International Journal of Horticultural Science and Technology
Journal homepage: http://ijhst.ut.ac.ir

Assessment of Varietal Attributes of Okra under Foliar Application of Zinc and Boron

Mahrin Binta Jahir Maliha[1], †, Mohammed Nuruzzaman[1]†, *, Belayet Hossain[2], Fariha Ahmed Trina[1], Nizam Uddin[1], and Anup Kumar Sarker[3]

1Department of Agriculture, Faculty of Science, Noakhali Science and Technology University, Noakhali-3814, Bangladesh
2Department of Horticulture, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh
3Department of Agronomy, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh
† These authors contributed equally to this work.

ARTICLE INFO

Article history:

Received: 4 April 2021,
Received in revised form: 15 June 2021,
Accepted: 22 August 2021

Article type:

Research paper

Keywords:

Okra,
micronutrients,
foliar application,
zinc,
boron

ABSTRACT

Micronutrients are required in small quantities for plant growth and development, nevertheless are indispensable for crop production. Soil application method of fertilizer is very common method for plant nutrition but foliar fertilization also plays effective role under certain circumstances. ZnSO4 applied as a source of Zinc (Zn) and borax utilized as the source boron (B), which are two micronutrients playing significant roles in growth and yield-related attributes of okra (*Abelmoschus esculentus* L.). Despite of their importance, foliar application of Zn and B on this economically valuable crop received little attention so far. Therefore, to assess the possible response of two okra varieties ('Chamak' denoted here as 'V1' and 'Jadoo' denoted as 'V2') to Zn and B, individual foliar spray of Zn and combination of Zn and B were applied on okra plants. The treatment consisted of T0 (Control), T1 (0.2% Zn), T2 (0.3% Zn), T3 (0.2% Zn + 0.2% B) and T4 (0.2% Zn + 0.3% B). Results showed that foliar application of micronutrients significantly improved the growth and yield-related parameters. Among the varieties, 'Chamak' showed highest plant growth, yield and yield-related attributes over 'Jadoo'. In the case of Zn and Zn-B combination, the highest yield (17.7 tone/ha) was noted from T4 compared to control (11 tone/ha). On the other hand, in terms of combination of varieties and treatments, the highest yield (15.77 tone/ha) was found in V1T4 whereas the lowest (8.35 tone/ha) yield was recorded in V2T0, indicating the good performance of Zn and Zn-B combination for the growth and yield-related attributes of okra.

Introduction

Okra that belongs to *Malvaceae* family is one of the most popular fruit vegetables, which is widely cultivated in Bangladesh and in wide range of tropical regions of the world. It is mainly cultivated for its tender green fruits that are available in the most of market of Bangladesh. It is a good source of a number of vitamins, minerals and is useful to fight against various diseases (Ahmad 1995; FAO, 2016; Rahman et al., 2017). Vegetable producers are believed with the problem of soil fertility and productivity. This is because of intensive agricultural practices and excessive use of chemical fertilizers which deteriorated the soil fertility and crop productivity (Ahmadi and Souri, 2019; Hatamian et al., 2020). This situation plus climatic constraints have resulted in mineral deficiency particularly in micronutrient deficiency (Souri and Hatamian,

* Corresponding Author, Email: nzaman.ag@nstu.edu.bd
DOI: 10.22059/IJHST.2021.321763.459

2019; Aghaye Noroozlo et al., 2019). Foliar application is a useful practice to combat minerals particularly micronutrient deficiencies (Aslani and Souri, 2018; Souri and Dehnavard, 2018). Farmers occasionally use micronutrients like zinc sulphate, borax and boric acid. Unluckily micronutrients have received less attention in fertilizer management investigation, expansion and extension programs.

