

INTERACTIVE EFFECTS OF FOLIAR BORON AND FARMYARD MANURE ON GROWTH, YIELD, AND OIL CONTENT OF SUNFLOWER.

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Abstract:

There was a field trial. In the fall of 2023, a study was carried out at Sindh Agriculture University Tando jam Research Area of the Students' Experimental Farm, Department of Agronomy. The purpose of the experiment was to investigate how boron administration affected sunflower plant growth, yield, and oil content. The methodology used in the experiment was a Randomized Complete Block Design (RCBD), with each treatment being replicated three times. Sunflower seeds were sown using a dibbler on ridges spaced 75 cm apart. The variety HO-1 was treated with different farmyard manure and boron foliar applications levels: T1 = 00% B + Farmyard Manure (Control), T2 = 0.5% B + Farmyard Manure @ 5 ton, T3 = 0.1% B + Farmyard Manure @ 5 ton, T4 = 0.2% B + Farmyard Manure @ 5 ton, T5 = 0.4% B + Farmyard Manure @ 5 ton. Experiment analysis of variance (ANOVA) shows significant difference ($P < 0.05$) for all growth, yield and oil content characteristics due to treatments. Maximum plant population (m-2) (9.1), plant height (cm) (236.0), stem girth (cm) (10.8), head diameter (cm) (45.3), seeds head-1 (1797.3), seed weight head-1 (g) (58.6), seed index (g) (32.6), Seed yield (2183.3 kg ha⁻¹) oil content of 40.00% were recorded on T5 = 0.4% B + Farmyard Manure @ 5 ton. Similarly, T4 = 0.2% B + Farmyard Manure @ 5 ton with high plant population (m-2) (8.2), plant height (cm) (231.0), stem girth (cm) (10.5), head diameter (cm) (43.3), seeds head-1 (1561.3), seed weight head-1 (g) (46.7), seed index (g) (30.0), Seed yield (1950.0 kg ha⁻¹), oil content of 39.1%. However minimum results were observed in T1 = 00% B + Farmyard Manure (Control) high plant population (m-2) (5.8), plant height (cm) (188.3), stem girth (cm) (9.0), diameter (cm) (24.3), seeds head-1 (1139.3), seed weight head-1 (g) of (24.1), seed index (g) (21.0), Seed yield (1458.3 kg ha⁻¹) the lowest mean oil content 36.2%. After going through the findings of the present research, it was concluded that the growth and yield of sunflower increased simultaneously with increasing Boron levels; and the sunflower fertilized with T5 = 0.4% B + Farmyard Manure @ 5 ton resulted in highest seed yield (2183.3 kg ha⁻¹), followed by T4 = 0.2% B + Farmyard Manure @ 5 ton (1950.0 kg ha⁻¹) and T3 = 0.1% B + Farmyard Manure @ 5 ton (1741.7 kg ha⁻¹). It was concluded that the impact of varying boron levels on sunflower growth, yield, and oil content reveals significant correlations, emphasizing the critical role of phosphorus in optimizing sunflower productivity.

Keywords: Crop yield, Growth; Boron fertilizers; Sunflower.

