Research Article

Comparison and Correlation of Extractable K for Wheat Fertilization in Soils of Potohar Plateau of Pakistan

Muhammad Zameer Khan[1], Sair Sarwar[1*], Ahmad Khan[1], Razaullah Khan[1], Munazza Yousra[1] and Muhammad Ilyas[2]

[1]Land Resources Research Institute, National Agricultural Research Centre, Islamabad, Pakistan; [2]University of Poonch Rawalakot, Azad Jamu and Kashmir, Pakistan

Abstract | Laboratory and greenhouse experiments were undertaken to study the response of applied K in prominent soil series of Potohar Plateau of Pakistan and to correlate soil extractable K with yield components, N, P, K concentration and uptake by wheat. Two extractants namely, AB-DTPA and NH_4OAc were tested for K extraction from soils. The results showed a high positive correlation between AB-DTPA and NH_4OAc extractable K, plant growth and yield parameters. The amounts of soil K had positive correlation with shoot K concentration and grain yield of wheat with r = 0.48 and 0.49, respectively for AB DTPA as compared to that of 0.40 and 0.42 for NH_4OAc K. On the basis of the study it was concluded that AB-DTPA soil test method can safely be used for evaluation of K status of soils derived from diverse parent material.

Received | September 18, 2017; **Accepted** | August 08, 2019; **Published** | October 10, 2019
***Correspondence** | Sair Sarwar, Land Resources Research Institute, National Agricultural Research Centre, Islamabad, Pakistan; **Email:** sardarsair@hotmail.com
Citation | Khan, M.Z., S. Sarwar, A. Khan, R. Khan, M. Yousra and M. Ilyas. 2019. Comparison and correlation of extractable k for wheat fertilization in soils of Potohar Plateau of Pakistan. *Sarhad Journal of Agriculture,* 35(4): 1020-1028.
DOI | http://dx.doi.org/10.17582/journal.sja/2019/35.4.1020.1028
Keywords | Exchangeable K, Wheat, Soils of potohar plateau, AB-DTPA and NH_4OAc

Introduction

Potohar plateau is plateau in north-eastren Pakistan, forming the northern part of Punjab province having latitude of 33.5° N and longitude of 73° E. Soils of Potohar plateau are diverse; loess, alluvial, mixed material and colluvial in nature (Ahmad, 1986; Awan et al., 1998). They have been developed under subtropical to semiarid climate. Most of them belong to Inceptisol, Entisol, Vertisols, Aridisol and to a small extent Alfisol are also present (Ali, 1967). The routine method used for soil testing for K is 1N NH_4OAc. Soil testing in Pakistan has attained more importance because of increased fertilizer use, high prices of fertilizer and low fertilizer use efficiency. The use of fertilizers is very low in rainfer regions whereas its use is inevitable in attaining the potential yields (Rashid et al., 1998). Response of crops to P is well established, whereas K is erratic and becoming low day by day because of its continuous mining (Nisar et al., 1988). Intensive agriculture has dramatically increased grain production in developing countries, but yield records in the dominant food-producing regions indicate a large gap between the current and potential yields of wheat (Neumann et al., 2010). Studies have shown positive significant response to balanced fertilizer application including K but it is site and crop specific which indicates application of K on soil test basis. Soil testing can be helpful in developing balanced fertilizer use program to attain the potential crop yield.

Crops yield and produce quality can significantly be enhanced per unit basis with balanced fertilization, but the crops response to applied K is sporadic and can not be generalized like N and P, as it is crop and site specific (Akhtar et al., 2003). Imbalance fertilizers use has led to K mining from soils (Akhtar and Khan, 2002), it is due to skewed and excessive use of N and P fertilizers in different cropping systems while the use of K in the country is meagre. Continuous use of NP would accelerate drainage of soil native K reserves. It will not only impoverish soil K but also adversely affect crop yields. Hence, there is a dire need to investigate the role of K in balance nutrient management for crop production on sustainable basis. The soils of the potohar plateau are Loess and have 2:1 type clay (Montmorillonite, illite) and the added K becomes fixed in clay lattice and a little quantity is available to crop (Krauss et al., 1996). Tributh et. al. (1987) reported that depletion of K from inter layers of clay minerals (iIlite) followed by their disintegration is due to K removal by plant from soil. The greenhouse experiment on different crops revealed that K uptake by clovers and ryegrass from non-exchangeable K fraction was related to rise in soil K fixation (Hennig and Jan, 2010). Often potash fertilizer applied to western europe soils did not result in crop response, although the exchangeable soil K was low. Tributh (1981) also indicated that permanent K release from interlayer of Illite led to its transformation into smectite or other mineral in soils if heavily cropped without K fertilization The soils have variable properties and it was needed to investigate the behaviour of K in the soils of the potohar in relation to wheat productivity: a main crop of the area. Thus, the study was carried out with the following objectives.

