling the M_1 fertilizer rates of 500 g N, 220 g P and 830 g K per palm per year had no effect on N, P and K levels in the palm leaves.

Changes in K levels of the leaves had antagonistic effects on leaf Mg ($r = -0.68^{**}$) and leaf Na ($r = -0.87^{**}$). As this effect brings leaf Mg close to deficiency values palms receiving K might need additional Mg as well.

The findings and interpretation of soil and leaf analysis data were confirmed by large yield responses to application of NPK fertilizers. Genetic differences between palms in their response to levels of nutrient supplies were apparent. The CDO × WCT hybrid outyielded the high yielding WCT variety especially when NPK was given at the M_1 level. The response in yield to applied fertilizers was linear for WCT and curvilinear for the hybrids CDO × WCT and WCT × CDO.

Introduction

The study was made to investigate the effect of a long term fertilizer application on leaf nutrient concentrations and yield of three coconut genotypes. It is known that different coconut varieties give different yield responses to fertilizer application [7, 12] and that heterotic vigour observed in other crops is often associated with higher fertilizer requirements for realising increased yields.

In this study foliar nutrient concentrations of coconut are related to critical levels for realising optimum yields as indicated by Manicot and others [9, 10]: 1.8–2.0% for N, 0.12% for P and 0.8–1.0% for K.

Materials and methods

The field experiment was started in 1965 at the Central Plantation Crops Research Institute. Three coconut genotypes with different yield potential were used: the high yielding West Coast Tall (WCT), the cross Chawghat

Dwarf Orange (CDO) × WCT and its reciprocal WCT × CDO. Palms were planted in 1965 at a distance of 7.5 m in a square system.

There were three fertilizer treatments. M_0: no fertilizer, M_1: 500 g N, 220 g P and 830 g K, and M_2: 1000 g N, 440 g P and 1660 g K. These figures are rates per palm per year. N was given as urea, P as single superphosphate and K as muriate of potash. Following standard practice applications were split: 1/3 in April-May and 2/3 in August-September. Fertilizers were applied broadcast in circular basins of 1.8 m around the palm.

The experiment had a randomized block design with three replications and six palms per plot.

The experimental site is located at about sea level. It has red sandy loam soils and receives an annual rainfall of 3500 mm.

Soil and leaf samples were collected simulatneously from each treatment in May 1983 prior to fertilizer application. Samples from replications were combined in composite samples. Soil samples were taken at 1.0 and 1.5 m from the bole from soil layers 0–25, 25–50 and 50–100 cm. The fine earth fraction (< 2 mm) was analysed for pH, mineralisable nitrogen (alkaline permanganate) [11], available P (Bray-1), K (1N NH_4 OAc) [6]. Available micronutrients in the DTPA extract [8] were analysed using a Varian AA-6 atomic absorption spectrophotometer (AAS). Leaf samples were collected from 14th leaf (diagnostic leaf) [3] washed with detergent solution, rinsed with distilled water, oven-dried at 65 °C for 72 hours and powdered in a Wiley mill with steel blades. This 0.5 mm fraction was analysed for P (vanadomolybdate), K (flame photometrically) [6] and Ca, Mg, Zn, Cu, Fe and Mn by AAS in 1:2 $HClO_4$: HNO_3 acid extract [1]. N was estimated by micro-Kjeldahl method [6].

Results and discussion

Effects on soil and leaf nutrient content

The mineralisable nitrogen content of M_0 plots varied from 72 to 79 ppm (Table 1) compared to 76 to 88 and 79 to 95 ppm, respectively, in M_1 and M_2 plots, indicating a slight increase in mineralisable nitrogen contents of fertilized plots. The effects of fertilizer applications on the N content of the leaves are more pronounced: 1.4% N on M_0 plots, 1.6–1.7% N on M_1 and 1.6–1.7% N on M_2 plots (Table 2). This suggests that the leaf analysis gives a better reflection of the effects of N fertilizers than soil analysis. Doubling the M_1 rate (e.g. using the M_2 level) has apparently no effect on the N content of the leaves and was also ineffective in raising it above the critical level.

