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Shatis Xaxa
Department of Horticulture, SHUATS, Allahabad, Uttar Pradesh, India

Praveen choyal
Department of Horticulture, SHUATS, Allahabad, Uttar Pradesh, India

Radhelal Dewangan
Department of Horticulture, SHUATS, Allahabad, Uttar Pradesh, India

Preeti Toppo
Department of Horticulture, SHUATS, Allahabad, Uttar Pradesh, India

Mithlesh Gupta
Department of Biological Science. SHUATS, Allahabad, Uttar Pradesh, India

Sunny Abhisek Tigga
Department of Soil Science, SHUATS, Allahabad, Uttar Pradesh, India

Correspondence
Shatis Xaxa
Department of Horticulture, SHUATS, Allahabad, Uttar Pradesh, India

Effect of different micronutrients on plant growth and yield of broccoli (*Brassica oleracea* var. *Italica*) Palam Samridhi

Shatis Xaxa, Praveen Choyal, Radhelal Dewangan, Preeti Toppo, Mithlesh Gupta and Sunny Abhisek Tigga

Abstract
A field experiment was conducted broccoli (*Brassica oleracea* var. *Italica*) cv. – Palam smaridhi" during rabi season of 2016-17 Horticulture Research farm, Department of Horticulture, Naini Agricultural Institute, SHUATS, Allahabad. The experiment laid out in Randomized Block Design (RBD) with three replications. The micronutrients (B, Mn and Zn) were applied at the rate of 2.5 kg (B), 3 kg (Mn), 2 kg (Zn) per hectare significantly increased the plant height (53.61 cm), number of leaves (25.23), Plant spread (54.51 cm), diameter of bud or head (17.81 cm), average bud weight of per plant (571.83 gm), yield ha-1 (134.05 q), vitamin c (92.34 mg), TSS (^{0}Brix) (8.23) content, Plant fresh weight (897.00 gm), dry plant matter (96.48 gm), root weight (46.63 gm) and dry weight (12.63 gm) were maximum in treatment T_5 and lowest in T_0 (control). It is also concluded that treatment T_5 (B + Mn +Zn) was found economically best in treatment of cost benefit ratio i.e. (1:3.47) followed by (1:2.99) with T_7 (B + Mo + Mn + Zn).

Keywords: Broccoli, micronutrient, growth and yield

Introduction
Broccoli (*Brassica oleracea* var. *italica*) which is one of the exotic vegetable introduced in India of the curciferae family is believed to be the first of the crops to evolve from the wild species of kale or cabbage and was cultivated by Romans. The first selection sprouting Broccoli was probably made in Greece and in the pre-Christian era (Heywood, 1978) [4].
Exotic vegetables laced with nutritionally important components vitamins, minerals, fibres, antioxidants and other micronutrients are presently considered one of the most indispensable items in human diet. Our country having diverse climatic conditions and well distinct cropping season, offers a great scope to grow these unconventional vegetables commercially (Pandey and Mathura Rai, 2005). The word broccoli comes from the Italian plural of broccolo, which means "the flowering crest of a cabbage", and is the diminutive form of brocco, meaning "small nail" or "sprout". Broccoli is often boiled or steamed but may be eaten raw. Broccoli commonly known as harigobhi or broccoli in Hindi is gainig popularity in India also. In the world market about 40 percent is marketed as fresh and remaining 60 percent as frozen. It is used in salad, cooked in curries, boiled and also processed (Sharma, 2003 and Bose, 2002) [8].
It also affects sugar transport and appears to be associated with some of the functions of calcium. Boron affects pollination and the development of viable seeds which in turn affect the normal development of fruit. Boron is taken up by plant roots as the neutral molecule $HB4O_7^-$ and BO_3^-. A molybdenum function of enzyme nitrate reductive which is responsible for reduction of nitrate to nitrite during N assimilation in plants. Molybdenum is available to plants as the $HMoO_4^-$ ion.

