

Evaluation of different levels of potassium and zinc fertilizer on the growth and yield of wheat

Abstract

The study pertaining to evaluation of different levels of potassium and zinc fertilizers on the growth and yield of wheat was conducted at Chakkanwali Reclamation Research Station District Gujranwala during Rabi 2015-16. Randomized complete block design with factorial arrangement used to lay out this experiment. Before sowing the seeds, the following nutrients were homogeneously incorporated into the soil; $K_1=0\text{kg ha}^{-1}$, $K_2=125\text{kg ha}^{-1}$, $K_3=250\text{kg ha}^{-1}$ and $K_4=375\text{kg ha}^{-1}$ and $Zn_1=0\text{kg ha}^{-1}$, $Zn_2=5\text{kg ha}^{-1}$, $Zn_3=10\text{kg ha}^{-1}$ and $Zn_4=15\text{kg ha}^{-1}$. Data regarding various agronomic traits (plant height, number of fertile tillers per unit area, spike length, number of spikelets per spike, number of grains per spike, 1000-grain weight, biological yield, grain yield and harvest index) of crop were recorded by using standard procedures. The data collected were analyzed statistically by adopting the computer software MSTAT C and LSD at 5% probability was used to compare the differences among treatments' means. Application of potassium fertilizer (375kg ha^{-1}) and zinc (15kg ha^{-1}) significantly improved the growth and yield parameters of wheat.

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Introduction

Wheat (*Triticum aestivum L.*) is the staple food and second most important food crop after rice in the country, which contributes nearly one-third of the total food grains production. It is consumed mostly in the form of bread as "Chapati". Wheat straw is used for feeding cattle. Wheat contains more protein than other cereal and has a relatively high content of niacin and thiamine.¹ It is basically concerned in providing the characteristics substance "Gluten" which is very essential for bakers. The production potential of wheat crop is the resultant of a number of interacting factors contributing its shares. Major nutrients (N, P and K) are important for increasing the crop production. However, farmers in this region generally used only nitrogen or nitrogen and phosphorus fertilizers. Intensification of cropping system with greater use of potassium free chemical fertilizers and adoption of high yielding varieties have resulted in the mining of soils leading to K deficiency. There is immense scope of increasing productivity through adequate application of K.² Wheat has proved to have a higher agronomic K efficiency as indicated by a greater relative yield under K deficient conditions.³ Better growth and yield of wheat crop has been observed with the addition of K.⁴ Potassium content in the plant tissue is crucial to the proper functioning of several important biochemical and physiological processes that directly determine crop productivity. Therefore, for sustaining soil fertility and optimum crop productivity on long term basis, K removal through the crops should be replenished with balanced and adequate K fertilization.

Zinc is one of the most functional micronutrients in plants, animals and humans and plays an important physiological role in their growth and development.⁵ Zinc deficiency is common in both crop plants and human beings, causing various serious health complications such as stunting, increased susceptibility to infectious diseases, impaired brain function and mental development, poor birth outcomes and anemia.⁶ It is estimated that more than one third of the population is affected by Zn deficiency, particularly children and pregnant women and low dietary intake of Zn has been discussed as a major reason.⁷ Enrichment of cereal crops with zinc is an important global challenge and a high-priority research area. Zinc is required for the growth and grain

nutritional quality of wheat, a staple food in a number of developing countries in the world and essential to ensure food safety and healthy diet.^{5,8} It has been reported that Zn concentration in wheat grains is different among wheat cultivars and subjects to the regulation of the environment and cultivation measures.⁹⁻¹¹ Genetic biofortification and agronomic biofortification are two important agricultural tools to improve Zn concentration in grains.⁹ It has been reported that grain Zn concentration can be enhanced to a certain extent by increasing the application of Zn fertilizer.¹²

