Original Research Article

Effect of foliar Application of Boron, Zinc and Manganese on growth, yield and oil contents of sunflower (*Helianthus annuus* L.)

Abstract

A field trial was conducted to assess the effect of exogenously applied boron, zinc and manganese on growth, yield and oil contents of sunflower at Research Area, University of Agriculture, Faisalabad during Spring, 2019. Randomized Complete Block Design (RCBD) was used for the allocation of treatments with 3 replications. Seed was sown using dibbler on 75 cm apart ridges. Treatments included Control (no application), Water spray, 0.6% boron (B), 0.6% zinc (Zn), 0.6% manganese (Mn), 0.3% B+0.3% Zn, 0.3% B+0.3% Mn, 0.3% Zn+0.3% Mn and 0.2% B+0.2% Zn+0.2% Mn). Boron, Zinc and Manganese were sprayed at 35 days and 55 days after sowing keeping Borax (H_3BO_3), Zinc Sulphate ($ZnSo_4$) and Manganese Sulphate ($MnSo_4$) as sources of B, Zn and Mn, respectively. Various phenological, physiological and agronomical traits were monitored and analysed using Fisher's ANOVA technique and HSD test. Spray of 0.2% B+0.2% Zn+0.2% Mn gave the high values of traits including number of achenes per head, 1000-achene weight (g), achene yield (kg ha^{-1}), biological yield (kg ha^{-1}), harvest index (%), oil yield (kg ha^{-1}) and achene-oil content (%) however, further investigation is needed to understand the growth and yield behaviour of sunflower in detail.

Key words: Sunflower, micronutrients, growth, yield, quality and exogenous

Introduction

Foliar application also helpful in increases the efficiency of different nutrient elements in sunflower crop (Babaeian et al., 2011). Foliar application has been more effective in nutrient utilization as it reduced the nutrient losses and fixation while maximizing the crop productivity (Saleem et al., 2020). Each micronutrient has its own function in plant growth, but boron is considered to reduce male sterility in wheat (Tahir et al., 2009).Foliar application is helpful in increasing the efficiency of different nutrient elements in sunflower crop (Babaeian et al., 2011). Zinc play an imperative role in metabolic activities of plant (Potarzycki and Grzebisz, 2009). Zinc contributes significantly in regulating the enzyme activities and this improves nitrogen metabolism and protein synthesis (Abdelwanis et al., 2022; Pasala et al., 2022). Zinc is being considered to be highly deficient element in all calcareous soils which results in zinc deficiency in plants, human and animals. Its deficiency due to high use of phosphate and neglected usage of zinc by our farmers. Approximately 70 percent of cultivable area in Pakistan is deficient in Zn due to calcareous nature of soil and it is considered as third foremost problem of nutrition after N and P (Rashid and Ryan, 2004).It was revealed by Abunyewa and Mercer-Quarshie (2004) in maize that Zn had enhanced the quantity and quality. Ahmad and Tahir (2017) demonstrated that zinc play a key role in many processes i.e. functions and structure of membranes, synthesis of proteins, indulgence against oxidative stress and genes expression. Furlani et al. (2005) concluded that zinc was systematically used by maize cultivars and it markedly increases the contents of zinc in maize plant. Harris et al. (2007) revealed, the grain yield by 16% in wheat and 26% in maize has enhanced by the $ZnSO_4$ application across a variety of production environments. Rehman et al. (2018) noticed that applying Zn by any method enhanced the biofortification of grain and bread wheat's grain yield. Lidon and Teixeira (2000) reported that at the plant cell level, the role of manganese is attach to chloroplast, possibly to outside surface of thylakoid membranes, influence photosynthetic rate and chloroplast structure. Fertilizer use efficiency and crop productivity may be enhanced by fertilizer management practices and growing crops which uptake fertilizer more efficiently (Hirel et al., 2007; White and Hammond, 2008). Manganese is very helpful for the leaves to breakdown the nitrogen and making amino acids and helps in protein synthesis (Monreal et al., 2015).Additionally, Hebbern et al. (2005) have also reported that manganese when applied in minute quantity in foliar form then they directly touch the leaves part and uptake by leaves easily. Mn is required in both lower and high plants for the Hill reaction the water splitting and oxygen evolving system in photosynthesis (Jabeen and Ahmad, 2011).Manganese is a microelement which is necessary for the crop growth, development and other metabolic processes. It is very helpful for the leaves to breakdown the nitrogen (Monreal et al., 2015).Similarly, Hebbern et al. (2005) also reported that zinc and manganese when applied in minute quantity in foliar form then they directly touch the leaves part and uptake by leaves easily and showing an immediate positive response. Manganese perform a vital role for the betterment of crop and help in regulation of metabolic processes in plant (Zain et al., 2015). Foliar application of manganese highly beneficial to crops when the roots have failed to access the nutrients to meet the requirements of crop at critical stages (Brar and Brar, 2004).