- To compare soil K extracted with AB-DTPA and NH_4OAc with each other.
- To correlate soil Extractable K with grain yield, K concentration and uptake by wheat.

Materials and Methods

Soil selection and sampling

The study was conducted on thirteen prominent soil series of the Potohar plateau of Pakistan, namely; Bahtar, Balkassar, Basal, Chakwal, Guliana, Kahutta, Khore, Missa, Rajar, Satwal, Talagang, Tirnual and Tharpal. Soil samples from a depth of 0-15 cm were collected from locations as earmarked by the Soil Survey of Pakistan (Ali, 1967) reports of the respective area. The air-dried soil samples were ground in mortar and pestle, sieved and placed in plastic containers. The soil samples were analysed for physical and chemical characteristics using procedures given by Ryan et al. (2001). The selected soils differed in their physical and and chemical properties (Table 1). Selected soils were catogaries in suffient, maginal and deficient on the basis of K availability. The NH_4OAc Extractable K of soils belonging to Talagang, Therpal and Satwal series were in sufficient, Bahtar, Basal, Chakwal and Guliana were in marginal while remaining soil series under investigation were in deficient range.

Greenhouse study

Pot experiment was conducted in greenhouse of the National Agricultural Research Centre, (NARC) Islamabad during October 2008 to March 2009. The experiment was comprised of thirteen soil series and two K levels, in triplicate which consist of 78 pots (13 soil series × 2 K levels × 3 Reps). Pots size was 8.5 inches upper dia. × 6.5 inches lower dia. × 7.5 inches hight and five kg soil was placed in each pot. The N, P_2O_5 and Zn were applied @ 150, 100 and 5 mgkg^{-1} soil as urea, di-ammonium phosphate (DAP) and zinc sulphate, respectively. Two K levels; 0 and 150 mg K_2O kg^{-1} soil as muriate of potash was applied. Five seeds of wheat (*Triticum aestivum* L.) Margalla-99 variety was sown in November 2008. After 30 days of sowing when seedling established, three plants were retained in each pot. Distilled water was applied by a hand sprinkler throughout the growing season and pots were not drained. The pots were placed randomly in the glass house and the experiment was laidout in CRD with five replications. A plant tissue (shoot and root) was sampled at pre-heading stage at first week of February 2009. During experiment, data regarding fresh and dry weight (g plant^{-1}), grain and straw weight were recorded and straw and grain samples were collected at the time of harvesting. The plant samples were washed with distilled water, air and oven dried at 65°C and prepared for K determination. The K concentration in grains and straw were determined and uptake of K was calculated on the basis of plant dry matter. Soil extractable K was correlated with K concentrations in grain, straw and K uptake.

AB-DTPA (Soltanpur and Workman, 1979) and NH_4OAc (Jackson, 1968) extractants were used for plant available K extraction from prominent soils of Potohar plateau. Potassium extracted was determined by flame photometer (Winkleman et al., 1990). The amounts of K extracted from soils by bothextractants were correlated with each other and plant K concentration and uptake by wheat.

