Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2018; 7(4): 493-497
Received: 01-05-2018
Accepted: 05-06-2018

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Studies on yield of broccoli (*Brassica oleracea* var. *italica*) cv. green magic as influenced by different micronutrients

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Abstract
A field experiment was conducted at Vegetable Research Field, Central Orcherd, Department of Horticulture, Allahabad School of Agriculture, Sam Higginbottom Institute of Agriculture Technology and Sciences Allahabad (U. P.) India to find out the effect of different micronutrient on vegetative growth of broccoli (*Brassica oleracea var. Italica*) cv. Green Magic during *rabi* season 2015-16. The experiment was laid out in Randomized Block Design (RBD) with 10 treatments and each replicated thrice. There were four treatment B, Mo, Mn and Zn micronutrients which applied @ of (3:0.5:2:2.5 kg/ha) in plot single and combination during season. Results of different micronutrients application significantly influenced the bud or head diameter over control. The maximum bud diameter 18.02 cm was recorded with T_5 (B + Mn +Zn) followed by 16.22 cm in T_8 (B +Zn) and T_7 (B + Mo + Mn + Zn) i.e. 16.87 cm, which were significantly higher than other treatment. The treatment T_5 (B + Mn + Zn) had significantly the highest bud weight (511.50 gm) followed by T_7 (B + Mo + Mn +Zn) is 343.00 gm. Lowest bud weight 198.02 gm was observed in T_0 (control). Maximum number of frouds (18.32) was observed in T_5 (B + Mn + Zn) followed by 15.89 T_4 (Mo+B) and minimum (12.98) were found in T_0 (control). The treatment T_5 (B + Mn + Zn) had significantly more yield per hectare (138.58 q/ha followed bye T_7 (B + Mo + Mn +Zn) 116.23 q/ha. than other treatment. The yield of treatment T_2 (Mo) and T_3 (Mn) was almost similar (98.03q/ha and 98.99 q/ha) respectively. The treatment T_0 (control) recorded lowest yield per hectare (72.98 q/ha).

Keywords: broccoli, *rabi*, micronutrients, bud, head, yields

Introduction
Broccoli is an edible green plant in the cabbage family whose large, flowering head is eaten as a vegetable. 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 (*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 (Heywood, 1978) [6]. 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. India is world's largest producer of vegetables next to China with an annual production around 162.187 (Million tonnes) from 92.05 (Million hectare) of land, (Annonymous, 2015a). This quantity is much less than our requirements and serves capita^{-1} intake on only 135 g against the recommended requirement of 300 g capita^{-1} day^{-1} for balance diet. The vegetable requirement for the country has been estimated 225 million tonnes by 2020. India rank second area and production in cauliflower and Broccoli. World area and production are1.21 million hectare and 20.88 Million tonne and Indian production and area are 6745 thousand tonnes and 369 thousand hectares (Annonymous, 2015b). 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. Broccoli has about 14 times more beta-carotene a precursor of vitamin A than commonly cultivated cabbage (Sharma, 2000) [13].
Even though micronutrients are required in minute quantities, they are essential for healthy plant growth & profitable crop production. Micronutrients provide an economical source for

correcting nutrient deficiencies & improving plant health. Micronutrients are fully chelated & can be used in both foliar & soil applied applications. Micronutrients, which include boron, chlorine, copper, iron, manganese, molybdenum, nickel, and zinc, are required in smaller amounts than the other essential nutrients. Generally, soils contain sufficient levels of micronutrients to meet crop demands; however, in some areas micronutrient shortages occur and may limit yields. Some crops have a higher demand for certain micronutrients than others and should be considered in determining whether a micronutrient fertilizer should be applied (Moniruzzaman *et al.,* 2007) [9]. The modern Indian agriculture depends heavily on chemical fertilizers, pesticides and fungicides and is responsible for deterioration of soil health. But the plant nutrient deficiency of Indian soils is increasing. Hence involving organic manure and chemical fertilizers will go a long easy in building soil fertility and productivity. As the nutrient management system will supply all the nutrients judiciously to increase the production of crops. To increase the yield and quality, plenty of chemical fertilizers along with a small quantity of organic manure are being used by the growers, which ultimately determinate the soil texture and health. Horticultural crops suffer widely in zinc deficiency followed by boron, manganese, copper, iron (mostly induced) and Mo deficiencies. Cl, Cu, Fe and Mn are involved in various processes related to photosynthesis and Zn, Cu, Fe, and Mn are associated with various enzyme systems; Mo is specific for nitrate reductase only. B is the only micronutrient not specifically associated with either photosynthesis or enzyme function, but it is associated with the carbohydrate chemistry and reproductive system of the plant. Boron is much required for cell division and development in the growth regions of the plant near the tips of shoots and roots. 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. Zinc applied in the row should not come in contact with the seed. For crops showing zinc deficiency during the growing season, foliar applications of zinc chelate (2 oz/A actual zinc) are suggested (Lucas and Knezek. 1973) [7].