Hence, employing exogenously applied metals proved affecting the growth and yield response of oilseeds to a major extent. Hence, this experiment was executed to understand the behavior of sunflower when applied with various combinations of metal compounds.

Materials and Methods

Field trial was performed to assess the effectiveness of B, Zn and Mn spray on Sunflower at Agronomy Research Area, University of Agriculture Faisalabad during Feb-June 2019. Crop season weather data is depicted (**Error! Reference source not found.**).

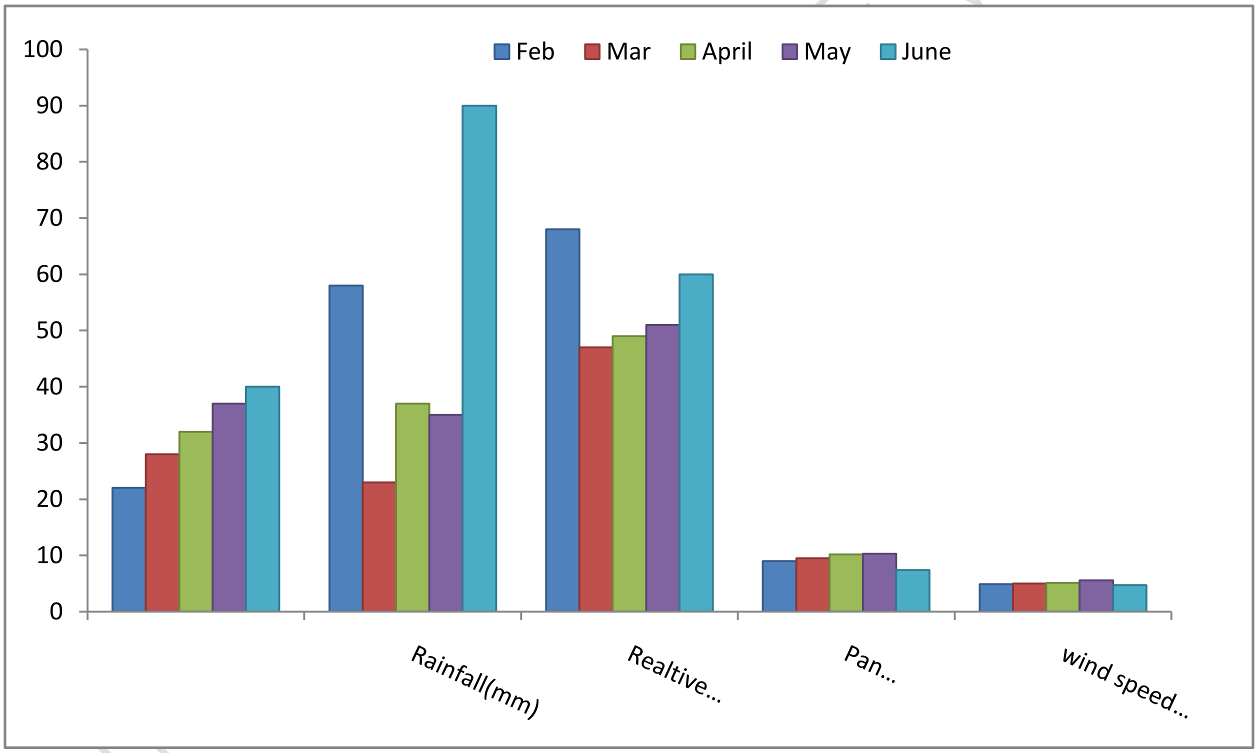

Figure 1: Average monthly data of temperature (ºC), Rainfall (mm), relative humidity (%), Pan evaporation (mm) and wind speed (km/h)

The soil properties of experimental site is shown in (Table 1: Physiochemical properties of experimental site).

