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Wheat growth and performance under nutrient management in Iraq

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ABSTRACT

This research considers the influence of potassium (K) and zinc (Zn) fertilization on the growth and yield parameters of two wheat varieties, IBA 99 and BUHOTH 22, under a field experiment carried out at Al-Zubair/Alluhais in Basrah, Iraq. The randomized experiment included complete block designs, K, Zn, K and Zn, and control groups. Significant growth parameters such as height of plants, number of leaves, number of branches, number of spikes, seed weight, and total yield per hectare were captured. The results showed that the most abundant seed yield (5.258 tons/hectare) was obtained with the combined treatment of 8 kg K/hectare and 8 g Zn/hectare for IBA 99, compared to the control group, which yielded only 4.18 tons/hectare. The average value of plant height increased sharply to 126.33 cm with Zn treatment, while K treatment achieved an average of 36.20 grams of seed weight per 1000 grains. BUHOTH 22 was also noted for yielding 5.245 tons per hectare, with total plant height reaching 114 cm. This research illustrates the necessity of the balanced management of nutrients, especially with Zn, for increasing wheat production. The results are pertinent to farmers and agronomists because they show how proper management of K and Zn can yield better quality wheat and improve food security relative to the growing challenges in agriculture. Further research should investigate these treatments' long-term impacts and their relationships with different nutrients under various environmental settings.

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1. Introduction

Wheat is one of the most important crops because it is one of the main food sources worldwide. Wheat heads the list of agricultural products and is the most widely grown staple food in numerous countries (Collins, 1993). Wheat is produced in nearly every country in the world, and Iraq has cultivated approximately 2 million hectares of wheat in the past few years, with an average yield of 2.5 tons per hectare and total production reaching around 5 million tons (Schnepf, 2004). Wheat is one of those crops that gets depleted by extraction during growth, with soil nutrients being removed in larger amounts than can be replaced by fertilization (Yahaya et al., 2023). Therefore, fertilizers must be applied even before the growing season of these crops. Macronutrient fertilizers such as nitrogen, phosphorus, and potassium have a pronounced impact on plant height, number of spikes, dry matter, seed weight, and total yield, with lesser efficacy of micro fertilizers like iron and zinc (Saquee et al., 2023; Yahaya et al., 2023). Potassium (K) is another macro element that has a direct relationship with the quality and quantity of wheat produced. It helps to maintain the water balance in the plant and is important for its absorption as well as maintaining osmotic pressure within the cell. It also aids in energy and photosynthesis and assists in combating the diseases and environmental stress of the plant.

Lack of potassium may cause stunted growth, unveil yellowing leaves, and cause lower seed output. As one of the macro elements, potassium is one of the most important in aiding plant survival during environmental stress such as drought or salting of lands. Potassium helps in aiding the osmotic pressure and water balance. Potassium greatly improves the functions of irrigation systems and also Internal Physiological Drought Tolerance which enables a plant to survive better during times of drought. Under saline conditions, potassium can help mitigate the detrimental effects of salt accumulation in tissues, therefore increasing the ability of plants to thrive in adverse conditions (Chowdhury et al., 2024). A random complete block design with factorial treatments of two different nutrients was conducted in which four nitrogen treatments (urea) (control, 23, 46, 69 kg/hectare) and three potassium treatments (potassium sulfate) (control, 30, 60 kg/hectare) were administered. Results suggest that application of 46 kg of nitrogen and 30 kg of potassium per hectare produced the maximum seed yield of 4392 kg per hectare. This was significantly higher than the control treatment which had a yield of 1041 kg per hectare. These results are in line with findings by Godebo et al. (2021) who reported high seed yield and economic return for wheat farmers in the region. Provided that the plants received enough water for irrigation, several other factors contributed to yield such as the application of Zinc, which is an essential micronutrient that promotes grain filling and development. It is involved in protein and enzyme synthesis; serves as a catalyst for many biochemical reactions, plays a role in chlorophyll formation, as well as in the photosynthesis of plants, which affects energy and their overall growth. The lack of Zinc in plants affects their growth by causing various symptoms which include leaf yellowing, reduced growth and low seed yield. It is also noteworthy that zinc significantly improves plant tolerance to environmental stresses such as salinity and drought. It enhances enzyme and protein functions and participates in metabolic processes that lead to stress tolerance, thereby improving plant performance. Zinc also contributes to improving the structure and function of cell membranes, which reduces damage from oxidative stress and increases the plant's ability to maintain water balance. Under saline conditions, zinc can help improve water and nutrient absorption, allowing plants to better adapt to unfavorable environmental conditions (Nandal and Solanki, 2021; Mishra et al., 2025). Zinc is a vital micronutrient for wheat; however, excess amounts can be detrimental towards the growth of wheat. One study analyzed the morphological and physiological changes of two wheat varieties inflicted with different concentration levels of zinc between 0-1000 micromoles over the course of 14 days. The study found that membrane damage and changes in antioxidant enzyme activities were prevalent as Zn concentrations increased (Wei et al., 2022). This research is being undertaken because of the need to better understand how potassium and zinc fertilization impacts the yield of two wheat cultivars, IBA 99 and BUHOTH 22, on a farm located in Al-Zubair/Alluhais, a city in the Basrah province of Iraq, especially when coupled with previously given soil-based fertilizers and environmental stressors.

