



Growth and yield performance of different wheat genotypes under various potassium levels

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Abstract

Wheat requires potassium for its optimal growth and development. Adequate potassium supply can increase the quality of the plants by improving crop against biotic and abiotic stresses. Current study was carried out to observe overall performance of wheat genotypes under various potassium levels during 2014-15. The experiment was set under completely randomized design (CRD) with factorial arrangements in three replications. Present study displayed that growth and yield mechanisms of different wheat genotypes positively responded under adequate and deficient K levels. The results showed that mean values under adequate K level were found highest ($P < 0.05$) i.e. 100.0 cm plant height, 23.0 tillers plant⁻¹, 21.0 spikes plant⁻¹, 17.0 cm spike length, 60.0 grains spike⁻¹, 37.0 g seed index value, 24000.0 kg ha⁻¹ biological yield and 7700.0 kg ha⁻¹ grain yield in SD-4086/3 genotype respectively, as compared to the deficient K level i.e. 85.0 cm plant height, 18.0 tillers plant⁻¹, 17.0 spikes plant⁻¹, 15.0 cm spike length, 46.0 grains spike⁻¹, 32.0 g seed index value, 20000.0 kg ha⁻¹ biological yield and 7000.0 kg ha⁻¹ grain yield in SD-4086/3 genotype respectively. Furthermore, the genotypic response at both adequate and deficient K levels in all observations were recorded lower in genotype NIA-MB-II. Whereas, overall performance of all genotypes under adequate and deficient K levels was satisfactory but genotype SD-4085/3 responded better than other genotypes in each character. It could be concluded that genotype SD-4085/3 seems to be performed excellent under adequate and deficient potassium environment.

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Introduction

Wheat (*Triticum aestivum* L.) is the most important food crop grown during the rabi season among the cereal crops of the Pakistan and it is ranked on first as compare to the other cereal crops (Lak *et al.*, 2013) and the second most important grain feeding cereal crop in the whole world followed by maize. Generally, crop yield depends on genetic makeup of seed, soil fertility/soil nutrients, environmental effects and their interactions. Wheat is the highly essential and primarily used as a staple food grain providing adequate protein than other cereal crops of Pakistan. It is consumed in many types like cakes, bread, biscuits and different other products. It is also an excellent source of feedstuff for poultry and livestock in Pakistan. Wheat grain contributes 53 to 59 percent of the different types of regular calories as well as protein in the daily consumption for humans (Landes and Mark, 1993). Wheat grain flour helps living organisms in biochemical mechanisms, includes (68%) biological multiple compounds like simple carbohydrate or complex carbohydrate, (15.4%) protein substances, and (12.2%) fibers, correspondingly (Anjum *et al.*, 2005). Among the sixteen essential mineral nutrients, the potassium (K) is a key mineral substance for crops, its active and successive role in bio-chemical processes of plant is to make various types of enzymes active, protein synthesis, biological compounds and fat assimilation through the (K) create drought tolerances, frost resistance, lodging, photosynthesis, stomatal movement and water relation (turgor regulation and osmotic adjustment), to protect the many type of insect pests as well as pathogenic problems (Marschner, 1995 ; Egilla *et al.*, 2001). It plays a vital role in the organic structure and metabolic functions of the plants (Celik *et al.*, 2010). Beside that through the potassium increases better plant dry matter production and leaf area development as well as it is effective for the plants tissues and helps water retention when plants are under severe water stress conditions (Lindhauer, 1985). Therefore potassium deficit in soil may cause lower yield, and also create disturbing condition in the physiological and biochemical activities under the plant cell organs (Ali *et al.*, 2008).

Keeping in view the importance of potassium, different wheat genotypes were selected to observe the influence of adequate and deficient potassium levels on growth and yield attributes under both conditions.

Materials and methods

Plant Material and Experimental Arrangements

A sand culture experiment was organized in rain protected wire netted house of the Plant Physiology Division, Nuclear Institute of Agriculture (NIA) Tandojam during Rabi season 2014-15. The five wheat genotypes, viz. SD-4085/3, SD-222, SD-502, NIA 8/7 and NIA-MB-II were collected from Plant Breeding and Genetics Division, Nuclear Institute of Agriculture (NIA), Tandojam, Sindh, Pakistan. The experiment was laid out under completely randomized design (CRD) with factorial arrangement in three replicates. Experiment was conducted in the cemented tanks receiving net plot size i.e. 4.4 m x 4.5 m (19.8 m²). The tanks were filled with nutrient free Indus river sandy soil having an EC 0.48 dS m⁻¹, pH 7.4 and organic matter 0.8%. The tanks were artificially irrigated with ground/tap water for the given period. The seeds of all genotypes in fresh, healthy and disease free state were seed primed in (3%) potassium hypochlorite only for 10 minutes. After seed treatment the treated seeds were sown under moist sandy soil conditions within the tanks with the help of single row hand dibbler. The row length 2.0 m, row to row distance 20 cm and plant to plant distance 10 cm, were maintained throughout the experiment. From start of the experiment, routinely soil samples were taken for the identification of nutrient status as well as irrigation requirement.

