THE ASIAN JOURNAL OF HORTICULTURE
Volume **8** | Issue 2 | December, 2013 | 541-546

Research Paper

Article history :
Received : 18.06.2013
Revised : 19.09.2013
Accepted : 03.10.2013

Response of summer okra (cv. PHULE UTKARSHA) to iron, zinc and boron in inceptisol

N.R. SATPUTE, L.B. SURYAWANSHI[1], J.M. WAGHMARE[1] AND **P.B. JAGTAP[1]**

Members of the Research Forum

Associated Authors:
[1]Division of Soil Science and Agricultural Chemistry, College of Agriculture, PUNE (M.S.) INDIA

Author for correspondence :
N.R. SATPUTE
Zonal Agriculture Research Station, Krishak Bhawan, SOLAPUR (M.S.) INDIA
Email : satputentin1@gmail.com

ABSTRACT : A field experiment was conducted to study the response of summer okra (cv. Phule Utkarsha) to iron, zinc and boron in Inceptisol at Regional Fruit Research Station, Ganeshkhind, Pune (M.S.) during 2007-08. The objective of experiment was to study the effect of iron, zinc and boron on growth, yield, quality, nutrient uptake of okra and soil properties after harvest of okra. There were twelve treatments *viz.*, water spray, foliar spray $FeSO_4$ (0.5 %), foliar spray $ZnSO_4$ (0.5 %), foliar spray boric acid (0.2 %), foliar spray $FeSO_4$ + $ZnSO_4$ (0.5 % each), foliar spray $FeSO_4$ (0.5 %) + boric acid (0.2 %), foliar spray $ZnSO_4$ (0.5 %) + boric acid (0.2 %), foliar spray $FeSO_4$ + $ZnSO_4$ (0.5 % each) + boric acid (0.2%), soil application of $FeSO_4$ @ 20 kg ha^{-1}, soil application of $ZnSO_4$ @ 20 kg ha^{-1}, soil application of $FeSO_4$ + $ZnSO_4$ @ 20 kg ha^{-1} each and soil application of $FeSO_4$ + $ZnSO_4$ @ 20 kg ha^{-1} each + borax @ 5 kg ha^{-1}. The experiment was laid in Randomized Block Design with three replications. The foliar sprays of micronutrients were done at 30 days and 45 days after sowing of okra. The soil application of micronutrients were done at the time of sowing. The results of experiment indicated that the soil application of $FeSO_4$ + $ZnSO_4$ @ 20 kg ha^{-1}each + borax @ 5 kg ha^{-1} registered significantly higher plant height (155.64cm), higher number of nodes per plant (24.96), higher number of days to 50 % flowering (43.67). The higher average fruit diameter (1.60 cm), higher fruit length (11.30 cm) and average fruit weight (11.67 g) were found in T_{11}. The micronutrient application to okra helped to improve yield parameters. The soil application of $FeSO_4$ + $ZnSO_4$ @ 20 kg ha^{-1} each + borax @ 5 kg ha^{-1} yielded significantly higher yield (205.8 q ha^{-1}) and was at par with foliar spray $FeSO_4$ + $ZnSO_4$ (0.5 % each) + boric acid (0.2%) (196.4 q ha^{-1}), soil application of $FeSO_4$ + $ZnSO_4$ @ 20 kg ha^{-1} each (191.2 q ha^{-1}) and foliar spray $FeSO_4$ + $ZnSO_4$ (0.5 % each) (191.2 q ha^{-1}). In general the combined application of $FeSO_4$ + $ZnSO_4$ @ 20 kg ha^{-1} each + borax@ 5 kg ha^{-1} as soil application and foliar sprays of $FeSO_4$ (0.5 %) + $ZnSO_4$ (0.5 %) + boric acid (0.2%), both treatments were found significantly effective in increasing the yield of okra and maintained soil properties. The uptake of nitrogen was significantly higher due to soil application of $FeSO_4$ + $ZnSO_4$ + borax (48.03 kg ha^{-1}) and at par with foliar spray $FeSO_4$ + $ZnSO_4$ + boric acid (45.84 kg ha^{-1}) and soil application of $FeSO_4$ + $ZnSO_4$ @ 20 kg ha^{-1} each (45.61 kg ha^{-1}). The similar treatment showed significantly higher uptake of phosphorus and potassium. The application of $FeSO_4$, $ZnSO_4$ and borax either alone or in combination helped to increase the uptake of iron, zinc, boron, manganese and copper by okra.

