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Effect of micronutrients on vegetative growth, yield and quality of Chilli (*Capsicum annum*)

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Abstract
The present experiment was carried out during June to October, 2018 in Research Field of Department of Horticulture, SHUATS, Prayagraj. The experiment was conducted in Randomized Block Design (RBD), with ten treatments, replicated thrice of Micronutrients and NPK. the treatments were T_0 (Control), T_1 ($ZnSo_4$ (0.2%), T_2 ($ZnSo_4$ (0.4%), T_3 ($ZnSo_4$ (0.6%), T_4 (Boric acid 0.25%), T_5 (Boric acid 0.50%), T_6 (Boric acid 0.75%), T_7 ($CuSo_4$ 0.2%), T_8 ($CuSo_4$ 0.4%) and T_9 ($CuSo_4$ 0.6%). From the present experimental findings it is found that the treatment T_6 (Boric acid (0.75%) was found superior over other treatments in terms of growth, yield and quality of Chilli, followed by treatment T_5 (Boric acid (0.50%), in terms of economics treatment T_6 (Boric acid 0.75%) recorded maximum gross return and Net return but maximum cost benefit ratio 1:2.70 was recorded in treatment T_4 (Boric acid (0.25%).

Keywords: Chilli, micronutrients, zinc, boron and copper

Introduction
Chilli (*Capsicum annum* L.) is one the most important vegetable as well as spice crop, It is a self-pollinated crop bearing a pod like fruit (berry) and has a predominant position among the spices grown all over lindia. It is being grown for green/red chillies in U.P. during summer rainy and winter season. Chilli is an indispensable condiment in India. The important chemical constituents of chilli fruits include vitamin, pungency, colouring matter oleoresin contents, which are particularly important for food and spice industries.

Chilli is grown in both tropical and subtropical areas at altitudes ranging from sea level to 200 meters above A temperature ranging from 20-25 ^{0}C is ideal for chilli cultivation. As rainfed crop it is down pour is detrimental as it leads to poor fruit set, besides causing rotting of the fruit

India is the largest consumer of Chilli in the world. Around 90% of India's production is consumed within the country. India exports around 80000 – 100000 tons of chillies a year. India exports chillies in the form of dried chillies, Chilli powder, picked chillies and Chilli oleoresin. Indian Chilli is mainly exported to USA, Sri Lanka, Bangladesh, the Middle East and the Far East. Chilli is one of the most important commercial crops of India. It is grown almost throughout the country. There are more than 400 different varieties of chillies found all over the world. It is also called as hot pepper, cayenne pepper, sweet pepper, bell pepper, etc.

Micronutrients are completely available to the plant and thus particularly effective because they are not fixed or diluted in large volumes of soil. However, overdosing or application at undesired time can lead to crop damage. For intensive cropping with continuously high yield levels more micronutrients are required, and hence it is best to use more frequent applications at the lower rate.

Materials and Methods
The present Experiment was conducted in Randomized Block Design (RBD) with 10 treatments of Micronutrients with three replications in the Research field of Department of Horticulture, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj during June to October, 2018. Total number of treatments were Ten *viz.* T_0 (Control), T_1 ($ZnSo_4$ 0.2%), T_2 ($ZnSo_4$ 0.4%), T_3 ($ZnSo_4$ 0.6%), T_4 (Boric acid 0.25%), T_5 (Boric acid 0.5%), T_6 (Boric acid 0.75%), T_7 ($CuSo_4$ 0.2%), T_8 ($CuSo_4$ 0.4%), T_9 ($CuSo_4$ 0.6%), Variety, Naamdhari were used.

Climatic condition in the experimental site

The area of Prayagraj district comes under subtropical belt in the south east of Utter Pradesh, which experience extremely hot summer and fairly cold winter. The maximum temperature of the location reaches up to 46º C- 48 ºC and seldom falls as low as 4 ºC- 5 ºC. The relative humidity ranges between 20 to 94%. The average rainfall in this area is around 1013.4 mm annually. However, occasional precipitation is also not uncommon during winter months.

