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K Prabhakar
Scientist, Department of Agronomy, AICRP on Sunflower, RARS, Nandyal, ANGRAU, Andhra Pradesh, India

D Laksmi Kalyani
Scientist, Department of Agronomy, AICRP on Cotton, RARS, Nandyal, ANGRAU, Andhra Pradesh, India

S Balaji Nayak
Scientist (S S and A C), NARP, RARS, Nandyal, ANGRAU, Andhra Pradesh, India

K Venkataramanamma
Senior Scientist, Department of Plant Pathology), AICRP on Sunflower, RARS, Nandyal, ANGRAU, Andhra Pradesh, India

S Neelima
[5]Senior Scientist (Plant breeding), AICRP on Sunflower, RARS, Nandyal, ANGRAU, Andhra Pradesh, India

D Sampath Kumar
Programme Coordinator, Krishi Vignan Kendra, Kalyandurg, Ananthapuramu, ANGRAU, Andhra Pradesh, India

Corresponding Author:
K Prabhakar
Scientist, Department of Agronomy, AICRP on Sunflower, RARS, Nandyal, ANGRAU, Andhra Pradesh, India

Effect of boron foliar application at Critical growth stages on sunflower (*Helianthus annuus* L.) seed yield and oil yield

K Prabhakar, D Laksmi Kalyani, S Balaji Nayak, K Venkataramanamma, S Neelima and D Sampath Kumar

Abstract
A field experiment was undertaken at Regional Agricultural Research Station, Nandyal during *rabi*, 2019-20 and *rabi*, 2020-21 to explore the effect of time and dose of boron foliar application, on growth and yield of sunflower (*Helianthus annuus* l.). The pooled data revealed that boron foliar application of boron @ 0.3% twice at V-4 and R-3 stage increased the content of this element in plant and raised the production of sunflower plants. Application of boron fertilizer at V-4 stage increased N content in the plant. Sunflower seed yield was significantly higher with boron foliar application at @ 0.3% concentration twice at V-4 and R-3 stages and on par with treatment@ 0.2% concentration at V-4 and R-3 stage. Treatments showed no significant effect on oil content and oil yield.

Keywords: Boron, Foliar application, Sunflower seed yield

Introduction
Sunflower (*Helianthus annuus* L.) second most important oil seed crop grown in Andhra Pradesh with average productivity of 1.2 t/ha while genetic potential of sunflower is to produce as much as 5 tons per hectare. Adoption of new and more efficient varieties, as well as optimization of sunflower nutrition by means of foliar application of fertilizer could stimulate the yields.

Sunflower is a plant with high demand for boron (B) and depending on specific soil conditions, for the other trace elements. To some extent, the uptake of nutrients by plant roots depends on soil properties (particularly soil pH) and supply of micronutrients in the soil. The critical content of boron at the time of sunflower emergence is 20 mg kg-1 of soil. (Asad, 2002) [1]. That is the reason why farmers prefer foliar nutrition when applying micronutrients. Some scientists have described the effects of foliar application of boron on the growth and development of sunflower. Zerrari and Moustaoui (2005) [8] stated that the boron content corresponding to the deficit is 32.5 mg B kg-1 of dry matter. The demand of boron to sunflower is varied, depending on the stage of plant growth. The critical content of boron in sunflower at the age of 4 weeks is 46.0 - 63.0 mg B kg^{-1} of dry matter, while 8 week old plants need just 36.0 mg B kg^{-1} (Rashid and Rafique 2005) [4]. Sunflower plants with the tissue content of boron ranging from 16.5 and 23.0 mg kg^{-1} of dry matter require 300 g B ha^{-1}, and for plants containing between 23 and 32.5 mg B kg^{-1} of dry matter, the rate of 150 g B ha^{-1} is sufficient. Boron is an important element, which affects yields of sunflower, cotton (Dodas, 2006) [2] and rape (Asad *et al*., 2002) [1].