Among micronutrients, Zn and B are known to be very important micronutrients as they are essential for plant growth and development as well as soil productivity (Welch et al., 1991; Jahiruddin, 2015). Shoots and buds of Zn-deficient plants contain very low auxin causing dwarfism and growth reduction. Moreover, Zn deficiency stunted plants and lengthened duration of growth. Zn and B play important roles in chlorophyll formation, cell division, meristematic activity of tissue expansion of cell and formation of cell wall (Souri et al., 2017; Souri and Hatamian, 2019). It increases photosynthesis and translocation of food materials. On the other hand, B is required for proper development and differentiation of plant tissues (Mohan et al., 2008). B is necessary for cell wall formation, development of fruit and seed and helps in pollen formation, pollination and flowering of plants (Tohidloo and Souri, 2009; Khalaj et al., 2016). It is also involved in metabolism and transport of carbohydrates, nucleic acid synthesis, root elongation, photosynthetic activities and water absorption in plant parts. B increases the stability of plant cells and is involved in the reproductive phase of plants (Katyal and Randhawa, 1983; Pandav et al., 2016). It does not easily move around the plant and therefore, the deficiency appears first in young tissues, growing points, root tips and developing fruits. Its deficiency may cause sterility, poor fruit set, small fruit size and ultimately lower yield. Leaves may have thick coppery texture and sometimes curled and become brittle with scorched appearance. Growth is also ceased at the growing points. Deficiency of B also causes cracking and distorted growth in fruits (Bubarai et al., 2017). Although, there is wealth of information about soil applications of Zn and B but information regarding foliar application of Zn and B on growth and yield-related attributes of okra is scarce especially in Bangladesh. Therefore, considering the importance of micronutrients in okra the present investigation was undertaken to find out the effectiveness of foliar spray doses of B and combination of Zn and B on growth and yield of okra.

Materials and Methods

Planting materials

Two okra varieties ('Chamak' denoted here as 'V_1' and 'Jadoo' denoted as 'V_2') were used in this experiment. 'Chamak' is a high yielding variety in ACI that is a well-known seed company in Bangladesh. On the other hand, 'Jadoo' is also a high yielding variety of okra in Skyelon that is a well-known seed company in India.

Experimental site

The experiment was conducted at Nobogram Agriculture Farm, Sonapur, Noakhali, Bangladesh during June to September, 2019. The experimental area belongs to Young Meghna Estuarine Flood Plain under the Agroecological Zones-18 (FAO, 1988).

Experimental design

The two-factor experiment was laid out in randomized complete block design (RCBD) with three replications. Factor one consisted of okra varieties viz. V_1 = 'Chamak' and V_2 = 'Jadoo' and the factor having five levels of Zn and combination of Zn-B concentration viz. T_0 = Control, T_1 = 0.2% Zn, T_2 = 0.3% Zn, T_3 (mixture) = 0.2% Zn + 0.2% B and T_4 (mixture) = 0.2% Zn + 0.3% B.

Preparation of B and Zn solution and application method

As per the treatment details, 2 gr of zinc sulphate was dissolved in one liter of water in a container to make 0.2% zinc sulphate solution and 2 gr of borax was dissolved in one liter of water in another container to make the concentration of 0.2% zinc sulphate solution. Similarly 3 gr of zinc sulphate was dissolved in one liter of water to make 0.3% zinc sulphate solution. In addition to Zn and B, the crop was also fertilized with 10 tone cow dung, 250 kg urea, 250 kg triple super phosphate (TSP), 150 kg muriate of potash (MoP) and 100 kg gypsum per hectare, respectively (Alexander and Alvin, 2012). Entire amount of cow dung, TSP and gypsum, one fourth of urea and half of MoP were applied during the final land preparation. The rest amount of urea and MoP were top dressed in three equal installments at 20, 40 and 60 days after sowing (DAS) (Alexander and Alvin, 2012). Zinc and boron were sprayed at 30, 50 and 70 DAS according to treatment combinations. Zinc sulphate and borax were used as sources of Zn and B. No sticky substance in case of foliar application was used on the leaf, rather dissolved micronutrients in water was applied in the plant directly.