KEY WORDS : Okra, Micronutrients, Yield, Nutrient uptake, Soil properties

HOW TO CITE THIS ARTICLE : Satpute, N.R., Suryawanshi, L.B., Waghmare, J.M. and Jagtap, P.B. (2013). Response of summer okra (cv. PHULE UTKARSHA) to iron, zinc and boron in inceptisol. *Asian J. Hort.*, **8**(2) : 541-546.

Okra [*Abelmoschus esculentus* (L.) Moench] is one of the most important vegetable crops grown in tropical and subtropical region and is said to be native of South Africa and Asia. In India, it is cultivated almost in all states throughout the year and consumed by bulk of the people. The major okra growing states in India are Maharashtra, Uttar Pradesh, Bihar, West Bengal, Orissa, Assam, Andhra Pradesh and Karnataka. The total area under okra crop in India is about 4.09 lakh ha with production of 41.93 lakh metric tones, in 2007-08. It is one of the important vegetable crops grown in Maharashtra on an area about 26,300 ha with annual production of 1,65,400 metric tones in 2007-08 (Anonymous, 2008). It is largely grown in Pune, Nagapur, Nashik, Jalgaon, Aurangabad, Ahmednagar,

Amravati, Parbhani and Satara districts.

Okra is popular and favourable vegetable grown for tender fruits and fresh market consumption. It is one of the most nutritious vegetables which contains on an average 36 calories energy, 2.4 g proteins, 89 per cent moisture, 0.3 g fat, 7.6 g carbohydrates, 92 mg Ca, 51 mg P, 1.5 mg Fe, 3 mg Na and 103 mg K per 100 g of fresh fruits (Bose *et al.*, 1985). Water extract from the plants are used as clarifier in manufacture of jaggery. Mature fruits and stem contains crude fibre which is used in paper industry. The immature tender fruits are either boiled or sliced and fried for consumption. The root and stem are used for clearing cane juice in preparation of jaggery.

The quality of okra fruits is inferior in summer season compared with *Rabi* season. The application of zinc, boron and iron has been studied for the yield improvement of several vegetable crops. Bajapai and Chauhan (2001) studied effect of zinc, boron and manganese on yield in okra (*Abelmoschus esculentus*). All treatments, however, significantly improved the performance of okra in terms of the evaluated parameters. Hatwar *et al.* (2003) studied the effect of foliar application of micronutrients *viz.*, Zn, Fe and B singly and in combinations on growth and yield of chilli var. Jayanti. The combined application of Zn, Fe and B was found effective in respect of growth and yield of chilli as compared to other treatments. Patil *et al.* (2008) found the effect of foliar application of micronutrients on growth and yield of tomato significantly superior over other treatments but, little work has been done in this region particularly on okra. Therefore, the present investigation was aimed at studying the "response of summer okra cv. Phule Utkarsha to iron, zinc and boron in Inceptisol".

RESEARCH METHODS

The present investigation was undertaken to the study the response of summer okra cv. Phule Utkarsha to iron, zinc and boron in Inceptisol grown in summer season during 2008-2009 on the research farm at NARP, Ganeshkhind, Pune. The selection of experimental site was done on the basis of suitability of land for the cultivation of okra. The land was uniformly leveled with good drainage. The field experiment was conducted on Inceptisol soil. The soil was deficient in DTPA extractable Fe, Zn and hot water soluble boron content. The fertilizers were applied as per the recommended dose for okra. The variety of okra was selected the Phule Utkarsha with spacing 30 x 15 cm, recommended dose 100:50:50 $N:P_2O_5: K_2O$ kg ha^{-1} of fertilizers + FYM 10 t ha^{-1} and Randomized Block Design with 3 replications and 12 treatments. The dose of nitrogen was applied in two splits *i.e.* 50 per cent N at sowing and 50 per cent N one month after sowing. The 100 per cent dose of P and K was applied at the time of sowing. The soil application of $FeSO_4$, $ZnSO_4$ and borax was done at the time of sowing and foliar application of three micronutrients fertilizers were applied treatment wise at 30 days and 45 days after sowing.

