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GROWTH AND GROWTH ATTRIBUTES OF SUNFLOWER (*Helianthus annus* L.) AS INFLUENCED BY DIFFERENT LEVELS AND METHODS OF BORON APPLICATION IN ALFISOLS OF KARNATAKA

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ABSTRACT

Field experiment was conducted at Zonal Agricultural Research Station, University of Agricultural Sciences, Bengaluru, during *kharif* 2014 on sandy clay loam soils to investigate the influence of boron application on growth and growth attributes of sunflower using randomised complete block design with 3 replications and 11 treatments comprising control, seed treatment at 2, 4, 6 g of borax kg^{-1} of seed, soil application of borax @ 11 kg ha^{-1} , foliar application of borax at ray floret opening stage @ 0.2%, 0.4% and 0.6 % and dusting of borax at ray floret opening stage at 2 kg ha^{-1}, 3 kg ha^{-1} and 4 kg ha^{-1}. Study revealed that both at 30 and 60 DAS significantly higher plant height (19.73 cm and 146.4 cm respectively), number of leaves (10.6 and 24.73 respectively), leaf area (998.3 cm^2 $plant^{-1}$ and 4296 cm^2 $plant^{-1}$ respectively), root dry matter (2.30 g $plant^{-1}$ and 9.07 g $plant^{-1}$ respectively), shoot mater production (6.97 g $plant^{-1}$ and 8.07 g $plant^{-1}$ respectively), total dry matter (9.27 g and 87.13 g respectively), higher root to shoot ratio (0.43 and 0.13 respectively). Growth indices like LAD (44.12 days), AGR (2.60 g $plant^{-1}$ day^{-1}), CGR (14.42 g dm^{-2} day^{-1}), NAR (0.48 g day^{-1} dm^2) and RGR (1.89 g day^{-1} dm^2) were also significantly higher with soil application of borax.

KEYWORDS: *kharif*, sunflower, leaf area, plant height, LAD, CGR.

INTRODUCTION

During the last century, the cultivated sunflower (*Helianthus annus* L.) has emerged as one of the major oil seed crops in the world, ranking second in importance after soybean. Micronutrients are vital for plant growth and human health in plants, boron regulates the transport of sugars through plant cell membranes, the rate of cell development, cell division, and the synthesis of proteins. Sunflower is one of the most sensitive field crops to low B supply, and B deficiency in this crop has been reported from around the world (Blamey *et al*., 1997). Deficiency symptoms first become evident on the younger leaves which have a bronze colour and become hardened, malformed and necrotic (Blamey *et al*., 1997). Plant requirements for boron are critical, but only small amounts are needed to provide adequate growth, hence, it is categorized as a soil micronutrient. Soil and foliar applications are the most prevalent methods of micronutrient addition but the cost involved and difficulty in obtaining high quality micronutrient fertilizers are major concerns in developing countries. Micronutrient seed treatments, which include seed priming and seed coating, are an attractive and easy alternative. Micronutrient application through seed treatments improves the stand establishment, advances phenological events, and increases yield and micronutrient grain contents. In most cases, micronutrient application through seed treatment performed better or similar to other application methods. Being an easy and cost effective method of micronutrient application, seed treatments offer an attractive option for resource poor farmers. There have been limited studies performed on effects of B fertilization on growth of oil seed sunflower (*Helianthus annuus*) crop. Therefore this study was conducted to study the response of boron application on growth and growth attributes of sunflower.