K levels and Nutrient Solution Composition

Potassium nutrient solutions i.e. adequate K (3.0 mM) and deficient K (0.3 mM) were prepared from the source of Potassium Nitrate (KNO₃) and applied to the treatments as per their requirements. The other basic nutrients solutions were prepared as per crop requirements from the Johnsons solution recipe (Johnson *et al.*, 1957).

Growth and Yield Parameters

Healthy plants were selected randomly for recording growth parameters i.e. Plant height (cm), Tillers plant⁻¹, Spikes plant⁻¹, Spike length (cm) at the maturity stage of the crop from each treatment and average was worked out for further analysis. Furthermore, the yield traits for example grains per spike, seed index, biological yield (kg ha⁻¹) and grain yield (kg ha⁻¹) were recorded after harvesting of the crop. Biological and grain yield (kg ha⁻¹) were recorded by using the following formulas:

$$\text{Biological yield (kg ha}^{-1}\text{)} = \frac{\text{Biological yield (kg plot}^{-1}\text{)} \times 10000}{\text{Plot size (m}^2\text{)}}$$

$$\text{Grain yield (kg ha}^{-1}\text{)} = \frac{\text{Grain yield (kg plot}^{-1}\text{)} \times 10000}{\text{Plot size (m}^2\text{)}}$$

Statistical analysis

The data so collected was tabulated and analysed for Analysis of variance (ANOVA) by using computer statistical program student edition of statistics (Sxw), version 8.1 (copyright, 1996. Analytical software, USA).

Table 1. Various concentration and source of nutrients applied in solution.

Nutrient Elements	Concentrations in the solutions (mM)	Nutrient resources
N	6.0	NH ₄ NO ₃
P	0.2	Ca (H ₂ PO ₄) ₂
Ca	2.0	CaSO ₄
Mg	1.0	MgSO ₄
S	3.5	ZnSO ₄ .7H ₂ O
Cl	50.0	MnCl ₂ .4H ₂ O
B	25.0	H ₃ BO ₄
Mn	2.0	MnCl ₂ .4H ₂ O
Zn	2.0	ZnSO ₄ .7H ₂ O
Cu	0.5	CuSO ₄ .5H ₂ O
Mo	0.5	MoO ₃
Fe-EDTA	50.0	FeSO ₄ .7H ₂ O

However, the lowest plant height (72.0 cm) was recorded in genotype NIA-MB-II at the same K level. While in the deficient K level maximum plant height 85.0 cm was observed in SD-4086/3 genotype, followed by the average mean value were recoded as (78.0, 71.0, 63.0 cm) in SD-222, SD-502 and NIA 8/7 genotypes, respectively. Whereas the smallest plant height 55.0 cm was observed in NIA-MB-II genotype under the deficient K level.

The significance of difference among means was compared by used least significant difference (LSD 0.05) test.

Results and discussion

Plant height

The statistical analysis indicated that the plant height of wheat genotypes varied significantly (P<0.05) among the Potassium levels as well as interactive effect of potassium levels with genotypes were also found to be statistically significant (P<0.05) (Fig.1).

The results showed that SD-4086/3 genotype performed excellent with significantly higher (P<0.05) plant height (100.0 cm) followed by the moderate performed genotypes SD-222 (92.0cm), SD-502 (85.0cm) and NIA8/7 (78.7cm) respectively.

The present study results were supported by Ahmad *et al.* 2007) observed that potassium fertilizer applications moderate the favorable effects on plant growth and yield. Similarly (Iftikhar *et al.*, 2002) notified that applying of various NPK levels has achieved significant effect on plant height, in Inqulab-91 wheat variety were noted within the treatments of 105-75-75 kg NPK ha⁻¹.