2. Material and methods

A field experiment was conducted in the autumn agricultural season of 2023-2024 at a farm located in Al-Zubair/Alluhais, a city in the Basrah province of Iraq. The aim was to investigate the effects of various potassium and zinc fertilizers on their accumulation in the plant and the physical-chemical properties and yield of the crop. To identify the chemical and physical characteristics of the soil, soil samples were randomly collected from several areas of the farm before planting at a depth of 0-30 centimeters. These samples were then mixed, dried, ground, and sieved on a 2mm diameters. Analyses were conducted in laboratories associated with the Soil Science and Water Resources Department at the College of Agriculture, University of Basrah. The soil type in the studied area is sandy loam, characterized by a balanced combination of sand, silt, and clay. This type of soil, due to its specific composition, has suitable drainage and aeration capabilities and can provide optimal conditions for plant growth. The soil characteristics of this region were specifically assessed to evaluate its suitability for agricultural activities. During this study, the electrical conductivity of the soil (EC) was measured at 2.5 ds/m. This value indicates moderate salinity levels, which can affect some plants but may generally be acceptable.

Meanwhile, the electrical conductivity of the soil extract (EC) was significantly higher at 9.1 ds/m. This value indicates high salinity, which can negatively affect crop growth and require more management for suitable cultivation.

Additionally, the soil pH was recorded at 7.61, indicating neutral to slightly alkaline conditions. This pH level is generally suitable for most crops and suggests that the soil does not have excessive acidity, which can facilitate the selection of agricultural products. To enhance soil fertility and improve growth conditions, 50 kg of organic matter sourced from cattle manure was added to the land on November 1, 2023. This organic amendment was used to improve soil structure and facilitate nutrient availability for plants. This practice is particularly important for supporting healthy crop growth and ensuring high productivity in agricultural practices. Adding this type of organic matter can enhance not only the physical structure of the soil but also its biological activity, aiding in better water and nutrient absorption, ultimately leading to the production of high-quality crops and improved yields.

A comprehensive fertilization program was implemented to support crop growth in the study area. On November 23, 2023, during the mechanical planting of wheat, 25 kg of DAP (diammonium phosphate) per 2500 square meters was applied to provide essential nutrients, especially phosphorus, for the early establishment of the crop. To meet the nitrogen needs of the wheat plants, urea was applied in two stages on December 15, 2023. In total, 65 kg of urea per donum was used, including an initial dose of 25 kg at planting and a second dose of 40 kg. This strategic approach to fertilization aims to optimize nutrient availability and improve crop performance throughout the growing season.

The planting process began on November 23, 2023, and mechanical tillage was used to effectively prepare the seedbed. At this stage, two local wheat varieties named IBA 99 and BHOUTH 22 were planted. The average seeding rate was set at 50 kg per 2500 square meters to achieve optimal plant density and facilitate healthy crop growth and development.

A Randomized Complete Block Design (R.C.B.D.) was used for a split plot factorial experiment. In this experiment, seeds of the two local wheat varieties, IBA 99 and BHOUTH 22, were planted in the main plots. Additionally, three fertilizer treatments of potassium (K), zinc (Zn), and a combination of K+Zn, along with a control treatment, were applied with three replications, using 250 g/L for each potassium and zinc treatment. Thus, the total number of treatments was 24 for the two wheat varieties with three replications. The average results were statistically analyzed using SPSS version 20, and the Least Significant Differences Test (L.S.D.) was used to compare means at a significance level of 0.05.