Materials and Methods

The present research work entitled Studies on yield of broccoli (*Brassica oleracea* var. *italica*) cv. green magic as influenced by different micronutrients was conducted at Vegetable Research Field, Central Orcherd, Department of Horticulture, Allahabad School of Agriculture, Sam Higginbottom Institute of Agriculture Technology and Sciences. Allahabad (U.P.) India is situated in the agro-climatic zone (Sub-tropical belt) of Uttar Pradesh. The Geographically area falls under sub-tropical climate and is located in between 25.87^0 North latitude and 81.15^0 E longitude at an altitude of 98 m above the mean sea level(MSL). The maximum temperature of the location reaches up to 40^0 C to 50^0 C and seldom falls as low as 7^0 C to 10^0 C. The Relative humidity ranged between 20 to 94 %. The average rainfall in this area is around 850-1100 mm annually. There were 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). The experiment was laid out in Randomized Block Design (RBD) with 10 treatments and each treatment replicated thrice. According to the treatment the micronutrients (B: Mo: Mn: Zn – 3: 0.5: 2: 2.5 kg/ha) are applied before transplanting.

Soil characteristics of the experimental site

Particulars	Sand	Silt	Clay	Textural class	Soil pH	EC(dsm^{-1} at 25^0 C)	Organic carbon	Available nitrogen (k ha^{-1})	Available phosphorus (k ha^{-1})	Available potassium (k ha^{-1})
Value (0-30cm depth)	48.15%	20.30%	30.50%	Sandy Loam	7.2	0.28	0.57%	240.33	20.03	255.96

The broccoli plants were harvested at, when it attains full development and compactness and before bursting stage. The harvested plants were free from any pest and disease attack. The whole plants (except root) were cut just above the ground level. Yield components and yield per hectare were recorded, averaged and analyzed.

I. Diameter of the Flower Bud (cm)

The diameter of the curd of four plants was measured in cm at the widest circumference and average diameter per curd was calculated from each plot.

II. Flower Bud weight (g)

Head or bud of four selected plants was weighted on electrical balance in gm and average was found to give the bud weight per plant.

III. Number of frouds per curd

The numbers of frouds per curd were calculated manually by counting after dismantling the frouds in the head. The calculation of number of frouds was done after weighting the respective bud of four randomly selected plants.

IV. Total head (bud) yield ha^{-1} (q)

The yield ha^{-1} in quintals was calculated on the basis of the total head Yield per plot.

Statistical analysis

The data on growth yield and quality components were subjected to the Fisher 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.

Results and Discussion

Bud or Head Diameter (cm)

Different micronutrients application significantly influenced the bud or head diameter over control. Table and fig 1 revealed that the maximum bud diameter 18.02 cm was recorded with T_5 (B + Mn +Zn) followed by 16.22 cm in T_8 (B +Zn) and T_7 (B + Mo + Mn + Zn) i.e. 16.87 cm, which were significantly higher than other treatment. The lowest bud diameter (14.80 cm) was observed in treatment 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 Moniruzzaman *et al.,* (2007) [9] and Alam, *et al* (2010) [1] in broccoli.