RESEARCH FINDINGS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarised under following heads:

Influence of micronutrients on growth and yield parameters of okra:

The data pertaining to the growth parameters *viz.*, average plant height, number of nodes per plant, days to 50 per cent flowering, average fruit diameter, average fruit length, average fruit weight and yield influenced by micronutrients are presented in the Table 1.

The data in respect of average plant height indicated that there was significant influence of different micronutrients on plant height of okra. The soil application of $FeSO_4$ + $ZnSO_4$ @ 20 kg ha^{-1} each + borax @ 5 kg ha^{-1} registered significantly higher plant height (155.64 cm) over all other treatments. Further, it was also observed that each micronutrient either foliar spray or soil application significantly increased plant height as compared to water spray. It was interesting to note that combine spray of $FeSO_4$ + $ZnSO_4$ (0.5 % each) found significantly superior in increasing plant height (146.92 cm) over foliar spray of 0.5 per cent $FeSO_4$ (125.15 cm) and 0.5 per cent $ZnSO_4$ (127.23 cm) individually. The increase in height of plant might be due to effective role of micronutrients. An active synthesis of tryptophan, an amino acid in the presence of zinc, and it is precursor of IAA which stimulates the growth of plant tissues. Beside the zinc, boron also plays an essential role in development and growth of new cells in the plant. Plants require boron for synthesis of amino acids and protein and regulation of carbohydrate metabolism (Dyar and Webb, 1961). On the other hand, iron is a component and ferrodoxine an electron transferring protein and is associated with chloroplast. It helps in photosynthesis might have resulted in better vegetative growth. These results confirms the findings reported by Hatwar *et al.* (2003).

There was significant influence of different treatments on number of nodes per plant. The soil application of $FeSO_4$ + $ZnSO_4$ @ 20 kg ha^{-1} each + borax @ 5 kg ha^{-1} recorded significantly higher number of nodes per plant (24.96) over all other treatments, except foliar spray of $FeSO_4$ + $ZnSO_4$ (0.5 % each) + boric acid (0.2 %)(23.48). It was also noticed that combined application of micronutrients observed better over individual application of micronutrients. These results indicated the beneficial role of micronutrients on growth of okra. These micronutrients play a vital role in the physiology of plants.

The data on days to 50 per cent flowering showed that there was significantly less days were required for 50 per cent flowering under water spray (41.00). The soil application of $FeSO_4$ + $ZnSO_4$ @ 20 kg ha^{-1} each + borax @ 5 kg ha^{-1} and soil application of $ZnSO_4$ took higher number of days to 50 per cent flowering (43.67). The application of micronutrient might have helped for better vegetative growth resulted delayed flowering in okra.

The soil application of $FeSO_4$ + $ZnSO_4$ @ 20 kg ha^{-1} each recorded significantly higher fruit length (11.30 cm) which was at par with foliar spray of $FeSO_4$ + $ZnSO_4$ + Boric acid (11.07 cm), soil application of $ZnSO_4$ @ 20 kg ha^{-1} (11.01 cm) and soil application of $FeSO_4$ @ 20 kg ha^{-1} (10.98 cm). It was interesting to note that application of micronutrients either alone or in combination registered significantly higher fruit length, except foliar spray of $FeSO_4$.

The perusal of data on average fruit diameter revealed that the soil application of $FeSO_4$ + $ZnSO_4$ @ 20 kg ha^{-1} each registered significantly higher average fruit diameter (1.60 cm) and it was at par with soil application of $FeSO_4$ + $ZnSO_4$ @ 20 kg ha^{-1} + borax @ 5 kg ha^{-1} (1.59 cm), soil application of $FeSO_4$ @ 20 kg ha^{-1} (1.58 cm), foliar spray of $FeSO_4$ + $ZnSO_4$ (0.5% each) (1.58 cm) and soil application of $ZnSO_4$ (1.56 cm). The application of individual micronutrients through foliar spray did not increase diameter of fruit significantly over water spray (1.47 cm). The diameter of fruit ranged from 1.47 cm to 1.60 cm. The increase in diameter of fruit due to micronutrients might be due to their role in fundamental processes involved in the cellular mechanism and respiration. This effect positively for improvement in fruits size and fruit weight. Boron exhibits pronounce effect in improving the yield attribute and yield. It takes part in active photosynthesis, which ultimately helps towards increase in number and weight of fruits. These findings confirms the results reported by Singh and Maurya (1979), Srihari *et al*. (1987), Medhi and Kakati (1994), Singh and Verma (1991) and Singh and Hooda (1992).

