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Available potassium status and its relationship with different soil properties in soils under paddy cover of Udupi district, Karnataka

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Abstract
Potassium is the third most crucial plant nutrient, limiting plant growth and reducing crop yields. A study of the potassium status of soils and its relationship with different soil properties in soils provides valuable information for rational K fertilizer management. The investigation was conducted at UAHS, Shivamogga, to know the potassium status in soils under the paddy land use cover of the Udupi district, Karnataka. The results of the investigation revealed that the soils of the Udupi district under paddy cover were acidic with pH varying from 4.00-6.98 with low EC (0.01-0.28 dSm^{-1}) under range, organic carbon content was found to vary between low to high (0.60-25.30 g kg^{-1}) with low clay content and CEC, which varied from 11.20 to 23.12 cmol (p+) kg^{-1}. The status of available potassium in the soil varied from 26.34 to 659.90 kg ha^{-1}; out of 165 samples analyzed, 107 (64.85%) samples recorded low, 49(29.70%) samples medium, and only nine samples (5.45%) recorded high available potassium status. The potassium available in soils recorded a positive and significant correlation with clay (r = 0.482*) and a non-significant positive correlation with pH (r = 0.030), organic carbon (r = 0.010), and CEC (r = 0.308). The potassium available in soil recorded a nonsignificant negative correlation with sand (r = -0.438) and silt (r = -0.066).

Keywords: Available potassium status, potassium fixing capacity, CEC

Introduction

Potassium is the third most essential nutrient for plant nutrition after nitrogen and phosphorus. In plants, potassium is required to activate as many as 60 enzymes. It plays a vital role in osmotic regulation, energy relations, translocation of assimilates, photosynthesis, protein and starch synthesis, metabolic processes, and grain or seed formation, improving the quality of flowers, fruits, vegetables, and other field crops in terms of size, shape, color, taste, shelf life, and fibre quality, etc., It is also involved in the prevention of lodging in crops, imparting resistance against environmental stresses such as drought, cold and frost, and, improving resistance to pests and diseases. The concentration of potassium in plants is a function of its availability in soils, which, in turn, is influenced by potassium fixing capacity and potential buffering capacity of soils as affected by the mineralogy of soils, CEC, Non-exchangeable-K, soil temperature, and moisture, and plant factors such as type of crop, variety or hybrid, plant population and fertilizer, and management practices. The bulk of soil potassium (about 98% of total K) usually exists in unavailable form in primary (micas and feldspars) and secondary (illite group) clay minerals.

Paddy is cultivated as a rainfed crop in coastal alluvial soils of low and middle lands of small marginal holdings with improper fertilizer management; the productivity of the rice in these soils is found to be low (2270 kg ha-1) compared to the national average productivity (2372 kg ha-1). The reasons for the low productivity of these soils would be imbalanced nutrient status and other problems related to the acidity of these soils.

Scanty information is available on the available K status and its relationship with some soil properties that affect the availability of potassium in soils coming under paddy land use cover. To obtain information on potassium status and physic-chemical properties of the soils under paddy cover and to characterize the soils to formulate a suitable fertilizer recommendation for producing high yield, an investigation was undertaken in the Department of Soil Science and Agricultural Chemistry, College of Agriculture, Shivamogga to study the status of potassium in soils under paddy land use cover of Udupi district, Karnataka.

Material and Methods

For the investigation, one sixty-five surface (0-15cm) soil samples of paddy land use cover were collected from nine hoblis under Udupi district, Karnataka. Udupi, a Karnataka state coastal district, is located on the west coast of peninsular India. The Udupi district lies between 13o 04' and 13o 59' North latitude, 74o 35' and 75o 12' East longitude, covering an area of about 3575 sq km. It is 88 km in length and 80 km in widest part. Udupi district consists of three taluks, namely Udupi, Karkala, and Kundapur, and nine hoblies *viz*., Udupi, Kota, Kapu, Bramhavara, Byndoor, Vandse, Kundapura, Karkala, and Ajekaru as shown in Fig.1.