Materials and Methods
A field experiment was undertaken at Regional Agricultural Research Station, Nandyal during *rabi*, 2019-20 and *rabi*, 2020-21 to explore the effect of time and dose of boron foliar application, on growth and yield of sunflower. The experiment was laid out in a randomized block design with total ten treatments consists of three concentrations of boron foliar application, two stages of application and compared with no boron foliar spray. Soil of the site was medium in fertility and saline in reaction having pH 8.42, EC-0.24 dSm^{-1}, organic carbon (0.32%) with available N of 143 kg ha^{-1}, available P_2O_5 of 53 kg ha^{-1} available K_2O of 451 kg ha^{-1} and available boron 0.83 mg/kg^{-1}. The experiment was sown during rabi season in 2nd FN of October in both years using sunflower hybrid "PRABHATH" (NDSH 1012). Sowing was taken up in ideal soil moisture condition by dibbling the seed in 60 cm row to row and 30 cm

apart with in the row. An amount of 75kg N-90 kg P_2o5-30 kg K_2O/ ha were applied through urea and single SSP and given as nitrogen in split doses and P and K as basal dose. Healthy and matured seeds possessing high germination percentage was used for sowing. Seed @ 5 kg ha^{-1} was sown in the open furrows made with the help of hand hoe. The seeds were dropped to a depth of 4-6 cm and covered thoroughly. The crop was irrigated at star initiation stage and seed filling stage. Need based plant protections were taken up. Boron in the form of ethanolamine as sodium pentaborate was applied in the form of foliar nutrition during the developmental stages V-4 (4 developed leaves) and R-3 (reproductive ray florets opening stage)

The content of dry matter and levels of nutrients N, P, K, Ca, Mg and B were determined in plant tissue in developmental stages of V-4 and R-3 stages. The samples of plant tissue were dried at a temperature of 60 ^{0}c then crushed in a grinder and homogenized. The resultant crushed plant mass was mineralized using moisture of H_2SO_4 and H_2O_2. The amount of N in the mineralized sample was determined using the Kjeldahls method. The content of P in the extract was determined calorimetrically on an ATI Unicam 8625 UV/VIS spectrophotometer. The levels of K, Ca, Mg were determined in mineralized samples using Atomic Absorption Spectrophotometry (AAS) with a Carl Zeiss Jena AAS-30 instrument. The content of B was determined by ICP-AES. Sunflower was harvested when it reached physiological ripeness. The seed yield oil content and oil production were evaluated after harvest. The oil content was determined using Soxhlet method based on the extraction of sunflower seed in a continuos flow extractor. The data recorded on various parameters of crop during the course of investigation was statistically analyzed by following the analysis of variance procedure as suggested by Panse and Sukhatme (1985) [3]. Statistical significance was tested with 'F' test at 5 per cent level of probability and compared the treatment means with critical difference.

Results and Discussion

Effect on dry matter production and nutrient uptake

Results on drymatter production and nutrient uptake at V-4 and R-3 stage were presented in table 1 and 2. Indicating that foliar application of boron increased the boron content in the plant biomass, and the increase was significant. Skarpa (2013) [6] also reported that foliar application of boron increased the concentration of B in all parts of the sunflower plant. Boron application increased the uptake of macro biogenic nutrients (especially N)as can be seen in analysis of plants taken in stage R-3 (table 2). Foliar nutrition with boron at 0.2% and 0.3% concentration at V-4 also increased the dry matter yield of the plants (table 2).

Table 1: Dry weight (g/plant) and of nutrient concentration (% DM, mg kg-ha DM) of plant in V4 stage of sunflower

Treatments	Dry weight (g/plant)	Concentration of nutrient (% of DM)					mg/kg^{-1} DM
		N	P	K	Ca	Mg	B
T1: 0.1% at V-4 stage	2.73	3.86	0.40	5.03	1.92	0.69	34.23
T2: 0.2% at V-4 stage	2.84	3.92	0.39	4.99	1.88	0.71	34.11
T3: 0.3% at V-4 stage	2.96	4.10	0.41	5.02	1.87	0.66	34.35
T4: 0.1% at R-3 stage	2.63	3.82	0.41	5.01	1.91	0.65	32.95
T5: 0.2% at R-3 stage	2.66	3.72	0.42	4.89	1.90	0.72	32.58
T6: 0.3% at R-3 stage	2.64	3.63	0.38	4.77	1.86	0.70	32.19
T7: 0.1% at V-4 and R-3 stage	2.89	3.85	0.39	5.03	1.91	0.71	34.75
T8: 0.2% at V-4 and R-3 stage	2.91	3.87	0.37	5.03	1.93	0.68	34.77
T9: 0.3% at V-4 and R-3 stage	2.95	4.19	0.39	5.01	1.85	0.65	34.05
T10: Control	2.68	3.66	0.41	4.99	1.89	0.71	32.68
S.Em	0.33	0.11	0.23	0.62	0.34	0.38	0.12
CD (P=0.05)	NS	0.33	NS	NS	NS	NS	0.36
CV	15.8	10.2	9.8	11.5	12.7	11.4	13.8

