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Forms of potassium in wheat growing soils of Agra district, Uttar Pradesh

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ABSTRACT

The status of different forms of potassium was studied during rabi season of 2015 in wheat growing soils of Agra district of Uttar Pradesh and their relationship with soil properties was worked out. The results revealed that the soils were alkaline in reaction (pH 7.3-9.2), low to medium in organic carbon (2.5-5.6 g ha^{-1}). The ranges of EC, $CaCO_3$, CEC and clay content of these soils were 0.16 to 0.92 dSm^{-1}, traces to 50 g kg^{-1}, 7.0 to 14.0 cmol kg-1 soil and 10-28% with mean values of 0.40 dSm^{-1}, 20 g kg^{-1}, 9.5 cmol kg^{-1} and 19.5 percent, respectively. Total K ranged from 0.95 to 2.25% with a mean value of 1.57% indicating low to moderate reserve for K in these soils. Lattice K accounts 67% of total K. Water soluble K ranged from 7.0 to 36.0 mg kg^{-1} which contributes, on an average 0.11% of total K. Exchangeable K ranged from 45 to 250 with a mean value of 95 mg kg^{-1} which accounted 0.60% of total K. Fixed K varied from 750 to 2000 mg kg^{-1} with a mean value of 1390 mg kg^{-1}, accounting to 8.8% of total K HCl soluble K ranged from 2375 to 5720 mg kg^{-1} with a mean value of 4769 mg kg^{-1}. Exchangeable-K was significantly and positively correlated with clay, organic carbon and CEC of soils indicating their positive influence on exchangeable potassium. Clay fraction of the soils was significantly correlated with fixed K indicating that finer fraction of soils is the main source of fixed-K.Data on correlation values indicated the existence of a dynamic equilibrium among various forms of potassium.

Keywords: Potassium fractions, wheat soils, properties of soils, Agra district.

INTRODUCTION

Potassium, a component of several minerals, is released to soluble and exchangeable forms by weathering of these minerals at widely differing rates. Soil potassium exists in dynamic equilibrium in four forms viz., water soluble, exchangeable, non-exchangeable and lattice K, of which the first two forms are important for the growth of higher plants and microbes. Potassium supplying capacity of soils depends on their total K content and release characteristics of that ion from different forms (pools) as influenced by physico-chemical properties of soils. The nature of various forms of K in a given soils are important for formulating a sound fertilizer application strategy (Srivastava *et al.* 2016 and Yadav *et al.* 2016). Understanding the relationship of different forms of soil K and their equilibrium in soil helps to predict the K supplying power of the soil vis-à-vis to refine the recommendation further as the total quantity and the relative abndence of various forms of K greatly influences it. Not much work has been done in soils of Agra district on the status of potassium fractious. Therefore, the present work was undertaken to study the status of various forms of potassium and their relationship with soil properties.

MATERIALS AND METHODS

One hundred samples of soils (0-20 cm) were collected from the cultivated fields of Agra district. These soil samples were analyzed for EC, pH, organic carbon and free lime, clay and CEC by standard procedures (Jackson 1973) Extraction of total potassium was done through percloric acid digestion of soil (Jackson 1973). The HCl soluble K was determined in HCl extract (Piper 1966), fixed and echangeable K fractions were determined by the methods given by Wood and DeTurk (1941) and Jackson (1973). Water soluble K was determined by shaking the soil with distilled water (1:5 ratio of soil and water). The estimation of potassium in all the cases was done flame photometrically.

RESULTS AND DISCUSSION

Wheat growing soils were alkaline in reaction, pH ranging from 7.5 to 8.9. The EC of the soil water suspension (1: 2.5) ranged between 0-10 and 0.50 dSm^{-1}. Organic carbon ranged from 1.5 to 6.0 g kg^{-1} with a mean value of 3.7 g kg^{-1}. The results showed that 80% soils were rated as low in the organic carbon content. The amount of free lime in these soils ranged from 5.0 to 25.0 g kg^{-1} with a mean value of 10 g kg^{-1}.

Total potassium

The total potassium content of the studied soils ranged from 0.95 to 2.20% with a mean value of 1.47 percent. These values were fairly comparable to the results reported by Chand and Swami (2000) for the soils of Bharatpur (Rajasthan) and Singh *et al.* (2010) for the soils of Agra (Uttar Pradesh). These results suggested that the coarse textured soils would be depleted of soil potassium sooner than fine textured ones. Therefore, continuous monitoring of soil potassium status is essential. Total potassium did not have any significant relationship with soil properties (Table 2). Similar results were reported by Singh (2016).