Table 1: *Physical and chemical characteristics of the soils selected for study.*

Soils	Text. Class	pH	EC_e (dS m^{-1})	HCO_3 (meL^{-1})	Cl	NO_3-N (mg kg^{-1})	P*	K**	$CaCO_3$ (g 100g^{-1})	OM	CEC (cmol$_c$ kg^{-1})
Talagang	Sandy loam	7.80	0.52	2.84	3.33	2.20	4.99	154	3.80	0.50	9.9
Therpal	Silt loam	7.80	0.33	3.00	2.50	1.99	5.37	178	0.20	0.99	9.7
Bahtar	Silt loam	7.60	0.41	3.00	2.33	0.73	3.10	118	8.80	0.81	13.9
Basal	Loam	8.11	1.33	3.00	2.42	1.89	4.32	104	0.30	0.68	12.7
Chakwal	Silt loam	7.97	0.82	3.17	4.67	2.74	3.11	126	13.75	0.92	14.4
Guliana	Loam	7.70	2.90	2.84	4.75	1.82	9.30	100	0.52	0.92	15.8
Missa	Silt loam	7.91	0.76	1.50	2.50	5.90	0.29	66	14.30	0.57	12.9
Rajar	Silt	8.11	0.25	2.00	2.17	1.51	0.45	72	13.20	0.58	13.4
Satwal	Clay loam	7.80	0.35	3.32	2.25	2.22	11.79	288	2.45	1.10	21.6
Balkassar	Loam	8.21	0.48	2.83	2.34	1.72	13.81	68	0.75	0.70	10.6
Kahutta	Sandy loam	7.70	0.63	2.50	3.09	1.55	10.34	86	0.06	0.87	12.7
Khaur	Silt loam	7.80	0.38	3.00	1.92	1.88	3.26	96	6.30	0.47	16.5
Tirnaul	Silt loam	7.70	0.68	1.50	2.50	2.45	0.29	58	9.50	0.58	8.4

** $NaHCO_3$ extractable P; ** NH_4OAc extractable K; OM: Organic Matter; CEC: Cation Exchange Capacity.*

Table 2: *Effect of potash on fresh and dry weight of wheat grown in different soils.*

Soils	Fresh weight (g $plant^{-1}$)			Dry weight (g $plant^{-1}$)		
	K0	K150	Mean	K0	K150	Mean
Talagang	31.95 f-j	41.41 abc	36.68 BC	9.18 c-f	10.23 a-d	7.55 DEF
Thermal	35.80 c-g	36.04 mn	35.92BC	8.81 d-g	10.27 c-f	6.47 F
Bahtar	26.37j-m	29.25 h-k	27.93 CD	5.69 hi	8.19 d-g	7.40 DEF
Bassal	45.12 a	48.85 a	46.98 A	12.47 a	14.31 a	10.26 AB
Chaka	21.34 mn	28.11 i –l	24.73 EF	9.25 c-g	13.93 a	6.77 EF
Guliana	35.15 d-g	37.32 g-j	36.23 BC	8.37 efg	10.64 d-g	12.72 A
Missa	38.85 b-e	43.77 ab	41.31 AB	9.85 c-f	11.94 ab	8.06 C-F
Rajar	25.14 klm	40.97 a-d	38.28 AB	6.87 f-i	12.96 a	9.80 BCD
Satwal	33.96 e-h	35.17 d-g	34.57 BC	11.48 abc	13.42 ab	8.72 B-F
Balkasar	38.08 b-e	41.40 ab	39.74 BC	9.41 c-f	12.67 ab	9.02 B-F
Kahutta	25.10 klm	29.52 lmn	27.31 BC	6.98 f-i	7.54 i	10.40 ABC
Khaur	18.85 n	37.41 c-f	28.13 DE	5.66 hi	9.10 c-f	9.34 B-E
Tirnaul	35.55 c-g	38.15 c-l	36.85 BC	8.79 d-g	9.11 c-f	7.18 EF
Mean	31.63	37.47		7.93	9.62	
CV (%)	7.90			12.6		
LSD	Soils = 3.73 K-Levels = 2.12 Soils x K-Levels = 5.27			Soils = 1.63 K-Levels = 1.23 Soils x K-Levels = 2.31		

Mean separated by same upper or lower case letter under each column were not statistically different by the LSD; test at P≤0.05.

