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PHYSIOLOGICAL RESPONSES OF POTASSIUM EFFICIENT AND NON-EFFICIENT WHEAT GENOTYPES

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ABSTRACT

Potassium deficiency in the soils of Pakistan is spreading rapidly and has become one of the most important nutritional limiting factors for increasing crop yield. Due to rapid to depletion of soil potassium and increasing cost of potassium fertilizer in Pakistan, the potassium efficient genotypes have become very important for agricultural sustainability. Keeping this important issue in view, water culture experiment was conducted to evaluate wheat genotypes for potassium uptake and use efficiency. Six wheat genotypes namely SD-4085/3, SD-222, SD-502, NIA-8/7, NIA-MB-II and 22-03 were collected from Plant Breeding and Genetics Division, Nuclear Institute of Agriculture (NIA), Tando Jam, Sindh, Pakistan. The experiment was carried out in completely randomized design (CRD) with two treatments i.e. adequate-K (3.0 mM) and deficient K (0.3 mM) in polyethylene lined iron tubs with three replicates. Data showed significant variations among the genotypes for shoot and root length (cm), shoot and root fresh, shoot and root dry weight (g plant-1), total dry weight (g plant-1), shoot and root potassium concentrations (mg g-1dry wt), shoot and root uptake (mg plant-1), chlorophyll content (mg g-1 fresh wt) and nitrate re-educates activity (µ mol g-1 fresh wt h-1). Generally, K-deficiency decreased biomass production, K-uptake and K-use efficiency, however higher genetic potential genotypes maintained their growth and potassium accumulation even at low K-level. The genotype 22-03, NIA-8/7 and SD-502 exhibited comparatively less relative reduction (%) in most of the growth and physiological parameters, showing that these genotypes have potential to grow well under deficient-K condition.

Keywords: Potassium deficiency, Potassium efficient genotypes, wheat genotypes

1. INTRODUCTION

Wheat (*Triticum aestivum*L) is the important crop of Pakistan. It is cultivated on an area of 9.042 million hectares with production of 23.864 million ton with an average yield of 2639 kg ha^{-1} contributing 3 percent to GDP to economy of Pakistan (Anonymous, 2013-14). This yield is alarmingly low compared to other wheat growing countries of the world (Shahnaz *et al*., 2009).

Potassium is the third major element in plant nutrition and is vital for many important metabolic functions. After nitrogen, plants require K in larger amounts than any other element. Its total reserves in the soil are generally adequate and it is the seventh most abundant element in the soils of the world (Elington, 1980). However in Pakistan agriculture, this important element is being generally ignored due to very high cost of the fertilizer (Zia *et al.*, 2011) and due to general consensus that soils of Pakistan contain sufficient amount of K due to dominance of illite in their clay fraction (Ranjha *et al.*, 1990). In Pakistan potassium is being used only @ of 0.8 kg ha^{-1} yr^{-1} (Ahmad and Rashid, 2003), (Ashiq *et al.*, 2011)as compared to world average which is 15.1 kg ha^{-1} (Anonymous, 2007).Due to negligible use of this element, the increase in cropping intensity and the introduction of high yielding crop varieties have resulted in depletion of soil potassium reserves, which in turn caused an annual deficit of 0.265 million tons of K from Pakistani soils (Bajwa, 1994), (Rafique *et al.*, 2012). In soils of Pakistan although total soil K is quite high but its release fails to meet the immediate K requirement of crops. As potassium fertilizer is very costly therefore this study will be fruitful for poor grower's community as they can grow K-efficient genotypes which have the ability to uptake potassium even from K-deficient as well as K sufficient soil.

