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GROWTH AND YIELD OF BARLEY (HORDEUM VULGARE L.) AS INFLUENCED BY POTASSIUM UNDER WATER DEFICIT CONDITIONS OF PESHAWAR VALLEY

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Abstract. Potassium plays a major role in enhancing tolerance of plants to drought by increasing translocation and maintaining water balance. Experiment was conducted to investigate the performance of barley (Hordeum vulgare L.) under the different levels of Potassium and irrigation levels during 2016-17 having four replications in a complete randomized block design. The treatments consisted of three irrigation and three potassium levels. The results showed that potassium and irrigation levels had significantly affected ($P \leq 0.05$) the yield components of barley. Among irrigation levels, significantly ($P \leq 0.05$) highest grain yield (2175.2 kg ha^{-1}) was recorded with two irrigations (30 and 60 DAS). In case of potassium levels, considerably ($P \leq 0.05$) maximum grain yield (2202.3 kg ha^{-1}) was noted with potassium application rate of 45 kg ha^{-1}. With respect to interactive effects, higher, though statistically equal ($P \geq 0.05$), grain yield was documented in interactive effect of irrigation applied twice (30 and 60 DAS) x potassium applied at 50 kg ha^{-1}, and one irrigation (30 DAS) x potassium at 45 kg ha^{-1}, respectively. Our results suggest that Potassium can compensate drought stress and its application at 40 kg ha^{-1} coupled with one irrigation (30 DAS) and/or two irrigations (30 and 60 DAS) can be suitable for obtaining optimum yield of barley.

Keywords: *barley, growth, irrigation, potassium, water deficit conditions, yield.*

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1. Introduction

Barley gives good yields with lesser agriculture inputs and it could also replenish the damaged soils (Naheed et al., 2015). Barley, like all other crops is affected by the saline soils, but due to its high resistance it can give better yields than other crops (Shaukat, 2013). In Pakistan during 2014-15 barley crop was cultivated on area of in 66,000 hectares of land and the production obtained was 61,000 tons (Government of Pakistan, 2015). Soliman et al. (2011) reported that tolerance of barley plants to water stress conditions is of advantageous under shortage of irrigation water. Nevertheless, barley has been reported to have four water sensitive growth stages; the germination, booting, anthesis and milky stage. Irrigation management under water deficit conditions is the key factor to achieve desired yields in barley (Soliman et al., 2011)

Potassium is essentially required for plant growth and needed by plants in large quantities. Cakmak (2005) reported that potassium can enhance drought tolerance in plants by mitigating harmful effects as a result of increasing translocation and maintaining water balance. Potassium has the major role in osmoregulation, photosynthesis, transpiration, stomatal opening and closing, and synthesis of proteins (Milford et al., 2007). The harmful effects occurring due to drought could be minimized by sufficient supply of potassium (Sangakkara et al., 2000). Aown et al. (2012) reported that water deficit stress at critical growth stages adversely affected the agronomic parameters which results ultimately the grain yield of wheat, but application of potassium compensated the damage caused by water stress. Shekhawat et al. (2013) reported that considerable increase was observed in plant height, plant dry matter accumulation, total tillers, effective tillers, grains per spike, spike weight, 1000-grains weight, grain and straw yield of barley due to application of potassium.

Keeping in view the importance of the importance of potassium in water deficient environment, this experiment was conducted to investigate Growth and Yield of Barley as affected by different potassium levels under drought stress condition of Peshawar Valley.

