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Response of Sunflower (*Helianthus Annuus* l.) Growth, Yield, and Oil Content to Varying Zinc Levels

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ABSTRACT

The experiment consists of four treatments of Zn levels, repeated three times. The variety HO-1 was treated with different Zn levels: Zn 1 = 00 kg per ha, Zn 2 = 6.5 kg per ha, Zn 3 = 7.5 kg per ha, and Zn 4 = 8.5 kg per ha. Experiment ANOVA revealed a significant difference ($P<0.05$) for all growth, yield, and oil content characteristics due to treatments. The results of treatment 4, where zinc was applied at a rate of 8.5 kg ha-1, showed the highest plant population (8.2 m-2), the tallest plant (223 cm), the maximum stem girth (9.6 cm), the maximum head diameter (38.8 cm), the maximum seeds per head (1586.7), the maximum seed weight per head (43.7 g), the seed index 1000-seed weight (29 g), the maximum seed yield (2556.7 kg per ha), and the highest oil content (40.36%). The minimum plant population was 5.2 m-2, the smallest plant was 168.3 cm, the minimum stem girth was 6.5 cm, the minimum head diameter was 19.4 cm, the minimum number of seeds per head was 1131.7, the minimum seed weight per head was 27 g, the seed index was 18 g, the minimum seed yield was 2039.7 kg/ha, and the minimum oil content was 35.41%. Therefore, we recommend applying 8.5 kg ha-1 of Zn to achieve better growth and higher seed yield and oil content (%) in sunflowers

Introduction

Sunflower is the world's most important oilseed crop and belongs to the Asteraceae family. Its substantial contribution to Pakistan's vegetable oil production has elevated it to the status of an economically significant crop in the country (Manzoor et al., 2024). Sunflower, originally hailing from North America, is an oilseed crop that finds cultivation across the globe. The majority of its derivatives have found commercial applications in the realms of culinary and livestock feed (Yegorov et al., 2019). Furthermore, its oil's widespread preference for culinary use recognizes it as a significant oilseed crop. Sunflower farming in Pakistan occurs during two periods: the spring and summer seasons (PARC, 2019). Sunflowers' adaptability to diverse climate and soil environments has significantly boosted their farming as oilseed plants worldwide (Forleo, 2018). Sunflowers have been hailed as a promising alternative to traditional farming systems, especially in semi-arid regions (Manzoor et al., 2024). Globally, farmers cultivate sunflowers over a vast expanse of 27.29 million hectares, resulting in an annual production of 49.56 million tons and a productivity of 1820 kg per hectare in the given year (Kaleri et al., 2024). Sunflower seeds, boasting a protein content ranging from 20% to 27%, are commonly consumed in their roasted form, often seasoned with salt. Furthermore, people recognize sunflower oil for its remarkable nutritional attributes, which include a substantial proportion of polyunsaturated fatty acids, specifically linoleic acid at 72.5% and oleic acid at 16.0%. This higher oil content, ranging from 35% to 48%, plays a role in managing human blood cholesterol levels (Laghari et al., 2023). Successful sunflower growth necessitates fertile soil, adequate precipitation, seed vigor, and other favorable conditions. Sunflower, one of the top three global oilseed crops alongside soybean and rapeseed, distinguishes itself as a substantial provider of premium edible oil, highly valued for its culinary uses (Gawande et al., 2022). Globally, people regard sunflowers as one of the active oilseed crops, providing excellent oil and dietary fiber that significantly enhance human health (Kaleri et al., 2024). In specific nations like India and South Africa, sunflower cultivation could provide a better economic model than other crops like maize, soybean, and sorghum (Magsi, et al., 2023).

