



Effect of boron on sunflower (*Helianthus annuus*) productivity and grain composition under sulphate dominated saline conditions

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Received: 12 April 2019; Accepted: 18 July 2019

ABSTRACT

The present study was carried out at CCS Haryana Agricultural University, Hisar, India in 2015–16 to examine the response of Boron applications to sunflower (*Helianthus annuus* L.) under sulphate dominated salinity with four salinity (EC) levels (Control, 4, 8 and 12 dS/m) and five Boron levels (Control, 1, 3, 6, 12 mg/kg). The per cent decrease in germination with increasing levels of salinity at high boron level was 1.87, 2.74 and 13.21, respectively, as compared to the control. The per cent reduction in seed yield of sunflower as compared to control was 7.35, 24.80 and 52.06% at salinity levels of 4, 8 and 12 dS/m at 12 mg/kg boron level, respectively. Similarly increase in Boron levels significantly reduced the seed yield of sunflower. Maximum oil content (40.93%) was observed in control while minimum oil content (34.40%) was observed at high salinity and boron level. Salinity stress at 12 dS/m reduced protein content 13.53% as compared to control conditions. Protein content was decreased significantly at 6 and 12 mg/kg. The salinity and boron have detrimental effects on germination, seed yield, protein content and oil content of sunflower. The concentration of ions (Ca^{2+} , Na^+ , SO_4^{2-} and Cl^-) in sunflower seed was higher in saline condition. Boron levels increased the concentration of Ca^{2+} , Na^+ and Cl^- in sunflower seed under sulphate dominated salinity which further reduced plant survival and negates the productivity.

Key words: Boron, Salinity, Sulphate, Sunflower

Sunflower (*Helianthus annuus* L.) is an important oilseed crop as it covered 26.19 Mha area worldwide with 51.47 million metric tonnes production and 1.97 mt/ha productivity in 2018–19 (USDA 2019). A reasonable fertilization of sunflower on macro and micronutrients is one of the major limitations for its productivity. Concerning its requirement in micronutrients, sunflower is reported as sensitive crop to boron (B) deficiency (Souza *et al.* 2004). The kernel sunflower yield and its oil content can be enhanced by B supply (Mekki B 2015). However, a close line between B deficiency and its phytotoxicity has been reported by many authors (Ruiz *et al.* 2016). Indeed, B may become toxic to plants at a slightly high B soil content. Soil salinity, on the other hand, occupies wide regions of the world and is particularly serious problem in arid or semi-arid areas especially where faulty irrigation practices were

followed. It reduces seed germination (Shiela *et al.* 2016) and ultimately reduces plant growth (Haque *et al.* 2014). Sunflower is photo and thermo insensitive, short duration, deep rooted drought resistant, widely adaptable, salt tolerant crop, high oil quality (Kotsova B 2010) offers promise for its cultivation under varied agro-climatic conditions and diverse cropping systems and subsistence farming situations for boosting oilseed production. However, excess of B can leads to toxicity of B in arid and semi-arid areas is major concern due to accumulation of B through saline. Therefore, present study was carried out with to examine the effects of various levels of boron in relation to salinity hazards on yield and chemical composition of sunflower.

MATERIALS AND METHODS

The pot culture and laboratory studies of this experiment were conducted in the screen house of Chaudhary Charan Singh Haryana Agricultural University, Hisar in 2015–16. Bulk surface soil samples (0–15 cm) were collected from the experimental field. Four representative soil samples were drawn from different places before filling the soil in pot. Composite samples prepared by passing through 2 mm mesh sieve, were analyzed to determine the physical and chemical properties of the soil. The experimental soil had sand, silt and clay contents of 88%, 10% and 2%, respectively, electricity conductivity of 0.15 dS/m, pH 8.1

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(1:2 soil : water suspension) oxidizable organic carbon 0.15% (Walkley and Black 1934), available N 65.2 kg/ha (Subbiah B and Asija G 1956), available P 7.37 kg/ha (Olsen *et al.* 1954), 160 kg/ha (Richards L 1954).