MATERIALS & METHODS

A field experiment was carried out to study the "Boron nutrition in sunflower (*Helianthus annuus* L.)" during *Kharif* 2014 at All India Co-ordinate Research Project on Sunflower, Zonal Agricultural Research Station, University of Agricultural Sciences, Bengaluru. Soil texture of the experimental site where the experiment was carried out was red sandy loam. There were 11 treatments combinations included for the study viz., $\mathbf{T_1}$ **:** Control (RDF- 90:90:60 kg NPK ha^{-1} and FYM 7.5 t ha^{-1}), $\mathbf{T_2}$**:** T_1 + Borax @ 2 g kg^{-1} of seed as seed treatment, $\mathbf{T_3}$**:** T_1 + Borax @ 4 g kg^{-1} of seed as seed treatment, $\mathbf{T_4}$**:** T_1 + Borax @ 6 g kg^{-1} of seed as seed treatment, $\mathbf{T_5}$**:** T_1 + Soil application of borax @ 11 kg ha^{-1}, $\mathbf{T_6}$**:**T_1 + Borax @ 0.2 % spray to capitulum at ray floret opening stage, $\mathbf{T_7}$**:** T_1 + Borax @ 0.4 % spray to capitulum at ray floret opening stage, $\mathbf{T_8}$**:**T_1 + Borax @ 0.6 % spray to capitulum at ray floret opening stage, $\mathbf{T_9}$: T_1 + Dusting of borax @ 2 kg ha^{-1} on capitulum at ray floret opening stage, $\mathbf{T_{10}}$: T_1 + Dusting of borax @ 3 kg ha^{-1} on capitulum at ray floret opening stage and $\mathbf{T_{11}}$: T_1 + Dusting of borax @ 4 kg ha^{-1} on capitulum at ray floret opening stage.

In Seed treatment according to the treatments, manually seeds were treated at 2, 4, 6 g borax kg^{-1} seeds with the help of 2 % gum acasia solution @ 10 ml kg^{-1} seed and seeds were allowed to dry for 4 hours at room temperature.

In foliar application of micronutrients, treatments were imposed when the crop was at ray floret stage. Foliar application of borax @ 0.2 %, 0.4 % and 0.6 % was carried out by taking calculated quantity of borax and dissolving in hot water to prepare solutions of required concentrations and sprayed to capitulum according to the treatments. Dusting of borax @ 2, 3 and 4 kg ha^{-1} was done by taking calculated quantity of well ground borax in a muslin cloth and dusted on capitulum as per treatments. The growth parameters were recorded at periodical intervals of 30 and 60 DAS from the randomly selected five plants in each treatment and growth indices were calculated by using following formulas.

Leaf Area Index (LAI)

$$LAI = \frac{\text{Leaf area (cm}^2\text{ plant}^{-1})}{\text{Spacing (cm}^2\text{ plant}^{-1})}$$

Leaf Area Duration (LAD) (days)

$$LAD = \frac{Li+(Li+1)}{2} \times t_2 - t_1$$

Where, Li= LAI at ith stage, Li+1 = LAI at (i+1)th stage, $t_2 - t_1$ = time interval between Li and Li+1 stage

Absolute Growth Rate (AGR) (g plant^{-1}day^{-1})

$$AGR = \frac{(W_2-W_1)}{(t_2-t_1)}$$

Where, W_2 and W_1 are the plant dry weight (g) recorded at the time t_2 and t_1 (days), respectively.

Crop Growth Rate (CGR) (g^{-1} m^{-2} day^{-1})

$$CGR = \frac{(W_2-W_1)}{(t_2-t_1) \text{ x spacing}}$$

Where, W_2 and W_1 are the plant dry weight (g) recorded at the time t_2 and t_1 (days), respectively.

Net Assimilation Rate (NAR) (g day^{-1} dm^{-2})

$$NAR = \frac{(W_2-W_1) \text{ x } (Log_eL_2-log_eL_1)}{(t_2- t_1) \text{ x } (L_2-L_1)}$$

Where, W_2 and W_1 are the dry weight of plant (g) recorded at time t_2 and t_1 (days) respectively. L_2 and L_1 are the leaf area (dm^2) recorded at the time t_2 and t_1 (days), respectively.