INTRODUCTION

Sunflower (*Helianthus annuus* L.), a member of the family Asteraceae, is widely cultivated as an important oilseed crop because of its high-quality edible oil and broad adaptability. The term “sunflower” reflects its characteristic floral form and heliotropic association, and the crop is valued for both oil and protein production. Sunflower seed typically contains 30–42% oil and 20–21% protein, which makes it useful for edible purposes and as a component of animal feed (Magsi et al., 2025). Its oil is rich in nutritionally desirable unsaturated fatty acids, particularly oleic (18:1) and linoleic (18:2) acids (Aslam et al., 2021). In addition to oil, sunflower seeds contain biologically active compounds such as antioxidants, flavanols, phytosterols, amino acids, dietary fiber, and essential minerals, which further enhances their dietary and industrial value (Soomro et al., 2023). In Pakistan, edible oil demand has increased rapidly due to population growth and evolving consumption patterns, but local oilseed production has not kept pace, resulting in a persistent supply demand gap (Manzoor et al., 2024). Consequently, Pakistan depends heavily on imported edible oil to meet national requirements. For instance, during 2013–2014, Pakistan imported 1.72 million tons of edible oil valued at approximately US\$ 1.43 billion, while domestic production remained comparatively low (GoP, 2015). This deficit has continued to exert economic pressure, with imports costing the country a substantial amount annually and contributing to Pakistan being ranked among the world’s major edible oil importers (GoP, 2020). Estimates also indicate that out of a total edible oil requirement of about 2.966 million tons, only around 0.83 million tons (28%) is produced domestically, while the remainder is met through imports (Manzoor et al., 2024). Oilseed crops therefore hold strategic importance for national food and economic security, contributing more than 17% of domestic edible oil supply, and sunflower represents a key crop within this group by contributing roughly 11% of national edible oil production (GoP, 2021). Improving sunflower productivity and oil quality requires integrated nutrient management that strengthens soil health while ensuring adequate nutrient availability during critical crop stages. Farmyard manure (FYM) is an effective organic amendment that enhances soil organic matter, improves soil physical condition, reduces compaction and surface crusting, and increases water-holding capacity, thereby supporting better crop establishment and growth (Kaleri et al., 2024). In addition, FYM contributes to improved nutrient supply, better soil structure, and a favourable environment for beneficial soil microorganisms, which collectively support nutrient uptake and crop performance (Khosro et al., 2024). While macronutrients are essential for yield formation, micronutrients are equally critical because they regulate key physiological and biochemical processes across the plant life cycle, and their deficiency can limit yield even when primary nutrients are adequately supplied (Kaleri et al., 2023). Among micronutrients, foliar feeding is widely considered an efficient approach for correcting nutrient deficiencies because it delivers nutrients directly to the plant canopy, often producing a faster response than soil application under conditions where nutrient availability is restricted by soil chemistry or moisture limitations (Prabhakar et al., 2021). Boron (B) is a particularly important micronutrient due to its involvement in multiple plant functions, including enzyme-related activity, carbohydrate transport, ion absorption, and the synthesis of structural and metabolic compounds such as nucleic acids (DNA and RNA), lignin, cellulose, and proteins (Ravikumar et al., 2021). Boron is strongly linked with cell wall formation, membrane stability, sugar transport, nucleic acid and phenolic metabolism, and hormone-associated processes (Amin et al., 2023). These roles explain why boron deficiency can severely disrupt growth and reproduction in many crops, especially those sensitive to boron availability. Sunflower is regarded as highly responsive and

sensitive to boron nutrition, and boron deficiency can impair vegetative growth, reproductive development, and yield formation by affecting leaves, stems, reproductive organs, dry matter accumulation, and yield components (Khalid et al., 2020). Evidence indicates that boron demand becomes particularly critical during the reproductive phase, when successful pollination, fertilization, and seed filling determine final yield and quality (Jagadala et al., 2020). Boron contributes to fundamental physiological processes such as cell wall organization, sugar transport, cell division, enzyme catalysis, and growth regulation, which collectively influence head development, seed set, and grain quality in sunflower (Maqbool et al., 2023). Visible and hidden boron deficiency symptoms may therefore translate into reduced yield and inferior seed quality, and sunflower is frequently reported to show pronounced yield and quality losses under inadequate boron supply (Ahmad et al., 2021). For this reason, foliar application of boron is often recommended as a practical strategy to enhance pollination efficiency, seed filling, and overall productivity in sunflower under field conditions (Crista et al., 2023).

MATERIAL AND METHOD

A research project was undertaken at the Department of Agronomy's Students' Farm at Sindh Agriculture University in Tando Jam to examine the impact of boron foliar fertilizers on the growth and yield of sunflowers. The experiment was structured using a completely randomized block design, with each plot measuring 6m x 5m (30m²). Land preparation techniques tailored for sunflower cultivation were employed, and the local sunflower variety HO-1 was selected for the study, with three replications. Boron fertilizer was administered through foliar spray at recommended dosages, in conjunction with the application of farmyard manure.