The available phosphate content of the soil was found to by significantly influenced by fertilizer application. A mean available P of around 15 ppm was found to be sufficient in maintaining adequate plant P levels. Genotype and fertilizer genotype interactions were not significant for plant P levels. Even after continued fertilizer application over 18 years plant P levels could not be

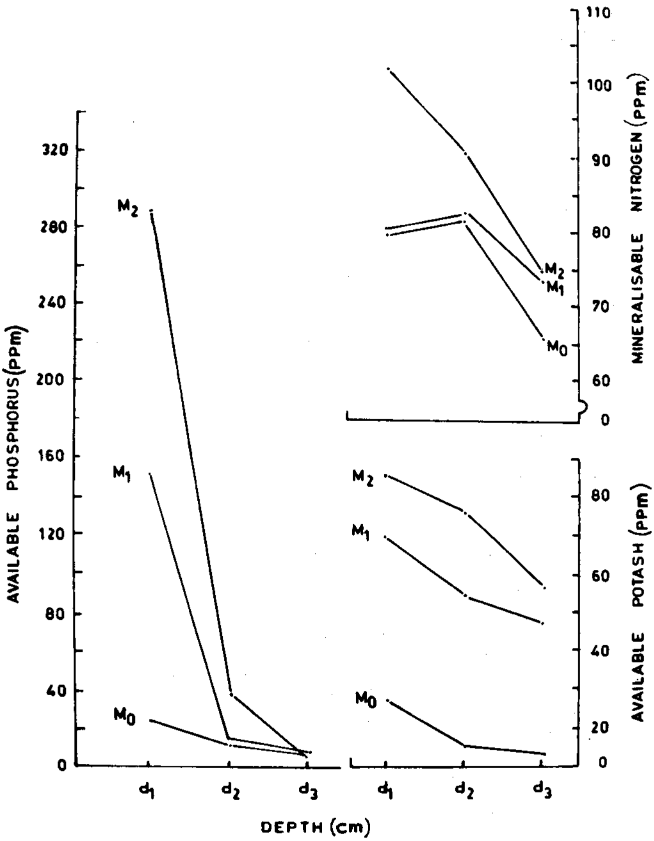

Figure 1. Effect of NPK fertilizers on levels of soil nutrients at different depths (d_1 = 0–25 cm; d_2 = 25–50 cm; d_3 = 50–100 cm).

raised to the levels of critical levels proposed by IRHO [9, 10]. Hameed Khan et al. (1984) recorded similar low P contents in well fertilized adult coconut palms.

Available potassium levels were very low (19 ppm) in M_0 plots and found to increase to 55 and 70 ppm with M_1 and M_2 levels of fertilizer application. Application of KCl increased the available K contents of the profile (Fig. 1). As in the M_0 plots a gradual reduction with increase in depth was also observed in the M_1 and M_2 plots.

The leaf K content reflects the poor K content of M_0 plots. K fertilizers raised the K content of the leaves to or just beyond the critical level (0.8–1.0%). Doubling the M_1 rate has little effect indicating that rates beyond 830 gK per tree are probably not needed.

Changes in the K content of the palms are known to effect the levels of Ca, Mg and Na in order to maintain the cation balance. While the levels of Ca

Table 1. Soil nutrient status under different levels of fertilizer application (Samples from 0–100 cm layer, taken May 1983).

Genotype	Fertilizer level	pH (H_2O)	Mineralisable N (ppm)	Available P (ppm)	Available K (ppm)	Available micronutrients (ppm) Zn	Cu	Fe	Mn
	M_0	5.1	74	17	19	0.17	0.31	10	28
WCT	M_1	4.6	76	52	55	0.29	0.39	15	34
	M_2	4.7	79	89	61	0.33	0.48	17	40
	M_0	5.2	72	20	19	0.21	0.30	10	37
CDO	M_1	4.9	76	81	56	0.21	0.34	12	46
x WCT	M_2	4.6	85	106	70	0.30	0.38	17	47
	M_0	5.2	79	9	18	0.27	0.44	11	27
WCT	M_1	4.7	89	58	55	0.34	0.55	15	44
x CDO	M_2	4.7	95	85	81	0.45	0.65	18	47
LSD at 5%									
Fertilizers		0.08	6.1	19.3	9.9	0.06	0.10	1.6	3.9
Genotypes			6.1			0.06	0.10		3.9