Application of Zn fertilizers not only improves nutritional quality but also contributes significantly to grain production in Zn deficient soils.^{5,13} Hao et al.¹⁴ found that after applying Zn fertilizer, Zn absorption in wheat increased significantly and its concentration in wheat grains increased by 18.8%. Studies have shown that exogenous Zn^{2+} can significantly improve the dry weight of seedling roots and shoots.¹¹ ease winter wheat seedlings peroxidation, enhance SOD and CAT activities and promote chlorophyll synthesis, thereby affecting photosynthesis.¹⁵ Adequate Zn can accelerate the wheat growth, tillers and anthesis, while excessive Zn content in the environment will inhibit the growth of wheat seedlings, exacerbate flag leaf membrane peroxidation at the grain filling stage and lead to yield loss.¹⁶⁻¹⁸ In this view, it was imperative to evaluate the role of potassium and zinc on the growth and yield parameters of wheat.

Materials and methods

The study pertaining to evaluation of different levels of potassium and zinc fertilizers on the growth and yield of wheat was conducted at Chakkanwali Reclamation Research Station District Gujranwala during 2015-16. Experiment was laid out in a randomized complete block design (RCBD) with factorial arrangement. Wheat cultivar Punjab 2011 was used as a test crop. The sowing was done by hand drill in well prepared seed bed on 20th November 2015 using the seed rate 125kg ha^{-1} . Nitrogen and phosphorus were applied @ 200 and 150kg ha^{-1} , respectively by using urea and triple superphosphate. Whole phosphorus and half of nitrogen were applied at sowing time and remaining nitrogen was applied with first irrigation.

Before sowing the seeds, the following nutrients homogeneously incorporated into the soil; $K_1=0\text{kgha}^{-1}$, $K_2=125\text{kgha}^{-1}$, $K_3=250\text{kgha}^{-1}$ and $K_4=375\text{kgha}^{-1}$ and $Zn_1=0\text{kgha}^{-1}$, $Zn_2=5\text{kgha}^{-1}$, $Zn_3=10\text{kgha}^{-1}$ and $Zn_4=15\text{kgha}^{-1}$. Murate of potash and zinc sulfate used as a source of potassium and zinc respectively. All other agronomic practices were kept same for all the treatments. Standard procedures was used to record data and subjected to the analysis of variance by adopting the computer software MSTAT C. LSD test was used to compare means at 5% level of probability.¹⁹

Results and discussion

Plant height (cm)

Plant height is one of the main vegetative growth parameter of wheat plant which represents the genetic variation and fertilizer effect. Plant height data (Figure 1) was significantly ($P\leq 0.05$) affected by the potassium and zinc levels. Maximum plant height (91.13cm) was observed in the highest potassium and zinc doses of 375 and 15 kgha^{-1} , respectively. While minimum plant height (64.55cm) was observed from control plots. Application of potassium might have improved the photosynthesis and activated many enzymes and helped in transport of assimilates toward stem. Potassium might have greater role in plant physiology²⁰ and even in plant morphology. The increase in plant height might be due to the involvement of Zn in different physiological process like enzyme activation,²¹ stomatal regulation²² and chlorophyll formation²³ etc., which ultimately increase the plant height.²⁴

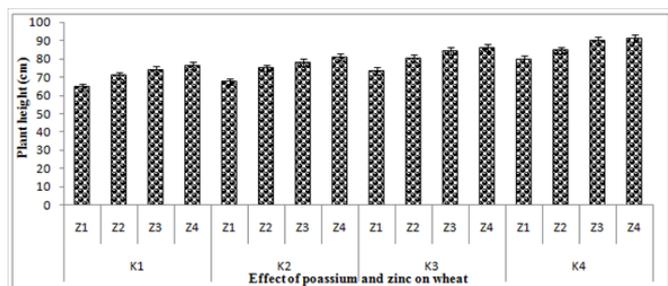


Figure 1 Effect of potassium and zinc on plant height (cm).

