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INFLUENCE OF ZINC SULPHATE LEVELS ON GROWTH PERFORMANCE AND YIELD OF WHEAT

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Abstract

Zinc deficiency is a major constraint on wheat productivity, especially in arid regions, where the optimal zinc sulphate ($ZnSO_4$) application rate is not well established. This study investigated the impact of different $ZnSO_4$ levels on the growth and yield of the wheat variety Azric at the Experimental Research Site, Gomal University, Dera Ismail Khan, during 2022–2023. The experiment included six treatments, each replicated three times. Key agronomic traits measured were plant height, spike length, number of spikelets per spike, grains per spike, 1000-grain weight, grain yield, and straw yield.Results showed that applying $ZnSO_4$ at 12 kg ha^{-1} (T_6) significantly enhanced all measured growth and yield parameters compared to the control. Increases observed included 6.93% in plant height, 24.2% in spike length, 18.42% in spikelets per spike, 18.61% in grains per spike, 25.58% in 1000-grain weight, 60.25% in grain yield, and 9.96% in straw yield. These findings indicate that 12 kg ha^{-1} of $ZnSO_4$ is the most effective rate for maximizing wheat productivity under arid conditions. Proper zinc fertilization not only boosts yield and grain quality but also enhances soil fertility, contributing to improved food security and human health.

INTRODUCTION

Soils of Pakistan and specially Dera Ismail Khan (D.I. Khan) are generally calcareous in nature. Having low micronutrients, particularly when cereals grown on that soil have Zinc deficit (Maqsood *et al.*, 2009). High metallic cations, pH, low Zn, and organic matter (OM) contents and phosphate in the soil solution badly affect the obtainability of Zn to plant (Saboor *et al.* (2021). The domestication and cultivation of wheat was a basic element in the first civilization in the Fertile Crescent. Wheat supply energy in human diet and also is the first source of protein and nowadays their assets are decreased for that reason their nutritional quality should be improved within viewpoint of sustainable agriculture, which would be more economic in term of input and more environmentally friendly (Katamadze *et al.*, 2023).

Wheat is the major food crop of Pakistan. Its meet About 1/3 food requirement of the population. Its cultivated area is 8358000 hectares with an annual production of 21612 million tons and an average harvest of 2585 kg/ha (Anonymous, 2005). Wheat has always been one of the most reliable traditional food grain crops of semi-arid and continental climates. Indus plains are the largest wheat growing area. Fertilization, seed rate, sowing date and irrigation practices play an important role in increasing wheat production. Wheat is the most important cereal crop in connection of energy and protein supply to the human being. About one third of the world population meets their food requirement from

wheat crops. It is the main food crops of Asia and especially in Pakistan (Smolenaars *et al.,* 2023). Rice on flooded and wheat on calcareous soils are also highly disposed to Zn deficiency. Zn deficiency is concealed with Zinc fertilizer application and in the bio fortification of cereal grains (Alloway, 2009).

The presence of zinc in small quantities is essential for the maintenance of normal functioning of many vital physiological functions. These physiological functions play important role in the process of photosynthesis, formation of sugars, synthesis of proteins, maintaining soil fertility, the production of seed and protection of many lethal plant diseases. Unequal fertilization makes the soil to become nutrient deficit. Zinc plays an important role in growth and reproduction of plants (Rudani *et al.,* 2018). In the absence of normal amounts of zinc, the vital physiological functions will be affected leading to poor plant health and drastic decrease in seed yield and poor quality. Zinc is considered an important plant nutrient vital for the growth and survival of crops. Zinc is considered important for the normal functioning of various enzymes and proteins which take part in the metabolism of carbohydrates and auxin, formation of pollens, maintenance of different biological processes, and provide protection against variety of pathogens involved in many plant diseases (Alloway 2009). The deficiency of zinc in plants inhibits the normal functioning of photosynthetic processes and the metabolism of nitrogen, leads to minimum number of flower formation and reduced development of fruits, increased developmental duration, lowers the quantity and quality of produce and leads to reduced nutrient use efficiency of plants (Rudani *et al.,* 2018).

