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Effect of boron on growth and yield parameters of sunflower in acid soil

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Abstract
Sunflower (*Helianthus annus* L.) is an exotic North American plant but its commercialization as a crop started in Russia and now widespread across the globe. Boron has a synergistic effect on nitrogen uptake, which is directly linked with amino acids, RNA, and protein synthesis thereby enhancing the relative growth rate and absolute growth rate. Although numerous studies emphasized the positive effects of boron application on growth, yield and oil content of sunflower, limited information is available on the influence of boron nutrient in sunflower crop cultivated in acid laterite soils. The experiment was laid out in factorial completely randomised block design in Sunflower (*Helianthus annus* L.) in laterite Soil during *Zadi*, in 2018 at AICRP on Micronutrients, department Soil science and Agricultural chemistry, OUAT, Bhubaneswar, with two factors (5 Soil types and 5 boron doses of 0kg boron/ha, 0.5kg boron/ha, 1.0kg boron/ha, 1.5kg boron/ha and 2kg boron/ha.) with 25 treatments replicated twice. All the yield parameters showed positive and significant correlation with the soil boron application in all soil types except in soil type 2 and soil type 3 where the growth declined after 1.5 kg/ha and 1 kg/ha respectively. The maximum head diameter (6.33cm at 75 days after sowing) and head dry weight (20.64g) was in Soil type 1 with boron dose 2 kg/ha. Soil type 1 with boron dose 2 kg/ha was also recorded the highest of number of filled seeds per head(183) and seed weight (6.15g),maximum oil content(29.105 %). In Soil type 3 boron dose 2 kg/ha maximum total boron concentration (120.2ppm) and maximum the seed concentration of boron (24.79ppm) was observed. Harvest Index was observed to be maximum in Soil type 1 boron dose 2 kg/ ha it was maximum (16.70%).

Keywords: Boron, acid soil, RBD, growth, yield

Introduction
Sunflower (*Helianthus annus* L.) is an exotic North American plant but its commercialization as a crop started in Russia and now widespread across the globe. It is distinctly superior over other oil seed crops owing to its wider adaptability to different agro climates, cropping patterns, photo insensitivity, drought tolerance, short duration and premium quality oil. It is the third most important oil seed crops after soya bean and oil palm. Sunflower oil is also known as 'Premium oil' due to presence of essential fatty acids like oleic acids (16%) and linoleic acids (72%) along with 60% unsaturated fatty acid which gives it an anti-cholesterol property. It is estimated that the oil content and quality of sunflower improved by the application of boron. Studies by Rahman *et al.*, 2001 [9] shows the role of boron in high oleic and low linolenic acid content in Soybean. Boron plays a key role in many metabolic processes including sugar transport, cell wall synthesis and maintenance, membrane integrity, RNA, indole acetic acid (IAA) and phenol metabolism (Dordas and Brown, 2001). Boron has a synergistic effect on N uptake, which is directly linked with amino acids, RNA, and protein synthesis thereby enhancing the relative growth rate and absolute growth rate. The harvest index and oil content is enhanced due to boron application due to phyto-biomass partition at reproductive stage (Martin *et al.*, 2010) [7]. Although numerous studies emphasized the positive effects of boron application on growth, yield and oil content of sunflower, limited information is available on the influence of boron nutrient in sunflower crop cultivated in acid laterite soils. Therefore, the current study was planned to explore the impact of soil boron application upon the yield attributes of sunflower for the different soil types taken, with the objective to identify the growth response of sunflower to different doses of soil boron application and its effect on yield of the crop grown in acid soil.

Material and Methods
The plant height and total number of leaves was estimated from 15 DAS up to final stage of growth at 15 days interval. After harvest, all heads were sorted and put inside paper packets.

All the packets were kept inside an oven at 90 ºC till a constant weight was obtained and the head dry weight was found. Oven dry weight of seed was also estimated. Estimation of oil content was by *Soxhlet* apparatus. The relative growth rate and absolute growth rate was calculated by using the following formula. (Radford, 1967). Harvest Index was calculated by taking the ratio of economic yield (yield of main product) and total biological yield and expressed in percentage. Estimation of boron was done by procedure given by Jackon *et al*., 1973 using *Azomethine -H* colorimetric method.

