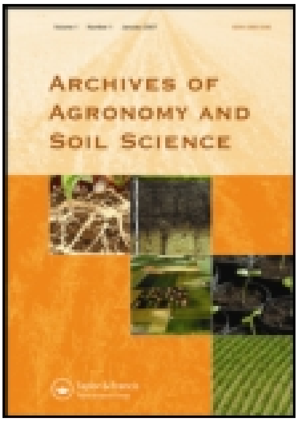

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Distribution of forms of potassium in relation to different agroecological regions of North-Eastern India

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Distribution of forms of potassium in relation to different agroecological regions of North-Eastern India

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Distribution of potassium (K) in soils is governed by the agroecological region (AERs), as the operational intensity of factors and processes of soil formation vary with AER. Therefore, we aimed at finding out the relationship between the forms of K(K forms) with AER and the association of K forms with soil properties in the North-Eastern region of India. For this, horizon-wise soil samples were collected from pedons, three each from three AERs (15 (hot sub-humid to humid), 16 (warm per-humid) and 17 (warm per-humid with less cool winter)) in the North-Eastern India. The water balance diagram for AER shows that precipitation (P) exceeds the potential evapo-transpiration (PET) from June to October, AER 16 shows almost no period when the PET is more than the P and AER 17 shows that the region experiences only a short water deficit of 100–150 mm during post-monsoon period. Soil samples were analysed for physical and chemical properties and K forms. The soils were acidic to neutral with low cation exchange capacity (CEC). The water-soluble K ranged between 0.006 and 0.144 cmol kg^{-1}, exchangeable K between 0.07 and 0.54 cmol kg^{-1}, fixed K from 16.7 to 61.3 cmol kg^{-1} and total K from 17.4 to 63.6 cmol kg^{-1} in soils of different horizons. Further, the results revealed that all the K forms followed the trend of AER 16 > AER 17 >AER 15. Exchangeable K showed higher correlation with clay (r = 0.519**), while fixed K with organic carbon (r = 0.390*).

Keywords: forms of K; potassium-profile distribution; agroecological regions; North-Eastern India

Introduction

Potassium (K) is an element essential for plant growth and its importance in agriculture is well recognised (Sparks & Huang 1985; Krauss & Johnson 2002). Exchangeable K is widely used to evaluate the soil K status and to predict the crop K requirements (Askegaard & Jørgen 2002). However, other studies (Mutscher 1995) have shown that the exchangeable K alone cannot be used as the basis for evaluating K availability under intensive cropping. Research (Kirkman et al. 1994; Bansal et al. 2002) has shown that there is a continuous but slow transfer of K from the primary minerals to the exchangeable and slowly available forms. Release of K from these non-exchangeable forms of K (from here K forms) occurs when the levels of exchangeable K and solution K (labile K) are decreased by crop removal and/or leaching (Sparks et al. 1980). The soil K is typically divided into four forms: soil solution K, exchangeable K, non-exchangeable K and K in soil minerals (Sparks 1987). Major portion of the soil K exists as a part of mineral

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structure and in a fixed or non-exchangeable form with small fraction as water-soluble and exchangeable K in soil (Pasricha 2002; Sharma et al. 2006).

The distribution of K forms differs with the depth and space depending on some overriding environmental and soil factors. Different types of soils are found in different regions of India. Their K content varies according to parent material, particle size distribution, degree of weathering and management practices. The K status of illitic soils depends largely on the clay mineral content but in smectitic soils, it depends on the relative abundance of associated minerals and particle size (Srinivasarao et al. 2006). A range of alluvial soils in Assam is medium to high in exchangeable and medium to very high in non-exchangeable K and the brown forest soils in the Western Himalayas are variable (low to high) in both exchangeable and non-exchangeable K (Subba Rao et al. 2011).

The National Bureau of Soil Survey and Land Use Planning, India, has established 20 agroecological regions (AERs) based on physiography, soil, agroclimatic conditions, length of growing season and land use (Sehgal et al. 1992). An attempt has been made to assess the linkage between AERs and K status in the form of a publication 'Potassium Status and Crop Response to Potassium on the Soils of Agroecological Regions of India' brought out by the International Potash Institute, Switzerland (Subba Rao et al. 2011). However, the available information on different K forms in different AERs of North-Eastern India was lacking in this publication. This study was, therefore, aimed at finding out the relationship between forms of K forms with AER and the association of K forms with soil properties.