Culture Practices

The soil underwent meticulous preparation, involving two rounds of ploughing and leveling before seed sowing. Each treatment received the requisite quantity of farmyard manure during the sowing process. Boron foliar applications were consistently administered at different stages of sunflower growth throughout the duration of the study. To monitor the agronomic attributes of the plants, five specimens were selected from each plot at five-day intervals during the initial 10 days following crop emergence.

T₁ = 00% B + Farmyard Manure (Control)

T₂ = 0.5% B + Farmyard Manure @ 5 ton

T₃ = 0.1% B + Farmyard Manure @ 5 ton

T₄ = 0.2% B + Farmyard Manure @ 5 ton

T₅ = 0.4% B + Farmyard Manure @ 5 ton

The sunflower crop received two timely irrigations, and measures were taken to control diseases, weeds, and pests at the experimental sites. Fifteen plants were taken from each experimental unit throughout the maturity stage to determine their plant height (cm), stem girth (cm) and head diameter (cm). The seed heads were separated from each plant, threshed, and used to calculate the number of seeds head⁻¹, Seed weight head⁻¹ (g), weight of 1000 seeds (seed index), seed yield (kg ha⁻¹) and oil content (%) all of which were recorded.

Statistical analysis

The gathered data underwent analysis utilizing ANOVA with the assistance of Statistix-8.1 Computer Software (Statistix, 2006). When necessary, the LSD test was employed to assess the efficacy of different treatments.

RESULTS

Plant Population (m^{-2})

The outcome demonstrated a significant difference ($p < 0.05$) in sunflower at different boron and farmyard waste concentrations. The result proved the significantly changes ($p < 0.05$) in sunflower by various levels of Boron foliar applications. The experiment was consisting of five boron and farmyard manure levels i.e. $T_1 = 00\% \text{ B} + \text{Farmyard Manure (Control)}$, $T_2 = 0.5\% \text{ B} + \text{Farmyard Manure @ 5 ton}$, $T_3 = 0.1\% \text{ B} + \text{Farmyard Manure @ 5 ton}$, $T_4 = 0.2\% \text{ B} + \text{Farmyard Manure @ 5 ton}$, $T_5 = 0.4\% \text{ B} + \text{Farmyard Manure @ 5 ton}$. The maximum plant population (m^{-2}) of (9.1) were recorded in treatment $T_5 = 0.4\% \text{ B} + \text{Farmyard Manure @ 5 ton}$, followed by $T_4 = 0.2\% \text{ B} + \text{Farmyard Manure @ 5 ton}$ plant population (m^{-2}) of (8.2). Similarly, the followed mean plant population (m^{-2}) 7.1 and 6.1 was observed when crop treated with $T_3 = 0.1\% \text{ B} + \text{Farmyard Manure @ 5 ton}$ and $T_2 = 0.5\% \text{ B} + \text{Farmyard Manure @ 5 ton}$ were applied (Table 1). Further, the minimum plant population (m^{-2}) of (5.8) was observed in control $T_1 = 00\% \text{ B} + \text{Farmyard Manure (Control)}$. This suggested that $T_5 = 0.4\% \text{ B} + \text{Farmyard Manure @ 5 ton}$ could be considered as an optimum level so far the response of sunflower variety HO-1 is concerned for its plant population (m^{-2}) trait.