2. MATERIALS AND METHODS

The water culture experiment was conducted at Nuclear Institute of Agriculture (NIA), Tando Jam during Rabi season 2014-15 by creating two potassium levels i.e. adequate-K (3.0 mM) and deficient-K (0.3 mM). The experiment was carried out in completely randomized design (CRD) and each treatment was replicated thrice. Six wheat genotypes namely, SD-4085/3, SD-222, SD-502, NIA-8/7, NIA-MB-II and 22-03 were collected from Plant Breeding and Genetics Division, Nuclear Institute of Agriculture (NIA), Tando Jam, Pakistan. Seeds were germinated in plastic bowls and transplanted into foam plugged holes of thermocol sheet floating on iron tubs (0.6m x 0.6 m x 0.15 m) containing 20 L half strength Johnson's modified solutions (Johnson *et al.*, 1957).The basal composition of nutrient solution (mM) was N 8.0, P 0.25, Ca2.0, Mg 1.0, S 2.0, B 0.025, Zn 0.002, Cu 0.0005, Mo 0.0005 and EDTA 0.04. Seedlings were harvested fourteen days after transplantation and separated cautiously into shoots and roots, thoroughly washed with distilled water and blotted dry. The fresh and dry weight of shoot and root were recorded and the samples were fine ground in a Wiley mill to pass through 1 mm (40 meshes) sieve. Uniformly ground samples were digested in di-acid mixture of nitric (HNO_3) and per caloric acid ($HClO_4$) in a 3.1(Miller, 1998). The potassium concentration (mg g^{-1} dry wt.) of shoot and root were determined using flame photometer (PFP-7, Jenway). Potassium uptake (mg $plant^{-1}$) was computed using formula shoot K uptake = SDW x SKC and root K uptake = RDW x RKC (mg g^{-1} dry weight). Potassium use efficiency (KUE) was determined by dividing SDW (g $plant^{-1}$) with SKC (mg g^{-1} dry wt.) or KUE = (1/K concentration in shoot x SDW) (Siddiqi and Glass, 1981). Potassium stress factor (KSF) was calculated using the following formula: SDW adq-SDW def / SDW adq *100. Nitrate reeducates activity was determined following the method of (Jordon, 1984). While Chlorophyll contents were measured using the method of Lichten thaler, 1987.

3 .RESULTS AND DISCUSSIONS

Shoot and root length (cm)

Shoot and root length of wheat genotypes grown under adequate and deficient-k level is presented Table 1. The genotype SD-222 exhibited significantly higher (23.50 cm) and genotype SD-502 lower (0.90 cm) shoot length respectively under adequate-k level. Under deficient-k significantly higher shoot length was observed by the genotypes SD-222 (17.76 cm) while the genotype 22-03 (13.53 cm) showed significantly lower shoot length. The genotype SD-502 has increased shoot length by (1484.4 %) and highly decreased in genotype NIA-8/7 under deficient-k was (501.11 %). The genotype NIA-MB-II showed significantly higher root length (19.13cm) and genotype 22-03 (17.90 cm) under adequate-k, while under deficient-k significantly higher root length was observed by the genotype NIA-MB-II (15.90 cm), followed by in genotype SD-222 (13.26 cm). The wheat genotype 22-03 (64.78 %) and genotype NIA/8/7 (8.43 %) has increased their root length under deficient-k. The results fully supported by (Yan *et al.*, 2008) for adequate-k and deficient-k.

Table 1. Effect of adequate-k, deficient-k on the shoot length and root length (cm) of different wheat genotypes

Genotypes	**Shoot length (cm)**		Relative decrease/increase (%)	**Root length (cm)**		Relative decrease/increase (%)
	Potassium level			Potassium level		
	Adequate -K	Deficient - K		Adequate -K	Deficient - K	
NIA-8/7	2.60 b	15.63 bc	50.12	13.40 b	14.53 ab	-8.5
22-03	1.90 b	13.53 d	61.26	17. 90 a	14.80 ab	-17.3
SD-4085/3	1.63 b	16.80 ab	99.90	15.40 ab	13.50 b	12.3
SD-502	0.90 b	14.26 cd	14.85	14.80 ab	13.63 b	7.9
SD- 222	23.50 a	17.76 a	24.40	15.53 ab	13.26 b	14.6
NIA-MB-II	22.76 a	16.90 ab	25.77	19.13 a	15.90 a	16.9
Mean	15.81 a	15.81 a		14.36 a	15.55 a	
Tukey HSD (0.05)	1.830	2.256		3.893	4.453	

Mean values followed by similar letters in the same column do not differ at significantly p≤0.05 and values in the parenthesis (%) increase over adequate-k

Shoot and root fresh weight (g plant^{-1})

