Effects of foliar application of micronutrients on growth, yield and quality of onion

K. Ballabh, D.K. Rana* and S.S. Rawat
Department of Horticulture, Chauras Campus, HNB Garhwal University, Srinagar (Garhwal) 246 174, Uttarakhand

ABSTRACT

A field experiment was conducted to determine the effects of foliar application of micronutrients on growth, yield and quality of onion (*Allium cepa* L.) cv. Pusa Red. The experiment was laid out in randomized block design with three replications. The treatments consist of foliar sprays of five micronutrients, *viz*., Cu, Zn, B, Fe, and Mn, each in two concentrations (Cu @ 2 and 4 mg l^{-1}, Zn @ 4 and 6 mg l^{-1}, B @ 1 and 2 mg l^{-1}, Fe @ 100 and 200 mg l^{-1}, Mn @ 1 and 2 mg l^{-1}) along with tap water as control. Two foliar sprays of micronutrients were done at 15 days intervals after 50 days of seedling transplanting. Results were found to be significant in most of the growth, yield and quality contributing parameters of onion. The number of leaves per plant (14.1), plant height (66.9 cm), leaf width (4.3 cm), leaf length (63.9 cm), neck length (1.6 cm), neck diameter (2.0 cm), roots length (8.1 cm), number of roots per plant (162.1), bulb diameter (7.6 cm), plant weight (226.3 g), bulb fresh weight (171.7 g), leaves fresh weight (54.5 g), roots fresh weight (4.2 g), number of scales (12.6), total sugars (6.6%), total soluble solids (14.2%), volume (148.5 ml), specific gravity (1.3), dry weight of bulb (13.2 g), dry weight of leaves (21.0 g), dry weight of roots (2.0 g) and yield ha^{-1} (419.8 q) were maximum in Zn @ 4 mg l^{-1} treatment, while treatment Zn @ 6 mg l^{-1} shows maximum ascorbic acid (17.4 mg/100 g). The results clearly indicated that foliar feeding of Zn @ 4 mg l^{-1} significantly improved vegetative growth parameters, total yield and quality contents in bulb tissues compared to other micronutrients and control. Foliar spraying of Zn gave the superiority in all measured parameters than other treatments.

Key word: Foliar feeding, micronutrients, onion, growth, yield, quality.

INTRODUCTION

Onion (*Allium cepa* L.) is one of the most important commercial vegetable crops belongs to Amaryllidaceae family being grown all over the country. It has diuretic properties, relieves heat sensation, hysterical faintness, insect bites and is also heart stimulation. Application of micronutrients to soil deficient in them has shown remarkable increase in yield of several crops. Micronutrients play an active role in the plant metabolic process from cell wall development to respiration, photosynthesis, chlorophyll formation, enzymes activity, nitrogen fixation etc. Micronutrients work as a co-enzyme for a large number of enzymes. In addition, they play an essential role in improving yield and quality, and highly required for better plant growth and yield of many crops (Alam *et al.*, 1; Barker and Pilbeam, 2; El-Gamelli, 4; El-Shafie *et al.*, 5; El-Tohamy *et al.*, 6; Hansch and Mendel, 8; Sliman *et al.*, 20). Foliar application of micronutrients during crop growth was successfully used for correcting their deficits and improving the mineral status of plants as well as increasing the crop yield and quality (Kolota and Osinska, 10). In earlier studies, onion cv. Pusa Red showed that foliar application of Fe or Zn at 60 and 70 days after transplanting significantly increases plant vegetative growth (Singh and Tiwari, 17) as well as bulb yield and quality (Singh and Tiwari, 18). The onion, like any other crops not only needs macronutrients but also micronutrients in adequate and balanced amounts. The use of micronutrients should be made with great caution because of their small amounts needed and interactions with other nutrients. Improvement in onion growth and yield has been reported through micronutrient by many scientists at different types of soils. But very little information is available on these aspect under sub-tropical valley conditions. Keeping in view, the present experiment was undertaken.

