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EFFECT OF NITROGEN AND ZINC FERTILIZER LEVELS ON THE GROWTH AND YIELD OF SUNFLOWER (HELIANTHUS ANNUUS L.)

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Abstract

In the case of sunflower production, precision agriculture can be used to determine the optimal fertilizer application rates and timings based on the specific soil and climatic conditions of a particular field. The response of sunflower to macro- and micronutrient applications has been observed. Field conditions were used to assess the effectiveness of applying nitrogen, zinc, and boron alone or in a mixture to improve the growth and production of sunflower HO-1. The experiment followed an RCBD design with a net plot of 5 m x 4 m (20 m^2) .The study examined the impact of different applied soil fertilizers, including NPK. The suggested doses were T1 = Nitrogen + Zinc @ 00 kg ha-1 (control), T2 = Nitrogen + Zinc @ 100 kg ha-1, T3 = Nitrogen @ 150 kg ha-1, T4 = Zinc @ 15 kg ha-1, T5 = Zinc @ 20 kg ha-1, T6 = Nitrogen + Zinc @ 100 + 15 kg ha-1, T8 = Nitrogen + Zinc @ 150 + 15 kg ha-1, and T9 = Nitrogen + Zinc @ 150 + 20 kg ha-1. For the best plant height (176.41 cm), stem girth (5.64 cm), head diameter (19.57 cm), number of seeds per head (g), seed weight (61.52 kg head-1), seed index (1000 seed weight, g), seed yield (2346 kg ha-1), and oil content (43.77%), the soil had to be fertilized with 150 kg of nitrogen and 20 kg of zinc. The findings suggest that the combined application of nitrogen + zinc 150 + 20 kg ha^{-1} as soil fertilizers emerged as the most effective treatment for achieving maximum plant growth and seed yield in sunflower crops. As farmers and researchers continue to seek sustainable practices, the insights from this study contribute valuable information to the ongoing dialogue surrounding enhanced crop productivity and quality.

Keywords: nitrogen, zinc, soil applied, sunflower

Introduction

Native to North America, sunflower (Helianthus annuus L.) is a widely cultivated annual crop worldwide. They are commonly known for their large, vibrant yellow flowers, which turn their heads to face the sun throughout the day. However, sunflowers also play a significant role in the production of seeds that are rich in oil and protein (Kaleri et al., 2024). Sunflower is one of the important oilseed crops that falls under the intermediate water requirement. Due to its short life cycle, photosensitivity, and adaptability to various agro-climatic regions and soil types, sunflower ranks as the fourth oilseed crop globally in terms of area. Sunflower has a well-developed and branched root system and maintains its stomata open in conditions of high evapotranspiration rate demand (Fagundes et al., 2007). As stated by Arshad et al. (2010), Pakistan relies on sunflower as its second major source of vegetable oil after cotton seed. The food sector extensively uses sunflower oil, a refined edible oil suitable for frying, baking, and salad preparation. Biodiesel, a natural fuel source in the modern world, also uses sunflower oil in its manufacture. Besides serving as animal feed, people consume sunflower seeds as food and use them in baking, confectionery, and other industries (Mishra and Singh, 2017). Not only do people use sunflowers as food and fuel, but they also use them for medical purposes to treat a variety of illnesses. Sunflower oil is well known for having anti-inflammatory and anti-oxidizing properties that help treat eczema and acne. Sunflower seeds contain additional substances like phytosterols, linked to cholesterol control (Yavuz et al., 2017). One of the vital elements required for the growth and development of sunflowers is nitrogen (N). Proteins, amino acids, nucleic acids, enzymes, and other structural and metabolic elements of plant cells contain this nutrient. It is a nutrient that is necessary for the synthesis of enzymes, proteins, amino acids, and nucleic acids, among other structural and metabolic polymers found in plant cells (Coelho et al., 2022). Ladha et al. (2020) assert that all crops utilize nitrogen to enhance their yields, productivity, and quality (Leghari et al., 2016). Furthermore, when the N rates were raised, the photosynthetic processes, the growth of the leaf area, the lengths of the leaf area, and the net uptake rate all increased (Wang et al., 2024). Thus, scientists have identified zinc as the essential nutrient for plant survival. It is a component of several enzymes and is actively involved in the production of the plant hormone indole acetic acid. It contributes to the synthesis of proteins and nucleic acids, the metabolism of phosphorus and nitrogen, and the germination and growth of seeds. Additionally, it functions as an additional component for membranes, DNA-binding proteins, proteins, and Zn-fingers (Tavallali, 2017). One of the most crucial elements needed for the growth of the sunflower is zinc. Furthermore, zinc performs various undefined functions, including stabilizing membranes, proteins, and DNA-binding proteins like zinc fingers (Tavallali, 2017).