The statistical analysis of variance indicated that all varieties of wheat were highly significant for fresh shoot and root and data are presented Table 2. Shoot fresh weight of wheat genotypes grown under adequate and deficient-k Table 2. Under adequate-k significantly higher shoot fresh weight was found in the genotype SD-222 (2.26 g plant^{-1}), while significantly lower shoot fresh weight under grow in SD-502 (1.03g plant^{-1}). Under deficient-k levels increased the shoot fresh weight in the genotype 22-03 (1.27 g plant^{-1}) and significantly lower shoot fresh was observed in the genotype SD-4085/3 (0.50 g plant^{-1}). Superior performance increase in the genotype 22-03 (5.83 %) and maximum relative decreased was found in genotypes SD-502 (19.42 %). Root fresh weight of the genotypes grown under adequate and deficient-k in genotype SD-222 exhibited significantly higher root fresh weight (2.62g plant^{-1}), whereas significantly lower root fresh weight under was grown in NIA-8/7 (0.63 g plant^{-1}). Under deficient-k levels, where the higher root fresh weight was recorded in the genotype NIA-MB-II (1.03 g plant^{-1}) and lower shoot fresh weight in the genotype SD-4085/3 (0.35g plant^{-1}) and significantly higher performance the genotype 22-03 was observed (35.82 %). The maximum relative decreased in the genotypes SD-502 (5.88 %). The root fresh weight showed significantly difference between K- levels. The results support by (Ashraf *et al*., 2013).

Table 2. Effect of adequate and deficient-k on the shoot, root fresh weight (g plant^{-1}) of different wheat genotypes

Genotypes	**Shoot fresh weight (g plant^{-1})**		Relative decrease/increase (%)	**Root fresh weight (g plant^{-1})**		Relative decrease/increase (%)
	Potassium level			Potassium level		
	Adequate -K	Deficient - K		Adequate -K	Deficient - K	
NIA-8/7	1.09 e	0.74 e	31.78	0.63 e	0.55 e	12.02
22-03	1.20 d	1.27 a	(5.36)	0.67 d	0.91 b	(35.06)
SD-4085/3	1.28 c	0.50 f	60.51	0.86 c	0.35 f	59.21
SD-502	1.03 f	0.83 d	19.37	0.68 d	0.64 d	5.91
SD- 222	2.26 a	0.95 b	57.92	2.62 a	0.78 c	70.09
NIA-MB-	1.56 b	0.93 c	40.18	1.94 b	1.03 a	46.99

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Mean	1.40 a	0.87 b		1.23 a	0.71 b	
Tukey HSD (0.05)	0.0179	0.0158		0.0124	0.0080	

Mean values followed by similar letters in the same column do not differ at significantly p≤0.05 and values in the parenthesis (%) are % increase over adequate-k

Shoot and root dry weight (g plant^{-1})

Shoot and root dry weight is considered to be the most important plant responses parameter to nutrient deficiency. It is generally used as a selection measure for evaluating genotypes under nutrient deficiency at seedling stage. The statistical analysis of variance indicated that all varieties of wheat were highly significant for dry shoot and root weight and data are presented Table 3. The shoot dry weight under adequate in the potassium showed significantly higher in genotype SD-222 (0.26 g plant^{-1}), followed by significant variation in the genotypes and NIA-8/7 (0.15 g plant^{-1}).Under deficient-k higher shoot dry weight was found in the genotypes 22-03 (0.18 g plant^{-1}) and minimum decreased in the genotype SD-4085/3 (0.07 g plant^{-1}), The highly increase value (5.88 %) and potassium stress factor KSF (%) variation decreased observed in the genotypes SD-502 (22.00 %).Root dry weight of different wheat genotypes as performed under adequate-k showed significantly higher root dry weight (0.18 g plant^{-1}) in genotype SD-222 and low root dry weight was observed (0.07 g plant^{-1}) in genotype NIA-8/7,22-03,SD-502 under adequate-k. Under deficient-k in the genotypes 22-03 showed higher root dry weight (0.10 g plant^{-1}and decreased the root dry weight in genotypes SD-4085/3 (0.03 g plant^{-1}). The genotypes 22-03 showed maximum relative increased (42.86 %) and relative decreased in the wheat genotypes SD-502 (14.29 %). The results are agreement with well documented that general plant health can be guessed on the basis of a number of growth parameters. Amongst different parameters, shoot and root dry weight are considered to be the most sensitive plant response parameter to nutrient deficiency and is given a pivotal place in screening experiments (Fageria*et al.*, 1988; Gill *et al.*, 2005; Fageria*et al.*, 2010). It is, therefore, generally used as a selection criterion for evaluating genotype for nutrient efficiency at seedling stage and results also agreed with (Umer 2006) who observed that significant increase in root dry weight by the increase in application of adequate k.

