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Potassium Release Characteristic of Some Soils of Arecanut Gardens

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Abstract

Potassium release characteristics by repeated extractions with boiling 1N HNO_3 were studied in the sixteen surface and sub surface soils of three different zones (hilly, coastal and central dry zones) of Karnataka. Potassium release parameters varied widely in different zones indicating a wide variation in K-supplying capacity of these soils. Cumulative Potassium Release (CPR), Total Step Potassium (TSK) and Constant Rate Potassium (CRK) had positive and significant relationship with each other. Both the potassium release parameters and forms of potassium were positively and significantly correlated with each other. Significant positive correlation of CPR and TSK with non exchangeable potassium having 'r' values (r= 0.992** and 0.991**, respectively) may serve as a good index of the K-supplying capacity of these soils.

The dynamic equilibrium among different forms of soil potassium *viz*, water soluble, exchangeable, non-exchangeable and lattice K indicates that a change in the magnitude of any form is replenished by the release of K from other forms. Under intensive cropping, readily available exchangeable K is removed by crop and more K would become exchangeable from non-exchangeable forms. Since areca is a perennial crop, it requires sustainable supply of K throughout the crop growth. Therefore an understanding of the K release behaviour of soils and establishing the relationships among various K release parameters would help to draw appropriate K management strategy under such perennial crops. So, an attempt was made to determine the K releasing behaviour in some arecanut growing soils of three different zones of Karnataka.

Material and Methods

Sixteen surface and subsurface soil samples from three different zones (hilly, coastal, and central dry zones) of Karnataka were collected. Water soluble potassium was determined by the method proposed by Dhawan *et al.* (1968), exchangeable K was determined by 1N NH_4OAc (Jackson, 1967). Non-exchangeable K was determined from the difference between 1N HNO_3 extractable K and NH_4OAc extractable K (Wood and DeTurk, 1940). Total K was determined by digesting the soil sample with nitric acid and perchloric acid (Lim and Jackson, 1982). Lattice K was determined from the difference between total K and 1N HNO_3 extractable K (Wiklander, 1954). The potassium release parameters were estimated by the repeated extraction with boiling 1N HNO_3 as suggested by Haylock (1956).

Results and Discussion

Physico-chemical soil characteristics : The pH values were acidic in the soils from hilly zone and coastal zone and neutral to alkaline in the soils from the central dry zone. The mean values of pH in the surface and subsurface soils were 5.52 and 5.73 for the hilly zone, 5.23 and 5.50 for the coastal zone soils and 7.94 and 7.91 for the coastal zone soils, respectively.

The average CEC values were comparatively higher in the soils from central dry zone with mean values of 25.08 and 27.24 in the surface and subsurface soils, respectively. The average CEC values in the surface and subsurface were 18.92 and 18.03 and 16.92 and 16.75 in the soils from hilly zone coastal zone, respectively.

The clay content of the surface soils from hilly zone and coastal zone had mean values of 21.87 and

25.72 per cent, respectively whereas the values were 22.63 and 27.20 per cent for the subsurface soils. Little higher mean values of clay content were observed in the soils from central dry zone (31.31 and 32.81%) in the surface and subsurface, respectively.

Forms of K : Different forms of potassium in soils from different zones were higher in the surface layer than in the subsurface soils. The soils from central dry zone recorded higher amount of different forms of K compared to soils from hilly zone and coastal zone. The values of total K, lattice K, non-exchangeable K, exchangeable K and water soluble K ranged from, 2350 to 11250 mg kg^{-1}, 1849 to 9186 mg kg^{-1}, 158 to 1729 mg kg^{-1}, 41 to 296 mg kg^{-1} and 6 to 29 mg kg^{-1} in the surface soils and from 2200 to 11100 mg kg^{-1}, 1796 to 9129 mg kg^{-1}, 138 to 1695 mg kg^{-1}, 36 to 247 mg kg^{-1} and 9 to 39 mg kg^{-1} in the sub surface soils, respectively.

Potassium release characteristics : The requirement of potassium for perennial crops like arecanut from labile pool alone may not give correct picture. For such crops a long term sustainable supply of potassium from the reserve pool *viz.*, non^{-1} exchangeable forms have to be assessed as suggested by Subba Rao (1984). Therefore, potassium release characteristics of soils, which simulates the K depletion pattern in arecanut garden, has been discussed here.