3. Results and discussion

This study examines the impact of two nutrient elements, potassium (K) and zinc (Zn), on two wheat varieties, IBA 99 and BUHOTH 22, regarding their growth parameters and yield. The study analyzes changes in plant height, number of leaves, number of branches, number of spikes, weight of 1000 grains, and yield per hectare. The results obtained highlight the importance of using these elements to improve the quality and quantity of wheat production.

3.1. Analysis of wheat variety IBA 99 under different treatments of zinc and potassium

Table 1 shows the effects of different treatments on the growth and yield of the wheat variety IBA 99. The treatments included a control group, potassium (K), zinc (Zn), and a combination of potassium and zinc (K + Zn). The following parameters were measured: plant height, number of leaves, number of branches, number of spikes, weight of 1000 grains, and yield per hectare.

3.1.1. Plant height

The average height of plants varied significantly among the different treatments. The control group had an average height of 108.89 cm (SD, ±17.97), while the K treatment increased the height to 117.33 cm (SD, ±31.09). The Zn treatment raised the plant height to 126.33 cm (SD, ±33.48), indicating a significant positive effect of zinc on growth. The combined treatment K + Zn produced a height of 119.44 cm (SD, ±31.65), demonstrating that both nutrients contributed to plant growth, but the effect of zinc was more pronounced.

3.1.2. Number of leaves

The number of leaves per plant also varied significantly across the different treatments. The control group averaged 4.67 leaves (SD, ±0.91). The use of K increased the number of leaves to 5.67 (SD, ±0.77), while the Zn treatment resulted in a further increase to 6.00 leaves (SD, ±1.5). The K + Zn treatment produced an average of 4.76 leaves (SD, ±1.26), indicating the positive effect of both nutrients on leaf development, with the effect of zinc being more evident.

3.1.3. Number of branches

Branching is a critical factor in determining overall wheat production. The control group averaged 3.33 branches (SD, ±0.68). The K treatment increased this number to 5.17 (SD, ±1.37), and the Zn treatment produced an average of 5.83 branches (SD, ±1.58). The K + Zn treatment yielded an average of 6.00 branches (SD, ±1.61), indicating that both treatments significantly contributed to increased branching, with the combined treatment showing the highest branching potential.

3.1.4. Number of spikes

The number of spikes is another important component of yield. The control group recorded 3.67 spikes (SD, ±0.86), while the K treatment increased this number to 5.00 spikes (SD, ±1.33). The Zn treatment also raised the number of spikes to 5.67 (SD, ±1.5), and the K + Zn treatment produced an average of 5.33 spikes (SD, ±1.41). These results indicate that both potassium and zinc treatments significantly enhance spike development, with the effect of zinc being more pronounced.

3.1.5. Weight of 1000 grains

The weight of 1000 grains are a vital indicator of seed quality. The control group averaged a weight of 29.33 grams (SD, ±5.28). The K treatment increased this weight to 36.20 grams (SD, ±9.59), while the Zn treatment produced a weight of 29.90 grams (SD, ±7.83). The K + Zn treatment resulted in a weight of 34.47 grams (SD, ±9.36), indicating that potassium significantly increases grain weight, while the effect of zinc is less pronounced.

3.1.6. Yield per hectare

Finally, yield per hectare is a crucial measure of agricultural productivity. The control group had a yield of 4.18 tons (SD, ±1.11). The K treatment increased the yield to 4.752 tons (SD, ±1.28), while the Zn treatment produced a yield of 4.673 tons (SD, ±1.24). The K + Zn treatment achieved the highest yield of 5.258 tons (SD, ±1.47), indicating that the combination of potassium and zinc significantly and meaningfully increases overall yield (P-value ≤0.05). The results suggest that the use of potassium and zinc positively affects the growth and yield of the wheat variety IBA 99. In particular, zinc had a significant impact on plant height, number of leaves, branches, and spikes, while potassium notably contributed to grain weight and overall yield. These findings emphasize the necessity of balanced nutrient management, especially with zinc, to optimize wheat production.

Table 1. Effects of different treatments of zinc and potassium on growth and yield of wheat variety IBA 99.

