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Effect of Different Micronutrients on PlantGrowth, Yield and Flower Bud Quality of Broccoli (*Brassica Oleracea Var. Italica*)

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ABSTRACT

A field experiment was conducted to study the "Effect of different micro nutrients on plant growth, yield and flower bud quality of broccoli (*Brassica oleracea Var. Italica*) cv. – Green Bud" during *rabi* season of 2014-15 Research field, Department of Horticulture, Allahabad School of Agriculture, Sam Higgin bottom Institute of Agriculture, Technology and Sciences Allahabad. The experiment consists of 10 treatment *viz,* T_0 (control), T_1 (B), T_2 (Mo), T_3 (Mn), T_4 (B + Mo), T_5 (B+ Mn +Zn), T_6 (Mo +Mn), T_7 (B +Mo +Mn +Zn), T_8 (B +Zn), T_9 (Zn**)** laid out in Randomized Block Design (RBD) with three replications. The micronutrients (B, Mo, Mn and Zn) were applied at the rate of 2 kg (B), 0.5 kg (Mo), 2.5 kg (Mn), 3 kg (Zn) per hectare significantly increased the plant height (51.30 cm), number of leaves(22.92), Plant spread (52.83 cm), diameter of bud or head (16.90 cm), average bud weight of per plant (303.69 gm), yield ha^{-1}(121.48q), vitamin 'C' (93.92 mg), TSS (^{0}Brix) (8.37) content, Plant fresh weight (908.28 gm), dry plant matter(95.61 gm), root weight (45.02 gm) and dry weight(11.65 gm) were maximum in treatment T_5 and lowest in T_0 (control) under Allahabad agro climatic condition.

Keyword: Broccoli, Bud yield, Dry matter, Growth parameter, , TSS, Vitamin-C

INTRODUCTION

Broccoli (*Brassica oleracea var. italic*) 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 [8]. Broccoli probably evolved in Roman times from wild or primitive cultivated forms of (*Brassica oleracea*) from the Mediterranean region. A remarkable diversity of cauliflower and broccoli-like vegetables developed in Italy. Broccoli is an edible green plant in the cabbage family whose large, flowering head is eaten as a vegetable.[15] 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[4]. A Broccoli consists of immature flowering buds which would commonly contain the energy for a plant to fruit it is very high nutrients and often termed as super- food. Broccoli which is nutritious among cole crops being rich in vitamin and minerals and boiling broccoli reduces the levels of suspected anti-carcinogenic compounds, such as sulforaphane[1]. Broccoli has about 14 times more beta-carotene a precursor of vitamin A than commonly cultivated cabbage[21]. It has high amount of vitamin C and significant amount of potassium, folic acid and several phytochemicals. It can also be a good source of calcium and this can be enhanced if the soil is limed. It has anti carcinogenic properties and has been found useful for number of other diseases. Due to its high levels of vitamin C, beta carotene and fibre broccoli is a powerful antioxidant. High fibre content also believed to be of benefit in case of diabetes. It has as much calcium as milk, and is therefore an important source of nutrition for those with osteoporosis or calcium deficiencies.[15]

Manganese is necessary for chlorophyll formation for photosynthesis, respiration, and nitrate assimilation and for the activity of several enzymes. The form available to plants is the Mn^{++} ion. Manganese availability is related more to soil pH than soil test manganese levels.

Boron is much required for cell division and development in the growth regions of the plant near the tips of shoots and roots. 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 $HB_4O_7^-$ 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.

Zinc is important for the formation and activity of chlorophyll and in the functioning of several enzymes and the growth hormone, Auxin. The form of zinc available to plants is the Zn^{2+} ion. Zinc deficiency can occur on alkaline soils and sandy soils low in organic matter.[7,18]

MATERIALS AND METHODS

The experiment entitled "Effect of different micro nutrients on plant growth, yield and flower bud quality of broccoli **(***Brassica oleracea var. Italica***)** cv. – Green Bud" was carried out at Research field, Department of Horticulture, Allahabad School of Agriculture, Sam Higgin bottom Institute of Agriculture, Technology and Sciences (formerly known as Allahabad Agriculture Institute Deemed to-be University, AAI-DU) Allahabad during year 2014-2015. The Geographical area falls under sub-tropical climate and is located in between 25.87^0 North latitude and 81.15^0 E longitudes at an altitude of 78 meter above the mean sea level (MSL).

