



Soil potassium fractions under two contrasting land use systems of Assam

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ABSTRACT

Potassium (K) plays an important role in growth, yield, quality, osmotic regulation, ionic balance and stress resistance of crops. Fertilizer application in Indian agriculture has remained largely skewed towards nitrogen (N) and phosphorus (P), while K remained neglected for over last five decades. On this background, the present study evaluates the soil K fractions under two contrasting land use systems, viz. rice-fallow and forest under three soil depths (0-15, 15-30 and 30-60 cm) and categorisation of soils based on exchangeable K (Exch-K) and non-exchangeable K (NEK) with the strategy for proper K management. Results indicated that the soils of rice-fallow land use system were present in a category which is low in both Exch-K and NEK and as a result it requires adequate K fertilization. Both Exch-K and NEK were higher in the forest soils as compared to rice-fallow soils in the three soil depths. The ratio of NEK/Exch-K was higher in the forest than rice-fallow land use system. The ratio was increased with increase in depth in the forest land use system which indicates that it has more potential to supply subsoil K in long term. This categorisation of soils into different groups provides a comprehensive assessment of K availability for different land use systems and better recommendation of K fertilizer for efficient K management.

Key words: Exchangeable K, Land use systems, Non-exchangeable K, Potassium fractions

Potassium (K) is the seventh most abundant element constituting about 2.1–2.3% of the earth's crust (Zorb *et al.* 2014). It is one of the most important nutrients which plays an important role in ionic balance, quality and stress resistance of crops against pests and diseases (Zorb *et al.* 2014). The K-requirement of most of the crops is equal to or even more than nitrogen (N). Despite this fact, fertilizer application in Indian agriculture has remained largely skewed towards N and phosphorus (P), while K remained neglected for over last five decades. Large amount of K is required for growing crops, but farmers of Assam often do not fertilize their crops with K due to high costs, which lead to K deficiencies in large areas of farmland. Such low K application affects the soil's K-fertility status over long period (Das *et al.* 2018, 2019b). Moreover, K-fertilizer in India is totally imported due to which it imposes heavy burden on Government exchequer.

Studies on some Indian soils shows that crop K needs were mostly met from non-exchangeable K (NEK) in absence of adequate supply. Studies on K status under mulberry, sugarcane, tea and rice-mustard land use systems

of Assam indicated that none of the soils out of seventeen sites were high in Exch-K and NEK (Das *et al.* 2019a). Crop removal of K often exceeds annual addition without any appreciable change in the available K status of soils; thereby suggesting that part of NEK becomes available (Benipal and Pasricha 2002). The NEK is the major portion of the reserve of available K in soil and a primary factor in determining soil K fertility (Wang *et al.* 2016). The objectives of present study were aimed to assess the K fractions of soils under two contrasting land use systems and categorising these soils for K-fertility based on the contents of Exch-K and NEK with the purpose of strategies for K management.

MATERIALS AND METHODS

Soil samples were collected during 2017 from three depths, viz. 0-15, 15-30 and 30-60 cm from 7 sites to represent two contrasting land use systems namely, rice-fallow and forest land use systems of Jorhat, Assam, India. Out of 7 sites, 4 sites namely Titabor-1 (S1), Titabor-2 (S2), Titabor-3 (S3) and Titabor-4 (S4) represent Inceptisols and the rest 3 namely, Jakhlabandha-1 (S5), Jakhlabandha-2 (S6) and Jakhlabandha-4 (S7) represent Ultisols. Rice-fallow land use system was under Inceptisol, whereas forest land use system was under Ultisol. The collected soil samples were air-dried, ground, passed through a 2-mm sieve and used for characterization of different physicochemical properties. The soil pH was measured with the combined electrode (glass and calomel electrode) of a digital pH meter in 1:2.5:: soil: water suspensions (Jackson 1973). The soil

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textural class was determined by hydrometer method using USDA triangular diagram (Bouyoucos 1962). Water soluble potassium (WSK) was extracted using distilled water (soil: water:: 1:5) with shaking time of 1 h. Exchangeable K was determined by using 1 N ammonium acetate of pH 7.0 (soil: solution:: 1:5) as described by Hanway and Heidel (1952). Non-exchangeable K was determined by using boiling 1 NHNO_3 (soil: solution:: 1:10) as described by Wood and deTurk (1941).

RESULTS AND DISCUSSION

Soil properties: Different physico-chemical properties of the soils collected from two districts under two contrasting land use systems in three depths indicated that the soils were acidic in reaction. The soil pH, EC (dS/m) and textural class of the sampling sites are given in Table 1.