Seed sowing and intercultural operation

Three seeds per pit/hole were sown maintaining 45 cm x 45 cm plant spacing. After 12 days of sowing (5-6 leaves stage), comparatively weak seedlings were removed from each pit and finally only one healthy and vigorous seedling was kept in a pit. Weeding, mulching, irrigation and crop protection measures were taken as and when necessary. The soil was treated with Nuben 14.35 kg/ ha only a single period when the plot was finally ploughed to protect the young seedlings from the attack of several pest.

Data collection and analysis

Data on different parameters including plant height, plant branch, stem diameter, leaf length, petiole length, fruit length, fruit girth, fruit number, fruit stalk length, single fruit weight, yield plot^{-1}, and total yield were collected.

Data were recorded on yield and yield attributes and then analyzed using MSTAT-C statistical program and Microsoft office Excel 2013 to find out the significancy or non-significancy within treatments. Treatment means were separated at 1% and 5% probability level (Gomez and Gomez, 1984).

Results

Effect of varieties on growth and yield attributes of okra

The data presented in Table 1 showed significant variation in both varieties of okra. Comparatively, higher plant height (163.40 cm) was attained from the variety (V1) of 'Chamak' compared to the variety (V2) of 'Jadoo' that was counted 160.10 cm due to the application of same doses of Zn and Zn-B combination as foliar spray. Stem diameter of the selected varieties was meaningfully influenced by the assigned treatments. The study showed that higher stem diameter (2.60 cm) was found from V1 while the lower result (2.50 cm) was observed in V2. Number of branches was significantly affected due to the application of micronutrient treatments. Maximum number of branches was found from V1 (4.90) compared to V2 (4.60) with the foliar spray of same treatments for both varieties. In case of leaf length, significantly higher leaf length was observed in V1 (27.90 cm) compared to V2 (25.40 cm) from the foliar fertilization of same doses of Zn and Zn-B combination for the both examined varieties. Likewise, significantly maximum petiole length (29.80 cm), fruit size (14.70 cm), fruit girth (1.80 cm), fruit number (27.7) and fruit stalk (2.60 cm) were found from V1 with the foliar treatments of Zn and combination of Zn and B while lower values of 27.6 cm (petiole length), 13.20 cm (fruit size), 1.70 cm (fruit girth), 25.80 (fruit number) and 2.40 cm (fruit stalk) were observed in V2 from the same foliar spray. Fruit weight is one of the most important factors in reproductive trait. In this case, both varieties showed significant and positive effect on fruit weight, which was maximum in V1 (29.5 g) compared to V2 (27.50 g). Finally, highest yield of okra per plot was produced from V1 (16.56 kg; 12.23 tone/ha) that was statistically higher than that of V2 (13.36 kg; 11.05 tone/ha).

Table 1. Effects of varieties ('Chamak' denoted as V_1 and 'Jadoo' denoted as V_2) on growth and yield releated attributes of okra.

Variety	Plant Height (cm)	Stem Diameter (cm)	Branch No.	Leaf Length (cm)	Petiole length (cm)	Fruit Length (cm)	Fruit Girth (cm)	Fruit No.	Stalk Length (cm)	Individual Fruit Weight (g)	Yield Per Plot (kg)	Yield per ha (ton)
V_1	163.4	2.6	4.9	27.9	29.8	14.7	1.8	27.7	2.6	29.5	16.6	12.2
V_2	160.1	2.5	4.6	25.4	27.6	13.2	1.7	25.8	2.4	27.5	15.4	11.1
S.E (±)	1.35	0.04	0.12	1.02	0.90	0.61	0.04	0.77	0.08	0.81	0.5	0.5
CV (%)	1.17%	9.12%	2.80%	2.57%	2.41%	3.14%	3.1%	4.0%	2.11%	2.59%	5.61%	6.03%
Level of Significance	*	*	*	*	*	*	*	*	*	*	*	*

Data were analyzed using two-factor MSTAT-C computer package program in Randomized Complete Block Design (RCBD) method. K and F test were done to find out the difference between two varieties. The average values of different parameters with error means indicate significant difference at *p<0.05. Co-efficient variation (CV) is noted to clarify the varieties aloofness.

