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POTASSIUM RELEASE CHARACTERISTICS OF SOILS THROUGH CROPPING

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A pot experiment was conducted to study the K release characteristics of five soil series (Sarhad, Shahdara, Sultanpur, Lalian and Pacca) at the Experimental Farm of Atomic Energy Agricultural Research Centre, Tandojam, through cropping, with and without K addition. Results showed a high rate of K release by these series. Non-exchangeable K contributed to the total K uptake upto 95%. Even with addition of 100 kg K/ha, plants utilized 58% of non-exchangeable K. However, part of 200 kg K/ha (soil applied) was fixed by some soils. Amount of K released by soil series studied with no K addition was directly related to clay content and was in the order: Pacca > Sultanpur > Lalian > Shahdara > Sarhad.

Key words: Potassium release, Potassium uptake, Soil series.

Introduction

Soils may contain 40,000 to 50,000 kg of total K/ha, but the amount of K available to plants usually is only a few hundred kg/ha. The rest of K is in non-available or fixed form. Potassium from this fraction is released to plant-available form. This release of potassium varies from soil to soil.

No responses to applied potash have been reported in many field experiments conducted on soils of this country [1-3]. Probably, the extent of release of non-exchangeable potassium and its subsequent uptake by plants have been the main reasons for such poor responses. No attempt has been made to study the release characteristics and the extent of release by Pakistani soils. The objective of the present pot study was to determine the pattern of potassium release from non-exchangeable form and the extent to which this release in different soil series is influenced by varying levels of applied K through cropping.

Materials and Methods

Surface samples of five soil series *viz.* Sarhad, Sultanpur, Shahdara, Lalian and Pacca were collected from the Experimental Farm of Atomic Energy Agricultural research Centre, Tandojam. Nine kg of each soil, after having been air-dried and passed through 2mm sieve, was added to plastic pots (25cm dia.). Levels of K application (as potassium sulphate) to each soil series were 0, 100 and 200 kg K/ha (0,450 and 900 mg. K/pot). Each treatment was replicated three times. A basal dose of 120 kg N as urea and 90 kg P/ha as single superphosphate (540 mg N and 405 mg P/pot) was given to each pot. Five plants of a local cultivar of maize *(Zea mays* L.) were maintained in each pot which were harvested one month after sowing. Dry-matter yield and K uptake from each pot was obtained. Soil from each pot, after harvesting of maize plants, was analysed for its exchangeable K content.

Exchangeable K was extracted with 1 N NH_4OAc. Non-exchangeable K was obtained by substracting exchangeable K from the HNO_3 extracted K [4], the latter was determined by using the method followed by Black [5]. Plant material was digested in HNO_3:$HClO_4$ (5:1) mixture, and its potassium was determined by a flame photometer. Total soluble salts (TSS), soil pH, organic matter content and soil texture were determined by methods described by Black [5]. Release of K from non-exchangeable fraction in soil was calculated as under:

Release (uptake) of K from non-exchangeable fraction = Total K uptake by plants - (decrease in exchangeable K + K applied).

Results and Discussion

Physico-chemical characteristics of the five soil series are given in Table 1. The soils under study varied from sandy clayloam to clayey in texture, and contained non-exchangeable K from 1720 to 2545 ppm. Data on the exchangeable K,

TABLE 1. PHYSICO-CHEMICAL CHARACTERISTICS OF FIVE SOIL SERIES.

Soil series	Total soluble salt (ppm)	pH	Organic matter (%)	Non-exchangeable K(ppm)	Clay (%)	Silt %	Sand (%)	Textural class
Sarhad	776	7.8	0.558	1950	27	48	25	Sandyclay
Sultanpur	3189	7.6	0.926	1880	36	26	38	Clayloam
Lalian	1854	7.6	0.704	1720	25	27	48	Loam
Shahdara	1958	7.9	0.945	2230	33	31	36	Clayloam
Pacca	3250	7.8	1.157	2545	43	38	19	Clay

initially and after harvesting, dry matter yield of maize plants, K uptake and K release from non-exchangeable K by soil series through cropping is presented in Table 2.

Potassium application did not increase dry matter yield of maize in any soil series except Sarhad series where application of 200 kg K/ha gave higher yield than control. In Shahdara series, dry matter yield decreased with K application. The lowest yield was obtained in Pacca soil series. Decrease in yield with K application was probably due to interaction of K with other elements. Patel *et al.* [6] also reported decrease in yield and increasing trend in K uptake with K addition. On the other hand, Conyers [7] did not obtain increase in K uptake with application of potash in some soils during early stages of growth.

For the treatment where potassium was not applied, maximum decrease in exchangeable K content occurred after harvesting in all soil series. The decrease was maximum in Sarhad series and minimum in Pacca series. On the other hand, maximum K from non- exchangeable fraction was released from the control by Pacca soil series and minimum in Sarhad series. Least release of non- exchangeable K in Sarhad soil series is understandable because manimum k was taken up by plants from its exchangeable pool of K. But maximum K (95%) was removed from non-exchangeable content of K in

TABLE 2. K STATUS OF SOIL SERIES (BEFORE AND AFTER CROPPING), DRY-MATTER YIELD OF MAIZE PLANTS, TOTAL K UPTAKE AND K RELEASE THROUGH CROPPING WITH AND WITHOUT K APPLICATION.

