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RESPONSE OF SOME WHEAT (*TRITICUM AESTIVUM L.*) VARIETIES TO FOLIAR APPLICATION OF N & K UNDER RAINFED CONDITIONS

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Abstract

Experiments were conducted at different sites to evaluate the response of wheat to foliar application of N and K under rainfed conditions of potohar region of Punjab. These studies were conducted to compare the effect of K (KNO_3 and KCl) sources as foliar application at different growth stages of wheat. The treatments were (1) Control (No spray); (2) K 0.5% solution (as KNO_3); (3) N & K 0.5% and 0.2 % solution (as KC+ Urea); (4) K @ 0.5% solution (as KCl); (5) N @ 0.2 % solution as Urea. Biological yield of wheat improved significantly with N and K application. The highest biological yield 10938 was obtained by foliar application of KCl along with nitrogen. The response of foliar potash application on Chakwal-86 wheat variety was significant among the different treatments. This study proved that both sources of potash i.e. KNO_3 and KCl are equally effective in increasing wheat yield and can be helpful in achieving maximum realizable yield. Nitrogen application improved the N and K content in the leaf tissues and uptake by plant which resulted in more production. Foliar application of potash at critical stages can be helpful in *barani* areas of Pakistan to realize optimum economic yield.

Introduction

Potassium is required by plants in much greater amounts than that of all the other soil supplied nutrients (Tisdale *et al*., 1985). Adequate supply of potassium fertilizer is necessary for sustainable crop production. Plants obtain K primarily from the soil in the form of K^+ which is also strongly absorbed by soil components. Particularly by clay particles and is, therefore, not readily mobile in soils (Brady, 1984; Tisdale, *et al*., 1985). Although, Potassium contents in Pakistani soils has traditionally been considered adequate for normal plant growth (Rashid *et al*., 1998). However awareness has been grown on the importance of K in crop production and need for potash have been realized in Pakistan (Rashid *et al*., 1998). Under continuous cropping, fertilizer responsive varieties with improved management practices are further resulting in K mining. Wheat crop can remove more than 400 kg K_2O ha^{-1} per year. It is estimated that wheat crop with 6 t/ha grain in a rice-wheat system will remove 187 kg N ha^{-1}, 55 kg P_2O_5 kg ha^{-1} and 252 kg K_2O ha^{-1} from soil IFA (1986). In the absence of K fertilizer or with low applied levels and intensive continuous cropping will result in the depletion of soil K reserves. Even soils which are initially well supplied with K will become deficient under such management system. Total consumption of K from soil by wheat having yield 10 t ha^{-1} varies from 160 to 242 kg K ha^{-1} (Kemmler, 1983). The use of N and P fertilizer has been established and potash has got least importance in the past and still now this element is being ignored. The potash use as mineral fertilizer is very low in Pakistan, (NFDC 1998) and the ratio of nutrient fertilizer (N: P: K) is imbalanced. The existing soil K reserves

will not be sufficient to supply with K for optimum crop yields. K reserves are being mined rapidly due to intensive cropping and use of high yielding varieties. Low response to applied K is indication of nutrient mining from the soil. The reason for low use of K in the country may be the economic status, low return from investment in cereals. However the farmers growing potato, sugarcane, vegetables, fruits especially banana growers are very carefully regarding the K fertilizer use.

As the potash use levels are low, the applied K to crops sometime do not responds, because applied K becomes fixed in the clay lattice and low K application hardly fulfill the soil thrust, that is why crops do not respond to applied K and yield is suffered. It does not become available to plant when needed, or plant cannot absorb through soils quickly and meet K requirements. Keeping in view the low response to soil applied K, foliar application of N and K sources was planned to see its effect on wheat crop. Foliar application has the advantage of its rapid absorption by the leaf tissues and efficient movement to the developing parts of plant ultimately in results increase in yield of crops (Heitholt, 1994; Howard & Gwathmey, 1995; Chang & Oosterhuis, 1995). Our objectives for these studies were (1) to evaluate K sources for foliar application, and (2) to optimize appropriate doses of N& K in foliar spray.

Material and Methods

A field experiment was conducted at NARC, Islamabad and Tamman Multan area of District Chakwal to study the effect of foliar application of nitrogen and two sources of Potash on biological and grain yield of wheat varieties during rabi 2003 to 2005. Basal N and P @ 100 and 60 kg ha^{-1} were applied at planting time. Five foliar treatments in different combinations having two sources of potash were; (1) Control (No spray); (2) K 0.5% solution in water (as KNO_3); (3) N & K 0.5% solution in water and 0.2 % solution in water (as KCl + Urea); (4) K @ 0.5% solution in water (as KCl); (5) N @ 0.2 % solution in water as Urea.