Zinc is a micronutrient that plays a vital role in various physiological and metabolic activities occurring in the plant system (Umar et al., 2020). This microelement plays an important role in the structure of macromolecules such as DNA and activates various metabolic and regulatory enzymes. Zinc is one of the eight essential micronutrients that play an important role in plant growth and development, as well as affect the plant's morphology, physiology, and biochemical activities (Abbasifar et al., 2020). Zinc deficiency in crop grains poses a severe problem to human nutritional health, especially among children. This can lead to loss of appetite, stunted growth, poor development, a slow rate of healing of wounds, and other abnormalities in the immune system (Awuchi et al. 2020). Zinc is one of the most important micronutrients involved in many biological processes, one of which is protein synthesis. An estimated 2800 human proteins can bind with zinc, underscoring the metal's significance in a wide range of biological activities. According to the study by Duan et al. (2023), Consequently, a decrease in zinc levels within plants directly results in reduced zinc intake for humans, a phenomenon observed in various regions across the globe, including India, Pakistan, China, Iran, and Turkey. This presents a significant challenge in the agricultural sector with far-reaching implications for public health, demanding urgent attention and intervention (Arafat et al., 2023).

Materials And Methods

The Department of Agronomy at Sindh Agriculture University in Tandojam conducted the field trial at the Student's Experimental Farm. The field was designed with an RCBD design net plot size of (12 m2). A good seedbed was prepared to adopt a suitable land preparation as per recommended practice for sunflower. The experiment was repeated three times using the prescribed doses of N, P, and K, while Zn was applied in accordance with the protocol. Treatments that were examined were: 00, 6.75, 7.5, and 8.25 kg ha-1; zinc (Zn levels) 04 = (control). Five plants were chosen at maturity for each of the experimental plots and measurement units. Utilizing a tap to measure plant height (cm), stem thickness (cm), head diameter (cm), number of seeds per head (g), 1000-seed weight (g), seed yield kg/ha, and oil content (%), the plant population (m-2) was determined.

Statistical Analysis

To do statistical analysis on the information obtained, ANOVA Computer Software Statistix-8.1 was used (Statistix, 2006). The LSD test was used in situations in which it was deemed necessary to provide a comparison of the relative effectiveness of several treatments.

Results

The results regarding mean of Plant population (m^{-2}), plant height (cm), stem girth (cm), and head diameter (cm) of sunflower as affected by various levels of zinc are present in (Table 01). The results proved the significant difference ($p<0.05$) in sunflower at various levels of zinc. The zinc 8.5 kg ha^{-1} produced better with maximum plant population (m^{-2}) of (8.2), followed by zinc was 7.5 kg ha^{-1} plant population of (7.5), whereas plant population of (6.3) was recorded where zinc was applied 6.5 kg ha^{-1} and the lowest plant population of (5.2) observed when no apply zinc was control. The zinc 8.5 kg ha^{-1} produced better with maximum plant height (cm) of (223.0), followed by zinc was 7.5 kg ha^{-1} plant height (cm) of (203.3), whereas plant height (cm) of (184.7) was recorded where zinc was applied 6.5 kg ha^{-1} and the lowest plant height (cm) of (168.3) observed when no apply zinc was control. The zinc 8.5 kg ha^{-1} produced better with maximum stem girth (cm) of (9.6), followed by zinc was 7.5 kg ha^{-1} stem girth (cm) of (8.5), whereas stem girth (cm) of (7.5) was recorded where zinc was applied 6.5 kg ha^{-1} and the lowest stem girth (cm) of (6.5) observed when no apply zinc was control. The zinc 8.5 kg ha^{-1} produced better with maximum head diameter (cm) of (38.8), followed by zinc was 7.5 kg ha^{-1} head diameter (cm) of (33.1), whereas head diameter (cm) of (24.2) was recorded where zinc was applied 6.5 kg ha^{-1} and the lowest head diameter (cm) of (19.4) observed when no apply zinc was control.

Table No. 1 Different Zinc levels on growth yield and oil content response of sunflower.