Table 2: Dry weight g/plant and of nutrient concentration (% DM, mg kg-ha DM) of plant in R3 stage of sunflower

Treatments	Dry weight (g/plant)	Concentration of nutrient (% of DM)					mg/kg^{-1} DM
		N	P	K	Ca	Mg	B
T1: 0.1% at V-4 stage	52.53	2.83	0.31	3.72	1.68	0.72	42.09
T2: 0.2% at V-4 stage	52.02	2.91	0.27	3.63	1.72	0.69	42.26
T3: 0.3% at V-4 stage	53.17	3.08	0.30	3.62	1.65	0.73	42.71
T4: 0.1% at R-3 stage	52.79	3.90	0.29	3.72	1.71	0.75	42.83
T5: 0.2% at R-3 stage	52.23	2.95	0.32	3.36	1.65	0.76	42.02
T6: 0.3% at R-3 stage	52.13	2.87	0.31	3.52	1.73	0.68	42.27
T7: 0.1% at V-4 and R-3 stage	54.23	3.27	0.29	3.89	1.68	0.69	42.87
T8: 0.2% at V-4 and R-3 stage	55.69	3.39	0.33	3.74	1.82	0.73	43.05
T9: 0.3% at V-4 and R-3 stage	56.71	3.62	0.31	3.92	1.72	0.71	43.27
T10: Control	49.62	2.02	0.29	3.74	1.73	0.69	39.08
S.Em	0.55	0.12	0.11	0.22	0.36	0.21	0.33
CD (P=0.05)	1.63	0.34	NS	NS	NS	NS	0.97
CV	12.5	8.6	9.2	10.1	11.4	10.5	11.0

The positive effect of boron fertilization in stage R-3 on dry matter production (0.3%) is obvious from the results of analysis of plants in stage R-3 (table 2). Foliar boron application at 0.2% and 0.3% concentration, increased the boron content in the sunflower plant biomass statistically significantly verses the unfertilized treatment (T_{10}). Boron application significantly increases not only its content in the plant but also the dry matter production and seed yield

Sharma *et al*., 1999, Rashid and Rafique, 2005) [5, 4].

Effect on yield attributes

Results on yield attributes were recorded and presented in table 3 indicated that foliar application of B at V-4 and R-3 stage significantly influenced the head diameter (cm) seed yield (g/plant), 100 seed weight (g) and volume weight (g/100 ml. Boron foliar application at 0.2% - 0.3% concentration twice at V-4 and R-3 stage significantly higher values when compared with boron foliar application at V-4 stage alone at 0.1% and 0.3% and no boron spray treatment (control). Boron foliar application at V-4 stage alone at 0.1% and 0.3% failed influence significant effect on yield attributes.

Table 3: Sunflower yield attributes and yield influenced by boron foliar spray at different crop growth stages