During 2004-05, water spray as an additional treatment was included in research plan to know, the response of wheat to water. The soil samples were taken from the each experimental sites before planting at two depths i.e., 0-15 and 15-30 cm. Chemical characteristics of the soil were determined; NO_3-N, P and K were extracted with AB-DTPA extractant for analysis. Nitrogen and phosphorus were determined by Auto analyzer and colorimetrically whereas K by flame photometer (Winkleman *et al*., 1990). The CO_3^{2-}, HCO_3^-, Cl^- and Ca^{2+}+ Mg^{2+} from saturated paste extract were determined using procedures given by U. S. Salinity Lab. Staff (1954). The plant tissues were sampled after three sprays and analyzed for N, P, K and Cl in plant tissues. Nitrogen was determined by auto analyzer, P calorimetrically, K by flame photometer and Cl by titration against Ag NO_3.

Chakwal-86, Chakwal-97, Margalla-99 and Bakhtawar wheat varieties were used as test varieties. The experiment was laid out in Randomized Complete Block Design in three replications. Plot size was 10x20 m at farmer's field, while at NARC the plot size was 10x 30 m. Basal dose of N and P_2O_5 was applied at the rate of 100 and 60 kg ha^{-1} respectively. Foliar fertilizers were sprayed at three growth stages i.e. booting, milking and grain filling stage. At maturity an area of one meter square from each treatment was harvested and other data regarding yield components was also recorded. All the data collected were subjected to analysis of variance to test the significance of treatments. The treatments mean were compared by using least significant difference (LSD) (Steel & Torri, 1986).

Results and Discussion

The experimental areas falls in medium to high rainfall of Potohar region while Tamman Multan in the low rainfall area. The soils of experimental sites were normal having pH range from 7.3 to 8.0, ECe, 0.17 to 1.07 dS m^{-1}. Nutrients status of soils is given in Table 1. The soils have adequate levels of N, P & K. Average content of NO_3– N was 20 mg kg^{-1} soil (Sultanpour *et al.*, 1987), extractable P 10 mg kg^{-1} soil (Olsen & Somer, 1982) and K 100 mg kg^{-1} soil (Sadiq, 1986). The soils were deficient in all three nutrients.

The result regarding plant tissue analysis showed that N contents improved with application of K as compared to control in chakwal 86. Phosphorus remained unaffected while K contents also improved with K application at Tamman Multan field area (Table 2). On average N, P and K contents in the plant tissue ranged from 0.75 to 1.00, 0.11 to 0.12 and 2.60 to 2.70 % respectively. In the same variety at NARC Islamabad, the trend was more or less similar during 2003-2005 to that of Tamman Multan regarding the plant nutrient contents in the plant tissue. However K contents in the plant tissue were low as compared to Tamman Multan, which ranged from 0.80 to 1.92 per cent. In Bakhtawar variety at NARC, N contents were low as compared to earlier varieties but the K contents were higher than Chakwal-86 at NARC Islamabad. Foliar application of N and K positively affected the plant tissue nutrient composition. Nitrogen increased with N and K application, maximum value was observed in N treatment as urea (Table 3). Results regarding biological yield of Chakwal-86 variety at Tammam Multan district Chakwal area during 2003-5 as affected by N & K application is given in Table 4. The highest biological yield of 10938 kg ha^{-1} was obtained by foliar application of K as KCl along with Nitrogen. This was followed by K as sole KCl, which gave the yield of 10675 kg ha^{-1}. The biological yield ranged from 8663 kg ha^{-1} in control to 10938 kg ha^{-1} in N + K as KCl + Urea treatments respectively.

Table 1. Soil Chemical characteristics of the experimental sites.