Table 1: Effect of different micronutrients on plant height, Number of leaves and plant spread at 60 DATof broccoli

Treatment symbol	Treatment combination	Plant height (cm)	Number of leaves	Plant spread (cm)
T0	Control	42.84	19.00	43.89
T1	B	46.81	20.42	46.41
T2	Mo	45.53	21.33	44.09
T3	Mn	47.89	21.58	47.89
T4	B + Mo	45.37	21.83	45.54
T5	B + Mn + Zn	51.30	24.25	52.83
T6	Mo + Mn	48.03	22.08	49.06
T7	B + Mo + Mn + Zn	48.99	22.92	46.15
T8	B + Zn	47.05	22.33	48.24
T9	Zn	47.47	22.50	49.15
S.Ed(±)		0.36	0.32	0.47
CD at 5%		0.75	0.67	0.98

Soil characteristics of the experimental site

The experimental site is fairly level land with sandy loam soil of uniform fertility status with low clay and high send percentage. Composition soil sample were collected at random spots from depth of 0-30 cm and the sol was analyzed for pH, electrical conductivity (EC), organic carbon, available nitrogen, available phosphorous and available potassium are presented in table.

Experimental Design

Ten treatments having one variety were laid out in Randomized Block Design (RBD) with three replications. The treatments in each replication were allotted randomly. Ten treatments having one variety were tried in the experimental design. According to the treatment the micro nutrients (B: Mo: Mn: Zn – 2: 0.5: 2.5: 3 kg/ha) are applied (Soil incorporate) before transplanting.

Treatment combination

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

Statistical analysis

The data on growth yield and quality components were subjected to Fisher's method of analysis of variance (ANOVA), where the 'F' tests was significant for comparison of the treatment means, CD values were worked out at 5% probability level.[2]

Analysis of Variance (ANOVA)

Analysis of treatment for all treatments in Randomized Block Design was carried out. For testing the hypothesis the following ANOVA table was used.

Skeleton of ANOVA

Where, d.f.= Degree of freedom, r=replication, S.S.=Sum of squares, t=treatment, M.S.S. =Mean sum of squares, R.S.S. =Replication sum of squares, T.S.S.=Total sum of squares, E.S.S.=Error sum of squares, M.R.S.S.=Mean replication sum of squares, M.T.S.S.=Mean treatment sum of squares, M.E.S.S.=S.E. (d) x't' error d.f. at 5% level of significance

$$\text{S.E. (d)} = \sqrt{\frac{2 \times \text{M.E.S.S.}}{r}}$$

The significance and non-significance of the treatment effect was judged with the help of 'F' variance ratio test. Calculated 'F' value was compared with the table value of 'F' at 5% level significant. If the calculated value exceeds the table value, the effect was considered to be significant.

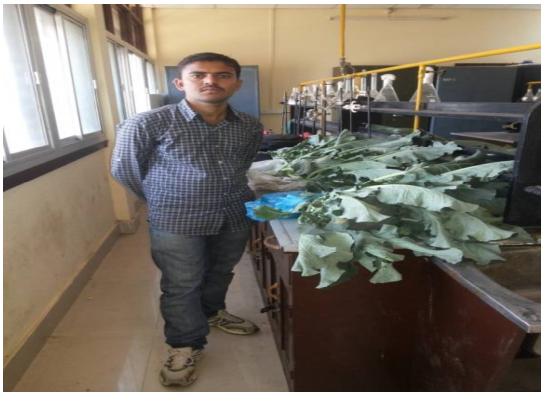

Fig. 1

The significant differences between the mean were tested against the critical differences at 5% level of significance. For testing the hypothesis, the ANOVA table was used.

Table: Physical and chemical properties of soil of experimental site (SHIATS, Allahabad)

S. No.	Particulars	Value(0-30 cm depth)	Method followed
Physical properties			
1.	Sand	48.15%	Bouyoucos hydrometer method [5]
2.	Silt	20.30%	
3.	Clay	30.50%	
4.	Textural class	Sandy laom	
Chemical properties			
1.	Soil pH	6.89	Potentiometer
2.	EC(dsm^{-1} at 25^{0} C)	0.21	Electrical Conductivity Meter
3.	Organic carbon	0.46%	Hydrochloric oxidation method [25]
4.	Available nitrogen (k ha^{-1})	214.6	Alkaline permangananate method [23]
5.	Available phosphorus (k ha^{-1})	36.64	Olsen's Colorimetric method [16]
6.	Available potassium (k ha^{-1})	212.05	Flame Photometric method [9].
7	Available Zinc (mg/kg)	0.016	MDLs (Method Detection Limits)
8	Available Molybdenum (mg/kg)	0.08	MDLs (Method Detection Limits)
9	Available Boron (mg/kg)	0.020	MDLs (Method Detection Limits)
10	Available Manganese (mg/kg)	0.04	MDLs (Method Detection Limits)[2]

