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EFFECT OF ZINC TREATMENT ON VARIOUS TRAITS OF DIFFERENT VARIETIES OF CULTIVATED WHEAT (*TRITICUM AESTIVUM*)

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Abstract *This research paper focuses on the effects of zinc treatment on various traits of cultivated wheat varieties in Pakistan. Zinc is a vital nutrient for plant growth, and its deficiency can lead to reduced growth, seed production, and visual symptoms such as chlorosis and necrosis in plants. The study aims to analyze the impact of zinc treatment on traits, including the grain yield, biological yield, plant height, number of grains per spike, number of spikelets per spike, spike length, and number of tillers. A randomized complete block design was employed to evaluate wheat traits experimentally. Multiple wheat varieties were treated with two doses of zinc, and a control group was included. The study site was selected based on soil fertility, irrigation facilities, and favourable climatic conditions for wheat cultivation. Standard agricultural practices were followed, including proper planting, crop management, and data collection. Statistical analysis revealed significant effects of zinc treatments on the evaluated traits. Zinc-treated groups generally exhibited higher values for biological yield, grain yield, number of tillers, number of spikelets per spike, number of grains per spike, plant height, and spike length than the control group. The results of this study suggest that applying zinc, particularly at specific doses, can significantly improve wheat crop traits and enhance overall productivity. The findings have implications for agricultural practices, highlighting the importance of zinc supplementation in optimizing crop yield. Further research and field trials are recommended to investigate the underlying mechanisms and optimize zinc dosage and application methods for maximum efficacy. By shedding light on the effects of zinc supplementation on wheat crops, this research contributes to our understanding of the role of nutrients in promoting agricultural productivity. The findings support the potential use of zinc as a beneficial nutrient for sustainable agriculture, ultimately aiding food security*.

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Keywords: *Wheat Production; Fertilizers; Zinc Treatment; morphological traits*

Introduction

In an era marked by a burgeoning global population, ensuring food security has emerged as a paramount challenge. As one of the world's most important cereal crops, wheat plays a pivotal role in meeting the dietary needs of millions. Wheat crop productivity, however, faces multifaceted threats such as climate change, pests, diseases, and dwindling arable land. Addressing these challenges demands innovative research and sustainable agricultural practices to enhance wheat yield, while preserving the environment and safeguarding farmers' livelihoods {Rasheed, 2022 #3}. Wheat is the primary crop, ensuring the country's food security (FAO). It is cultivated across a vast expanse of around 22 million acres, contributing to about 8.0% of the value added in the agricultural sector and shooting 2.0% of the GDP (MAFW India, 2021). During the 2021-22 season, the area dedicated to wheat cultivation decreased by 2.1 percent (USDA, 2022). Correspondingly, wheat production experienced a decline, reaching 26.40 million tonnes, down by four percent compared to the production of 27.50 million tonnes in the preceding year (USDA, 2022). Multiple factors contributed to this decline in wheat production, including reduced sowing area, unfavorable conditions of drought when sowing, improper supply of irrigation water, reduced fertilizer absorption, and a heatwave experienced in March-April (Economic Survey of Pakistan, 2022).

This research paper aims to delve into the multifaceted aspects of wheat crop production, primarily regarding fertilizer application. Among fertilizers, Zinc, as a plant nutrient, is known for its wide range of influence on the plant. Zinc plays a well-established role as a vital nutrient for plant growth, including wheat cultivation. Zinc deficiency and its plant responses have been observed in various regions worldwide, including Pakistan. Soil zinc content typically ranges from less than 10 to 1000 ppm, and plants take up zinc as Zn^{++} ions. Zinc is involved in many enzymatic/catalytic activities, including metabolism of plant hormone auxin and the functioning of hydrogenase, carbonic anhydrase, cytochrome synthesis, and ribosomal stabilization. Zinc deficiency in plants leads to visual symptoms such as small leaves, mottled rosettes, die-back, browning, yellowing, and brown spots. The specific symptoms of zinc deficiency can vary depending on factors like species, variety, soil conditions, water availability, fertilizer use, planting methods, growth stage, and season (Sami et al., 2023; Khalid and Amjad, 2018ab; Farooq et al., 2011; Batool et al., 2023; Javed et al., 2022) Generally, zinc-deficient plants exhibit poor growth, interveinal leaf chlorosis and necrosis in lower leaves, and older leaves may develop reddish or brownish spots. Additionally, seed production is significantly reduced in the presence of zinc deficiency. This study analyses the effects of zinc treatment on multiple growth parameters of wheat crop such as No. of Tillers, Plant height, Spike Length, No. of Spikelets per spike, No. of Grains per spike, Biological yield and Grain yield.