Locations	Depth (cm)	pH	Ece (dS m^{-1})	NO_3-N	P	K	Ca+Mg	Zn	HCO_3	Cl
				…… (mg/kg) ……			….……. (meq/L) ……..…….			
Tamman	0-15	7.5	0.36	1.33	1.01	74	16.66	0.52	9.5	2.0
	15-30	7.7	1.07	1.30	1.84	82	18.00	0.78	7.67	2.0
NARC	0-15	7.7	0.44	0.85	1.87	60	25.00	0.34	5.00	5.5
Site1	15-30	7.9	0.43	0.64	4.67	42	22.00	0.28	5.00	5.0
NARC	0-15	8.0	0.13	1.43	4.0	94	10.24	0.86	4.33	1.5
Site2	15-30	8.0	0.17	1.20	2.9	74	9.78	0.34	4.12	1.7
NARC	0-15	7.3	0.49	0.29	2.94	80	5.00	0.60	3.10	0.5
Site3	15-30	7.7	0.28	0.51	0.10	62	2.80	0.57	2.40	0.4

Table 2. Chemical composition of wheat leaf as affected by foliar N and K at Tamman Multan, Distt. Chakwal during 2003-2005.

Treatments	N	P	K	Cl
	(%)			
Control (No spray)	0.75 c	0.12	2.60 c	1.12
0.5% KNO_3 Solution	0.80 ab	0.12	2.90 b	1.13
0.5% and 0.2 % (as KCl + Urea Solution)	0.80 ab	0.12	2.80 ab	1.19
0.5 % as KCI Solution	1.00 a	0.12	3.00 a	1.17
0.2 % Urea Solution	0.90 b	0.11	2.70 bc	1.21
LSD 0.5%	0.1	NS	0.45	NS

Table 3. Leaf composition of wheat cultivars Chakwal-86 and Bakhtawar as affected by foliar N and K at NARC, Islamabad during 2003-2005.

Treatments	N		P		K		Cl	
	(%)							
	Ch-86	Bakht	Ch-86	Bakht	Ch-86	Bakht	Ch-86	Bakht
Control (No spray)	0.61 ab	0.25 c	0.105	0.103 b	0.80 c	1.64 a	0.23 c	0.32 bc
0.5% K as KNO_3 Solution	0.68 a	0.29 c	0.105	0.105 a	0.92 bc	1.68 a	0.50 ab	0.32 bc
0.5% K and 0.2 % N (as KCl + Urea Solution)	0.39 b	0.94 b	0.105	0.105 a	1.92 a	1.28 b	0.48 bc	0.42 b
0.5% K as KCI Solution	0.65 a	0.75 ab	0.105	0.105 a	1.16 bc	1.64 a	0.64 a	0.57 a
0.2% K Urea Solution	0.68 a	1.19 a	0.103	0.105 a	1.40 b	0.96 c	0.24 c	0.28 c
LSD 0.5%	0.21	0.61	NS	0.001	0.39	0.30	0.21	0.12

Table 4. Response of wheat cv. Chakwal-86 to foliar application of K at Tamman Multan district Chakwal during 2003-2005.

Treatment	Bio-mass (kg/ha)	Grain wt. (kg/ha)	1000-sed wt. (g)	VCR
Control (No spray)	8663 d	2724 d	32.1 c	
0.5% K as KNO_3 Solution	9975 bc	3238 bc	53.2 b	11: 1
0.5% K and 0.2 % N (as KCl + Urea Solution)	10938 a	3575 a	39.0 a	22: 1
0.5 % K as KCI Solution	10675 ab	3500 ab	38.4 a	21: 1
0.2 % N Urea Solution	9250 cd	3060 c	34.7 b	10: 1
LSD 0.5%	873	278	2.42	-

The grain yield ranged from 2724 to 3575 kg ha^{-1}, the highest grain yield was obtained in KCl + Urea, followed by sole KCl treatment. The KNO_3 application increased yield but the magnitude of response was lower compared to KCl + Urea treatment. In case of thousand grain weight, highest value was also observed in KCl and KCl + Urea treatment, which were significantly higher than all other treatment including control treatment. As far as VCR is concerned the highest value was observed in KCl + Urea applied treatment, followed by sole KCl and KNO_3 while lowest VCR 9.7: 1 was obtained in sole N as urea compared to other treatments including control. Similar beneficial effects of K foliar spray have also been observed by Chapagain & Wiesman (2004), but the potential mechanisms for these effects have not been investigated. Increase in yield by foliar application of K was also observed by Hartz *et al*., (2005).