Table 1: Physiochemical properties of experimental site

Physiochemical characteristics	Values
Texture	Loamy soil
pH	7.89
Electrical Conductivity	2.18 d S m^{-1}
Sodium Absorption Ratio	1.6 (mmol L^{-1})
Organic matter	0.70%
Phosphorus	4.13 ppm
Potassium	281 ppm

Experiment was conducted using Randomized Complete Block Design (RCBD) on an area of 900 m^2. Treatments were applied in sequence i.e. 1^{st} at 35 DAS (days after sowing) and second at 55 DAS. Borax (H_3BO_3) with 11% B was used as source of B, Zinc Sulphate ($ZnSO_4$) with 33% Zn was used as source of Zn and Manganese Sulphate ($MnSO_4$) with 22% Mn was used for the purpose.

Crop seeds were sown by using dibbling method on ridges in plots having net size 5.0 × 3.75 m^2. Hybrid of sunflower "AGSUN-5264" was sown by using 5 kg ha^{-1}seed rate on 18^{th} Feb 2019. Soil sampling and analysis was done before sowing of crop. Recommended N:P:K fertilizer dose i.e. 148:100:61 kg ha^{-1} were applied, respectively using Urea, DAP and SOP as sources. The crop was harvested when fully ripened. The threshing was done after sun drying. All cultural practices kept constant. Details of all treatments are given (control, water spray, 0.6% B, 0.6% Zn, 0.6% Mn, 0.3% B+ 0.3% Zn, 0.3% B+ 0.3% Mn, 0.3% Zn+ 0.3% Mn and 0.2% B + 0.2% Zn + 0.2% Mn). At maturity, equal sized area from each treatment was harvested for the calculation of different parameters regarding growth, yield and quality. The sample which was collected for experimental observations was evaluated from the sample by using HSD test at 5% probability level (Steel et al., 1997).

Results and Discussion

It is in direct relation with rate and amount of photosynthesis of the plant. The highest LAI (5.82) was recorded in treatment T_8 where 0.2% B, 0.2% Zn and 0.2% Mn. While, the lowest LAI (4.1) were observed in treatment T_0 control where we not apply any treatment as shown in (Figure 2). The highest LAD (51.73) was recorded in treatment T_8 where 0.2% B, 0.2% Zn and 0.2% Mn. While, the lowest LAD (44.12) was observed in treatment T_0 control where we not apply any treatment (Figure 2). The highest mean CGR (7.18 $gm^{-2}d^{-1}$) was recorded in treatment T_8 where 0.2% B, 0.2% Zn and 0.2% Mn. While, the lowest CGR (5.14 $gm^{-2}d^{-1}$) were observed in treatment T_0. T_0 control where we not apply any treatment as shown in (Figure 2). The highest mean NAR (22.62 $gm^{-2}d^{-1}$) was recorded in treatment T_8 where 0.2% B, 0.2% Zn and 0.2% Mn. While, the lowest CGR (18.03 $gm^{-2}d^{-1}$) were observed in treatment T_0. T_0 control where we not apply any treatment as shown in (Figure 2). In particular the mobility of micronutrients within plants is an important characteristic that determines plant growth and yield under conditions of limited nutrient availability (Marschner, 2012).