2. Material and methods

An experiment was conducted at Screen house, Department of Plants breeding and Genetics, The University of Agriculture Peshawar during Rabi season 2016-17. The design used for experiment was split plot design having four replications. The treatments for experiment were three irrigation levels (I_0 = Full Irrigation, I_1 = one irrigation at 30 days after sowing (DAS) and I_2 = two irrigations at 30 and 65 DAS), and three potassium levels (K_0 = 0.0 kg ha^{-1} (control), K_1 = 30 kg K_2O ha^{-1} and K_2 = 45 kg K_2O ha^{-1}). SOP was used as a source of Potasium. In case of Full Irrigation, all the fertilizers (N, P, and K) were applied as basal application. In case of two irrigations, all P and K, and 1/3rd of nitrogen was applied at sowing time and subsequent nitrogen was applied at 1st irrigation and at 2nd irrigation in two splits, respectively .The observations were recorded for growth and yield parameters of economic importance such as number of tillers per m^2, plant height (cm), spike length (cm), grains spike^{-1}, seed index (1000-grain weight, g) and grain yield (kg ha^{-1}). Data was subscribed on the parameters No of tillers, Plant height, Spike length, No of grains spike^{-1}, grain yield and thousand grain weights. Data regarding tillers m^{-2} was recorded by counting the number of tillers in one meter long row at three randomly selected places in each sub plots and then converted into spikes m^{-2}.Plant height of four plants were measured by the measuring tape from bottom till the tip of the plant and averaged. Data regarding number of grains spike^{-1} were recorded by counting the number of grains from ten randomly selected spikes in each sub plot and averaged. For thousand grains weight data after threshing thousand grains from each sub plot and plot were counted weighed with an electronic balance. For grain yield (kg ha^{-1}) four central rows from each sub plot were harvested, weighted and converted in to kg ha^{-1}. Data regarding grain yield (kg ha^{-1}).

Statistical analysis: Statistical analysis of the data collected during the course of this study were statistically analyzed using Fishers analysis of variance technique and significant means were separated using least significant difference test (LSD) at 5% probability level (Steel et al., 1997)

3. Results and discussion

No. of Tillers

Statistical analysis of data showed significant ($P \leq 0.05$) effect of irrigation and potassium levels and their interaction on number of tillers per m^{-2} of barley. The number of tillers per m^{-2} was significantly ($P \leq 0.05$) highest (312.0) in two irrigations (30 and 65 DAS) as compared to one irrigation at 30 DAS (286) and soaking dose (252) (Table 1). Potassium at 45 kg ha^{-1} produced markedly ($P \leq 0.05$) maximum number of tillers (335). In case of interactive effects two irrigations at 30 and 65 DAS with potassium at 45 kg K_2O ha^{-1} and one irrigation at 30 DAS with potassium @ 45 kg K_2O ha^{-1} produced maximum (335 and 300 m^{-2} and statistically similar ($P \geq 0.05$) number of tillers with each other. The results was also in agreements with the Shekhawat et al. (2013) who reported that application of potassium at 40 kg ha^{-1} caused significant increase in total tillers of barley.

Plant Height

The data (Table 2) showed that crop under two irrigations (30 and 65 DAS) resulted in considerably ($P \leq 0.05$) tallest plants (61.9 cm). The plant height declined to 56.3 cm in one irrigation (30 DAS) and 52.7 cm in no irrigation (soaking dose). In case of potassium levels, tallest plants (61.6 cm) were recorded when crop was fertilized with potassium at 45 kg K_2O ha^{-1}. The plant height was decreased to 56.9 cm under potassium at 30 kg K_2O ha^{-1} and smaller plant height (52.3 cm) was noticed under control. For interactive effects, maximum height of plants were 69.3 and 68.3 cm with statistical no differences ($P \geq 0.05$) with each other were observed in two irrigation at 30 and 60 DAS with potassium applied at 45 kg K_2O ha^{-1} and one irrigation at 30 DAS with potassium at 45 kg K_2O ha^{-1}. The results was also in line with the researcher Dahmardeh et al. (2015) revealed that water stress in dry regions decreased plant height of barley but potassium application increased plant height in water stress condition.

Spike length

The results (Table 3) indicated that two irrigations at 30 and 60 DAS have significant ($P \leq 0.05$) affect and maximum spike length (6.90 cm). The spike length diminished to 5.67 cm under one irrigation at 30 DAS, whereas the minimum spike length (4.07 cm) was recorded under soaking dose. The significantly ($P \leq 0.05$) highest spike length of 5.90 cm was recorded under potassium at 45 kg ha^{-1}. The spike length decreased to 5.57 cm under potassium applied at 30 kg K_2O ha^{-1} and the minimum spike length of 5.17 cm was recorded under control. The data further revealed that spike length with statistically at par ($P \geq 0.05$) values of 6.90 and 5.67 cm was observed under the interaction of two irrigations at 30 and 60 DAS with potassium applied at 45 kg ha^{-1} and one irrigation at 30 DAS x potassium applied at 45 kg K_2O ha^{-1}. The statistically equal ($P \geq 0.05$) spike length under the interaction of one irrigation with potassium applied at 45 kg K_2O ha^{-1} and two irrigations x potassium applied at 45 kg K_2O ha^{-1} with each other Similarly the results are also in finding with the Alderfasi and Refay (2010) reported that low water supplies treatments reduced spike length of wheat. Application of 40 kg K_2O ha^{-1} significantly increased the spike length of barley (Shekhawat et al., 2013). Mesbah (2009) and Aowan et al. (2012) suggested that potassium has important role in increasing the plant tolerance to water deficit conditions.

