

Potassium in Coconut Growing Soils

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ABSTRACT

Coconut is generally cultivated in acid laterite, lateritic and red soils where the K content is low. The critical level of soil potassium is between 0.15 to 0.20 me 100g⁻¹, equivalent to 59-78 ppm of potassium. Based on the assumption that about 80 ppm K is needed to maintain the optimum K content in the diagnostic leaf (0.8-1.0%) a desorption equilibrium model has been developed for laterite and sandy loam soils from which site specific recommendations can be successfully made. The absorption of K by coconut not merely depends on the absolute K concentrations in situ but it depends on relative concentrations of Na⁺, Mg⁺⁺, Ca⁺⁺ and NH₄⁺ in the soil. This is primarily because of the antagonism offered by these ions in the uptake of K by coconut. The selective distribution of applied K in the soil indicated that the major portion of K would be held in the boiling HNO₃ fraction followed by 1N NH₄OAc extractable form. The desorption studies showed that about 80% of the applied K could be desorbed within 2-3 extractions and further desorption is very steady upto 10 subsequent extractions.

2.0 INTRODUCTION

Coconut is grown under highly heterogenous conditions of soil, ranging from littoral sand to clay in situations from poorly drained low lying marshes to well drained uplands and hills slopes and in strongly acid to highly calcareous soils (Sankaranarayanan and Velayuthan, 1976 and Hameed Khan *et al.*, 1978). The present area under coconut in the country is 7.43 m. ha of which 60.51% is in Kerala, 14.8% in Karnataka, 12.8% in Tamil Nadu and 3.42% in Andhra Pradesh. The rest of the area is distributed in Orissa, Goa, Diu, Daman, Andaman & Nicobar Islands; West Bengal, Maharashtra, Assam, Tripura, Lakshadweep and Pondicherry.

Potassium is a very important nutrient in coconut nutrition as it regulate

water economy and helps in root development, and it is necessary for the formation of sugar, fat and fibrous materials. Potassium is also known to favour early bearing in coconut. K-deficiency leads to chlorosis, leaf scorch and the development of poor crown with short fronds (Salgado, 1953 and Manciot *et al.*, 1979). Nevertheless potash requirement of coconut is very high as indicated by the amount of nutrients removed annually by the palm (Table 1).

3.0 REMOVAL OF POTASSIUM

Partitioning of some of the observations reported above indicates that large consumption of potash by coconut is diverted to the production of the economic produce, viz., the nuts, thus establishing potash as the most important ingredient in coconut nutrition (Table 2)

Table 1. Annual nutrient removal by coconut palm

Location	Basis	Nutrient removal						Reference
		kg			ratio			
		N	P	K	N	P	K	
India	2000 nuts ac ⁻¹ yr ⁻¹	8.2	1.0	14.3	1	0.12	1.74	Pillai (1919)
India	recommended annual addition acre ⁻¹	10.9	2.4	17.6	1	0.22	1.61	Patel (1938)
India	70 palms ac ⁻¹ yielding 40 nuts palm ⁻¹	22.5	5.2	28.4	1	0.23	1.26	Pillai and Davis (1963)
India	175 palms ha ⁻¹	97.3	21.0	121.1	1	0.22	1.24	Ramadasan and Lal (1960)
Sri Lanka	70 palms ha ⁻¹	10.2	2.4	12.9	1	0.23	1.26	Nethsinghe (1960)
Ivory Coast (IR HO)	Hybrid palms (PB 121) 6-7 tons copra ha ⁻¹	174	20	249	1	0.12	1.43	Ouvrier and Ochs (1978)

Table 2. Percentage removal of nutrients for the yield of nuts and for the growth and development of stem and leaves by west coast tall (India) and the hybrid PB 121 (Ivory coast)

Cultivar		Nutrients %							
		N	P	K	Ca	Mg	Na	Cl	S
West Coast tall (India)	Stem+	49	50	22	77	59	NA	NA	NA
	Leaves								
Hybrid PB 121	Nuts	51	50	78	23	41	NA	NA	NA
	Stem+								
	Leaves	38	25	22	87	62	63	50	70
	Nuts	62	75	78	13	32	37	50	30

(Source: Pillai and Davis, 1963 and Ouvrier and Ochs, 1978)

4.0 POTASSIUM STATUS OF SOILS

Potash demands of coconut are high and it is an elusive nutrient element in soil, the availability of which is conditioned by the clay mineral make up and the dynamic equilibrium that is restored in the soil nutrient pool. Coconut plantations in India suffer from potash deficiency as major coconut area is under the exhausted lateritic soils and red soils with poor native potassium status. Hameed Khan *et al.* (1978) reported that potassium status of coconut growing soils in India is generally poor (Table 3) except in the locations studied in Andhra Pradesh, West Bengal and Tamil Nadu.

