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Status and Distribution of Potassium in Soils under Arecanut Gardens of Bhadra Command Area of Davanagere District, India

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A B S T R A C T

An investigation was carried out at College of Agriculture, Shivamogga during the year 2016-17 in order to know the status of potassium in soils under arecanut gardens of Davanagere district, Karnataka. For the study, 200 surface and sub-surface samples were collected from soils under arecanut garden of four taluks (Channagiri, Honnali, Harihara and Davanagere) of Davanagere district. After processing, samples were analyzed for potassium fractions. Results of the study indicated that, in surface and sub-surface soils of different taluks, the mean water soluble potassium was highest in Channagiri taluk (18.93 mg kg^{-1}) and lowest in Davanagere taluk (10.22 mg kg^{-1}), while the mean exchangeable potassium was highest in Channagiri taluk (127.89 mg kg^{-1}) and lowest in Davanagere taluk (64.39 mg kg^{-1}) and the mean non-exchangeable potassium was highest in Channagiri taluk (289.11 mg kg^{-1}) and lowest in Davanagere taluk (137.93 mg kg^{-1}). Similarly, the mean lattice and total potassium was highest in Channagiri taluk (3103.17 and 3539.10 mg kg^{-1}) and lowest in Davanagere taluk (2077.11 and 2289.65 mg kg^{-1}).

Introduction

The importance of potassium in the Indian agriculture needs no emphasis. It is a key nutrient which is required/removed from the soil in quantities comparable to or more than the nitrogen. The various forms of potassium in soil exist in equilibrium with one another and depletion of one form is replenished by other forms (Chandel *et al.*, 1976). The removal of exchangeable K lead to release of the non-exchangeable fraction but in certain situation, the release rate may be insufficient to meet crop needs. In the nature, the potassium cycle consists of depletion from soil reserve on account of leaching losses beyond root zone, uptake and removal by the crops and addition through release of K from

minerals, fertilizers and organic matter and debris. In plants, potassium helps in maintaining ionic balance in the cell, water relations and helps in root development. It is necessary for the formation of sugar, fat and fibrous materials and also favours early bearing. Knowing the fertilizer usage with regard to potassium, it can safely be said that now at least more than 50% of the soils will definitely require K application in order to give optimum crop yields (Tandon and Narayan, 1990). Therefore, an attempt has been made to study the different forms of potassium in soils under arecanut gardens of Bhadra command area of Davanagere district.

Materials and Methods

Characterization of surface soil (0-15 cm) and sub-surface soil (15-30 cm) was studied by taking fifty representative samples of arecanut gardens in each taluk of Channagiri, Honnali, Harihara, and Davanagere. Major land use pattern of these areas consists of intercropping of arecanut with banana, coconut and black pepper. The topsoil of these areas vary in colour which include brown, light and dark reddish brown, yellowish red, yellowish brown and black. The soils are gentle to moderately slope (3-10 %) in nature with moderately well drained condition having acidic pH ranging from 4.5-6.5.

Soil samples were air-dried under shade and then powdered and sieved through 2 mm sieve and stored in clean polyethylene containers. Processed soil samples were analyzed in the laboratory for various physico-chemical parameters *viz.*, the soil pH was measured in 1:2.5 soil water suspension using pH meter and EC (dS m^{-1}) was measured in the supernatant solution of 1:2.5 soil water extract using conductivity bridge (Sparks, 1996). Organic carbon was estimated by Walkley and Black's wet oxidation method (Sparks, 1996). Exchangeable calcium and magnesium was determined by Versenate titration method (Black, 1965) and CEC by Neutral N ammonium acetate saturation method (Page *et al.*, 1982). Particle size distribution of soil samples were determined by International pipette method (Piper, 2002). Available potassium was extracted with neutral normal ammonium acetate extract and determined by using flame photometer as described by Jackson (1973). The laboratory analysis of soil samples was conducted at Agricultural and Horticultural Research station, Kathalagere, Davanagere, Karnataka during 2016-17.

Results and Discussion

Data on available and different fractions of potassium is presented in Table 1 to 4.