Observational details

Five plants from each net plot were randomly selected and they were labeled. These plants were used for recording all morphological observations in respect of growth, yield and fruit bud quality of the crop. The details of the observations recorded are given below:

Pre- Harvest observations

- Plant Height (cm) (60 DAT)
- Number of leaves per plant (60 DAT)
- Plant Spread (cm) (60 DAT)

Post-Harvest Observations

- Diameter of the Flower Bud (cm)
- Flower Bud weight (g)
- Total head (bud) yield ha^{-1} (q)
- Vitamin-C content in head (mg/100 g)
- Total Soluble Solid (T.S.S. ^{0}Brix)
- Fresh weight of plant (g)
- Root weight (g)

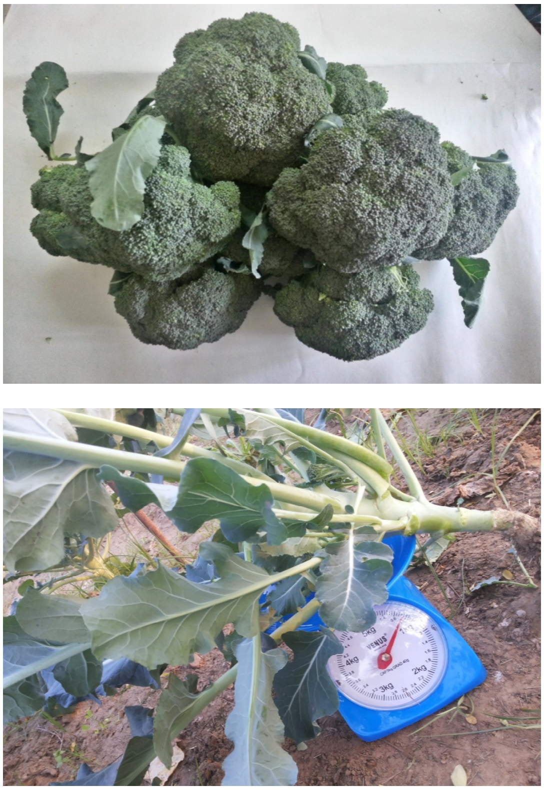

Fig. 2

Table Skeleton of ANOVA

Source of variation	d.f.	S.S.	M.S.S.	F.cal.	F(table) at Result5%
Due to replication	(r-1)	R.S.S.	$\frac{\text{R.S.S.}}{\text{r-1}}$	$\frac{\text{M.R.S.S.}}{\text{M.E.S.S.}}$	
Due to treatment	(t-1)	T.S.S.	$\frac{\text{T.S.S}}{\text{t-1}}$	$\frac{\text{M.T.S.S.}}{\text{M.E.S.S.}}$	(r-1) (t-1)
Due to error	(r-1) (t-1)	E.S.S.	$\frac{\text{E.S.S.}}{\text{(r-1) (t-1)}}$	M.E.S.S.	F(t-1) (r-1)(t-1)
Total	(rt-1)	TSS	-	-	-

Table 2: Micronutrients combinations

S. N.	Micro-nutrients	Fertilizers source	% content	fertilizer Kg/ha	Micro-nutrient kg/ha	Per plot (mg)	Per plant (mg)
1	Boron	Borax	11	18.18	2	300	50
2	Molybdenum (Mo)	Sodium Molybdenum	39	1.28	0.5	80	13.33
3	Manganese (Mn)	Manganese sulphate	32	9.81	2.5	380	63.3
4	Zinc	Zinc Sulphate	23	13.04	3	450	75

Table 2: Effect of different micronutrients on post harvest Observation and quality parameters of broccoli

Treatment symbol	Treatment combination	Bud diameter (cm)	Bud weight /plant(g)	Head yield / hectare (q)	TSS (0brix)	Vitamin 'c' (mg)	Fresh weight (g) of per plant	Root weight of per plant (g)
T0	Control	14.04	182.15	72.86	6.46	78.81	725.92	35.43
T1	B	14.53	238.32	95.33	6.67	81.81	754.12	42.09
T2	Mo	14.98	242.47	96.99	7.28	80.22	728.78	39.22
T3	Mn	15.35	241.77	96.71	7.00	84.74	835.77	41.62
T4	B + Mo	14.39	285.98	114.39	7.60	87.67	839.79	42.57
T5	B + Mn + Zn	16.90	303.69	121.48	8.37	93.92	908.28	45.02
T6	Mo + Mn	15.58	260.57	104.23	7.38	88.43	741.23	43.91
T7	B + Mo + Mn + Zn	15.73	287.61	115.04	7.53	80.83	867.65	43.19
T8	B + Zn	16.28	261.82	104.73	7.68	81.24	826.00	43.52
T9	Zn	15.95	265.17	106.07	7.89	85.01	826.74	42.88
S.Ed(±)		0.50	6.37	2.55	0.15	0.97	18.51	0.46
CD at 5%		1.05	13.38	5.35	0.31	2.04	38.88	0.97