Cumulative Potassium Release (CPR) : The cumulative potassium release values (Table I) in surface soils varied from 326 to 3248 mg kg^{-1}. The corresponding values for subsurface soils varied from 304 to 3065 mg kg^{-1} (Table II). Much of the total cumulative K was released by the end of the third extraction and subsequent release of potassium was gradual. Highest value of CPR in central dry zone may be due to presence of more weatherable K bearing minerals like illite and associated minerals like smectite and mica in clay. The soils under study also recorded relatively higher amounts of non exchangeable potassium and clay. Relatively lower amounts of CPR were noticed in soils of hilly and coastal zone. Boruah *et al.* (1990) reported that lower cumulative potassium release from coarse textured soils of hilly regions than fine textured soils of plains.

Total Step Potassium (TSK) : Step K provides an estimate of availability of K from the non^{-1} exchangeable and mineral lattice sources (Haylock, 1956). The total amount of step K in the soils of different zones of southern Karnataka ranged from 310 to 2960 mg kg^{-1} in surface and from 288 to 2823 mg kg^{-1} in subsurface soils. The values obtained are slightly higher than those reported by Pal *et al.* (2000). Total step K was found to be less in subsurface than in surface soils suggesting that the stepwise removal of labile K was more than surface soil. According to Haylock (1956), all the soils recorded are high in total step K (more than 19 mg 100 g^{-1}) and hence may not respond to applied potassium. The higher value of step K was found in soils of central dry zone which could be attributed to the presence of abundant potash bearing mineral illite and associated minerals like micas in clay fraction, contrast to soils of hilly and coastal zone.

Constant Rate Potassium (CRK) : The constant rate potassium (CRK) is a measure of K is difficulty available to crops from the mineral lattice sources (Haylock, 1956). The results indicate that CRK was obtained between 7 and 12 extractions in soils of hilly, coastal and central dry zone respectively. CRK is not much varied between surface and subsurface soils. The highest CRK value was noticed in Vasanthanagar soil of central dry zone, which may be due to the dominance of potassium rich minerals, and also due to high clay content. This suggests that the soil may supply higher amount of K from lattice source for a longer period. The lowest CRK observed in case of Belur of hilly zone indicating very low in sustainable supply of potassium to arecanut since CRK was less than 0.2 cmol (p^+) kg^{-1} in subsurface soils than in surface, which could be attributed to relatively higher organic carbon, intense weathering and faster potassium removal from top soil. Brijlal *et al.* (1998) also reported similar observations in surface and subsurface soils.

Correlation studies : All the forms of potassium were positively and significantly correlated with each other (Table III), suggesting the existence of dynamic

TABLE I

Release characteristics of potassium (mg K kg^{-1}) in sorface soils

Location Hilly Zone	Successive extraction (number) with 1 N HNO_3															Total step K
	1	2	3	4	5	6	7	8	9	10	11	12	13	CPR	CRK	
Hilly Zone - (IX)																
Belve	310	200	110	72	48	32	24	16	4	4	4	-	-	816	4	780
Bharathipura	332	200	122	82	68	36	36	12	6	6	6	-	-	894	6	810
Jambavalli	300	220	142	76	54	28	18	8	8	8	-	-	-	846	8	782
Nagalapura	297	182	66	38	22	16	16	6	6	6	-	-	-	643	6	595
Hosakoppa	321	150	78	78	52	40	28	16	10	10	10	-	-	773	10	683
Doddavanne	365	280	100	84	68	42	26	18	6	6	6	-	-	989	6	935
Shidle	370	284	124	70	48	32	24	24	12	12	12	-	-	988	12	880
Addagadde	330	210	146	92	46	38	16	8	8	8	-	-	-	886	8	822
Malwe	140	79	58	36	22	16	6	6	6	6	-	-	-	357	6	315
Belur	120	82	38	32	24	18	10	2	2	2	-	-	-	326	2	310
Handigodu	205	124	88	52	38	20	8	4	4	4	-	-	-	611	4	579
Coastal Zone -- (X)																
Seethanadi	213	108	60	40	22	18	6	6	6	-	-	-	-	469	6	437
Halady	232	190	86	72	40	28	20	18	8	8	8	-	-	694	8	622
Central Dry Zone- (IV)																
Bheemasamudra	662	520	400	240	184	112	112	88	56	34	20	20	20	2428	20	2208
Vasanthnagar	804	720	580	360	272	172	114	84	52	38	28	24	24	3248	24	2960
B. Durga	660	520	380	164	140	118	82	76	44	28	18	18	18	2232	18	2063