Materials and Methods
The experiment was carried out at the Horticulture Research Farm, Department of Horticulture, Naini Agricultural Institute, SHUATS, Allahabad U.P. Design and layout of experiment Ten treatments having one variety were laid out in Randomized Block Design (RBD) with three replications. The treatments (Table 1&2) in each replication were allotted randomly. Ten treatments having one variety were tried in the experimental design. Allahabad is situated in the agro-climatic zone (Sub-tropical belt) of Uttar Pradesh.

The Geographical area falls under sub-tropical climate and is located in between 25.870 North latitude and 81.150 E longitudes at an altitude of 78 meter above the mean sea level (MSL). The area of Allahabad District comes under sub-tropical belt in the south eastern Uttar Pradesh.

Table 1: Details of Treatments

Treatment Symbol	Treatment Combination
T_0	Control
T_1	Boron(B) (2.5 kg/ha)
T_2	Molybdenum(Mo)(0.5kg/ha)
T_3	Manganese(Mn) (3 Kg/ha)
T_4	Boron(2.5kg/ha) + Molybdenum(0.5 kg/ha)
T_5	Boron(2.5 kg/ha) + Manganese (0.5) + Zinc (2 kg /ha)
T_6	Molybdenum(0.5 kg/ha) + Manganese(3 kg/ha)
T_7	Boron(2.5 kg/ha) + Molybdenum(0.5 kg/ha) + Manganese(3 kg/ha) + Zinc(2 kg/ha)
T_8	Boron(2.5 kg/ha) + Zinc(2 kg /ha)
T_9	Zinc(Zn) (2 kg/ha)

Table 2: Micronutrients combinations

S. No	Micro Nutrients	Fertilizers source	% Content	Fertilizer Kg/ha	Micro nutrient	Per plot (mg)	Per plant (mg)
1.	Boron	Borax	10.50	12.50	2.50	300	50.00
2.	Molybdenum	Sodium Molybdenum	39.00	2.00	0.50	80.0	13.33
3.	Manganese	Manganese sulphate	30.50	12.00	3.00	380	63.30
4.	Zinc	Zinc sulphate	23.00	8.00	2.00	450	75.00

Results and Discussion

The results of the analysis of variance for different quantitative characters for 10 treatment and one variety of broccoli. The results indicated that there is highly significant variation among the genotypes for almost all the characters under study. The results of the experiments are presented separately under this chapter with following heading.

Pre- Harvest observations

Plant height (cm)

At 20 DAT the plant height was maximum (15.03 cm) in T_5 (B + Mn + Zn) followed by T_7 (B + Mo + Mn + Zn) (14.11) and T_9 (Zn) (13.33) the lowest plant height (11.67) cm. found in T_0 (control).

At 40 DAT the plant height was maximum (35.36) in T_5 (B + Mn + Zn) followed by T_6 (Mo + Mn) (34.94) and T_8 (B + Zn) (34.27). The lowest plant height (31.79) cm. found in T_0 (control).

At 60 DAT the plant height was maximum (53.61) in T_5 (B + Mn + Zn) followed by T_3 (Mn) (49.31) and T_7 (B + Mo + Mn + Zn) (48.07), the lowest plant height (43.09) cm. found in T_0 (control). These results similar finding were recorded by Alam and Azad (2010) [3] on onion.

Number of leaves per plant

At 20 DAT the number of leaves per plant was maximum (7.07) in T_5 (B + Mn + Zn) followed by T_7 (B + Mo + Mn + Zn) (6.53) and T_6 (Mo + Mn) (6.40). The lowest number of leaves per plant (4.80) cm. found in T_0 (control).

At 40 DAT the number of leaves per plant was maximum (14.07) in T_5 (B + Mn + Zn) followed by T_8 (B + Z) (13.27) and T_3 (Mn) (12.40).The lowest number of leaves per plant (8.80) cm. found in T_0 (control).