The proper amounts of zinc is necessary for the normal functioning of all body processes in all living organisms (Andreini *et al.* 2006; Broadley *et al.* 2007). One of the easiest and economical way to prevent the zinc deficiency in different type of soils is the supply of proper amounts of zinc to agricultural crops. The zinc fertilizer is available in the markets in different forms which can be used to maintain the proper amounts of zinc in the crops and prevent the zinc deficiency in the biological organisms.

ZnSO4 is an excellent fertilizer choice due to its high solubility and availability of zinc, a vital element required for plant growth and development. ZnSO4 is more soluble in water than other zinc fertilizers such as zinc oxide or zinc carbonate, allowing plants to absorb it more readily. Its solubility allows it to serve as a readily available supply of zinc, correcting inadequacies and supporting healthy plant growth, especially in zinc-deficient soils. It is a popular choice for many agricultural applications due to its efficacy and ease of use (Yousra *et al.* 2019).

Keeping in view the importance of wheat yield and Zinc as an essential micro-nutrient, a study was carried out with the objectives, (1) to see the effect of ZnSO4 on the grain yield and yield contributing traits of wheat, (2) to determine the economics of zinc application on wheat. This study will offer optimization of ZnSO4 doses to enhance wheat crop productivity, addresses zinc deficiency, which is a significant restriction towards wheat production, contributing to global food security and environmental sustainability. The outcomes of this study will offer recommendations for farmers, agricultural practitioners, and policymakers.

1. Materials and methods

1.1 Details of experiment

The research trial was carried out at experimental site of the Faculty of Agriculture, Gomal University, Dera Ismail Khan (D.I. Khan) in 2022–2023. The crops grown in this region need irrigation, because of less rainfall than evapotranspiration in that area i.e. annual rainfall up to 250

mm. The trial was conducted on calcareous clay soil which was low in macro-nutrients. The trial was carried out in Randomized Complete Block design, with three replicates and having six treatments. The plot size was 3x2 m^{-2}. The field was well prepared with disc harrow, followed by three tillers. Basal dose of nitrogen @ 150 kg/ha, phosphorous @

120 kg/ha, potassium @ 90 kg/ha were applied to all treatments. All phosphorous and potassium along with ½ of nitrogen were applied at the time of sowing, when the field come into wattar condition, Zinc @ 4,6, 8, 10, and 12 kg/ha and half N were applied at first irrigation. The wheat variety "Agric" was sown manually after the preparation of seed bed on 14/11/2022**.** The detail of treatments was as: T1 = control, T2 = ZnSO4 4.0 kg ha^{-1}, T3 = ZnSO4 6.0 kg ha^{-1}, T4 = ZnSO4 8.0 kg ha^{-1}, T5 = ZnSO4 10.0 kg ha^{-1}, T6 = ZnSO4 12.0 kg ha^{-1}. The physico-chemical characteristics of soil before sowing were measured according to the standard procedures and are shown in Table 1.

1.2 Observations and measurements

The observed parameters were included as plant height, number of tillers m^{-2}, spike length, number of spikelet's per spike, number of grains /spikes, 1000-grain wt, grain harvest, biological harvest, economics of Zn along with NPK recommended doses.

Table 1: Physico-chemical characteristics of soil before sowing

Parameters	Quantity
Clay	45 %
Silt	24 %
Sand	12 %
Organic matter	0.80 %
pH	8.4
EC	2.5 dsm^{-1}
Available	0.047 N %
Extractable P	6.5 (ppm)
Available K	180 (ppm)
Available Zn	2.94 (ppm)

1.3 Statistical analysis

The harvest data was recorded and analyzed statistically by using analysis of variance technique and the differences among treatment means was compared by using the least significant difference test (statistic 8.1).