Material and Methods

Methodology

The researcher aimed to compare the effects of soil-buried fertilizers on sunflower growth and yield in this field experiment. With a randomized complete block design, the experiment was carried out in a net plot of 4 by 5 (20 m2). The recommended methods of preparing the land for sunflower crops were implemented. In this research, a total of three replications were made to investigate the local variety HO-1. Some of the fertilizers that were applied to the soil included zinc and nitrogen.

Culture Practices

The soil was carefully prepared by conducting two rounds of plowing and leveling the surface. Prior to sowing, the appropriate amount of NPK fertilizer was evenly spread across all plots. Zinc and nitrogen were given to sunflower seedlings at different stages during this investigation. Throughout the first ten days after crop development, five plants from each plot were chosen at intervals of five days in order to observe the agronomical characteristics of the plants.

1. T_1=Nitrogen Zinc @ 00+00 kg ha^{-1}(Control)
2. T_2=Nitrogen@ 100 kg ha^{-1}
3. T_3=Nitrogen@ 150 kg ha^{-1}
4. T_4=Zinc @ 15 kg ha^{-1}
5. T_5=Zinc @ 20 kg ha^{-1}
6. T_6=Nitrogen + Zinc @ 100+15 kg ha^{-1}
7. T_7=Nitrogen+ Zinc @100+20kg ha^{-1}
8. T_8=Nitrogen + Zinc @ 150+15 kg ha^{-1}
9. T_9=Nitrogen + Zinc @ 150+20 kg ha^{-1}

In each experimental area, the stem girth (cm), number of leaves, and height (cm) of fifteen plants were measured at the maturity stage. The seed heads that were taken away from each plant, threshed, and recorded were used to calculate the number of seeds per head, head weight, weight of 1000 seeds (seed index), and seed yield.

Statistical analysis

The statistical software MSTAT-C was used to do an ANOVA on the data. When comparing means superiority, the LSD test was used (Russel and Eisensmith, 1983).

Results

Plant height (cm)

Plant height (cm) is one of the main vegetative growth parameters of sunflower plants, which represents the genetic variation and fertilizer effect. Statistical analysis of the data indicated nitrogen and zinc fertilizer levels significantly affected the plant height of sunflower and results are presented and analyses of variance are shown in Table 1. Taller plants (176.41 cm) were produced in plots where nitrogen + zinc fertilizer was applied at the rate of 150+20 kg ha-1, followed by 169.44 and 165.99 cm of plant height observed with the application of nitrogen + zinc at 150+15 kg ha-1 and 100+20 kg ha-1.The control group recorded a lower plant height of 79.59 cm

Stem girth (cm)

Nitrogen and zinc fertilizer applications significantly increased the stem girth of sunflower and an analysis of variance is shown in Table 1. The statistical analysis of the data showed that the treatment with nitrogen and zinc fertilizer at 100+20 kg ha-1 had the largest stem girth (5.64 cm). This was followed by plots with nitrogen + zinc at 150+15 kg ha-1 and 100+20 kg ha-1, which had stem girths of 5.58 cm and 5.36 cm, respectively. The results also showed that nitrogen + zinc at 100+15 kg ha-1 had the smallest stem girth (4.36 cm). However, the control treatment significantly recorded the lowest stem girth of 2.13 cm.

Head diameter (cm)

Head diameter is the most crucial factor among the others for determining yield. The size of a sunflower crop's head determines its potential for production. The size of the sunflower head significantly influences the final achene production, impacting both the weight and quantity of achenes. The application of nitrogen and zinc significantly increased the head diameter of sunflowers, as shown in Table 1 and Appendix 3's analyses of variance. The statistical analysis of the data showed that the treatment with nitrogen + zinc application at 150+20 kg ha-1 produced the highest head diameter (19.57 cm), closely followed by plots with nitrogen + zinc application at 100+15 kg ha-1 and 100+20 kg ha-1, resulting in head diameters of 19.29 and 19.965 cm, respectively. Significantly, T1 (nitrogen and zinc @ 00 kg ha-1) recorded the minimum head diameter of 10.14 cm.

Table 1 shows how applied soil fertilisers, both alone and in combination, affect sunflower agronomic parameters.