Achenes head^{-1}

Achenes in the head of sunflower are key contributor to final yield in sunflower. These also determine the potential of crop plants to boost up the yields and efficiency of the plants to convert their assimilated to grains. Significant differences among different nutrients and their interactions were noticed from the experiment. Data recorded for achenes per head in sunflower is provided in Table 1 which revealed that significantly the maximum number for achenes (1427.3) in head of sunflower was recorded where 0.2% B, 0.2% Zn and 0.2% Mn were applied as foliar spray in a mixture. Whereas, the lowest number for achenes head^{-1} (1404.7) was observed in control. Increase in achenes head^{-1} was due to application of B and Zn as both of these contribute in grain formation, while, the Mn was important in photosynthesis and enzymatic activities. All these nutrients enhanced the functions of each other and thus increased the number of achenes head^{-1} in sunflower. These findings are supported by the findings of Heitholt et al. (2002) as they also advocated an escalation in achenes head^{-1} of sunflower with the application of micronutrients mixture. Similarly, Siddiqui et al. (2009b) also concluded an increase in the seeds per head of sunflower from their experimental results when they used micronutrients in mixture along with macronutrients. Baraich et al. (2016) also concluded from their experiment that micronutrients mixture application as foliar spray was significant in improving achenes head^{-1} in sunflower.

1000-achene weight (g)

Heavy achenes are sign of enhanced and good quality produce of achenes from sunflower field. Achenes weight also contributes directly to final yield. This achene weight is a result of different management techniques and nutritional availability to crop throughout life season of the crop. Spray of micronutrients significantly improved 1000-achene weight in sunflower as shown in (Table 1). Data recorded depicted that significantly the maximum 1000-achene weight (59.33 g) was noticed where 0.2% B, 0.2% Zn and 0.2% Mn were sprayed in combination. Lowest 1000-achene weight (51.66 g) was recorded from controlled plot. These results are supported by Baraich et al. (2016) who concluded from their experiment that micronutrients mixture application as foliar spray was significant in improving 1000-achene weight in sunflower.

Soylu et al. (2005) also documented an increase in 1000-seed weight in sunflower with combined application of micronutrients. Similarly, Heitholt et al. (2002) also advocated an escalation in 1000-achene weight of sunflower with the application of micronutrients mixture. Mirzapour et al. (2006) also advocated enhanced in seed index with application of Boron in sunflower.

Achene yield (kg ha^{-1})

Achene yield was also positively enhanced with application of micronutrients mixture as foliar spray given in (Table 1). Data depicted that significantly the highest achene yield (3653.3 kg ha^{-1}) in sunflower was obtained from plants sprayed with 0.2% B, 0.2% Zn and 0.2% Mn in a combination. While, the lowest achene yield (3020 kg ha^{-1}) was recorded from controlled plot. These results are in line with Siddiqui et al. (2009b) as they have also concluded increase in achene weight of sunflower when they used micronutrients in mixture along with macronutrients. This increase in achene weight was the reason behind the increase of achene yield in sunflower.

Biological yield (kg ha^{-1})

Biological yield in sunflower was significantly affected by spray of micronutrients. Data recorded is provided in Table 1 which revealed that significantly increased biological yield (9423.3 kg ha^{-1}) was recorded from the treatment where of 0.2% B, 0.2% Zn and 0.2% Mn was applied as foliar spray on sunflower. Whereas, the lowest biological yield (8790 kg ha^{-1}) was obtained from the control. Improvement in sunflower yield was due to enhanced assimilates translocation, chlorophyll formation, improved plant growth and activation of various enzymes in response to applied micronutrients in combination (Movahhedy-Dehnavy et al., 2009). Tavassoli et al. (2010) also concluded positive increase in yield parameters with application of micronutrients. All these nutrients improved the effectiveness and efficiency of each other and helped the plants to gain more weigh and produce more outcomes. Ali *et al*. (2009) advocated that biological yield was increased with spray of B. Khan et al. (2010) observed increase in biological yield with application of micronutrients.

Harvest index (%)

It indicated the efficiency of crop plants to convert photosynthates into grain yield. The higher is the harvest index (HI), the higher will be the efficiency of crop. It is the ratio of grain yield to biological yield. Spray of B, Zn and Mn in interactions proved to be significant in increasing harvest index in sunflower as shown in (Table 1). Data recorded which showed that significantly Highest HI (38.76%) was recorded from treatment where 0.2% spray of each B, Zn and Mn in a single dose, while, the lowest HI (34.35%) was attributed from control. This increase in HI with micronutrients spray was due to increased grain yield from the same treatments.