Channagiri

Available potassium content ranged from 83.69 to 266.75 and 67.04 to 196.63 mg kg^{-1} in surface and sub-surface soils, respectively. Its content decreased with increase in soil depth. Water soluble potassium content ranged from 11.19 to 28.43 and 7.00 to 23.03 mg kg^{-1} in surface and sub-surface soils, respectively. The mean water soluble potassium content of Channagiri taluk was 18.93 and 13.95 mg kg^{-1} in surface and sub-surface soils, respectively. Exchangeable potassium content ranged from 72.50 to 254.75 and 59.00 to 189.63 mg kg^{-1} in surface and sub-surface soils, respectively. The mean exchangeable potassium content of Channagiri taluk was 127.89 and 90.88 mg kg^{-1} in surface and sub-surface soils, respectively. The non-exchangeable potassium content varied from 258.00 to 310.00 mg kg^{-1} in surface soils whereas, in sub-surface soils it varied from 238.23 to 281.22 mg kg^{-1}. Lattice form of K varied from 2649.18 to 3963.17 mg kg^{-1} in the surface and 2353.90 to 3342.78 mg kg^{-1} in the sub-surface soils. The total potassium content varied from 3054.01 to 4369.06 and 2753.41 to 3651.11 mg kg^{-1} in

surface and sub-surface soils, respectively. The highest mean value 3539.10 mg kg^{-1} of total potassium was recorded in surface soils than in sub-surface soils (3106.06 mg kg^{-1}) of Channagiri taluk.

Honnali

Available potassium content varied from 58.21 to 188.24 and 50.01 to 125.81 mg kg^{-1} in surface and sub-surface soils, respectively. The water soluble potassium ranged from 9.44 to 21.13 and 8.46 to 18.33 mg kg^{-1} in surface and sub-surface soils, respectively. The mean water soluble potassium content of Honnali taluk was 14.31 mg kg^{-1} and 12.13 mg kg^{-1} in surface and sub-surface soils, respectively. The data indicated that, the exchangeable potassium content ranged from 41.23 to 175.12 and 36.44 to 114.13 mg kg^{-1} in surface and sub-surface soils, respectively. The mean exchangeable potassium content of Honnali taluk was 113.99 and 81.10 mg kg^{-1} in surface and sub-surface soils, respectively. The highest mean value 173.40 mg kg^{-1} of non-exchangeable potassium was recorded in surface soils than in sub-surface soils (158.63 mg kg^{-1}) of Honnali taluk. The lattice potassium values of surface and sub-surface soils of Honnali taluk ranged from 2249.17 to 3587.88 mg kg^{-1} and 2131.00 to 3249.49 mg kg^{-1} respectively. The highest mean value 2938.49 mg kg^{-1} of total potassium was recorded in surface soils than in sub-surface soils (2876.79 mg kg^{-1}) of Honnali taluk.

Harihara

The data clearly noticed that the status of available potassium in Harihara taluk was found in the range 103.02 to 141.98 mg kg^{-1} and 76.70 to 109.09 mg kg^{-1} in surface and sub-surface soils, respectively. The water soluble potassium ranged from 8.23 to 22.20 and 6.11 to 17.32 mg kg^{-1} in surface and sub-surface soils, respectively. The mean water soluble potassium content of Harihara taluk was 13.11 and 11.07 mg kg^{-1} in surface and sub-surface soils, respectively. Among all forms of potassium the water soluble potassium content found lowest in Harihara taluk.

The data indicated that, the exchangeable potassium content ranged from 93.31 to 132.33 and 66.00 to 95.46 mg kg^{-1} in surface and sub-surface soils, respectively. The mean exchangeable potassium content of Harihara taluk was 104.78 and 76.56 mg kg^{-1} in surface and sub-surface soils, respectively. The highest mean value 154.51 mg kg^{-1} of non-exchangeable potassium was recorded in surface soils than in sub-surface soils (142.30 mg kg^{-1}) of Harihara taluk. The lattice potassium values of surface and sub-surface soils of Harihara taluk ranged from 2249.00 to 2987.00 and 2131.00 to 2792.96 mg kg^{-1} respectively. The highest mean value 2828.92 mg kg^{-1} of total potassium was recorded in surface soils than in sub-surface soils (2672.79 mg kg^{-1}) of Harihara taluk.

Davanagere

The data clearly noticed that the status of available potassium in Davanagere taluk was found in the range 81.00 to 130.26 and 58.58 to 89.59 mg kg^{-1} in surface and sub-surface soils, respectively. The content of water soluble form of potassium in the surface layer of soil varied from 8.00 to 18.13 mg kg^{-1}. Whereas, in sub-surface, the highest value of 14.13 mg kg^{-1} and lowest value of 6.45 mg kg^{-1} was noticed in soils of Davanagere. The content of exchangeable potassium in the surface layer of soil ranged from 73.00 to 112.13 mg kg^{-1}. In sub-surface soils, the highest value of 75.46 mg kg^{-1} and lowest value of 52.13 mg kg^{-1} was noticed in soils of Davanagere. The non-exchangeable potassium content varied from 95.94 to 285.90 mg kg^{-1} in surface soils.