MATERIALS AND METHODS

The experiment was carried out at Horticultural Research Centre, HNB Garhwal University, Srinagar (Garhwal), Uttarakhand, during winter season (2010-2011). The experiment was laid out in a randomized block design with three replications. Srinagar (Garhwal) is located in the Alaknanda valley (78°48' 04.93'' E longitude and 30°13' 25.26'' N latitude and at an elevation of 540 m asl), a semi-arid, subtropical climate with dry summer and rigorous winters with occasional dense fog in the morning hours from mid

*Corresponding author's E-mail: drdkrana@gmail.com

December to mid February. For assessing the exact nature of the micronutrients, a composite soil sample up to 20 cm depth was taken from the experimental field before transplanting of crop and was subjected to chemical analysis (Jackson, 9). The physical and chemical properties of the experimental soil are given in Table 1. The experiment consists of five micronutrients, *viz.*, Cu, Zn, B, Fe, and Mn each in two concentrations (Cu @ 2 and 4 mg l^{-1}; Zn @ 4 and 6 mg l^{-1}; B @ 1 and 2 mg l^{-1}; Fe @ 100 and 200 mg l^{-1} and Mn @ 1 and 2 mg l^{-1}) which were sprayed twice after 50 days of transplanting during mid Feb., 2011) and 15 days (during 1st week of March, 2011) after first spray. Thus, total number of treatments were 11, *viz.*, T_1 (Cu @ 2 mg l^{-1}), T_2 (Cu @ 4 mg l^{-1}), T_3 (Zn @ 4 mg l^{-1}), T_4 (Zn @ 6 mg l^{-1}), T_5 (B @ 1 mg l^{-1}), T_6 (B @ 2 mg l^{-1}), T_7 (Fe @ 100 mg l^{-1}), T_8 (Fe @ 200 mg l^{-1}), T_9 (Mn @ 1 mg l^{-1}), T_{10} (Mn @ 2 mg l^{-1}) and T_{11} control using tap water. Boron was given in the form of boric acid while for the rest of micronutrients, their sulphate forms were used. Micronutrients for each plot was sprayed with the help of hand sprayer. Eight-week-old seedlings of onion cv. Pusa Red was transplanted in flat beds during the last week of December, 2010 at a spacing of 15 cm × 10 cm in a plot size of 3.6 m × 1.8 m. FYM @ 20 t ha^{-1} along with N, P and K @ 80:50:50 kg ha^{-1}, respectively, and was applied uniformly in all experimental plots in the form of urea, SSP and muriate of potash. Urea was applied in two splits, *i.e.*, at the time of transplanting and second dose 30 days after transplanting. The all intercultural operations were uniformly followed during the whole experiment period to raise a successful crop. At the time of harvest (during the May, 2011), randomly ten plants from each plot were selected to record the observations on plant height, number of leaves per plant, leaf width, leaf length, neck length, neck diameter, roots length, bulb diameter, number roots per plant, plant weight, fresh weight of leaves, fresh weight of bulb, fresh weight of roots, number of scales per bulb, total sugars, ascorbic acid, TSS, volume, specific gravity, dry weight of bulb, dry weight of leaves, dry weight of roots and yield. Plant height was measured with the help of metre scale. Neck thickness and bulb diameter was measured with the help of Vernier callipers after harvesting. Total soluble solids were measured with the help of hand refractometer (0-32%). Dry weight of the bulb, leaves and roots was determined by keeping them in oven at 50°C for 72 h for drying and weighed on electronic balance. Ascorbic acid was analyzed according to Ranganna (14). Similarly, total sugars was determined by the method of McCready *et al.* (12). The data were obtained subjected to statistical analysis as per the standard procedure (Gomez and Gomez, 7) and means were subjected to Duncan's Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