The average fruit weight ranged between 9.93 g to 11.67 g. The significantly higher fruit weight registered in soil application of $FeSO_4$ + $ZnSO_4$ @ 20 kg ha^{-1} each (11.67 g) and it was at par with T_{12} (11.40 g), T_{10} and T_9 (11.30 g). Further it was also noticed that soil application of micronutrients helped more than foliar application in respect of average fruit weight.

The perusal of data on yield of okra revealed that the soil application of $FeSO_4$ + $ZnSO_4$ @ 20 kg ha^{-1} each + borax @ 5 kg ha^{-1} yielded significantly higher (205.8 q ha^{-1}) over rest of the treatments except T_8 (196.4 q ha^{-1}), T_{11} and T_5 (191.2 q ha^{-1}). The results clearly indicated that combined application of micronutrients either through soil or foliar spray found equally beneficial for increase in the yield of okra. In general, it was observed that micronutrients applied alone or in combination found significantly effective in increasing the yield of okra as compared with water

Table 1 : Influence of micronutrients on growth and yield parameters of okra

Tr. No.	Treatments	Av. plant height (cm)	Av. no. of nodes per plant	Days to 50% flowering	Av. fruit length (cm)	Av. fruit diameter (cm)	Av. fruit weight (g)	Yield (q ha^{-1})
T_1	Water spray (Control)	115.29	18.27	41.00	9.52	1.47	9.93	149.58
T_2	Foliar spray $FeSO_4$ (0.5 %)	125.15	19.22	42.00	10.05	1.50	10.33	170.55
T_3	Foliar spray $ZnSO_4$ (0.5 %)	127.23	20.25	42.33	10.35	1.50	10.50	176.67
T_4	Foliar spray boric acid (0.2%)	135.90	20.44	42.67	10.34	1.50	10.50	179.17
T_5	Foliar spray $FeSO_4$ (0.5 %) + $ZnSO_4$ (0.5 %)	146.92	22.42	43.00	10.73	1.58	10.90	191.94
T_6	Foliar spray $FeSO_4$ (0.5 %) + boric acid (0.2 %)	127.48	18.18	44.00	9.95	1.50	10.30	175.42
T_7	Foliar spray $ZnSO_4$ (0.5 %) + boric acid (0.2 %)	129.84	18.88	42.00	10.04	1.50	10.40	177.22
T_8	Foliar spray $FeSO_4$ (0.5 %) + $ZnSO_4$ (0.5 %) + boric acid (0.2 %)	146.00	23.48	42.67	11.07	1.60	11.27	196.39
T_9	Soil appl. of $FeSO_4$ @ 20 $kgha^{-1}$	142.40	20.67	43.00	10.98	1.58	11.30	175.42
T_{10}	Soil appl. of $ZnSO_4$ @ 20 $kgha^{-1}$	144.73	21.22	43.67	11.01	1.56	11.30	178.75
T_{11}	Soil appl. of $FeSO_4$ + $ZnSO_4$ @ 20 $kgha^{-1}$ each	142.27	22.19	42.67	11.30	1.60	11.67	189.17
T_{12}	Soil appl. of $FeSO_4$ + $ZnSO_4$ @ 20 $kgha^{-1}$each + borax@5 $kgha^{-1}$	155.64	24.96	43.67	10.79	1.59	11.40	205.83
S.E.±		2.59	0.50	0.51	0.22	0.021	0.15	5.14
C.D. (P=0.05)		7.57	1.46	1.50	0.65	0.062	0.42	15.00

sprays.Increased yield due to micronutrients application may be attributed to enhanced photosynthesis activity and increased in production and accumulation of carbohydrates and favorable effect on vegetative growth, and retention of flowers and fruits. Kumbhar and Deshmukh (1993) and Bose and Tripathi (1996) revealed that the increased dry matter production may be attributed to greater accumulation of photosynthates by vegetative parts and fruits in tomato. The presence of Zn activates the synthesis of tryptophan, precursor of IAA and it is responsible to stimulate plant growth. Fe plays vital role in promoting growth characters being a component of ferrodoxin, and electron transport protein and is associated with chloroplast. It helps in photosynthesis might have helped in better vegetative growth. Kumar and Sen (2005) reported that the increase in yield of okra due to application of zinc and boron through soil.