Plant Height (cm)

The result proved in sunflower at various levels of Boron and farmyard manure. The highest plant height (cm) of (236.0) were recorded in treatment $T_5 = 0.4\% \text{ B} + \text{Farmyard Manure @ 5 ton}$, followed by $T_4 = 0.2\% \text{ B} + \text{Farmyard Manure @ 5 ton}$ plant height (cm) of (231.0). Similarly, the followed mean plant height (cm) 221.0 and 206.0 was observed when crop treated with $T_3 = 0.1\% \text{ B} + \text{Farmyard Manure @ 5 ton}$ and $T_2 = 0.5\% \text{ B} + \text{Farmyard Manure @ 5 ton}$ were applied (Table 1). Further, the least plant height (cm) of (188.3) was observed in control $T_1 = 00\% \text{ B} + \text{Farmyard Manure (Control)}$. This suggested that $T_5 = 0.4\% \text{ B} + \text{Farmyard Manure @ 5 ton}$ could be considered as an optimum level so far the response of sunflower variety HO-1 is concerned for its maximum plant height (cm) trait.

Stem Girth (cm)

The result proved in sunflower at various levels of Boron and farmyard manure. The highest stem girth (cm) of (10.8) were recorded in treatment $T_5 = 0.4\% \text{ B} + \text{Farmyard Manure @ 5 ton}$, followed by $T_4 = 0.2\% \text{ B} + \text{Farmyard Manure @ 5 ton}$ stem girth (cm) of (10.5). Similarly, the followed mean stem girth (cm) 10.2 and 9.3 was observed when crop treated with $T_3 = 0.1\% \text{ B} + \text{Farmyard Manure @ 5 ton}$ and $T_2 = 0.5\% \text{ B} + \text{Farmyard Manure @ 5 ton}$ were applied (Table 1). Further, the least stem girth (cm) of (9.0) was observed in control $T_1 = 00\% \text{ B} + \text{Farmyard Manure (Control)}$.

(Control). This suggested that $T_5 = 0.4\% \text{ B} + \text{Farmyard Manure @ 5 ton}$ could be considered as an optimum level so far the response of sunflower variety HO-1 is concerned for its maximum stem girth (cm) trait.

Head Diameter (cm)

The result proved in sunflower at various levels of Boron and farmyard manure. The highest head diameter (cm) of (45.3) were recorded in treatment $T_5 = 0.4\% \text{ B} + \text{Farmyard Manure @ 5 ton}$, followed by $T_4 = 0.2\% \text{ B} + \text{Farmyard Manure @ 5 ton}$ head diameter (cm) of (43.3). Similarly, the followed mean head diameter (cm) 37.3 and 32.1 was observed when crop treated with $T_3 = 0.1\% \text{ B} + \text{Farmyard Manure @ 5 ton}$ and $T_2 = 0.5\% \text{ B} + \text{Farmyard Manure @ 5 ton}$ were applied (Table 1). Further, and the least head diameter (cm) of (24.3) was observed in control $T_1 = 00\% \text{ B} + \text{Farmyard Manure (Control)}$. This suggested that $T_5 = 0.4\% \text{ B} + \text{Farmyard Manure @ 5 ton}$ could be considered as an optimum level so far the response of sunflower variety HO-1 is concerned for its maximum head diameter (cm) trait.

Seeds Head⁻¹

The result proved in sunflower at various levels of Boron and farmyard manure. The highest number of seeds head⁻¹ of (1797.3) were recorded in treatment $T_5 = 0.4\% \text{ B} + \text{Farmyard Manure @ 5 ton}$, followed by $T_4 = 0.2\% \text{ B} + \text{Farmyard Manure @ 5 ton}$ number of seeds head⁻¹ of (1561.3). Similarly, the followed mean seeds head⁻¹ 1409.3 and 1248.3 was observed when crop treated with $T_3 = 0.1\% \text{ B} + \text{Farmyard Manure @ 5 ton}$ and $T_2 = 0.5\% \text{ B} + \text{Farmyard Manure @ 5 ton}$ were applied (Table 1). Further, the least number of seeds head⁻¹ of (1139.3) was observed in control $T_1 = 00\% \text{ B} + \text{Farmyard Manure (Control)}$. This suggested that $T_5 = 0.4\% \text{ B} + \text{Farmyard Manure @ 5 ton}$ could be considered as an optimum level so far the response of sunflower variety HO-1 is concerned for its maximum number of seeds head⁻¹ trait.