RESULTS AND DISCUSSION

Pre- Harvest observations

Plant height

The results pertaining of the effect applied through different micro nutrients on plant Height (cm) of broccoli at 60 DAT (Day after transplanting) are presented in table 1. The plant height at 60 DAT found maximum in T_5 (B + Mn + Zn) is 51.30 cm. followed by 48.99 in T_6 (B + Mo + Mn + Zn). The minimum was found in T_0 (control) 42.84 cm.[3,6]

Number of leaves per plant

The data presented in table 1 clearly showed that the micro nutrients played significant role in directly affecting the number of leaves per plant. The maximum number of leaves per plant was recorded statistically significant with micro nutrients application of B+Mn+Zn (T_9), which was recorded (24.25) leaves, followed by T_9 (B + Mo + Mn + Zn) (22.92) leaves. The minimum number of leaves per plant (19.00) was noticed with control.[6,10]

Plant Spread

The data on plant spread which was which was observed at 60 DAT Day after transplanting are presented in the table 1. At 60 DAT maximum plant spread was found in T_5 (B + Mn + Zn) 52.8cm followed by 49.15 cm in T_9 (Zn). The minimum plant spread 29.76 cm and 43.89 cm was found T_0 (control).[3,6]

Post-Harvest Observations

Bud or Head Diameter

Different micro nutrients application significantly influenced the bud or head diameter over control. The maximum bud Diameter is 16.90 cm was recorded with T_5 (B + Mn +Zn) followed by 16.28 cm in T_{8} (B +Zn) and T_7 (B + Mo + Mn + Zn) i.e. 15.73 cm, which were significantly higher than other. The lowest bud diameter (14.04 cm) was observed in treatment T_0 (control).[11,12,13]

Bud or Head Weight

Table 2 shows that the bud weight was significantly influenced by the different treatment combination tried. The treatment T_5 (B + Mn + Zn) had significantly the highest bud weight (303.69 g followed by T_7 (B + Mo + Mn +Zn) was 287.61 g. Lowest bud weight 182.15 g was observed in T_0 (control).[12,13,14]

Bud or Head yield per hectare

The table 2 shows that the treatment T_5 (B + Mn + Zn) and T_7 (B + Mo + Mn +Zn) had significantly more yield per hectare than other treatment (121.48 and 115.04 q/ha. The yield of treatment T_2 (Mo) and T_3 (Mn) was almost similar (96.99 and 96.71 q/ha, respectively. The treatment T_0 (control) recorded lowest yield per hectare (72.86 q/ha).[12,13,14,19]

Total soluble solid (^{0}BRIX)

There was a significant difference among various treatment combinations. The maximum T.S.S (^{0}Brix) value T_5 (B + Mn + Zn) 8.37, followed by T_9 (Zn) 7*.89*. The lowest T.S.S (^{0}Brix) value was recorded in T_0 (control) 6.46 Table 2.[14,19]

Vitamin C (mg/100gm Broccoli fresh tissue)

Table 2 shows that the maximum vitamin C mg/100gm recorded (93.92 mg) in T_5 (B + Mn + Zn) followed by T_7 (Mo + Mn) 88.43 mg. The lowest vitamin was found in case of T_0 (control) 78.81 followed by (80.22 mg) T_2 (Mo).[22]

Fresh weight of plant

The various treatment combinations significantly influenced the fresh weight of plant. In treatment T_5 (B + Mn +Zn) fresh weight of plant was highest (908.28 g followed by (867.65 g T_7 (B + Mo + Mn +Zn). The lowest fresh plant weight found in T_0 (control) 725.92 g.[13,19,22]

Root weight

Table 2 shows that various treatment combinations significantly influenced the weight of plant root. In treatment T_5 (B + Mn +Zn) weight of root was highest (45.02 g followed by (43.91 g T_7 (B + Mo + Mn +Zn). The lowest root weight found in T_0 (control) 35.43 gm. The root weight in T_6 (Mo + Mn) and T_8 (B + Zn) had almost similar (43.19 g and 43.52 g respectively). Positive effects of micro nutrients 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.[13,19,22]

CONCLUSION

From the present investigation it was concluded that treatment T5 (B 2 kg/ha+ Mn 2.5 kg/ ha +Zn 3 kg/ha) was found to be the best treatment combinations to obtain the higher growth, yield, and flower bud quality.

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