Relative Growth Rate (RGR) (g g^{-1} day^{-1}

$$RGR = \frac{Log_e W_2 - Log_e W_1}{t_2 - t_1}$$

Where, Log_e: Logarithm to the base, W_1: Dry weights of the plant at t_1, W_2: Dry weights of the plant at t_2

RESULTS & DISCUSSION

Effect of different levels and methods of borax application on growth and growth attributes

Different levels and methods of borax application significantly influenced the growth and growth attributes of sunflower. At 30 DAS application of RDF (90:90:60 kg NPK ha^{-1} and FYM 7.5 t ha^{-1}) along with soil application of borax @ 11 kg ha^{-1} at the time of sowing recorded significantly higher plant height (19.73 cm), number of leaves (10.6), leaf area (998.3 cm^2 plant^{-1}), root dry matter (2.30 g plant^{-1}), shoot mater production (6.97 g plant^{-1}), total dry matter (9.27 g), higher root to shoot ratio (0.43) which was on par with application of RDF along with seed treatment of borax @ 2 g kg^{-1} of seed (19.18 cm, 10.0, 973.9 cm^2 plant^{-1}, 2.13 g, 6.46 g, 0.41 respectively) this may be due to availability of boron might have enhanced cell division and cell elongation resulted in increased growth of sunflower. Application of RDF + seed treatment with borax @ 6 g kg^{-1} of seed recorded significantly less plant height (13.87 cm), number of leaves (6.33), leaf area (523.6 cm^2 plant^{-1}), root dry matter (1.13 g plant^{-1}), shoot mater production (4.20 g plant^{-1}), total dry matter (5.33 g), root to shoot ratio (0.25). This might be due to application of borax as a seed treatment at higher dose causes toxicity and may reduce the enzymatic activity.

At 60 DAS the higher plant height, number of leaves, leaf area obtained with the application of RDF+ soil application of borax @ 11 kg ha^{-1} at the time of sowing (146.4 cm, 24.73, 4296 cm^2 plant^{-1}, respectively) which was on par with RDF + borax @ 0.4 % spray to capitulum at ray floret opening stage (140.0 cm, 23.87, 4269 cm^2 plant^{-1}, respectively). Higher chlorophyll (SAPD) reading (44.38) was recorded in RDF + borax @ 0.4 % spray to capitulum at ray floret opening stage which was on par with RDF + borax @ 0.2 % spray to capitulum at ray floret opening stage (43.18). This increase in growth might be associated with boron role in increasing photosynthetic activity thus resulting in more plant height and number of leaves per plant, hence more leaf area was obtained in these treatments. Such an inference was earlier reported by Sharma *et al.* (2000) and Ayad Shaker and Saad Mohammed (2011). Whereas, significantly lower plant height, number of leaves per plant, leaf area were recorded in RDF + seed treatment with borax @ 6 g kg^{-1} of seed (101.5 cm, 16.40, 3284 cm^2 plant^{-1}, respectively) as compared to other treatments at 60 DAS. This might be due to application of borax as a seed treatment at higher dose causes toxicity and may reduce the enzymatic activity. These results are in line with the findings of Reid (2007) and Muntean (2009).

The dry matter production is the result of cumulative and complementary effect of plant height, number of leaves, leaf area, root weight. Dry matter production differed significantly due to application of different levels and methods of borax. at 60 DAS, among the different treatments RDF+ soil application of borax @ 11 kg ha^{-1} at the time of sowing recorded higher dry matter production (87.13 g) which was on par with RDF + borax @ 0.2 % spray to capitulum at ray floret opening stage (84.55 g), RDF + borax @ 0.4 % spray to capitulum at ray floret opening stage (86.01 g) and RDF + borax dusting @ 2 kg ha^{-1} to capitulum at ray floret opening stage (83.90 g). The higher dry matter production in these treatments might be due to the boron role in increasing photosynthetic activity, which resulted in increase in plant height, number of leaves, leaf area and root growth. The same findings were also reported by Asad *et al.* (2003) and Al Amery *et al.* (2011). However significantly lower plant dry matter (62.96 g) noticed in RDF + seed treatment with borax @ 6 g kg^{-1} of seed in the experiment was due to boron toxicity at the time of sowing reduced the plant growth and development and dry matter accumulation**,** as also reported by Reid 2007.