The data of various parameters were analysed statistically by "analysis of variance" technique. Duncan's multiple range tests was applied to determine the significant differences among treatments with the help of MSTAT-C Microsoft package while for correlation analysis and plotting graphs, Microsoft EXCEL package was used. The correlation studies among the soil K with K concentration in plant, and K uptake, agronomic parameters and yield of wheat were carried out according to statistical procedures (Steel et al., 1997).

Results and Discussion

Physical and chemical properties and parent materials from which the selected soils had been derived are presented in Table 1. The soils varied in texture and ranged from coarse to fine in texture. The soils were alkaline in reaction with pH ranging from 7.6 to 8.2, EC_e from 0.25 to 2.90 dSm^{-1} and HCO_3 1.5 to 3.32 mmol L^{-1}. The NO_3-N was in low range in almost all soils, P ranged from 0.29 to 11.79 mg kg^{-1} and K from 58 to 288 mg kg^{-1}. Organic matter content was less than 1% in all the soils except the Satwal soil. Calcium carbonate content varied widely and ranged from 0.06 to 14.3%. Cation exchange capacity of the soils varied from 8.4 to 21.6 $cmol_c$ kg^{-1} soils.

Fresh weight of wheat differed in plants grown in various soils. The plants grown in Bassal soil had the maximum fresh weight followed by Missa soil (Table 2). The lowest fresh weight was produced by plants of Khaur soil (18.85g $plant^{-1}$). Fresh weight produced by wheat in Balkassar, Guliana, Satwal, Talagang, Therpal, Tirnaul and Kahutta soils were at par statisticaly with each other. Soil and K interaction pertaining to plant fresh weight was significant and ranged from 18.85 in Khaur soil to 45.12g $plant^{-1}$ in Basal soil in control, while in K treated soils it ranged from 28.11 in Chakwal soil to 48.85g $plant^{-1}$ again in Basal soil. On overall basis, fresh weight of plants treated with K was found high as compared to control. In case of Khaur, it was doubled with K application.

The highest dry weight of 12.72g $plant^{-1}$ was produced by plants raised in Guliana soil and it was followed by Kahutta soil with 10.40g $plant^{-1}$ while the lowest of 6.47 g $plant^{-1}$ was recorded in Therpal soil. Talagang, Balkassar, Bahtar, Chakwal, Missa, Rajjar, Satwal, Bassal, Khaur, and Tirnaul soils plants were at par statistically with each other. Interactive effect of soil and K was significant and dry weight of plants grown without K application ranged from 5.66 to 12.47 g $plant^{-1}$, while in K treated plant it ranged from 7.54 to 14.31g $plant^{-1}$. In Talagang, Chakwal, Therpal, Bahatar, Guliana, Kahutta, khaur and Tirnaul soils, the magnitude of response to K was low as compared to other soils. On average, wheat response to applied K was positive; about 21% dry weights were obtained from plants treated with K as compared to control treatment (Table 2). As the most of the soils were low in soil extractable K, its application increased fresh and dry weight of wheat significantly in all the soils but the magnitude of response varied in different soils. The findings are in agreement with those stated by Sirajul et al. (1994). They revealed that potassium application enhanced the dry weight of wheat and also to those reported by Khan and Makhdum (1990) who reported the maximum wheat yield by K application at 60 kg K_2O ha^{-1}. Ahmed and Nazir (1978), Agarwal and Singh (1975), Sarma and Das (1982) and Davide et al. (1986) had also confirmed that K fertilization increased wheat yield by 10 to 15 per cent over that of nitrogen and phosphorus treatments alone or in combination. Krauss et al. (1996) also observed an increase in wheat yield with K application on a silty soil. Khan et al. (1994) reported the maximum yield of 4650 kg ha^{-1} with the application of K_2O @120 kg ha^{-1}, which was 29% more than grain yield of NP treatment alone. In another study, Bhatti et al. (1988) reported 16 % increase in wheat grain yield by K fertilization in NWFP soils of Pakistan. It has been reported that response of wheat to K is only realized at high levels of K application as advocated by Gething (1990). This may be attributed to equilibrium between the various forms of soil K and subsequently the degree of fixation/supply of K to the standing crop. Nabhan et al. (1989) made an attempt to throw more light on this aspect by reporting data from 684 trials in which they clearly indicated that an increase in yield of wheat up to 12% could be achieved with potassium application to highly and moderately responsive soils of the Punjab.