Materials and Methods

Experimental Design

The evaluation of wheat crop traits, including No. of Tillers, Plant Height, Spike Length, No. of Spikelets per Spike, No. of Grains per Spike, Biological Yield, and Grain Yield, was conducted using a randomized complete block design (RCBD). The experiment included multiple wheat varieties treated with two doses of zinc and a control, replicated three times to ensure statistical reliability.

Study Site and Crop Cultivation

The study was conducted at a selected agricultural research farm suitable for wheat cultivation in Faisalabad. The site was chosen based on soil fertility, irrigation facilities, and climatic conditions conducive to wheat growth. The field was appropriately prepared, and all necessary pre-planting soil treatments, such as fertilization and weed control, followed standard agricultural practices.

Planting and Crop Management

Wheat seeds of the selected varieties viz. E46, E47, E48, E49, E50, E60, E91, E92, E93, E94, E95, E22, E23, E24, E25 were procured from reliable sources, ensuring their genetic purity and quality. Based on the local agricultural calendar and climatic conditions, a suitable sowing date was determined to ensure optimal germination and growth. The seeds were sown using standard seeding rates and planting techniques, maintaining uniformity across all experimental plots.

Throughout the crop growth cycle, essential cultural practices were implemented, including irrigation management, timely application of fertilizers based on soil test recommendations, weed control measures, and pest and disease management, following integrated pest management (IPM) strategies. The application of growth regulators or other treatments, if any, was carried out according to specific research objectives.

Data Collection and Trait Measurement

Data collection commenced at the appropriate growth stage(s) for each trait under evaluation. The following traits were assessed: No. of Tillers: The number of tillers per plant was counted by visually inspecting and recording the count for each plot. Plant Height: The height of the main shoot from the ground level to the tip of the flag leaf was measured using a measuring tape or a graduated rod, ensuring accurate measurements. Spike Length: The fully emerged spike(s) length was measured from the base to the tip using a ruler or a measuring tape. No. of Spikelets per Spike: The number of spikelets present on each spike was counted manually, ensuring consistent counting methods. No. of Grains per Spike: After maturity, the number of grains on each spike was counted carefully. Biological Yield: At harvest, the above-ground plant biomass from each plot was harvested, dried to a constant weight, and recorded as the biological yield. Grain Yield: The harvested grains from each plot were threshed, cleaned, and weighed to determine the grain yield.

Zinc Treatments

Plants were treated with two different zinc concentrations of 5kg (Zn1) and 10kg (Zn2) along with a control group (C) upon which zinc wasn’t applied. The fertilizers were thoroughly mixed with the soil in individual pot. A sub-sample of about 100 g was collected from each pot for chemical analysis.

Data Analysis

Collected data on the evaluated traits were subjected to appropriate statistical analyses using software such as Statistix 8.1. Descriptive statistics, such as mean, standard deviation, and coefficient of variation, were calculated. Variance (ANOVA) was analysed to assess significant differences among treatments or varieties.

Statistical Interpretation and Conclusion

The statistical results were interpreted to determine significant variations in the evaluated traits among treatments or varieties. Conclusions were drawn based on the findings, highlighting the performance of different wheat varieties or treatments regarding the assessed traits. The implications and practical relevance of the results were discussed, and recommendations for further research or agronomic practices were made if deemed necessary.

Results and Discussions

The present study investigated the effects of different doses of zinc (Zn1 and Zn2) on various traits of wheat crops. The traits studied include grain yield, biological yield, plant height, number of grains per spike, number of spikelets per spike, spike length, and number of tillers. A control group (C) was also included for comparison. The analysis of variance (ANOVA) tables for each trait provide valuable insights into the significance of the treatments and their impact on the different traits.

Biological Yield

The ANOVA table 1 (Supplementary material) for biological yield indicates that the treatment factor significantly affects the yield of wheat crops (F = 35.40, $p < 0.0000$). The means of biological yield for each treatment show that Zn1 (35.311) and Zn2 (38.667) resulted in higher yields compared to the control group (32.844). The observations per mean were 45, and the standard error of a mean was 0.4912. The standard error of the difference between two means was 0.6946 (Figure 1).