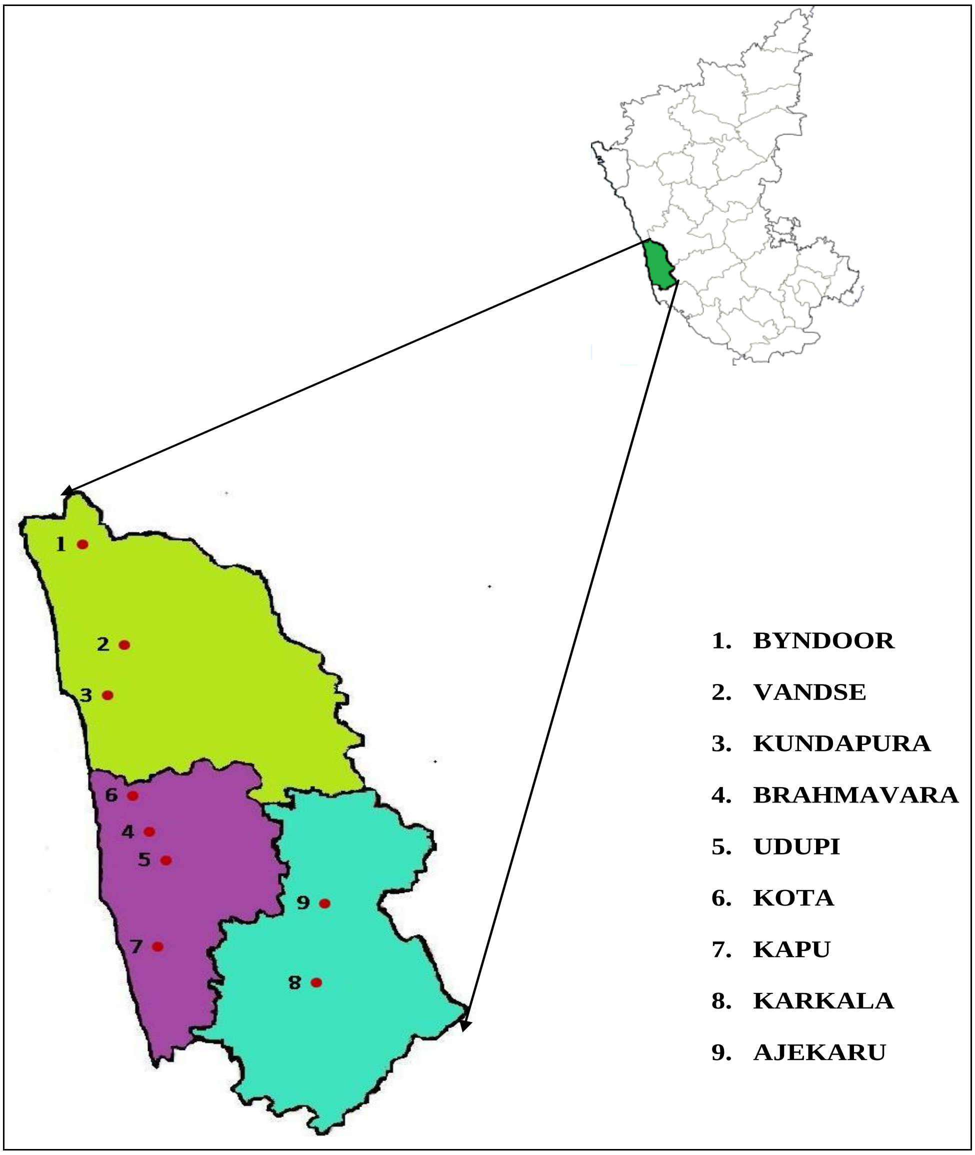

Fig 1: Map showing Udupi district with nine hoblies

Collected representative soil samples were processed and analyzed for pH, EC, organic carbon, texture, CEC, available potassium, and potassium fixing capacity of the soils using standard methods.

Five gram of soil was taken in a 50 ml centrifuge tube in which 25 ml of neutral N ammonium acetate was added to estimate the amount of available potassium. After shaking for 5 minutes, the contents were filtered. The potassium in the filtrate was estimated using flame photometry (Jackson, 1973).