Results and Discussion

The present investigation entitled **"**Effect of micronutrients on vegetative growth, yield and quality of chilli (*Capsicum annum*)" was carried out during June to October 2018 in Research Field of Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (U.P.) India. The results of the present investigation, regarding the effect of Micronutrients on vegetative growth, yield and quality of Chilli, have been discussed and interpreted in the light of previous research work done in India and abroad. The experiment was conducted in Randomized block design with 10 treatments, three replications.

The results of the experiment are summarized below.

Growth Parameters

In terms of Plant Height, treatment T_6 (Boric acid (0.75%)) recorded maximum (31.31, 44.85 and 57.91 cm) Plant Height at 30, 60 and 90 days respectively, after application micronutrients followed by T_5 (Boric acid (0.50%)) with (28.33, 40.92 and 53.36 cm) where as minimum Plant Height (10.37, 20.14 and 29.28 cm) was recorded in treatment T_0 (Control).

In terms of Plant spread, treatment T_6 (Boric acid (0.75%)) recorded maximum (24, 34.24 and 42.26 cm) Plant spread at 30, 60 and 90 days respectively, after application micronutrients followed by T_5 (Boric acid (0.50%)) with (20.54, 29.66 and 40.43 cm) where as minimum Plant spread (6.93, 14.31 and 21.89 cm) was recorded in treatment T_0 (Control). The improvement in Plant Height and Plant spread as a result of foliar feeding of micronutrients might be due to enhanced photosynthetic and other metabolic activities which lead to increase in various plant metabolites responsible for cell division and elongation as opined by Hatwar *et al.* (2003) [7] and Hazra *et al.* (1987) [8]. These results are in agreement with the findings of earlier workers Narayanamma *et al.* (2009) [16] in bitter gourd, Rab and Haq (2012) [18] in tomato and Kumar *et al.* (2010) [10] in cauliflower.

In terms of Number of Primary Branches/plant, treatment T_6 (Boric acid (0.75%)) recorded maximum (9.10, 11.42 and 12.27) Number of Primary Branches/plant at 30, 60 and 90 days respectively, after application micronutrients followed by T_5 (Boric acid (0.50%)) with (7.34, 10.83 and 11.57) where as minimum Number of Primary Branches/plant (2.97, 4.14 and 4.41) was recorded in treatment T_0 (Control).

In terms of Number of Secondary Branches/plant, treatment T_6 (Boric acid (0.75%)) recorded maximum (19.73) Number of Secondary Branches/plant, after application micronutrients followed by T_5 (Boric acid (0.50%)) with (16.81) where as minimum Number of Secondary Branches/plant (12.17) was recorded in treatment T_0 (Control). The increased number of branches might be due to better sink developed by auxiliary branches to a large amount of available nutrients as reported by Maya (1996) [12] in sweet pepper cv. (Califlornia Wonder). The results of present experiment are in consonance with the findings of Sabina (1995) in geraminium, Rab and Haq (2012) [18] in tomato, Shukla (2011) [20] in gooseberry.

Flowering Parameters

In terms of days to flower initiation, treatment T_6 (Boric acid (0.75%)) recorded minimum (31.61 days) for days to flower initiation, after application micronutrients followed by T_5 (Boric acid (0.50%)) with (32.90 days) where as maximum days for flower initiation (42.13 days) was recorded in treatment T_0 (Control).

In terms of days to 50% flowering, treatment T_6 (Boric acid (0.75%)) recorded minimum (37.14 days) for days to 50% flowering, after application micronutrients followed by T_5 (Boric acid (0.50%)) with (38.23 days) where as maximum days for 50% flowering (48.68 days) was recorded in treatment T_0 (Control). It may be due to the fact that the boron has significant role in mobilization of food materials from source to sink. Similar results were have also been obtained by Shukla (2011) [20] in Gooseberry.