The four salinity levels, viz. Control, T_1 (4 dS/m), T_2 (8 dS/m) and T_3 (12 dS/m) were created by differing ECs under sulphate dominated salinity by different ion concentrations of Na^+ , Ca^{2+} , Mg^{2+} , Cl^- and SO_4^{2-} in solution (Manchanda H and Sharma S 1989). These solutions were sprayed over 2 cm thick well spread soil till saturation level. These treated soils then, immediately, covered with polythene sheets to check evaporation. This step was repeated till soil reached its full capacity. Each type of saline soils were then thoroughly mixed, air dried and grinded to pass through 2 mm sieve and ECs of soils were analyzed before each experiment. Boron solutions of 1, 3, 6 and 12 ppm were made and mixed to each type of saline soils. 5 kg of these synthesized saline soils with different boron concentrations were filled in polythene bags (16×18 inches) along with control to raised the crop. The nutrient solutions of macro and micronutrients were added according to recommended doses. Hybrid Jwalamukhi was used as experimental material. Each treatment was replicated thrice. Seeds were considered germinated when radical had protruded 2 mm through seed coat. The number of seeds germinated was recorded daily up to 10 days and germination percentage was calculated. The results were analyzed by completely randomized design with three replications.

RESULTS AND DISCUSSION

Germination: Seeds were considered germinated when radical had protruded 2 mm through seed coat. The number of seeds germinated was recorded daily for up to 10 days and germination percentage was calculated. Germination percentage was higher under control (83.53%) as compared to the treatments. Lowest germination percentage was recorded under 12 dS/m (70.38%). Seed germination decreased significantly with increase in boron levels. At 3 ppm, the decrease in germination percent was more than 9% and at 12 ppm, it further decreased to 23% (Table 1). The interaction between B and salinity was found significant. The lower germination percentage was observed under higher level of salinity and Boron. The germination percentage was drastically reduced at 4 dS/m salinity and 3 ppm Boron levels. Under saline condition water uptake is reduced due to osmotic effect and ion toxicity inhibits cell growth and division (Saberli *et al.* 2019).

Seed yield: The highest seed yield of 7.84 g was recorded in control while the yield was lowest (3.96) at salinity level 12 dS/m which showed 49.5% decrease over the control (Table 1). Lowest seed yield was recorded at 12 ppm B level. B × salinity treatment was highly significant with maximum seed weight in control (8.39 g) and minimum in 12 ppm B and 12 dS/m salinity (3.13 g). It was earlier reported by Grieve C and Poss J (2000) that production of biomass, yield components and grain yield of wheat decreases significantly due to combined effects

of B toxicity and salinity. The possible mechanism may be role of B in preventing nutrient imbalances under saline conditions (Bastias *et al.* 2010).

Oil content: The seed oil contents decreased significantly with increasing level of salinity and Boron toxicity (Table 1). Oil content in seed increased at 4 dS/m level after that declined trend was observed. The reduction in oil content was 7.5% at 12 dS/m salinity level compare with control. Oil content decreased by 2.05, 4.75, 9.01 and 10.92% was observed at 1, 3, 6 and 12 ppm of boron level as compared with control. Similarly under Boron treatment oil content declined with boron levels start at 3 ppm and onward. Interaction effect found significant and highest oil content was obtain with 4 dS/m salinity level and no application of boron followed by 1 ppm boron application. The reduction in oil content might be due to increase in the osmotic pressure of soil solution and imbalances in nutrients and essential elements (Toorchii *et al.* 2011) or the retarded development of seed and early maturity of plants in high saline conditions (Cucci *et al.* 2007).

Protein content: The protein content of sunflower was higher in control in comparison to salinity and boron treatments (Table 1). In non-saline treatment protein content was 0.32, 6.16 and 11.23% higher as compared to salinity level 4, 8 and 12 dS/m levels respectively. Protein content was decreased significantly at 3 ppm and subsequent increment in boron levels. Protein content in sunflower was 11.0% higher in control as compared to content in 12 ppm level of boron. Protein content affects badly by salinity (Khatorn *et al.* 2000).

Ca content in seed: Ca content in seed was significantly increased with salinity level and it was highest at 12 dS/m level which is 47.23% more than other salinity levels (Table 2). Under Boron levels, Ca content was decreased with increasing Boron levels in soil. At 12 dS/m salinity level, 20.4 % lower Ca content was recorded as compared to control (33.73). Interaction effect of salinity × B was found significant and the Ca concentration was highest at lowest level of B. The increase in total Ca content under high B supply is less well known but an enhanced Ca^{2+} transport under high B supply has been previously recorded in roses (Granmore-Neumann R and Davidov S 1993). The mechanism still unknown but could be related to formation of B- Ca^{2+} complexes (Carpena *et al.* 2000).