Based on the ratings of Muhr *et al.* (1963), Pillai (1975) has reported that all the soils groups of Kerala under coconut are generally deficient in available K and no soil group following under high ratings. His mean values for coastal sandy soil in the 0-50 cm and 50-100 cm layers were 12.2 and 10.9 ppm and corresponding values for sandy loam soils were 28.4 and 28 ppm, respectively. Robert Cecil (1981) reported similar values for the sandy loam soil of Kayamkulam. Surveying the soils of Badagara taluk, a premier coconut growing tract, Ramanandan (1977) reported that the soils were poor in K. Krishnakumar and Koshy (1985) held similar opinion for 'Poonthalpadam' area in Kerala

Table 3. Potash status and related parameters in selected coconut growing soils in India (values - mean profile depth).

Location	Clay %	CEC m.e 100 g ⁻¹	K satu- ration %	Avail. K ppm	Profile depth (cm)
I. Kerala					
(i) Nemanda (L)	63.06	9.06	10.57	47.60	0-91
(ii) Vellayani (RSL)	18.08	4.50	17.11	51.00	0-180
(iii) Onathukara (S)	1.23	2.03	52.58	13.30	0-180
II. Karnataka					
(i) Vittal (L)	39.45	6.45	16.65	40.25	0-180
III. Tamil Nadu					
(i) Muthupet	26.3	14.00	3.90	110.75	0-135
IV. Andhra Pradesh					
(i) Madhavapuram (C)	49.78	34.08	1.22	165.25	0-150
V. Maharashtra					
(i) Dapoli (L)	63.51	11.90	2.00	86.00	0-180
VI. Orissa					
(i) Prayagi	Sand	3.07	2.38	36.50	0-180
VII. West Bengal					
Mathurapur	30.40	13.90	3.04	156.50	0-180
VIII. Assam					
Korara	16.15	10.48	1.41	45.25	0-150
IX. Andaman Island					
Carbyn's cove	7.00	2.70	27.85	89.50	0-20
X. Lakshadweep Island					
Minicoy	2.18	4.68	-	22.17	0-103

where the exch. K varied from 0.07 to 0.24 m.e 100g⁻¹. Bastin and Venugopal (1986) indicated that the alfisols which are intensively cultivated for coconut are generally low to medium in potash status (Table 4).

5.0 POTASSIUM DESORPTION

Critical studies on soil potassium in relation to coconut nutrition are lacking except some manurial experiments with potassium as one of the factorial component. Hameed Khan *et al.* (1982) found that K adsorption was comparatively more and uniform in laterite soils than in red sandy loam, river alluvium and coastal sands cultivated to coconut. The magnitude of the constants K and 1/n and the difference in the values of Freundlich adsorption isotherm was attributed to the contents and nature of clay minerals in these soils. The influence clay minerals in K supply to the nutrient pool was also indicated by Kansal and Sekhon (1976) and Ramanathan and Krishnamoorthy (1976).

Hameed Khan *et al.* (1982) further observed that desorption of applied K showed a constant release after third and fourth extraction, irrespective of soil groups (Figure. 1). Even after the 8th extraction, a constant release of 1.5 to 2.5 ppm K was observed. However, on an average 90% of total extractable K was removed in two extractions. The soils under the present study were dominated by kaolinite clay minerals which has no interlattice binding sites for K, and hence cannot hold any non-exchangeable K (Patil *et al.*, 1976). As K is likely to get depleted more easily from the feeding zone and the K pool also cannot restore much K needed by the coconut palm which has a heavy demand for potassium, there is a need for evolving a more suitable way of K management. Report of John and Jacob (1959) on extensive