Treatments	Head diameter (cm)	Seed yield (g/plant)	100 seed weight (g)	Volume weight (g/100 ml)	Seed yield (kg/ha)	Oil content (%)	Oil yield (kg/ha)
T1: 0.1% at V-4 stage	15.4	41.34	5.38	41.13	1856	44.87	833
T2: 0.2% at V-4 stage	14.93	39.55	5.37	40.55	1902	45.27	861
T3: 0.3% at V-4 stage	15.32	40.32	5.61	41.30	1871	45.65	854
T4: 0.1% at R-3 stage	16.28	42.10	5.88	43.45	1937	44.29	858
T5: 0.2% at R-3 stage	17.45	45.35	5.79	43.27	2207	44.76	988
T6: 0.3% at R-3 stage	17.33	46.77	5.86	44.60	2289	44.29	1014
T7: 0.1% at V-4 and R-3 stage	17.82	50.95	5.99	45.41	2076	45.14	937
T8: 0.2% at V-4 and R-3 stage	19.01	53.40	6.34	46.13	2355	44.82	1056
T9: 0.3% at V-4 and R-3 stage	18.61	57.22	6.58	46.27	2479	45.17	1120
T10: Control	14.60	39.54	4.12	39.88	1837	44.23	813
S.Em	0.42	2.56	0.19	1.04	60	0.42	43
CD (P=0.05)	1.06	7.93	0.57	3.09	169	NS	128
CV	8.3	10.5	7.34	4.12	11.8	4.9	6.4

Effect on seed yield, oil content and oil production

Boron foliar application significantly influenced the seed yield and oil seed production but failed to show significant effect on seed oil content (fig.1). Boron foliar application at 0.3% concentration twice at V-4 and R-3 stage (T9) significantly higher values (2479 kg/ha) followed by 0.2% concentration twice at V-4 and R-3 stage (T8) (2355 kg/ha). Boron foliar application at 02% concentration at R-3 stage (T6) treatment recorded 2289 kg/ha seed yield which statistically on par with treatment 0.2% concentration at R-3 stage (2207 kg/ha). However boron foliar application of B at 0.1%-0.3% concentration at V-4 alone treatments failed to differ with no B foliar application treatment (T 10). These results were also agreeing with results reported by Sumathi *et al.* (2005) [7]. Oil production (kg/ha) also followed the similar trends as explained in seed yield.

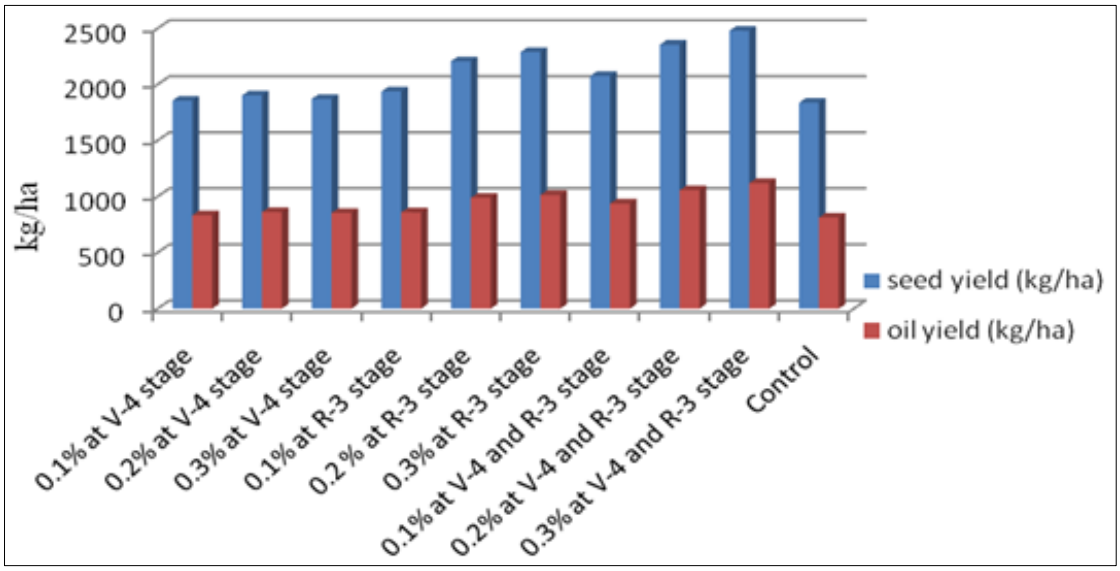

Fig 1: Sunflower seed yield (kg/ha) and Oil seed production (kg/ha) as influenced by boron foliar spray at different concentrations and stages

Conclusion

The study revealed that in sunflower application of boron fertilizer at V-4 stage increased N content in the plant. Sunflower seed yield was significantly higher with boron foliar application at 0.2%-0.3% concentration twice at V-4 and R.-3 stages followed by foliar spray at 0.2% concentration at R-3 stage.

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