Seed Weight Head⁻¹ (g)

The result proved in sunflower at various levels of Boron and farmyard manure. The highest seed weight head⁻¹ (g) of (58.6) were recorded in treatment $T_5 = 0.4\% \text{ B} + \text{Farmyard Manure @ 5 ton}$, followed by $T_4 = 0.2\% \text{ B} + \text{Farmyard Manure @ 5 ton}$ seed weight head⁻¹ (g) of (46.7). Similarly, the followed mean seed weight head⁻¹ (g) 38.0 and 29.9 was observed when crop treated with $T_3 = 0.1\% \text{ B} + \text{Farmyard Manure @ 5 ton}$ and $T_2 = 0.5\% \text{ B} + \text{Farmyard Manure @ 5 ton}$ were applied (Table 1). Further, the least seed weight head⁻¹ (g) of (24.1) was observed in control $T_1 = 00\% \text{ B} + \text{Farmyard Manure (Control)}$. This suggested that $T_5 = 0.4\% \text{ B} + \text{Farmyard Manure @ 5 ton}$ could be considered as an optimum level so far the response of sunflower variety HO-1 is concerned for its maximum number of seed weight head⁻¹ trait.

Table 1. Different levels of Boron foliar applications and farmyard manure on the growth parameters of sunflower

Treatments	Plant population (m ⁻²)	Plant height (cm)	Stem girth (cm)	Head diameter (cm)	Number of seeds head ⁻¹	Seeds weight head ⁻¹ (g)
T ₁ = 00% B + Farmyard Manure (Control)	5.8 e	188.3 e	9.0 e	24.3 e	1139.3 e	24.1 e
T ₂ = 0.5% B + Farmyard Manure @ 5 ton	6.1 d	206.0 d	9.3 d	32.1 d	1248.3 d	29.9 d
T ₃ = 0.1% B + Farmyard Manure @ 5 ton	7.1 c	221.0 c	10.2 c	37.6 c	1409.3 c	38.0 c
T ₄ = 0.2% B + Farmyard Manure @ 5 ton	8.2 b	231.0 b	10.5 b	43.3 b	1561.3 b	46.7 b
T ₅ = 0.4% B + Farmyard Manure @ 5 ton	9.1 a	236.0 a	10.8 a	45.3 a	1797.3 a	58.6 a
S.E	0.1174	2.0602	0.1183	0.5708	39.206	1.3200
P value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
LSD (0.05)	0.2707	4.7508	0.2729	1.3162	90.410	3.0439

Seed Index (g)

The result proved in sunflower at various levels of Boron and farmyard manure. The highest seed index (g) of (32.6) were recorded in treatment T₅ = 0.4% B + Farmyard Manure @ 5 ton, followed by T₄ = 0.2% B + Farmyard Manure @ 5 ton seed index (g) of (30.0). Similarly, the followed mean seed index (g) 27.0 and 24.0 was observed when crop treated with T₃ = 0.1% B + Farmyard Manure @ 5 ton and T₂ = 0.5% B + Farmyard Manure @ 5 ton were applied (Table 2). Further, the least seed index (g) of (21.0) was observed in control T₁ = 00% B + Farmyard Manure (Control). This suggested that T₅ = 0.4% B + Farmyard Manure @ 5 ton could be considered as

an optimum level so far the response of sunflower variety HO-1 is concerned for its maximum number of seed index (g) trait.

Seed Yield (kg ha⁻¹)

The result proved in sunflower at various levels of Boron and farmyard manure. The highest Seed yield of (2183.3 kg ha⁻¹) were recorded in treatment T₅ = 0.4% B + Farmyard Manure @ 5 ton, followed by T₄ = 0.2% B + Farmyard Manure @ 5 ton Seed yield of (1950.0 kg ha⁻¹). Similarly, the followed Seed yield (1741.7 kg ha⁻¹) and (1563.7 kg ha⁻¹) was observed when crop treated with T₃ = 0.1% B + Farmyard Manure @ 5 ton and T₂ = 0.5% B + Farmyard Manure @ 5 ton were applied (Table 2). Further, the least Seed yield of (1458.3 kg ha⁻¹) was observed in control T₁ = 00% B + Farmyard Manure (Control). This suggested that T₅ = 0.4% B + Farmyard Manure @ 5 ton could be considered as an optimum level so far the response of sunflower variety HO-1 is concerned for its maximum number of Seed yield (kg ha⁻¹) trait.