Table 4. Available K status in different red soil (alfisols) series of Kerala

Soil series/ Location	Available potassium status (PPM)		
	Mean	Range	Rating
Vellayani (Trivandrum)	23.7	12.1-36.6	Low
Cheriyoor (Quilon)	34.2	12.3-68.1	Low, Medium
Bhavanikkavu (Quilon)	44.4	20.2-75.1	Low, Medium
Beypore (Calicut)	36.8	6.0-112.7	Low, Medium
Chirakkal (Cannore)	40.8	12.1-113.6	Low, Medium
Kunhimangalam (Kasaragod)	19.6	4.5-34.3	Low

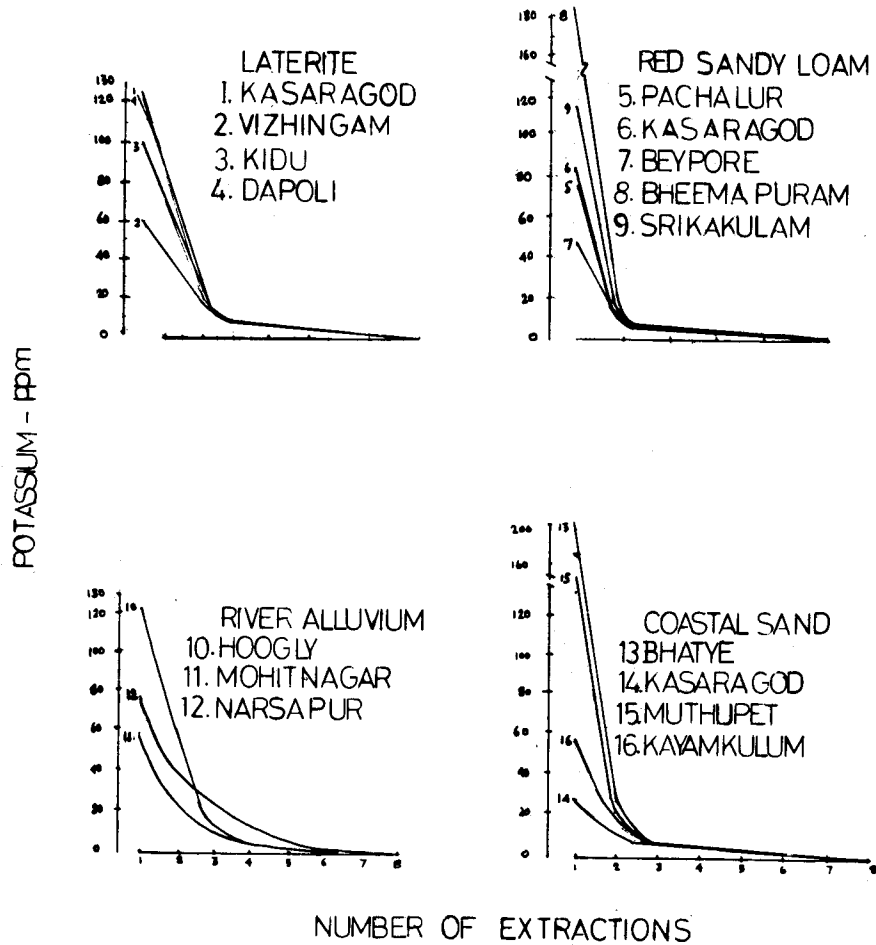


Fig. 1. Potassium desorption patterns

fertilizer demonstration studies involving 24,000 coconut trees in the west coast of India adds support to the above contention. They indicated that application of additional dose of potash and higher doses of NPK resulted in increased yields where standard dose failed to show adequate response in farmer's field.

The selective distribution of potassium in representative soils (Hameed Khan *et al.*, 1982) revealed that the major part of applied K was extracted with boiling HNO_3 followed by 1 N NH_4OAc and more or less uniform extraction of K in 0.01 M CaCl_2 (Table 5). Variation in water soluble K among soil groups was attributed to initial available K in soils, prior to saturation with K for the study. There was evidence to show that applied K was converted into difficult exchangeable forms and the equilibrium between exchangeable and labile-K is maintained relatively faster in these soils.