Materials and methods

Study area

The study area is located between latitudes 21° 51′ N and 29° 28′ and longitudes 88° 2′ and 97° 24′ E covering Assam, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Tripura and Sikkim states of North-Eastern India (Figure 1). The hilly region is bounded by Bhutan and Tibet in the north, Burma (Myanmar) in the east and Bangladesh in the south and west. The total geographical area of the region is 262,300 km^2. The dominant land cover of the region is forest except the state of Assam. The North-Eastern states are falling under three AERs, namely AER 15, AER 16 and AER 17, prepared by the National Bureau of Soil Survey and Land Use Planning (Sehgal et al. 1992). AERs are the units encompassing relatively homogeneous regions in terms of soil, climate and physiography and conducive moisture availability periods, i.e. length of growing period (LGP). Four basic maps, i.e. soil, physiography, LGP and bio-climate are superimposed to delineate AERs (Sehgal et al. 1992). A brief description of each AER covering in North-Eastern India is given below:

AER 15: The climate is characterised by hot summers and mild-to-moderate cool winter. The mean annual rainfall ranges from 1800 to 2000 mm. The mean temperatures of summer and winter are ranged in 35−38°C and 10–25°C, respectively. The LPG, in general, is more than 210 days in a year. The dominant soils are Halaqualfs and Eutrochrepts. These are slightly to strongly acidic, low to moderate in base status and high in organic matter, and have kaolinite and illite as dominant clay minerals. Natural vegetation comprises of tropical moist and dry deciduous forests. Taking benefit of the high rainfall, the cropping system is mainly rice based, particularly in the plains of the Brahmaputra.

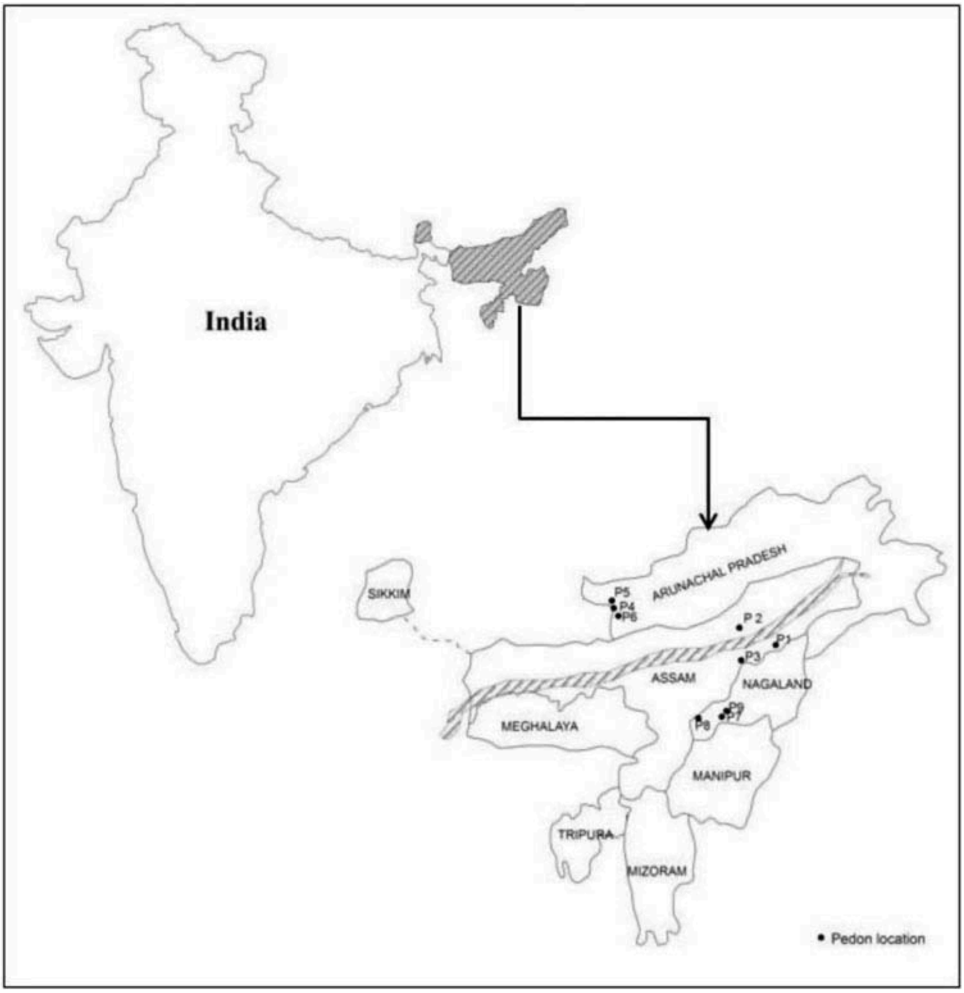

Figure 1. Map showing North-Eastern India and location of the pedons.