In terms of Number of flowers/cluster, treatment T_6 (Boric acid (0.75%)) recorded maximum (15.86 flowers) for Number of flowers/cluster, after application micronutrients followed by T_5 (Boric acid (0.50%)) with (14.07 flowers) where as minimum Number of flower/cluster (6.14) was recorded in treatment T_0 (Control). The improvement in number of flowers per cluster as a result of feeding of micronutrients might be due to enhanced photosynthetic and other metabolic activities which lead to increase in various plant metabolites responsible for cell division and elongation as opined by Hatwar *et al.* (2003) [7] and Hazra *et al.* (1987) [8]. These results are in agreement with the findings of earlier workers, Rab and Haq (2012) [18] in tomato and Kumar *et al.* (2010) [10] in cauliflower.

Yield Parameters

In terms of Days to first picking, treatment T_6 (Boric acid (0.75%)) recorded minimum (81.84 days) for Days to first picking, after application micronutrients followed by T_5 (Boric acid (0.50%)) with (84.21 days) where as maximum Days for first picking (97.47 days) was recorded in treatment T_0 (Control).

In terms of Number of fruits/plant, treatment T_6 (Boric acid (0.75%)) recorded maximum (85.13 fruits/plant) for Number of fruits/plant, after application micronutrients followed by T_5 (Boric acid (0.50%)) with (78.73 fruits/plant) where as minimum Number of fruits/plant (44.13) was recorded in treatment T_0 (Control). The improvement in number of days taken for first fruit picking and Number of fruits per plant as a result of feeding of micronutrients might be due to enhanced photosynthetic and other metabolic activities which lead to increase in various plant metabolites responsible for cell division and elongation as opined by Hatwar *et al.* (2003) [7] and Hazra *et al.* (1987) [8]. These results are in agreement with the findings of earlier workers, Rab and Haq (2012) [18] in tomato and Kumar *et al.* (2010) [10] in cauliflower.

In terms of Fruit weight, treatment T_6 (Boric acid (0.75%)) recorded maximum (3.14 g) for Weight of fruit, after application micronutrients followed by T_5 (Boric acid (0.50%)) with (3.01 g) where as minimum Weight of fruit (1.37 g) was recorded in treatment T_0 (Control).

In terms of fruit length, treatment T_6 (Boric acid (0.75%)) recorded maximum (12.40 cm) for Length of fruit, after application micronutrients followed by T_5 (Boric acid (0.50%)) with (11.15 cm) where as minimum Length of fruit (6.47 cm) was recorded in treatment T_0 (Control). Increased

fruit weight and size attributed due to micronutrients application might be attributed to enhanced photosynthesis, accumulation of carbohydrates and favourable effect on vegetative growth which increased the fruits variety besides increasing the fruit size. These results get support from the findings of Kumbhlar and Deshmukh (1993), Bose and Tripathi (1996) [1] in tomato, Meenakshi *et al.* (2007) [14] and Narayanamma *et al*., (2009) [16] in bitter gourd.

In terms of Fruit yield/plot, treatment T_6 (Boric acid (0.75%)) recorded maximum (2.12 kg) for Fruit yield/plot, after application micronutrients followed by T_5 (Boric acid (0.50%)) with (1.89 kg) whereas minimum Yield of fruit/plot (0.483 kg) was recorded in treatment T_0 (Control).

In terms of Fruit yield/ha, treatment T_6 (Boric acid (0.75%)) recorded maximum (11.78 tones) for Fruit yield/ha, after application micronutrients followed by T_5 (Boric acid (0.50%)) with (10.50 tones) where as minimum Yield of fruit/ha (2.67 tones) was recorded in treatment T_0 (Control). The fruit growth and yield depends on the continued supply of food material and water (Huett and Deltmann, 1988) [9]. Since boron helps in the absorption of water and carbohydrates metabolism (Haque *et al*., 2011) [6], its deficiency may cause sterility, small fruit size and poor yield (Davis, *et al.*, 2003) [3]. The results of the present investigation in terms of number of fruit yield per plant are in collaborative with the findings of Narayanamma *et al.* (2009) [16] in bitter gourd and Meenakshi *et al.* (2007) [14] in bitter gourd and Venkatasalam and Krishnasamy (2011), Rab & Haq (2012) [18] in tomato.