Table 9: Forms of potassium in arecanut garden soils of Channagiri taluk

Sl. No.	Available K		Water soluble K		Exchangeable K		Non-Exchangeable K		Lattice K		Total K	
	← mg kg^{-1} →											
	0-15cm	15-30cm	0-15cm	15-30cm	0-15cm	15-30cm	0-15cm	15-30cm	0-15cm	15-30cm	0-15cm	15-30cm
1	98.25	78.17	22.11	15.04	76.14	63.13	284.23	118.19	2811.12	2665.23	3193.60	2861.59
2	83.69	67.04	11.19	8.04	72.50	59.00	300.66	279.16	3281.86	2677.17	3666.21	3023.37
3	201.56	105.77	14.26	9.33	187.30	96.44	286.83	231.91	3189.32	2691.37	3677.71	3029.05
4	94.52	84.24	21.02	19.01	73.50	65.23	268.22	120.63	3035.23	2909.03	3397.97	3113.90
5	190.18	113.21	28.43	20.10	161.75	93.11	292.19	195.12	3360.19	3342.78	3842.56	3651.11
6	103.20	93.59	23.00	23.03	80.20	70.56	302.69	281.22	3963.17	2738.33	4369.06	3113.14
7	130.09	100.51	26.09	9.12	104.00	91.39	310.00	238.23	3257.11	2985.65	3697.20	3324.39
8	111.95	98.26	18.00	17.00	93.95	81.26	292.88	234.39	2649.18	2513.61	3054.01	2846.26
9	188.09	111.02	13.21	11.89	174.88	99.13	295.33	288.49	2742.98	2353.90	3226.40	2753.41
10	266.75	196.63	12.00	7.00	254.75	189.63	258.08	238.67	2741.55	2909.23	3266.38	3344.53
Mean	**146.82**	**104.83**	**18.93**	**13.95**	**127.89**	**90.88**	**289.11**	**222.60**	**3103.17**	**2778.63**	**3539.10**	**3106.06**
Range	**83.69-266.75**	**67.04-196.63**	**11.19-28.43**	**7.00-23.03**	**72.50-254.75**	**59.00-189.63**	**258.00-310.00**	**238.23-281.22**	**2649.18-3963.17**	**2353.90-3342.78**	**3054.01-4369.06**	**2753.41-3651.11**

Table 2 : Forms of potassium in arecanut garden soils of Honnalli taluk

Sl. No.	Available K		Water soluble K		Exchangeable K		Non-Exchangeable K		Lattice K		Total K	
	← mg kg^{-1} →											
	0-15cm	15-30cm	0-15cm	15-30cm	0-15cm	15-30cm	0-15cm	15-30cm	0-15cm	15-30cm	0-15cm	15-30cm
1	188.24	105.76	13.12	11.13	175.12	94.63	160.88	147.78	2315.87	2314.19	2664.99	2567.73
2	127.82	103.88	11.49	9.44	116.33	94.44	174.23	159.11	2298.43	2390.41	2600.48	2653.40
3	126.75	82.77	15.75	12.91	111.00	69.86	128.31	122.00	2930.37	2826.17	3185.43	3030.94
4	131.93	104.68	9.44	8.89	122.49	95.79	146.00	134.49	2384.71	2494.14	2662.64	2733.31
5	142.00	111.76	21.13	18.33	120.87	93.43	214.31	199.23	3587.88	3249.49	3944.19	3560.48
6	130.63	125.81	14.00	13.10	116.63	112.71	190.56	170.13	2874.75	2992.96	3195.94	3288.90
7	163.26	122.59	9.80	8.46	153.46	114.13	161.47	151.00	2337.63	2422.44	2662.36	2696.03
8	58.21	50.01	16.98	13.57	41.23	36.44	189.13	164.11	3114.13	3230.33	3361.47	3444.45
9	105.92	82.45	12.43	9.45	93.49	73.00	158.99	140.17	2275.00	2131.00	2539.91	2353.62
10	108.37	69.57	19.00	16.11	89.37	53.46	210.16	198.33	2249.17	2198.17	2567.70	2466.07
Mean	**128.30**	**93.23**	**14.31**	**12.13**	**113.99**	**81.10**	**173.40**	**158.63**	**2636.79**	**2624.93**	**2938.49**	**2876.79**
Range	**58.21-188.24**	**50.01-125.81**	**9.44-21.13**	**8.46-18.33**	**41.23-175.12**	**36.44-114.13**	**128.31-214.31**	**122.00-199.23**	**2249.17-3587.88**	**2131.00-3249.49**	**2539.91-3944.19**	**2353.62-3560.48**

