



Research Article

Effect of sulphur, zinc and boron on the growth and yield enhancement of sunflower (*Helianthus annuus* L.)

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Abstract

Oilseed crops grown in different types of soil experience nutrient deficiency, especially sulphur, zinc and boron, which affect crop productivity. To tackle it, nutrient management practices must be streamlined to avoid improper fertilizations and deterioration of soil health. With this background, experimental trials were conducted to study the effect of sulphur, zinc and boron application on the growth, yield components and yield of hybrid sunflower at AyanAthur village, Ariyalur district (TN) during the summer seasons of 2016 and 2017. The experiments were laid out in Randomized Block Design (RBD) with three replications. The growth components of sunflower (plant height, leaf area index, dry matter production, leaf area duration (LAD) and growth analysis parameters such as crop growth rate (CGR), relative growth rate (RGR), net assimilation rate (NAR) and chlorophyll content, yield components and seed yield were significantly (level of significance $P > 0.05$) influenced by foliar application of 0.5% Zn on bud initiation stage and seed formation stage and B @ 0.3% on bud initiation stage and ray floret formation stage along with S (sulphur) @ 40 kg ha⁻¹ and RDF (recommended dose of fertilizers) as a soil application. Growth and yield parameters responded very little with the RDF alone. From both experimental results, we found that foliar application of Zn @ 0.5% and B @ 0.3% along with S @ 40 kg ha⁻¹ and RDF recorded the highest percentage of dry matter production (44.4%), number of filled seeds (30.1%) and yield (32.4%) of hybrid sunflower.

Keywords: Boron, Chlorophyll content, Foliar spray, Sulphur, Sunflower, Zinc

INTRODUCTION

Sunflower (*Helianthus annuus* L.) is one of the most important oilseed crops grown worldwide by its high-quality edible oil. Its high synthetic capacity and harvest index allows this crop to be productive in a broad range of environments (Agele, 2003). This crop occupies over 22.81 million hectares in the world, with a global production accounted to about 60.5 million tons. (FAO, 2019) In India, total sunflower seed production is about 0.24 mt 2018-19 with a sizable oil production of 0.068 mt, whereas projected demand of 0.77 mt and 0.40 mt

for seed production and oil yield respectively in 2024-25. Furthermore, the per capita edible oil consumption rise from 19.3 to 23.20 kg/person/annum during the corresponding period will escalate the edible oil requirement from 25.74 to 33.38 mt in 2025 (Vishnuvardhan *et al.*, 2020). Nowadays, the consumption of edible oil is increasing, whereas production is declining due to the imbalanced application of nutrients in India. The increased demand for food grain production has led to intensive cultivation, which paves continuous depletion of soil micronutrient fertility. As a result, there is a steady fall in nutrient use efficiency and that is part-

ly attributed due to the increased incidences of deficiencies of zinc and boron in many parts of the country (Singh and Goswami, 2014).

The deficiency of micronutrients during the last three decades has grown in both magnitude and extent because of increased use of high analysis fertilizers, use of high yielding crop varieties and increase in cropping intensity. Tamil Nadu ranks 4th in Zn (58.4%) and Fe (17%) deficiency and 5th for B (21%) deficiency in soils (GOI, 2015). Likewise, ICRISAT also reported the coexistence of sulphur (S) and Boron (B) deficiencies, where S deficiency ranged from 46 to 96% and B from 56 to 100% in various semi-arid tropical states of India (Rego *et al.*, 2007 and Wani *et al.*, 2011). Apart from the major nutrients, sulphur is increasingly being recognized as the fourth major plant nutrient after nitrogen, phosphorus and potassium (Tandon and Messick, 2002). Sulphur plays a predominant role in improving the seed quality of sunflower crop and also the use efficiency of nitrogen and phosphorus. In oilseeds, sulphur plays a vital role in the development of seed and improving quality (Naser *et al.*, 2012).