	Treatment			
Item	**Control**	**K**	**Zn**	**K+ Zn**
Height of plant (cm)	108.89±17.97	117.33±31.09	126.33±33.48	119.44±31.65
Number of leaves	4.67±0.91	5.67±0.77	6.00±1.5	4.76±1.26
Number of BRANCH	3.33±0.68	5.17±1.37	5.83±1.58	6±1.61
Number of Spiks	3.67±0.86	5.00±1.33	5.67±1.5	5.33±1.41
Weight of 1000 grains (gram)	29.33±5.28	36.20±9.59	29.90±7.83	34.47±9.36
Yield (ton/Hectare)	4.18±1.11	4.752±1.28	4.673±1.24	5.258±1.47

3.2. Analysis of wheat variety BUHOTH 22 under different treatments of zinc and potassium

This study examines the effects of various treatments on the growth and yield of the wheat variety BUHOTH 22. The treatments included a control group, potassium (K), zinc (Zn), and a combination of potassium and zinc (K + Zn). The following parameters were evaluated: plant height, number of leaves, number of branches, number of spikes, weight of 1000 grains, and yield per hectare.

3.2.1. Plant height

The average height of plants varied significantly among the different treatments. The control group had an average height of

81.31 cm (±13.67). The use of potassium (K) increased the height to 103.33 cm (±29.38). The zinc (Zn) treatment raised the plant height to 108.33 cm (SD, ±32.71), indicating a significant positive effect of zinc on growth. The combined treatment K + Zn produced the highest height with an average of 114 cm (SD, ±31.21). These results show that both potassium and zinc nutrients positively affect plant growth, with the effect of zinc being particularly stronger.

3.2.2. Number of leaves

The number of leaves per plant also varied among the different treatments. The control group averaged 4.50 leaves (SD, ±0.94). The potassium treatment increased the number of leaves to 5.50 (SD, ±1.64), while the zinc treatment maintained this number at 5.50 (SD, ±0.99). The K + Zn treatment produced an average of 5.00 leaves (SD, ±1.66). These findings indicate that potassium significantly impacts leaf development, while zinc also plays a role in maintaining the number of leaves.

3.2.3. Number of branches

Branching is a vital factor in determining overall wheat production. The control group averaged 3.67 branches (SD, ±0.82). The K treatment increased this number to 5.00 branches (SD, ±2.28), and the Zn treatment raised it to 5.67 branches (SD, ±1.65). The K + Zn treatment produced an average of 5.33 branches (SD, ±1.91). These results indicate that both potassium and zinc treatments significantly contribute to increased branching, with the effect of zinc being more pronounced.

3.2.4. Number of spikes

The number of spikes is another important component of yield. The control group recorded an average of 3.33 spikes (SD, ±0.94). The K treatment increased this number to 5.17 spikes (SD, ±1.37), while the Zn treatment raised the number of spikes to 5.83 (SD, ±1.59). The K + Zn treatment produced an average of 6.00 spikes (SD, ±2.45). These data indicate that both potassium and zinc treatments significantly improve spike development, with the combined treatment showing the highest number of spikes.

3.2.5. Weight of 1000 grains

The weight of 1000 grains are a vital indicator of seed quality. The control group averaged a weight of 30.81 grams (SD, ±5.08). The K treatment increased this weight to 32.88 grams (SD, ±8.71), while the Zn treatment produced a weight of 36.13 grams (SD, ±9.57). The K + Zn treatment resulted in a weight of 37.18 grams (SD, ±9.85), indicating that both potassium and zinc nutrients positively affect grain weight, with the effect of zinc being particularly stronger.

3.2.6. Yield per hectare

Finally, yield per hectare is a crucial measure of agricultural productivity. The control group had a yield of 2.633 tons (SD, ±0.93). The K treatment increased the yield to 4.089 tons (SD, ±1.09), while the Zn treatment produced a yield of 4.867 tons (SD, ±1.96). The K + Zn treatment achieved the highest yield of 5.245 tons (SD, ±2.31), indicating that the combination of potassium and zinc significantly increases overall yield (P-value ≤0.05). The results suggest that the use of potassium and zinc has a positive impact on the growth and yield of the wheat variety BUHOTH 22. Zinc showed particularly significant effects on plant height, number of branches, spikes, and grain weight, while potassium significantly contributed to overall yield. These findings emphasize the importance of balanced nutrient management, especially with zinc, to optimize wheat production (Table 2).

Table 2: Effects of different treatments of zinc and potassium on growth and yield of wheat variety BUHOTH 22.