Table 3. Effect of adequate and deficient-k on the shoot, root dry weight (g plant^{-1}) of differentwheat genotypes

Genotypes	**Dry shoot length (g plant^{-1})**		Relative decrease/increase	**Dry root length (g plant^{-1})**		Relative decrease/increase

	Potassium level		(%)	Potassium level		(%)
	Adequate -K	Deficient - K		Adequate -K	Deficient - K	
NIA-8/7	0.15 f	0.10 e	31.82	0.07 f	0.05 e	15.74
22-03	0.17 c	0.18 a	-5.32	0.07 e	0.10 a	-37.70
SD-4085/3	0.17 d	0.07 f	55.56	0.08 c	0.03 f	57.63
SD-502	0.15 e	0.12 d	21.98	0.07 d	0.06 d	11.93
SD- 222	0.26 a	0.13 c	50.24	0.18 a	0.08 c	56.96
NIA-MB-II	0.18 b	0.13 b	26.44	0.12 b	0.08 b	32.71
Mean	0.18 a	0.12 b		0.10 a	0.07 b	
Tukey HSD (0.05)	0.0160	0.0058		0.0012	0.0054	

Mean values followed by similar letters in the same column do not differ at significantly p≤0.05 and values in the parenthesis (%) increase over adequate-k

Shoot and root potassium concentrations (mg g^{-1}dry wt)

The statistical analysis of variance indicated that all varieties of wheat were highly significant for shoot, root dry weight and data are presented Table 4. The genotype SD-222 exhibited significantly higher shoot potassium concentrations (68.66 mg g^{-1} dry wt.), followed by at par in the genotypes NIA-8/7 (67.33 mg g^{-1} dry wt.), NIA-MB-II (66.00 mg g^{-1} dry wt.), while as significantly lower shoot potassium concentrations was found in 22-03 (52.67 mg g^{-1} dry wt.) under adequate-k. Significantly higher shoot potassium concentrations under deficient-k in the genotype 22-03 (10.24 mg g^{-1} dry wt.), followed by NIA-8/7 (10.00 mg g^{-1} dry wt.), while lower shoot potassium concentrations was observed at par in the genotypes SD-4085/3 and SD-502 (9.28 mg g^{-1} dry wt.) with. Significantly higher shoot potassium concentrations increase in the genotype SD-222 (85.79 %), and decreased percentage in the genotype 22-03 (80.56 %).The genotype SD-222 exhibited significantly higher root potassium concentrations (59.33mg g^{-1} dry wt.), whereas lower root potassium concentrations was exhibited by SD-502 (38.66 mg g^{-1}dry wt) at adequate-k. The genotype NIA-8/7 (34.20 mg g^{-1}dry wt), and minimum root potassium concentrations in the genotype SD-222 (25.36 mg g^{-1}dry wt) under deficient-k. The genotype SD-222 showed maximum increased (57.26 %) and minimum decreased percentage in the genotypes NIA-8/7 (17.91 %). The increase in root dry weight hydroponically grown in wheat

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genotypes and proposed that under- k deficiency wheat can translocation more k from root to shoot to cope with k deficiency stress. Potassium concentration of shoot indicates the efficiency of plants to take up from k deficient growth medium and uptake is the total amount of k that actually taken up by plant in producing shoot dry weight at a particular stage of growth and results fully supported by (Asharf*et al*., 2011). Potassium concentration differed with k treatment, while the differences among the genotypes were significantly in 3.0 mM k treatment and maximum k uptake was observed at deficient k level and results agreed with (Clark, 2003).