At 60 DAT the number of leaves per plant was maximum (25.23) in T_5 (B + Mn + Zn) followed by T_7 (B + Mo + Mn + Zn) (23.67) and T_6 (Mo + Mn) (23.13). The lowest number of leaves per plant (19.53) cm. found in T_0 (control). These results are similar recorded by Alam and Azad (2010) [3] on onion and Naga *et al.* (2011) in tomato.

Plant Spread (cm)

At 20 DAT the plant spread was maximum (15.04) in T_5 (B + Mn + Zn) followed by T_7 (B + Mo + Mn + Zn) (14.26) and T_4 (B + Mo) (13.93). The lowest plant spread (10.73) cm. found in T_0 (control).

At 40 DAT the plant spread was maximum (35.74) in T_5 (B + Mn + Zn). Followed by T_7 (B + Mo + Mn + Zn) (34.39) and T_4 (B + Mo) (34.09). The lowest plant spread (29.93) cm. found in T_0 (control).

At 60 DAT the plant spread was maximum (54.51) in T_5 (B + Mn + Zn) followed by T_6 (Mo + Mn) (49.77) and T_9 (Zn) (48.52). The lowest plant spread (43.49) found in T_0 (control). These results finding are closely by Inayat Rahman, *et al.*, (2013) [5] in cauliflower.

Post-Harvest Observations

Bud or head diameter (cm)

Maximum number of frouds (17.81) was observed in T_5 (B + Mn + Zn) followed by T_7 (B + Mo + Mn + Zn) (16.94). T_6 (Mo + Mn) (16.35) and minimum Head diameters (cm) (13.34) were found in T_0 (control). Positive effects of micronutrients on bud or head diameter may be due to the better availability of soil nutrients that produced healthy plant with large vegetative growth, which reflected head diameter and improvement soil chemical and physical properties by using different micronutrients. These results were finding similar by Niruzzaman and Rahman *et al*., (2007) in broccoli, Jamre, *et al*., (2010) [6], and Alam, *et al*. (2010) [3].

Head weight per plant

The maximum head bud weight per plant T_5 (B + Mn + Zn) (571.83), followed by T1 (B) (368.99) and T_7 (B + Mo + Mn + Zn) (353.01). The lowest head bud weight per plant was recorded in T_0 (control) (190.87).

Head yield per ha of broccoli

The maximum head or bud yield per ha recorded (134.05 mg) in T_5 (B + Mn + Zn) followed by T_4 (B+ Mo) (119.09) and T_7 (B + Mo + Mg + Zn) (115.55). The lowest head or bud yield per ha was found in case of T_0 (control) (72.17).

The Significant variations in bud weight might have been due to bud, bud diameter and number of froud per bud. These results are similar finding by Alam *et al.,* (2010) [3] and Naga *et al.,* (2011).

Fresh Weight (gm)
Different micronutrients application significantly influenced the fresh weight (gm) over control. Table and fig 4.11 reveals that the maximum fresh weight 897.00 cm was recorded with T_5 (B + Mn + Zn) followed by T_9 (Zn) (870.13) and T_6 (Mo + Mn) (841), which were significantly higher than other treatment. The lowest fresh weight (676.87 cm) was observed in treatment T_0 (control).

Fresh root weight of per plant
The fresh root weight of per plant was significantly influenced by the different treatment combination tried. The treatment T_5 (B + Mn + Zn) had significantly the highest fresh root weight of per plant (46.63 gm) followed by T_7 (B + Mo + Mn + Zn) (54.53) and T_6 (Mo + Mn) (44.69). Lowest fresh root weight of per plant (34.65gm) was observed in T_0 (control).

Dry weight of per plant
The dry weight of per plant was significantly influenced by the different treatment combination tried. The treatment T_5 (B + Mn + Zn) had significantly the highest dry weight of per plant (96.48 gm) followed by T_7 (B + Mo + Mn + Zn) (92.35) and T_9 (Zn) (86.54). Lowest dry weight of per plant (74.10 gm) was observed in T_0 (control).