Micronutrients are involved in the key physiological processes of photosynthesis and respiration (Marchner, 1995). Among the micronutrients, zinc is actively involved as both functional and structural components in the synthesis of several enzymes (Hemantaranjan, 1996). Its deficiency leads to many aberrations in plants' reproductive organs, leading to lower productivity (Neena and Chitrekha, 2001). Scientific reports proved that the application of small doses of B along with S reduces the deficiency of S and B in crops precisely and helps in enhancing the use efficiency of NPK and other micronutrients (Singh *et al.*, 2019). However the requirement of micronutrients is low. The application of these nutrients through foliar fertilization is a prominent one due to rapid translocation of these nutrients to leaf and seed is superior to soil application (Abdul Aziz *et al.*, 2016). Foliar nutrients usually penetrate the leaf cuticle or stomata and enter the cells facilitating the easy entry of nutrients. Hence an attempt was made to study the effect of micronutrients through foliar application along with primary and secondary nutrients on the growth and yield enhancement of sunflower (*Helianthus annuus* L).

MATERIALS AND METHODS

The experiments on the effect of Zn and B as foliar application with different levels of sulphur along with recommended dose of fertilizers (RDF) on the growth and yield enhancement of sunflower were conducted at Ayanathur village, Ariyalur district, Tamilnadu, India, from February to April for two years in 2016 and 2017. The experimental site of the study is geographically located at 11° 23'N latitudes, 79° 29'E longitudes and

an altitude of +26.0 m of above mean sea level. The average rainfall of Ariyalur district is 1071.4 mm, with the Southwest monsoon rain of 375mm, Northeast monsoon rain of 585 mm, summer rain of 83 mm and winter rain of 29 mm during the agricultural year 2016-17. A composite soil sample was collected at a depth of 0-30 cm. It was air dried, crushed, and tested for physical and chemical properties. The soil was sandy clay loam in texture with soil reaction of (pH 7.6), electrical conductivity 0.69 dS m⁻¹, organic matter (0.72%), available nitrogen (152.7 kg ha⁻¹), phosphorus (10.4 kg ha⁻¹), potassium (174.0 kg ha⁻¹), sulphur (7.2 mg kg⁻¹), Zn (0.72 mg/kg) and available B (0.56 mg/kg). Experiments were carried out in a randomized block design with nine treatments (T₁- RDF alone, T₂- RDF+ S @ 20 kg ha⁻¹, T₃- RDF+ S @ 20 kg ha⁻¹+ Zn @ 0.25% as foliar spray, T₄- RDF + S @ 20 kg ha⁻¹+ B @ 0.15% as foliar spray, T₅- RDF + S @ 20 kg ha⁻¹+ Zn @0.25% and B @ 0.15% as foliar spray, T₆- RDF + S @ 40 kg ha⁻¹, T₇- RDF + S @ 40 kg ha⁻¹+ Zn @ 0.5% as foliar spray, T₈- RDF + S @ 40 kg ha⁻¹+B @ 0.3% as foliar spray, T₉- RDF + S @ 40 kg ha⁻¹+ Zn @ 0.5%and B @ 0.3% as foliar spray. and replicated thrice. Experimental plots consisted of two levels of sulphur (20 and 40 kg ha⁻¹) as soil application, Zn (0.25 and 0.5 %) and B (0.15 and 0.3%) as foliar application and control i.e., recommended N, P and K (60:90:60 kg. ha⁻¹) alone as soil application. All the treatments were applied by balancing to the initial soil test values and crop requirements to justify the crop response to the supplied nutrients in both years.

Crop management

The land was thoroughly ploughed with a tractor-drawn implement with a criss-cross manner and levelled properly. The plots were prepared with the dimension of 8 m × 5 m and seeds of hybrid sunflower Sunbred-275 were sown with a spacing of 60×30 cm. For fertilization, the RDF treatment 100% of P through DAP and S through elemental sulphur, 50% of N through urea and K through MOP was applied basally as a soil application. Remaining 50% of N and K applied at the pre-flowering stage. Treatments possessing micro nutrients viz., Zn supplemented through zinc chloride @ 0.25 and 0.5% as a foliar application at bud initiation stage and seed formation stage and B through boric acid @ 0.15 and 0.3% as a foliar application at bud initiation stage and ray floret formation stage respectively. Tween – twenty as surfactant used @ 0.5cc/L added to enhance the persistence capacity of spray solution on the leaf during the spray. At 4 - 5 leaf stage plants were thinned to appropriate density. Irrigation was given uniformly and regularly to all plots as per the requirement to prevent the crop from water stress at any stage. The crop biometric observations of growth attributes such as plant height, LAI (Leaf Area Index), LAD (Leaf Area

Duration), DMP (Dry matter production) and also growth indices of CGR (Crop Growth Rate), RGR (Relative Growth Rate) and chlorophyll content were recorded during the study.