The data presented in Table 2, strongly showed that there was a significant ($P<0.05$) effect of foliar spray of micronutrients on vegetative growth parameters of onion plants. Foliar application of onion plants with Zn resulted in the highest value of vegetative growth parameters. The maximum plant height (66.9 cm) was recorded in Zn @ 4 mgl^{-1} and the minimum (49.8 cm) under control and an increase plant height to the extent of 25.5%, over the control. The maximum number of leaves (14.1 $plant^{-1}$) was obtained in the Zn @ 4 mgl^{-1} with an increase of 33.3% over control. The maximum leaf width (4.3 cm) was observed in Zn @ 4 mgl^{-1} followed by B @ 1 mgl^{-1} (3.9 cm) and Mn @ 1 mgl^{-1} (3.9 cm) both was at par and lowest leaf width (2.7 cm) was found in control. The highest leaf length (63.9 cm) was found in application of Zn 4 @ mgl^{-1} and the second highest leaf length (58.5 cm) and (58.0 cm) were found in B @ 1 mgl^{-1} and B @ 2 mgl^{-1} and lowest leaf length (44.4 cm) was found in control. The highest neck diameter (2 cm) at maturity stage was found in Zn @ 4 mgl^{-1} and lowest (1.3 cm) was found under control. Therefore, it was found that zinc plays an active role in vegetative growth of

Table 1. Physical and chemical properties of the experimental soil.

Particulars	Description/ Value		
Texture	Sandy clay		
pH	7.2		
Organic matter (%)	0.84		
Exchangeable macronutrients (kg ha^{-1})		Available micronutrient (mg kg^{-1} soil)	
Available nitrogen	96.6	Zn	1.25
Available phosphorus	3.05	Cu	2.14
Available potassium	136	Mn	7.56
		Fe	15.74

Table 2. Effects of foliar feeding of micronutrients on growth parameters of onion.

Treatment	Plant height (cm)	Leaves plant^{-1}	Leaf width (cm)	Leaf length (cm)	Neck length (cm)	Neck diameter (cm)	Fresh weight of leaves (g)	Roots plant^{-1}
T_1 (Cu @ 2 mgl^{-1})	58.2^{bcd}	9.0^{ef}	3.6^{bcd}	47.8^{de}	8.6^{b}	1.8^{b}	51.2^{ab}	125.1^{ab}
T_2 (Cu @ 4 mgl^{-1})	61.2^{bc}	8.8^{f}	3.3^{de}	54.4^{bcd}	7.4^{bcd}	1.4^{de}	44.0^{abc}	133.7^{ab}
T_3 (Zn @ 4 mgl^{-1})	66.9^{a}	14.1^{a}	4.3^{a}	63.9^{a}	11.6^{a}	2.0^{a}	54.5^{a}	162.1^{a}
T_4 (Zn @ 6 mgl^{-1})	61.3^{bc}	12.0^{b}	3.6^{bcd}	56.2^{bc}	5.3^{e}	1.5^{cd}	48.1^{ab}	141.4^{ab}
T_5 (B @ 1 mgl^{-1})	56.0^{cd}	11.2^{bc}	3.9^{b}	58.5^{ab}	6.2^{de}	1.6^{c}	48.2^{ab}	133.6^{ab}
T_6 (B @ 2 mgl^{-1})	60.4^{bcd}	10.1^{cdef}	3.2^{e}	58.0^{ab}	6.8^{cde}	1.6^{c}	44.2^{abc}	129.0^{ab}
T_7 (Fe @ 100 mgl^{-1})	56.0^{cd}	9.8^{def}	3.7^{bc}	50.3^{cde}	6.6^{cde}	1.4^{de}	36.5^{bc}	118.7^{abc}
T_8 (Fe @ 200 mgl^{-1})	55.5^{d}	10.6^{cd}	3.5^{cde}	53.7^{bcd}	7.8^{bcd}	1.5^{cd}	42.2^{abc}	132.5^{ab}
T_9 (Mn @ 1 mgl^{-1})	60.8^{bcd}	10.8^{bcd}	3.9^{b}	56.2^{bc}	8.1^{bc}	1.5^{cd}	49.9^{ab}	160.3^{a}
T_{10} (Mn @ 2 mgl^{-1})	62.0^{ab}	10.2^{cde}	3.6^{bcd}	52.4^{bcd}	9.0^{b}	1.6^{c}	54.4^{a}	110.4^{bc}
T_{11} (Control)	49.8^{e}	9.4^{ef}	2.7^{f}	44.4^{e}	5.5^{e}	1.3^{e}	27.2^{c}	77.5^{c}
CD at 5%	5.4	1.4	0.4	7.7	1.8	0.2	15.4	46.5