	Treatment			
Item	**Control**	**K**	**Zn**	**K+ Zn**
Height of plant (cm)	81.31 ±13.67	103.33± 29.38	108.33±32.71	114±31.21
Number of leaves	4.50±0.94	5.50±1.64	5.50±0.99	5±1.66
Number of BRANCH	3.67±0.82	5.00±2.28	5.67±1.65	5.33±1.91
Number of Spiks	3.33±0.94	5.17±1.37	5.83±1.59	6±2.45
Weight of 1000 grains (gram)	30.81±5.08	32.88±8.71	36.13±9.57	37.18±9.85
Yield (ton/Hectare)	2.633±0.93	4.089±1.09	4.867±1.96	5.245±2.31

3.3. Comparison of the effects of potassium (K) and zinc (Zn) treatments on two wheat varieties, IBA 99 and BUHOTH 22

Fig. 1 shows the comparison of the effects of potassium (K) and zinc (Zn) treatments on two wheat varieties, IBA 99 and BUHOTH 22, in various growth and yield parameters. For both varieties, the highest plant height was observed with the Zn treatment, with IBA 99 reaching 126.33 cm and BUHOTH 22 reaching 114 cm with the combined treatment K + Zn. The number of leaves also significantly increased, with IBA 99 showing the highest number of 6.00 leaves under the Zn treatment, while BUHOTH 22 reached 5.50 leaves with both K and Zn treatments. In terms of branching, K + Zn produced the most branches in IBA 99 (6.00), while the Zn treatment brought the highest number in BUHOTH 22 (5.67), showing a significant increase (P-value ≤0.05). The number of spikes followed a similar trend, with IBA 99 reaching 5.67 spikes under the Zn treatment and BUHOTH 22 achieving 6.00 spikes with K + Zn. In the assessment of 1000 grain weight, the K treatment produced the heaviest grains for IBA 99 at 36.20 grams, while the K + Zn treatment reached 37.18 grams for BUHOTH 22. Yield per hectare peaked with K + Zn treatments in both varieties, with IBA 99 yielding 5.258 tons and BUHOTH 22 yielding 5.245 tons, significantly higher than the control groups (P-value ≤0.05). Overall, the results indicate that both potassium and zinc treatments are effective, and the combined application yields the highest improvements in growth and productivity, emphasizing the importance of balanced nutrient management in wheat cultivation.

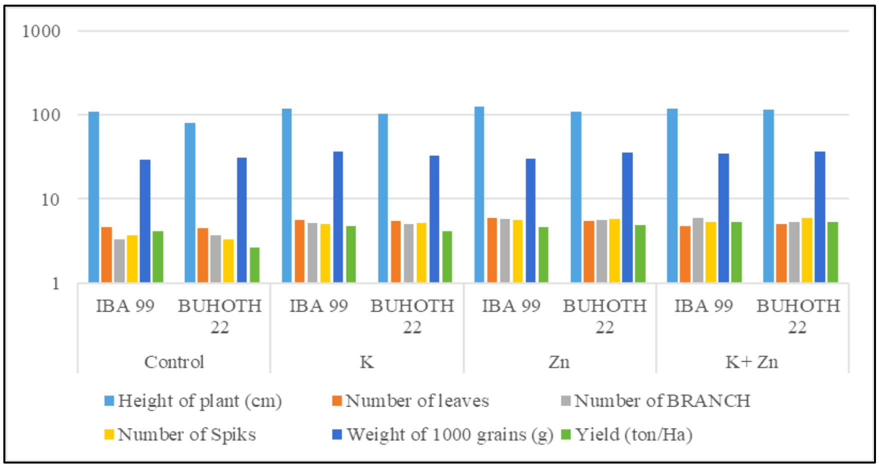

Fig. 1. Comparison of the effects of potassium (K) and Zinc (Zn) treatments on two wheat varieties, IBA 99 and BUHOTH 22.