TABLE II

Release characteristics of potassium (mg K kg^{-1}) in sub surface soils

Location	Successive extraction (number) with 1 N HNO_3															Total step K
	1	2	3	4	5	6	7	8	9	10	11	12	13	CPR	CRK	
Hilly Zone – (IX)																
Belve	196	160	98	76	58	22	14	4	4	4	-	-	-	628	4	596
Bharathipura	310	122	82	68	36	22	16	6	6	6	-	-	-	662	6	614
Jambavalli	280	178	112	86	52	34	18	6	6	6	-	-	-	766	6	718
Nagalapura	197	102	66	38	22	16	4	4	4	-	-	-	-	445	4	417
Hosakoppa	240	138	100	78	50	32	20	4	4	4	-	-	-	662	4	630
Doddavanne	335	200	120	90	70	68	42	24	4	4	-	-	-	953	4	909
Shidle	295	182	98	74	58	40	22	18	8	8	-	-	-	795	8	723
Addagadde	285	200	136	88	64	38	20	8	8	8	-	-	-	839	8	775
Malwe	124	84	58	32	18	8	4	4	4	-	-	-	-	328	4	300
Belur	98	70	46	38	24	16	10	2	2	2	-	-	-	304	2	288
Handigodu	328	240	138	80	64	46	32	20	8	8	-	-	-	956	8	884
Coastal Zone – (X)																
Seethanadi	280	200	108	62	40	22	18	6	6	6	-	-	-	736	6	688
Halady	192	110	88	56	32	24	16	4	4	4	-	-	-	522	4	490
Central Dry Zone-(IV)																
Bheemasamudra	631	440	360	220	122	84	68	46	38	24	18	18	18	2051	18	1853
Vasanthnagar	773	640	500	380	260	176	124	88	62	40	22	22	22	3065	22	2823
B. Durga	620	408	320	178	104	88	64	40	36	26	16	16	16	1900	16	1730

equilibrium among the different pools of K in soil. This would mean that depletion of K concentration in one pool is replenished from the other pools of soil K. Similar observations were also made by Das *et al.* (1997).

Potassium release characteristics showed positive and significant correlation (Table III) among themselves and with forms of potassium. These results are in conformity with the works of Pal *et al.* (2000) for laterite soils of Cuttack district, Orissa. Boruah *et al.* (1990) also showed similar results. The correlation between potassium release characteristics and soil properties revealed positive and significant correlation with pH, clay, CEC and ECEC (Table IV). Deshmukh and Khera (1992) also reported similar results from their studies.

TABLE III

Correlation co-efficient among different forms and release characteristics of K at surface and subsurface soils

	Subsurface (0 – 20 cm)							
	WS-K	Ex-K	NE-K	Lattice-K	Total-K	CPR	CRK	Step-K
WS-K	1.000							
Ex-K	0.733**	1.000						
NE-K	0.778**	0.761**	1.000					
L-K	0.700**	0.576*	0.947**	1.000				
Total-K	0.732**	0.637**	0.968**	0.996**	1.000			
CPR	0.770**	0.750**	0.992**	0.935**	0.959**	1.000		
CRK	0.789**	0.762**	0.950**	0.878**	0.905**	0.948**	1.000	
Step-K	0.771**	0.750**	0.991**	0.933**	0.958**	0.999**	0.941**	1.000

	Subsurface (20 – 40 cm)							
	WS-K	Ex-K	NE-K	Lattice-K	Total-K	CPR	CRK	Step-K
WS-K	1.000							
Ex-K	0.543**	1.000						
NE-K	0.637**	0.832**	1.000					
L-K	0.581**	0.672*	0.939**	1.000				
Total-K	0.614**	0.734**	0.969**	0.994**	1.000			
CPR	0.669**	0.784**	0.977**	0.921**	0.949**	1.000		
CRK	0.109**	0.791**	0.975**	0.928**	0.950**	0.999**	1.000	
Step-K	0.675**	0.780**	0.975**	0.921**	0.949**	0.999*	0.964**	1.000

* Significant at 5% ** Significant at 1%

TABLE IV

Correlation coefficients of release characteristic of K with soil properties

Forms of K	Subsurface (0 – 20 cm)					
	pH	OC	Clay	Exchange acidity	ECEC	CEC
Cumulative Potassium Release (CPR)	0.820**	-0.106	0.772**	-0.306	0.931**	0.801**
Constant Rate Potassium (CRK)	0.827**	0.107	0.762**	-0.229	0.892**	0.764**
Total Step Potassium (TSK)	0.816**	-0.185	0.765**	-0.307	0.928**	0.797**
Subsurface (20 – 40 cm)						
Cumulative Potassium Release (CPR)	0.859**	-0.118	0.693**	-0.451	0.921**	0.695**
Constant Rate Potassium (CRK)	0.840**	0.127	0.763**	-0.481	0.935**	0.715**
Total Step Potassium (TSK)	0.855**	-0.121	0.685**	-0.445	0.815**	0.692**

* Significant at 5% ** Significant at 1%

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