Values in the same column bearing different superscript letters differ significantly ($p<0.05$).

onion plant. These results are in accordance with the investigations of Samad *et al.* (15), and Schmidt (16) in onion crop. An examination of data presented in Table 2 showed significant superior results for fresh weight of leaves under Zn @ 4 mgl^{-1} as compared to control in which increase in fresh weight of leaves to the extent of 50 percent over the control. Application of different micronutrients significantly influences the leaf length, neck length and roots length. The maximum number of roots (162.1 plant^{-1}) was recorded in Zn @ 4 mgl^{-1} and lowest number of roots (77.5) was found in control, which increases the number of roots to the extent of 52.1%, over the control. The favourable effect of micronutrients on plant growth might be due to its role in many physiological processes and cellular functions within the plants. Battal (3), and Hansch and Mendel (8) mentioned that in addition, they play an essential role in improving plant growth, through the biosynthesis of endogenous hormones which are responsible for promoting of plant growth. The same trends were also recorded by many authors on onion (Alam *et al.* 1, El-Gamelli, 4; El-Shafie *et al.* 5; El-Tohamy *et al.*, 6, and Sliman *et al.* (20). They reported that growth parameters of onion plant were positively affected by application of micronutrients. Moreover, Singh and Tiwari (17) found that plant height and bulb fresh weight, bulb diameters of onion were recorded highest with spraying of Zn.

A perusal of data presented in Table 3 revealed that all the treatments were found significantly superior to control. The maximum bulb fresh weight (171.7 g) was obtained by applying Zn @ 4 mgl^{-1} followed by B@ 2 mgl^{-1} with an increase of 59.6 and 57.5 per cent respectively, over control. The highest of bulb diameter (7.6 cm) was recorded from the treatment Zn @ 4 mgl^{-1}, and the lowest value (5.6 cm) was found in control. The highest total plant weight (226.3 g) was found under Zn @ 4 mgl^{-1} followed by Mn @ 1 mgl^{-1} (213.9 g) and the lowest total plant weight (99.9 g) was recorded in control, and thus resulted an increase in weight 55.8 and 53.2 per cent, respectively, over the control. Application of different micronutrients influenced the fresh weight of onion roots. The maximum fresh weight of roots (4.2 g) was produced under treatment Zn @ 4 mgl^{-1}, while the minimum (2 g) was found in Mn @ 2 mgl^{-1}. Yield data presented in Table 3 shows that different micronutrients produced significant variations for bulb yield of onion. The maximum bulb yield (419.8 q ha^{-1}) was observed in receiving the treatment Zn @ 4 mgl^{-1}, and the minimum yield (254.1q ha^{-1}) was found in control. The treatment Zn @ 4 mgl^{-1} performed as the highest yielder by 39.4 per cent, over control. This effect might be due to the fact that micronutrients played a pivotal role in strengthening plant cell walls and translocation of carbohydrates from leaves to other parts of the plant, this means that a possibility of increasing dry matter percentage as well as yield. Barker and Pilbeam (2), and Hansch and Mendel (8) reported that it is highly required for better yield of many crops since it could serve as counter ion. According to Singh and Tiwari (18), a high yield is a reflection of vigorous vegetative growth and healthy

Table 3. Effects of foliar feeding of micronutrients on yield parameters of onion.