Table 4. Effect of adequate and deficient-k on the shoot, root potassium concentrations (mg g^{-1} dry wt.) of different wheat genotypes

Genotypes	**Shoot potassium concentrations (mg g^{-1} dry wt.)**		Relative decrease/increase (%)	**Root potassium concentrations (mg g^{-1} dry wt.)**		Relative decrease/increase (%)
	Potassium level			Potassium level		
	Adequate -K	Deficient - K		Adequate -K	Deficient - K	
NIA-8/7	67.33 a	9.64 a	85.68	41.66 b	34.20 a	17.92
22-03	52.67 b	10.24 a	80.56	44.00 b	30.00 a-c	31.82
SD-4085/3	59.00 ab	9.28 a	84.26	44.00 b	27.06 bc	38.48
SD-502	58.00 ab	9.28 a	83.99	38.66 b	26.53 bc	31.38
SD- 222	68.66 a	9.76 a	85.79	59.33 a	25.36 c	57.25
NIA-MB-II	66.00 a	10.00 a	84.85	58.00 a	32.50 ab	43.97
Mean	61.94 a	9.70 b		47.61 a	29.27 b	
Tukey HSD (0.05)	11.637	3.086		6.432	6.367	

Mean values followed by similar letters in the same column do not differ at significantly p≤0.05 and values in the parenthesis (%) increase over adequate-k

Shoot, root potassium uptake (mg $plant^{-1}$)

The statistical analysis of variance indicated that all varieties of wheat were highly significant for shoot and root dry weight and data are presented Table 5. The genotype SD-222 exhibited significantly higher shoot potassium uptake (18.32 mg plant^{-1}), whereas significantly lower uptake was observed in SD-502 (9.23 mg plant^{-1}) under adequate-k. 22-03 in the genotype significantly high shoot potassium uptake (1.90 mg plant^{-1}) and lower uptake genotype SD-4085/3 (0.72 mg plant^{-1}) under deficient-k.The genotypes SD-4085/3 showed (92.97 %) and SD-222 (92.92 %) decrease in shoot potassium uptake. The minimum relative decreased in the genotypes 22-03 (79.57 %). Root potassium higher uptake in the genotype SD-222 (11.20 mg plant^{-1}), while lower uptake was found (2.93 mg plant^{-1}) in genotype NIA-8/7 under adequate-k. The genotypes 22-03 showed (3.15 mg plant^{-1}), followed by (1.01 mg plant^{-1}) in SD-4085/3 in shoot potassium uptake.The genotypes SD-222 showed maximum increase (81.61 %) in root potassium uptake, while minimum in the genotypes 22-03 (6.25 %). All genotype showed relatively more K-uptake in roots than shoot under deficient-K condition but the magnitude of response is genotype dependent. Generally Potassium is not known to affect root growth but it has been recently reported by (Tischner*et al.*, 2000 and Zhao *et al.*, 2001) that k significantly improved rooting system in dicots. Root and shoot dry weight by enhancing total K-uptake under deficiency stress. As potassium is diffusion supplied nutrient thus the efficiency of plant to uptake potassium under its deficiency stress largely depends upon root morphology, root hair, root exudates, and release of potassium from non-exchangeable pool (Demon and Rengel, 2008). Potassium uptake differed due to k treatment; however the differences among the genotypes were significant only in 3.0 mM potassium treatment. Wheat genotypes grown with 3.0 mM potassium had about 6 fold and 11 fold higher up-takes as compared with deficient k. The maximum potassium uptake was observed at deficient- k level.

Table 5. Effect of adequate and deficient-k on the shoot, root potassium uptake (mg plant^{-1}) of different wheat genotypes

Genotypes	**shoot potassium uptake (mg plant^{-1})**		Relative decrease/increase (%)	**Root potassium uptake (mg plant^{-1})**		Relative decrease/increase (%)
	Potassium level			Potassium level		
	Adequate -K	Deficient - K		Adequate -K	Deficient - K	
NIA-8/7	10.37 bc	1.01 bc	90.23	2.93 d	2.03 b	30.87
22-03	9.30 c	1.90 a	79.50	3.36 cd	3.15 a	6.24
SD-4085/3	10.24 bc	0.72 c	92.97	3.89 c	1.01 c	73.97
SD-502	9.23 c	1.15 b	87.47	3.04 cd	1.84 b	39.61
SD- 222	18.32 a	1.29 b	92.92	11.20 a	2.06 b	81.59

NIA-MB-II	12.25 b	1.36 b	88.85	7.44 b	2.80 a	62.29
Mean	11.62 a	1.24 b		5.31 a	2.15 b	
Tukey HSD (0.05)	2.0973	0.3792		0.9049	0.4352	

Mean values followed by similar letters in the same column do not differ at significantly p≤0.05 and values in the parenthesis (%) increase over adequate-k