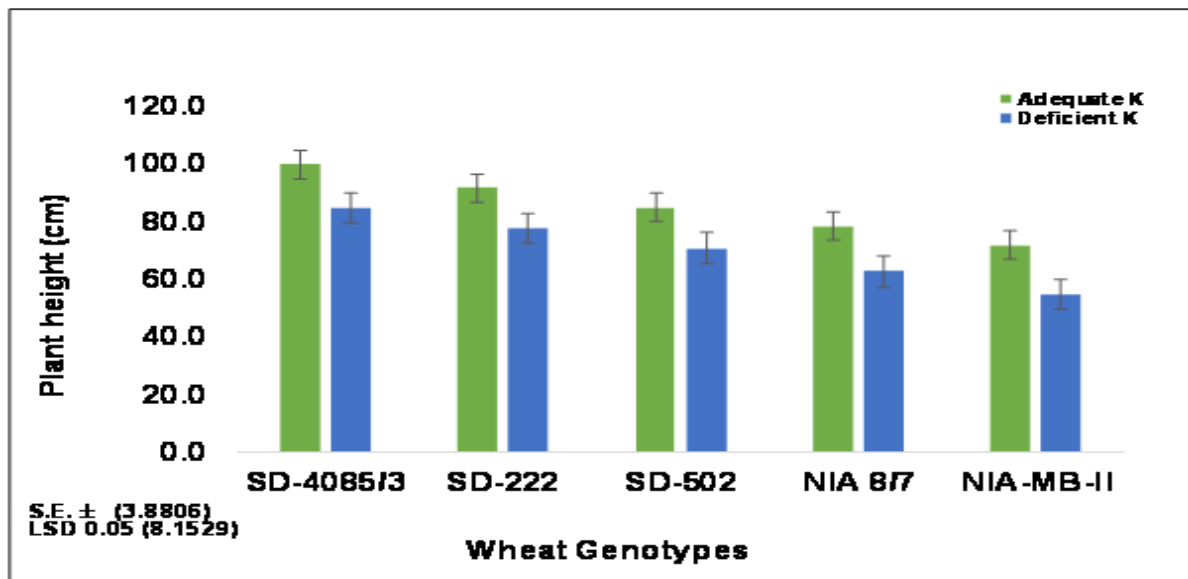


Fig. 1. Plant height of wheat genotypes as affected by potassium levels.

Tillers plant⁻¹

The better performance of wheat genotypes treated with K levels (adequate) observed for the tillers plant⁻¹ 23.0 in SD-4086/3, followed by 20.0, 17.0, 14.0 and 13.0 in SD-222, SD-502, NIA 8/7 and NIA-MB-II genotypes, respectively (Fig.2). However under the

deficient K level maximum tillers plant⁻¹ 18.0 was noted in SD-4086/3, than that of tillers plant⁻¹ 15.0, 12.0 and 9.0 found in SD-222, SD-502 and NIA 8/7 genotypes respectively, while the minimum value for the tillers plant⁻¹ 6.0 was recorded in NIA-MB-II genotype under the similar deficient K treatment.

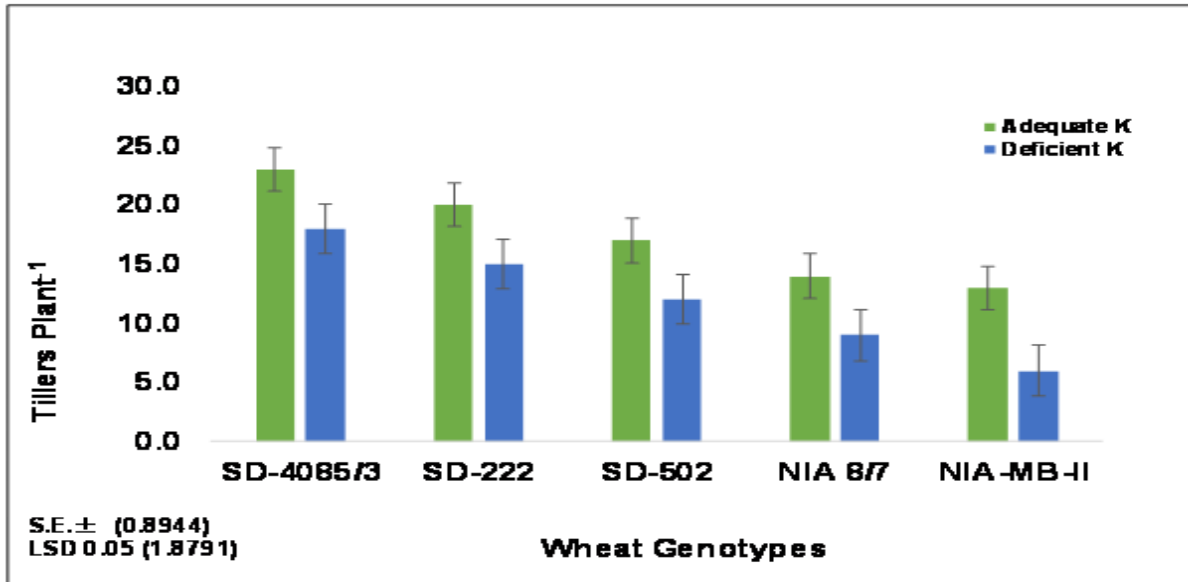


Fig. 2. Tillers plant⁻¹ of wheat genotypes as affected by potassium levels.