AER 16: The climate is characterised by warm summer and cool winter. The mean annual precipitation exceeds 2000 mm per annum. The mean temperatures of summer and winter are 26°C and 8°C, respectively. The area experiences a short period of water stress during the post-rainy period because of the seasonal water deficit. The LPG, in general, is more than 270 days. The dominant soils are Dystrochrepts, Hapludalfs and Paleudults. The soils are loamy to clayey in texture, acidic and have high organic matter contents. Natural vegetation comprises of subtropical pine forest with temperate wet evergreen forests, subalpine forest, etc. In general, Jhum (shifting) cultivation, the traditional farming practice, is followed in the region.

AER 17: The agroclimate of the region is characterised by warm summer and cool winter. The mean annual precipitation varies from 2000 to 3000 mm. The mean temperatures of summer and winter are ranged in 22–27°C and 14–18°C, respectively. LPG exceeds 270 days. The dominant soils are Dystrochrepts, Hapludalfs, Paleudults, Hapludults and Rhodustalfs. They occur both at high and low altitudes. These soils are acidic and have high organic matter content. Natural vegetation comprises of wet evergreen and tropical moist deciduous forests. Jhum cultivation, the traditional farming practices, is followed in the region. Rice is the dominant crop grown in valley and on hill terraces.

Methods

Nine sites, three from each AER (Table 1), were chosen for profile excavation based on the land use. The profiles were described, sampled and classified following the procedure outlined by Soil Survey Staff (1993). A combined glass calomel electrode was used to determine the pH in H_2O and 1M KCl at a soil:solution ratio of 1:2.5. Organic carbon (OC) was determined by the method of Walkley and Black (1934). Cation exchange capacity (CEC) and the exchangeable Ca, Mg, K and Na were determined by 1M ammonium acetate (NH_4OAc) (pH 7) method. The cations were measured by atomic absorption spectrophotometer (AAS; Model AA–6300, Shimadzu, Japan). Water-soluble K (WSK) was determined in the soil extract with distilled water at 1:5 ratio. Exchangeable K was determined by leaching soil samples with 1M NH_4OAc and analysing the extract. The WSK values were subtracted from the 1M NH_4OAc extraction values to obtain exchangeable K fraction (Jackson 1973). Soil sample of 5 g was boiled for 10 min with 50 ml (1:10 w/v) of 1N HNO_3 (mobile K), and the extract was analysed. The 1M NH_4OAc extraction values were subtracted from HNO_3 extraction values to obtain fixed K fraction (Piper 1950; Haylock 1956). For total K fraction, 0.1 g sample was digested by the fluoro-boric acid digestion procedure in a microwave digester (model Start D, Milestone, Italy). Lattice K was estimated by subtracting boiling HNO_3-K from total K values. Potassium was determined using atomic absorption spectroscopy (AAS).

Statistics

All the statistical analyses were performed using SPSS 15.0 (SPSS Inc., Chicago, IL, USA). One-way analysis of variance was performed to test the effect of AERs on K forms. Pearson correlation coefficients were estimated within different K forms as well as their relationships with various soil properties.

Results and discussion

Characteristics of soils

The soil properties varied between and within AERs (Table 2). The pH of the soils ranged from 5.1 to 7.2, 5.2 to 6.0 and 5.2 to 5.8 in AER 15, AER 16 and AER 17, respectively. The OC, ranging between 0.71% and 1.04%, was observed in AER 16 soils. The ranges of OC content of the other two AERs were 0.40–0.57% (AER 15) and 0.45–0.98% (AER 17). The ranges of sand, silt and clay of AER 15 were 34.2–63.6%, 19.6–41.9% and 16.8–28.4%, respectively. A higher level of silt (45.2–49.4%) and clay (27.7–39.1%) was observed in AER 17. The CEC of the soils ranged from 5.6 to 10.5 cmol kg^{-1}, 4.3 to 8.3 cmol kg^{-1} and 9.0 to 11.4 cmol kg^{-1} in AER 15, AER 16 and AER 17 soils, respectively. The range of CEC of AER 15 and AER 16 are in agreement with the ranges of 5.0–10.0 cmol kg^{-1}, which were reported in the soils of Assam (Sen et al. 1997) and 4.3–20.8 cmol kg^{-1} in the soils of Manipur (Singh et al. 1999), respectively.