Number of fertile tiller m^{-2}

Tillering is an important developmental stage that allows the plants to compensate under low plant populations or taking advantage of good growing conditions. The appearance of tillers is closely coordinated with leaves on the main stem while the number of tillers formed depends on the variety and growing conditions.²⁵ Number of fertile tillers per square meter data (Figure 2) was significantly ($P\leq 0.05$) affected by the potassium and zinc levels. Maximum number of fertile tillers per square meter (309.71) was observed with the application of 375 and 15 kgha^{-1} , potassium and zinc, respectively. While minimum number of fertile tillers per square meter (196.58cm) was observed from control plots. Application of essential nutrients on leaves might have increased the production of metabolites synthesized and thus the plant had the chance to bear more number of fertile tillers per unit area.^{26,27} Similarly involvement of Zn in physiological processes like enzyme activation and chlorophyll formation.²⁸ Similar results were reported by Rahimi et al.²⁹ Who observed that application of zinc fertilizer improved the number of tillers of wheat.

Spike length (cm)

Data regarding spike length (Figure 3) was significantly ($P\leq 0.05$)

affected by the potassium and zinc levels. Maximum spike length (14.01cm) was observed with the application of highest potassium and zinc @ 375 and 15 kgha^{-1} , respectively. While minimum spike length (8.16cm) was observed from control plots. 4.3. Number of spikelets per spike Data regarding spikelets per spike (Figure 4) was significantly ($P\leq 0.05$) affected by the potassium and zinc levels. Maximum number of spikelets per spike (16.66cm) was observed in the higher potassium and zinc doses of 375 and 15 kgha^{-1} , respectively. However minimum number of spikelets per spike (8.16cm) was observed from minimum (0 kgha^{-1}) dose of potassium and 10 kgha^{-1} zinc. These results are in accordance with finding of Ali et al.³⁰ who concluded that growth and yield was improved by adding appropriate amounts of potassium.

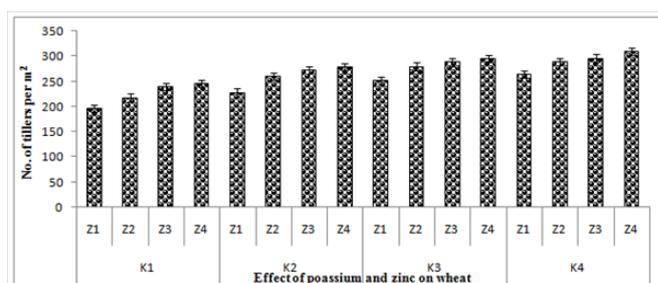


Figure 2 Effect of potassium and zinc on number of tillers per unit area.

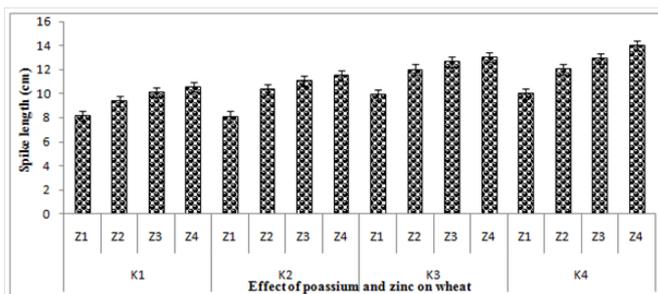


Figure 3 Effect of potassium and zinc on spike length (cm).

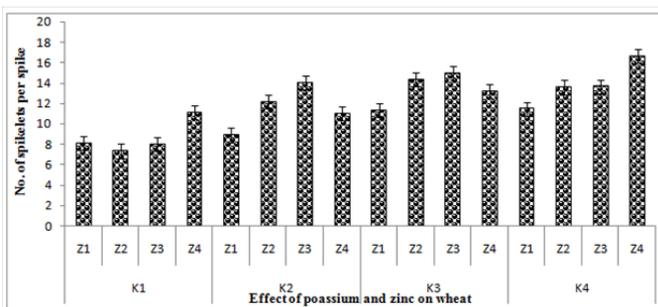


Figure 4 Effect of potassium and zinc on number of spikelets per spike.