Oil yield (kgha^{-1})

Sunflowers grains were taken from each treatment after harvesting and threshing. Then oil extraction was done for each treatment separately. Oil and seed cake was separated by the extractor. The oil after extraction was weighted using electronic balance. Data recorded which showed that significantly affect the highest oil yield (1473.3 kg ha^{-1}) was calculated from treatment where 0.2% spray of each B, Zn and Mn in a single dose, while, the lowest oil yield (840.0 kg ha^{-1}) was attributed form control as given in (Table 1). Baraich et al. (2016) also concluded from their experiment that micronutrients mixture application as foliar spray was proved to be significant in maximizing the oil yield in sunflower. Farokhi et al. (2014) also stated that application of micronutrients in mixture significantly oil percentage diameter in sunflower. Increased percentage of oil in each achene resulted in an increase in overall yield production. Jadia and Fulekar (2008) also documented increase oil yield with application of Zn in sunflower field. Likewise, Arabporian et al., (2014) concluded that consumption of B significantly improved oil percentage in seeds of safflower. Similarly, Ghofran-Maghsud et al. (2014) also reported increased oil yield with application of micronutrients mixture.

Qualitative characteristics:

Achene - Oil content (%)

Achenes oil contents in sunflower were improved significantly with application of B, Zn and Mn. Data recorded which showed in (Table 1) that significantly the maximum achene-oil contents (46.3%) were calculated from treatment where 0.2% spray of each B, Zn and Mn in a single dose, while, the lowest oil contents (40.9%) was attributed form control. These results are supported by Ravi et al. (2008) who concluded that micronutrients are responsible for improving oil contents. Farokhi et al. (2014) also stated that application of micronutrients in mixture significantly oil percentage diameter in sunflower. These results are supported by Manjushri et al. (2018) who advocated an increase in oil yield of sunflower after using micronutrients in combination.

Conclusion

Results from all treatments indicated significant effects of micronutrients on different parameters of the Sunflower. From the results, it is concluded that micronutrients spray at lateral stage is much effective to increase growth, yield and quality of the crop as spray is much beneficial for plants as it provides less chances of fixation and improves nutrient availability. Application of micronutrients significantly enhanced LAI, LAD, CGR, NAR, achene head^{-1}, 1000 achene weight, biological yield, achene yield, oil yield, acen oil contents, proteins and the harvest index. It is being concluded that a mixed application of 0.2% B, 0.2% Zn and 0.2% Mn provided the maximum results in field conditions. Spray of these nutrients is recommended for farmers to achieve higher yield.

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Table 1: Treatment comparison of different traits of sunflower

Treatment	Achene/head	1000 Achene weight(g)	Achene yield($kgha^{-1}$)	Biological Yield($kgha^{-1}$)	Harvest index (%)	Oil yield($kgha^{-1}$)	Achene Oil Content (%)
Control	1404.7 f	51.66 e	51.66 e	8790.0 f	34.35 f	840.0 f	40.96e
Water spray	1405.7 f	51.90 e	51.90 e	8790.0 f	34.35 f	840.0 f	41.30 e
0.6%B	1408.0ef	52.33 e	52.33 e	8823.3ef	34.60ef	873.3ef	41.63 de
0.6% Zn	1409.7 de	53.33 de	53.33 de	8856.7ef	34.84ef	906.7ef	42.30 cde
0.6% Mn	1411.0 de	54.66 cd	54.66 cd	8923.3 de	35.33 de	973.3 de	42.63bcde
0.3%B+Zn	1412.7 d	55.66bc	55.66bc	9023.3 cd	36.05 cd	1073.3 cd	43.30bcd
0.3%B+Mn	1417.0 c	56.33bc	56.33bc	9123.3bc	36.75 bc	1173.3bc	43.96bc
0.3%Zn+Mn	1422.3 b	57.23 b	57.23 b	9223.3 b	37.44 b	1273.3 b	44.30 b
0.2%B+0.2%Zn+0.2%Mn	1427.3 a	59.33 a	59.33 a	9423.3 a	38.76 a	1473.3 a	46.30 a
HSD Value	**3.91**	**1.77**	**131.2**	**131.2**	**1.26**	**131.2**	**1.87**

