



Response of okra (*Abelmoschus esculentus*) to foliar application of micronutrients

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ABSTRACT

The experiment was conducted at SKUAST-Kashmir, Shalimar during 2018 to evaluate the effects of foliar sprays of different micronutrients, viz. B, Zn Cu, Mo, Fe and Mn, on plant growth, physiological and yield attributes of okra. Treatments were prepared as 100 ppm aqueous solution of each boric acid, zinc sulphate, copper sulphate, ferrous sulphate and magnesium sulphate, except ammonium molybdate (taken as 50ppm). Each treatment was applied individually as well as in different combinations at 30, 45 and 60 DAS, thus making total of 14 treatments with three replications. Results indicated that different treatments markedly increased the plant growth, chlorophyll and yield of okra. The maximum plant height (156.40 cm), leaf area (5938.55 cm²), leaf area (5938.55/plant), LAI (4.39), SLW (10.1) mg/cm² as well as leaf chlorophyll content (0.80 mg/ g) were recorded when all the micronutrients were applied in combination (T₇). The same treatment also recorded earliest fruit harvest (45.43 DAS) with highest number of fruits per plant (23.20), maximum fruit size (1.37 cm × 11.25 cm) and thus, fruit yield (241.74 g/plant) against the minimum plant height (116.45 cm), LAI (1.90), SLW (6.12 mg/cm²), chlorophyll content (0.50 mg/g), number of fruits (20.29/plant), fruit size (1.11 cm × 9.56 cm) and yield (183.01 g/plant) with maximum time taken (71.8 DAS) to first harvest. Finally, it can be stated that combined application of micronutrients (B, Zn Cu, Mo, Fe and Mn) as foliar sprays at 30, 45 and 60 DAS is most effective in improving plant growth, yield and yield attributes of okra.

Keywords: Chlorophyll, Fruit yield, Micronutrients, Okra

Okra [*Abelmoschus esculentus* (L.) Moench] is an important vegetable widely grown in tropical, subtropical, and warm temperate regions. It belongs to the genus *Abelmoschus* and family *Malvaceae*. The fruits or pods containing seeds are harvested when immature and are eaten as vegetables. The composition of okra pods per 100 g edible portion is: water 88.6 g, energy 144.00 kJ (36 kcal), protein 2.10 g, carbohydrate 8.20 g, fat 0.20 g, fibre 1.70 g, Ca 84.00 mg, P 90.00 mg, Fe 1.20 mg, β -carotene 185.00 μ g, riboflavin 0.08 mg, thiamin 0.04 mg, niacin 0.60 mg, ascorbic acid 47.00 mg. Carbohydrates are mainly present in the form of mucilage that is highly soluble in water. Potassium, Sodium, Magnesium and Calcium are the principal elements in pods. Although, the requirement of micronutrients like Zn, Cu, Mn, Fe, B and Mo are relatively less but their role in normal crop production is indispensable because of their active role in plant metabolic processes involving cell

wall development, respiration, photosynthesis, chlorophyll formation, enzyme activity and nitrogen fixation. Foliar fertilization with multi-nutrients to achieve balanced plant nutrition is considered to play a significant role in modern sustainable vegetable production. This mode of applying fertilizers to the crops provides a valuable supplement to the application of nutrients via the soil (Fageria *et al.* 2009). The particular value of this technique is that it ensures immediate uptake and translocation of nutrients to various plant organs via the leaf tissues and thus enables rapid correction of nutrient deficiencies (Fageria *et al.* 2009). Moreover, foliar fertilization has been recommended for integrated crop production since it not only increases crop yield and quality but is also environmentally safe (Fageria *et al.* 2009). However, literatures available with this respect, especially on okra are scanty. Therefore, the present investigation was carried out to determine the role of micronutrients in improving the plant growth yield and quality of okra.