Table 1. General site characteristics of collected soil profiles.

	Location	Lattitude and Longitude	Slope (%)	Rainfall (mm)	Land use
Agroecological region 15.0: Assam and Bengal plain, hot sub-humid to humid (inclusion of per-humid)					
Pedon 1	Sonari Tea State, Sibsagar, Assam	94° 54′ 41″ E, 26° 58′ 44″ N	3–8	1500–1750	Tea plantation
Pedon 2	Majuli River Island, Jorhat, Assam	94° 21′ 10″ E, 27° 02′ 20″ N	1–3	1950–2000	Cultivated
Pedon 3	Disai valley, Jorhat, Assam	94° 21′ 21″ E, 26° 35′ 40″ N	15–30	1950–2000	Forest
Agroecological region 16.0: Eastern Himalayas, warm per-humid					
Pedon 4	Chung village, West Kameng, Arunachal Pradesh	92° 12′ 36″ E, 27° 26′ 10″ N	15–30	2000–2200	Cultivated
Pedon 5	Chung village, West Kameng, Arunachal Pradesh	92° 12′ 10″ E, 27° 26′ 18″ N	8–15	2000–2200	Forest
Pedon 6	Warzong village, West Kameng, Arunachal Pradesh	92° 24′ 10″ E, 27° 17′ 52″ N	15–30	2000–2200	Tea plantation
Agroecological region 17.0: North-Eastern hills (Pruvanchal), warm per-humid					
Pedon 7	Zubza village, Kohima, Nagaland	94° 03′ 19″ E, 25° 40′ 32″ N	15–30	1150–1250	Cultivated
Pedon 8	Dhansiri village, Dimapur, Nagaland	93° 38′ 10″ E, 25° 47′ 18″ N	3–8	1150–1250	Forest
Pedon 9	Merima village, kohima, Nagaland	94° 07′ 40″ E, 25° 44′ 10″ N	30–50	1650–1750	Forest

Table 2. Some physical and chemical soil properties in different agroecological regions.

Statistical parameters	Sand (%)	Silt (%)	Clay (%)	pH (1:2.5)	OC (%)	CEC (cmol kg^{-1})
Agroecological region 15						
Pedon 1						
Range	27.6–38.5	33.4–47.4	25.0–30.5	5.2–5.7	0.40–1.04	5.6–7.2
Weighted mean	34.2	37.4	28.4	5.4	0.57	6.6
Pedon 2						
Range	23.2–43.2	38.6–49.3	15.7–27.5	7.1–7.2	0.20–1.72	8.2–11.6
Weighted mean	38.2	41.9	19.9	7.2	0.52	10.5
Pedon 3						
Range	53.0–66.4	16.5–26.8	15.1–20.3	5.0–5.3	0.19–1.48	4.0–8.3
Weighted mean	63.6	19.6	16.8	5.1	0.40	5.6
Agroecological region 16						
Pedon 4						
Range	54.5–56.1	23.9–28.9	15.0–20.1	5.5–6.6	0.25–1.30	4.1–4.9
Weighted mean	55.6	26.6	17.8	6.0	0.71	4.3
Pedon 5						
Range	31.8–49.0	25.6–38.0	25.0–40.2	4.7–5.4	0.41–2.29	7.2–9.4
Weighted mean	39.8	29.4	30.8	5.2	1.04	8.3
Pedon 6						
Range	33.4–51.8	28.1–36.6	15.0–30.5	5.1–6.1	0.20–2.90	6.3–9.6
Weighted mean	42.1	32.5	25.4	5.8	1.02	8.2
Agroecological region 17						
Pedon 7						
Range	12.7–17.2	32.8–63.9	20.0–50.0	5.2–6.0	0.10–1.62	5.5–13.9
Weighted mean	15.7	45.2	39.1	5.7	0.45	9.0
Pedon 8						
Range	13.5–19.1	41.3–58.8	25.0–45.2	5.2–5.3	0.38–1.77	5.3–13.8
Weighted mean	15.7	49.4	35.2	5.2	0.76	9.1
Pedon 9						
Range	15.2–40.2	35.0–54.6	24.8–30.2	5.6–6.2	0.52–1.62	10.8–12.3
Weighted mean	27.1	45.2	27.7	5.8	0.98	11.4