Experimental Results

Chemical properties of soils under paddy land use cover of Udupi district

The soils of the Udupi district were found to be acidic, with values ranging between 4.00 and 6.98 (Table 1). Analysis of 165 samples collected from nine hoblies belonging to three taluks of the Udupi district indicated that 9.70, 32.12, 38.18, 15.67, and 1.82 percent samples were recorded as extremely, very strongly, strongly, moderately, and slightly acidic soils, respectively (Fig. 2). Only 2.42 percent of the samples had a normal range of pH, the pH in Byndoor, Vandse, Kundapur, Brahmavara, Udupi, Kota, Kapu, Karkala, Ajekaru hoblies varied from 4.38-6.86, 4.08-6.26, 4.71-6.17, 4.00-6.98, 4.01-6.85, 4.06-5.97, 4.08-5.86, 4.72-5.98, 4.65-6.64 respectively.

The EC of the soils was found to be low (0.01 to 0.28 dSm-1) (Table 1) under range varying from 0.01-0.20, 0.02-0.25, 0.06-0.25, 0.02-0.27, 0.02-0.27, 0.01-0.28, 0.12-0.27, 0.02-0.27, 0.12-0.26 dSm-1 in soils of Byndoor, Vandse, Kundapur, Brahmavara, Udupi, Kota, Kapu, Karkala, Ajekaru hoblies respectively.

Table 1: physical and chemical properties of the soils under paddy cover of Byndoor hobli, Kundapur taluk, Udupi district

Sl. No	Hobli	pH	OC (g kg^{-1})	Sand	Silt	Clay	Texture	CEC (cmol (p+) kg^{-1})
				←	(%)	→		
1	Byndoor	5.00	18.90	84.50	6.91	8.59	Loamy sand	11.20
2	Byndoor	5.14	2.10	80.20	8.28	11.52	Sandy loam	11.98
3	Vandse	5.90	1.20	79.12	7.28	13.60	Sandy loam	22.00
4	Vandse	4.63	2.70	79.13	8.37	12.50	Sandy loam	12.00
5	Kundapura	5.70	1.20	70.50	7.38	22.12	Sandy clay loam	21.20
6	Kundapura	5.91	3.60	79.12	7.28	13.60	Sandy loam	13.25
7	Bramhavara	5.04	5.70	78.88	7.50	13.62	Sandy loam	13.00
8	Bramhavara	5.80	5.70	75.12	11.28	13.60	Sandy loam	13.21
9	Udupi	6.85	3.90	79.11	8.30	12.59	Sandy loam	12.25
10	Udupi	5.60	10.20	75.80	7.00	17.20	Sandy loam	20.12
11	Kota	5.97	6.90	68.40	9.72	21.88	Sandy clay loam	22.62
12	Kota	5.53	8.10	79.12	8.68	13.20	Sandy loam	12.28
13	Kapu	5.35	19.20	83.60	7.90	8.50	Loamy sand	11.25
14	Kapu	4.08	7.20	79.50	8.00	12.50	sandy loam	12.00
15	Karkala	4.94	19.20	68.25	8.83	22.92	Sandy clay loam	22.52
16	Karkala	5.29	9.00	69.10	9.40	21.50	Sandy clay loam	22.52
17	Ajekaru	4.74	16.20	74.10	8.90	17.00	Sandy loam	21.91
18	Ajekaru	5.21	13.50	69.00	7.00	24.00	Sandy clay loam	23.12

It was noticed from the results given in Table 1 and Fig.3 33.94, 20.61, and 45.45 percent of the samples recorded low, medium and high organic carbon status, respectively Organic carbon content was low to high (0.60 to 25.30 g kg-1) and varied from 0.60-18.90, 0.90-22.2, 0.60-13.80, 0.60-20.70, 2.70-16.20, 4.20-19.80, 0.60-19.20, 8.40-25.20, 6.90-25.30 g kg-1 in soils of Byndoor, Vandse, Kundapur, Brahmavara, Udupi, Kota, Kapu, Karkala, Ajekaru hoblies respectively.