MATERIALS AND METHODS

The present study was carried out at Vegetable Experimental Farm, Division of Vegetable Science, SKUAST-Kashmir, Shalimar, Srinagar during *kharif* 2018 under Randomized Complete Block Design (RCBD) with

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14 treatments and three replications. The initial status of Zn, Mo, Fe, Cu and Mn in the soil was estimated as 1.10, 3.05, 30.21, 1.58 and 19.16 mg/kg. Various treatments of micronutrients include boric acid 100ppm (T_1), zinc sulphate 100 ppm (T_2), ammonium molybdate 50 ppm (T_3), copper sulphate 100 ppm (T_4), ferrous sulphate 100 ppm (T_5), manganese sulphate 100 ppm (T_6), mixture of all T_1 to T_6 (T_7), mixture of all excluding T_1 (T_8), mixture of all excluding T_2 (T_9), mixture of all excluding T_3 (T_{10}), mixture of all excluding T_4 (T_{11}), mixture of all excluding T_5 (T_{12}), mixture of all excluding T_6 (T_{13}) and control, i.e. no nutrient spray (T_{14}). Basal doses of FYM @ 20-25 t/ha and NPK @ 120:90:60 kg/ha were given at the time of field preparation in all the treatments. Foliar application of the micronutrient solutions were done at 30, 45 and 60 days after sowing. Picking of fruits was done at tender edible stage at an interval of 3-5 days.

Observations were recorded on plant height, leaf area, leaf chlorophyll content, leaf area index (LAI), specific leaf weight (SLW), days to first harvest, fruit length, fruit diameter, fruit weight, fruit No. and fruit yield. Leaf area (length $\times$ width $\times 0.62$), LAI (leaf area unit of land area) and SLW (leaf dry weight/leaf area) were calculated as per the method described by Khan *et al.* (2016), Sestak *et al.* (1971) and Radford (1967), respectively. Leaf chlorophyll content was estimated as (Jayaraman 1981):

$$\text{Total chlorophyll (mg/g)} = \frac{20.2 (A_{645}) + 8.02 (A_{663}) \times V}{1000 \times W}$$

where, A= Absorbance at specific wave length (nm); V= Volume of chlorophyll extract in 80% acetone and W= Fresh weight of tissue extracted (g).

RESULTS AND DISCUSSION

Study revealed that foliar application of micronutrients either alone or in combination affected plant growth and physiological attributes significantly in relation to control (Table 1). Among different treatments, the maximum plant height (156.40 cm) was recorded in treatment T_7 which was statistically at par with treatment T_8 and T_{10} with recorded plant height of 154.51 and 155.77 cm, respectively. The best treatment in terms of plant height was significantly followed by T_{11} with observed plant height of 135.85 cm in contrast to the minimum plant height of 116.45cm recorded in T_{14} (control). Like plant height, micronutrient application also resulted in significant increase in the leaf area of okra and T_7 with leaf area of 5938.55 cm²/plant was proved as significantly superior to all other treatments wherein T_{14} remained as most inferior with a leaf area value of 2574.50 cm²/plant. Similarly, data revealed that value of LAI varied from 1.90 in control (T_{14}) to 4.39 in T_7 treatment which was followed by treatment T_8 with leaf area index of 4.28. Perusal of the data again indicates that T_7 was found as the best treatment in improving the leaf thickness in terms of SLW and its value ranged from 6.12 mg/cm² w (control) to 10.11 mg/cm² (T_7) which is immediately followed by T_9 with a SLW value of 9.97 mg cm⁻². Requirement of micronutrients by the plants are

Table 1 Effect of Foliar application of micronutrients on plant growth and physiological attributes of okra