Water-soluble K

The WSK in the soils ranged from 0.006 to 0.027 cmol kg^{-1}, 0.022 to 0.144 cmol kg^{-1} and 0.009 to 0.067 cmol kg^{-1} (Table 3) with the mean values of 0.010 to 0.022 cmol kg^{-1}, 0.049 to 0.079 cmol kg^{-1} and 0.022 to 0.045 cmol kg^{-1} (Table 4) in AER 15, AER 16 and AER 17, respectively. Further, the results revealed that the mean WSK in AER 16 was significantly higher (0.063 cmol kg^{-1}) than AER 17 (0.034 cmol kg^{-1}) and AER 15 (0.017 cmol kg^{-1}; Table 5). The mean values of 0.010–0.022 cmol kg^{-1} of AER 15 and 0.049–0.079 cmol kg^{-1} of AER 16 WSK are in agreement with the ranges of 0.017–0.037 cmol kg^{-1}, which were reported in the soils of Jorhat, Assam (Bhaskar et al. 2001) and 0.078 cmol kg^{-1} in the soils of Arunachal Pradesh (Singh et al. 1999), respectively. The pattern of distribution of WSK in different profiles decreased with the depth but increased in profiles (Pedons 4 and 9). This may be due to the leaching of WSK in the soil solution (Singh et al. 1999, 2006). The WSK was significantly and positively correlated with OC (r = 0.305*) and clay (r = 0.313*; Table 6).

Exchangeable K

The exchangeable K in the soils ranged from 0.07 to 0.30 cmol kg^{-1}, 0.25 to 0.54 cmol kg^{-1} and 0.20 to 0.45 cmol kg^{-1} (Table 3) with the mean values of 0.10–0.22 cmol kg^{-1}, 0.28–0.54 cmol kg^{-1} and 0.33–0.41 cmol kg^{-1} (Table 4) in AER 15, AER 16 and AER 17, respectively. Further, the results revealed that the mean exchangeable K in AER 16 was significantly higher (0.40 cmol kg^{-1}) than AER 15 (0.18 cmol kg^{-1}; Table 5), but variation was not significant in AER 17 (0.35 cmol kg^{-1}). In AER 15, acidic alluvial soils are dominant. They are predominantly low to medium in exchangeable K probably due to kaolinitic dominant minerals (Sehgal et al. 1992). However, AER 16 contain medium to high (>0.32 cmol kg^{-1}) exchangeable K with a few areas having very high values probably due to illitic dominant minerals (Subba Rao et al. 2011). Singh et al. (1999) and Bhaskar et al. (2001) also made similar observations about the exchangeable K in this region. In AER 17, the major soils were Dystrochrepts, Hapludalfs, Paleudults, Hapludults and Rhodustalfs having medium (0.13–0.32 cmol kg^{-1}) available K (Baruah & Barthakur 1997). Exchangeable K had positive and significant correlation with CEC (r = 0.325*) and clay (r = 0.519**; Table 6).

Fixed K

Fixed K content varied from 0.26 to 2.99 cmol kg^{-1} (Table 3). Data (Table 4) suggest wide variation between AER and also within the profiles, which could be a reflection of large-scale variations in parent materials and intensity of weathering that these soils have experienced. Singh and Datta (1986) and Singh et al. (1999) made similar observations. Wide variations in the clay contents and mineralogy of these soils could have also contributed to the large variation in the fixed K content of these soils (Table 2). The mean value of the fixed K in AER 16 was significantly higher (2.26 cmol kg^{-1}) than that of AER 15 (0.69 cmol kg^{-1}); however, the mean values of fixed K in AERs 16 and 17 were not significantly different (p < 0.05; Table 5). A high level of fixed K in AER 16 may be due to the fact that this region is rich in K-bearing minerals (Sehgal et al. 1992). Fixed K was highly significant and positive correlation with clay (r = 0.534**; Table 6). It was also significantly and negatively correlated with pH (r = –0.328*) and significantly and positively correlated with OC (r = 0.390*).

Table 3. Forms of potassium in different agroecological regions.

