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Short Communication

Effect of potassium levels on its fractions in soil under rice (*Oryza sativa* L.) cultivation

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Total K content in mineral soils ranges from 0.04–3% K, however most proportion of soil K (90-98%) is fixed into lattice clay mineral structure and ultimately restricts its availability to the plants. There are four pools of potassium and classified depending upon its availability to plants: water-soluble, exchangeable, non-exchangeable and structural/lattice forms. The readily available pools of potassium are water-soluble K and Exchangeable K, of which water soluble K is easily become available to plants and microbes and exposed to leaching loss, while second pool is electro-statically bound as an outer-sphere complex to the surfaces of clay minerals and humic substances. However, these pools are very small in size and constitute only about 0.1–0.2% and 1–2% of the total K in soil, respectively. The slowly or unavailable pool of potassium are non-exchangeable and structural/lattice. But, these pools have significant contribution in the long term. The dynamic equilibrium exists between the pools of potassium determines the plant-available and non-available K in the soil. A fraction of the added K may increase water soluble K instance, however maximum get adsorbed on exchange sites, or fixed into non-exchangeable forms that will not immediately equilibrate with water soluble. The K release from the non-exchangeable sites in soil can serve as an indicator of K storage in soil to identify the need of K fertilization. Hence there is a need to understand the optimum level of potassium application for crop production which will helpful to improve stabilization in crop yield. Among these three fractions, the distribution of added K, especially fixed K, is an important factor in the soil–plant system, affecting. Fertilization effectiveness and being one of the most important factors in terms of soil fertility and plant nutrition. Hence, this study was conducted to find out how plants take soil K from respective pools of potassium after applying different rates of potassium fertilization and how it affects other pools which are in dynamic equilibrium.

Table 1: Effect of different levels of potassium fertilization on its pools [c mol (p^+) kg^{-1}] at different stage of rice

Treatment details	Tillering			Flowering			Harvesting		
$N:P_2O_5:K_2O$ mg kg^{-1}	Ws-K	Ex-K	NEx-K	Ws-K	Ex-K	NEx-K	Ws-K	Ex-K	NEx-K
T_1 0:0:0	0.063	0.336	5.03	0.060	0.329	4.94	0.058	0.318	4.85
T_2 60:30:0	0.060	0.331	5.01	0.058	0.325	4.91	0.054	0.314	4.83
T_3 60:30:10	0.066	0.339	5.11	0.063	0.331	5.02	0.061	0.324	4.94
T_4 60:30:20	0.070	0.343	5.22	0.068	0.339	5.04	0.066	0.331	4.98
T_5 60:30:30	0.073	0.350	5.27	0.071	0.346	5.12	0.069	0.340	5.07
T_6 60:30:40	0.077	0.362	5.34	0.074	0.353	5.20	0.070	0.346	5.14
T_7 60:30:50	0.080	0.371	5.41	0.077	0.363	5.32	0.074	0.352	5.23
SEm(±)	0.001	0.005	0.08	0.001	0.004	0.08	0.001	0.004	0.09
CD (P=0.05)	0.004	0.016	0.24	0.004	0.012	0.23	0.003	0.013	0.25

A pot experiment was conducted for two consecutive years of (2018 and 2019) at the Department of Soil Science and Agricultural Chemistry, BHU, Varanasi. The soil was

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collected from the Agriculture Research farm of BHU, from. 0-15 cm layer. Soil sample was ground and passed through 2.0 mm sieve and analyzed for water soluble exchangeable K and non-exchangeable K. The initial soil had Kws, Kex and Knx with value of 0.065 0.36 and 5.10 cmol (p+) kg^{-1}respectively. The experiment was delineated in completely randomized design (CRD) with three replicates and seven treatments comprising control (N:P_2O_5 : K_2O – 0 ; 0 : 0) and different levels of K (0, 10, 20, 30, 40 and 50 mg/kg), in combinations with N and P_2O_5 applied as (60:30 mg/kg) common in all treatments except control. N, P_2O_5 and K_2O were applied as urea, single superphosphate (SSP) and muriate of potash (MOP). Rice test crop of variety HUR-36 or Malaviya Dhan-36 was sown in pot with10 kg soil capacity and four seedlings per pot were maintained. The standard package and practices was followed for raising a healthy crop production. The soil samples were collected at tillering, flowering and after harvest and mean data of both the years were compiled. After processing, the soil samples were subjected to different chemical treatments following the standard protocol: water soluble fraction was determined by the method of Grewal and Kanwar (1966), exchangeable pool by Pratt (1965) and non-exchangeable K by Knudsen *et al.* (1982). The statistical analysis of data was done using ANOVA (Gomez an Gomez 1984). The variance ratio test at $p \leq 0.05$ was used to assess the significance of the treatment effect.

The mean water soluble (Kws) fraction of potassium in soil fluctuated from 0.060 to 0.080, 0.058 to 0.077 and 0.054 to 0.071 c mol (p^+) kg^{-1}at tillering, flowering and harvest stage, respectively. The maximum and significant value was observed in the treatment receiving 50 mg kg^{-1} K at the tillering stage, conversely the lowest data was found in treatment omitted with K but supplied with N and P_2O_5. The ample supply of nitrogen and phosphorous without K creates faster extraction of K from soil and this will leads to mining under imbalance fertilization. The decreasing trend was observed from tillering to harvesting indicates that this fraction is highly mobile and easy to available to plants compared to others two. The similar result was observed and reported by Mandal *et al.* (2007).The plant available K next to water soluble is exchangeable pool. The mean of value of exchangeable K (Kex) ranged from 0.331 to 0.371, 0.325 to 0.363 and 0.314 to 0.352 c mol (p^+) kg^{-1} across the treatments at different stages of tillering, flowering and harvesting respectively. The Kex was maximum in the treatment of 50 mg kg^{-1} K_2O + 60 mg kg^{-1} N and 30 mg kg^{-1} P_2O_5 and significantly greater than the rest of the treatments. Among the all growth stages, the tillering stage was found to be larger in Kex in soil. Compared to initial value, the Kex was decreased in control and treatment receiving only the nitrogen and phosphorus N+P_2O_5+K_2O-60+30+0 mg kg^{-1}. Similar observation was made by Das *et al.* (2018). The Non-Exchangeable potassium (Knx) was highest under treatment of NPK-60:30:50 mg kg^{-1} (5.41, 5.32 and 5.23 mg kg^{-1}), closely followed by the treatment supplied NPK-60:30:40 mg kg^{-1}. The Knx was decreased as the crop reaching towards maturity and this might be due to continuous removal of Kws and Kex from soil solutions and soil is maintaining the solution K conc. through reserve pool. The treatment supplied with N+ P_2O_5 had the lowest Knx as compared to rest of treatments. This indicates that how the Knx reserve of soil depletes due to continuous omission of K input, while other two major nutrients are present in the fertilization Kaskar *et al.* (2001).

It may be concluded from the results that the application of nitrogen and phosphorus without potassium (K) or inadequate K fertilizer application would cause greater mining of reserve soil K. Hence prior to crop production adequate K fertilizer application is needed.

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