Total dry weight (g)

The statistical analysis of variance indicated that all varieties of wheat were highly significant for total dry weight and data are presented Table 6. The data of total dry weight of wheat genotypes grow under adequate-k showed significantly higher total dry weight was recorded in genotype SD-222 (0.45 g), followed by (0.31 g) in genotype NIA-MB-II and lowest total dry weight was recorded (0.22 g) in genotype NIA-8/7 under adequate-k. Under deficient-k it was noted that total dry weight was observed the genotype 22-03 (0.29 g) and low concert was showed in the genotype SD-4085/3 (0.11 g). The genotypes 22-03 showed (16.00 %) increase in total dry weight and minimum relative decrease in the genotypes SD-502 (17.39 %). It is generally noted that shoot and root are interdependent, shoot attains nutrient through root while root depend on shoot for photosynthesis. In this study, wide differences were observed among genotypes for root dry weight at each k level (Asharf*et al*., 2011).

Table 6. Effect of adequate and deficient-k on the total dry weight (g) of different wheat genotypes

Genotypes	**Potassium level**		**Relative decrease/increase (%)**
	Adequate -K	**Deficient - K**	
NIA-8/7	0.22 f	0.16 e	26.77
22-03	0.25 d	0.29 a	-15.10
SD-4085/3	0.26 c	0.11 f	56.25
SD-502	0.23 e	0.19 d	18.62
SD- 222	0.45 a	0.21 c	53.03
NIA-MB-II	0.31 b	0.22 b	28.98

Mean	0.29 a	0.20 b	
Tukey HSD (0.05)	0.0017	0.0010	

Chlorophyll content (mg g^{-1} fresh wt)

The statistical analysis of variance indicated that all varieties of wheat were highly significant for chlorophyll content and data are presented Table 7. Chlorophyll content (mg g^{-1} fresh wt) of wheat grown under adequate-k showed the genotype SD-4085/3 exhibited significantly higher chlorophyll (1.33mg g^{-1} fresh wt) and lower variation was observed in the genotype SD-222 (0.75 mg g^{-1} fresh wt). under the deficient-k results showed that maximum chlorophyll content was observed (1.05 mg g^{-1} fresh wt) in the genotype SD-4085/3 followed by (0.67 mg g^{-1} fresh wt) was noted in genotype NIA-8/7. The relative increase chlorophyll content in the genotypes SD-502 (27.19 %) and minimum relative decreased was recorded by the genotypes SD-222 (3.07 %). The genotypes SD-502 increase its chlorophyll content by 27.19% under deficient-k, which showed the genotype has the capability to retain its chlorophyll contents ever under deficient-k condition and reduced photosynthetic activity which reported by (Cakmak, 2005). Generally higher chlorophyll contents under adequate-k, low under deficient-k and also effected and results noted by (Liu, J.X. *et al*., 2000).

Table 7. Effect of adequate and deficient-k on the chlorophyll content (mg g^{-1} fresh wt.) of different wheat genotypes

Genotypes	**Potassium level**		**Relative decrease/increase (%)**
	Adequate -K	**Deficient - K**	
NIA-8/7	1.085 b	0.675 f	37.79
22-03	0.912 c	0.850 c	6.80
SD-4085/3	1.333 a	1.046 a	21.53
SD-502	0.743 d	0.945 b	-27.19
SD- 222	0.748 d	0.725 d	3.07
NIA-MB-II	1.004 b	0.681 e	32.17
Mean	0.971 a	0.820 b	
Tukey HSD (0.05)	0.124	0.0026	

Nitrate reeducates activity (µ mol g^{-1}fresh wt h^{-1})