The response to foliar potash application on Chakwal-86 wheat variety was significant among the different treatments (Table 5). The highest biomass yield of 6750 kg ha^{-1} was obtained with the N & K application as KCI along with urea. This was significantly higher over control and N as urea treatment followed by K as KCI alone which gave the yield of 6521 kg ha^{-1} biomass. Applications of K as KNO_3 alone gave the yield of 6370 kg ha^{-1} which was significantly higher as compared to control. This shows that foliar application of K increased the yield which supports the research findings of Defan e*t al*., (1986). Grain yield was also affected positively with K application, KCl alone treatment gave significantly higher (3750 kg ha^{-1}) as compared to all other treatments. This was followed by the KNO_3 application, which was 3091-kg ha^{-1}. As for as value cast ratio (VCR) is concerned, maximum return was obtained from KCI treatment which was 33: 1, it means that expending one rupees as input will return rupees 33. In the KCI+ Urea and sole Urea treatments the VCR was at par to each other. Lower VCR was observed in KNO_3-K compared to KCl-K source. The effect of K application was also significant on 1000 grain weight (TGW). TGW were improved with N and K application. These findings agree with research conducted by Milley & Oosterhuis (1994), but differ from those of Mullins & Ooesterhuis (1995); however, Miley & Ooesterhuis (1994) reported higher total lint yields from K foliar applied.

Table 5. Response of wheat cv. Chakwal-86 to foliar application of K at NARC, Islamabad during 2003-2005.

Treatments	Bio-mass	Grain Yield (kg/ha)	1000 grain weight(g)	VCR
Control (No spray)	5500 b	2490 d	30.1	-
0.5% K as KNO_3 Solution	6370 a	2737 c	34.0 b	5.3
0.5% K and 0.2 % N (as KCl + Urea Solution)	6750 a	3091 b	36.3 a	15.5
0.5 % K as KCI Solution	6521 a	3750 a	36.0 a	33.9
0.2 % N Urea Solution	6130 ab	3010 b	34.0 b	15.0
LSD 0.5%	748	211	1.36	-

Table 6. Response of wheat cv. Bakhtawar to foliar application of K at NARC, Islamabad during 2003-2005.

Treatment	Bio-mass	Grain weight	1000 seed wt.	VCR
	(kg ha^{-1})	(kg ha^{-1})	(g)	
Control (No spray)	7976 d	2010 d	32.1 b	
0.5% K as KNO_3 Solution	9140 a	3025 a	39.0 a	21.5
0.5% K and 0.2% N (as KCl + Urea Solution)	8650 b	2890 ab	40.8 a	22.5
0.5 % K as KCI Solution	8620 bc	2780 b	38.6 a	20.3
0.2 % N Urea Solution	8350 c	2421 c	37.2 a	11.5
LSD 0.5%	278	208	4.57	

In case of Bakhtawar variety at NARC the trend of response was similar to chakwal-86 wheat variety however; response was more to KCl, as compared to KNO_3 source (Table 6) which gave the biomass of 9140 kg ha^{-1}. This was followed by N + K and then N alone, while, the applications of K as KCI alone showed very low response than the other treatment except control. Grain yield of 3025 kg ha^{-1} was obtained with the application of KNO_3, which was significantly higher as compared to control and N treatment both K sources significantly differed as compared to control and sole N treatments respectively. Thousand grain weights remained unaffected with N and K treatments but significantly differed as compared to control treatment.

Results showed that maximum grain yield was obtained from foliar KCl + Urea treatment which is 45% greater than control. Potash as KNO_3 showed positive response of biomass production. The grain yield increased by N and K treatments, maximum response to K as KCl was observed followed by KNO_3 and N + K treatment. The results of two wheat varieties grown during 2003-05, are given in the (Table 7& 8). Data regarding growth parameters showed non-significant response to foliar N and K treatments, whereas biomass and grain yield significantly affected with foliar K application. Maximum biomass yield of 10950-kg ha^{-1} was observed in K as KNO_3 treatment, followed by N + K as KCl + Urea and as KNO_3 treatment. More or less similar trend was observed in case of grain yield. The data regarding yield components of Margalla-99 variety during 2003-05 is given in Table 7. The result showed that there is a positive of response to foliar K regarding biomass and grain yield, but the trend of response to K, sources differed than that of Chakwal-97 variety. This variety responded to KCl more effectively as compared to KNO_3 sources, which means the choice of this variety is for KCl not for KNO_3.

Table 7. Response of wheat (Chakwal-97) to foliar application of K at NARC, Islamabad during 2003-05.