Effects of Zn and B on growth and yield attributes of okra

All the treatments showed significant effect on growth and yield attributes of okra (Table 2). The highest result for all of the growth and yield parameters was observed in T_4 (0.3% Zn with0.2% B). Results showed that maximum

plant height (174.2 cm), branch (6), stem diameter (2.9 cm), leaf length (35 cm), petiole length (35 cm), fruit length (16.3 cm), fruit girth (2.1cm), fruit number (33.2), stalk length (2.8 cm), single fruit weight (34.3 g), yield per plot (24 kg), yield per ha (17.7 tone) were found from those plots which were treated with T_4. On the other hand, minimum plant height (148.3 cm), branching (3.3), stem diameter (2.2 cm), leaf length (21.3 cm), petiole length (22 cm), fruit length (10.8 cm), fruit girth (1.4 cm), fruit number (18.8), stalk length (2.1cm), single fruit weight (23.7 g), yield per plot (15 kg), and yield per ha (11 tone) were observed from control (T_0). At the same time T_1, T_2, T_3 offered average result for all the growth and related attributes (Table 2).

Table 2. Effects of zinc (Zn) and boron (B) on growth and yield related attributes of two okra varities namley 'Chamak' and 'Jadoo.

Treatments	Plant Height (cm)	Stem Diameter. (cm)	Branch No.	Leaf Length (cm)	Petiole length (cm)	Fruit Length (cm)	Fruit Girth (cm)	Fruit No.	Stalk Length (cm)	Single Fruit Weight (g)	Yield Per Plot (kg)	Yield per ha (ton)
T_0	148.3	2.2	3.3	21.3	22.0	10.8	1.4	18.8	2.1	23.7	15.0	11.0
T_1	155.3	2.4	4.2	25.3	26.5	13.3	1.6	24.3	2.4	26.0	17.0	13.0
T_2	162.2	2.6	4.8	27.7	28.5	14.2	1.7	26.2	2.5	28.0	18.5	14.0
T_3	168.7	2.8	5.5	31.5	31.5	15.2	1.8	31.2	2.7	31.7	21.0	15.5
T_4	174.2	2.9	6.0	35.0	35.0	16.3	2.1	33.2	2.8	34.3	24.0	17.7
S.E (±)	5.96	0.61	0.17	3.07	2.85	1.21	0.15	3.30	0.16	2.47	2.0	1.5
CV(%)	1.17	9.12	2.80	2.57	2.41	3.14	3.11	4.09	2.11	2.59	5.61	6.03
Level of significance	**	*	**	**	**	**	**	**	**	**	**	**

T_0 = Control, T_1 = 0.2% Zn, T_2 = 0.3%Zn, T_3 = mixture of 0.2% Zn with 0.2% B, T_4 = mixture of 0.3% Zn with 0.2% B. Data were analyzed using two factor MSTAT-C computer package program in Randomized Complete

Block Design method (RCBD). K and F test were done to find out the difference among treatments. The average values of different parameters with error means indicate significant difference at $*p<0.05$ and $**p<0.01$. Co-efficient variation (CV) is noted to clarify the varieties aloofness.