Dry root weight of per plant
The Dry root weight of per plant was significantly influenced by the different treatment combination tried. The treatment T_5 (B + Mn + Zn) had significantly the highest Dry root weight of per plant (12.63 gm) followed by T_7 (B + Mo + Mn + Zn) (12.49)and T_4 (B + Mo) (11.84). Lowest Dry root weight of per plant (8.35gm) was observed in T_0 (control).

Table 3: Effect of different micronutrients on plant height, Number of leaves and plant spread at 60 DAT of broccoli

Treatment symbol	Treatment combination	Plant height (cm)			Number of leaves/ plant			Plant spread (cm)		
		20 DAT	40 DAT	60 DAT	20 DAT	40 DAT	60 DAT	20 DAT	40 DAT	60 DAT
T_0	Control	11.67	31.79	43.09	4.80	8.80	19.53	10.73	29.28	43.49
T_1	B	12.68	32.30	46.98	5.40	9.20	21.47	12.97	33.34	45.34
T_2	Mo	12.51	32.92	47.07	5.67	10.40	20.60	11.97	30.93	44.97
T_3	Mn	12.93	33.58	49.31	6.07	12.40	21.53	13.33	33.52	46.75
T_4	B + Mo	13.08	33.97	45.94	6.20	11.80	23.07	13.93	34.09	45.55
T_5	B + Mn + Zn	15.03	35.36	53.61	7.07	14.07	25.53	15.04	35.74	54.51
T_6	Mo + Mn	13.08	34.94	47.90	6.40	12.33	23.13	13.37	32.89	49.77
T_7	B + Mo + Mn + Zn	14.11	33.41	48.07	6.53	11.60	23.67	14.26	34.39	46.06
T_8	B + Zn	13.19	34.27	46.88	5.87	13.27	21.93	13.31	33.03	47.39
T_9	Zn	13.33	33.75	47.96	4.93	12.27	22.47	13.54	33.45	48.52
F-test		S	S	S	S	S	S	S	S	S
$S.E_d(\pm)$		0.268	0.185	0.185	0.199	0.313	0.392	0.118	0.143	0.106
C.D at 5%		0.562	0.388	0.389	0.418	0.658	0.824	0.248	0.301	0.222

Table 4: Effect of different micronutrients on post-harvest Observation and quality parameters of broccoli

Treatment symbol	Treatment combination	Head diameter (c.m)	Head bud weight per plant	Fresh weight (gm)	Fresh root weight of /plant	Dry weight of per plant	Dry root weight of per plant	Head or bud yield per ha
T_0	Control	13.34	190.87	676.87	34.65	74.10	8.35	72.17
T_1	B	14.43	368.99	768.00	42.94	81.36	9.93	94.99
T_2	Mo	16.21	320.53	763.60	41.73	77.15	11.43	97.23
T_3	Mn	14.25	294.36	832.80	43.86	86.73	11.56	97.16
T_4	B + Mo	16.20	349.60	446.07	43.59	86.29	11.84	119.09
T_5	B + Mn + Zn	17.81	571.83	897.00	46.63	96.48	12.63	134.05
T_6	Mo + Mn	16.35	331.35	841.00	44.69	81.15	10.70	113.39
T_7	B + Mo + Mn + Zn	16.94	353.01	821.00	45.53	92.35	12.49	115.55
T_8	B + Zn	15.56	293.50	783.40	43.55	85.39	10.49	108.51
T_9	Zn	14.43	333.57	870.13	42.75	86.54	11.45	111.72
F-test		S	S	S	S	S	S	S
$S.E_d(\pm)$		0.091	1.176	4.766	0.120	0.332	0.108	0.371
C.D at 5%		0.190	2.471	10.013	0.251	0.697	0.227	0.779

Conclusion
The present investigation it is concluded that treatment T5 B (2.5 kg/ha) + Mn (3kg/ha) + Zn (2 kg /ha) was found to be the best treatment combinations in terms of growth, yield, and flower bud quality. Where the highest Benefit cost ratio i.e. (1:3.78) was also found to be the best with treatment T5 B (2.5 kg/ha) + Mn (2kg/ha) +Zn (2kg/ha).

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