Experimental Details

Factorial completely randomized block design was adopted for this experiment with 25 treatments (5 doses of boron and 5 types of soil) with 2 replications each (Table 1). Black polybags were used for the experiment having an approximate 5 kg soil. To each polybag recommended NPK in 60:80:80 ratio was given. Boron was applied in form of borate to soil in 5 doses of 0kg boron/ha, 0.5kg boron/ha, 1.0kg boron/ha, 1.5kg boron/ha and 2kg boron/ha. Simultaneously, the initial properties of soil were recorded (Table 2).

Table 1: Factorial completely randomized block design with 25 treatments

Serial No.	Treatments
1	S1B0 - Soil type1 with a boron dose of 0kg boron/ha (control)
2	S1B0.5- Soil type1 with a boron dose of 0.5kg boron/ha
3	S1B1.0- Soil type1 with a boron dose of 1.0kg boron/ha
4	S1B1.5- Soil type1 with a boron dose of 1.5kg boron/ha
5	S1B2.0- Soil type1 with a boron dose of 2.0kg boron/ha
6	S2B0 -Soil type2 with a boron dose of 0kg boron/ha (control)
7	S2B0.5- Soil type2 with a boron dose of 0.5kg boron/ha
8	S2B1.0- Soil type2 with a boron dose of 1.0kg boron/ha
9	S2B1.5- Soil type2 with a boron dose of 1.5kg boron/ha
10	S3B0- Soil type3 with a boron dose of 0kg boron/ha (control)
11	S3B0.5- Soil type3 with a boron dose of 0.5kg boron/ha
12	S3B1.0- Soil type3 with a boron dose of 1.0kg boron/ha
13	S31.5- Soil type3 with a boron dose of 1.5kg boron/ha
14	S32.0- Soil type3 with a boron dose of 2.0kg boron/ha
15	S4B0- Soil type4 with a boron dose of 0kg boron/ha (control)
16	S4B0.5- Soil type4 with a boron dose of 0.5kg boron/ha
17	S4B1.0- Soil type4 with a boron dose of 1.0 kg boron/ha
18	S4B1.5- Soil type4 with a boron dose of 1.5kg boron/ha
19	S4B2.0- Soil type4 with a boron dose of 2.0kg boron/ha
20	S5B0- Soil type5 with a boron dose of 0kg boron/ha (control)
21	S5B0.5- Soil type5 with a boron dose of 0.5 kg boron/ha
22	S5B1.0- Soil type5with a boron dose of 1.0kg boron/ha
23	S5B1.5- Soil type5 with a boron dose of 1.5kg boron/ha
24	S5B2.0- Soil type5 with a boron dose of 2.0kg boron/ha
25	S2B2.0- Soil type2 with a boron dose of 2.0kg boron/ha

Table 2: Initial properties of soil

Treatments	Soil PH	Soil EC (dSm^{-1})	Soil OC (%)	Soil Boron (ppm)
S1	5.19	0.28	0.458	0.08
S2	4.47	0.36	0.725	0.62
S3	4.81	0.26	0.305	3.21
S4	5.03	0.27	0.362	0.21
S5	5.18	0.33	0.515	0.16

EC – Electrical Conductivity. OC – organic carbon, ppm – parts per million

Results and Discussion

Yield is a function of complex inter-relationships of its components, which was determined from the growth in vegetative phase and its subsequent reflection in reproductive phase of the plant. Seed yield is directly used for assessing the productivity in oil seed crops. In the present investigations the mean RGR and AGR values increased with boron treatments. Our results were confirmed by (Sathya *et al*., 2013) [14] reported that both boron and nitrogen were found to interact positively to improve the growth parameters suggesting enhanced assimilation of nitrogen in the presence of sufficient boron contents. At soil type 1 boron dose 2 kg/ha maximum AGR (0.70 g/ day) and RGR (0.46g/g/day) were recorded between 45 DAS to 75 DAS. During this period the total dry matter decreased considerably. Soil type 1 showed significantly higher dry weight and growth parameters over other soil types. This may be due to higher organic carbon status in the soil type1. This is in line with study of (Sarwar & Mubeen, 2015) [13] on the impact of soil organic matter on boron availability. Total boron content (120.2ppm) at 45DAS Total boron content of plant was determined at 45 DAS. Boron content of leaves and seed was determined at 75 DAS. The boron concentration in plant increased progressively up to highest level of boron application in all the soil types. This may be due to the fact that on application of boron there is absorption by root and translocation to different parts and increases the concentration in plant tissues the results are supported by the results Ramesha *et al.*, (2011). Higher capitulum diameter (6.33 cm at 75 DAS), total number of filled seed per capitulum (183) were recorded in application of 2kg boron/ha in soil type 1. There is a tremendous response to application of boron fertilizer on reproductive growth of sunflower. This finding is in line with Renukadevi *et al*., 2003conducted similar studies to study the effect of boron on crop plants.