Our findings were extremely supported by several previous studies; (Iftikhar *et al.*, 2002) claimed that use of various NPK levels remarked significant effect on number of tillers per plant, in wheat variety Inqulab-91 within these treatments 105-75-75 kg NPK ha⁻¹.

In another report authors (Baraich *et al.*, 2008) proved that special effect of K and P on growth and yield features and produced the maximum number of tillers plant⁻¹ (6.36 plant⁻¹), by using maximum rate of K.

Spikes plant⁻¹

The statistical analysis exposed that the Spikes plant⁻¹ of wheat genotypes varied significantly ($P < 0.05$) within the genotypes as well as within the treatments (Fig.3). The results indicated that there was significant variation between genotype to genotype.

The maximum ($P < 0.05$) mean value for spikes plant⁻¹ were detected 21.0 in SD-4085/3 genotype, 18.0, 14.0, 11.0 and 9.0 in (SD-222, SD-502, NIA 8/7 and NIA-MB-II) genotypes, respectively, under the adequate K level.

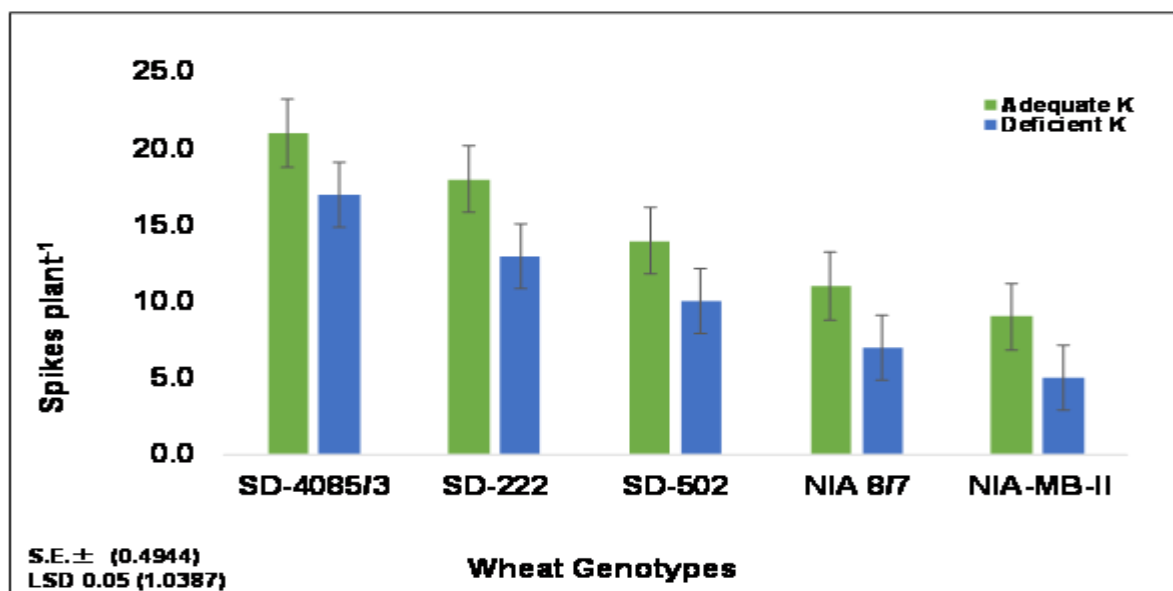


Fig. 3. Spikes plant⁻¹ of wheat genotypes as affected by potassium levels.

The Spikes plant⁻¹ of similar wheat genotypes treated with deficient K level revealed 17.0 Spikes plant⁻¹ (SD-4086/3), 13.00 (SD-222), 10.0 (SD-502), 7.0 (NIA 8/7) and 5.0 (NIA-MB-II) respectively. These findings are in accordance with (Hamouda *et al.*, 2015)

reported that growth status of wheat plants as affected by potassium application in sandy soil, they achieved very respectable quantity as well as quality spikes per plant when they applied K plus Fe (500 ppm).