The results pertaining to effect of K fertilization on grain and straw weight of wheat is presented in Table 3. It is obvious from the data that averaged across soils the application of K fertilizer increased the grain weight significantly than control treatment. On an average, 26% more grain weight was attained by plants fertilized with K over control treatment. The grain weight of wheat varied significantly in plants grown in different soils. The maximum (10.4 g $plant^{-1}$) was recorded in plants grown in Guliana soil followed by Chakwal and Bassal soils, while the mean minimum of 8.1 g $plant^{-1}$ was observed in Talagang soil. The interactive effect of soils and K fertilization was significant and grain weight of wheat grown in different soils without K ranged from 6.92 in Kahutta soil to 9.72 g $plant^{-1}$ in Guliana soil, whereas in K fertilized plants it ranged from 8.66 g $plant^{-1}$ in Talagang soil to 11.15 g $plant^{-1}$ in Guliana soil. Similarly, straw weight of wheat was affectesd by K fertilization and an increasing trend was observed but it did not differ significantly as compared to control. On an average, 3.1% more straw weight was achieved by plants fertilized with K over control. The straw weight of wheat grown in different soils varied and

Table 3: *Effect of potash on grain and straw weight of wheat grown in different soils.*

Soils	Grain weight (g plant^{-1})			Straw weight (g plant^{-1})		
	K0	K150	Mean	K0	K150	Mean
Talagang	7.54 i	8.66 def	8.1 CD	14.54 b-f	14.97 ab	14.8 CDE
Thermal	7.67 i	9.26 ab	8.5 ABC	14.23 f	14.66 ab	14.4 C-F
Bahtar	8.87 gh	10.13 ab	9.5 AB	17.61 ab	19.2 a	18.4 A
Bassal	8.97 gh	11.08 a	10.0 A	11.41 ab	14.43 a-e	12.9 D-F
Chaka	9.13 fgh	10.84 ab	10.0 A	17.38 ab	17.65 ab	17.5 AB
Guliana	9.72 fgh	11.15 a	10.4 A	14.98 abc	16.48 ab	15.7 BC
Missa	7.68 i	10.52 ab	9.1 CD	10.83 c-f	12.2 b-f	11.5 EF
Rajar	7.51 i	9.88 a-d	8.7 BCD	13.34 ef	13.43 c-f	13.4 EF
Satwal	7.8 i	10.53 a-d	9.2 AB	11.55 c-f	12.96 a-d	12.3 CDE
Balkasar	7.61 i	10.2 ab	8.9 CD	13.34 b-f	15.84 b-f	14.6 CDE
Kahutta	6.92 d-g	9.85 ab	8.4 C	13.74 c-f	14.08 b-e	13.9 CDE
Khaur	8.69 gh	11.18 a	9.9 AB	11.84 f	13.13 def	12.5 F
Tirnaul	7.79 h	11.1 a	9.4 AB	10.86 c-f	11.69 c-f	11.3 EF
Mean	8.16 Y	10.34 X		14.1 X	14.54 X	
CV (%)	5.57			12.6		
LSD	Soils = 1.73 K-Levels = 2.12 Soils x K-Levels = 1.27			Soils = 2.20 K-Levels = 0.23 Soils x K-Levels = 3.21		

it ranged from 11.3g plant^{-1} in Tirnoul soil to 18.4 g plant^{-1} in Bahtar soil. Straw weight produced by plants grown in all other soils except Bahtar soil were almost at par statistically with one another. The soils and K fertilization interaction significantly affected the straw weight of wheat. The straw weight differed in soils without K application and ranged from 10.86g plant^{-1} in Tirnoul soil to 17.61 g plant^{-1} in Bahtar soil, Similar trend was observed in K fertilized plants it ranged from 11.69 g plant^{-1} in Ternoul soil to 19.2 g plant^{-1} in Bahtar soil.