Treatments	**Plant height (cm)**	**Stem girth(cm)**	**Head diameter (cm)**
T_1=Nitrogen+ Zinc@ 00+00 kgha^{-1}(Control)	79.59 g	2.13 g	10.14 f
T_2=Nitrogen@ 100kgha^{-1}	147.22 d	3.03 f	16.21 c
T_3=Nitrogen@ 150kgha^{-1}	154.22 c	4.09 d	16.90 bc
T_4=Zinc @15kgha^{-1}	118.84 f	3.67 e	13.13 e
T_5 =Zinc @20 kgha^{-1}	114.18 f	3.78 e	13.91 d
T_6 =Nitrogen + Zinc@ 100+15 kgha^{-1}	163.25 c	4.36 c	17.40 b
T_7=Nitrogen+ Zinc@100+20kgha^{-1}	165.99 bc	5.36 b	18.95 a
T_8 =Nitrogen + Zinc@ 150+15 kgha^{-1}	169.44 b	5.58a	19.29 a
T_9 =Nitrogen + Zinc@ 150+20 kgha^{-1}	176.41 a	5.64a	19.57 a
S.E.	2.2751	0.0775	0.3685
LSD(0.05)	4.8231	0.1643	0.7812
P-Value	0.0000	0.0000	0.0000

Number of seeds heads: 1

Zinc and nitrogen treatments significantly increased the diameter of sunflower heads, and the number of seeds per head directly influences the total produced by seeds. Table 2 shows the findings of the analysis of variance. The data clearly show that the plots fertilized with nitrogen + zinc at 150+20 kg ha-1 had the highest number of seeds per head (1179), closely followed by the plots applied with nitrogen + zinc at 150+15 and 100+20 kg ha-1 kg ha-1, which produced (1172 and 1158) number of seeds per head. The control treatment yielded the smallest number of seeds per head, namely 774.

Seeds weight head-1 (g)

Table-2 presents the results of the analysis of variance, along with the effects of zinc and nitrogen on the weighthead-1 (g) of sunflower seeds. The findings indicated that the zinc and nitrogen treatments significantly (P <0.05) affected the seed weight (g head-1) of the sunflower variety HO-1. The results showed that the plots receiving nitrogen + zinc at 150+20 kg ha-1 had the highest seed weight per head (61.52 g), closely followed by the plots receiving nitrogen + zinc at 100+15 and 100+20 kg ha-1, which produced seed weight per head of (61.41 and 60.21 g). However, it is significant that the control treatment had the lowest seed weight per head (22.12 g).

Table 2: The effects of single and combined soil fertilizer applications on sunflower agronomic traits

Treatments	**Number of seeds head^{-1}**	**Seeds weight head^{-1}(g)**
T_1=Nitrogen+ Zinc@ 00+00 kgha^{-1}(Control)	774 f	22.12 e
T_2=Nitrogen@ 100kgha^{-1}	1024 c	46.58 c
T_3=Nitrogen@ 150kgha^{-1}	1033 c	48.44 c
T_4=Zinc @15kgha^{-1}	854 e	34.92 d
T_5 =Zinc @20 kgha^{-1}	881 d	36.42 d
T_6 =Nitrogen + Zinc@ 100+15 kgha^{-1}	1108 b	56.26 b
T_7=Nitrogen+ Zinc@ 100+20kgha^{-1}	1158 a	60.21 a
T_8 =Nitrogen + Zinc@ 150+15 kgha^{-1}	1172 a	61.41 a
T_9 =Nitrogen + Zinc@ 150+20 kgha^{-1}	1179 a	61.52 a
S.E.	11.624	1.1127
LSD(0.05)	24.643	2.3588
P-Value	0.0000	0.0000

Seed index (1000-seeds wt., g)

The data relating to seed index (1000-seeds weight, g) of sunflower as affected by application of nitrogen & zinc and analysis of variance are shown in (Table 3)

The results suggested that application of nitrogen and zinc significantly (P <0.05) affected seed index (1000-seed wt., g) of sunflower variety HO-1. It is clear from the data that maximum seed index (1000-seeds weight (57.18 g) was noted in plots fertilized with nitrogen + zinc @ 150+20 kg ha^{-1} closely followed by plots applied the application of nitrogen + zinc @ 100+15 and 100+20 kg ha^{-1} kg ha^{-1}which resulted in(56.91 and 55.82 g) of seed index (1000-seeds wt. However, significantly, the minimum seed index (1000-seeds wt., 27.28 g) was noted in control treatment.