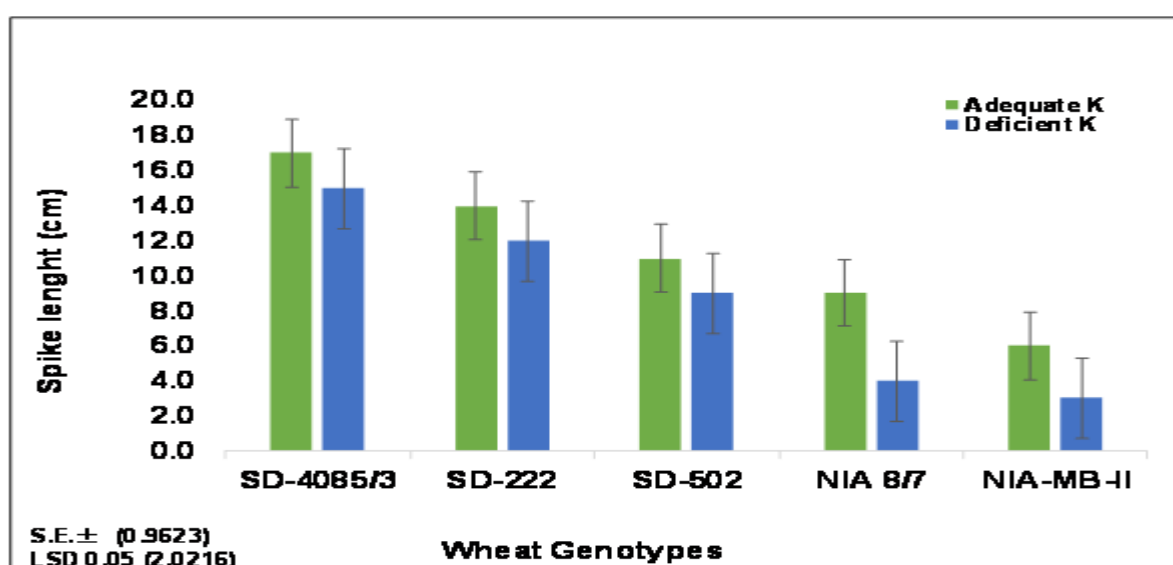


Fig. 4. Spike length (cm) of wheat genotypes as affected by potassium levels

Spike length (cm)

The results showed that average mean value for spike length was found to be higher 17.0 cm in genotype SD-4086/3 followed by mean values i.e. 14.0, 11.0, 9.0 and 6.0 cm observed in SD-222, SD-502, NIA 8/7 and NIA-MB-II genotypes treated with adequate K level (Fig.4). While in case of deficient K level

treatment significantly higher ($P < 0.05$) spike length (cm) was observed as 15.0 cm in genotype SD-4086/3 compared to that of 12.0, 9.0 cm were recorded in SD-222 and SD-502 genotypes respectively. It is of interest to note that lower ($P < 0.05$) spikes length 4.0 and 3.0 cm were measured in genotypes NIA 8/7 and NIA-MB-II, respectively at deficient K treatment.

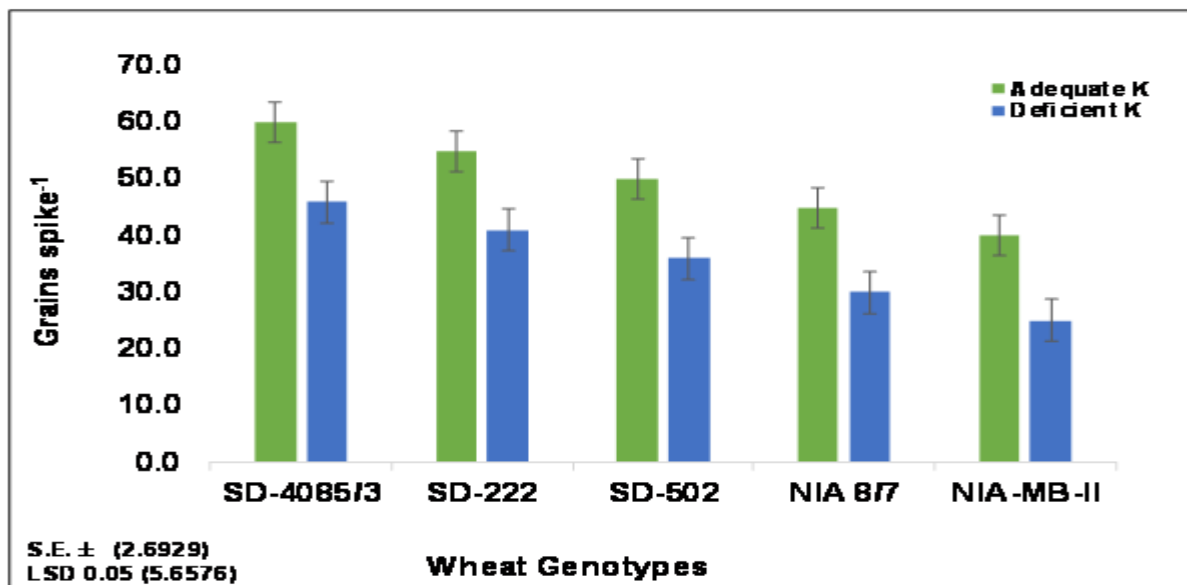


Fig. 5. Grains spike⁻¹ of wheat genotypes as affected by potassium levels.