Table 1. Number Tillers plant as affected by different potassium levels under various irrigation levels

	irrigation levels			
Potassium levels (kg K_2O/ha)	**soaking dose**	**30 DAS**	**30 and 65 DAS**	**Mean**
Control	208	260	295	254c
30	250	297	306	284b
45	298	300	335	311a
Mean	252ab	286b	312a	
LSD	21.2	9.89	17.78	

Table 2. Plant Height (cm) as affected by different potassium levels under various irrigation levels

	Irrigation Levels			
Potassium levels (kg K_2O/ha)	**soaking dose**	**30 DAS**	**30 and 65 DAS**	**Mean**
Control	48.9	51.6	56.4	52.3ab
30	52.5	56.7	61.6	56.9b
45	56.8	60.5	67.6	61.6a
Mean	52.7ab	56.3b	61.9a	
LSD	0.27	0.36	0.87	

Table 3. Spike Length (cm) as affected by different potassium levels under various irrigation levels

	irrigation levels			
Potassium levels (kg K_2O/ha)	**soaking dose**	**30 DAS**	**30 and 65 DAS**	**Mean**
Control	3.80	5.2	6.5	5.17ab
30	4.1	5.7	6.9	5.57ab
45	4.3	6.1	7.3	5.90a
Mean	4.07c	5.67b	6.90a	
LSD	0.19	0.33	6.89	

Number of grains spike^{-1}

The means value of the data showed that effect of irrigation, potassium and their interaction was significant ($P \leq 0.05$) on number of grains spike^{-1} is shown in table 4. The grains spike^{-1} (Table 4) were significantly ($P \leq 0.05$) higher (30.03) under two irrigations at 30 and 60 DAS as compared to 29.9 and 24.53 recorded under one irrigation at 30 DAS and soaking dose, respectively. Potassium applied at 45 kg K_2O ha^{-1} produced markedly ($P \leq 0.05$) maximum (32.47) grains spike^{-1}. However, potassium applied at 30 kg K_2O ha^{-1} and control produced less number of grains spike^{-1} (28.03 and 23.97, respectively). The interaction of two irrigations at 30 and 60 DAS x potassium applied at 45 kg K_2O ha^{-1} and one irrigation at 30 x potassium applied at 45 kg K_2O ha^{-1} resulted in maximum and statistically similar ($P \geq 0.05$) grains spike^{-1} of 35.6 and 34.2. The non-significant ($P \geq 0.05$) interactive effect of one irrigation x potassium applied at

50 kg K_2O ha^{-1} with two irrigations x potassium applied at 45 kg K_2O ha^{-1} for grains spike$_{-1}$ may be attributed to compensating role of potassium to barley plants under drought conditions. Potash spray at various growth stages of wheat under drought conditions ameliorated the adverse effects of stress by improving the number of grains per spike to a significant level (Aown et al., 2012). Yadov (2006) stated that potassium plays a key role in improving the plant tolerance to stress conditions.