TABLE 1: Plant height (cm), Number of leaves plant^{-1} and leaf area (cm^2 plant^{-1}) of sunflower as influenced by different levels and methods of borax application

Treatments	Plant height		Number of leaves		Leaf area	
	30 DAS	60 DAS	30 DAS	60 DAS	30 DAS	60 DAS
T_1 :RDF (90:90:60 kg NPK ha^{-1} and FYM 7.5 t ha^{-1})	17.07	132.1	8.33	21.40	716.6	3899
T_2 : T_1 + Borax @ 2 g kg^{-1} seed as ST	19.18	136.1	10.0	22.27	973.9	4065
T_3 : T_1 + Borax @ 4 g kg^{-1} seed as ST	14.90	110.9	6.67	17.33	613.6	3541
T_4 : T_1 + Borax @ 6 g kg^{-1} seed as ST	13.87	101.5	6.33	16.40	523.6	3284
T_5 : T_1 + Soil application of borax @ 11 kg ha^{-1}	19.73	146.4	10.6	24.73	998.3	4296
T_6 : T_1 + Borax at 0.2 % spray to capitulum at RFO stage	17.07	137.2	8.67	21.10	723.9	4254
T_7 : T_1 + Borax @ 0.4 % spray to capitulum at RFO stage	18.10	140.0	9.00	23.87	753.0	4269
T_8 : T_1 + Borax @ 0.6 % spray to capitulum at RFO stage	17.83	133.6	8.67	21.43	718.7	4134
T_9 : T_1 + Dusting of borax @ 2 kg ha^{-1} on capitulum at RFO stage	17.53	136.1	8.33	21.67	728.8	4264
T_{10}:T_1 + Dusting of borax @ 3 kg ha^{-1} on capitulum at RFO stage	17.27	133.1	8.00	21.77	705.6	4120
T_{11}: T_1+ Dusting of borax @ 4 kg ha^{-1} on capitulum at RFO stage	17.93	132.5	8.33	22.07	708.1	4073
S.Em±	0.39	2.20	0.48	0.58	27.15	87.98
CD (p= 0.05)	1.14	6.55	1.41	1.70	80.08	259.5
CV (%)	8.61	9.40	9.79	7.3	6.39	7.30

RDF: Recommended dose of fertilizer, **ST:** Seed treatment, **RFO:** Ray floret opening

TABLE 2: Root dry weight (g plant^{-1}), shoot dry weight (g plant^{-1}), total dry matter (g plant^{-1}) and Root to shoot ratio of sunflower as influenced by different levels and methods of borax application

Treatments	30 DAS			60 DAS			30 DAS	60 DAS
	Root dry weight	Shoot dry weight	Total dry matter	Root dry weight	Shoot dry weight	Total dry matter	Root to shoot ratio	Root to shoot ratio
T_1 :RDF (90:90:60 kg NPK ha^{-1} and FYM 7.5 t ha^{-1})	1.61	5.10	6.71	7.86	70.84	78.70	0.32	0.11
T_2 : T_1 + Borax @ 2 g kg^{-1} seed as ST	2.13	6.46	8.59	8.43	72.38	80.81	0.41	0.12
T_3 : T_1 + Borax @ 4 g kg^{-1} seed as ST	1.40	4.66	6.06	6.10	64.54	70.64	0.28	0.10
T_4 : T_1 + Borax @ 6 g kg^{-1} seed as ST	1.13	4.20	5.33	5.40	57.56	62.96	0.25	0.09
T_5 : T_1 + Soil application of borax @ 11 kg ha^{-1}	2.30	6.97	9.27	9.07	78.07	87.13	0.43	0.13
T_6 : T_1 + Borax @ 0.2 % spray to capitulum at RFO stage	1.65	5.26	6.91	9.20	75.35	84.55	0.31	0.12
T_7 : T_1 + Borax @ 0.4 % spray to capitulum at RFO stage	1.75	5.80	7.55	9.58	76.43	86.01	0.30	0.15
T_8 : T_1 + Borax @ 0.6 % spray to capitulum at RFO stage	1.65	5.30	6.95	8.43	71.37	79.80	0.31	0.12
T_9 : T_1 + Dusting of borax @ 2 kg ha^{-1} on capitulum at RFO stage	1.65	5.29	6.94	8.88	74.42	83.30	0.31	0.12
T_{10}:T_1 + Dusting of borax @ 3 kg ha^{-1} on capitulum at RFO stage	1.59	5.40	6.99	8.23	73.47	81.7	0.32	0.12
T_{11}: T_1+ Dusting of borax @ 4 kg ha^{-1} on capitulum at RFO stage	1.63	5.10	6.98	8.19	71.20	79.39	0.33	0.12
S.Em±	0.09	0.27	0.25	0.40	2.45	2.39	0.02	0.01
CD (p= 0.05)	0.27	0.76	0.73	1.12	7.22	7.06	0.05	0.02
CV (%)	7.57	6.06	7.10	6.95	8.32	6.23	8.62	9.92