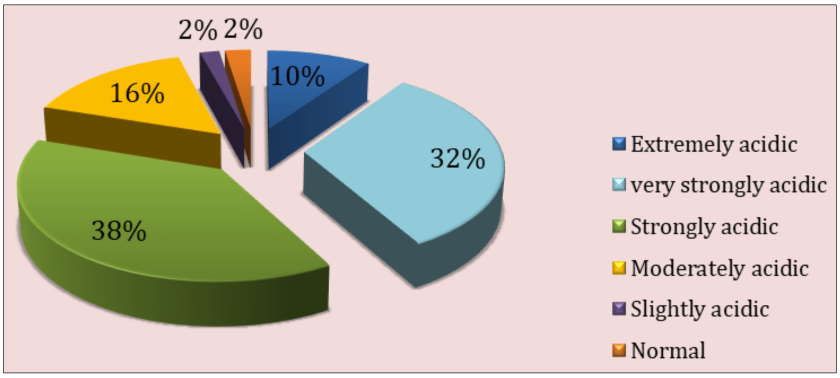

Fig 2: pH of soils under paddy cover of Udupi district, Karnataka

The EC of the soils was found to be low (0.01 to 0.28 dSm^{-1}) (Table 1) under range varying from 0.01-0.20, 0.02-0.25, 0.06-0.25, 0.02-0.27, 0.02-0.27, 0.01-0.28, 0.12-0.27, 0.02-0.27, 0.12-0.26 dSm^{-1} in soils of Byndoor, Vandse, Kundapur, Brahmavara, Udupi, Kota, Kapu, Karkala, Ajekaru hoblies respectively.

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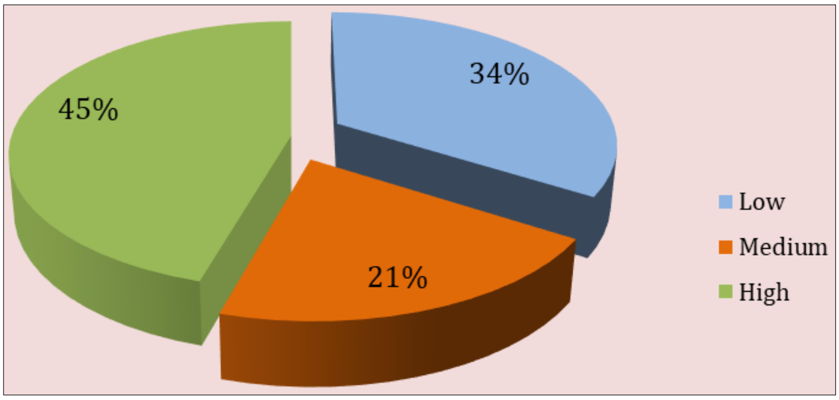

Fig 3: Organic carbon status in soils under paddy cover of Udupi distrcit, Karnataka

The CEC of the selected 18 samples varied from 11.20 to 23.12 cmol (p+) kg^{-1}. The CEC in soils of Byndoor, Vandse, Kundapur, Brahmavara, Udupi, Kota, Kapu, Karkala, Ajekaru hoblies varied from 11.20-11.98, 22.00-12.00, 21.20-13.25, 13.00-13.21, 12.25-20.12, 22.62-12.28, 11.25-12.00, 22.52-22.52, 21.91-23.12 cmol (p+) kg^{-1}. The sandy clay loam soils recorded more CEC than sandy loam and loamy sand soils. The potassium fixing capacity of these soils was found to be low. It was in the range of 0.12 to 0.29 cmol (p+) kg^{-1} and varied from 0.16-0.19, 0.20-0.12, 0.22-0.16,0.17-0.13, 0.10-0.18, 0.26-0.15, 0.06- 0.10, 0.20- 0.25, 0.22-0.29 cmol (p+) kg^{-1} in soils of Byndoor, Vandse, Kundapur, Brahmavara, Udupi, Kota, Kapu, Karkala, Ajekaru hoblies respectively (table 1).

In relation to the particle size distribution, out of 18 selected soil samples analyzed, five samples were recorded as sandy clay loam in texture with sand, silt, clay contents varied from 68.25 to 70.50, 7.00 to 9.72, 21.50 to 24.00 percent, respectively. Two samples were found to be loamy sand with sand, silt and clay contents in the range of 83.60 to 84.50, 6.91 to 7.90, and 8.50 to 8.59 percent, respectively, and the remaining samples (11 samples) belonged to sandy loam texture with sand, silt, and clay contents varying from 74.10 to 80.20, 7.00 to 11.28 and 11.52 to 17.20 percent, respectively (Table 1).