Influence of micronutrients on nutrients uptake by okra:

The data pertaining to nutrient uptake as influenced by micronutrient application are presented in Table 2.

Uptake of nitrogen:

The data in respect of nitrogen uptake revealed that soil application of $FeSO_4$ + $ZnSO_4$ + borax recorded significantly higher uptake of nitrogen (48.03 kg ha^{-1}) which was at par with treatment foliar spray of $FeSO_4$ + $ZnSO_4$ + boric acid (45.84 kg ha^{-1}) and soil application of $FeSO_4$ + $ZnSO_4$@ 20 kg ha^{-1} each (45.61 kg ha^{-1}). It was also observed that micronutrient application increased uptake of nitrogen significantly over water spray. Combined foliar spray of $FeSO_4$ + $ZnSO_4$ registered significantly higher uptake of nitrogen (42.34 kg ha-1) over foliar spray of $FeSO_4$ (33.81 kg ha^{-1}) and foliar spray of $ZnSO_4$ (38.47 kg ha^{-1}) individually. These findings are supportive to earlier results reported by Samui *et al.* (1981), Singh *et al.* (1993), Balasubramanium *et al.* (1998), Bhatt and Srivastava (2006), Radder *et al.* (2008) and Ravi (2008).

Uptake of phosphorus:

There was significant influence of different treatments on uptake of phosphorus. The uptake of phosphorus ranged from 6.73 to 10.15 kg ha^{-1}. The foliar spray $FeSO_4$ + $ZnSO_4$ found significantly superior (10.43 kg ha^{-1}) which was at par with T_{12} (10.15 kg ha^{-1}) and T_8 (10.05 kg ha^{-1}). It was interesting to note that the foliar application of $ZnSO_4$ (8.93 kg ha^{-1}) was significantly superior over foliar spray of $FeSO_4$ (7.85 kg ha^{-1}), however soil application of $FeSO_4$ (9.62 kg ha^{-1}) was superior over soil application of $ZnSO_4$ (8.93 kg ha^{-1}). It indicated that soil application of $ZnSO_4$ showed antagonistic effect in respect of uptake of phosphorus. Similar antagonistic effect of Zn in respect of P uptake has been reported by Hossain *et al.*(2008) and Chandra Deo and Khandelwal (2009). The amounts of NPK content in leaf material were slightly increased by spraying plants (*Visica faba*) with iron (EI-Naggar and Awad 1986). The concentration of N and P in chickpea plants increased with increased level of applied Fe (Singh *et al.*,1993). The application of sulphur, zinc and iron increased uptake of NPK significantly over control (Ravi *et al.,* 2008).

Table 2 : Influence of micronutrients on nutrients uptake by okra

Tr. No.	Treatments	N	P	K	Fe	Zn	B	Mn	Cu
		kg ha^{-1}							
T_1	Water spray (Control)	29.48	6.73	27.21	4.04	0.23	0.11	0.36	0.036
T_2	Foliar spray $FeSO_4$ (0.5 %)	33.81	7.85	32.02	5.34	0.31	0.12	0.49	0.056
T_3	Foliar spray $ZnSO_4$ (0.5 %)	38.47	8.93	35.36	5.20	0.38	0.14	0.54	0.059
T_4	Foliar spray boric acid (0.2%)	41.15	9.64	35.99	5.17	0.30	0.15	0.47	0.054
T_5	Foliar spray $FeSO_4$ (0.5 %) + $ZnSO_4$ (0.5 %)	42.34	10.43	40.84	7.00	0.45	0.14	0.64	0.085
T_6	Foliar spray $FeSO_4$ (0.5 %) + boric acid (0.2 %)	35.07	8.47	32.24	5.42	0.32	0.15	0.50	0.060
T_7	Foliar spray $ZnSO_4$ (0.5 %) + boric acid (0.2 %)	39.24	9.37	35.75	5.36	0.38	0.16	0.55	0.068
T_8	Foliar spray $FeSO_4$ (0.5 %) + $ZnSO_4$ (0.5 %) + boric acid (0.2 %)	45.84	10.05	42.18	7.20	0.47	0.17	0.66	0.087
T_9	Soil appl. of $FeSO_4$ @ 20 $kgha^{-1}$	40.48	9.62	36.72	7.25	0.31	0.15	0.48	0.070
T_{10}	Soil appl. of $ZnSO_4$ @ 20 $kgha^{-1}$	38.99	8.93	35.81	5.90	0.42	0.14	0.55	0.071
T_{11}	Soil appl. of $FeSO_4$ + $ZnSO_4$ @ 20 $kgha^{-1}$ each	45.61	9.62	42.90	6.98	0.48	0.15	0.68	0.078
T_{12}	Soil appl. of $FeSO_4$ + $ZnSO_4$ @ 20 $kgha^{-1}$each + borax @5 $kgha^{-1}$	48.03	10.15	43.85	7.43	0.49	0.17	0.69	0.094
S.E.±		0.95	0.24	0.87	0.14	0.009	0.001	0.013	0.002
C.D. (P=0.05)		2.79	0.69	2.55	0.41	0.028	0.003	0.039	0.005