Chlorophyll assay

The total chlorophyll content of leaves was determined by using 80 % acetone extraction suggested by Arnon (1949). About 250 mg of fresh leaf material from each plot was taken and crushed thoroughly with 80% acetone. A homogeneous paste was made and filtered through Whatman No.1 filter paper, made up the volume with 80 % acetone 25 ml. Since the extract is subjected to evaporation and photo-oxidation. The optical activity or density of chlorophyll 'a' and 'b' recorded at 645 nm and 663 nm wavelength respectively and chlorophyll a and b were calculated using the formula.

Chlorophyll a = $20.2 \times \text{O.D value at 645 nm} \times 100 / 1000 \text{ mg.g}^{-1}$ Eq. 1

Chlorophyll b = $8.02 \times \text{O.D value at 663 nm} \times 100 / 1000 \text{ mg.g}^{-1}$ Eq. 2

Total chlorophyll content = chlorophyll a + chlorophyll b.

Statistical analysis

The experimental data were statistically analyzed, as suggested by Gomez and Gomez (1976). For significant results, the critical difference was worked out at 5 per cent level.

RESULTS AND DISCUSSION

Effect of S, Zn and B on the growth components of sunflower

The observations recorded on growth components and growth analysis parameters are presented in Fig. 1 and 2 revealed that the effect of different levels of the sulphur application combines with micronutrients and had a positive influence on all growth components viz., plant height, LAI, DMP, and LAD and growth analysis viz., CGR, RGR and chlorophyll content in both the crop period. Among the different levels of sulphur, higher plant height of 172.3 cm and 168.4 cm, LAI of 6.9 and 6.6, DMP of 7130.4 and 6725.0 kg ha⁻¹ and LAD of 53.5 and 51.9 days were recorded with the application of elemental sulphur @ 40 kg ha⁻¹ along with RDF (60:90:60 kg ha⁻¹) and micronutrients both Zn @ 0.5% and B @ 0.3% as foliar spray over other levels and combinations of treatments. The same trend was noticed in the growth analysis parameters such as CGR, RGR, NAR and total chlorophyll during both the crop period. This might be due to that S plays a predominant role in more synthesis of amino acids increased chlorophyll content in a growing region and improving the photosynthetic activity, ultimately enhancing cell division resulted in an increment in plant height, higher LAI and DMP of sesame crop (Raja *et al.*, 2007). Besides,

the application of boron increased growth parameters due to its contribution to cell wall formation and the deficient plants remain stunted at the same time boron supply reduces the lignifications. Hence, histologically, the plant cell continues to grow, especially at the tips with elongation of epicotyls and hypocotyls. Further, the results proved that positive interaction between B and S might synergistically enhance the dry matter and seed yields. These results were in line with the findings of Bahaa El-Din , 2015) for sunflower.

Effect of S, Zn and B on the yield components and yield of sunflower

The yield determining components such as head diameter and the number of seeds per head were significantly increased with the treatment supplied through S @ 40 kg ha⁻¹ as soil application and Zn @ 0.5% and B @0.3% as foliar spray during both the year of crop period (Table 1). Among the sulphur levels, 40 kg of S recorded higher yield components viz., head diameter of 17.1 and 16.7 cm, and a number of filled seeds per head of 924 and 895 during both the crop period. Besides, the cumulative effect of micronutrients such as Zn and B, predominantly play an important role in the enhancement of yield components. This might be due to the positive interaction between inorganic N and S results in fulfilling the crop nutrient need in the quickest manner.