Interactive effects between varieties and Zn and B on growth and yield attributes of okra

The interactions between varieties and treatments were found to be significant on growth and yield-related attributes of okra (Table 3). It was detected that interactions were influenced by the changes of variety and treatment. Because same treatments were applied on both varieties but interactional effect showed different results in terms of growth and yield parameters in okra. The tallest plant (176 cm) was recorded from the treatments of T_4 (combination of 0.3% zinc sulphate and 0.2% borax) in V_1 while the most dwarf height (146 cm) observed in V_2T_0. In case of branch number, significantly the highest branch number of plant (6.7) was recorded from T_4 treatment in V_1 whereas the lowest number of branch (3.0) was found in control (T_0) on V_2. The highest stem diameter (2.8 cm) was in V_4 with the treatment of T_4 compared to all other treatments. Results revealed that maximum leaf length (32.3 cm) and petiole length (36 cm) were found in T_4 whereas the least leaf length (20.3 cm) and petiole length (20.7 cm) were initiated in V_2T_0. Likewise, the highest fruit girth (2.2 cm) and stalk length (2.9 cm) were found in T_4 treatment in V_1, while the lowest fruit girth (1.3 cm) and stalk length (2.1cm) were observed in V_2T_0. In terms of fruit number, significantly the highest fruit number (34.5) was noted from T_4 which was statistically similar to the other treatments while the lowest was detected from V_2T_0 (18.0). The interaction between variety and treatment also had positive effect on the fruit weight whereas the maximum fruit weight (35.3 g) obtained from V_1T_4 and minimum fruit weight (21.7) was gained from V_2T_0. The yield per plot also increased with the changes of varieties and variation of treatments. This was found to be maximum (19 kg) in T_4 treatment in V_1 and the lowest yield (11.3 kg) was recorded from V_2T_0. Regarding yield per ha of okra, the highest yield (15.77 tone/ha) was perceived between interactional effect of V_1 and T_4 and the lowest amount of yield (8.35 tone/ha) was observed between V_2 and T_0 treatment (Table 3).

Table 3: Interactive effects between varieties and zinc and boron on growth and yield related attributes of two okra varieties namely 'Chamak' denoted as V_1 and 'Jadoo' denoted as V_2.

Treatment combination	Plant Height (cm)	Stem Diameter. (cm)	Branch No.	Leaf Length (cm)	Petiole length (cm)	Fruit Length (cm)	Fruit Girth (cm)	Fruit No.	Stalk Length (cm)	Single Fruit weight (g)	Yield Per Plot (kg)	Yield per ha (ton)
V_1T_0	150.7	2.3	3.7	22.3	23.3±2	11.7	1.4	19.0	2.2	23.3	12.7	9.38
V_2T_0	146.0	2.1	3.0	20.3	20.7	10.0	1.3	18.0	2.1	21.7	11.3	8.35
V_1T_1	156.7	2.5	4.3	26.0	27.3	14.0	1.7	25.0	2.4	27.0	15.3	11.3
V_2T_1	154.0	2.4	4.0	24.0	25.7	12.7	1.5	23.0	2.2	25.0	13.8	10.19
V_1T_2	163.7	2.6	6.0	27.7	29.3	15.0	1.8	27.3	2.6	29.0	16.8	12.41
V_2T_2	160.7	2.5	4.7	26.7	27.6	13.3	1.6	25.0	2.5	27.0	15.7	11.6
V_1T_3	170.0	2.7	5.3	30.0	33.0	16.0	1.9	32.4	2.7	32.7	18.0	13.29
V_2T_3	167.0	2.6	5.7	29.0	30.0	14.0	1.7	30.0	2.6	30.7	17.0	12.56
V_1T_4	176.0	2.8	6.7	32.3	36.0	17.0	2.2	34.5	2.9	35.3	2.0	15.77
V_2T_4	172.3	2.7	5.3	30.0	34.0	15.0	2.0	32.0	2.7	33.3	19.0	14.0
S.E (±)	5.96	0.61	0.17	3.07	2.85	1.21	0.15	3.3	0.16	2.6	1.8	1.6
CV (%)	1.17	9.12	2.80	2.57	2.41	3.14	3.1	4.0	2.11	2.59	5.61	6.03
Level of Significance	**	**	**	**	**	**	**	**	**	**	**	**

V_1 = Chamak, V_2 = Jadoo, T_0 = Control, T_1 = 0.2% Zn, T_2 = 0.3% Zn, T_3 = mixture of 0.2% Zn with 0.2% B, T_4 = mixture of 0.3% Zn with 0.2% B. Data were analyzed using two factor MSTAT-C computer package program in Randomized Complete Block Design (RCBD) method. K and F test were done to find out the relation between variety and treatments. The average values of different parameters with error means indicate significant difference at $^{**}p<0.01$ .Co-efficient variation (CV) is noted to clarify the varieties aloofness.