Treatment	Plant Ht. (cm)	Tiller Plant^{-1}	5 ear Length (cm)		Biomass (kg ha^{-1})	Grain yield (kg ha^{-1})	Spike. Wt.	
			Sec.	pri.			Pri.	Sec.
Control (No spray)	85	5	6	11	7810 c	3310 c	3.4 c	2.8
0.5% K KNO_3 Solution	84	5	6	10	8170 c	3416 c	3.6 bc	3.0
K and N @ 0.5% and 0.2% (as KCl + Urea Solution)	84	6	6	11	10950 a	4784 a	4.0 a	3.0
0.5 % as KCI Solution	86	5	6	10	10730 a	3913 b	3.9 a	3.0
0.2 % Urea Solution	84	6	6	11	9660 b	4890 a	4.1 a	3.1
	84	5	6	11	9360 b	3760 b	3.6 bc	2.6
LSD 0.5%	NS	NS	NS	NS	614	310	0.3	NS

Table 8. Response of wheat (Margalla-99) to foliar application of K at NARC, Islamabad during 2003-05.

Treatment	Plant Ht. (cm)	Tiller Plant^{-1}	Length of 5 spike (cm)		Biomass (kg ha^{-1})	Grain yield (kg ha^{-1})	Spike. Wt.	
			Sec.	pri.			Pri.	Sec.
Control (No spray)	88	6	7	12	6930 d	2270 c	3.2	2.3
0.5% KNO_3 Solution	93	5	7	11	7080 cd	2710 bc	3.8	2.6
K and N @ 0.5% and 0.2 % (as KCl + Urea Solution)	91	6	7	10	7210 cd	2900 b	3.8	2.9
0.5 % K as KCI Solution	93	6	7	11	8420 a	3400 a	3.3	2.4
0.2 % N Urea Solution	93	6	7	10	8000 b	3250 a	3.5	2.8
	92	5	7	11	6980 c	2770 bc	3.3	2.7
LSD 0.5%	NS	NS	NS	NS	412	260	NS	NS

The trend of response was different in case of grain yield; maximum grain yield was obtained from KCl treatment followed by KNO_3 and then KCl + Urea treatment. These findings agree with research conducted by Miley & Ooesthuis (1994) but differ from those of Mullins and Burmester (1995). Result regarding water spray indicated an increase in biomass and grain yield by 4.6 and 3.2% respectively, which is very low as compared to N and K treatments. If we exclude the response due to water, even then the response to N as urea is 10% and to potash on overall basis 25%. On average response of two varieties to foliar N and K application regarding biomass and grain yield was positive. Biomass significantly increased with N and K application. Application of KNO_3 produced highest biomass in all the treatments followed by KCl + Urea and KCl treatment. In case of grain yield the maximum yield was obtained with KCl followed by KCl + Urea and then N as urea and lastly with KNO_3 treatment. Ooesterhuis (1993) pointed out that the peak demand for K is at boll fill, with greater need by the plant for K.

Conclusion

Foliar K application improved wheat yield. Those findings gave clue about the fertilizer application techniques to enhance yield and net benefit from agri business. It also indicated that at later growth stage fertilizer use in foliar form can also be helpful to maximize net benefit. Moreover one should keep in mind not to omit soil application because foliar use is only for meeting urgent requirement otherwise it will lead to K missing.

References

Aydeniz, A. and A.R. Brohi. 1981. Effect of aerial spray of urea on yield and yield components of Pak-70 wheat variety. *A.U. Ziraat Fak. Yilligi, cilt: 29, fasikul: 2, Ankara.*

Brady, N.C. 1984. Supply and availability of phosphorus and potassium. p. 327-362. In: *The nature and properties of soils*. (Ed.): N.C. Brady. 9th ed. MacMillan Publ. Co., New York.

Chang, M.A., and D.M. Oosterhuis, 1995. Effect of foliar application to cotton of potassium compounds at different pH levels. P 1364-1366. In: (Ed.): D.A. Richter. *Proc. Beltwide cotton Conf., San Antonio. TX. 4-7 Jan1995. Natl. Cotton Council of America, Memphis, TN*.

Chapagain, B.P and Z. Wiesman. 2004. Effect of Nutri-Vant-Peak foliar spray on plant development, yield, and fruit quality in greenhouse tomatoes. *Sci. Hort*., 102: 177-188.

Hartz, T.K., P.R. Johnstone, D.M. Francis and E.M. Miyao. 2005. Processing tomato yield and quality improved with potassium fertigation. *Hoert Science*, 40:1862-1865.