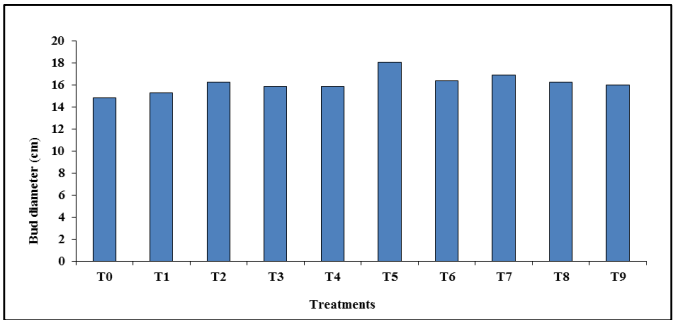

Fig 1: Effect of different micronutrients on bud diameter (cm) of broccoli

Bud or head weight (g)

Table 1 and fig. 2 showed 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 (511.50 gm) followed by T_7 (B + Mo + Mn +Zn) is 343.00 gm. Lowest bud weight 198.02 gm was observed 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 are closely recorded by Moniruzzaman *et al.,* (2007) [9] in broccoli.

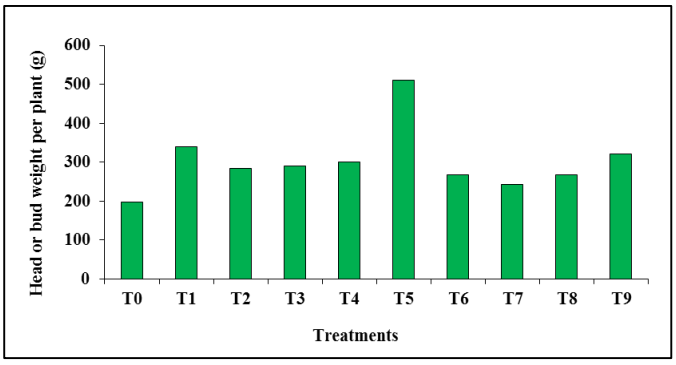

Fig 2: Effect of different micronutrients on head or bud weight per plant (g) of broccoli

Number of frouds per Head or Bud

On observing the data, table 1 and fig. 3 showed that there was significant difference among various treatment combinations regarding number of frouds/bud. Maximum number of frouds (18.32) was observed in T_5 (B + Mn + Zn) followed by 15.89 T_4 (Mo+B) and minimum (12.98) 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 are similar finding by Alam *et al.,* (2010) [1] and Naga *et al.,* (2013) [10].

Bud or Head yield per hectare (q/ha)

Results of table 1 and fig 4 showed that the treatment T_5 (B + Mn + Zn) and T_7 (B + Mo + Mn +Zn) had significantly more yield per hectare (138.58 q/ha and 116.23 q/ha.) than other treatment. The yield of treatment T_2 (Mo) and T_3 (Mn) was almost similar (98.03q/ha and 98.99 q/ha) respectively. The treatment T_0 (control) recorded lowest yield per hectare (72.98 q/ha). 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) [1] and Naga *et al.,* (2013) [10].

These findings are in conformity with Suresh *et al.,* (2010) found that both boron and molybdenum has profound effect on vegetative growth either applied individually or in combination. The same treatment recorded more curd weight, width, length and curd yield. Santosh *et al.,* (2010) [12] observed that various levels of boron and molybdenum as foliar and soil application on growth, yield and economics of cauliflower cv. Snowball K-1. Among the various treatments borax 20 kg/ha + sodium molybdate 2 kg/ha as soil application in combination of recommended dose of NPK @ 120: 60: 60 kg/ha (T12) gave the maximum height of plant, length of leaf, width of leaf, total weight of plant, width of curd, average weight of curd and yield of curd, while foliar application of boron @ 100 ppm + molybdenum @ 50 ppm alongwith recommended dose of NPK @ 120: 60: 60 kg/ha (T4) gave highest growth and yield among all the foliar application treatments. Singh, *et al.,* (2011) reported that the maximum value of all the characters *viz*; plant height (63.98 cm), number of leaves (16.25), plant weight (1439.30 g), curd weight (758.70g), curd diameter (16.85 cm), curd depth (12.25 cm) and yield (446.20q/ha) were recorded in the plots receiving Boron @1.50 kg/ha. While the minimum viz; 48.12 cm, 2.88 cm. 906.25g, 387.45 g, 12.60cm., 8.10 cm and 215.23 q/ha. was noted in the control plots. Mohamed *et al.,* (2011) reported that 30 and 45 µg/l Mo significantly improved vegetative growth parameters, curds yield and its components and chemical composition of leaves and curds. Likewise, using 0.50 and 0.75% Mg significantly enhanced foliar fresh weight, plant height, leaves fresh weight and leaves dry weight, total and marketable curds yield and chemical composition of leaves and curds.