These findings are sustained to the (Baraich *et al.*, 2008) who identified that the special effects of K and P on growth and yield of wheat crop. They have determined that maximum spike length (10.85 cm), produced by maximum rate of potash. Similarly (Laghari *et al.*, 2010) suggested that the use of NPK fertilizer level has significant impact on growth and yield observations of wheat crop, they observed maximum spike length, in remarkable NPK level from their experiment. Our results are also in agreement with (Hamouda *et al.*, 2015), authors revealed that Growth, status of wheat plants are affected by potassium application in sandy soil, they achieved very suitable spike length with the application of K plus Fe (500 ppm) treatments.

Grains spike⁻¹

The statistical investigation showed that the grains Spike⁻¹ of wheat genotypes varied significantly ($P < 0.05$) under the adequate and deficient K levels (Fig.5).

The findings showed that at the adequate K level, comparatively increased ($P < 0.05$) grains spike⁻¹ (60.0) was recorded under SD-4086/ genotype than that of SD-222 (55.0), SD-502 (50.0) and NIA 8/7 (45.0), respectively; while the smallest mean value for 40.0 was noted in NIA-MB-II genotype at same K level. The efficacy of wheat genotypes in the deficient K level revealed that maximum grains spike⁻¹ 46.0 was achieved in genotype SD-4086/3, followed by the average mean 41.0, 36.0 and 30.0 in the genotypes SD-222, SD-502 and NIA 8/7 respectively; however the minimum grains spike⁻¹ 25.0 was recorded in NIA-MB-II genotype. These observations are in accordance with (Baraich *et al.*, 2008) who reported that the singular effect of K and P on growth and yield features in wheat produced highest number of grains (66.33 spike⁻¹), with the use of maximum rate of potash. In another study (Tahir *et al.*, 2008) reported that effect of potassium on growth and yield component of wheat. They observed that numbers of grains spike⁻¹ were better by increasing K level.

Similarly (Abbas *et al.*, 2013) inspected that effect of potassium levels on all factors of wheat crop. They reported significant effect ($P < 0.05$) for number of grains spike⁻¹, with the increase of K₂O up to 93 kg ha⁻¹.

Seed index (1000 grain weight, g)

Seed index is a quantitative observation to show the grain yield in wheat and this trait is remarkably varies within the genotypes and treatments. The results indicating seed index (1000 grain weight, g) of wheat

genotypes as influenced by the potassium levels (Fig.6). Statistical analysis revealed that the seed index of wheat genotypes significantly varied ($P < 0.05$) with the potassium levels.

The results showed that the higher ($P < 0.05$) seed index was 37.0 g, recorded in SD-4086/3 genotype followed by 33.0 g (SD-222), 28.0 g (SD-502) and 25.0 g (NIA 8/7) and 22.0 g (NIA-MB-II), respectively at the adequate K level..

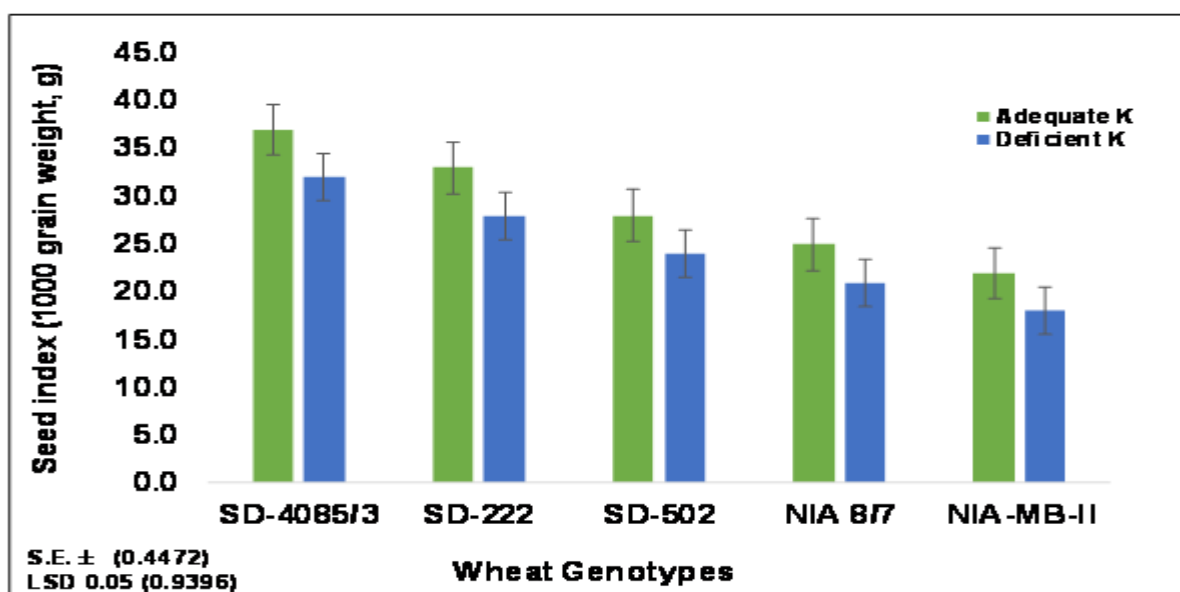


Fig. 6. Seed index (1000-grains weight, g) of wheat genotypes as affected by potassium levels.