Discussion

Among micronutrients, Zn and B are two key micronutrients playing a pivotal role in growth and development of many horticultural crops. Plants absorb nutrients when applied as foliar spray in appropriate concentration (Sinha et al., 1999). Okra is a widely produced vegetable whose productivity adversely affected by soil and environment situations including low soil nutrient availability during reproductive growth stage of plants, therefore, it is important to elucidate the possible growing technique of okra for improving its performance. From the study, it was found that foliar application of Z and B either alone or in combination helped to improve growth and yield-related components of okra. The results showed that the maximum plant height, number of branch, length of leaf, petiole, stalk and fruit, number of fruits of okra were recorded in combined application of T4: 0.2% borax and 0.3% zinc sulphate followed by T4:0.2% borax and 0.2% zinc sulphate. This agrees with the results of a research, where the authors found a considerable improvement in yield, yield-attributes and quality of okra seeds following foliar application of Zn and B either single or in combination (Polara et al., 2017; Sarkar et al., 2018; Rahman et al., 2020). Different rates of B and Zn as well as their combinations were found to contribute significantly to improve the number of seeds in fruit, leaf area, chlorophyll content of leaves, and number of branches of okra (Kumar and Sen 2005). In another study, the highest immature green fruit, dry pod, dry stalk, and yield were obtained from Zn application of okra (Satpute et al., 2013). It was also found that B application on plant can increase the vegetative growth of okra since B is related to the development of cell wall, root, and shoot growth of plant (Pilbeam and Kirkby 1983). Similar results were also found when B-Zn combination was applied as foliar application in summer tomato (Ali et al., 2015). The highest yield in this study was recorded from the treatment of combination of Zn and B. The previous study also reported that Zn and B foliar application improves the yield of okra (Shruti et al., 2001; Al-Dulaimi et al., 2017; Shukla et al., 2018). Therefore, the higher yield can be achieved by Zn and B application in foliar fertilization which might have impact in improving yield. However, further experiment is required to understand the mechanism of Zn and B for improving yield of okra. The present study demonstrated that the interaction effect of Zn and B significantly influenced the fruit set of okra. The maximum number of fruit per plant was recorded from the plants receiving foliar application of 0.2% borax and 0.2% zinc sulphate. Combination of boron and zinc application might have helped in balanced

absorption of nutrients, increasing the rate of photosynthesis; as a result fruit per plant was increased. These results support the previous findings of Mahesh et al. (2004) and Sharma et al. (2018) suggesting that the interaction effect of Zn and B on okra might be helpful for better pollen germination and growth of pollen tube and more fruit set. The foliar application of Zn and B and also their interaction had significant effect on fruit length of okra. It was previously reported that Zn and B application is able to increase the fruit length (Muhammad et al., 2019; Quratulain et al., 2016). The above results and discussion indicated that application of Zn and B are associated with improvement in many physiological activities and yield performance of okra.

Conclusion

From the result of this experiment it can be concluded that the highest plant height, number of branches, stem diameter, leaf size, petiole length, fruit length, fruit diameter, fruit stalk length, fruit number, single fruit weight, yield per plot, and total yield obtained from 'Chamak' variety compared to 'Jadoo' variety which was treated with T_4 (0.2% Zn + 0.3% B). In terms of combined application of varieties and treatments, highest growth and yield attributes was obtained from 'Chamak' along with application of 0.2% Zn + 0.3% B.