Uptake of potassium:

There was significant increase in uptake of potassium due to micronutrient application. The soil application of $FeSO_4$ + $ZnSO_4$ + borax increased uptake of potassium significantly (43.85 kg ha^{-1}) which was at par with T_{11} (42.90 kg ha^{-1}) and T_8 (42.18 kg ha^{-1}). The combined application of $FeSO_4$ + $ZnSO_4$ showed significantly higher uptake of potassium than individual application of $FeSO_4$ and $ZnSO_4$ either through foliar spray or through soil. All treatments exhibited significant increase in uptake of potassium over water spray. Samui *et al.*(1981) reported that potassium uptake was increased due to Fe application. The amounts of NPK content in leaf material were slightly increased by spraying plants (*Visica faba*) with iron (EI-Naggar and Awad 1986). The application of sulphur, zinc and iron increased uptake of NPK significantly over control (Ravi *et al.*, 2008).

Uptake of iron :

The application of micronutrients exhibited significant increase in uptake of iron over water spray. The significantly higher uptake of iron (7.43 kg ha^{-1}) was recorded in soil application of $FeSO_4$ + $ZnSO_4$ + borax. This treatment registered at par uptake of iron with T_9 (7.25 kg ha^{-1}), T_8 (7.20 kg ha^{-1}) and T_5 (7.00 kg ha^{-1}). The application of $FeSO_4$ along with $ZnSO_4$ or borax showed beneficial effect. The increase in uptake of iron due to $FeSO_4$ might be attributed to easily availability of iron from $FeSO_4$. The $ZnSO_4$ plays synergetic effect for availability of iron. The uptake of Fe by the crop significantly increased up to 5 ppm, and decreased at higher level of Zn application (Subrahmanyam *et al.*, 1991). The higher Fe content was recorded in combination treatment of 0.5 kg boron ha^{-1} with 2.5 kg zinc ha^{-1} (Varghese and Duraisami, 2005). Pahlvan-Rad and Pessarakali (2009) reported that foliar application of Zn increased Zn concentration and Fe concentration in wheat grains 99 per cent and 8 per cent, respectively.

Uptake of zinc :

The soil application of $FeSO_4$ + $ZnSO_4$ + borax registered significantly higher uptake of zinc (0.49 kg ha^{-1}) and at par with T_{11} (0.48 kg ha^{-1}) and T_8 (0.47 kg ha^{-1}). The foliar application of $ZnSO_4$ was found significantly superior over water spray. Further it was also noticed that soil application of $ZnSO_4$ was more beneficial than foliar application in respect of uptake of zinc. Raj *et al.* (2001) reported significant increase in Zn and Fe contents in fruit through respective application either through soil or foliage. Hossain *et al.* (2008) reported that the Zn and N concentrations of grains were significantly increased with Zn application. Chandra Deo and Khandelwal (2009) noticed that application of Zn and P significantly increased the P and Zn uptake. The application of $ZnSO_4$ might have supplied sufficient quantity of zinc to the crop resulting in its better uptake. The addition of $ZnSO_4$ along with $FeSO_4$ and borax found beneficial.

Uptake of boron :

The data on uptake of boron showed that there was significant increase in uptake of boron due to different treatments. The significantly highest uptake of boron was observed in the soil application of $FeSO_4$ + $ZnSO_4$ + borax (0.17 kg ha^{-1}) over all other treatments. It was also observed that application of boron either through foliar spray or through soil increased the uptake of boron. Further, it could be noticed from data, that the application of $FeSO_4$ or $ZnSO_4$ helped to increase the uptake of boron compared with water spray.