Quality Parameters

In terms of Capsaicin content, treatment T_6 (Boric acid (0.75%)) recorded maximum (0.84%) for Capsaicin content, after application micronutrients followed by T_5 (Boric acid (0.50%)) with (0.81%) where as minimum Capsaicin content (0.71%) was recorded in treatment T_0 (Control). This lead to higher concentration of NPK and micronutrients in leaves and fruits and resulted in better accumulation of assimilates resulting in better quality parameters (Meenakshi *et al.*, 2007) [14] in bitter gourd. These results are in consonance with the findings of Shukla (2011) [20] in Indian goose berry.

In terms of Vitamin C, treatment T_6 (Boric acid (0.75%)) recorded maximum (153.14 mg) for Vitamin C, after application micronutrients followed by T_5 (Boric acid (0.50%)) with (147.09 mg) where as minimum Vitamin C mg/100g (116.94 mg) was recorded in treatment T_0 (Control). This lead to higher concentration of NPK and micronutrients in leaves and fruits and resulted in better accumulation of assimilates resulting in better quality parameters (Meenakshi *et al.*, 2007) [14] in bitter gourd. The Vitamin C content of fruits have been shown to correlate with available boron and are increased by both foliar and soil application of boron (Sathya *et al*., 2010) [19]. These results are in consonance with the findings of Shukla (2011) [20], in Indian goose berry and Rab and Haq (2012) [18] in tomato.

Economics

In terms of economics maximum gross return Rs. 530100.00 and Net Return Rs. 320226.00 was recorded in treatment T_6 (Boric acid 0.75%) but maximum Cost benefit ratio 1:2.70 was recorded in treatment T_4 (Boric acid (0.25%) followed by treatment T_6 (Boric acid (0.75%) with 1:2.52 and minimum Gross Return, Net Return and Cost Benefit Ratio (Rs. 277200.00, Rs. 29127.00 and 1:1.11 respectively) was recorded in treatment T_9 ($CuSo_4$ (0.6%).

Table 1: Effect of micronutrients on Plant height (cm), Plant Spread (cm), Number of primary branches/plant, Number of Secondary branches/plant, Days to flower initiation, Days to 50% Flowering and Number of flowers/cluster of Chilli (*Capsicum annum*).

Treatment Symbol	Treatment Combination	Plant Height (cm)			Plant Spread (cm)			Number of Primary Branches/plant			Number of Secondary Branches/ Plant	Days to Flower Initiation	Days to 50% Flowering	Number of Flower/ Cluster
		30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS				
T_0	Control	10.37	20.14	29.28	6.93	14.31	21.89	2.97	4.14	4.41	12.17	42.13	48.68	6.14
T_1	$ZnSo_4$ (0.2%)	16.00	31.02	42.64	10.88	19.94	30.24	3.45	6.73	7.26	13.21	38.19	44.27	7.64
T_2	$ZnSo_4$ (0.4%)	17.25	33.49	45.03	11.72	22.05	32.49	3.90	7.65	7.93	14.50	37.52	43.24	8.88
T_3	$ZnSo_4$ (0.6%)	16.73	27.84	40.44	11.22	21.31	31.00	4.02	6.89	7.70	13.40	38.12	43.56	10.05
T_4	Boric acid (0.25%)	26.22	37.38	48.25	18.02	26.29	36.72	7.18	9.58	10.24	15.44	35.63	41.81	12.67
T_5	Boric acid (0.5%)	28.33	40.92	53.36	20.54	29.66	40.43	7.34	10.83	11.57	16.81	32.90	38.23	14.07
T_6	Boric acid (0.75%)	31.31	44.85	57.91	24.00	34.24	42.15	9.10	11.42	12.27	19.73	31.61	37.14	15.86
T_7	$CuSo_4$ (0.2%)	23.10	35.85	45.68	16.45	25.80	34.12	5.52	8.57	9.19	13.08	34.59	40.20	8.34
T_8	$CuSo_4$ (0.4%)	24.38	36.10	46.88	16.67	26.12	35.14	5.86	9.17	9.68	14.17	36.33	43.29	10.97
T_9	$CuSo_4$ (0.6%)	25.53	37.65	47.87	17.78	27.46	36.24	5.59	9.24	10.05	13.54	35.57	42.80	10.65
F-Test		S	S	S	S	S	S	S	S	S	S	S	S	S
SE(d)		0.713	1.012	1.238	1.120	0.928	1.333	0.350	0.371	0.483	0.489	0.611	0.683	0.782
C.V.		3.984	3.591	3.315	8.896	4.600	4.795	7.804	5.399	6.558	4.100	2.064	1.976	9.098
C.D. at 5%		1.510	2.143	2.621	2.372	1.966	2.822	0.741	0.786	1.024	1.035	1.294	1.446	1.656