A study conducted in Dera Ismail Khan, Pakistan, investigated the effects of potassium (K) and zinc (Zn) fertilizers on the growth, yield, and quality of the Hashim-08 wheat cultivar and a local landrace during the 2019–2020 growing season (Bashir et al., 2023). Results showed that both cultivars responded positively to the fertilizers, with the local landrace achieving maximum plant height and biological yield, while Hashim-08 exhibited enhanced agronomic traits such as increased tillers and spike length. The application of Zn and K significantly improved grain yield, harvest index, and Zn uptake, although crude protein and grain potassium levels remained stable. Overall, the combined use of Zn and K fertilizers effectively enhanced wheat growth and quality, with the local landrace demonstrating superior nutrient uptake despite a lower grain yield compared to Hashim-08 (Bashir et al., 2023). A study evaluated the effects of foliar application of zinc sulfate on three wheat varieties (Zincol, Fakher-e-Bhakkar, and Faisalabad-2008) using three zinc levels (control, 4%, and 6%) at different growth stages. Results indicated that the Fakher-e-Bhakkar variety showed the highest responsiveness to the 6% zinc application, resulting in increased plant height, spikelet count, spike length, 100-grain weight, and overall yield compared to the other varieties. Additionally, the nutritional quality, including protein, gluten, starch, and zinc content, varied among the varieties and zinc levels. The findings suggest that Fakher-e-Bhakkar is optimal for maximizing yield and grain zinc content in Layyah, Punjab, Pakistan (Sher et al., 2022). A study assessed the impact of foliar application of zinc (Zn) and various potassium (K) fertilizers on wheat (Triticum aestivum L., var. Sakha 93) under saline conditions. Using a split-plot design with Zn levels (0 and 300 mg L^{-1} Zn-EDTA) and five K sources (control, K-sulfate, K-humate, K-silicate, and mono K-phosphate at 2 g L^{-1}), results indicated that Zn-EDTA significantly improved growth, chlorophyll content, yield, and nutrient status. Potassium silicate and humate were particularly effective under salinity. The study concludes that combining Zn-EDTA with potassium silicate or humate enhances wheat yield in salt-stressed conditions (Sakara and AlBakry, 2022). The Figs 2 and 3 presents data comparing the effects of different treatments—Control, potassium (K), zinc (Zn), and a combination of K+Zn on two wheat varieties, IBA 99 and BUHOTH 22, focusing on the concentration of zinc and potassium in both grains and shoots. In terms of zinc concentration, the highest levels in grains were observed with the K + Zn treatment, reaching 32.04 mg/kg for IBA 99 and 29.44 mg/kg for BUHOTH 22, indicating that the combined treatment is most effective for enhancing zinc uptake. Similarly, the shoots exhibited the highest zinc concentrations in the K + Zn treatment, with values of 71.74 mg/kg for IBA 99 and 66.99 mg/kg for BUHOTH 22. Regarding potassium, the K treatment resulted in the highest concentrations in grains, measuring 0.54% for IBA 99 and 0.51% for BUHOTH 22, highlighting its significant impact on grain potassium content. Additionally, in the shoots, the K + Zn treatment again led to the highest potassium levels at 1.76% for IBA 99 and 1.24% for BUHOTH 22. Overall, these findings suggest that both potassium and zinc treatments, particularly when applied together, significantly improve the nutrient content of grains and shoots in the studied wheat varieties, emphasizing the importance of balanced nutrient management for optimizing wheat growth and productivity.

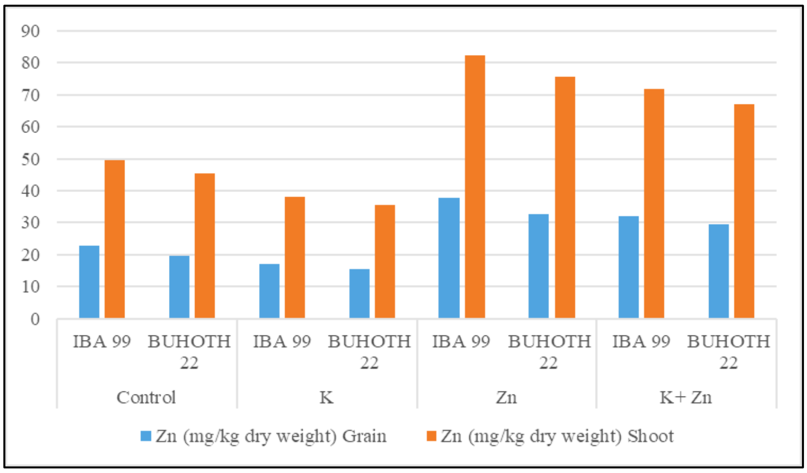

Fig. 2. Comparison of the zinc concentration in grain and shoot (mg/kg dry weight) on two wheat varieties, IBA 99 and BUHOTH 22 under different treatment.