Besides, efficient crop architecture as brought by an increased leaf number and consequent LAI coupled with effective uptake of nutrients, especially adequate supply of S might have resulted in the increased synthesis of photosynthates and produced a higher floret number of sunflower crop (Ravikumar *et al.*, 2016). Furthermore, the cumulative effect of Zn and B and their positive interaction with S and their unanimous role in the synthesis of IAA, metabolism of auxin and formation of chlorophyll synthesis) and predominant role of boron helps in increasing the yield of the crop. The lowest value of head diameter and number of seeds per head recorded in RDF alone supplied treatments. This might be due to the very meagre availability of secondary and micronutrients such as Zn and B. Even though the soil has above critical Zn and B levels, the soil may realise low mineralization of these elements might have reduced the availability and causes the deficiency of plants. Where the supply of these elements in other treatments may satisfy the crop requirements, the seed yield and stalk yield were increased with S at 40 kg as soil application + Zn @ 0.5% + B 0.3% as foliar spray with the value of 2371 and 2127 kg ha⁻¹ and stalk yield of 3312 and 3142 kg ha⁻¹ during both the crop period. This could be ascribed due to a positive interaction of S and B with N and interaction themselves led to increased crop growth parameters. These enhanced growth attributes jointly contributed

Table 1. Effect of S and micronutrients (Zn and B) on yield components and yield of sunflower.

Treatments	Crop I				Crop II			
	Head Diameter in cm	No of filled seeds/ Head	Seed yield kg / ha	Stalk yield kg / ha	Head Diameter in cm	No of filled seeds/ Head	Seed yield kg / ha	Stalk yield kg / ha
T ₁ - RDF alone as soil application	12.0	710	1791	2725	11.7	680	1665	2681
T ₂ - RDF+ S @ 20 kg ha ⁻¹ as soil application	12.4	760	1854	2842	12.2	741	1701	2790
T ₃ - RDF+ S @ 20 kg ha ⁻¹ + Zn @ 0.25% as foliar spray	13.5	792	1946	2891	13.0	775	1769	2833
T ₄ - RDF + S @ 20 kg ha ⁻¹ + B @ 0.15% as foliar spray	13.9	824	1992	2922	13.5	801	1811	2876
T ₅ - RDF + S @ 20 kg ha ⁻¹ + Zn @0.25% and B @ 0.15% as foliar spray	14.8	851	2112	2965	14.4	818	1881	2946
T ₆ - RDF + S @ 40 kg ha ⁻¹ as soil application	15.1	865	2162	2998	14.8	830	1920	2980
T ₇ - RDF + S @ 40 kg ha ⁻¹ + Zn @ 0.5% as foliar spray	15.8	892	2241	3132	15.6	853	1991	3017
T ₈ - RDF + S @ 40 kg ha ⁻¹ + B @ 0.3% as foliar spray	16.2	902	2287	3175	15.9	868	2033	3051
T ₉ - RDF + S @ 40 kg ha ⁻¹ + Zn @ 0.5% and B @ 0.3% as foliar spray	17.1	924	2371	3312	16.7	895	2127	3142
C.D (P=0.05)	0.67	17.3	60.4	55.9	0.60	16.6	56.6	50.5