Uptake of manganese :

The perusal of data on uptake of manganese revealed that application of micronutrients was found significantly superior in respect of manganese uptake. Among these treatments T_{10} registered significantly higher uptake of manganese (0.69 kg ha^{-1}) and it was at par with T_{11} (0.68 kg ha^{-1}), T_8 (0.66 kg ha^{-1}) and T_5 (0.64 kg ha^{-1}). The uptake of manganese ranged from 0.36 to 0.69 kg ha^{-1}. The application of micronutrients *viz.*, $FeSO_4$, $ZnSO_4$ or borax showed synergetic effect for manganese uptake. Fe application improved Mn content of crop (Swarup, 1981). Janaki *et al.* (2004) reported that foliar application of boron significantly increased Mn.

Uptake of copper :

There was increase in uptake of copper significantly over water spray. The soil application of $FeSO_4$ + $ZnSO_4$ + borax showed significant increase in uptake of copper (0.094 kg ha^{-1}) over rest of the treatments. However, application of micronutrients either through foliar spray or soil showed significant increase in uptake of copper. The values of uptake of copper ranged from 0.036 to 0.094 kg ha^{-1}.

Conclusion:

From the present investigation on response of summer okra (cv. Phule Utkarsha) to iron, zinc and boron in Inceptisol, it is concluded that the combined application $FeSO_4$ + $ZnSO_4$ @ 20 kg ha^{-1} each + borax@ 5 kg ha^{-1} as soil application and foliar sprays of $FeSO_4$ (0.5 %) + $ZnSO_4$ (0.5 %) + boric acid (0.2%), both treatments found significantly effective in increasing the yield of okra and maintained soil properties.

REFERENCES

Bajapai, S. and Chauhan, S.V.S. (2001). Effect of zinc, boron and manganese on yield in okra (*Abelmoschus esculentus*). *Indian J. Agric. Sci*., **71** (5) : 332-333.

Balasubramanium, P., Mani, A.K., Durasiwamy, P. and Kandsawami, M. (1998). Effect of organic and inorganic nutrients on the yield and uptake of tomato (*Lycopersicon esculentum*) in Alfisol. *South Indian J. Hort.,* **46**(3-4) : 143-147.

Bhatt, Lalit and Srivastava, B.K. (2006). Effect of foliar application of micronutrients on the nutrient composition of tomato. *Indian J. Hort.,* **63**(3): 286-288.

Bose, T.K., Som, M.G. and Kabir, J. (1985). *Vegetable crops*. Naya Prakash, Calcutta. pp. 711-724.

Bose, U.S. and Tripathi, S.K. (1996). Effect of micronutrients on growth, yield and quality of tomato. cv. PUSA RUBY. in M.P. *Cro. Res.* **12** (1) : 61-64.

Chandra, Deo and Khandelwal, R.B. (2009). Effect of zinc and phosphorus on yield, nutrient uptake and oil content of mustard grown on gypsum treated sodic soil. *J. Indian Soc. Soil Sci.,* **57**(1): 66-70.

Dyar, J.J. and Webb, K.L. (1961). A relation between boron and auxin in C14 translocation in bean plants. *Pl. Physiol.,* **36** (5) : 672-676.

El-Naggar, S.M. and Awad, F. (1986). Effect of foliar application of some micronutrients on plant growth in new reclaimed areas. In : *Development in plant and soil science foliar fertilization*. A. Alexzander. Martinus Nijhoff Publisher. pp. 142-152.

Hatwar, G.P., Gondane, S.U., Urkude, S.M. and Gahukar, O.V. (2003). Effect of micronutrients on growth and yield of chilli. *J. Soils & Crops.,* **13** (1) : 123-125.

Hossain, M.A., Jahiruddin, M., Islam, M.R. and Mian, M.H. (2008). The requirement of zinc for improvement of crop yield and mineral nutrition in the maize-mungbeen-rice system. *Plant Soil.,* **306** : 13-22

Janaki, D., Velu, V. and Savithri, P. (2004). Effect of sources, concentration and frequencies of B application on petiole nutrient content in grapes (*Vitis vinifera*) cv. MUSCAT. *Madras Agric. J.,* **91** (7-12) : 383-388.