Table 11: Forms of potassium in arecanut garden soils of Harihara taluk

Sl. No.	Available K		Water soluble K		Exchangeable K		Non-Exchangeable K		Lattice K		Total K	
	← mg kg^{-1} →											
	0-15cm	15-30cm	0-15cm	15-30cm	0-15cm	15-30cm	0-15cm	15-30cm	0-15cm	15-30cm	0-15cm	15-30cm
1	105.06	77.35	8.85	6.23	96.21	71.12	157.83	137.71	2315.11	2264.19	2578.00	2479.25
2	110.38	76.70	9.05	7.22	101.33	69.48	164.28	149.11	2298.00	2270.44	2572.66	2496.25
3	115.74	92.99	17.45	15.53	98.29	77.46	138.31	122.11	2930.31	2756.17	3184.36	2971.27
4	110.46	82.12	17.15	16.12	93.31	66.00	126.00	130.49	2384.55	2314.14	2621.01	2526.75
5	117.39	109.09	15.20	13.63	102.19	95.46	194.37	179.43	2987.00	2749.17	3298.76	3037.69
6	119.40	81.98	13.52	12.98	105.88	69.00	190.59	160.13	2874.78	2792.96	3184.77	3035.07
7	132.76	84.32	22.20	17.32	110.56	67.00	131.47	141.44	2337.00	2222.44	2601.23	2448.20
8	103.02	84.11	8.23	6.11	94.79	78.00	169.16	144.11	2914.00	2730.11	3186.18	2958.33
9	119.74	89.69	9.85	7.56	109.89	82.13	138.99	140.17	2275.54	2131.00	2534.27	2360.86
10	141.98	97.98	9.65	8.00	132.33	89.98	134.13	118.33	2249.00	2198.00	2525.11	2414.31
Mean	**117.89**	**87.63**	**13.11**	**11.07**	**104.78**	**76.56**	**154.51**	**142.30**	**2556.52**	**2442.86**	**2828.92**	**2672.79**
Range	**103.02-141.98**	**76.70-109.09**	**8.23-22.20**	**6.11-17.32**	**93.31-132.33**	**66.00-95.46**	**126.00-194.37**	**118.33-179.43**	**2249.00-2987.00**	**2131.00-2792.96**	**2525.11-3298.76**	**2360.86-3037.69**

Table 12: Forms of potassium in arecanut garden soils of Davanagere taluk

Sl. No.	Available K		Water soluble K		Exchangeable K		Non-Exchangeable K		Lattice K		Total K	
	mg kg^{-1}											
	0-15cm	15-30cm	0-15cm	15-30cm	0-15cm	15-30cm	0-15cm	15-30cm	0-15cm	15-30cm	0-15cm	15-30cm
1	108.29	73.25	12.12	10.13	96.17	63.12	95.94	86.23	1990.33	1894.07	2194.56	2053.55
2	102.64	70.92	11.49	9.44	91.15	61.48	104.08	93.58	2169.43	2094.13	2376.15	2258.63
3	114.75	81.37	13.75	12.91	101.00	68.46	225.23	186.33	1103.91	990.24	1443.89	1257.94
4	81.00	63.24	8.00	6.81	73.00	56.43	113.75	95.65	2369.29	2138.37	2564.04	2297.26
5	130.26	89.59	18.13	14.13	112.13	75.46	112.13	94.12	2248.37	2143.93	2490.76	2327.64
6	119.44	82.72	14.00	11.19	105.44	71.53	110.75	104.53	2301.12	1983.41	2531.31	2170.66
7	119.80	82.44	9.80	8.46	110.00	73.98	121.85	117.49	2509.17	2409.23	2750.82	2609.16
8	108.31	74.9	16.98	13.57	91.33	61.33	129.02	122.33	2688.81	2498.21	2926.14	2695.44
9	84.55	58.58	8.43	6.45	76.12	52.13	243.95	212.39	2829.37	2486.00	3157.87	2756.97
10	86.33	69.16	10.14	9.18	76.19	59.98	285.9	266.74	2293.66	2133.49	2665.89	2469.39
Mean	**105.53**	**74.61**	**12.28**	**10.22**	**93.25**	**64.39**	**154.26**	**137.93**	**2250.35**	**2077.11**	**2510.14**	**2289.65**
Range	**81.00-130.26**	**58.58-89.59**	**8.00-18.13**	**6.45-14.13**	**73.00-112.13**	**52.13-75.46**	**95.94-285.90**	**86.23-266.74**	**1103.91-2829.37**	**990.24-2498.21**	**1443.89-3157.87**	**1257.94-2756.97**

In sub-surface soils, the non-exchangeable potassium content varied from 86.23 to 266.74 mg kg^{-1}, this form of potassium varied from 1103.91 to 2829.37 mg kg^{-1} in the surface and from 990.24 to 2492.21 mg kg^{-1} in the sub-surface soils. The total potassium content varied from 1443.89 to 3157.87 mg kg^{-1} and 1257.94 to 2756.97 mg kg^{-1} in surface and sub-surface soils, respectively.