Horizon	Depth (cm)	Water-soluble K	Exchangeable K	Fixed K	Lattice K	Total K
		cmol kg^{-1}				
Agroecological region 15						
Pedon 1 (Oxyaquic Dystrudepts)						
Ap	0–19	0.015	0.30	1.08	34.6	35.9
Bw1	19–39	0.006	0.22	1.05	44.9	46.2
Bw2	39–64	0.009	0.25	0.89	19.5	20.5
Bw3	64–95	0.012	0.18	1.08	28.5	29.7
Cg	95–150	0.010	0.21	1.31	33.3	34.9
Pedon 2 (Typic Fluvaquepts)						
Ap	0–20	0.025	0.14	0.29	42.6	43.1
Bg1	20–40	0.023	0.10	0.26	30.5	30.8
Bg2	40–78	0.015	0.07	0.27	35.6	35.9
Bg3	78–125	0.025	0.11	0.35	26.4	26.7
Pedon 3 (Typic Dystrudepts)						
A	0–20	0.027	0.29	0.83	18.5	19.5
Bw1	20–42	0.018	0.21	0.54	16.7	17.4
Bw2	42–86	0.017	0.24	0.38	17.9	18.5
Bw3	86–120	0.013	0.18	0.45	21.0	21.5
Bw4	120–150	0.022	0.20	1.18	19.2	20.5
Agroecological region 16						
Pedon 4 (Typic Dystrudepts)						
Ap	0–18	0.024	0.33	2.44	28.5	34.9
Bw1	18–40	0.028	0.26	2.19	46.9	52.3
Bw2	40–72	0.144	0.49	2.02	44.1	51.8
Pedon 5 (Typic Dystrudepts)						
A	0–19	0.069	0.28	2.45	38.2	41.0
Bw1	19–41	0.041	0.25	2.39	28.2	30.8
Bw2	41–62	0.041	0.28	2.61	40.3	43.1
Bw3	62–90	0.047	0.30	2.45	30.0	32.8
Bw4	90–120	0.052	0.27	2.99	30.5	33.8
Pedon 6 (Humic Dystrudepts)						
Ap	0–21	0.134	0.50	2.30	61.3	63.6
Bw1	21–39	0.083	0.52	2.39	58.2	60.5
Bw2	39–65	0.022	0.39	1.67	35.1	36.9
Bw3	65–95	0.034	0.54	1.81	37.2	39.0
Agroecological region 17						
Pedon 7 (Typic Haludalfs)						
Ap	0–20	0.039	0.31	1.69	31.8	33.8
Bt1	20–40	0.025	0.20	1.56	23.8	25.6
Bt2	40–64	0.028	0.23	1.78	22.6	24.6
Bt3	64–94	0.018	0.36	2.04	28.5	30.8
Bt4	94–130	0.009	0.41	2.13	33.3	35.9
Pedon 8 (Typic Kanhapludalfs)						
A	0–20	0.043	0.18	1.43	24.1	25.6
Bw1	20–40	0.047	0.24	0.99	35.6	36.9
Bw2	40–78	0.045	0.31	1.31	31.3	32.8
Bt1	78–102	0.012	0.40	1.37	24.9	26.7
Bt2	102–140	0.028	0.45	2.33	20.8	23.6
Pedon 9 (Typic Udorthents)						
A	0–17	0.023	0.39	0.99	22.3	23.6
C1	17–38	0.028	0.42	0.70	26.7	27.7
C2	38–71	0.067	0.41	1.31	36.2	37.9

Table 4. Profile weighted means of forms of potassium in different agroecological regions.*

	Water-soluble K	Exchangeable K	Fixed K	Lattice K	Total K
Pedon	cmol kg^{-1}				
Agroecological region 15					
Pedon 1	0.010	0.22	1.13	31.8	33.1
Pedon 2	0.022	0.10	0.30	32.3	32.8
Pedon 3	0.018	0.22	0.64	18.7	19.5
Agroecological region 16					
Pedon 4	0.079	0.38	2.18	41.0	47.7
Pedon 5	0.049	0.28	2.60	32.8	35.9
Pedon 6	0.062	0.54	1.99	45.9	52.8
Agroecological region 17					
Pedon 7	0.022	0.32	1.89	28.5	30.8
Pedon 8	0.035	0.33	1.57	26.9	28.7
Pedon 9	0.045	0.41	1.05	30.0	31.5

Note: *The profile weighted mean was computed by multiplying the depth of each horizon with their respective forms of K and the sum divided by total depth of the profile.