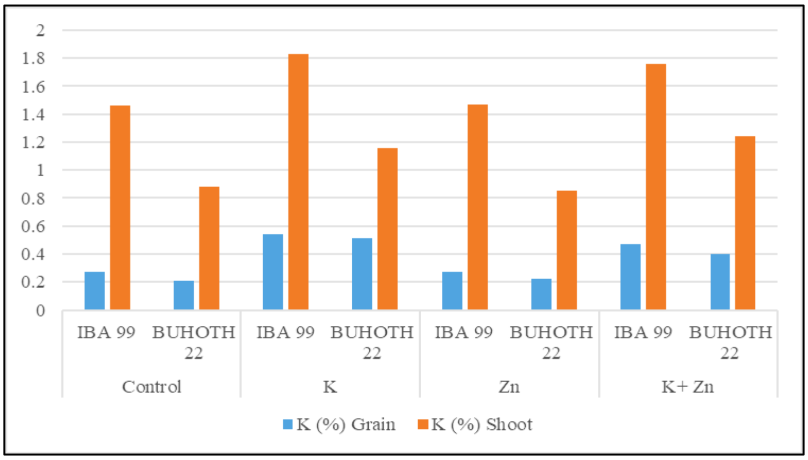

Fig. 3. Comparison of the potassium concentration in grain and shoot (%) on two wheat varieties, IBA 99 and BUHOTH 22 under different treatment.

Naeem and colleagues studied the influence of potassium (K) application on zinc (Zn) uptake and concentration in wheat (Triticum aestivum L. Cv. Galaxy 2013) as affected by different levels of phosphorus (P). It was found that application of Zn, P, and K improved growth and grain yield whenever these nutrients were applied at optimal levels. However, plant growth was stunted when nutrients were provided at sub-optimal levels. While Zn application increased its concentration in straw and grains, optimal P reduced grain Zn concentration but improved Zn uptake by straw. The combined applications of Zn and P lowered the grain Zn concentration from 43 to 32 mg kg^{-1}. Besides, K application increased the remobilization of Zn from straw to grains by 50%, benefiting grain Zn uptake of 891 µg per pot to 1249 µg per pot without causing a significant decline in yield. In summary, K increased grain Zn concentration by enhancing post-anthesis Zn uptake and remobilization after P negative (Naeem et al., 2018).

A study focuses on how nitrogen (N) management may influence the zinc (Zn) concentration in the shoots and grains of winter wheat with respect to past research mainly conducted inside growth pots. Results from field trials over two cropping seasons (2007–2008 and 2008–2009) demonstrated that applying the optimal N rates of 198 kg N ha^{-1} in 2007–2008 and 195 kg N ha^{-1} in 2008–2009, resulted in significantly higher grain Zn concentration and content as compared to lower N treatments. Zn concentrations also increased from 21.5 mg kg^{-1} to 30.9 mg kg^{-1} and from 24.7 mg kg^{-1} to 29.1 mg kg, without further significant increases due to over-supply of N. In the shoot Zn development pattern, by anthesis 72% to 100% of shoot Zn requirements were met which supported 67% to 100% of grain Zn content through remobilization from pre-anthesis uptake. These results indicate that improved shoot Zn nutrition achieved through optimal N management enhances remobilization of Zn from shoots to grains resulting in higher concentration of Zn in grains to alleviate human malnutrition (Xue et al., 2012).

4. Conclusion

In summary, the present study investigates the impact of potassium (K) and zinc (Zn) treatments on growth and yield parameters of two wheat varieties, IBA 99 and BUHOTH 22. These two nutrients combine to raise plant height, number of leaves, branching, number of spikes, grain weight, and yield per hectare, illustrating their crucial importance in agriculture. For the IBA 99 variety, the zinc treatment was more effective, especially in plant height and leaf progression; however, potassium was more important in terms of grain weight and yield. In the same manner, for BUHOTH 22, both nutrients improved the growth parameters; however, zinc was more effective in plant height and branching. Application of potassium and zinc together produced the greatest benefits for all parameters measured and is an illustration of the interacting nature of these nutrients.

The combined application of potassium and zinc synergistically alters the nutrient composition of the grains and the shoots of the wheat varieties IBA 99 and BUHOTH 22, demonstrating the effect of nutrient management on the crop yield and quality. The observations of this study suggest that proper nutrient management with an emphasis on zinc will enhance wheat crop production significantly. In essence, this study makes a significant contribution to farming and agricultural research by advocating that effective management of potassium and zinc can enhance both the yield and grade of wheat, hence assisting in food security amidst emerging agricultural issues. More research should be done on the impacts of these interventions and how they combine with other nutrients over a longer period under different environmental settings.

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