Oil content (%)

The result proved in sunflower at various levels of Boron and farmyard manure. The effect of Boron foliar levels on the oil content was statistically significant (p<0.05). Oil content (%) of sunflower as affected by different levels of Boron foliar levels were recorded and the treatment T₅ = 0.4% B + Farmyard Manure @ 5 ton produced maximum oil content of 40.00%, while the crop receiving T₄ = 0.2% B + Farmyard Manure @ 5 ton and T₃ = 0.1% B + Farmyard Manure @ 5 ton resulted in mean oil content of 39.1% and 38.7% and T₂ = 0.5% B + Farmyard Manure @ 5 ton were oil content of 37.2%. Further, the lowest mean oil content 36.2% was noted with T₁ = 00% B + Farmyard Manure (Control). This suggested that T₅ = 0.4% B + Farmyard Manure @ 5 ton could be considered as an optimum level so far the response of sunflower variety HO-1 is concerned for its oil content (%) trait.

Table 2. Different levels of Boron foliar applications and farmyard manure on the growth parameters of sunflower

Treatments	Seed index (1000-seeds wt., g)	Seed yield kg ha ⁻¹	Oil content (%)
T₁ = 00% B + Farmyard Manure (Control)	21.0 e	1458.3 e	36.2 e
T₂ = 0.5% B + Farmyard Manure @ 5 ton	24.0 d	1563.7 d	37.2 d
T₃ = 0.1% B + Farmyard Manure @ 5 ton	27.0 c	1741.7 c	38.7 c

T₄ = 0.2% B + Farmyard Manure @ 5 ton	30.0 b	1950.0 b	39.1 b
T₅ = 0.4% B + Farmyard Manure @ 5 ton	32.6 a	2183.3 a	40.00 a
S.E	0.6146	40.230	0.0315
P value	0.0000	0.0000	0.0000
LSD (0.05)	1.4174	92.772	0.0701

DISCUSSION

The results demonstrated that the high plant population (m^{-2}) (9.1), plant height (cm) (236.0), stem girth (cm) (10.8), head diameter (cm) (45.3), seeds head⁻¹ (1797.3), seed weight head⁻¹ (g) (58.6), seed index (g) (32.6), Seed yield (2183.3 kg ha⁻¹) oil content of 40.00% were recorded on T₅ = 0.4% B + Farmyard Manure @ 5 ton. Similarly, T₄ = 0.2% B + Farmyard Manure @ 5 ton with high plant population (m^{-2}) (8.2), plant height (cm) (231.0), stem girth (cm) (10.5), head diameter (cm) (43.3), seeds head⁻¹ (1561.3), seed weight head⁻¹ (g) (46.7), seed index (g) (30.0), Seed yield (1950.0 kg ha⁻¹), oil content of 39.1%. However minimum results were observed in T₁ = 00% B + Farmyard Manure (Control) plant population (m^{-2}) (5.8), plant height (cm) (188.3), stem girth (cm) (9.0), diameter (cm) (24.3), seeds head⁻¹ (1139.3), seed weight head⁻¹ (g) of (24.1), seed index (g) (21.0), Seed yield (1458.3 kg ha⁻¹) the lowest mean oil content 36.2%. After going through the findings of the present research, it was concluded that the growth and yield of sunflower increased simultaneously with increasing Boron levels; and the sunflower fertilized with T₅ = 0.4% B + Farmyard Manure @ 5 ton resulted in highest seed yield (2183.3 kg ha⁻¹), followed by T₄ = 0.2% B + Farmyard Manure @ 5 ton (1950.0 kg ha⁻¹) and T₃ = 0.1% B + Farmyard Manure @ 5 ton (1741.7 kg ha⁻¹). The current study's results are corroborated by prior research conducted by Akpojotor et al. (2019), who It was also noted that treatments without balanced fertilizer had poorer sunflower growth and productivity, including seed yield and other agricultural traits. This goes to show that it is better to apply a balanced fertilizer than opting for separate treatments because it significantly affects the production of sunflowers. Thus, it is recommended to use a fertilizer that would be balanced and applied on the field to increase the yield and production of sunflowers. Also, the discussion delves into how farmyard waste influences sunflower yield and growth, according to Laghari et al., (2023). As it is axiomatic, high oleic hybrids have a lower iodine value as compared to that of linoleic hybrids. investigated that there is a negative correlation between oleic and linoleic acid content in sunflower oil (Popa et al., 2017). Hence, the utilization of farmyard manure, which represents a readily available source of organic matter still has great relevance in the supply of nutrients to the soil (Alzamel et al., 2022). This organic matter not only improves the soil structure but also increases the water-holding capacity of the soil making it more resistant to drought conditions Soomro et al. (2023). Studies have shown that the use of farmyard