Treatment	Plant weight (g)	Fresh weight of bulb (g)	Fresh weight of roots (g)	Root length (cm)	Bulb diameter (cm)	Yield ha^{-1} (q)
T_1 (Cu @ 2 mgl^{-1})	183.1^{bcd}	125.6^{a}	2.5^{bc}	7.9^{a}	6.4^{cd}	306.6^{ab}
T_2 (Cu @ 4 mgl^{-1})	169.9^{cd}	123.5^{a}	2.6^{bc}	7.3^{a}	6.2^{d}	379.6^{ab}
T_3 (Zn @ 4 mgl^{-1})	226.3^{a}	171.7^{a}	4.2^{a}	8.0^{a}	7.6^{a}	419.8^{a}
T_4 (Zn @ 6 mgl^{-1})	165.4^{d}	131.3^{a}	3.6^{ab}	7.5^{a}	6.7^{bcd}	279.1^{b}
T_5 (B @ 1 mgl^{-1})	206.8^{abc}	139.2^{a}	3.1^{abc}	7.1^{a}	7.0^{b}	323.4^{ab}
T_6 (B @ 2 mgl^{-1})	195.5^{abcd}	162.9^{a}	2.8^{bc}	8.1^{a}	6.9^{bc}	332.0^{ab}
T_7 (Fe @ 100 mgl^{-1})	185.1^{bcd}	136.5^{a}	2.5^{bc}	7.1^{a}	6.8^{bc}	297.5^{ab}
T_8 (Fe @ 200 mgl^{-1})	176.1^{bcd}	132.4^{a}	2.2^{c}	7.5^{a}	6.8^{bc}	275.2^{b}
T_9 (Mn @ 1 mgl^{-1})	213.9^{ab}	157.6^{a}	2.6^{bc}	7.7^{a}	7.2^{ab}	359.6^{ab}
T_{10} (Mn @ 2 mgl^{-1})	202.0^{abcd}	145.6^{a}	2.0^{c}	7.1^{a}	6.9^{bc}	347.8^{ab}
T_{11} (Control)	99.96^{e}	69.2^{b}	2.1^{c}	5.5^{b}	5.6^{c}	254.1^{b}
CD at 5%	40.8	32.3	1.3	1.2	0.6	127.5

Values in the same column bearing different superscript letters differ significantly ($p<0.05$).

plants. Similar results were also obtained by Alam *et al.* (1), El-Gamelli (4), El-Shafie *et al.* (5), Samad *et al.* (15), and Sliman *et al.* (20). El-Tohamy *et al.* (6) revealed that yield of onion cv. Giza 6 significantly increased by the application of Fe or Zn compared to control plants. Maurya and Lal (13) found significant increase in yield of onion with zinc treatment. Dry weights of leaves (21 g) were observed higher in Zn @ 4 mgl^{-1} which gave 60.4 per cent increase in dry weight of leaves over control (Table 4). Application of Zn significantly influenced the dry weight of onion. The maximum dry weight of bulbs (13.2 g) and roots (2.0 g) was found in Zn @ 4 mgl^{-1}, while the lowest values (9.6 and 0.7 g, respectively) were recorded under control. These findings are in agreement with Maurya and Lal (13), who also observed an increase dry matter content with zinc treatment in onion. The effect of micronutrients on quality of onion was studied in terms of TSS, ascorbic acid and total sugars of bulb and presented in Table 4. The treatment Zn @ 4 mgl^{-1} recorded the maximum TSS of 14.2% followed by B @ 1 mgl^{-1} (13.9%) with an increase of 15.4 and 13.6 per cent respectively, over control. The treatment Zn @ 6 mgl^{-1} produced the highest ascorbic acid content (17.4 mg/100 g) about 29.8 per cent higher over control. Malick (11) reported similar results of increased ascorbic acid content in tomato with increasing level of $ZnSO_4$ application. The highest volume (148.5 ml) was found in treatment Mn @ 2 mgl^{-1} with an increasing of 57.2 per cent, over control and the maximum specific gravity (1.3) was found in Zn @ 4 mgl^{-1} with an increase of 23 per cent over control. The total sugars in onion was found to be increased significantly by application of micronutrients in different levels. The maximum total sugars (6.6%) was found in Zn @ 4 mg l^{-1} followed by Cu @ 4 mgl^{-1} (6.1%) with an increase 56 and 52.4 per cent, over the control. Maurya and Lal (13) observed increase contain of reducing, non-reducing and total sugars by zinc nutrition. Samad *et al.* (15) mentioned that foliar spraying of Zn and/or Fe could give the best results of onion plant growth parameters, yield and quality of onion bulbs as well as macro and micronutrient contents in bulb under newly sandy reclaimed soil conditions. In the present study, similar trends were observed for vegetative, yield and quality characters.