The performance of wheat genotype under deficient K level appeared as 32.0, 28.0, 24.0, 21.0 and 18.0 g seed index was found in SD-4086/3, SD-222, SD-502, NIA 8/7 and NIA-MB-II genotypes, respectively.

Our results are supported by the other reports i.e. (Iftikhar *et al.*, 2002) recommended that the various NPK levels has positively significant effect on the 1000 grain weight, in wheat variety Inqulab-91 within the treatments of 105-75-75 kg NPK ha⁻¹. Similarly Baraich *et al.* (2008) identified that the special effects of K and P on growth and yield features of wheat and observed the maximum 1000 grain weight (48.38 g) by using increased concentration of potash.

In another reported work (Tahir *et al.*, 2008) observed that 1000-grain weight (g) increased through the better accumulative usage of K level.

Biological yield (kg ha⁻¹)

The results observing biological yield (kg ha⁻¹) of wheat genotypes as influenced by the potassium levels (Fig.7). The statistical analysis proved significant difference ($P < 0.05$) for the biological yield (kg ha⁻¹) of wheat genotypes under the different potassium levels as well as mutual impact of potassium levels with genotypes. The results appeared that maximum average mean for biological yield 24000.0 kg ha⁻¹ was documented in SD-4086/3 genotype, followed by the average means 21000, 18000.0 and 15000.0 kg ha⁻¹ were given by SD-222, SD-502 and NIA 8/7 genotypes. While the minimum biological yield 12000.0 kg ha⁻¹ was recorded in the genotype NIA-MB-II under adequate K level. However the same positive effect was found under deficient K level. The results showed that supreme biological yield 20000.0 kg ha⁻¹ recorded in genotype

SD-4086/3, followed by SD-222, SD-502, and NIA 8/7 genotypes, which produced 16000.0, 12000.0, 8000.0 biological yield kg ha^{-1} ; while the minimum biological yield under deficient K level was 4000.0 kg ha^{-1} recorded in genotype NIA-MB-II. These observations are in consistency with the previous other investigations, i.e. (Laghari *et al.*, 2010) suggested that the NPK fertilizer application impact on the growth and yield of wheat were given prominent biological yield at the remarkable dose of

NPK. Similarly (Hamouda *et al.*, 2015) showed that growth status of wheat plants as influenced by potassium application in sandy soil gave suitable biological yield with K and Fe (500 ppm) treatments. In another study Tabatabaei *et al.*, (2014) also found that effect of different levels of potassium Sulphate on yield, yield components and protein content of wheat cultivars achieved a positive response about the biological yield when they have applied 160 kg K ha^{-1} .

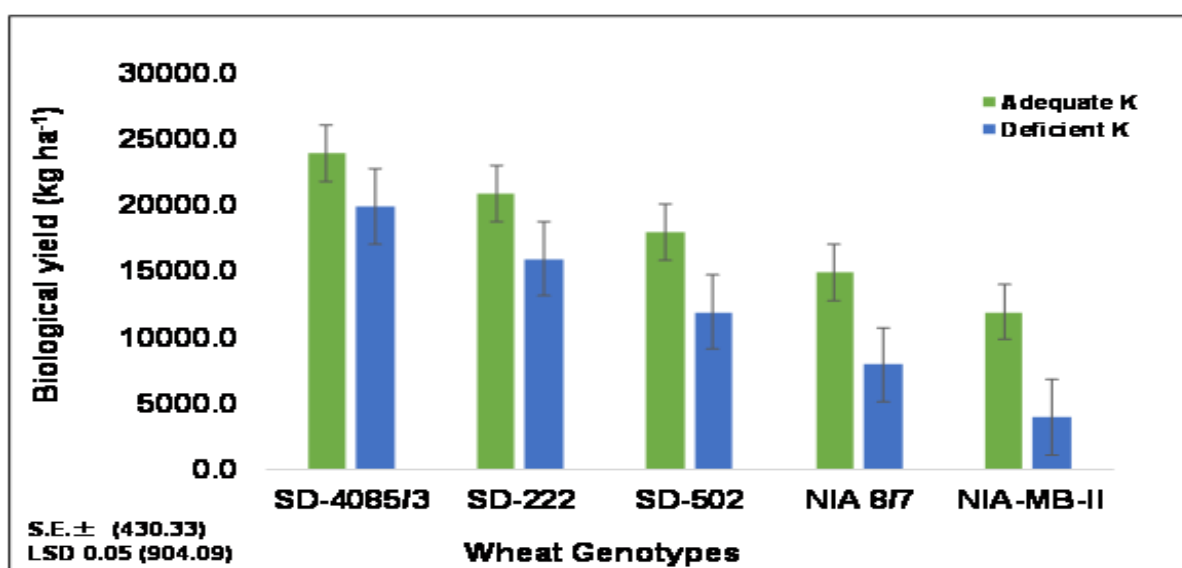


Fig. 7. Biological yield (kg ha^{-1}) of wheat genotypes as affected by potassium levels.