manure increases crop yields, especially in field sunflowers how much farmyard manure is required depends on crop nutrient demanding capacity soil type, and various conditions of the environment (Islam et al., 2024). Thus, poor and nutrient-deficient ground and those having an improper structure will respond well when treated with a higher quantity of farmyard manure. However, it must be applied cautiously to prevent such things as nutrient displacements and their resultant complications that may be witnessed in patients as per (Mallick et al., 2023). Moreover, foliar application of a boron supplement has been proven to improve most of the plant growth phases which include, days to inflorescence emergence, flowering, and maturity according to Rehman et al. 2023. Part of this is due to an increase in vegetative indices and increased boron content within the plants. As a result, the improvement is quite evident in the aspects of metabolic activities, photosynthetic pigments, and biological and enzymatic activities (Shehzad et al., 2016). The study also reveals that enhanced sunflower crop characteristics including of number of achenes head⁻¹, 1000-achene weight, biological yield, and achene yield can be obtained from Boron (B) application when sunflower crops suffer from water stress conditions. It is common to have a reduced number of achenes per head in water-stressed plants mainly attributed to factors such as pollen fertilization incompatibility, delayed development, sterility, and pollen abortion which in turn limits the respiration and photosynthesis in the sunflower plants (Ariraman et al., 2020). However, foliar application of Boron (B) in water stress situations can substantially increase the number of achenes head⁻¹ by enhancing enzyme activity, charge balance, pollen formation, and other plant growth. The boron application results in the increase of achene yield because boron helps in the enhancement of the achene numbers and the achene weights (Abido et al., 2020). On the other hand, Boron deficiency might have resulted in the decrease in achene yield by the development of seeds with hollow structures attached at the central head part and lighter achene weights (Gupta et al., 2023). In dehydrated plant cases, Boron deficiency can also negatively impact net photosynthesis since this process requires functional membrane structures (YK et al., 2021). In addition, Boron deficiencies can be reduced by decreasing the content of protein and chlorophyll, the rate of photosynthesis in the leaves, the value of stomatal conductance, and certain levels of assimilation of CO₂. Such effects may collectively lead to reduced seed weight and achene yield in sunflowers as can be seen from the study by Keerio et al., (2020).

CONCLUSIONS

It was concluded that sunflower yield and growth increased together with the increase in farmyard manure and boron foliar application levels, and again the sunflower was fertilized with T₅ = 0.4% B + FYM at 5 tons gave the maximum yield of seed (2183.3 kg ha⁻¹) and 40% highest oil content.

RECOMMENDATIONS

Based on the present research, it was suggested that the sunflower variety HO-1 must be recommended for general cultivation since it showed improved yield performance. T₅ = 0.4% B plus Farmyard Manure at 5 tons was recommended based on higher seed yields and oil content.

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