Seed yield (kg ha^{-1})

Table 3 shows data on sunflower seed yield (kg ha-1) as influenced by nitrogen and zinc applications as well as analysis of variance. The results showed that the sunflower variety HO-1's seed yield kg ha-1 was significantly (P <0.05) impacted by the treatment of zinc and nitrogen. The data make it clear that the plots with nitrogen + zinc treated at 150+20 kg ha-1 produced the highest seed yield (2299 kg ha-1), which was closely followed by plots with nitrogen + zinc applied at 100+15 and 100+20 kg ha-1, which produced 2323 and 2299 kg ha-1 of seed yield, respectively. On the other hand, it is noted that the treatment that produced the lowest seed production (1090 kg ha-1) did so without the use of nitrogen and zinc fertilizers.

Oil content (%)

Information about the percentage of oil in sunflower seeds as impacted by applying nitrogen and zinc, as well as variance analysis, is displayed in Table 3.

The results showed that the sunflower variety HO-1's head oil content (%) was considerably (P <0.05) impacted by the treatment of zinc and nitrogen. The results make it clear that the plots with the highest oil content (42.92%) were those that received nitrogen + zinc at 150 + 20 kg ha-1. The plots that received nitrogen + zinc at 100 + 15 and 100 + 20 kg ha-1 closely trailed these plots, yielding oil contents of 43.03 and 42.92%, respectively. However, it is notable that the control treatment had the lowest oil content (25.47%).

Table 3: The effects of both integrated and solely applied soil fertilizers on the agronomic parameters of sunflower

Treatments	**Seed index (1000-seedswt.,g)**	**Seed yield (kg ha^{-1})**	**Oil content (%)**
T_1=Nitrogen+ Zinc@00+00kgha^{-1}(Control)	27.28 d	1090 e	25.47 g

T_2=Nitrogen @100 kgha^{-1}	47.70 b	2030 c	39.16 d
T_3=Nitrogen@ 150kgha^{-1}	49.57 b	2072 c	40.60 c
T_4=Zinc @15kgha^{-1}	40.82 c	1424 d	34.86 e
T_5 =Zinc @20 kgha^{-1}	41.86 c	1466 d	37.93 f
T_6 =Nitrogen + Zinc@ 100+15 kgha^{-1}	50.54 b	2174 b	41. 20 b
T_7=Nitrogen+ Zinc@ 100+20kgha^{-1}	55.82 a	2299 a	42.92 a
T_8 =Nitrogen + Zinc@ 150+15 kgha^{-1}	56.91 a	2323 a	43.03 a
T_9 =Nitrogen + Zinc@ 150+20 kgha^{-1}	57.18 a	2346 a	43.77 a
S.E.	1.3082	34.986	0.4916
LSD(0.05)	2.7733	74.167	1.0422
P-Value	0.0000	0.0000	0.0000

DISCUSSION

The main cause of a yield below potential is a lack of production technology, specifically an uneven application of fertilizers. Management practices positively affect sunflower crops, and the intake of nutrients during the crop's growth cycle directly influences overall production. The main nutrient is nitrogen, which helps in better root systems and vegetation germination. However, other trace elements are also essential for the longevity of sunflower plants and contribute to various metabolic activities.

Micronutrient deficiencies are reducing the quality of produced items and harming crop productivity. Foods and food products that have low micronutrient content pose health risks to both humans and animals. When combined with micronutrients, certain macronutrients absorb and use more efficiently. The use of micronutrients improves seed quality and size as well as crop yield quality in some cases. According to recent research, the soils are currently deficient in a number of micronutrients, including zinc (Maqsood et al. 2009). The utilization of nitrogen (N) and zinc (Zn) in Treatment 9 led to a notable rise in the maximum plant height when compared to alternative treatments (Control). This underscores the favorable impact of the integrated fertilization method on the overall growth of the plants. Notably, the combined application of nitrogen with zinc in Treatment 9 exhibited greater effectiveness. The results showed that the maximum plant height (176.41 cm), stem girth (5.64 cm), head diameter (19.57 cm), number of seeds per head (g), seed weight (61.52 g head-1), seed index (1000 - seed weight, g), seed yield (2346 kg ha-1), and oil content (43.77%) were achieved by applying soil-applied fertilizers nitrogen + zinc 150 + 20 kg ha-1. Fertilizers, nucleic acids, amino acids, and chlorophyll pigments all work together with nitrogen to help plants grow (Sadras and Angus, 2006; Kaleri et al., 2023) because nitrogen gives the cell membrane structure and helps non-structural parts build up. Ravikumar et al. (2021) and Jalilian et al. (2012) reported that the application of N fertilizer also increases protein concentration. Additionally, zinc is crucial to the process of producing biomass. According to Hacsalihoglu (2020), it is necessary for fertilization, pollen function, and chlorophyll generation. Micronutrients, especially zinc, play an important role in the overall growth of the plants in terms of their quality and quantity (Li et al., 2022). Applying zinc to crops at the correct development phase and concentration is also crucial to enhancing agricultural yields. Many enzymatic reactions involve zinc, either as a metal component of the enzymes themselves or as a structural, functional, or regulatory co-factor (Grotz & Guerinot, 2016). Additionally, zinc plays a crucial role in the formation of biomass material during its synthesis process.