Treatment	Plant height (cm)	Leaf area (cm ² /plant)	Leaf area index	Specific leaf weight (mg/cm ²)	Leaf chlorophyll content (mg /g)
T_1 Boric acid (H_3BO_3)	125.03	4941.36	3.66	8.92	0.60
T_2 Zinc sulphate ($ZnSO_4$)	126.96	4010.56	2.97	8.53	0.71
T_3 Ammonium molybdate [$(NH_4)_6Mo_7$]	127.11	4862.13	3.60	7.97	0.78
T_4 Copper sulphate ($CuSO_4$)	121.00	3760.32	2.78	6.52	0.68
T_5 Ferrous sulphate ($FeSO_4$)	121.79	2686.65	1.99	7.80	0.64
T_6 Manganese sulphate ($MnSO_4$)	121.25	3314.01	2.45	7.12	0.58
T_7 Mixture of all (T_1 to T_6)	156.40	5938.55	4.39	10.11	0.80
T_8 Mixture of all without boric acid (T_7 minus T_1)	154.51	5799.72	4.28	9.50	0.72
T_9 Mixture of all without zinc sulphate (T_7 minus T_2)	133.46	4962.96	3.67	9.97	0.55
T_{10} Mixture of all without ammonium molybdate (T_7 minus T_3)	155.77	5504.80	4.07	8.00	0.52
T_{11} Mixture of all without copper sulphate (T_7 minus T_4)	135.85	3254.02	2.41	9.89	0.74
T_{12} Mixture of all without ferrous sulphate (T_7 minus T_5)	132.27	5372.44	3.97	9.29	0.75
T_{13} Mixture of all without manganese sulphate (T_7 minus T_6)	134.53	5302.72	3.92	9.93	0.61
T_{14} Control	116.45	2574.50	1.90	6.12	0.50
CD (P=0.05)	3.79	1.33	0.01	0.03	0.03

Table 2 Effect of foliar application of micronutrients on fruit growth and yield attributes of okra

Treatment		Fruit length (cm)	Fruit diameter (cm)	Average fruit weight (g)	Number of fruits/plant	Fruit weight/ plant (g)	Fruit yield (q/ha)
T ₁	Boric acid (H ₃ BO ₃)	10.39	1.21	9.30	22.48	209.06	154.86
T ₂	Zinc sulphate (ZnSO ₄)	10.28	1.20	9.28	22.06	204.71	151.64
T ₃	Ammonium molybdate [(NH ₄) ₆ Mo ₇]	10.13	1.17	9.26	21.58	199.83	148.02
T ₄	Copper sulphate (CuSO ₄)	9.73	1.14	9.03	20.92	188.90	139.93
T ₅	Ferrous sulphate (FeSO ₄)	10.94	1.15	9.13	21.53	196.56	145.60
T ₆	Manganese sulphate (MnSO ₄)	9.98	1.16	9.26	20.86	193.16	143.08
T ₇	Mixture of all (T ₁ to T ₆)	11.25	1.37	10.42	23.20	241.74	179.06
T ₈	Mixture of all without boric acid (T ₇ minus T ₁)	10.67	1.22	9.41	22.83	214.83	159.13
T ₉	Mixture of all without zinc sulphate (T ₇ minus T ₂)	11.16	1.31	10.27	22.75	233.64	173.06
T ₁₀	Mixture of all without ammonium molybdate (T ₇ minus T ₃)	10.77	1.34	10.32	22.95	236.84	175.44
T ₁₁	Mixture of all without copper sulphate (T ₇ minus T ₄)	10.85	1.24	10.26	22.50	230.85	171.00
T ₁₂	Mixture of all without ferrous sulphate (T ₇ minus T ₅)	10.51	1.23	10.08	21.79	219.64	162.69
T ₁₃	Mixture of all without manganese sulphate (T ₇ minus T ₆)	11.07	1.30	10.24	22.42	229.58	170.05
T ₁₄	Control	9.56	1.11	9.02	20.29	183.01	135.56
	CD (P=0.05)	0.01	0.01	0.03	0.03	0.01	0.03