Table 5. Selective distribution of K (ppm) in soils

Location	Water soluble	0.01 M CaCl ₂	0.1 N NH ₄ OKc	Boiling HNO ₃
<i>Laterite</i>				
Kasaragod (K)	23	61	68	50
Vizhengam (K)	26	39	26	285
Kidu (KA)	26	58	51	135
Dapoli (M)	11	34	76	112
<i>Red Sandy loam</i>				
Pachalur (K)	75	48	26	25
Kasaragod (K)	37	43	32	70
Bey pore (K)	31	41	26	46
Bheemapuram (AP)	64	79	76	250
Srikakulam (AP)	67	56	43	120
<i>River alluvium</i>				
Hooghley (WB)	30	33	118	238
Mohitnagar (A)	14	20	43	95
Narsapur (AP)	55	55	155	127
<i>Coastal Sand</i>				
Bhatye (M)	18	56	125	100
Kasaragod (K)	61	22	7	20
Muthupet (TN)	31	61	59	120
Kayamkulam (K)	62	39	19	25

K – Kerala; KA – Karnataka; AP – Andhra Pradesh; TM – Tamil Nadu; M – Maharashtra; WB – West Bengal; A – Assam

6.0 LONG TERM FERTILIZER STUDIES ON SOIL K STATUS

Effect of long term fertilizer application on soil and plant nutrient status of three coconut cultivars (West coast tall (WCT); Chawghat Dwarf orange x WCT and its reciprocal cross has been reported by Hameed Khan *et al.* (1986). After 18 years of coconut growth, the control (M_0) plot analyzed 19 ppm available K where as it was 55 and 70 ppm in M_1 and M_2 treatments, respectively (Table 6). K levels in the control and treated plots decreased with depth.

The leaf K contents reflected poor soil K content of the control plot (M_0). K fertilizers raised the K contents of the leaves to the critical levels (0.8-1.0%) and above. Doubling the M_1 rate had little effect indicating that rates beyond 830 g K (1000 g K_2O) per tree per year are probably not needed. Thus a soil available K (1 N NH_4OAc) content of 50-60 ppm (0.128 to 0.153 me 100g⁻¹) is adequate for maintaining sufficiency levels in coconut. Manicot *et al.* (1979) reported that 0.15 to 0.20 me 100g⁻¹ (59-78 ppm) and Loganathan and Balakrishnamoorthy (1980) suggested that 0.13 me 100⁻¹ (51 ppm) of exchangeable K is sufficient for satisfactory growth of coconut palm.

In a longterm fertilizer study (22 years), Anil Kumar and Wahid (1989) found that application of muriate of potash increased available K (Table 7)

Table 6. Soil nutrient status under different levels of K fertilizer application to red sandy loam soils (Arenic Paleustulf) 0-100 cm layer

Cultivar	Fertilizer level	pH	Mineralisable N(ppm)	Available nutrients	
				P(ppm)	K(ppm)
WCT	M ₀	5.1	74	17	19
	M ₁	4.6	76	52	55
	M ₂	4.7	79	89	61
CDOxWCT	M ₀	5.2	72	20	19
	M ₁	4.9	76	81	56
	M ₂	4.6	85	106	70
WCTxCDO	M ₀	5.2	79	9	18
	M ₁	4.7	89	58	55
	M ₂	4.7	95	85	81
LSD 5%	Fertilizers	0.08	6.1	19.3	9.9

(M₀ – Control; M₁ – 500-220-830; M₂ – 1000-440-1660 gram NPK, respectively)

Table 7. Effect of N x K fertilizer interaction on soil exchangeable K (ppm)

	K ₀	K ₁	K ₂	Mean
N ₀	41.3	125.8	115.1	94.1
N ₁	54.9	75.3	69.2	66.5
N ₂	38.7	69.2	88.3	65.4
Mean	45.0	90.1	70.9	–
CD (0.05) comparison of N x K = 10.9				

and organic carbon status of soil. The effect of soil K was N-dependent as revealed from the significant N x K interaction. Higher rates of (NH₄)₂SO₄ lead to reduction in exchangeable K. They observed accumulation of K in lower depths in contrast to the observations recorded by Hameed Khan *et al.*, (1986) in red sandy loam (ultisol).