Soil potassium fractions: At 0-15 cm soil depth, water soluble K (WSK) varied from 5.0 to 21.3 mg/kg. Exch-K fractions were higher in the forest (58.4 mg/kg) than the rice-fallow land use system (16.9 mg/kg). Under forest land use system, the highest amount of Exch-K was found in Jakhalabandha-2 (73 mg/kg) followed by Jakhalabandha-1 (68.7 mg/kg) and Jakhalabandha-3 (33.4 mg/kg). The highest amount of NEK in the rice-fallow land use system was found in Titabor-3 (114.5 mg/kg) whereas, in forest land use system, the highest amount of NEK was found in Jakhalabandha-1 (533 mg/kg). The NEK reserves were higher in the forest (428.7 mg/kg) as compared to rice-fallow

land use system (100.6 mg/kg). NEK content ranged from 85.9 to 114.5 mg/kg in the rice-fallow land use system. At 15-30 cm soil depth, WSK ranged from 2.4 to 12.6 mg/kg. Exch-K fractions were higher in the forest land use system (42.6 mg/kg) as compared to rice-fallow system (19 mg/kg). Under forest land use system, the highest amount of Exch-K was found in Jakhalabandha-1 (56.9 mg/kg) followed by Jakhalabandha-3 (37 mg/kg) and Jakhalabandha-2 (33.8 mg/kg) (Table 2). The highest amount of NEK in the rice-fallow land use system was found in Titabor-1 (155 mg/kg) whereas, in forest land use system, the highest amount was found in Jakhalabandha-1 (826 mg/kg). NEK reserves were higher in the forest land use system (602 mg/kg) as compared to rice-fallow system (139.1 mg/kg). In the rice-fallow land use system, NEK content varied from 114 to 155 mg/kg.

At 30-60 cm soil depth WSK varied from 5.1 to 14.7 mg/kg. The Exch-K fractions were higher in the forest (35.1 mg/kg) as compared to rice-fallow land use system (19.9 mg/kg). Under forest land use system, the highest amount of Exch-K was found in Jakhalabandha-1 (39.4 mg/kg) and in the rice-fallow land use system highest amount of Exch-K was found in Titabor-3 (24 mg/kg). The NEK reserves were higher in the forest (575 mg/kg) than rice-fallow land use system (133.4 mg/kg). In the forest land use system, NEK content ranged from 371 to 710 mg/kg. The NEK content in the rice-fallow land use system varied from 112 to 145 mg/kg. The ratio of NEK/Exch-K was generally higher in the forest land use system than rice-fallow land use system

Table 1 Different physico-chemical properties of soils of sampling sites under three soil depths

Site	pH			EC (dS/m)			Textural class		
	0-15 cm	15-30 cm	30-60 cm	0-15 cm	15-30 cm	30-60 cm	0-15 cm	15-30 cm	30-60 cm
S1	4.3	4.0	4.0	0.16	0.41	0.36	Clay loam	Clay loam	Clay loam
S2	4.2	4.7	4.4	0.69	0.66	0.56	Clay loam	Clay loam	Silty clay
S3	4.0	4.3	4.3	0.22	0.32	0.44	Clay loam	Clay loam	Clay loam
S4	4.4	4.2	4.5	0.26	0.35	0.39	Clay loam	Clay loam	Clay loam
S5	4.5	4.3	5.1	0.58	0.40	0.43	Clay	Clay	Clay loam
S6	3.8	4.1	4.0	0.37	0.44	0.46	Clay loam	Clay loam	Silty clay
S7	4.0	3.8	4.1	0.24	0.21	0.33	Silty clay	Silty clay	Clay loam

Table 2 Soil potassium fractions under two contrasting land use systems in three soil depths

Land use system	Place	Site	0-15 cm soil depth			15-30 cm soil depth			30-60 cm soil depth		
			WSK (mg/kg)	Exch-K (mg/kg)	NEK (mg/kg)	WSK (mg/kg)	Exch-K (mg/kg)	NEK (mg/kg)	WSK (mg/kg)	Exch-K (mg/kg)	NEK (mg/kg)
Rice-fallow	Titabor-1	S1	5.0	11.4	98.1	4.8	14.3	155	8.2	14.9	143
Rice-fallow	Titabor-2	S2	21.3	20.1	85.9	5.2	19.7	114	9.2	19.4	112
Rice-fallow	Titabor-3	S3	6.2	12.3	114.5	2.4	17.6	145	5.1	24.0	134
Rice-fallow	Titabor-4	S4	9.2	23.9	104.1	2.8	24.5	143	5.9	21.3	145
Mean			10.4	16.9	100.6	3.8	19.0	139.1	7.0	19.9	133.4
Forest	Jakhalabandha-1	S5	19.0	68.7	533	5.0	56.9	826	14.4	39.4	710
Forest	Jakhalabandha-2	S6	16.5	73.0	356	12.6	33.8	394	14.7	31.0	371
Forest	Jakhalabandha-3	S7	11.8	33.4	397	5.4	37.0	586	5.8	35.2	644
Mean			15.7	58.4	428.7	7.7	42.6	602	11.7	35.1	575