Available potassium status in soils under paddy cover of Udupi District

The available potassium status (Table 2) varied from 26.34 to 659.90 kg K_2O ha^{-1} in the soils of the Udupi district. The available potassium status in Byndoor, Vandse, Kundapur, Brahmavara, Udupi, Kota, Kapu, Karkala, Ajekaru hoblies varied from 51.07-172.03, 52.82-175.12, 30.64-311.67, 26.75-214.37, 26.34-170.82, 45.83-177.95, 53.63-261.54, 30.24-553.73, 70.29-659.90 kg K_2O ha^{-1}. It was observed from the results in Table 2 that out of 165 soil samples analyzed, 64.85 per cent of the samples analyzed (107 samples) recorded low potassium status, and 29.00 percent of the samples (49 samples) showed medium status. Only 5.45 percent (9 samples) recorded high a status of available potassium. From the results presented in Table 2, it was observed that more than 60 percent of the samples coming under the paddy land use cover of the Udupi district were found to be low in available potassium status, and remaining samples had medium status.

However, 65 percent of the soils recorded low status, and about 30 percent recorded a medium status as depicted in the Fig.3.

Table 2: Available potassium status in soils under paddy cover in different hoblies of Udupi district

Taluk	Hobli	Number of samples	Organic carbon status			Available K_2O (kg ha^{-1})	Available potassium status		
			Low	Medium	High		Low	Medium	High
Kundapur	Byndoor	20	11 (55.00)	3 (15.00)	06 (30.00)	51.07-172.03	14 (70.00)	6 (30.00)	-
	Vandse	25	10 (40.00)	5 (20.00)	10 (40.00)	52.82-175.12	18 (72.00)	7 (28.00)	-
	Kundapur	25	14 (56.00)	8 (32.00)	03 (12.00)	30.64-311.67	18 (72.00)	7 (28.00)	-
Udupi	Brahmavara	24	12 (50.00)	7 (29.17)	05 (20.83)	26.75-214.37	16 (66.67)	8 (33.33)	-
	Udupi	09	05 (55.56)	1 (11.11)	03 (33.33)	26.34-170.82	08 (88.89)	1 (11.11)	-
	Kota	15	01 (06.67)	4 (26.67)	10 (66.67)	45.83-177.95	11 (73.33)	4 (26.67)	-
	Kapu	13	02 (15.38)	5 (38.46)	06 (46.15)	53.63-261.54	10 (76.92)	3 (23.08)	-
Karkala	Karkala	22	-	-	22 (100.0)	30.24-553.73	11 (50.00)	5 (22.73)	6 (27.27)
	Ajekaru	12	01 (8.33)	1 (8.33)	10 (83.33)	70.29-659.90	01 (08.33)	8 (66.67)	3 (25.00)
		Total=165	56 (33.94)	34 (20.61)	75 (45.45)	26.34-659.90	107 (64.85)	49 (29.70)	9(05.45)

Figures in the paranthesis indicate per cent organic carbon and available potassium status

Sl. No.	Ratings	Organic carbon (g kg^{-1})	Available K_2O (kg ha^{-1})
1	Low	< 5	<141
2	Medium	5 to 7.5	141 to 336
3	High	>7.5	>336