Levels of K applied (kg/ha)	Initial exchangeable K content (mg kg^{-1})	Exchangeable K after haryest (mg kg^{-1})	Decrease in exchangeable K (mg/pot)	Dry-matter yield (gm/pot)	K content of plants (%)	Total K uptake by plants (mg/pot)	K release (mg/pot)	Percent K removed from non-exchangeable K
Sarhad								
0	140 (1260mg/pot)	80 (720mg/pot)	542	27.07bcd	3.50ab	947.45b	431.95	44.54
100	140	100 (900mg/pot)	361	28.67ab	3.55ab	1020.93ab	210.96	20.72
200	140	113 (1017mg/pot)	244	30.41a	3.49ab	1054.00a	-89.01	–
Sultanpur								
0	155 (1395mg/pot)	123 (1107mg/pot)	289	28.14ab	3.37bc	957.92bc	669.96	69.99
100	155	134 (1206mg/pot)	188	28.18ab	3.69a	1047.98a	408.96	39.08
200	155	131 (1179mg/pot)	215	28.05ab	3.73a	1059.04a	-57.06	–
Lalian								
0	160 (1440mg/pot)	127 (1143mg/pot)	296	29.78ab	3.21c	965.82bc	668.97	69.34
100	160	116 (1044mg/pot)	395	29.07ab	3.39bc	999.12ab	152.95	14.98
200	160	153 (1377mg/pot)	64	27.81abc	3.65a	1021.20ab	57.96	5.60
Shahdara								
0	205 (1845mg/pot)	159 (1431mg/pot)	416	27.74abc	3.24c	899.05cd	484.96	53.90
100	205	190 (1710mg/pot)	134	24.66cde	3.56ab	863.87de	278.91	32.33
200	205	203 (1827mg/pot)	17	24.17de	3.66a	869.89d	-48.01	–
Pacca								
0	245 (2205mg/pot)	241 (2169mg/pot)	35	22.56e	3.31bc	757.08f	720.99	95.19
100	245	260 (2340mg/pot)	-136	23.14e	3.35bc	773.15f	457.96	58.31
200	245	261 (2349mg/pot)	-143	21.78e	3.70a	796.24ef	39.96	5.13

Means followed by same letters do not differ significantly from one another at 5% level of probability.

Pacca soil series and only a small amount (5%) was removed from its exchangeable K, although the level of the latter in this series was maximum. Potassium in this soil, probably, is in a clay mineral system which maintains a higher exchangeable K level as well as maximum release rate [8]. Another reason for the maximum K release in Pacca soil series may be its higher clay content. This was indicated by highly significant linear relationship between clay content and the corresponding K release (Table 3). Singh and Grosh [9] also reported maximum K release in a soil which had the highest amount of clay.

TABLE 3. RELATIONSHIP OF CLAY WITH THE RELEASE OF K FROM NON- EXCHANGEABLE K FRACTION OF SOIL.

Clay (%)	K release (mg/pot)	Percent K removed from non-exchangeable K
27	432	45
33	670	70
25	485	54
36	669	69
45	721	95
	r = 0.882	r = 0.956
	(P < 0.05)	(P < 0.01)

Removal of K from non-exchangeable K fraction in Sultanpur, Lalian and Shahdara soil series at K_0 was 69.99, 69.34 and 53.90%, respectively. Release of K from non-exchangeable fraction (Table 2) seems positively correlated with initial exchangeable K of all soil series except Shahdara. On the other hand, total K uptake by plants seems to be negatively correlated with initial exchangeable K content of all soil series studies. These observations are indicative of high rate of K release by these soil series. Similar findings were reported by Kadrekar and kibe [10] in Maharashtra soils.

The extent of release of fixed (non-exchangeable) potassium, when K was applied @ 100 kg/ha, was much less than in no potash treated pots. The non-exchangeable form contributed 15 to 58.3% of total K uptake. Decrease in exchangeable K content of the soils with the addition of this amount of potash was also less than that when no potash was added. The Lalian soil series was the only exception where decrease in exchangeable K content was more with addition of 100 kg K/ha than that with no K addition. However, least amount of K (15%) was removed from non- exchangeable K in this soil series with addition of 100 kg K/ha. Maximum amount (58.31%) of K was removed from non-exchangeable fraction in Pacca soil series at this dose of K application. So instead of decrease in exchangeable K content, an increase was observed in its pool with application of 100 kg K/ha.

General decrease in K release and in exchangeable K content with K addition could be attributed to the fact that in the presence of applied K, plants need lesser amount of this nutrient from non-exchangeable and exchangeable K. Thus, the plants actually utilized more K from the applied source and did not depend much on the available (exchangeable) and fixed (non- exchangeable) K in the soil.

With addition of 200 kg K/ha, plants utilized exchangeable and applied K, and no release from non-exchangeable fraction occurred except in Lalian and Pacca soil series where some K (about 5%) was removed by maize plants from non-exchangeable K. Part of added K was fixed in Sarhad, Sultanpur and Shahdara soil series. When most of the 200 kg K/ha applied seemed to be used in enhancing the exchangeable K pool of the Pacca series, in the Lalian soil series all of it seemed to be taken up by plants.

Decrease in K release and in exchangeable K content with K addition as compared with no K addition was also reported by other workers [7-9].

Above results lead to the conclusion that all five soil series studied have a high rate of potassium release. This rapid rate of release may soon exhaust the potassium reserves unless replenished by K addition.

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