Acknowledgement

We express our gratitude to Amena Khatun, Assistant Professor, Department of Agriculture, Noakhali Science and Technology University, Bangladesh for giving us timely suggestions about the research work and idea. The partial supported in terms of funding of the study by the research cell, Noakhali Science and Technology University is greatly appreciated.

Conflict of Interest

The authors indicate no conflict of interest for this work.

References

Ahmadi Mohammad, M. Souri. 2019. Nutrient uptake, proline content and antioxidant enzymes activity of pepper (*Capsicum annuum* L.) under higher electrical conductivity of nutrient solution created by nitrate or chloride salts of potassium and calcium. Acta Scientiarum Polonorum Hortorum Cultus, 18: 113-122.

Ahmad K.U. 1995. Phul-phal O Shak-Shabji (in Bangla) Fifth edition. Mrs. Momtaj kamal. Mirpur, Dhaka, Bangladesh. p.353.

Al- dulaimi A H T, Al-jumaili M A. 2017. Role of iron, zinc and organic nutrient on yield of green beans. The Iraqi Journal of Agricultural Sciences, 48 (2), 462-471.

Ali M R, Mehraj H, Jamal A F M. 2015. Effects of foliar application of zinc and boron on growth and yield of summer tomato. Journal of Bioscience and Agriculture Research, 6(01), 512-517.

Aslani M, Souri M K. 2018. Growth and quality of green bean (*Phaseolus vulgaris* L.) under foliar application of organic-chelate fertilizers. Open Agriculture, 3.1: 146-154.

Alexander, Alvin, ed. 2012. Foliar fertilization: proceedings of the first international symposium on foliar fertilization, organized by schering agrochemical division, special fertilizer group, Berlin (FRG), Springer Science and Business Media.

Bubarai M L, Tahir A M, Solomon R I. 2017. The micronutrients boron its influence on growth and development of plants and factors affecting availability. Journal of Agriculture and Veterinary Science, 10(12), 10-13.

FAO. 2016. Food and agriculture organization. Faostat, FAO Statistics Division.

FAO. 1988. Production year book, Food; Agricultural Organization of the United Nation: Rome, 42: 90‑193.

Gomez, K. A. and Gomez, A. A. (1984). Statistical procedures for agricultural research (2nd ed.). John Wiley and Sons, New York. pp. 28-192.

Hatamian M, Rezaei Nejad A, Kafi M, Souri M. K, Shahbazi K. 2020. Interaction of lead and cadmium on growth and leaf morphophysiological characteristics of European hackberry (*Celtis australis*) seedlings. Chemical and Biological Technologies in Agriculture, 7, 1-8.

Jahiruddin M. 2015. Zinc and boron deficiency in crops and their management in Bangladesh. Department of Soil Science, Bangladesh Agricultural University, Mymensingh, pp 1-27.

Katyal J C, Randhawa N S. 1983. Micronutrients in fertilizers and plant nutrition. FAO.

Kumar M, Sen N L. 2005. Effect of zinc, boron and gibberellic acid on yield of okra *Abelmoschus esculentus L.* Indian Journal of Horticulture, 62(3), 308-309.

Khalaj K, Ahmadi N, Souri, M K. 2017. Improvement of postharvest quality of Asian pear fruits by foliar application of boron and calcium. Horticulturae, *3*(1), 15.

Mohan, Bindumathi, Srinivasan T S. 2008. Evaluation of organic growth promoters on yield of dryland vegetable crops in India. Journal of Organic Systems, 3(1): 23-36.

Mahesh K, Sen N L. 2004. Interaction effect of zinc and boron on okra (*Abelmoschus esculentus* L. *Moench*) cv. Prabhani Kranti. Agricultural Science Digest, 24 (4), 307-308.

Muhammad A B, Abdul Q. G, Muhammad I. J, Tariq A, Sher A, Mohammad I. M Muhammad S, Javed A A, Syed I A S. 2019. Response of okra verities to zinc and boron supplement under the agro-climatic condition of Tandojam Pakistan. Pure and Applied Biology, 8 (1),

601-608.