Treatments	Plant population (m^{-2})	Plant height (cm)	Stem girth (cm)	Head diameter (cm)
T_1=No Zinc 00 kg ha^{-1} (Control)	5.2 d	168.3 d	6.5 d	19.4 d
T_2=Zinc 6.5 kg ha^{-1}	6.3 c	184.7 c	7.5 c	24.2 c
T_3=Zinc 7.5 kg/ha	7.5 b	203.3 b	8.5 b	33.1 b
T_4=Zinc 8.5 kg ha^{-1}	8.2 a	223.0 a	9. a	38.8 a
S. E. ±	0.0680	12398	0.3052	0.7661
P. Value	0.0000	0.0000	0.0000	0.0000
LSD 0.05	0.1665	3.0336	0.7468	1.8745

The results regarding mean of seeds $head^{-1}$, seeds weight $head^{-1}$ (g), seed index (1000-seeds weight, g), seed yield (kg ha^{-1}), and oil content (%) of sunflower as affected by various levels of zinc are present in (Table 02). The results proved the significant difference ($p<0.05$) in sunflower at various levels of zinc. The zinc 8.5 kg ha^{-1} produced better with maximum number of seeds $head^{-1}$ of (1586.7), followed by zinc was 7.5 kg ha^{-1} number of seeds $head^{-1}$ of (1446.7), whereas number of seeds $head^{-1}$ of (1266.7) was recorded where zinc was applied 6.5 kg ha^{-1} and the lowest number of seeds $head^{-1}$ of (1131.7) observed when no apply zinc was control. The zinc 8.5 kg ha^{-1} produced better with maximum seeds weight $head^{-1}$ (g) of (43.7), followed by zinc was 7.5 kg ha^{-1} seeds weight $head^{-1}$ (g) of (40.1), whereas seeds weight $head^{-1}$ (g) of (34.5) was recorded where zinc was applied 6.5 kg ha^{-1} and the lowest seeds weight $head^{-1}$ (g) of (27.0) observed when no apply zinc was control. The zinc 8.5 kg ha^{-1} produced better with maximum seed index (g) of (29.0), followed by zinc was 7.5 kg ha^{-1} seed index (g) of (26.0), whereas seed index (g) of (21.7) was recorded where zinc was applied 6.5 kg ha^{-1} and the lowest seed index (g) of (18.7) observed when no apply zinc was control. The zinc 8.5 kg ha^{-1} produced better with maximum seed yield of (2556.7 kg ha^{-1}), followed by zinc was 7.5 kg ha^{-1} seed yield of (2316.7 kg ha^{-1}), whereas seed yield of (2173.3 kg ha^{-1}) was recorded where zinc was applied 6.5 kg ha^{-1} and the lowest seed yield of (2039.7 kg ha^{-1}) observed when no apply zinc was control. The zinc 8.5 kg ha^{-1} produced better with maximum Oil content of (40.36%), followed by zinc was 7.5 kg ha^{-1} Oil content of (38.71%), whereas Oil content of (37.89%), was recorded where zinc was applied 6.5 kg ha^{-1} and the lowest Oil content of (35.41%), observed when no apply zinc was control.

Table No. 2 Different Zinc levels response on yieldcomponents and oil content (%) of sunflower.

Treatments	**Seeds/head**	**Seed wt./head (g)**	**Seed index (1000-seeds wt., g)**	**Seed yield kg/ha**	**Oil content (%)**
T_1=No Zinc 00 kg ha^{-1} (Control)	1131.7 d	27.0 d	18.7 d	2039.7 d	35. 41 d
T_2=Zinc 6.5 kg ha^{-1}	1266.7 c	34.5 c	21.7 c	2173.3 c	37. 89 c
T_3=Zinc 7.5 kg/ha	1446.7 b	40.1 b	26.0 b	2316.7 b	38. 71 b
T_4=Zinc 8.5 kg ha^{-1}	1586.7 a	43.7 a	29.0 a	2556.7 a	40.36 a
S.E ±	16.708	0.9544	0.7577	41.451	0.0311
P value	0.0000	0.0000	0.0000	0.0000	0.0000
LSD 0.05	40.884	2.3354	1.8540	101.43	0.0680