relatively very small in quantity but these nutrients directly affect plant growth and development. Plants require them for cell wall synthesis, enzyme activation, regulation of cell division, cell differentiation and cell elongation, sugar transport, chloroplast development, hormonal regulation, etc. and involved in overall plant growth, flower and fruit, and seed development. Surendra *et al.* (2006) observed that foliar application of micronutrients on okra significantly increased plant height and leaf number per plant. Significant increase in plant height and leaf area due to foliar application of micronutrients has also been achieved through other studies (Mehraj *et al.* 2015, Mohammad *et al.* 2016). Significant increase in plant height and leaf growth in terms of area as well as thickness has also been recorded in the present study which conform the findings of above workers and also in accordance with the fundamental roles of the micronutrients ascribed for growth and development of plants.

So far as leaf chlorophyll content is concerned, the maximum value of 0.80 mg/g was recorded when all the micronutrients were applied together (T₇) and this was statistically at par with the treatment T₃ recording leaf chlorophyll content of 0.78 mg/g. The minimum leaf chlorophyll content of 0.50 mg/g was recorded in treatment T₁₄. Micronutrients especially Fe, Zn and Mn are involved in the synthesis of chlorophyll and essential for the maintenance of chloroplast structure and function and their omission from the nutrient solution reduced the chlorophyll content and photosynthetic rate of the plants (Roosta *et al.* 2018). Increased leaf chlorophyll content after the application

of zinc and iron individually or in combination has also been reported by Kandoliya *et al.* (2018). Our results also indicated that combined application of micro nutrients (B, Zn, Mo, Cu, Fe and Mn) as foliar feeding significantly improved the leaf chlorophyll content in okra. Improved plant growth and photosynthetic attributes due to the application of micronutrients were reflected as earliness in harvest and T₇ acquired earliest harvest (45.43 DAS) as compared to the most delayed fruit harvest (74.56 DAS) in control (T₁₄). In terms of earliness in harvesting, the best micronutrient treatment (T₇) was followed by T₁₀ and T₉ as they have reached at 48.28 and 49.76 DAS, respectively.

Data recorded on harvested tender fruits (Table 2) showed significant effect of various treatments on fruit length, fruit diameter, fruit weight as well as number of fruits per plant. Among different treatments, maximum fruit length of 11.25 cm was recorded in treatment T₇ followed by treatment T₉ which recorded fruit length of 11.16 cm. The minimum fruit length of 9.56 cm was recorded in treatment T₁₄. Treatment T₇ also recorded maximum fruit diameter of 1.37 cm followed by treatment, T₁₀ recording fruit diameter of 1.34 cm. The minimum fruit diameter of 1.11 cm was recorded in treatment T₁₄. Likewise, the highest fruit weight of 10.42 g was recorded with treatment T₇ which was statistically at par with treatment T₁₀ (10.32 g) followed by the treatment T₉ (10.27 g). However, minimum average fruit weight of 9.02 g was recorded in treatment T₁₄. Among the different treatments, maximum number of fruits/plant (23.20) was recorded in treatment T₇

followed by treatment T₁₀ (22.95). The lowest number of fruits/ plant was recorded in treatment T₁₄ (20.29). Finally it was noted that treatment T₇ resulted in highest fruit yield (241.74 g/plant) among different treatments, followed by the treatment T₁₀ (236.84 g) in comparison to lowest fruit yield recorded as 183.01 g/plant in control T₁₄. An early fruiting with combined application of micronutrients (T₇) may be attributed to progressive increase in absolute amounts of inorganic elements and subsequent storing of sufficient food material leading to early differentiation of buds into flower buds. These results obtained according to the findings of Naz *et al.* (2012) and Ali *et al.* (2013) in tomato.