Mg content in seed: The Mg content in seed in 12 dS/m treatment was higher than other salinity levels. At 12 dS/m levels Mg content was 21.1, 11.9 and 9.4% higher as compared to control, 4 dS/m and 8 dS/m, respectively. The different Boron levels exhibit significant difference in Mg content of seed. Maximum Mg content of seed was recorded by control (13.70 ppm) and lowest was at 12 ppm treatment (12.47 ppm). Salinity × B interaction on the Mg content of sunflower seed was found to be statistically significant (Table 2). Mg content of sunflower seed was the highest at the lowest B treatment under saline conditions. Magnesium concentrations in plant tissues tend to decrease as salinity increases (Grattan S and Grieve C 1999).

Table 1 Effect of boron on germination (%), seed yield (g/pot), oil content (%) and protein content (%) of sunflower under various levels of SO_4^{2-} dominated salinity

Salinity level (dS/m)	Boron levels (ppm)											
	0			1			3			6		
	Germi- nation (%)	Yield (g/pot)	Oil (%)	Protein (%)	Germi- nation (%)	Yield (g/pot)	Oil (%)	Protein (%)	Germi- nation (%)	Yield (g/pot)	Oil (%)	Protein (%)
Non saline	90.00	8.39	40.93	16.39	90.00	8.34	41.13	16.34	86.00	8.25	39.70	16.02
4	89.00	6.63	43.08	16.68	89.80	6.73	42.19	16.21	85.37	6.69	41.65	15.78
8	87.00	5.86	40.99	15.60	85.33	5.43	39.37	15.32	83.03	5.18	38.58	14.61
12	78.10	4.76	39.17	14.15	74.43	4.48	38.10	14.23	72.10	4.20	36.43	14.02
CD (at 5%)	0.94	0.31	0.53	0.38	0.94	0.31	0.53	0.38	0.94	0.31	0.53	0.38

Table 2 Effect of boron on chemical composition of Sunflower seeds under various levels of SO_4^{2-} dominated salinity

Salinity level (dS/m)	Boron levels (ppm)											
	0			1			3			6		
	Ca (ppm)	Mg (ppm)	Na (ppm)	SO ₄ (ppm)	Ca (ppm)	Mg (ppm)	Na (ppm)	SO ₄ (ppm)	Ca (ppm)	Mg (ppm)	Na (ppm)	SO ₄ (ppm)
Non saline	3.10	12.18	1.60	2.90	3.06	12.09	2.27	2.93	2.94	11.85	3.30	3.04
4	3.82	13.49	2.91	3.05	3.79	13.13	3.24	3.14	3.68	12.93	4.13	3.31
8	4.76	13.80	7.28	3.55	4.54	13.43	7.73	3.64	4.19	13.21	8.63	3.81
12	5.29	15.33	11.81	3.92	4.97	15.08	12.33	4.00	4.71	14.33	12.41	4.18
CD (at 5%)	0.07	0.09	0.19	0.06	0.07	0.09	0.19	0.06	0.07	0.09	0.19	0.06

Sodium content in seed: The Na^+ concentration in seed at 12 dS/m salinity level was 9.84, 8.84 and 4.39 ppm higher compared control, 4 and 8 dS/m salinity levels, respectively. Na^+ concentration was significantly increased with B levels and it was 26.0, 19.9, 10.8 and 6.4 % higher at 12 ppm Boron level compared to control, 1, 3 and 6 ppm Boron levels, respectively. Interaction effect of salinity and boron significantly increase Na^+ concentration (Table 2). In this connection, Kiarostami *et al.* (2010) suggested that increased accumulation of sodium (Na^+) and (Cl^-) ions in the tissues inhibits biochemical processes related to photosynthesis through direct toxicity and led to low water potential. Increase in Na^+ concentration with increase in salinity was also reported earlier, e.g. in sunflower by Nawaz *et al.* (2002). The presence of B in the growing medium further increased the Na^+ concentration in the shoot of all the varieties and made the conditions more adverse for plants survival.