Table 2: Effect of micronutrients on Days to first picking, Number of fruits/plant, Weight of fruit (g), Length of fruit (cm), Fruit yield/plant (kg), Fruit yield tones/ha, Capsaicin content (%), Vitaminc C mg/100g and Cost Benefit ratio of Chilli (*Capsicum annum*).

Treatment Symbol	Treatment Combination	Days to first Picking	Number of Fruits/Plant	Weight of Fruit (g)	Length of Fruits (cm)	Fruit Yield/Plot (Kg)	Fruit Yield Tones/ha	Capsaicin Content (%)	Vitamin C mg/100 g	Cost Benefit Ratio
T_0	Control	97.47	44.13	1.37	6.47	0.483	2.67	0.71	116.94	1:1.41
T_1	$ZnSo_4$ (0.2%)	92.12	60.61	2.08	8.65	0.995	5.52	0.74	128.03	1:2.09
T_2	$ZnSo_4$ (0.4%)	90.44	64.29	2.52	9.70	1.28	7.11	0.75	132.19	1:2.10
T_3	$ZnSo_4$ (0.6%)	93.14	61.70	2.23	9.32	1.09	6.05	0.73	130.37	1:1.46
T_4	Boric acid (0.25%)	87.24	70.17	2.65	10.61	1.48	8.22	0.78	142.35	1:2.70
T_5	Boric acid (0.5%)	84.21	78.73	3.01	11.15	1.89	10.50	0.81	147.09	1:2.49
T_6	Boric acid (0.75%)	81.84	85.13	3.14	12.40	2.12	11.78	0.84	153.14	1:2.52
T_7	$CuSo_4$ (0.2%)	91.35	58.61	2.22	8.68	1.03	5.72	0.74	124.82	1:1.84
T_8	$CuSo_4$ (0.4%)	92.39	62.19	2.42	9.57	1.19	6.61	0.76	129.87	1:1.53
T_9	$CuSo_4$ (0.6%)	92.64	60.64	2.31	9.28	1.11	6.16	0.75	126.75	1:1.11
F-Test		S	92.64	S	S	S	S	S	S	
SE(d)		1.183	1.528	0.182	0.384	0.089	0.498	0.032	1.792	
C.V.		1.604	2.896	9.300	4.911	8.628	8.666	5.117	1.648	
C.D. at 5%		2.504	3.235	0.385	0.814	0.189	1.054	0.067	3.794	

Conclusion

From the present experimental findings it is concluded that the treatment T_6 (Boric acid (0.75%) was found superior over other treatments in terms of growth, yield and quality of Chilli, followed by treatment T_5 (Boric acid (0.50%), in terms of economics treatment T_6 (Boric acid 0.75%) recorded maximum gross return and Net return but maximum cost benefit ratio 1:2.70 was recorded in treatment T_4 (Boric acid (0.25%).

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