In Pakistan and many other countries, it is considered that nitrogen is imperative for high yields and 120 kg N ha^{-1} is recommended for optimum yield. However, it is essential that along with such high N dressings, adequate P and K should be applied for realizing optimum crop yields. Brhane et al., 2017 applied different levels of K on wheat cropvand reported highest biological yield (straw+grain) and grain yields of wheat increased with K application.

Loue (1978) on the basis of results of 26 experiments conducted in France, concluded that response to extra-nitrogen (150 vs. 90 kg N ha^{-1}) increased wheat yield concurrently as the K application increased. Hence, application of K greatly increased the efficiency of N fertilizer. In the present study, K application increased the grain and straw yield but grain yield was more affected than straw yield. Similar finding have been reported by Abbas et al., 2013 that maximum 1000-grain weight (47.83 g) and yield (4533 kg ha (-1)) were achieved by the application of 93 kg of K2O ha (-1) on wheat crop. The results are also in conformity to those reported by Khan and Makhdum, (1990), who reported the maximum wheat yield by K application at 60 kg K_2O ha^{-1}. Ahmad and Nazir (1978), Saleem (1983), Agarwal and Singh (1975) and Davide et al. (1986) had also reported that K fertilization increased wheat yield by 10 to 15 per cent over that of nitrogen and phosphorus treatments alone or in combination. Krauss et al. (1996) also observed an increase in wheat yield with K application on a silty soil. Khan et al. (1994) reported the maximum yield of 4650 kg ha^{-1} with the application of K_2O @120 kg ha^{-1}, which was 29% more than grain yield of NP treatment alone. The yield obtained by the application of 120 kg K_2O was at par with 160 kg K_2O ha^{-1}. In another study, Adnan et al. (2016) reported significnt increase in wheat grain yield by N and K fertilization in NWFP soils of Pakistan. It has been reported that response of wheat to K is only realized at high levels of K application as advocated by Gething (1990). This may be attributed to equilibrium between the various forms of soil K and subsequently the degree of fixation/supply of K to the standing crop. Tariq et al. (2011) reported that K fertilization significantly increa growt and yield of maize in different textured soils of Haripur.

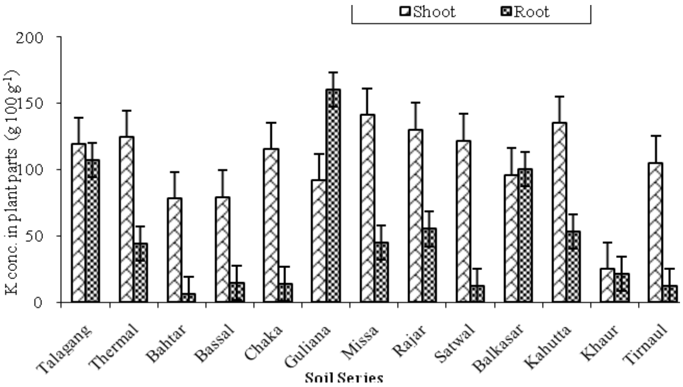

Figure 1: *Effect of K application on root and shoot K concentration of wheat.*

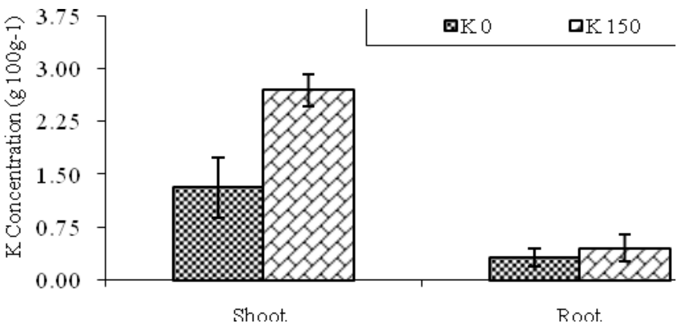

Figure 2: *Effect of K application on K conc. in plant parts of wheat in different soils.*