It is essential for fertilization, pollen function, and chlorophyll formation, according to Hacsalihoglu (2020). Micronutrients, particularly zinc, are important for plant production because they increase the number and quality of plants (Li et al., 2022). In order to increase agricultural output, zinc must be given to crops in sufficient quantities and at the appropriate stages of development. This study further demonstrated the impact of zinc and nitrogen on sunflower development and yield. The sunflower variety HO-1 saw the highest plant height in cm across all treatments when nitrogen and zinc were applied at a rate of 150 + 20 kg ha^{-1}. As a result, the nitrogen plant height at a rate of 150 + 15 kg ha^{-1}, the height at 100 + 20 kg ha^{-1}, and the lowest plant height of plants that did not get with nitrogen or zinc follow. These findings are in line with those of Qadeer et al. (2019), who noted that nitrogen applied at a rate of 180 kg/ha increased the height of sunflower plants. While Killi asserts that nitrogen control has no significant impact on sunflower plant height, Malik et al. have demonstrated that nitrogen levels also positively influence plant height. Nitrogen is essential to sunflower plants' vegetative growth and development, and numerous studies showed that nitrogen helps plants to grow taller (Sincik et al., 2013; Schultz et al., 2018). Maximum stem diameter of sunflowers was recorded at 150 and 200 kg ha^{-1} N, which accompanied the increase in stem thickness at higher N s. Moreover, Gul and Kara (2015) found out that nitrogen application enhanced stem girth. Cechin et al. (2004) and other authors also observed that achene weight increased regularly and almost linearly with the increase in nitrogen doses up to 160 kg ha^{-1}.

While Basha (2000) noted an increase in achene output with nitrogen treatment, Ali et al. (2012) reported that the plant produced the most achenes when it was given 150 kg ha^{-1} of nitrogen. Both generative and vegetative growth lead plants to become less nitrogen-deficient and mature earlier, which negatively impacts yield. According to Baloch et al. (2020), agricultural seed yield can be increased by applying nitrogen at a rate of up to 180 kg ha^{-1}. Laporte et al. (2015) report that the application of zinc led to a significant increase in the length of the sunflower shoot and root. Furthermore, Mirzapour and Khoshgoftar (2006) found that applying 10 kg of zinc per hectare in the field increased the oil content of sunflower seeds. This could be due to the increased availability of absorbers under these conditions (Khurana and Chatterjee, 2001). According to Patil et al. (2016), the soil application of $ZnSO_4$ at 10 and 20 kg/ha^{-1} and borax at 2 kg/ha^{-1} proved to be the most advantageous among all the treatments for enhancing the production and quality of sunflower seeds. Additionally, they observed an improvement in the seed output of sunflower crops upon applying 60 kg of borax and 25 kg of ZnSO2 per hectare. Gitte et al. (2005) discovered that applying zinc (5.2 kg ha^{-1}) and boron (6.3 kg ha^{-1}) improved HI, 100-seed weight, seed yield, and straw production when compared to the control. Furthermore, Sajjan and Pawar (2005) reported that the KBSH-1 hybrid sunflowers had improved production characteristics and better seed quality when compared

Conclusions

The results showed that the application of fertilizer, including zinc and nitrogen, significantly impacted the growth and yield of the sunflower variety HO-1. Applying nitrogen and zinc at higher rates yielded the highest seed yield values; however, the plots fertilized with nitrogen 100 + 20 zinc kgha-1 showed to be suitable for achieving the best sunflower yield under Tandojam agro-ecological conditions, as indicated by their non-significant statistical differences with plots that received higher doses of nitrogen and zinc.

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