DISCUSSION

The present research study shows that Zn 8.5 kg ha^{-1} significantly affected on sunflower variety HO-1 and produced maximum plant population 8.2 m^{-2}, plant height 223 cm, stem girth 9.6 cm, head diameter 38.8 cm, number seeds per head1586.7, seed wt., per head43.7 g, seed index 29 g, seed yield 2556.7 kg/ha, and oil content 40.36%. The control ranked least in performance plant population 5.2 m^{-2}, plant height 168.3 cm, stem girth 6.5 cm, head diameter 19.4 cm, number seed per head 1131.7, seed wt.per head27 g, seed index 18 g, seed yield 2039.7 kg per ha and oil content 35.41%. Zn fertilizer is becoming an increasingly popular practice with particular significance. to produce high value crops (Aziz et al., 2023). Zn fertilizer at flowering stage was most effective to improve growth and seed yield in sunflower (Eichert et al., 2023). In Pakistan, zinc deficiency has been documented in 49% of the trials, with 25% of these cases presenting acute forms displaying visible symptoms. Additionally, 24% of cases represented latent or hidden deficiencies, which were subsequently confirmed by observing yield responses to zinc amendments. This underscores the prevalence of zinc deficiency, affecting 50% to 70% of soils used for crop cultivation in the country (Bakheit et al., 2022). The deficiency of zinc in soils is a widespread issue in Pakistan. Consequently, soils with insufficient available zinc in both the topsoil and subsoil emerge as a pivotal limiting factor for achieving sustainable crop production (Aziz et al., 2023) the practice of applying zinc in combination with other fertilizers is commonly employed to address the issue of zinc deficiency. The notable impact of micronutrient application on sunflower growth, including parameters such as plant height, leaf count, and per-plant dry matter production, can be attributed to the enhanced metabolic functions facilitated by these micronutrients within the plant. (Fatima et al., 2024). Indeed, zinc plays a critical role in supporting the regular and healthy growth and reproduction of higher plants, animals, and humans. Due to its fundamental importance, it is referred to as an "essential trace element". Zinc fertilization holds significance in addressing nutrient deficiencies caused by stressful conditions like salinity and drought, which can adversely impact root growth and reduce nutrient absorption. Notably, the application of zinc has led to significant improvements in sunflower crops (Kumar et al., 2023). The Present research study shows that 8.5 kg/ha Zinc significantly produced maximum seed yield (2039.7 kg/ha)with oil content (40.36%) were affected sunflower variety HO-1 also better growth and oil content parameters from managing nutrients in paramount has importance when considering economic, agronomic, and environmental factors (Soomro et al., 2023) Sunflowers are one of the crops that often demonstrate favorable reactions to the application of micronutrients, including zinc (Zn), as well as other micronutrients such as (Fe), (B), (Mn), and (Mo). Several of these applications have been noted to increase both seed yield and quality in sunflower crops; there are many examples that show the positive impacts of these applications (Halimetal., 2023). The use of zinc fertilizer has importance regarding nutrient deficiencies which are further aggravated by stress factors including salinity and drought. These stressors can often deter the development of roots and limit the ability of the root to absorb nutrients. These challenges can be addressed and prevented by using Zinc which will help in the growth of the plants (Bakheit et al., 2022). In theory, zinc fertilization offers a more immediate and precisely targeted approach compared to soil fertilization. This is because nutrients, including zinc, are administered directly to plant tissues during crucial phases of plant development, ensuring a more efficient and effective uptake by the plants (Mokhtari et al., 2022). Maximizing the effectiveness of applied zinc nutrient management is of utmost significance concerning economic, agronomic, and environmental perspectives. The application of zinc before the pollination stage in sunflowers has been found to promote maximum growth and seed yield (Jan et al., 2022).

Conclusions

It is determined that, in comparison to the control group (no fertilizer), zinc levels had a substantial ($p<0.05$) impact on sunflower growth and seed yield. As zinc levels rose, seed production rose linearly. On the other hand, the plot fertilized with zinc fertilizer at 8.5 kg per hectare yielded the highest seed production (2556.7 kg per hectare) and the highest oil content (40.36%) of sunflowers.

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