The response of wheat to applied K pertaining to potassium concentration in shoots varied significantly and ranged from 20% in shoot grown in Khaur soil to 140% in Missa soil (Figure 1). It was at par statistically in plants grown in Talagang, Therpal, Chakwal, Satwal, Rajar and Kahutta soils. Addition of 0.15 g K kg^{-1} increased K concentration in shoot as compared to control treatment and more than 100 percent response was recorded with respect to control treatment (Figure 2). As far as response of wheat to applied K regarding root K concentration is concerned, it differed in various soils; it was maximum in Guliana soil (160%) followed by Talagang (110%) and Balkassar (95%) soils, while the lowest in Bahtar (10%) soil. The magnitude of response in different soils varied and it was 100 % in Balkassar and Talagang soils, while in Guliana it was more than 150 %. On overall basis, 33 % more K concentration was observed in K treated plants as compared to control (Figure 2). Effect of K application on K concentration in different plant parts of wheat also varied, it was more in shoot as compared to root and magnitude of response to K was higher in shoot as compared to root (Figure 2).

Potassium uptake by plants in different soils varied and the maximum of 200.43 mg kg^{-1} was observed in Basal soil followed by Guliana, Missa and Balkassar soils whereas the minimum (97.33 mg kg^{-1}) was recorded in Khaur soil. Interactive effect of soils and applied K pertaining to K uptake was significant and ranged from 90.73 mg kg^{-1} in Khaur soil to 174.8 mg kg^{-1} in Basal soil in case of without K application. In K treated soils, it ranged from 103.9 mg kg^{-1} to 226.1 mg kg^{-1} again in Khaur and Basal soils, respectively (Table 4). This indicated that K application enhanced K uptake in all the soils under investigation (Figure 3 and 4). Wani et al., 2014 studied the response of wheat to different level and application methods to wheat, they reported that split application of potassium @80 kg K2O ha^{-1} was found superior to single basal application in terms of grain yield (43.20 q ha^{-1}) and K uptake (22.89 kg ha^{-1}) by grains at harvest. The results are in line with those of Gething (1990), application of K not only increased K and N uptake but it also helped in absorbing more P by wheat and ultimately helped in enhancing yield of wheat.

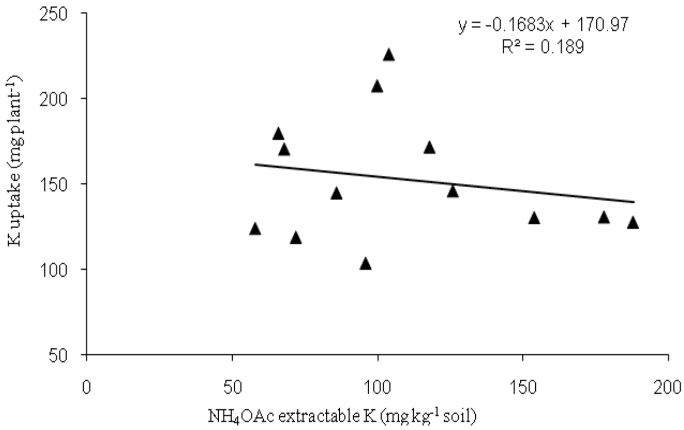

Figure 3: *Relationship between soil extractable K using NH_4OAc and K uptake by wheat grown in different soils.*

Correlation between the amounts of K extracted from soils by AB-DTPA and NH_4OAc extractants with K concentration, uptake, agronomic parameters of wheat was given in Table 5. The correlation coefficient between soil K and tillers plant^{-1}, plant height, fresh and dry weight, was r = 0.326, 0.403, 0.157 and 0.407 for AB-DTPA and 0.282, 0.384, 0.179 and -0.0.363 for NH_4OAc, respectively. In general, no consistent relationship was established between soils extractable K and the degree of wheat response to applied K, however, some trend of medium to high response of wheat to K had been observed. The results also indicated that the soil K had relatively stronger correlation with shoot and grain K concentration of wheat.