2. Results

2.1 Plant height (cm)

The data regarding plant height of all treatments is shown in Table 2. The highest plant height was noted in T6 among all treatments, which was followed by T5. However, minimum plant height was recorded in control.

2.2 Spike length (cm)

The key factor which contributes much toward the grain harvest is the size of the ear. The length of the ear, the more would be the grain per year and ultimately the harvest will be increased and vice versa. The data pertaining to spike length revealed that ear length was considerably influenced by different levels of ZnSO4. A comparison of treatment means indicated that the uppermost ear length (12.11 cm) was observed in T6 followed by treatment T5 (11.78 cm), while minimum was noticed in control. The treatment (T3, T2, T1) however did not show any significant difference, when compared with each other (Table 2).

2.3 Number of spikelets per spike

The data on the number of spikelet per spike showed that different treatment influenced the number of spikelet/spike (Table 2). The highest number of spikelets per spike were obtained in the treatment, receiving Zn @ 12 kg/ha, while the minimum spikelet was noted in control, but the other treatment has no much difference.

2.4 Number of fertile tillers (m^{-2})

The no of tillers in wheat play an important role in final grain harvest. The data pertaining to the total number of tillers m^{-2} as affected by different levels of ZnSO4 (Table 2). The uppermost no of the tillers was noted in the treatment, which get zinc sulphate @ of 12 kg/ha as compared to the rest of the treatments. While minimum number of tillers was recorded in control.

2.5 Number of grains /spike

Number of grain/spike play an important role in determining the final grain harvest of wheat. The data regarding the number of grain/spike was highly influenced by the application of different level of ZnSO4 (Table 3). A mean value indicates that T6 resulted in more grain/spike than the rest of the treatment, while minimum was recorded in control.

2.6 1000-grain wt (gm)

The data regarding 1000-grain wt. was affected considerably by different levels of ZnSO4 (Table 3). Among the treatment, a little increase in 1000-grain weight was recorded at higher level of ZnSO4, but the difference among the treatment did not reach the level of significant, however 1000-grain wt of untreated control was considerably difference from the rest of the treatment**.**

2.7 Grain harvest (kg/ha)

The result revealed that data regarding grain harvest was considerably affected with the application of different doses of ZnSO4 (Table 3). The means of the data showed that the grain harvest increased considerably in T6 and T5. The highest grain harvest was recorded in T6 which get Zn @12 kg/ha and followed by T5, while minimum grain harvest was noted in control.

2.8 Biological harvest (kg/ha)

The straw harvest/ha of wheat showed that different doses of ZnSO4 have no good response to straw harvest, however an increase trend was found in higher level of ZnSO4 (Table 3). The applied Zn gave a good response to reproductive rather than vegetative growth. Since there was no positive effect on plant height and straw harvest/ ha. However, the highest straw yield (8802.5) kg/ha was recorded in the treatment receiving Zn @ 12 kg/ha, while minimum straw yield was noted in control.

3. Discussions

In this study, the effect of different levels of Zinc sulfate fertilizer on wheat growth and yield attributes was studied. It was found that T6 (ZnSO4@12.0 kg ha^{-1}) significantly improved all the growth and yield traits of wheat. For instance, the highest plant height was achieved where maximum dose of Zn fertilizer was applied (ZnSO4@12.0 kg ha^{-1}). The results of the study are consistent with the outcomes of Kaya & Higgs (2002), who reported that plants grown in higher levels of ZnSO4 had increased height effective tillers $plant^{-1}$ (Islam et al. 1999) and number of grains $plant^{-1}$ (Genc et al. 2006). The present study witnessed on showed increased number of spikelets per spike. Such results are in accordance with Hussain and Yasin (2004), who reported that zinc application increases the number of spikelets per spike. Similarly, the number of fertile tillers m

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Table 2: Growth attributes of wheat crop as affected by different levels of zinc sulfate