Table 1: Physico-Chemical properties and potassium fractions in soils of Agra

Soil Characteristics	Range	Mean
Physico-Chemical Properties		
pH (1: 2.5)	7.3-9.2	-
EC (dSm^{-1})	0.16-0.92	0.40
Organic carbon ($g\ kg^{-1}$)	2.5-5.6	3.9
Free lime ($g\ kg^{-1}$)	Traces-50.0	20.0
CEC ($cmol\ kg^{-1}$)	7.0-14.0	9.5
Clay (%)	10.0-28.0	19.5
Potassium fraction		
Total K (%)	0.95-2.20	1.47
Lattice K (%)	0.41-1.16	0.98
HCl soluble K ($mg\ kg^{-1}$)	2375-5720	4169
Fixed K ($mg\ kg^{-1}$)	750-2000	1390
Exchangeable K ($mg\ kg^{-1}$)	45-252	95
Water soluble K ($mg\ kg^{-1}$)	7-36	18

Fixed K

The fixed K content in these soils ranged from 750 to 2000 mg kg^{-1} and constituted 8.8% of the total K. It had significant positive relationships with water soluble and exchangeable K (Table 2) showing thereby the existence of an equilibrium between the fixed form of K and available K. Fixed K also recorded positive and significant correlation with clay, HCl soluble K,$CaCO_3$ and non-significant one with organic carbon (Singh *et al.* 2010, Mandal *et al.* 2011).

Exchangeable

It varied from 45 to 252 mg kg^{-1} and constituted, on an average, 0.60 % of total K. Chand and Swami (2000) and Kumar *et al.* (2009) also reported similar values of exchangeable K in soils of Bharatpur (Rajasthan) and Santhal Paraganas Region of Jharkhand respectively. The exchangeable K showed a significant and positive correlation with total K and water soluble K, indicating the existence of an equilibrium in these soils (Table 2). It did not show any significant relationship with EC pH CaCO3 contents of the soils. But it was significantly and EC, pH positively related with CEC and organic carbon (Dhaliwal *et al.* 2004).

Lattice potassium

Lattice potassium content in these soils varied from 0.41 to 1.16 % with a mean value of 0.98%. It constituted 67 % of total K. Similar results were reported by Chand and Swami (2000) and Singh *et al.* (2010) in soils of Bharatpur (Rajasthan) and Agra (U.P.), respectively. It showed significant and positive relationship with other forms of K studied. Lattice K showed significant and positive correlation with EC and $CaCO_3$ (Singh et al. 2010).

Table 2: Correlation (r-value) between physico-chemical properties and potassium fractions

Soil Characteristics	Potassium fractions					
	Total	Lattice	HCL soluble	Fixed	Exchangeable	Watersolubly
pH	0.068	0.005	0.004	0.011	0.061	0.057
EC	0.041	0.185*	0.138*	0.155*	0.047	0.071
Organic carbon	0.016	0.018	0.077	0.081	0.147*	0.066
$CaCO_3$	0.021	0.180*	0.401**	0.388**	0.102	0.091
CEC	0.030	0.017	0.111	0.093	0.194*	0.030
Clay	0.168*	0.072	0.012	0.019	0.054	0.036
Water soluble K	0.275**	0.261**	0.237**	0.405**	0.575	
Exchangeable K	0.285**	0.460**	0.361**	0.695**		
Fixed K	0.356**	0.770**	0.666**			
HCl soluble K	0.370**	0.810**				
Lattice K	0.421**					

** Significant at 5% level, ** Significant at 1% level*

HCl soluble K

It varied from 2375 to 5720 mg kg^{-1} with a mean value of 4169 mg kg^{-1}. This fraction constituted, on an average 26.5 % of total K. Soils rich in total K possessed abundant quantities of HCl soluble K also as evident from the correlation coefficient between them, which was highly significant and positive (Table 2). This pool of soil K though, showed no significant relationship with pH and organic carbon, recorded significant positive correlation with soluble salt, calcium carbonate and clay contents. The results indicate that total K content predominantly decides the levels of HCl soluble K fraction in these soils with physico chemical properties of the soils having some modifying effect.

Water soluble K

The water soluble K content ranged from 7 to 36 with a mean value of 18 mg kg^{-1} It had a highly significant and positive correlation with exchangeable K indicating thereby replenishment of water soluble K by exchangeable K. Similarly this fraction showed significant and positive correlation with fixed K, HCl soluble and total K. But water soluble K did not record any significant relationship with pH, organic carbon and $CaCO_3$ content. Similar relationships were reported by Kumar *et al.* (2009) and Singh *et al.* (2010).

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