Table 3 Ratio of NEK/Exch-K in three depths under different land use systems of Assam

Site	Place	Land use system	Ratio of NEK/Exch-K		
			0-15 cm	15-30 cm	30-60 cm
S1	Titabor-1	Rice-fallow	8.6	10.8	9.6
S2	Titabor-2	Rice-fallow	4.3	5.8	5.8
S3	Titabor-3	Rice-fallow	9.3	8.2	5.6
S4	Titabor-4	Rice-fallow	4.3	5.8	6.8
Mean			6.6	7.6	6.9
S5	Jakhalabandha-1	Forest	7.7	14.5	18.0
S6	Jakhalabandha-2	Forest	4.9	11.6	11.9
S7	Jakhalabandha-3	Forest	11.9	15.8	18.3
Mean			8.1	13.9	16.0

(Table 3). The ratio was increased with increase in depth in the forest land use system. It varied from 7.7 to 11.9 at 0-15 cm, 11.6 to 15.8 at 15-30 cm and 11.9 to 18.3 at 30-60 cm soil depth in the forest land use system. Rice-fallow land use system with lower NEK and higher Exch-K showed a lower ratio whereas, forest land use system with higher NEK and lower Exch-K showed a higher ratio. The soils of order Inceptisols are generally rich in illite content. The rice-fallow land use system under Inceptisols showed lower amount of Exch-K which might be due to lower K-release from the limited expanding 2:1 Illite type of clay minerals. This is due to the fact that K fix snugly in the interlayer spaces of illite. The interlayer space of Illite minerals is also selective for K ions resulting in lower desorption (Sparks and Huang 1985).

Categorisation of soils: Plant availability of K in long term is also governed by the contribution from NEK reserve where K ions remain snugly fixed in between the interlayers of non-expanding 2:1 clay mineral. The NEK is not considered in most of the soil testing methods even though the contribution of K from NEK fraction is substantial in long run. Thus, for comprehensive assessment of K status, incorporation of non-exchangeable K along with exchangeable K was suggested (Subba Rao *et al.* 1993, Srinivasarao *et al.* 2001). Considering this fact, the K-fertility of soils have been categorised into 9 classes based on the contents of Exch-K and NEK (Srinivasarao *et al.* 2007). The soils were categorised based on Exch-K and NEK into 9 groups. The Exch-K were categorised into low (<50 mg/kg), medium (50-120 mg/kg) and high (>120 mg/kg) categories. Similarly, NEK were also categorised into low (<300 mg/kg), medium (300-600 mg/kg) and high (>600 mg/kg) categories.

Results revealed that most of the soils were low in Exch-K. Irrespective of depths, soils from 4 sites (rice-fallow: S1, S2, S3, S4) were present in category (I) with low amount of both Exch-K and NEK. Soil from only one site (forest: S5) in the 15-30 cm soil depth was high in NEK. However, none of the forest soils were present in category (I). One site from 0-15 cm, two from 15-30 cm

Table 4 Categorisation of soils based on Exch-K and NEK in three soil depths in two contrasting land use systems of Assam

Category	Exch-K	NEK	Site		
			0-15 cm depth	15-30 cm depth	30-60 cm depth
I	Low	Low	S1, S2, S3, S4	S1, S2, S3, S4	S1, S2, S3, S4
II	Low	Medium	S7	S6, S7	S6
III	Low	High	-	-	S5, S7
IV	Medium	Low	-	-	-
V	Medium	Medium	S5, S6	-	-
VI	Medium	High	-	S5	-
VII	High	Low	-	-	-
VIII	High	Medium	-	-	-
IX	High	High	-	-	-

and one from 30-60 cm were present in category (II) with low Exch-K and medium NEK (Table 4). From the present study it is concluded that across the depths, majority of the studied soils were low in K-fertility, especially with respect to exchangeable K. Moreover, none of the soils from the 7 sites were high in both exchangeable and non-exchangeable K. However, the rice-fallow soils of three depths were present in category (I) with low in both exchangeable and non-exchangeable K whereas, none of the soils from forest land use system were present in this category. Hence, rice-fallow land use system would require adequate K fertilization immediately. Similarly, K recommendations must be done for different categories based on soil K status. Higher amount of non-exchangeable K present in the deeper layers in the forest land use system indicated that it has more potential to contribute subsoil K in long term as compared to rice-fallow system. The ratio of NEK/Exch-K was also increased with increase in depth in the forest land use system. In the soils with lower non-exchangeable K, as in case of rice-fallow land use system, the NEK fraction may be depleted at faster rate and as a result it cannot replenish the exchangeable fraction. This categorisation of soils into different groups provides a comprehensive assessment of K availability for different land use systems and better recommendation of K fertilizer for efficient K management.

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