TABLE 3: Chlorophyll (SPAD) reading, Leaf Area Index, Leaf Area Duration (days), Absolute Growth Rate (g plant^{-1} day^{-1}), Crop Growth Rate (g dm^{-2} day^{-1}), Net Assimilation Rate (g day^{-1} dm^{-2}) and Relative Growth Rate (g day^{-1}dm^{-2}) in sunflower as influenced by different levels and methods of borax application

Treatments	Chlorophyll (SPAD) readings		LAI		LAD	AGR	CGR	NAR	RGR
	Star bud stage	50 % flowering	30 DAS	60 DAS					
T_1 :RDF (90:90:60 kg NPK ha^{-1} and FYM 7.5 t ha^{-1})	35.43	39.00	0.40	2.17	38.46	2.40	13.33	0.38	1.72
T_2 : T_1 + Borax @ 2 g kg^{-1} seed as ST	39.24	41.42	0.54	2.26	41.99	2.41	13.37	0.40	1.81
T_3 : T_1 + Borax @ 4 g kg^{-1} seed as ST	30.79	35.70	0.34	1.97	34.62	2.16	11.98	0.36	1.63
T_4 : T_1 + Borax @ 6 g kg^{-1} seed as ST	27.75	33.67	0.29	1.82	31.73	1.92	10.68	0.34	1.52
T_5 : T_1 + Soil application of borax @ 11 kg ha^{-1}	40.38	42.00	0.55	2.39	44.12	2.60	14.42	0.48	1.89
T_6 : T_1 + Borax @ 0.2 % spray to capitulum at RFO stage	36.14	43.18	0.40	2.36	41.49	2.59	14.38	0.44	1.83
T_7 : T_1 + Borax @ 0.4 % spray to capitulum at RFO stage	36.63	44.38	0.42	2.44	42.93	2.58	14.34	0.45	1.86
T_8 : T_1 + Borax @ 0.6 % spray to capitulum at RFO stage	36.17	40.90	0.40	2.30	40.44	2.51	13.49	0.42	1.79
T_9 : T_1 + Dusting of borax @ 2 kg ha^{-1} on capitulum at RFO stage	36.75	42.15	0.40	2.37	41.61	2.43	13.96	0.44	1.80
T_{10}:T_1 + Dusting of borax @ 3 kg ha^{-1} on capitulum at RFO stage	36.69	41.37	0.39	2.29	40.22	2.41	13.40	0.43	1.79
T_{11}: T_1+ Dusting of borax @ 4 kg ha^{-1} on capitulum at RFO stage	36.21	41.17	0.39	2.26	39.84	2.41	13.41	0.42	1.73
S.Em±	0.82	0.66	0.02	0.05	0.80	0.08	0.45	0.011	0.006
CD (p= 0.05)	9.80	6.6	0.05	0.14	2.48	0.24	1.33	0.034	0.020
CV (%)	3.29	1.95	9.8	7.8	6.3	5.98	6.82	10.32	8.30

Higher root to shoot ratio (0.15) at 60 DAS was recorded in RDF + borax @ 0.4 % spray to capitulum at ray floret opening stage followed by RDF+ soil application of borax @ 11 kg ha^{-1} at the time of sowing (0.13). The significant increase in root to shoot ratio might be due to the boron. Lowest root to shoot ratio was recorded in RDF + seed treatment with borax @ 6 g kg^{-1} of seed (0.09) this was mainly due to boron at higher concentrations inhibits root and shoot growth primarily through limiting cell division and cell elongation . Similar results were reported by Brown *et al*. (2002) and Nable *et al*. (1997).