Grain yield

The statistical analysis of mean data showed that irrigation, potassium and their interaction significantly ($P \leq 0.05$) affected barley grain yield. The results (Table 5) suggested that two irrigations at 30 and 60 DAS produced significantly ($P \leq 0.05$) highest grain yield (2175.2 kg ha^{-1}). The grain yield decreased to 2033.7 kg ha^{-1} when crop was irrigated once at 30 DAS and least grain yield (1804.4 kg ha^{-1}) of barley was noted under soaking dose. Among potassium levels, markedly ($P \leq 0.05$) maximum grain yield (2202.3 kg ha^{-1}) was recorded under the application of potassium at 45 kg K_2O ha^{-1}. The barley grain yield diminished to 1980.5 kg ha^{-1} when crop supplied with potassium at 30 kg K_2O $ha^{- 1}$ and the least grain yield (1830.5 kg ha^{-1}) were documented under potassium at 0.0 kg K_2O ha^{-1} (control). Among interactive effects, maximum and statistically equal ($P \geq 0.05$) to each other, grain yield (2367.8 and 2245.5 kg ha^{-1}) was noticed under interactive effect of two irrigations at 30 and 60 DAS x potassium applied at 45 kg ha^{-1} and one irrigation at 30 DAS x potassium applied at 45 kg K_2O ha^{-1}, respectively. The results of this study of this study are also in line with Anjum et al. (2011) and Brisson and Casals (2005) suggested that yield components and yield under drought stress can be improved by increasing plants stress tolerance. Potassium has important role in increasing the plant tolerance to water deficit conditions (Mesbah, 2009; and Aowan et al., 2012). Similarly, Shekhawat et al. (2013) revealed that application of 40 kg K_2O ha^{-1} markedly enhanced the grain yield of barley.

Thousand grains weight

The data (Table 6) indicated that crop under two irrigations at 30 and 60 DAS produced maximum ($P \leq 0.05$) seed index of 26.1 g. The thousand grain weight decreased to 23.4 g under one irrigation at 30 DAS while minimum thousand grain weight (21.6 g) was observed under soaking dose. In case of potassium, significantly ($P \leq 0.05$) highest (27.7 g) was noted when crop was supplied with potassium application at 45 kg K_2O ha^{-1}. The thousand grain weight was reduced to 23.6 g under potassium application at 30 kg K_2O ha^{-1} and least thousand grain weight (21.8 g) was noticed under control. However, maximum 1000 grain weight (27.9 and 25.7 g) with non-significant ($P \geq 0.05$) statistical values to each other was recorded under the interaction of two irrigations at 30 and 60 DAS x potassium at 45 kg K_2O ha^{-1} and one irrigation at 30 DAS x potassium at 45 kg K_2O ha^{-1}. The statistically equal ($P \geq 0.05$), LSD 0.05 seed index under the interaction of one irrigation x potassium at 45 kg K_2O ha^{-1} and two irrigations x potassium at 45 kg ha^{-1} with each other The results are also in line with Anjum et al. (2011) who reported that drought reduced grain weight of maize. Aowan et al. (2012) found that the drought stress caused significant effects on 1000-grain weight of wheat. Exogenous application of potassium significantly improved the 1000-grain weight. The crop produced bold grains when adequate water is supplied to the crop at different growth stages.

Table 4. Grains spike (cm) as affected by different potassium levels under various irrigation levels

	irrigation levels			
Potassium levels (kg K_2O/ha)	**soaking dose**	**30 DAS**	**30 and 65 DAS**	**Mean**
Control	21.5	25.7	24.7	23.97bc
30	24.5	29.8	29.8	28.03b
45	27.6	34.2	35.6	32.47a
Mean	24.53b	29.90a	30.03a	
LSD	0.76	1.42	3.15	

Table 5. Grain Yield (kg/ha) as affected by different potassium levels under various irrigation levels

	irrigation levels			
Potassium levels (kg K_2O/ha)	**soaking dose**	**30 DAS**	**30 and 65 DAS**	**Mean**
Control	1645.8	1855.8	1989.8	1830.ab
30	1773.9	1999.8	2167.9	1980.5b
45	1993.6	2245.5	2367.8	2202.3a
Mean	1804.4c	2033.7b	2175.2a	
LSD	78.67	81.78	199.8	

Table 6. Thousand Grain Weight (g) as affected by different potassium levels under various irrigation levels

Potassium levels (kg K_2O/ha)	**soaking dose**	**30 DAS**	**30 and 65 DAS**	**Mean**
Control	19.5	20.7	23.8	21ab
30	21.7	22.8	25.9	23b
45	22.4	25.7	27.9	25a
Mean	21c	23b	26a	
LSD	1.14	1.25	3.11	

4. Conclusion and recommendations

Potassium plays a major role in enhancing tolerance of plants to drought by increasing translocation and maintaining water balance. From this research we conclude that potassium application at 40 kg ha^{-1} together with one irrigation (30 DAS) and/or two irrigations (30 and 60 DAS) can be suitable for obtaining optimum yield of barley.

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