Treatments	Plant height (cm)	Spike length (cm)	Number of spikelets per spike	Number of tillers m^{-2}
T1	78.553 d	9.750 d	19.0	308.33 d
T2	79.443 cd	10.667 c	20.5	337.00 c
T3	80.223 c	11.220 bc	20.80	348.00 c
T4	81.777 b	11.553 ab	21.25	361.00 c
T5	82.887 ab	11.780 ab	22.0	410.67 b
T6	84.000 a	12.110 a	22.5	446.00 a
SE	2.9410	2.6769	2.1763	2.2742
LSD = 0.05	5.0243	4.1143	5.0443	6.0243

Table 3: Yield attributes of wheat crop as affected by different levels of zinc sulfate

Treatments	Number of grains /spike	1000-grain wt (gm)	Grain harvest (kg ha^{-1})	Biological harvest (kg ha^{-1})
T1	53.113 e	34.12 c	5560	8005.0
T2	55.220 d	36.30 c	6210	8107.5
T3	56.333 d	39.60 b	6580	8230.0
T4	59.447 c	40.25 b	6980	8654.0
T5	61.220 b	42.29 a	7520	8705.0
T6	63.000 a	42.85 a	8910	8802.5
SE	3.9410	2.4761	2.2764	2.2723
LSD = C	5.0221	4.2243	4.0443	5.0243

Note: Different letters indicate significant differences at p< 0.05

^{2} were noticed to be increased which is in line with the results compared to plants grown at lower levels of ZnSO4. The spike length was also increased due to different doses of Zn application. This result is agreement with the findings of Khan *et al.* (2008). Previously, some scientists found that zinc application caused improvement in spike length and of khan (2008) who reported that application of ZnSO4 increased fertility of crops.

The number of grain per spike also increased, which may again be contributed by the

availability of ZnSO4 at optimum level. Similar findings were reported by Hemmat *et al.* (2023). Similarly, 1000-grain wt was enhanced and these results are accordance to the finding of kaya *et al.* (2002), who reported that 1000-grain wt increased with application of Zn fertilizer. The results on grain harvest kg/ha are in great analogy with the Abbas *et al.* (2010), who stated that Zn application is necessary for obtaining the highest economic harvest. Grain yield improvement can also be attributed to increased biomass production, particularly through fertilizer inputs and crop protection (Siddique et al. 1989; Donmez et al. 2001). Modaihsh (1997) also observed that zinc application increased biological yield and grain yield of wheat cultivated on calcareous soils, which is supported here. Biological harvest kg/ha was found increased in this study. Our results disagree with that reported by Du *et al.* (2019), where ZnO nanoparticles (NPs) were studied as a potential solution to alleviate.

4. Conclusion and Recommendations

To study the effect of ZnSO4 on harvest and harvest component of wheat variety "Azric" was conducted at research site of Gomal University Dera Ismail Khan in year 2022-23. The experiment was laid out in randomize complete block design, having six treatments and thrice replicates with plot size 2x2 m^{-2}. The composite soil samples were prepared and were analysed for physic-chemical characteristics before sowing the crop. The approved wheat variety "Azric" was sown in mid-November 2022, on well-prepared soil, using 120 kg seed/ha. The sowing of crop was done with drill manually. The full dose of phosphorous as SSP and half dose of nitrogen as urea was applied as a basal dose to all treatments. The remaining half dose of nitrogen was applied with 1st irrigation, while Zn was applied in the form of ZnSO4 at the rate of 2, 4, 6, 8, 10, and 12 kg/ha with 1st irrigation, included one treatment of control. All the other cultural practices were uniform to all treatments.

On the basis of result, it is concluded that application of Zn not only increased harvest but also enhance the harvest component of wheat. Therefore, it is recommended that 9 kg ZnSO4/ha was found the best for obtaining the highest harvest of wheat crop.

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Conflict of Interest
The authors declare no conflict of interest.

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