Boron had a marked effect on number of seeds and a plant showed a significant response to boron. Soil type one having lowest initial boron content (0.08ppm) showed the maximum number of filled seeds as well as seed weight. Application of boron might have improved the cell wall structure, with transitory increase in elasticity module followed by reduced secondary thickening and increase in the incidence of plasma membrane bound reductase activity for better partitioning to sink, leading to higher DM partitioning. These results were supported by the findings of (Al-Amery *et al*. 2016), who pointed that seed yields also were increased with increasing in B application. There was a decline in seed weight and no of filled seed per head in Soil type 2 (0.620ppm initial soil boron) and Soil type 3 (3.21) ppm initial soil boron beyond boron dose 1.5kg B/ha and 2 kg/ha respectively.

This may be due to toxicity of boron at higher boron concentration. (Tahir *et al*. 2014) [15] who pointed that seed yield of sunflower crop was increased linearly in response to boron application as compared to the control. In the present investigation the Harvest Index was found that there was a remarkable increase in HI due to soil boron application (Fig 1). It enhances photosynthetic capacity during flowering and seed set or through improved partitioning from the increased biomass. Oyinlola, E. Y in 2007, also reported that the biggest effect of applied B resulted in an increase in seed yield, and this is partly may be due to the decrease in seed sterility. However it was observed that Harvest Index as well as oil content declined in Soil type 2 at boron dose1.5 kg/ha and soil type 3 at boron dose 1kg/ha because of high seed boron concentration in this treatment. This signifies that higher production and partitioning of dry matter to the seeds at optimum boron concentrations resulted in higher yields. The boron concentration in plant tissue did not show a linear response with total dry matter and seed yield in soil type 3 and soil type 2. Growth declined beyond the boron dose of 1.5kg/ha in soil type 2 and 1 kg/ha in soil type 3. This may be due to the high native boron content at this dose in these soil types. This is evident from the study of Bhattacharya k *et al*., 2015, who suggested that increasing levels of soil B application beyond optimum level in soil reduced crop productivity. In the present study visual symptoms of boron deficiency were not marked and toxic symptoms were noticed only at boron dose 2kg/ha in soil type 3.The oil content was recorded at 45 DAS. Maximum oil content was observed in Soil type 1 followed by Soil type 2. Soil type 1 boron dose 2 kg/ ha recorded maximum oil content (29.065%). Boron dose 1.5 kg/ha was superior over other treatments. The minimum performance was observed in control (0kg boron/ha) In a study by (Mekkii 2015) it was found that oil percentage was significantly increased with increasing boron concentration by 46.34%.