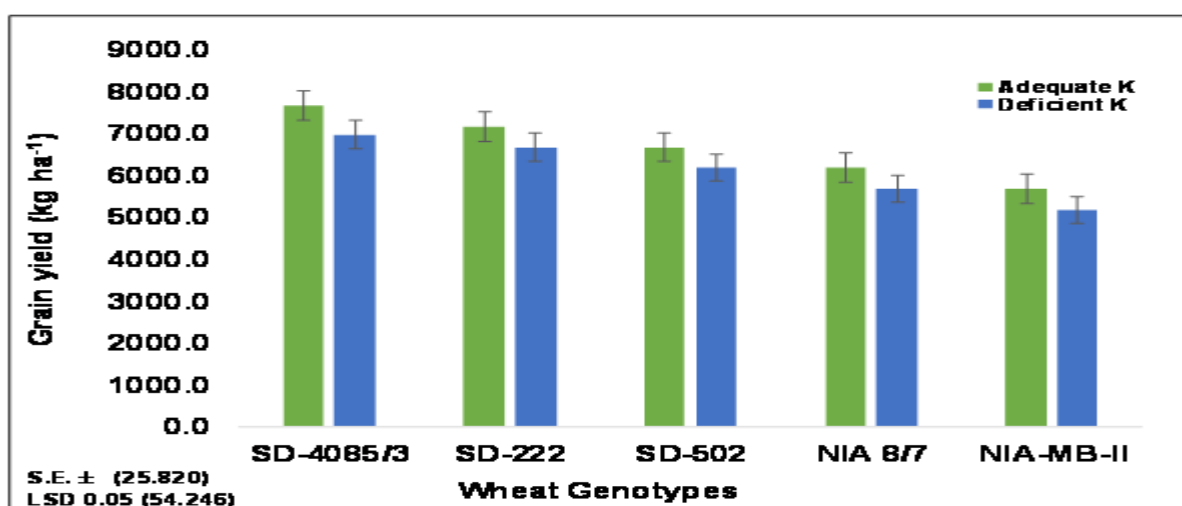


Fig. 8. Grain yield (kg ha^{-1}) of wheat genotypes as affected by potassium.

Grain yield (kg ha^{-1})

The results detecting grain yield (kg ha^{-1}) of wheat genotypes in relation to the potassium levels are shown in (Fig.8).

The statistical analysis revealed that the grain yield (kg ha^{-1}) of wheat genotypes differed significantly and including the potassium levels were also found to be statistically significant at ($P < 0.05$).

The maximum grain yield 7700.0 kg ha⁻¹ was achieved in SD-4086/3 genotype under adequate K level, followed by the average mean 7200.0, 6700.0, 6200.0 kg ha⁻¹ and 5700.0 kg ha⁻¹ (SD-222, SD-502, NIA 8/7 and NIA-MB-II genotypes, respectively). However, genotypes treated with deficient K level produced grain yield i.e. 7000.0 kg ha⁻¹ was recorded in genotype SD-4085/3, followed by the 6700.0, 6200.0 and 5700.0 kg ha⁻¹ (in SD-222, SD-502 and NIA 8/7 respectively genotypes); while the minimum grain yield 5200.0 kg ha⁻¹ was recorded in genotype NIA-MB-II at similar treatment (deficient K).

Our study results are in agreement with Tabatabaei *et al.* (2014) who observed significantly positive response in the grain yield kg ha⁻¹ at potassium concentration (160 kg ha⁻¹) and Abbas *et al.* (2013) also reported the significant results by the responses of potassium application on wheat crop i.e. the maximum grain yield kg ha⁻¹ was noted with the treatment of K₂O up to 93 kg ha⁻¹. Scientific report of the Laghari *et al.*, (2010) also suggested that the NPK fertilizer application impacts on the growth and yield of wheat are found significant in grain yield (kg ha⁻¹) at the remarkable dose of NPK.

Conclusion

The results of the present research concluded that both K treatments, genotypes and their interactive relations were statistically significant at (P<0.05) for all the growth and yield observations. It is of interest to note that among the genotypes SD-4085/3 genotype had capability to perform excellent; while NIA-MB-II genotype observed poor performance in all growth and yield parameters under both adequate and deficient potassium levels.

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