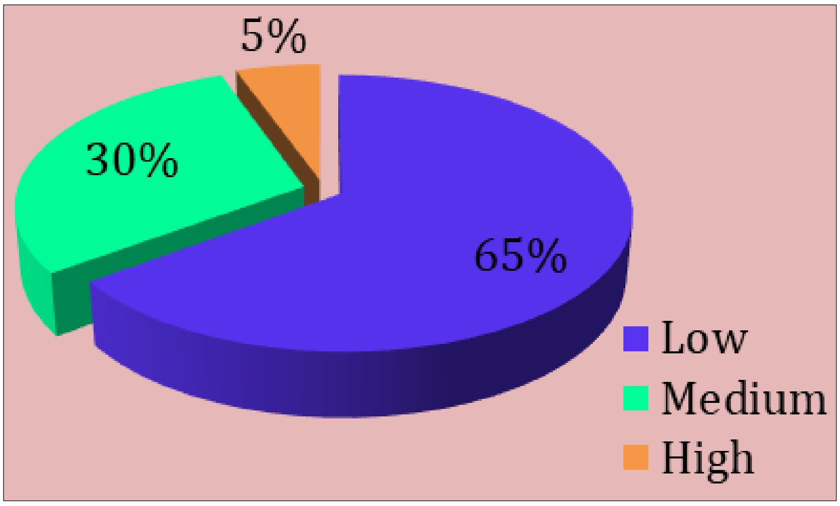

Fig 4: Available K status in soils under paddy cover of Udupi district

The low potassium status in these soils may be attributed to the following reasons

High intensity of weathering coupled with intensive leaching of bases due to heavy rainfall, accumulation of Fe and Al oxides and formation of kaolinite clay mineral. The low clay content, low CEC, and strongly acidic nature of these soils might cause leaching loss of potassium from soils due to heavy rainfall (victor *et al*., 2004; Sparks and Huang, 1985).

Removal of more K by rice than its addition by farmers and also imbalanced use of NPK fertilizers (Ashok, 1998). Removal of all the rice straw from the fields leads to potassium mining at alarming rates because 80 to 85 per cent of the potassium absorbed by rice crops is in the straw Bijay Singh *et al*. (2008).

Relationship between soil properties and available potassium status

Available potassium in soils recorded (Table 3) a positive and significant correlation with clay (r = 0.482*) and a non-significant positive correlation with organic carbon (r = 0.010), CEC (r = 0.308) and pH of soils (r = 0.030). The available potassium recorded a non-significant negative correlation with sand (r = -0.438), silt (r = -0.066) Variation in available potassium status in soils is mainly due to variation in the pH, CEC, clay content of these soils, as supported by a positive and significant correlation between available K, CEC and clay content and positive non-significant correlation with pH of these soils (Table 3). The results of the present investigation are in conformity with findings of many workers (Amoakwah and Frimpong, 2013, Singh and Mishra, 2012, Sharma, 2013, Kundu *et al*., 2014).

Table 3: Correlation coefficients (r=values) between soil properties and available potassium status of soils

Soil properties	(r = values)
Sand	-0.438
Silt	-0.066
Clay	0.482*
pH	-0.030
OC	0.010
CEC	0.308
K fixing capacity	0.435

Discussion

The results indicate that more than 80 per cent of the soils had pH in the range of extremely acidic to strongly acidic range. Continuous leaching of bases due to heavy rainfall might be the possible reason for low soluble salt concentration in soils.

The acidic nature of the soils may be attributed to the high intensity of weathering coupled with intensive leaching of bases due to heavy rainfall and accumulation of acidic constituents such as Fe and Al oxides in soils. Further, under strongly acidic condition, hydrogen saturated clay undergoes spontaneous decomposition, aluminium ions are liberated and adsorbed by the clay complex and H-Al clay will be formed which create more acidity by step wise hydrolysis and subsequent release of H^+ ions to the system (Shivanna, 2008).

The variation in organic carbon status may be attributed to management practices with or without addition of organic manures and also acidic nature of these soils. Application of FYM along with inorganic fertilizers helps in stimulating the growth and activity of micro organisms, higher production of biomass may be a possible reason for the higher status of organic carbon in soils (Bhabulkar *et al*., 2000).

It was noticed that the CEC of the selected samples varied from 11.20 to 23.12 cmol (p+) kg^{-1} and appeared to be low (Table1). The CEC vary with organic matter and clay content of these soils as evinced by a positive correlation observed between CEC, organic matter and clay content of these soils (Table3). Further, low CEC of the soils may be attributed to the lower amounts of clay dominated by kaolinite and Fe and Al oxides (Tripathi *et al*., 2006).

Conclusion

Finally, owing to coarse textured nature of strongly acidic soils with low CEC, soils coming under paddy cover of Udupi district recorded low to medium status with respect available K, indicating that frequent K fertilization with a small amount but in multiple times, so that K concentration in soil solution may be maintained at a higher and more stable value for sustainable production of crops.

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