The statistical analysis of variance indicated that all varieties of wheat were highly significant for nitrate reeducates activity and data ate presented Table 8. Nitrate reeducate is a first inducible nitrogen metabolism enzyme significantly higher under adequate-k indicated that the genotype NIA-8/7 and 22-03 were at par (0.75 and 0.73µ mol g^{-1} fresh wt h^{-1}), followed by genotypes SD-4085/3 (0.68µ mol g^{-1} fresh wt h^{-1}) and minimum in NIA-MB-II (0.43 µ mol g^{-1} fresh wt h^{-1}). Nitrate reeducate activity under deficient-K significantly higher was in the genotype NIA-8/7 (0.57 µ mol g^{-1} fresh wt h^{-1}), and lower nitrate reeducate activity was in the genotype NIA-MB-II (0.15 µ mol g^{-1}fresh wt h^{-1}). The maximum relative decreased in the genotype NIA-MB-II (65.12 %) and minimum relative decreased in genotype NIA-8/7 (24.00).Nitrate reeducates activity can be used as a biochemical tool for predicting grain yield and grain protein production. Under adequate-k condition increase in NRA is attributable to the fact that k activities more than low enzyme and lowest reduction in NRA activity in the genotype NIA-8/7, showed that maintained enzyemulation activity ever under deficient condition. Similar foundlings for same efficient genotypes regarding enzymation activities were also reported by (Boyer, 2002) and also result agreed with (Khanna *et al*., 1980, Sharma).

Table 8. Effect of adequate & deficient-k on the nitrate reeducates activity(µ mol g^{-1}fresh wt. h^{-1}) of different wheat genotypes

Genotypes	Potassium level		Relative decrease/increase (%)
	Adequate -K	Deficient - K	
NIA-8/7	0.75 a	0.57 a	23.68
22-03	0.73 a	0.34 b	53.21
SD-4085/3	0.68 ab	0.33 b	51.32
SD-502	0.61 b	0.23 bc	61.34
SD- 222	0.49 c	0.20 c	57.98
NIA-MB-II	0.43 c	0.15 c	63.68
Mean	0.61 a	0.30 b	
Tukey HSD (0.05)	0.1140	0.1059	

CONCLUSION

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Nutrient use efficient genotypes have potential to grow and yield extensively well under nutrient deficiency stresses by efficiently acquiring and utilization nutrients from deficient environments by means of their particular physiological mechanisms. Our result demonstrated differences among wheat genotypes for potassium use efficiency and potassium uptake under K deficiency stress. Potassium use efficiency had significant positive correlation with potassium uptake, concluding that an integration of these two most important plant characters could be used for selection of wheat genotypes under k deficient environment. The genotypes 22-03, NIA-8/7, SD-502 had higher potassium use efficiency among all the genotypes evaluated. It was concluded from this study that wheat genotypes differ in growth responses and potassium use efficiency when grown at deficient and adequate-K level.

REFERENCES

Ahmed, N. and M. Rashid. 2003. Fertilizers and their use in Pakistan. (3rd Ed) Training Bulletin, NFDC, Islamabad.

Analytical Software, 2005. Statistix 8.1 User’s Manual, Tallahassee, FL.

Anonymous, 2013. Economic survey of Pakistan finance division, Economic Adviso Wing, Islamabad Pakistan.

Anonymous. Economic Survey of Pakistan. 2007. Ministry of Food, Agriculture and Livestock (Federal Bureau of Statistics), Islamabad.

Ashiq Saleem, Habib Iqbal Javed, Rashid Saleem, Muhammad Ansar and M. Amir Zia. 2011. Effect of split application of potash fertilizer on maize and sorghum in Pakistan. Pakistan J. Agric. Res. 24(1-4): 31-34.

Ashraf, M., M. Afzal, R. Ahmad and S. Ali. 2011. Growth and yield components of wheat genotypes as influenced by potassium and farm yard manure on a saline sodic soil. Soil and Environment, 30: 115-121.

Ashraf, M.Y., N. Rafique, M. Ashraf, N. Azhar and M. Marchand. 2013. Effect of supplemental potassium ($K+$) on growth, physiological and biochemical attributes of wheat grown under saline conditions. Journal of Plant Nutrition, 36: 443-458.

Bajwa, M.I.1994. Soil potassium status, potash fertilizer usage and recommendations in Pakistan. Potash Review No. 3/1994. Subject 1,20th suite.International Potash Institute, Basel.

Boyer, P.D. 2002. A research Journey with ATP synthesis. J. Biological Chemistry. 277: 39045-39061.

CakmakIsmail .2005.The role of potassium in alleviating detrimental effects of abiotic stresses in plants. J. Plant Nutrition and Soil Sci., 168(4): 521-530.

Clark, R. B, 2003. Physiology of cereals for mineral nutrient uptake use and efficiency In Ballenger, V. C, Duncan, R.R, (eds). Crops as Enhancers of Nutrient Use. Academic Press, San Diego CA, pp. 131-209.

