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POTASSIUM AVAILABILITY IN RELATION TO MINERALOGY IN SOME FLOODPLAIN SOILS OF BANGLADESH

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Potassium originates in soils from some primary minerals such as orthoclase, muscovite and biotite and in altered phyllosilicate such as illite. As K is the third most important nutrient element it is studied in soils on the basis of its availability to plants. Potassium in soil is classified in three forms: unavailable, slowly available and readily available or exchangeable. Crystalline or unavailable K comprises approximately 90 - 98% of total soil K. Slowly available potassium, which is fixed and non-exchangeable, is the form trapped between the layers or sheets of certain kinds of clay minerals. Readily available potassium is a dissolved form of K (water soluble) or held on the surface of clay particles (exchangeable K). A dynamic equilibrium exists between the different forms of K in soils. Availability of K for plants therefore depends on weathering of K bearing minerals in soil system, release of exchangeable K from the inorganic colloidal complexes, the nutrient adsorption capacity and adsorption maxima of the organic colloids present in soil system. Information on clay mineralogy is therefore crucial in understanding the K status and its release in soil system to meet the demands of plants. Mineralogical composition of soils has a vital influence on K dynamics. Relationships between clay mineralogy and potassium forms can be utilized in evaluating potential soil K availability, prediction of K cycling as well as its uptake by plants. Knowledge on the NH_4OAc-K form of potassium along with information of clays' mineralogical composition can provide reliable information in the equilibrium and release of non-exchangeable K to plants and the need for applying fertilizers containing K. Information regarding various forms of potassium in relation to mineralogy on the extensively cultivated soils of the floodplain in Bangladesh is only sporadic even today (1, 2). No study in these soils linking K release with soil mineralogy has been reported so far. The present study is an attempt to provide information on potassium in relation to mineralogy in some floodplain soils of Bangladesh.

Nine surface (0 - 15 cm depth) soil samples representing nine typical soil series from the Ganges, Brahmaputra and Meghna floodplains of Bangladesh were collected for this study. The soil sampling sites as presented in Table 1 were recorded using a GPS. The collected soil samples were analyzed to determine different forms of K e.g. water soluble(3), exchangeable (extracted with 1M NH_4OAc) (4), and non-exchangeable or fixed K

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(extracted with boiling 1M HNO_3)(5). Total K was determined through digestion of soils with Na_2CO_3 fusion method. Potassium in minerals was calculated as the difference between total potassium and the sum of all extractable potassium. Flame photometer was used for potassium determination. Bulk and clay mineralogical composition of soils were determined following the method of Jackson(6).

Table 1 shows some basic properties of the studied soils, including clay content, pH and cation exchange capacity (CEC). The Gangetic soils had the highest clay content (17-77%) among the studied soils. As all the soils have developed on alluvial materials there is wide variation in clay content (Table 1). Soils of the Ganges and the Brahmaputra floodplains show big difference while the Meghna floodplain soils are uniform with respect to clay content. This kind of local variation is common in sedimentary environments. The pH values varied between 7.1 and 7.7 for Gangetic soils and between 6.1 and 6.6 for non-Gangetic soils. The CEC varied between 12.96 and 27.66 for Gangetic soils and between 7.08 and 12.08 for non-Gangetic soils. The CEC was comparatively higher in the Gangetic soils than that in the non-Gangetic soils. Nutrient availability for plants are linked with the type and amount of clay minerals and organic matter contents that regulates the CEC. The high nutrient holding capacity of the soils depends primarily on high CEC that controls the adsorption capacity of nutrient cations including K.

The water-soluble K, exchangeable K and acid extractable K ranged from 6.0 to 18.0, 122.5 to 306.3 and 760.3 to 992.3 mg/kg, respectively while mineral K and total K in the soils ranged from 25.2 to 31.8 and 26.2 to 33.1 g/kg, respectively (Table 1). The soils developed on the Ganges alluvium had higher content of exchangeable K due possibly to higher content of the soil vermiculite/ smectite minerals present in these soils. About 94 to 98 per cent of total K in all soils occurs in mineral K form (Table 1). The high content of total K in all nine soil samples is attributed to dominance of weatherable primary minerals such as muscovite, biotite and orthoclase. Martin and Sparks(7) and Sparks(8) stated that biotite is the main K releasing mineral in soils, though muscovite and orthoclase contain more than 90% of the total K in soils. The latter two minerals release potassium very slowly during weathering.

Mineralogical data indicate that layer silicate minerals predominated the bulk soils followed by quartz, feldspars (plagioclase and orthoclase) and amphiboles while illite was the dominant secondary silicate mineral in clay fraction of soils developed on Brahmaputra and Meghna floodplains. In the Gangetic soils 18Å vermiculite, illite and smectite dominate with traces of chlorite and some intergrade minerals.

Results showed that the Gangetic floodplain soils predominated with 18Å vermiculite > illite > smectite minerals contained higher amount of all forms of potassium compared to the Brahmaputra and Meghna floodplain soils in which illite and kaolinite predominated (Table 1). Sparks(8) reported that the major sources of non-exchangeable

Table 1. Location, some selected properties, K- forms and mineralogy of some floodplain soils of Bangladesh.