Range of available potassium is medium to high in all the taluks. Coarse textured soils recorded comparatively low available potassium status than heavy textured soils. The higher K values in heavy textured soils could be due to predominance of K rich micaceous and feldspars minerals in these soils. These results are in agreement with the findings of Ravikumar (2006) who recorded higher available potassium status in Vertisols compared to Alfisols. The surface soils contained higher potassium content than sub-surface soils. This could be attributed to more intense weathering, release of potassium from organic residues, application of potassium fertilizers and upward translocation of potassium from lower depth along with capillary rise of ground water. Similar findings were made by Varaprasad Rao *et al.*, (2008) (Table 1 to 4).

The water soluble potassium content was lower in the sub-surface layer than in surface layer of soils. This might be due to intense pedochemical weathering, higher organic carbon content and release of labile K from organic residues as suggested by Raskar and Pharande (1997). The reasons for higher concentration of water soluble K in surface soils may be due to the addition of fertilizers, presence of potassium bearing minerals, intensity of weathering and upward movement of soluble potassium from the lower layers due to capillary rise of ground water as reported by Ranganathan and Satyanarayana (1980), Sudharmai Devi *et al.*, (1990) in soils of different agro climatic zones of Karnataka and Kerala, respectively (Table 1 to 4).

The soils of Channagiri taluk contained higher amount of exchangeable potassium than other taluks. The soils differ in exchangeable potassium and such variations in different soils were reported by Sonar and Patil (1996). The exchangeable potassium status of Davanagere soils was comparatively low indicating the dominance of kaolinitic type of clay mineral. Similar findings were recorded by Zubillaga and Conti (2009) in red and laterite soils of Karnataka. Lower content of non- exchangeable potassium in soils of Davanagere taluk attributed to depletion of available potassium from soils by crop removal. Arecanut being a deep rooted and perennial crop might have utilized non-exchangeable potassium in sub-surface soils as compared to surface soils. Similar results were obtained by Vijay Kumar *et al.*, (1986). There is linear relationship between the amount of clay and non- exchangeable potassium and hence the Channagiri soils have high non- exchangeable potassium due to high clay content. This clearly indicates the influence of climate besides the variations in parent material for high content of non-exchangeable potassium in Channagiri soils. Sonar and Patil (1996) were also of the same opinion for the variations in non-exchangeable potassium content for different soils of Maharashtra (Table 1 to 4).

In general, lattice potassium contributed highest to the total potassium in all the soils. The highest content of lattice potassium in Channagiri soils could be due to its parent material. The variation in lattice potassium content is due to the abundance or insufficiency of K- bearing primary and secondary minerals as suggested by Hirekurabar *et al.*, (2000). According to Gangopadhyay *et al.*, (2005), the lattice

potassium constituted on an average of 91 per cent of total potassium in some soils of Karnataka. The contribution of different forms of potassium to total potassium in soils of different taluks under study can be arranged in the order of water-soluble potassium< exchangeable potassium< non-exchangeable potassium< lattice potassium. The wide variation in total potassium may be attributed to the preponderance or insufficiency of potash bearing minerals and particle size. Similar results were reported by Gangopadhyay *et al.,* (2005). The high content of total potassium in Channagiri soils could be due to the presence of potash bearing minerals *viz.,* mica and feldspar. Davanagere taluk soils had recorded low content of total potassium which might be due to the dominance of kaolinite clay fraction. Similar results were obtained by Jagadeesh (2003) for coastal soils of Karnataka (Table 1 to 4).

The area under arecanut cultivation in Davanagere district has increased, nut cracking in arecanut is a nutritional disorder caused due to potassium deficiency. Analysis of nutrient status in soils may throw light on the variation in nutrient compositions. In the present study, nutrient rating was found in the range of medium to high in most of all soils, which shows potassium status in the arecanut gardens was good and helps in better management of nutrients in different arecanut growing areas of Davanagere district. The morphological studies of surface and sub-surface soils showed that the soils of all the taluks are well drained and hence the incidence of diseases is least.

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