SO_4^{2-} content in seed: SO_4^{2-} content in seed at 12 dS/m salinity level was 37.7, 20.0, 3.3% ppm higher as compared to control, 4 and 8 dS/m, respectively. Among B treatment, SO_4^{2-} content was highest at 12 ppm (4.08 ppm) and lowest in control (3.35 ppm). Interaction effect of salinity and B on SO_4^{2-} content was found significant. Maximum SO_4^{2-} concentration in sunflower seed was recorded at high level of SO_4^{2-} and B. Increase SO_4^{2+} in the cell walls of seeds due to high salinity causes deleterious effects on water uptake and thus inhibits germination severely (Zhou *et al.* 2010).

Cl content in seed: Salinity and B levels increased Cl concentration of sunflower seed. Salinity $\times$ B interaction on the Cl concentration of sunflower seed was found to be statistically significant. Cl concentration of sunflower seed was the highest at the highest B treatment under saline conditions (Table 2). Jose *et al.* (2005) recorded that salinity increased Na and Cl content in plant. Suarez D and Grieve C (2013) also reported that chloride content of the plant organs increased as salinity increased.

The salinity and boron have detrimental effects on germination, seed yield, protein content and oil content of sunflower. The concentration of ions (Ca^{2+} , Na^+ , SO_4^{2-} and Cl^-) in sunflower seed was higher in saline condition. Boron levels increased the concentration of Ca^{2+} , Na^+ and Cl^- in sunflower seed under sulphate dominated salinity. In different studies, both salinity and B toxicity showed significant reduction in germination of maize and sorghum (Ismail A 2004). However, Khalid *et al.* (2018) noticed B supply higher than or equal to 5 mg/kg and 10 mg/kg in silty clay soil induced phytotoxicity symptoms without affecting growth, biomass and oil production in sunflower.

ACKNOWLEDGMENTS

The author is grateful to the Department of Soil Sciences, CCS Hisar Agricultural University, Hisar, Haryana for providing all necessary facilities for conducting research.

REFERENCES

Bastias E, Alcaraz-Lopez C, Bonilla I, Martinez-Ballesta M C,

- Bolanos L and Carvajal M. 2010. Interactions between salinity and boron toxicity in tomato plants involve apoplastic calcium. *Journal of Plant Physiology*. **167**: 54–60.
- Carpene R O, Esteban E, Sarro M J, Penalosa J, Garate A, Lucena J J and Zornoza P. 2000. Boron and calcium distribution in nitrogen-fixing pea plants. *Plant Science* **151**: 163–70.
- Cucci G, Rotunno T, De C A, Lacolla G, Di C R and Tarantino E. 2007. Effects of Saline and Sodic stress on yield and fatty acid profile in sunflower seeds. *Italian Journal of Agronomy*. **1**: 13–21.
- Ganmore- Neuman R and Davidov S. 1993. Uptake and distribution of calcium in rose plantlets as affected by calcium and boron concentration in culture solution. *Plant Soil* **155**(156): 151–4.
- Grattan S R and Grieve C M. 1991. Salinity-mineral nutrient relations in horticultural crops. *Scientia Horticulturae* **78**: 127–57.
- Grieve C M and Poss J P. 2000. Wheat responses to interactive effects of boron and salinity. *Journal of Plant Nutrition* **23**: 1217–26.
- Grieve C M, Poss J A, Grattan S R, Suarez D L and Smith T E. 2010. The combined effects of salinity and excess boron on mineral ion relations in broccoli. *Journal of Scientific Horticulture* **125**: 179–87.
- Haque M A, Jahiruddin M, Hoque M A, Rahman M Z and Clarke D. 2014. Temporal variability of soil and water salinity and its effect on crop at kalaparaupazila. *Journal of Environmental Sciences and Natural Resources* **7**(2): 111–14.
- Ismail A M. 2004. Response of Maize and Sorghum to Excess Boron and Salinity. *Biology of Plants* **47**: 313–16.
- Jackson M L. 1973. *Soil Chemical Analysis*. Prentice Hall of India Pvt. Ltd., New Delhi.
- Jose M F, Roldan A M, Sanchez C, Alexandre G and Benlloch M. 2005. K^+ starvation increases water uptake in whole sunflower plants. *Plant Science* **168**: 823–9.
- Khalid D, Saad D, Kacem M, Ezzahra N F, Fouad A and Abdelhadi A H. 2018. Sunflower response to Boron supply when grown in silty clay soil. *Journal of the Saudi Society of Agricultural Sciences* <http://doi.org/10.1016/j.jssas.2018.06.004>.
- Khatoon A, Qureshi M S and Hussain M K. 2000. Effect of salinity on some yield parameters of Sunflower (*Helianthus annuus* L.). *International Journal of Agriculture and Biology* **2**(4): 382–4.
- Kiarostami K, Mohsini R and Saboor A. 2010. Biochemical changes of *Rosamarinus officinalis* under salt stress. *Journal of Stress Physiology and Biochemistry* **6**: 114–22.
- Kostova B. 2010. Prospects for development of sunflower production in Bulgaria. *Trakia Journal of Science* **3**: 215–18.
- Maas E V and Hoffman G J. 1976. Crop salt tolerance: Evaluation of existing data. (In) Proceedings of International Salinity Conference, Lubbock, Texas, August, pp 187–98.
- Manchanda H R and Sharma S K. 1989. Tolerance of chloride and sulphate salinity in chickpea (*Cicer arietinum*). *Journal of Agricultural Sciences* **113**: 407–10.
- Mekki B B. 2015. Effect of boron foliar application on yield and quality of some sunflower (*Helianthus annuus* L.) cultivars. *Journal of Arabian Science and Technology* **5**: 309–16.
- Moodie C D, Smith H W and McCreery R A. 1959. *Laboratory Manual for Soil Fertility*. State College of Washington, Pullman. Washington, USA.
- Munns R, James R A and Läuchli A. 2006. Approaches to increasing the salt tolerance of wheat and other cereals. *Journal*