Soils	Location (Upazila and GPS coordinates)	Clay (%)	pH	CEC (cmol$^+$ kg^{-1})	Water soluble K (mg/kg)	Exchange able K (mg/kg)	HNO$_3$ extrac-table K (mg/kg)	Mineral K (g/kg)	Total K (g/kg)	Mineralogy*	
										Clay (< 2 µm fraction)	Bulk soils (< 2 mm fraction)
Ganges river floodplain											
Sara	Beramara 24^{0}01'.078" N & 89^{0}00'.624" E	17	7.7	12.96	9.8	122.5	856.5	31.2	32.2	I>S>V>Ch>K	Q>LS>P>KF
Ishurdi	Mirpur 23^{0}59'.580" N & 88^{0}58'.401" E	41	7.1	17.56	14.1	301.9	992.3	31.8	33.1	V>I>S>K>Ch	LS>Q>P>KF
Ghior	Mirpur 23^{0}59'.263" N & 88^{0}57'.521" E	77	7.2	27.66	11.4	306.3	981.0	31.4	32.7	V>I>S>K>Ch	LS>Q>P>KF
Mean		45	7.2	19.39	11.8	243.6	943.3	31.5	32.6	-	-
Brahmaputra floodplain											
Sonatala	Jamalpur Sadar 24^{0}49'.264" N & 89^{0}51'.524" E	15	6.1	7.08	6.0	131.2	850.3	27.5	28.5	I>K>Ch>V	Q>LS>P>KF
Silmandi	Jamalpur Sadar 24^{0}49'.263" N & 89^{0}51'.604" E	18	6.6	7.17	9.1	135.3	791.5	27.1	28.0	I>K>Ch>V	Q>LS>P>KF
Ghatail	Jamalpur Sadar 24^{0}49'.345" N & 89^{0}51'.599" E	47	6.1	9.77	8.2	187.1	992.3	28.1	30.1	I>K>Ch>V	LS>Q>P>KF
Mean		27	6.3	8.00	7.8	151.2	878.0	27.8	28.8	-	-
Meghna river floodplain											
Tippera	Faridganj 23^{0}12'.203" N & 90^{0}45'.363" E	26	6.6	7.14	11.8	139.4	760.3	26.2	27.1	V>I>K>Ch>S	Q>LS>P>KF
Debidwar	Faridganj 23^{0}13'.538" N & 90^{0}45'.407" E	32	6.1	8.13	12.2	144.0	818.1	26.0	27.0	I=K=Ch=V>S	LS>Q>P>KF
Burichang	Faridganj 23^{0}11'.958" N & 90^{0}44'.186" E	32	6.1	12.08	18.0	199.4	840.5	25.2	26.2	I=K=Ch=V	LS>Q>P>KF
Mean		30	6.3	6.30	14.0	160.9	806.4	25.8	26.8	-	-

*V = Soil vermiculite, I = Illite, S = Smectite, K = Kaolinite, Ch = Chlorite, LS = Layer silicates, Q = Quartz, P = Plagioclase, KF = Potash-feldspar.

potassium in soils are K-rich 2 : 1 clay minerals such as illite and vermiculite. Muhr *et al.*(9) reported that the soils containing vermiculite, smectite, chlorite and intergrade minerals release more K^+ ions than those rich in kaolinite.

Soils with high amount of total potassium contain high amount of 1M HNO_3 extractable and exchangeable K(5). All the soils under this study have high content of potassium rich weatherable primary and secondary minerals in different size fractions (Table 1). Orthoclase mineral structurally differs from the biotite and muscovite minerals as the formers have 3-D structure while the laters are platy phyllosilicates. In the weathering process feldspars (both orthoclase and plagioclase) release K through dissolution that means destruction of structures. The muscovite and biotite minerals release K from their interlattice space through alteration forming di- and tri-octahadral vermiculites and smectites(10). Loss of interlayer K^+ ion from mica due to weathering has been an interesting field of research for the mineralogist world over(8,10).

Loss and gain of K in soil system remains complex as some minerals there also have high affinity for K(11). Fanning and Keramidas (12) reported that soils with expanding 2 : 1 lattice minerals released K^+ in the soil system due to weathering is again fixed instead of getting lost which causes decrease of CEC because of alteration from smectite toward illite.

It becomes apparent from the present study that the soils exhibit different capabilities in releasing K due to variations in mineralogical composition as well as pedogenic processes. In fact, the diversity among the soils reflecting mainly K-bearing minerals and clay content have resulted in variation in content, forms and distribution of K. The Gangetic soils contained a high quantity of all forms of K and 18Å vermiculite > illite > smectite minerals. Exchangeable K which is used as an indicator for the availability of potassium in soils does not give similar trends in all mineralogical suites. Sometimes non-exchangeable K plays a significant role in supplying available K particularly in soils having K-bearing minerals. Therefore, determination of both exchangeable and HNO_3 extractable K along with mineralogy gives a better indication of K potential and availability in soils for effective crop production.

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