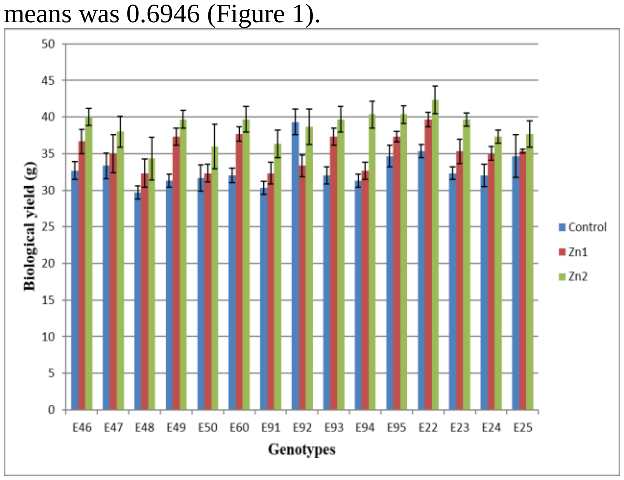

Figure 1. Biological yield of wheat genotypes

Grain Yield

Like biological yield, the ANOVA table 2 (Supplementary material) for grain yield demonstrates a significant effect of the treatment factor on wheat crop yield (F = 48.24, $p < 0.0000$). The mean grain yields for Zn1 (12.644) and Zn2 (14.911) were higher than the control group (10.667). The observations per mean were 45, and the standard error of a mean was 0.3058. The standard error of the difference between two means was 0.4324 (Figure 2).

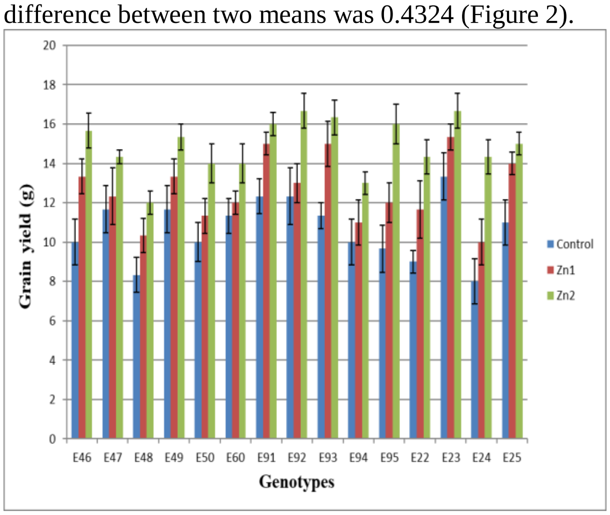

Figure 2. Grain yield of wheat genotypes

Number of Tillers

The number of tillers reveals the treatment factor's significant effect on wheat crop tillering (F = 21.62, $p < 0.0000$) Table 3 (Supplementary material). The mean number of tillers for Zn1 (5.5111) and Zn2 (6.1333) were higher than the control group (4.8889). The observations per mean were 45, and the standard error of a mean was 0.1338. The standard error of the difference between two means was 0.1892 (Figure 3).

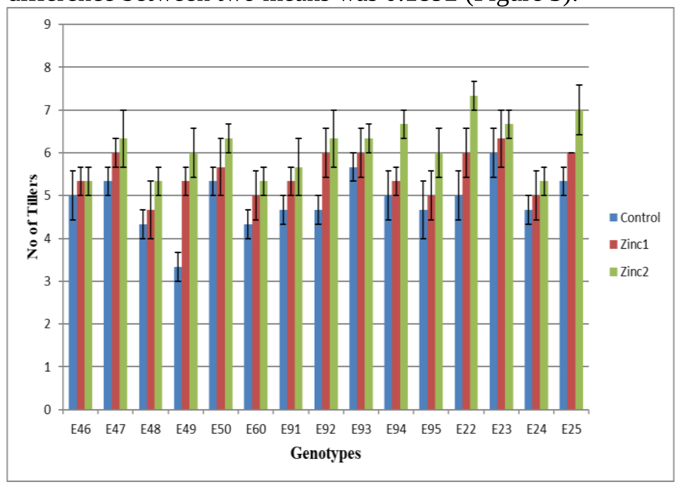

Figure 3. No of tillers in wheat genotypes

Number of Spikelets per Spike

The ANOVA table 4 (Supplementary material) for the number of spikelets per spike shows a significant effect of the treatment factor on spikelet formation in wheat crops (F = 52.44, $p < 0.0000$). The mean number of spikelets per spike for Zn1 (16.556) and Zn2 (17.889) was higher compared to the control group (14.689). The observations per mean were 45, and the standard error of a mean was 0.2220. The standard error of the difference between the two means was 0.3139 (Figure 4).