Table 5. Forms of K in relation to agroecological regions.*

	Water-soluble K	Exchangeable K	Fixed K	Lattice K	Total K
	cmol kg^{-1}				
AER 15	0.017^{a}	0.18^{a}	0.69^{a}	27.6^{a}	28.5^{a}
AER 16	0.063^{b}	0.40^{b}	2.26^{b}	39.9^{b}	45.5^{b}
AER 17	0.034^{c}	0.35^{bc}	1.50^{bc}	28.5^{ac}	30.3^{ac}

Notes: *Based on mean values of three pedons weighted mean in each AER.
Means within a column followed by a different letter are significantly different according to least significant difference (LSD), $p < 0.05$.

Table 6. Relationship of K forms and soil properties (Pearson correlation coefficient).

Soil properties	Water-soluble K	Exchangable K	Fixed K	Lattice K	Total K
pH	–0.232	–0.235	–0.328*	–0.377	0.097
OC	0.305*	0.123	0.390*	0.168	0.317*
CEC	0.203	0.325*	0.109	0.092	–0.139
Sand	–0.208	–0.108	–0.068	0.063	–0.623**
Silt	0.106	0.254	0.176	0.211	0.409**
Clay	0.313*	0.519**	0.534**	0.505**	0.219

Note: *significant at $p < 0.05$; **significant at $p < 0.01$.

Lattice K

The lattice K ranged from 16.7to 61.3 cmol kg^{-1} in the profiles (Table 3) with weighted mean values of 18.7–32.3 cmol kg^{-1}, 32.8–45.9 cmol kg^{-1} and 26.9–30.0 cmol kg^{-1} (Table 4) in AER 15, AER 16 and AER 17, respectively. Further, the results revealed that the mean lattice K in AER 16 was significantly higher (39.9 cmol kg^{-1}) than those of

Table 7. Relationship between forms of potassium (Pearson correlation coefficient).

	Water-soluble K	Exchangeable K	Fixed K	Lattice K	Total K
Water-soluble K	1.00				
Exchangeable K	0.608**	1.00			
Fixed K	0.526**	0.374*	1.00		
Lattice K	0.613**	0.592**	0.378*	1.00	
Total K	0.644**	0.607**	0.483**	0.994**	1.00

Note: *significant at $p < 0.05$; **significant at $p < 0.01$.

AER 17 (28.5 cmol kg^{-1}) and AER 15 (27.6 cmol kg^{-1}; Table 5). Highly significant positive relationship of lattice K with clay ($r = 0.505$**; Table 6) was observed.

Total K

Total K values varied with depths, and showed association with AER. It ranged from 17.4 to 63.6 cmol kg^{-1} in soils of different horizons (Table 3) and 19.5 to 52.8 cmol kg^{-1} in profiles (weighted mean; Table 4). Further, the results revealed that the mean total K in AER 16 was significantly higher (45.5 cmol kg^{-1}) than those of AER 17 (30.3 cmol kg^{-1}) and AER 15 (28.5 cmol kg^{-1}), which are statistically similar (Table 5). Therefore, it seems that the soils developed in warm per-humid climate contained higher quantities of total K than those of soils formed in warm per-humid with less cool and hot sub-humid to humid climate. The correlation study showed that total K was highly significantly and positively correlated with silt ($r = 0.409$**) and highly significantly and negatively correlated with sand ($r = -0.623$**; Table 6). It was also significantly and positively correlated with OC ($r = 0.317$*).

Relationship between K forms

The positive correlations among the K forms (Table 7) are indicative of the presence of interdependency and dynamic equilibrium between different K forms. Total K was significantly and positively correlated with WSK, exchangeable K, fixed K and lattice K ($p < 0.01$). Similarly, lattice K was significantly and positively correlated with WSK, exchangeable K and fixed K ($p < 0.01$). WSK was significantly and positively correlated with both exchangeable K and fixed K ($p < 0.01$), while exchangeable K was significantly and positively correlated with fixed K ($p < 0.05$).

Conclusion

The soils of North-Eastern India were found to be acidic to neutral with low CEC. Potassium-partitioning studies revealed that contents of all K forms followed the trend of AER 16 > AER 17 > AER 15. There is a strong association between K forms and AER, which suggests that K-management should be AER based rather than geographical units.

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