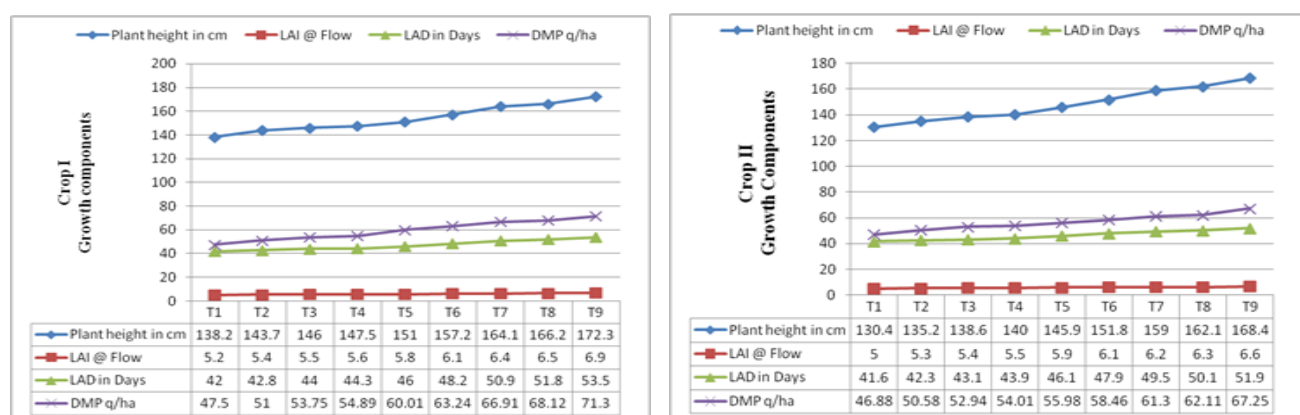


Fig.1. Effect of S, Zn and B on the growth components of hybrid sunflower.

and increased the yield potential (2371 and 2127 kg ha⁻¹) of the crop, as reflected by the higher seed yield. The reciprocation of overall improvement reflected in better source and sink relationship, tissue differentiation from somatic to reproductive and meristematic activity. The observed trend on seed yield and stalk yield in other treatments as follows T₈= T₇>T₆= T₅> T₄= T₃> T₂> T₁ during both the year of crop period. These results were concomitant with the findings of Oyinlola (2007) for sesame and (Abdul Aziz *et al.*, 2016) for sunflower.

Regression analysis

The quadratic response regression analysis on the

seed yield of sunflower predicted for the impact of the number of filled seeds per head and the results indicated that the increase in these parameters has positively influenced the seed yield of sunflower, which is indicated in the graph with the R² value and polynomial equation (Fig. 3 and 4). For instance, the polynomial equation and the results indicated that the increase in these parameters has significantly improved the yield of crop, which is reflected in the graph with the R² value and polynomial equation (Fig 3 and 4). For instance, polynomial equation Y = 0.0073x² - 9.1672x + 4616.6, with the R² value of 0.9958 was observed for the number of seed yield with seed yield during the first crop period. A

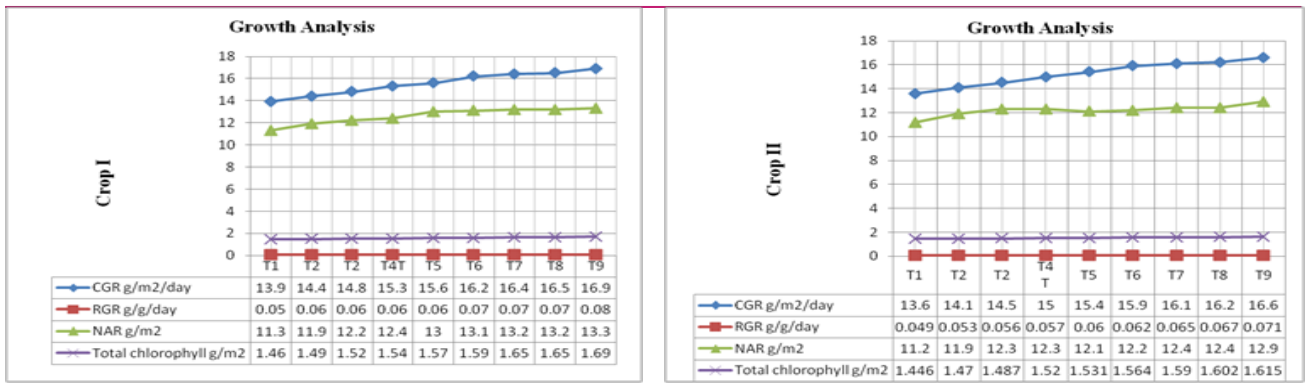


Fig. 2. Effect of S, Zn and B on the growth analysis of hybrid sunflower.