From the above results it could be concluded that foliar spraying of Zn @ 4 mg l^{-1} could improve plant growth parameters, yield and quality characters of onion bulbs under sub-tropical valley conditions.

REFERENCES

1. Alam, M.N., Abedin, M.J. and Azad, M.A.K. 2010. Effect of micronutrients on growth and yield of onion under calcareous soil environment. *Int. Res. J. Plant Sci.* **1**: 56-61.
2. Barker, A.V. and Pilbeam, D.J. 2007. *Handbook of Plant Nutrition*, CRC Press, London, New York.
3. Battal, P. 2004. Effects of some mineral nutrients on gibbrellic acid levels in maize plants. *Econ. Bot.* **58**: 195-203.

Table 4. Effects of foliar feeding of micronutrients on quality parameters of onion.

Treatment	Ascorbic acid (mg/100 g)	TSS (%)	Total sugars (%)	Volume (ml)	Specific gravity	Bulb dry weight/100 g fresh weight (g)	Leaf dry weight (g)	Root dry weight (g)	Scales plant^{-1}
T_1 (Cu @ 2 mgl^{-1})	10.3^{cd}	12.0^{d}	3.4^{ef}	108.3^{a}	1.1^{b}	9.9^{ef}	8.3^{d}	1.1^{bcd}	7.6^{c}
T_2 (Cu @ 4 mgl^{-1})	12.4^{cd}	12.5^{cd}	6.1^{ab}	127.3^{a}	0.9^{c}	10.1^{def}	13.3^{c}	1.0^{cd}	9.6^{bc}
T_3 (Zn @ 4 mgl^{-1})	17.3^{ab}	14.2^{a}	6.6^{a}	124.7^{a}	1.3^{a}	13.2^{a}	21.0^{a}	2.0^{a}	12.6^{a}
T_4 (Zn @ 6 mgl^{-1})	17.4^{a}	10.0^{f}	5.0^{cd}	116.1^{a}	1.1^{b}	11.0^{cd}	19.6^{a}	1.1^{bcd}	8.3^{bc}
T_5 (B @ 1 mgl^{-1})	10.3^{cd}	13.9^{ab}	5.9^{ab}	128.5^{a}	1.0^{bc}	10.8^{cde}	17.6^{abc}	1.5^{b}	8.3^{bc}
T_6 (B @ 2 mgl^{-1})	12.4^{cd}	13.2^{bc}	5.3^{bc}	148.5^{a}	1.0^{bc}	10.6^{cde}	14.3^{bc}	1.2^{bc}	8.6^{bc}
T_7 (Fe @ 100 mgl^{-1})	9.7^{cd}	11.0^{e}	2.7^{f}	121.1^{a}	1.1^{b}	11.3^{bc}	13.5^{c}	1.1^{bcd}	9.3^{bc}
T_8 (Fe @ 200 mgl^{-1})	9.1^{d}	11.8^{de}	3.8^{e}	122.6^{a}	1.0^{bc}	11.1^{cd}	12.2^{cd}	1.2^{bc}	7.3^{c}
T_9 (Mn @ 1 mgl^{-1})	13.3^{bc}	12.0^{d}	2.8^{f}	125.2^{a}	1.1^{b}	12.3^{ab}	18.0^{ab}	1.1^{bcd}	10.6^{b}
T_{10} (Mn @ 2 mgl^{-1})	13.0^{cd}	12.9^{bc}	4.1^{de}	130.0^{b}	1.1^{b}	11.1^{cd}	18.9^{ab}	1.1^{bcd}	10.6^{b}
T_{11} (Control)	12.2^{cd}	12.0^{d}	2.9^{f}	63.4	1.0^{bc}	9.6^{f}	8.3^{d}	0.7^{d}	7.3^{c}
CD at 5%	4.1	0.9	0.9	40.0	0.2	1.1	4.2	0.5	3.0