Combined application of all the micronutrients (T₇) recorded not only the maximum number of fruits per plant but also caused the highest fruit length and fruit as compared to all other treatments against the minimum values in control (T₁₄). These attributes in turn resulted in greater individual fruit weight and yield per plant. Increase in fruit length and fruit diameter may be attributed to enhanced photosynthetic attributes like leaf area, leaf thickness and leaf chlorophyll content (Jiang *et al.* 2017). These findings corroborate with the results obtained by Ali *et al.* (2013). It may be concluded from the present results the foliar application of micronutrients either individually or in their combinations improved plant growth and physiological attributes of okra which in turn resulted in more fruits yield per plant with improved fruit weight. These factors finally resulted in higher fruit yield per plant. Among all the treatments combined application of all micronutrients significantly resulted in highest fruit yield of okra as compared to all other treatments with lowest yield recorded in control.

REFERENCES

- Ali S, Javed H U, Rehman U R N, Sabir I A, Naeem M S, Siddiqui M Z, Saeed D A and Nawaz M A. 2013. Foliar application of some macro and micronutrients improves tomato growth, flowering and yield. *International Journal of Biosciences* 3(10): 280-87.
- Fageria N K, Filhoa M P B, Moreirab A and Guimaresa C M. 2009. Foliar fertilization of crop plants. *Journal of Plant Nutrition* 32(6): 1044-64.
- Gemedé H F, Ratta N, Haki G D, Woldegiorgis A Z and Beyene F. 2015. Nutritional quality and health benefits of okra (*Abelmoschus esculentus*): A review. *International Journal of Nutrition and Food Sciences* 4(2): 208-15.
- Jayaraman J. 1981. *Laboratory Manual in Biochemistry*. Willey Eastern Pvt Ltd, New Delhi.
- Jiang C, Jokhan M, Hohjo M, Tsukagoshi S, Ebihara M, Akio Nakaminami A and Maruo T. 2017. Photosynthesis, plant growth, and fruit production of single-truss tomato improves with supplemental lighting provided from underneath or within the inner canopy. *Scientia Horticulturae* 222: 221-29.
- Kandoliya R U, Sakarvadiya H L and Kunjadia B B. 2018. Effect of zinc and iron application on leaf chlorophyll, carotenoid, grain yield and quality of wheat in calcareous soil of Saurashtra region. *International Journal of Chemical Studies* 6(4): 2092-96.
- Khan F A, Banday F A, Narayan S, Khan F U and Bhat S A. 2016. Use of models as non-destructive method for leaf area estimation in horticultural crops. *IRA-International Journal of Applied Sciences* 4(1): 162-80.
- Mehraj H, Taufique T, Mandal M S H, Sikdar R K and Jamal Uddin A F M. 2015. Foliar feeding of micronutrient mixture on growth and yield of okra (*Abelmoschus esculantus*). *American-Eurasian Journal of Agriculture & Environment Science* 15(11): 2124-29.
- Mohammadi G, Khah E M, Petropoulos S A and Chachalis D B. 2016. Effect of foliar application of micronutrients on plant growth and seed germination of four okra cultivars. *Notulae Botanicae Horti Agrobotanici Cluj-Napoca*, 44(1): 257-63.
- Naz R M M, Muhammad S, Hamid A and Bibi F. 2012. Effect of boron on the flowering and fruiting of tomato. *Sarhad Journal of Agriculture* 28(1): 37-40.
- Radford P T 1967. Growth analysis formulae, their use and abuse. *Crop Science* 7(3): 171-75.
- Roosta H R, Estaji A and Niknam F. 2018. Effect of iron, zinc and manganese shortage-induced change on photosynthetic pigments, some osmoregulators and chlorophyll fluorescence parameters in lettuce. *Photosynthetica* 56(2): 606-15.
- Sestak Z 1971. Plant photosynthetic production. *Manual of Methods*, N.V. Publication, pp. 343-381. Catsky J and Jarris P G (Eds).
- Surendra P, Nawalagatti C M, Chetti M B and Hiremath S M. 2006. Effect of plant growth regulators and micronutrients on morphoPhysiological and biochemical traits and yield in okra. *Karnataka Journal of Agricultural Sciences* 19(3): 694-97