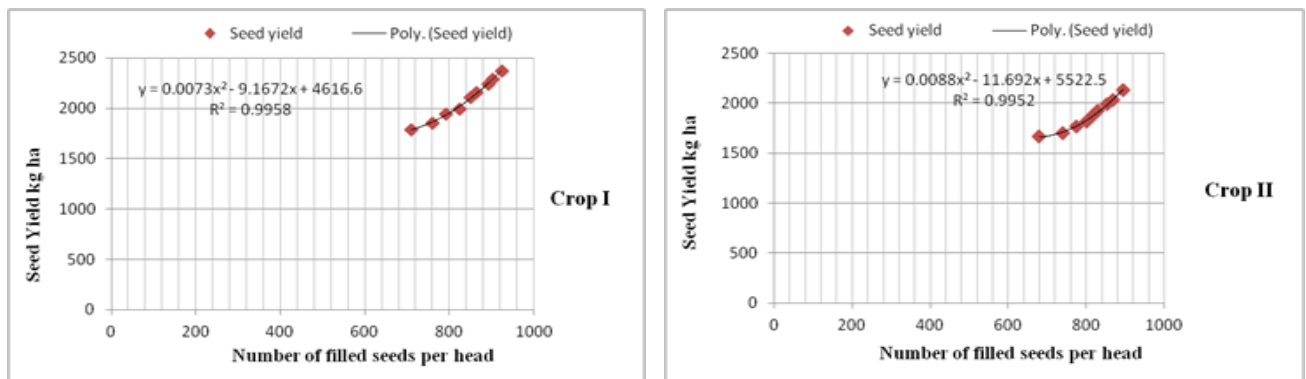


Fig. 3. Regression analysis of number of filled seeds vs seed yield.

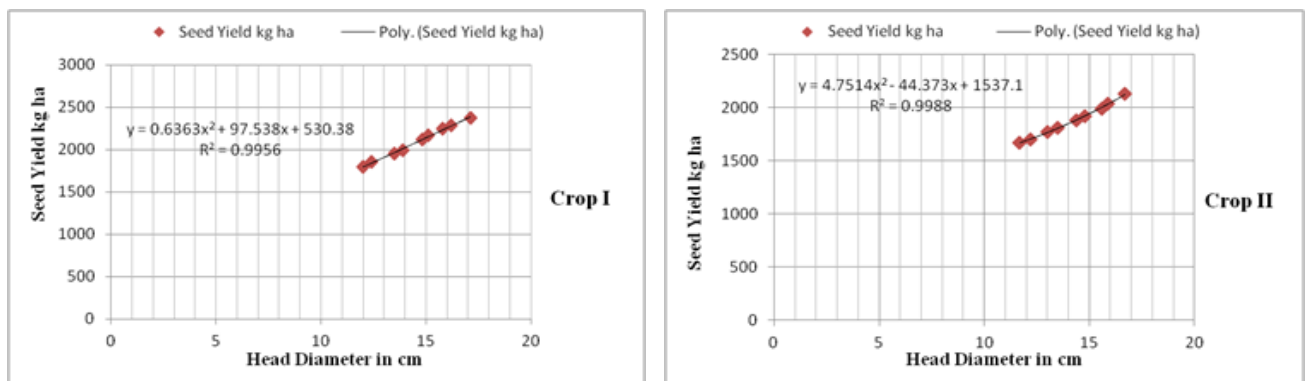


Fig. 4. Regression analysis of head diameter vs seed yield

similar trend was noticed in the head diameter (Fig 4). The final yield of the crop might be the cumulative effects of yield attributes that influence the complimentary parameters that could result in a positive relationship with higher productivity, which has been proved in the present study.

Conclusion

It may be concluded that application of S @ 40 kg ha⁻¹ basally as soil application along with RDF and micronutrients such as Zn @ 0.5% and B @ 0.3% as foliar application at bud initiation, seed formation and ray floret formation stages enhanced all the growth, yield components and seed yield of hybrid sunflower (*Helianthus annuus*.L) compared to RDF alone. It

showed that B and S supply to sunflower crops at optimum levels are important for its productivity with all the recommended nutrients supplied.

Conflict of interest

The authors declare that they have no conflict of interest.

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