Values in the same column bearing different superscript letter differ significantly ($p<0.05$).
B = Boron, Cu = Copper, Fe = Iron, Zn = Zinc, Mn = Manganese

4. El-Gamelli and El-Hadi, Hanna. 2000. The effect of some foliar fertilizers application on growth, bulb yield, quality and storage ability of Giza-20 onion cultivar (*Allium cepa* L.). *Ann. Agric. Sci.* **38**: 1727-37.

5. El-Shafie, S.F., Eida, G.E. and El-Gamaily. 2002. Effect of organic manure, sulphur and micro-elements on growth, bulb yield, storability and chemical composition of onion plants. *Minufiya J. Agri. Res.* **27**: 407-24.

6. El-Tohamy, W.A., Khalid, A.Kh., El-Abagy, H.M. and Abou-Hussein, S.D. 2009. Essential oil, growth and yield of onion (*Allium cepa* L.) in response to foliar application of some micronutrients. *Australian J. Basic Appl. Sci.* **3**: 201-5.

7. Gomez, K.A. and Gomez, A.A. 1983. *Statistical Procedures for Agricultural Research* (2nd edn.), John Wiley & Sons, New York.

8. Hansch, R. and Mendel, R.R. 2009. Physiological functions of mineral micronutrients (Cu, Zn, Mn, Fe, Ni, Mo, B, Cl). *Curr. Opin. Plant Biol.* **12**: 259-66.

9. Jackson, M.L. 1967. *Soil Chemical Analysis.* Prentice Hall of India, Pvt. Ltd., New Delhi.

10. Kolota, E. and Osinska, M. 2001. Efficiency of foliar nutrition of field vegetables grown at different nitrogen rates. *Acta Hort.* **563**: 87-91.

11. Malick, M. 1976. Effect of micronutrients on the morphological features of tomato ICAR Co-ordinanted scheme on micronutrients of soil and plants. *Annul Progress Report*, TNAU, Coimbatore.

12. McCready, R.M., Guggot, J., Silvaiera, V. and Owen, H.S. 1950. Determination of starch and amylase in vegetables. *Anal. Chem.* **22**: 1156-58.

13. Maurya, A.N. and Lal, S. 1975. Response of onion (*Allium cepa* L.) to zinc feeding. *Punjab Hort. J.* **15**: 61-64.

14. Ranganna, S. 2004. *Handbook of Analysis and Quality Control for Fruit and Vegetable Products* (2nd Edn.), Tata McGraw, Hill Publishing Co. Ltd., New Delhi.

15. Samad, A. El., Khalifa, R.K.M., Lashine, Z.A. and Shafeek, M.R. 2011. Influence of urea fertilization and foliar application of some micronutrients on growth, yield and bulb quality of onion. *Australian J. Basic Appl. Sci.* **5**: 96-103.

16. Schmidt, W.A. 1964. Influence of zinc on the performance of vegetable in the Bajio region *Mexico. Proc. Carib. Reo. Aer. Soc. Hort. Sci.* **7**: 17-21.

17. Singh, D.P. and Tiwari, R.S. 1995. Effect of micronutrients on growth and yield of onion (*Allium cepa* L.) variety Pusa Red. *Recent Hort.* **2**: 70-77.

18. Singh, D.P. and Tiwari, R.S. 1996. Effect of micronutrients on yield and quality of onion (*Allium cepa* L.) variety Pusa Red. *Recent Hort.* **3**: 111-17.

19. Singh, S.S. and Tiwari, R.S. 1989. Effect of micronutrients on the growth characters of onion (*Allium cepa* L.) cv. Pusa Red. *Haryana J. Hort. Sci.* **18**: 146-49.

20. Sliman, Z.T., Abdelhakim, M.A. and Omran, A.A. 1999. Response of onion to foliar application of some micronutrients. *Egypt. J. Agric. Res.* **77**: 983-93.

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