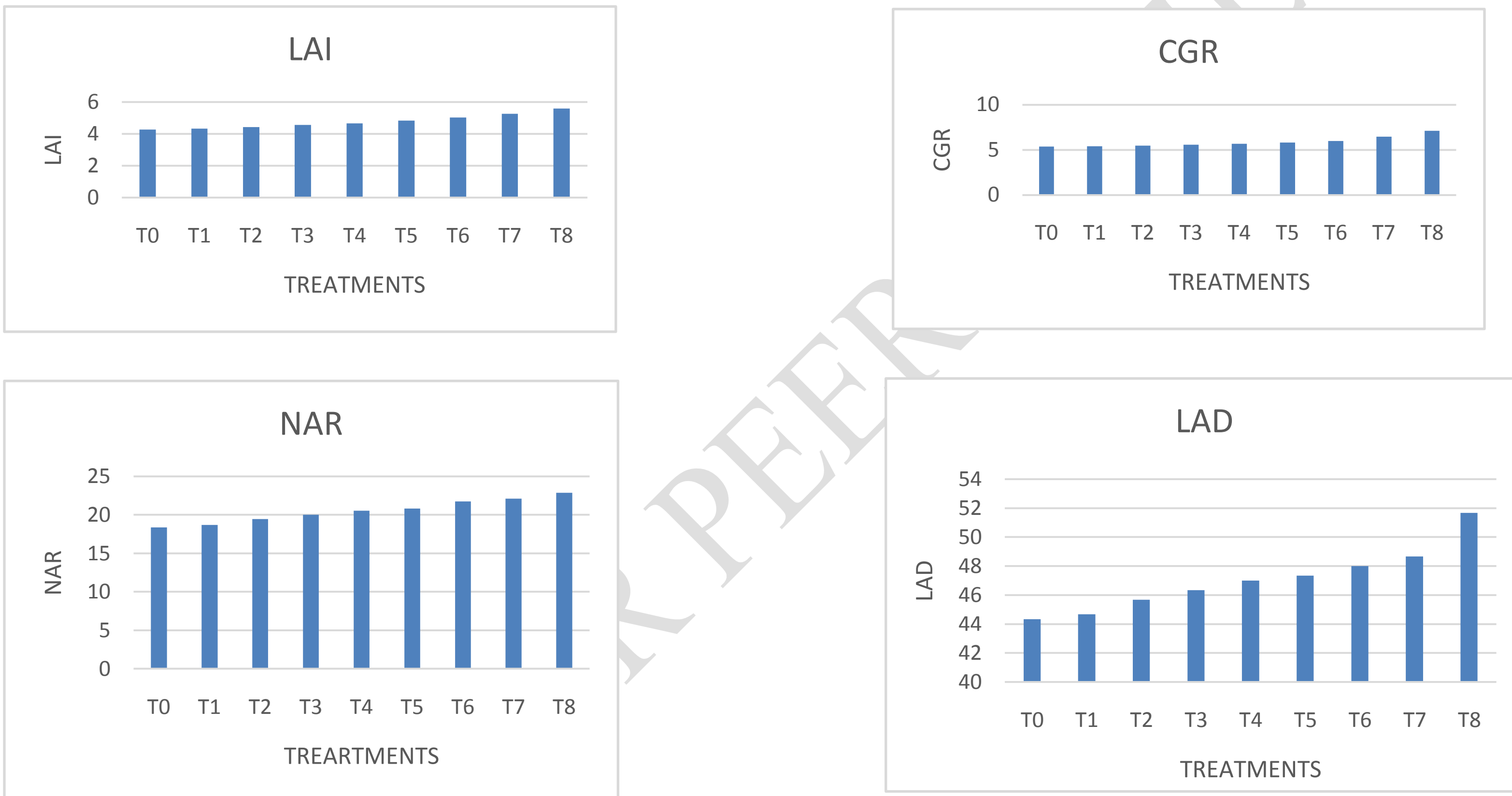

Figure 2: Average data of growth parameters leaf area index, leaf area duration (days), crop growth rate (gm-2day-1), net assimilation rate (gm-2day-1)