Kumbhar, V.S. and Deshmukh, S.S. (1993). Effect of soil application of ferrous sulphate on the uptake of nutrients, yield and quality of tomato cv. RUPALI. *South Indian J. Hort.,* **41** (3) : 144-147.

Mahesh Kumar and Sen, N.L. (2005). Effect of zinc, boron and gibberellic Acid on growth and yield of okra [*Ablmoschus esculentus* (L.) Moench]. *Indian J. Hort.,* **62**(3) : 308-309.

Medhi, G. and Kakati, R.N. (1994). Effect of micronutrients in increasing the growth and yield of *bhendi* (*Abelmoschus esculentus* L.). *The Hort. J.,* 7(2): 155-158.

Pahalvan-Rad, Mohammad, R. and Pessarakali, Mohammad (2009). Resonse of wheat plants to zinc, iron and manganese applications and uptake and concentration of zinc, iron and manganese in wheat grains. *Comm. Soil Sci. Pl. Analysis,* **40**(7/8):1322-1332.

Patil, B.C., Hosamani, R.M., Ajjappalavala, P.S., Naik, B.H. Smitha, R.P. and Ukkund, K.C. (2008). Effect of Foliar application of micronutrients on growth and yield components of tomato (*Lycopersicon esculentum* Mill.). *Karnataka J. Agric. Sci.,* **21**(3) : 428-430.

Radder, B.M., Patil, P.L., Aladakatti, Y.R. and Patil, S.G. (2008). Response of okra (*Abelmoschus esculentus* L.) to moisture regimes and micronutrients in Vertisols of Malaprabha Command, Karnataka. *J. Indian Soc. Soil Sci.,* **56**(3): 276-280.

Raj, G.B., Patnaik, M. C., Reddy, I.P. and Rao, A.P. (2001). Response of brinjal (*Solanum melongena* L.) to zinc and iron. *Veg. Sci.,* **28**(1) : 80-81.

Ravi, S., Channal, H.T., Hebsur, N.S., Patil, B.N. and Dharmatti, P.R. (2008). Effect of sulphur, zinc and iron nutrition on growth, yield, nutrient uptake and quality of safflower (*Carthamus tinctorius* L.) *Karnataka J. Agric. Sci.,* **21**(3): 382-385.

Samui, R.C., Bhattacharyya, P. and Dasgupta, S.K. (1981). Uptake of nutrients by mustard (*Brassica juncea* L.) as influenced by zinc and iron application. *J. Indian Soc. Soil Sci.,* **29** (1) : 101-106.

Singh, S. and Hooda, R.S. (1992). Effect of micronutrients on growth, yield and quality of muskmelon. *Agric. Sci. Digest,* **12**: 196-198.

Singh, S.S. and Verma, S.K. (1991). Influence of potassium , zinc and boron on growth yield of tomato.(*Lycopersicon esculentum* Mill). *Veg. Sci.,* **18**(2): 122-129.

Singh, V., Singh, V.P. and Khan, N. (1993). Effect of P and Fe application on the yield and nutrient contents in chickpea. *J. Indian Soc. Soil Sci.,* **41** : 186-187.

Singh, S.S. and Maurya, A.N. (1979). A note on the effect of zinc application on the growth, yield and quality of okra [*Abelmoschus esculentus* (L.) Moench]. *Haryana J. Hort. Sci.,* **8** (3-4) : 158-159.

Srihari, D., Singh, B. P. and Rao, D.V.R. (1987). Effect of foliar sprays of zinc and molybdenum on growth and yield of okra [*Abelmoschus esculentus* (L.) Moench] cv. PUSA SAWANI. *Prog. Hort*., **19** (1-2) : 31-34.

Subramanyam, K., Nair, A.K., Chattopadhyay, A. and Singh, D.V. (1991). Effect of zinc on yield, quality and nutrient composition of Japanese mint and availability of nutrients in soil. *J. Indian Soc. Soil Sci.,* **39** (2) : 399-401.

Swarup, Anand (1981). Effect of iron and manganese application on the availability of micronutrients to rice in sodic soil. *Plant & Soil,* **60** : 481-485.

Varghese, A. and Duraiswami, V.P. (2005). Effect of boron and zinc on yield, quality and mineral content of cauliflower. *South Indian J. Hort.,* **53**(1-6): 126-133.

■ WEBLIOGRAPHY

Anonymous (2008). A report by National Horticulture Board database 2008. *Website-http://www.nhb.gov.in*