Number of grains per spike

It is an important yield contributing parameter which greatly influences the crop production. Potassium and zinc fertilizer levels significantly ($P<0.05$) differed in enhancing number of grains per spike (Figure 5). The potassium level of 375 kgha^{-1} and zinc 15 kgha^{-1} produced the highest (66.77) grains per spike against the minimum (31.78) was observed from control plots. Application of potassium nitrate improved the number of number of grains per spike which might be due to the favorable effects of potassium on nutrient uptake, photosynthetic activity, improving its mobilization.³¹ These results are

in close agreement with the findings of Jan et al.³² Similarly zinc play a significant role in enzyme activation,²¹ chlorophyll biosynthesis,⁵ pollen tube formation and pollen viability,³³ starch utilization,¹² ensuing in greater seed set. Many researchers has reported the same findings in wheat.^{34,35}

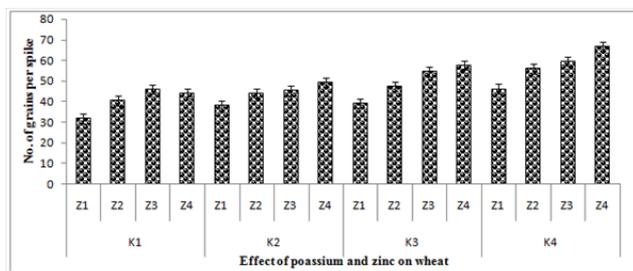


Figure 5 Effect of potassium and zinc on number of grains per spike.

1000 grain weight (g)

Potassium and zinc fertilizers used in this study significantly differed in enhancing 1000 grain weight (Figure 6) of wheat. The maximum increase of 45.32 g thousand grain weight was recorded from the plots fertilized with 375kg ha^{-1} potassium and 10kg ha^{-1} zinc. Minimum 1000 grain weight (28.06g) was recorded from control plots. Potassium has greater role in water use efficiency, improving growth of plants and cell division, make hydrocarbon and proteins and then their quick transfer towards grain.³⁶ It was concluded that application of potassium helped to increase 1000-grain weight in wheat. These results are in accordance with the findings Jan et al.³²

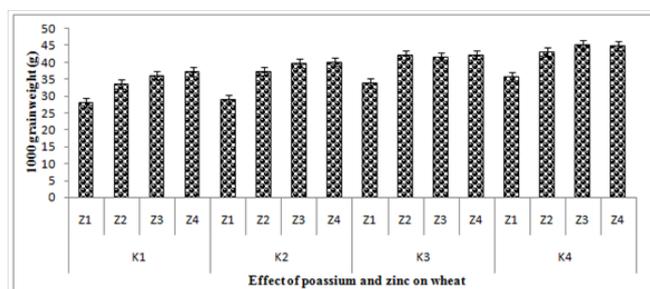


Figure 6 Effect of potassium and zinc on 1000 grain weight (g).

Biological yield (kg ha⁻¹)

Biological yield data (Figure 7) depicted a linear upward increment with the increase in potassium and zinc levels. The potassium 375kg ha^{-1} and zinc 15kg ha^{-1} produced the maximum biological yield of 10190 kg ha^{-1} in comparison to other levels of potassium and zinc. This could be due to taller plants in the treatment where maximum dose of potassium and zinc 375kg ha^{-1} and 15kg ha^{-1} was applied that ultimately helped in enhancement of crop biological yield. While minimum biological yield (7205kg ha^{-1}) was obtained from the control plots. In the present study application of potassium enhanced the biological yield per plant as compare to without potassium application. It was might be due to enhanced growth rate due to potassium application. These results suggested that forage can be harvested from initially high potassium soils without loss in dry matter yield as long as no additional potassium is added.³⁷

Grain yield (kg ha⁻¹)