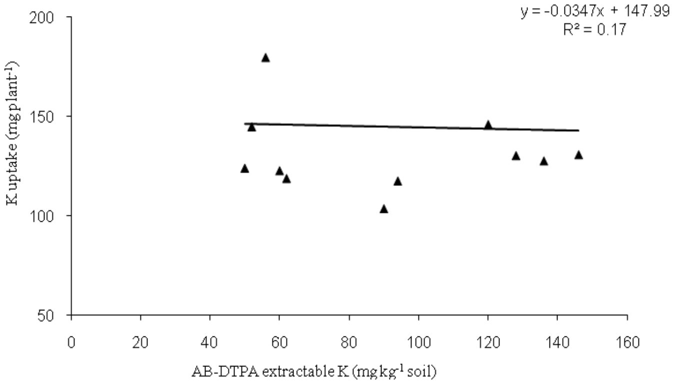

Figure 4: *Relationship between soil extractable K using AB-DTPA and K uptake by wheat grown in different soils.*

Table 4: *Effect of K application on K uptake by wheat grown in different soils.*

Soils	Total K uptake (g kg^{-1})		
	NKP00	NKP100	Means
Talagang	0.109 g-j	0.131 e-j	0.120 CD
Therpal	0.106 g-j	0.124 g-j	0.115 C-E
Bahtar	0.148 c-g	0.172 b-e	0.160 C
Basal	0.175 b-d	0.226 a	0.200 A
Chakwal	0.139 c-i	0.146 c-h	0.143 BC
Guliana	0.169 c-f	0.207.6 ab	0.189 A
Missa	0.135 d-i	0.180 bc	0.157 B
Rajar	0.101 ij	0.119 g-j	0.110 DE
Satwal	0.118 g-j	0.130 f-j	0.123 C-E
Balkassar	0.138 d-i	0.171 b-e	0.154 B
Kahutta	0.123 g-j	0.145 c-h	0.134 B-D
Khaur	0.091 j	0.104 h-j	0.097 E
Tirnaul	0.113 g-j	0.131 e-j	0.122 C-E
Mean	0.128 B	0.153 A	
CV (%)	15.59		
LSD	Soils = 0.025.42 K-Levels = 0.0122 Soils x K-Levels = 0.032		

The results also indicated that the soil K had relatively stronger correlation with grain K concenteration that indicates K role in increasing grain yield and this effect cannot be visualized in crop stand in the field. In general, NH_4OAc – K had showed better correlation with growth and yield parameters as compared to AB-DTPA extractable K (Table 5). Maftoon et al. (2004) observed significant simple correlation between the amount of K displaced by the extractants and K uptake. However, such correlation seems to be highest with NH_4OAc and lowest with AB-DTPA. Soltanpour and Workman (1985) observed that NH_4OAc-K showed a better correlation with dry matter yield, and K uptake by wheat than those of AB-DTPA-K extractant. Sirajul et al. (I994) reported that potassium application increased top dry weight, K concentration and K uptake by wheat. For instance, addition of 100 mg K kg^{-1} increased dry weight and K concentration and uptake by 9, 35 and 47 %, respectively, as compared to control treatment.

Table 5: *Relationship between soil extractable K and yield components of wheat.*

Parameters	Extractable K	
	AB-DTPA	NH_4OAc
Tillers plant^{-1}	0.326	0.282
Plant height (cm)	0.403	0.384
Fresh weight (g pot^{-1})	0.157	0.179
Dry weight (g pot^{-1})	0.407	0.363

Conclusions and Recommendations

The soil extractable K showed correlation with yield and growth parameters, K concentration in plant and uptake by wheat. As the soils under study had variable parent material and physical and chemical characteristics and the AB-DTPA extractable K had good correlation with that of NH_4OAc extractable K which indicated that AB-DTPA can be used safely for extraction and evaluation of soil K status and crop fertilization program in Pakistan.

Novelty Statement

Pottash is neglected nutrient in rainfed agriculture of Pakistan. The study highlighted the need of potash in agriculture and its impact on soil and crop productivity.

Authors' Contribution

Muhammad Zameer Khan: Designed and conducted the experiments, wrote the manuscript.
Sair Sarwar: Data collection and statistical analysis.
Ahmad Khan: Helped in conducting experiments and data analysis.
Razaullah Khan: Helped in editing the manuscript.
Munazza Yousra: Contributed in lab work.
Muhammad Ilyas: Helped in overall compiling of the manuscript.

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