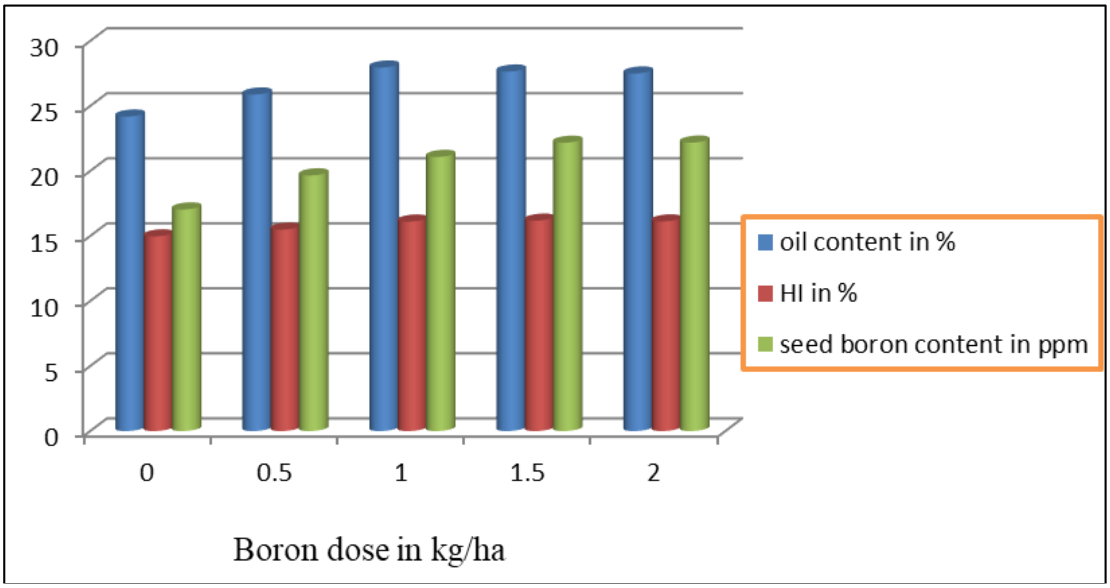

Fig 1: Comparison between the oil content and HI with seed boron content

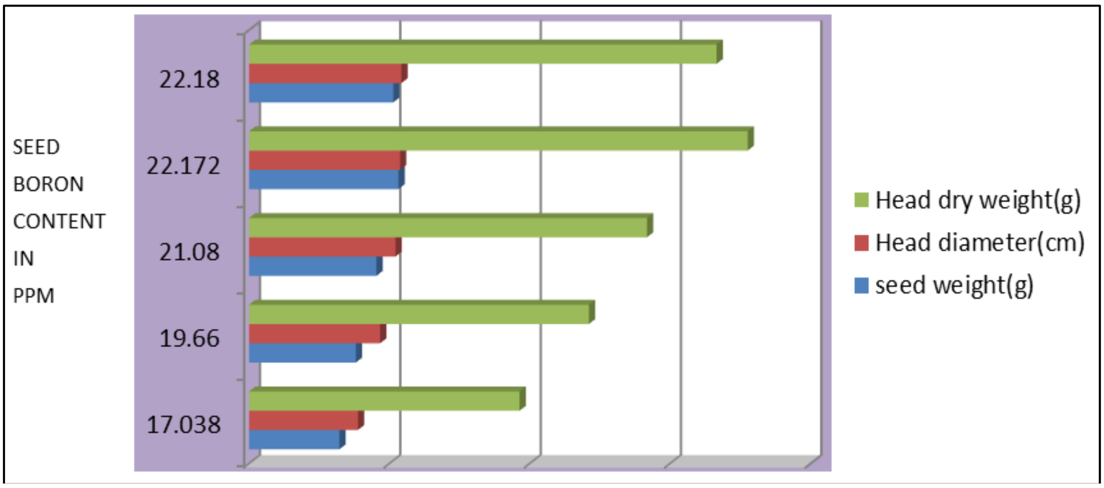

Fig 2: Comparison between head dry weight, head diameter and seed weight with seed boron content

Conclusion

From these observations in the present investigation it can be concluded that boron significantly influences the growth and metabolism of sunflower. Yield attributes such as number of filled seeds per head, seed weight, and oil content increased significantly over all treatments. This establishes the fact that boron facilitates the translocation of assimilates towards the economic sink. From the biochemical findings, it was found that application of boron exhibited enhanced uptake of calcium and magnesium, chlorophyll content along with increasing the carbohydrates and protein synthesis. Boron deficient soil i.e Soil type 1 and Soil type 5 showed enhanced response to fertilizer application over other soil types. On other hand Soil type 3 having the highest initial soil boron content showed good response at lower dose but the growth sharply declined beyond a boron dose 1kg/ha. There was similar decline in growth in soil type 2 beyond a boron dose of 1.5 kg/ha. The overall best performance was observed in S1B2 treatment. Toxic concentration of boron in plant was found to be 81.1 ppm in plant. At this concentration the plant response to boron application declined for all the parameters. This study was useful in understanding the role of boron on the morphological, physiological, biochemical activities of sunflower and their combined effect on the yield and oil content. It can be suggested that soil application of 1.5 kg boron is sufficient for optimum yield.

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