Performance of palms in terms of yield was on par with palms receiving full dose of K₂O and 50% K₂O substituted by Na₂O (Prema *et al.*, 1987) as observed from Table 8. As nutrition and yield were not affected, a recommendation to that effect was made for laterite soils. Substitution of K by Na in coconut nutrition has been reported by Smith (1969) when foliar concentration of K was less than 0.5% and that of Na less than 0.4%.

However in the study reported by Prema *et al.* (1987) the influence of chlorine in coconut nutrition has not been partitioned and discussed due to deficiency in the basic design of the experiment. Importance of chlorine in coconut nutrition has been studied elaborately by Ollagnier and Ochs (1971). However, Barrent (1975) concluded that coconut palm should be placed in the category of plants which respond to Na when available K status of the soil was in the medium to high status.

A direct reflect of available K status of the treatments was apparent in

Table 8. Soil nutrient status under different treatments

Treatment (g palm ⁻¹ yr ⁻¹)		Org. C (%)	Available nutrients (kg ha ⁻¹)			pH	CEC me 100g ⁻¹
K ₂ O	Na ₂ O		N	P	K		
0	0	1.11	116.6	57.06	168	5.14	11.6
1000	0	0.98	108.4	60.80	623	5.29	12.9
750	250	1.08	106.1	53.50	497	5.25	12.3
500	500	1.02	118.4	58.95	469	5.39	12.7
250	750	1.08	120.8	53.48	294	5.39	10.7
0	1000	1.15	130.7	63.86	189	5.40	12.8
CD (0.05)		NS	NS	NS	125	NS	NS

Table 9. Leaf nutrient status

Treatment (g palm ⁻¹ yr ⁻¹)		Nutrient content - Leaf %					
K ₂ O	Na ₂ O	N	P	K	Na	Mg	Cl
0	0	1.67	0.11	0.62	0.32	8.20	0.75
1000	0	1.88	0.12	1.12	0.25	0.17	0.80
750	250	1.86	0.12	0.94	0.30	0.14	0.77
500	500	1.68	0.12	0.87	0.34	0.27	0.82
250	750	2.01	0.12	0.84	0.36	0.14	0.76
0	1000	2.11	0.12	0.60	0.35	0.23	0.78
CD (0.05)		NS	NS	0.068	NS	NS	NS

the leaf analysis data (Table 8 and 9). A progressive increase in soil available K showed proportionate absorption of K by the palm.

The increased uptake of K depresses Mg uptake (Hameed Khan *et al.*, 1986) which is also evident from data presented in Table 9. This suggests the need to monitor the Mg levels wherever fertilizer application to neglected gardens is resorted to.

A desorption equilibrium model was prepared for potassium for laterite and red sandy loam soils for computation of the amount of K₂O palm⁻¹ needed to raise the available potassium content of soil to a desired level. Though Hameed Khan *et al.* (1986) have indicated 50-60 ppm of available K as a desired level (based on its reflect on plant K and yield) in the present study, 80 ppm available K (1 N NH₄OAC) was assumed as the base value in the coconut basin to maintain a plant content of 0.8-1.0%. (Annual report, 1985). To regulate satisfactory release of K for coconut, a ready reckoner table was prepared to guide the level of K₂O to be applied per palm (Table 10). It was observed that the potential buffering capacity (PBC^K) of laterite and red sandy loam soil with reference to potassium was different and hence the amount of K to be applied is less for laterite soil compared to red sandy loam to sustain available K content at 80 ppm.

Table 10. Dosage of K required for laterite soil to raise the soil test value of K to any predetermined level (g K₂O palm⁻¹ year⁻¹)

Soil test value	80	70	60	50	40	30	20	10
<i>Laterite soil</i>								
0	1514	1238	1062	885	708	531	334	177
10	1238	1062	885	708	531	354	177	0
20	1062	885	708	531	354	177	0	
30	885	708	531	354	177	0		
40	708	531	354	177	0			
50	531	354	177	0				
60	354	177	0					
70	177	0						
80	0							
<i>Red sandy loam soil</i>								
0	2087	1826	1565	1305	1043	782	520	260
10	1826	1565	1305	1043	782	522	220	0
20	1565	1305	1043	782	522	260	0	
30	1305	1043	782	522	260	0		
40	1043	782	522	260	0			
50	782	522	260	0				
60	522	260	0					
70	260	0						
80	0							

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