Damon, P.M and Z. Rengel. 2008. Crops and genotypes differ in efficiency of potassium uptake and use. Physiol. Plant 133: 624-636.

Elington, C.P., 1980. The production and age of potassium In: Potassium for Agriculture- A situation Analysis. Pub. Potash and Phosphate Institute. Canada.

Fageria, N.K. A.B. Santos and M.F. Moraes. 2010. Yield Potassium Uptake and Use Efficiency in Upland Rice Genotypes. Common. Soil Sci. Plan., 41: 2676-2684.

Fageria, N.K., R.J. Wright and V.C. Baligar, 1988. Rice cultivar evaluation for phosphorous use efficiency. *Plant Soil*, 111: 105–9.

Gill M.A. M.A. Tahir, Rahmatullah and A. Yusuf. 2005. Genotypic variation of chickpea (*Cicer arietinum* L.) grown under adequate and K deficiency stress in hydroponics culture. Pak. J. Agri. Sci.,42 (1-2): 22-26.

Johnson, C. M, R. R, Stout, T. C. Broyer and A. B, Carlton, 1957. Comparative chlorine requirements of different species. Plant Soil. 8: 327-353.

Jordon, 1984.Circadian rhythmicity of nitrate reductase activity in barley leaves. Agricultural Univ. of Norway, Dept of Botany. N-1432 Ås-NLH, Norway.

Kausar, A., M.Y. Ashraf, I. Ali, M. Niaz and Q. Abbass. 2012. Evaluation of sorghum varieties/lines for salt tolerance using physiological indices as screening tool. Pakistan J. Bot., 44(1): 47-52.

Khanna Chopra R, G.S. Chaturvedi, P.K. Aggarwal and S.K. Sinha. 1980. Effect of potassium on growth and nitrate reductase during water stress and recovery in maize. Physiologia Plantarum, 49: 445-500.

Liu, J.X., and X.E. Yang. 2000. Genotypic differences in potassium nutrition for rice plant (Oryza sativa L.) and their relationship with rice production. Common. Plant Physiol. 36:384-387.

Lichen, and H.K, Thaler, 1987. Chlorophyll and carotenoids pigments of photosynthetic bio membranes. Methods enzyme. 148:350-382.

Miller, R.O. 1998. Nitric – per choric wet acid digestion in on open vessel. In. YP. Kalra (ed.) Handbook of reference methods for plant analysis, CRC press, Washington, DC., U.S.A. 57-62.

Rafique, E., Mahmood-ul-Hassan, M., Rashid, A., Chaudhary, M.F. 2012. Nutrient balances as affected.

Ranjha, A.M., A. Jabbar and R.H. Qureshi. 1990. Effect of amount and type of clay minerals on potassium fixation in some Alluvial soils of Pakistan. Pak. J. Agri. Sci. 27: 187-192.

Shahnaz, A., Arifullah, F. Anwar, Chishti, Muhammad Zulfiqar, Ghazala Yasmeen, Neelum Farid and Iftikhar Ahmad. 2009. Estimating yield potential of the major crops and its implications for Pakistan's crops sector. Sarhad J. Agric. 25(4): 611-615.

Siddiqi, M.Y. ard A D, Glass. L981. Utilization Index: A modified aproached to the estimination and comperation of nutrients utilization efficiency in plant. Journal of plant nutrients, 4:289-302.

Tischner, R. 2000.''Nitrate uptake and reduction in higher and lower plants. Plant, cell and environment. 23(10): 1005-1024.

Umar, S. 2006. Alleviating adverse effects of water stress on yield of sorghum, mustard and groundnut by potassium application. Pakistan J. Bot., 38:1373-1380.

Yan-bo Jia, Xiao-e Yang, Ying Feng, and Ghulam Jilani. 2008. Differential response of root morphology to potassium deficient stress among rice genotypes varying in potassium efficiency.J Zhejiang Univ. Sci. B. 9(5): 427-434.

Zhao, D., D.M. Oosterhuis and C.W. Bednarz. 2001. Influence of potassium deficiency on photosynthesis, chlorophyll content, and chloroplast ultra structure of cotton plants.

Zia-ul-hassan, M. Arshad and A. Khalid, 2011. Evaluating potassium use efficient cotton genotypes using different ranking methods. J. Plant Nutr., 34: 1957-1972.