Noroozlo Y A, Souri M K, Delshad M. 2019. Effects of foliar application of glycine and glutamine amino acids on growth and quality of sweet basil. Advances in Horticultural Science, 33.4.

Pilbeam D J, Kirkby E A. 1983. The physiological role of boron in plants. Journal of plant nutrition, *6*(7), 563-582.

Polara K B, Ponkia H P, Sakarvadia H L, Vekaria L C, Babariya N B. 2017. Effect of multi-micronutrients fertilizers on yield and micronutrients uptake by okra (*Abelmoschus esculentus* L.) grown on medium black calcareous soils of Saurashtra Region of Gujarat. International Journal of Pure Applied Bioscience, 5(6), 258-264.

Pandav A K, Nalla M K, Aslam T, Rana M K, Bommesh J C. 2016. Effect of foliar application of micronutrients on growth and yield parameters in eggplant cv. HLB 12. Environment and Ecology, 35(3), 1745- 1748.

Quratulain G A, Ilyas M, Ahmad M, Begum F, Luqman A S, Khan M I, Shah K. 2016. Response of broccoli to foliar application of zinc and boron concentrations. Pure and Applied Biology, 5(4), 841-846.

Rahman M H, Quddus M A, Satter M A, Ali M R, Sarker M H, Trina,T N. Impact of foliar application of Boron and Zinc on growth, quality and seed yield of okra..

Sarker M M H, Jahiruddin M, Moslehuddin A Z M, Islam, M R. 2018. Micronutrient responsiveness of cauliflower, okra, and rice in a pattern in piedmont soil. Journal of Plant Nutrition, 41(11), 1358-1367.

Sinha A K, Singh C, Jain B P. 1999. Effect of plant-growth substances and micronutrients on fruit set, fruit drop, fruit retention and cracking of litchi cv. Purbi. Indian Journal of Horticulture, 56(4), 309-311.

Sharma R, Bairwa L N, Ola A, Lata K, Meena A R. 2018. Effect of zinc on growth, yield and quality of okra*Abelmoschus esculentus* (*L.*) *Moench*]. Journal of Pharmacognosy and Phytochemistry, 7(1), 2519-2521.

Shruti B, Chauhan S V S. 2001. Effect of zinc boron and manganese on yield in okra (*Abelmoschus esculentus*). Indian journal of Agricultural Sciences, 71 (5), 332-333.

Souri M K, Hatamian M. 2019. Aminochelates in plant nutrition: a review. Journal of Plant Nutrition, 42.1: 67-78.

Satpute N R, Suryawanshi L B, Waghmare J M, Jagtap P B. 2013. Response of summer okra to iron, zinc and boron in inceptisol. Asian Journal of horticulture, 8(2), 541-546.

Souri M K, Dehnavard S. 2018. Tomato plant growth, leaf nutrient concentrations and fruit quality under nitrogen foliar applications. Advances in Horticultural Science, *32*(1), 41-47.

Souri K, Mohammad, Sooraki F Y, Moghadamyar M. 2017. Growth and quality of cucumber, tomato, and green bean under foliar and soil applications of an aminochelate fertilizer. Horticulture, Environment, and Biotechnology 58.6: 530-536.

Shukla Y R, Kaushal M, Shilpa V I J. 2018. Studies on the effect of macro and micro nutrients on growth and yield of garlic (*Allium sativum L.*). International Journal of Current Microbiology Applied Science, 7(8), 4787-4791.

Tohidloo G, Souri, M K. 2009. Uptake and translocation of boron in two different tomato (*Lycopersicon esculentum* Mill) genotypes. Horticulture Environment. & Biotechnol, 50(6), 487-491.

Welch R M, Allaway W H, House W A, Kubota J. 1991. Geographic distribution of trace element problems. Micronutrients in agriculture, 4:31-57