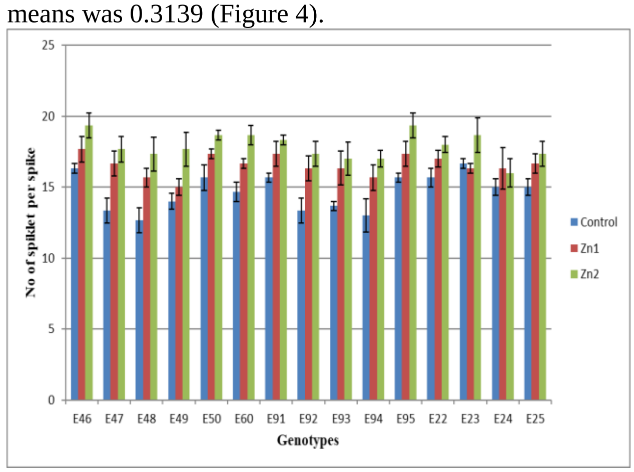

Figure 4. No of spikelets per spike

Number of Grains per Spike

The ANOVA table 5 (Supplementary material) for the number of grains per spike indicates a significant effect of the treatment factor on grain production in wheat crops (F = 56.44, $p < 0.0000$). The mean number of grains per spike for Zn-1 (46.267) and Zn-2 (53.044) was higher compared to the control group (39.489). The observations per mean were 45, and the standard error of a mean was 0.9022. The standard error of the difference between the two means was 1.2759 (Figure 5).

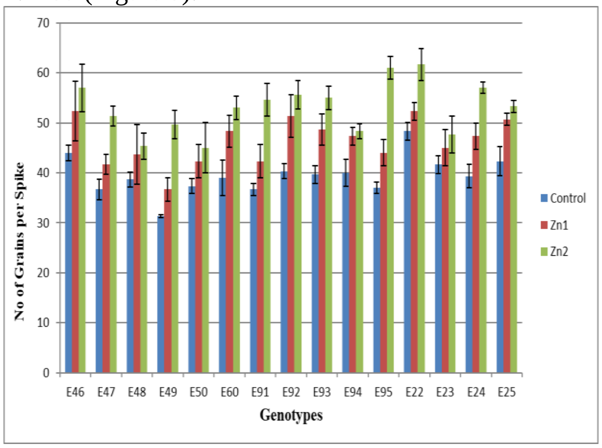

Figure 5. No of grains per spike in wheat genotypes

Plant Height

Plant height demonstrates a significant effect of the treatment factor on wheat crop height ($F = 31.09$, $p < 0.0000$) in Table 6 (Supplementary material). The mean plant height for Zn1 (76.689) and Zn2 (79.156) was higher compared to the control group (73.333). The observations per mean were 45, and the standard error of a mean was 0.5242. The standard error of the difference between the two means was 0.7413 (Figure 6).

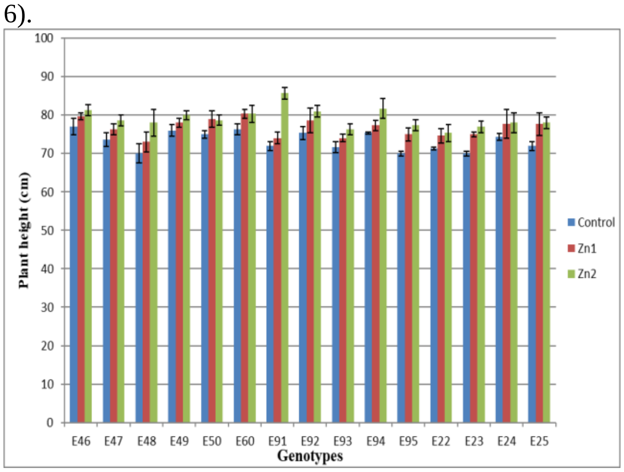

Figure 6. Plant height of wheat genotypes

Spike Length

Lastly, spike length reveals a significant effect of the treatment factor on the length of wheat spikes ($F = 33.02$, $p < 0.0000$) in Table 7 (Supplementary material). The mean spike lengths for Zn1 (12.244) and Zn2 (13.533) were higher than those of the control group (11.133). The observations per mean were 45, and the standard error of a mean was 0.2090. The standard error of the difference between two means was 0.2956 (Figure 7).