- of *Experimental Botany* **57**: 1025–43.
- Nawaz S, Akhtar M, Aslam M, Qureshi R H, Ahmad Z and Akhtar J. 2002. Anatomical morphological and physiological changes in sunflower varieties because of NaCl salinity. (In) *Proceedings of 9th International Congress of Soil Sciences, Pakistan, March 46*.
- Olsen S R, Cole C V, Watanabe F S and Dean L A. 1954. *Estimation of available phosphorus in soils by extraction with sodium bicarbonate*. United States Department of Agriculture, Washington, USA.
- Richards L A. 1954. *Diagnosis and improvement of saline and alkali soils*. USDA, Washington, USA.
- Ruiz M, Quiñones A, Martínez-Alcántara B, Aleza P, Morillon R, Navarro L, Primo-Millo E and Martínez-Cuenca M. 2016. Tetraploidy enhances boron-excess tolerance in carrizocitrangle (*Citrus sinensis* L. Osb. _ *Poncirus trifoliata* L. Raf.). *Frontiers in Plant Science* **27**: 701.
- Saberali S F and Moradi M. 2019. Effect of salinity on germination and seedling growth of *Trigonella foenum-graecum*, *Dracocephalum moldavica*, *Satureja hortensis* and *Anethum graveolens*. *Journal of the Saudi Society of Agricultural Sciences* **18**: 316–23.
- Shila A, Haque M A, Ahmed R and Howlader M H K. 2016. Effect of different levels of salinity on germination and early seedling growth of sunflower. *World Research Journal of Agricultural Sciences* **3**(1): 48–53.
- Souza A, Oliveira M F and Castiglioni V B. 2004. The boron on sunflower crop. *Semin.Ciênc.Agrár* **25**: 27–34.
- Suarez D L and Grieve C M. 2013. Growth, yield, and ion relations of strawberry in response to irrigation with chloride-dominated waters. *Journal of Plant Nutrition* **36**: 1963–1981.
- Subbiah B V and Asija G L. 1956. A rapid procedure for the determination of available nitrogen in soils. *Current Science* **25**: 259–60.
- Toorchii M, Naderi R, Kanbar A and Shakiba M R. 2011. Response of spring Canola cultivars to sodium chloride stress. *American Biological Research* **2**: 312–22.
- United States of Department of Agriculture (USDA). 2019. USDA-Foreign Agricultural Services, Office of Global Analysis International Production Assessment Division Circular Series WAP. pp 6–19.
- Walkley A and Black I A. 1934. An experiment of the Degtareff method for determination of soil organic matter and a proposed modification of the chronic acid titration method. *Soil Science* **37**: 29–38.
- Zhou D and Xiao M. 2010. Specific ion effects on the seed germination of sunflower. *Journal of Plant Nutrition* **33**(2): 255–66.