(M_0 = control; M_1 = 500 gN, 220 g P, 830 gK; M_2 = 1000 gN, 440 g P, 1660 gK/palm/year)

were not significantly affected (r = – 0.25) by increasing K contents of the plants, Mg (r = – 0.68**) and more prominantly Na (r = – 0.87**) were lowered indicating antagonistic relationships between them [13, 14]. The K–Mg antagonism lowered Mg contents to deficiency levels. Because of this effect it may be needed to include Mg fertilizers in the fertilizer programme for coconut hybrids and high yielding WCT cultivar. Brunin and Coomans reported both similar findings [2, 4].

NPK manuring increased available Zn, Cu, Fe and Mn in the soil (Table 1). However, plant Zn contents decreased with increasing levels of fettilizer application while the Cu and Mn content increased and Fe showed an irregular trend. The increase in Mn contents of the palm on fertilized plots may be due to the increase in exchangeable Mn contents resulting from the pH lowering effect of fertilizer application (r = – 0.40* to – 0.54**).

Effect on yields

The mean treatment yields over the period 1981–1983 clearly show large responses to fertilizers of all the three genotypes (Table 3). The M_1 treatment doubled yields of the WCT and CDO x WCT palms and raised the nut yield of WCT x CDO types three times. Doubling the M_1 rates had only effect with WCT palms. The cumulative yield data up to 1983 show even larger responses to the M_1 treatment reflecting positive effects of fertilizers on early bearing of palms.

As to genetic differences between palms. it is clear that the CDO x WCT hybrids greatly out-yielded the WCT variety and its reciprocal cross. The superiority of the CDO x WCT palms mainfests itself already without fertilizer use but it becomes far more pronounced with improved nutrient supply from the M_1 treatment.

Table 2. Effect of different levels of fertilizer application on plant (14th leaf) nutrient status of three coconut genotypes.

Genotype	Fertilizer level	%						ppm			
		N	P	K	Ca	Mg	Na	Zn	Cu	Fe	Mn
	M_0	1.4	0.11	0.7	0.23	0.23	0.25	20	6	93	593
WCT	M_1	1.7	0.11	1.0	0.33	0.17	0.13	18	6	86	711
	M_2	1.7	0.11	1.1	0.27	0.15	0.13	17	7	90	648
	M_0	1.4	0.11	0.6	0.26	0.22	0.24	19	6	99	599
CDO × WCT	M_1	1.6	0.11	1.0	0.26	0.13	0.11	16	8	108	585
	M_2	1.7	0.11	1.1	0.27	0.11	0.10	15	9	108	620
	M_0	1.4	0.10	0.6	0.25	0.26	0.27	24	10	96	521
WCT × CDO	M_1	1.6	0.11	1.1	0.26	0.16	0.14	18	8	86	615
	M_2	1.6	0.11	1.1	0.30	0.15	0.11	16	8	73	678
LSD at 5%											
Fertilizers		0.09	0.12		0.03	0.03	3.4				

Table 3. Yield of coconut genotypes under different fertilizer levels.

Genotype	Yield of nuts/palm/year (July 1981–June 1983)			Cumulative yield (from 1972 upto 1983)		
Fertilizer levels	M_0	M_1	M_2	M_0	M_1	M_2
WCT	33.7	66.9	84.4	131	435	578
CDO × WCT	45.9	92.2	94.7	293	936	737
WCT × CDO	26.4	79.2	80.4	87	473	503

Conclusions

Both soil and leaf analysis indicate that coconuts on the sandy loam soils of the Central Plantation Crops Research Institute require fertilizers (especially those containing N and K) for satisfactory growth and yield. This evaluation of nutrient data is confirmed by large responses of experimental palms to NPK treatments. The leaf data suggest that under Kerala conditions the critical values for realising high yields for N and P are somewhat lower than those reported by Manciot and others [9, 10]. While the variety WCT continues to respond to fertilizers beyond the M_1 rates, this is not the case with the hybrid palms. The data suggest that once the K levels in the soils and in the palms have been raised to sufficiency levels, K rates lower than M_1 can be used. The same applies to application of phosphate fertilizers especially on soils containing more than 15 ppm available P.

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