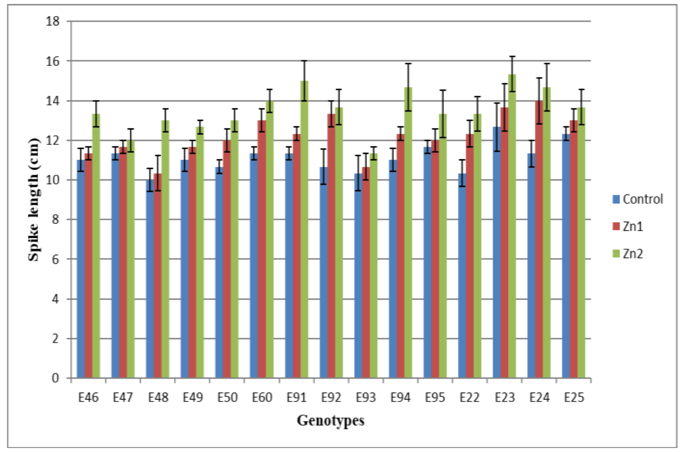

Figure 7. Spike length of wheat genotypes

Overall, the results indicate that the application of zinc in the form of Zn1 and Zn2 positively impacted most of the studied traits. The treated groups generally exhibited higher values for biological yield, grain yield, number of tillers, number of spikelets per spike, number of grains per spike, plant height, and spike length than the control group. These findings suggest that zinc supplementation can enhance the growth and productivity of wheat crops. When applied appropriately, it can improve quantitative and qualitative traits (Ali et al., 2013; Rani et al., 2019). Riffat and Samim in 2007 also noticed a significant increase after zinc application in many of the traits discussed here. Zinc also increases grain's nutritional quality when applied to foliage in the milking and booting stages (Esfandiari et al., 2016). Seed treatment of Zn has also improved wheat grain yield and Zn status (Rehman et al., 2018). Furthermore, the relative efficiency values indicate the effectiveness of the randomized complete block design in minimizing the experimental error. The coefficients of variation (CV) provide insights into the variability of the measurements for each trait (Ali et al., 2013; Ali et al., 2014; Ali et al., 2016; Mehboob et al., 2020; Iqra et al., 2020).

Conclusion

The present study examined the effects of two different doses of zinc (Zn1 and Zn2) on various traits of wheat crops, including biological yield, grain yield, number of tillers, number of spikelets per spike, number of grains per spike, plant height, and spike length. The analysis of variance (ANOVA) tables revealed significant effects of the zinc treatments on most of the studied traits. Applying zinc in the form of Zn1 and Zn2 resulted in higher yields of both biological and grain yield compared to the control group. This indicates that zinc supplementation positively influenced the overall productivity of the wheat crops. Moreover, the treated groups exhibited increased tillering, spikelet formation, and grain production, which are crucial determinants of yield. The enhanced plant height and spike length observed in the treated groups further suggest improved growth and development of the wheat plants.

The relative efficiencies calculated for the randomized complete block design demonstrated the effectiveness of this experimental design in reducing experimental error. The coefficients of variation (CV) provided an understanding of the variability in the measured traits, indicating the precision and consistency of the data. Based on these findings, it can be concluded that applying zinc, specifically at the Zn1 and Zn2 doses, can significantly improve the growth and productivity of wheat crops. These results have implications for agricultural practices and highlight the importance of zinc supplementation in optimizing crop yield. Further studies and field trials could be conducted to explore the underlying mechanisms of zinc's effects on wheat crops and to optimize the dosage and application methods for maximum efficacy.

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Declarations

Data Availability statement

All data generated or analyzed during the study are included in the manuscript.

Ethics approval and consent to participate

Not applicable

Consent for publication

Not applicable

Funding

Not applicable

Conflict of Interest

Regarding conflicts of interest, the authors state that their research was carried out independently without any affiliations or financial ties that could raise concerns about biases.