Crop productivity is the rate at which a crop accumulates organic

matter which depends primarily on the rate of photosynthesis and conversion of light energy to chemical energy by green plants.²⁵ Data in (Figure 8) highlighted that increase in fertilizer levels caused significant increase in grain yield. The highest grain yield 4535.8kg ha^{-1} was harvested at the potassium dose of 375kg ha^{-1} and zinc dose of 15kg ha^{-1} which was significantly higher and the grain yield observed in the rest of fertilizer levels used in this study. This would probably due to enhanced grain yield with optimum delivery of potassium and zinc, that might be the end result of belated senescence of leaf, continued photosynthesis in leaf at the time of grain filling phase and extensive period of filling of grains. The lowest yield of 2878kg ha^{-1} was obtained from control plots. The result revealed that grain yield progressively increased with increasing levels of K application upto 375K gha^{-1} . The data indicated that the cumulative effect of yield contributing characters, such as effective tillers/plant, spikelets/spike, grains/spike and 1000-grain weight had positive contribution to higher grain yield obtained from 375kg ha^{-1} . In case of control, the growth and development of plants were hampered due to imbalance uptake of essential elements which resulted in poor performance of yield attributes and ultimately gave the lowest grain yield. Similar response of K on grain yield has also been reported by Dwivedi³⁸ & Hamayun et al.³⁹ Zinc application plays a vital role in a variety of physiological and biochemical processes,⁴⁰ culminating in more dry matter and grain yield production in cereals.^{41,42}

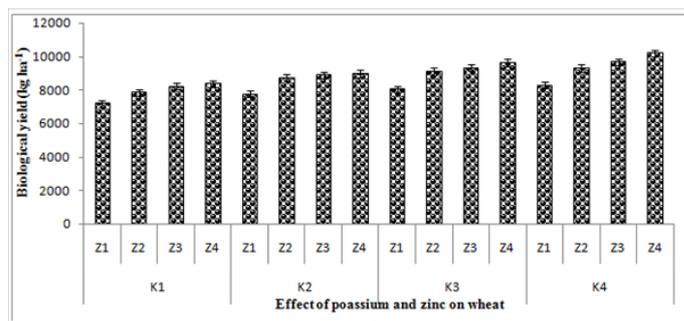


Figure 7 Effect of potassium and zinc on biological yield (kg ha⁻¹).

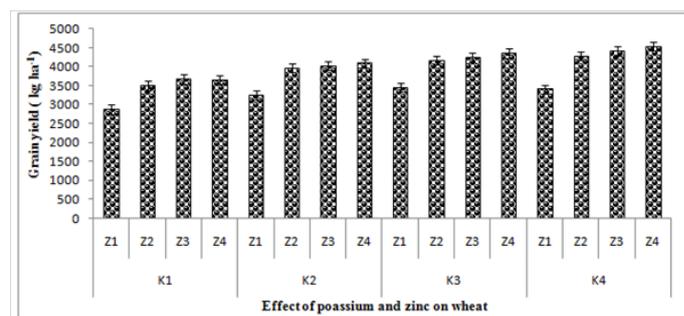


Figure 8 Effect of potassium and zinc on grain yield (kg ha⁻¹).

Harvest index (%)

Harvest index stands for physiological ability to convert photosynthates to grain yield. Data regarding harvest index (Figure 9) was non-significant ($P \leq 0.05$) due to application of different potassium and zinc levels. However maximum harvest index (46.09%) was recorded from the plots fertilized with 375kg ha^{-1} potassium and 5 kg ha^{-1} zinc. Minimum harvest index (39.91%) observed from control plots.⁴³

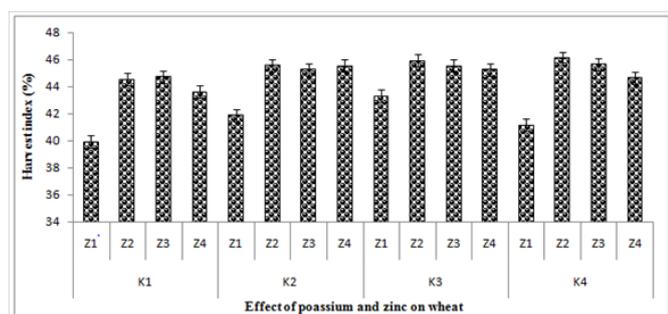


Figure 9 Effect of potassium and zinc on harvest index (%).

Acknowledgements

None.

Conflict of interest

The author declares no conflict of interest.

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