Application of different levels and methods of borax significantly influenced the growth indices significantly. The higher growth indices like LAD (44.12 days), AGR (2.60 g $plant^{-1}$ day^{-1}), CGR (14.42 g dm^{-2} day^{-1}), NAR (0.48 g day^{-1} dm^{2}) and RGR (1.89 g day^{-1} dm^{2}) were recorded in RDF + soil application of borax @ 11 kg ha^{-1} at the time of sowing. RDF + seed treatment with borax @ 6 g kg^{-1} of seed recorded significantly lower LAD (31.73 days), AGR (1.92 g $plant^{-1}$ day^{-1}), CGR (10.18 g dm^{-2} day^{-1}), NAR (0.34 g day^{-1} dm^{2}) and RGR (1.52 g day^{-1} dm^{2}). Increase in growth indices might be due to availability of boron increased the leaf area and total dry matter production and resulted in higher growth indices.

CONCLUSION

Results obtained from present investigation indicate that application of borax significantly influences the growth and growth attributes of sunflower. Boron availability during initial crop growth stages through soil application and seed treatment application is beneficial for vegetative growth, but correct dose of borax is very important as seed treatment of borax at higher concentration become toxic and adversely affect the germination and further growth of sunflower.

REFERENCES

Al-Amery, Mushtaq Ali and Qumar Mohyuddin (2011) Effect of boron foliar application on reproductive growth of sunflower (*Helianthus annuus* L.). *Int. J. Agron*., Article ID230712: (1-5).

Asad, A., Blamey, F.P.C. and Edwards, D.G. (2003) Effects of boron foliar applications on vegetative and reproductive growth of sunflower. *Ann. Bot*., **92**(4): 565-570.

involvement in cell elongation, cell division and meristematic growth increase the root and shoot growth. The similar result was reported by Josten and Kutschera (1999) and Khan *et al*. (2006).

Ayad shaker, T. & Saad Mohammed (2011) Effect of different levels and timing of boron foliar application on growth, yield and quality of sunflower (*Helianthus annuus* L.) genotypes. *Mesopotamia J. Agric*., **39**(3): 16-26.

Blamey, P.C., Zollinger, R.K. & Schneiter, A. A. (1997) Sunflower technology and production. *American Soc. Agron*., **3**: 595-670.

Brown, P.H., Bellaloui, N., Wimmer, M., BassiL, E.S., Riuz, J., Hu, H., Pfeffer, H., Dannel, F. and Romheld, V. (2002) Boron in plant biology. *Plant Biol*., **4**: 205-227.

Josten, P. and Kutschera, U. (1999) The micronutrient boron causes the development of adventitious roots in sunflower cuttings. *Ann. Bot*., **84**: 337-342.

Khan, R., Gurmani, A. H., GurmanI, A. R. & Zia, M.S. (2006) Effect of boron application on rice yield under wheat rice system. *Int. J. Agri. Biol*., **8**: 805-808.

Marschner, H. (1995) Mineral Nutrition of Higher Plants, 2nd edn. Academic Press, London, UK

Mengel, K., Kirkby, E.A., Kosegarten, H., Appel, T. (2001) Principles of Plant Nutrition. Kluwer Academic Publishers, Dordrecht, The Netherlands.

Munthean, N. (2009) Biochemical response of plants to boron toxicity- a review. *Plant Soil Environ*., **54**(3): 89-99.

Nable, R.O., Banuelos, G.S. & Paull, J.G. (1997) Boron toxicity. *Plant Soil*, **193**(12): 181-198.

Reid, R. (2007) Update on boron toxicity and tolerance in plants. *Adv. Plant Animal Boron Nutri*., 83-90.

Saad A. M., Al-doori, Moaid Y. H. and Al-dulaimy (2011) Influence of zinc fertilization levels on growth, yield and quality of some sunflower genotypes (*Helianthus annuus* L.). *Education Res., J*., **11**(4): 714-730.