Heitholt, J.J .1994. Supplemental boron, boll retension percentage, ovary carbohydrates and lint yield in modern cotton genotypes. *Agron. J*., 86:492-497.

Howard, D.D and C.O. Gwathmey. 1995. Surfactant effect on potassium uptake by cotton from foliar KNO_3 application. *J. Plant Nutr*., 18: 2669-2680.

Mathur, B.N., N.K. Agrawal and V.S. Singh. 1968. Effect of soil versus foliar application of urea on the yield American cotton variety '320'. *Indian J. Agric. Sci*., 38: 811-815.

Milay, W.N. and D.M. Ooesterhuis. 1994. Three-year compaign of foliar feeding of cotton with five potassium sources. P. 1534-1536. In: (Ed.): D.J. Herber *Proc. Beltwide cotton conference San Diego, CA. 5-8 Jan. 1994. Natl. Council of America , Memphis, TN*.

Mullins, G.L. and C.H. Burmster. 1995. Response of cotton to the source of foliar potassium. P 1313-1315. In: (Ed.): D.A. Richter. *Proc. Beltwide cotton conf., San Antonio, TX, 4-7 Jan. 1995. Natl. Cotton Council of America, Memphis, TN*.

Olsen, S.R. and L.E. Somers. 1982. Phosphorus: In: (Ed.): A.L. Page. *Methods of soil analysis, Agron. 9. Part 2, 2nd Edition. Am. Soc. Agron., Madison, Wisc., USA.*

Steel, R.G.D. and J.H. Torrie. 1980. *Procedures of statistics* (2nd Edition) McGraw Hill Book Co., Inc. New York, USA.

Winkleman, E., R. Amin, W.A. Rice and M.B. Tahir. 1990. *Methods manual soil laboratory*. BARD, PARC, Islamabad.

Walter, B., W. Koch and D. Bastgen. 1973. Experiences and results of urea foliar application to Grapes. Weinberk und Keller. 20: 265-274.

Olsen, S.R. and L.E. Somers. 1982. Phosphorus: In: (Ed.): A.L. Page. *Methods of soil analysis, Agron. 9. Part 2, 2nd Edition. Am. Soc. Agron., Madison, Wisc., USA.*

Oosterhuis, D.M. 1993. Foliar fertilization of cotton with potassium p-34-63. In: (Ed.): L.S. Murphy. *Foliar fertilization of soybeans and cotton. PPI and FAR Spec. Publ. Potash nd Phosphate Institute and foundation for Agronomic Research, Norcross,GA.*

Rashid, M., Bashir and Akhtar 1998. Plant nutrient management under rainfed conditions. *Proceeding of symposium of symposium on (plant nutrients management for sustainable agriculture growth) NFDC*. pp. 111-119.

Rice, W.A., M.E. Akhtar, Y. Rohul Amin and J.A. Campbell. 1988. Wheat response to nitrogen and phosphorus fertilizers in rain fed areas of Pakistan: In: *Proc. 3rd regional workshop on soil test calibration in west Asia and North Africa 3-9 September 1988. Amman, Jordan*. pp. 52-65.

Sadiq, M. 1985. Potash status in Pakistan soils. *Proc. XII Int. Forum of Soil Taxonomy and Agrotechnology Transfer*: 113-118.

Saleem, M.T. 1983. Water and Fertilizer management for wheat in Pakistan. *17th Coll. Int. Potash Institute*, 1983.

Sharma, Rad Das N. 1982. Response of draft wheat to NPK and Ca. *Indian J. Plant Physiol*., 25: 364-370.

Siddique, T., J. Aslam and M. Ilyas. 1997. Response of wheat to potassium application in different soil series of Punjab. *Pak. J. Soil Sci*., 13(1-4): 92-96.

Soltanpour, P.N., M. El Gharous, A. Azzaoui and M. Abdelmonem. 1987. Nitrogen and phosphorus soil-test calibration studies in the Chaouia region Morocco: In: *Proc. Second regional workshop on soil test calibration in west Asia and North Africa 1-6 September 1987. Ankara,Turkey*. pp. 67-81.

Tisdale, S.L., W.L. Nelson and J.D. Beaton. 1985. Soil and fertilizer potassium, p. 249-291. In: *Soil fertility and fertilizers*. (Eds.): S.I. Tisdale, W.I. Nelson and J.D Beaton. 4th ed. MacMillan publ. Co., New York.

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