Similarly, Bishnu *et al.,* (2004) [5] also reported maximum plant height (42.05 cm) was observed when the crop was supplied with 25 kg borax ha^{-1} which was almost 13.95 percent higher than that of non-treated control crop. The curd size (diameter) was increased with increasing levels of borax up to 15 kg ha^{-1}. The maximum curd diameter (10.28 cm) was produced when the crop was treated with 25 kg borax ha^{-1}. Highly significant effect of boron levels were observed on the curd production. The maximum curd weight (10.9 t ha^{-1}) was observed when the crop was supplied with 25 kg borax ha^{-1}. Raghav and Singh (2004) [11] observed maximum tuber yield and growth at Zn 8 kg ha^{-1} and this treatment produced 16 per cent higher yield than the control and 4.5% higher than foliar spraying thrice. In cauliflower the maximum curd yield was obtained under N at 1% + Zn at 30 ppm whereas the maximum plant height, spread and number of leaves were noted under N at 1.5%. Singh and Singh (2004) observed that foliar application of zinc at 30 ppm produced maximum plant height and plant spread in cauliflower cv. Snowball-16. The highest net return (Rs. 52628.30 ha^{-1}) and cost benefit ratio (1:2.8) were recorded for 1.0% N + 30 ppm Zn followed by 1.0% N + 0 ppm Zn. Thapa, (2016) also observed that mineral fertilizer improves growth and yield of broccoli due to the role of nitrogen, phosphorus, and potassium on the meristematic activity. Boron and molybdenum are essential micronutrients required for normal plant growth and development. Under favorable agro-climatic conditions, the application of 18 kg borax and 1.8 kg ammonium molybdate/ ha was found beneficial for growth, yield, and quality of broccoli.

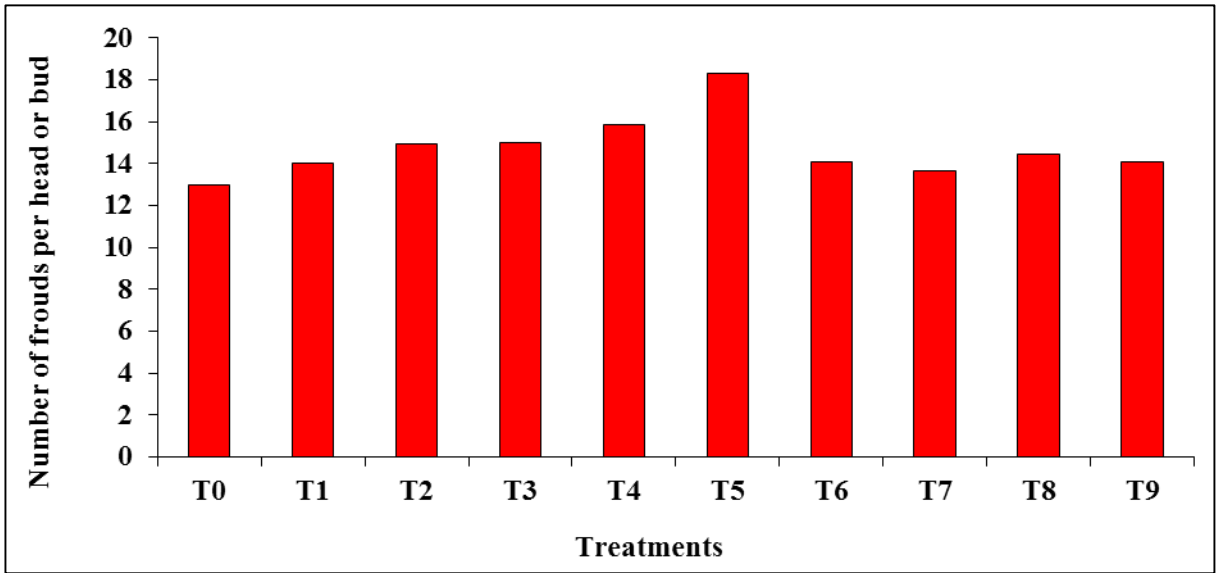

Fig 3: Effect of different micronutrients on number of frouds per head or bud of broccoli

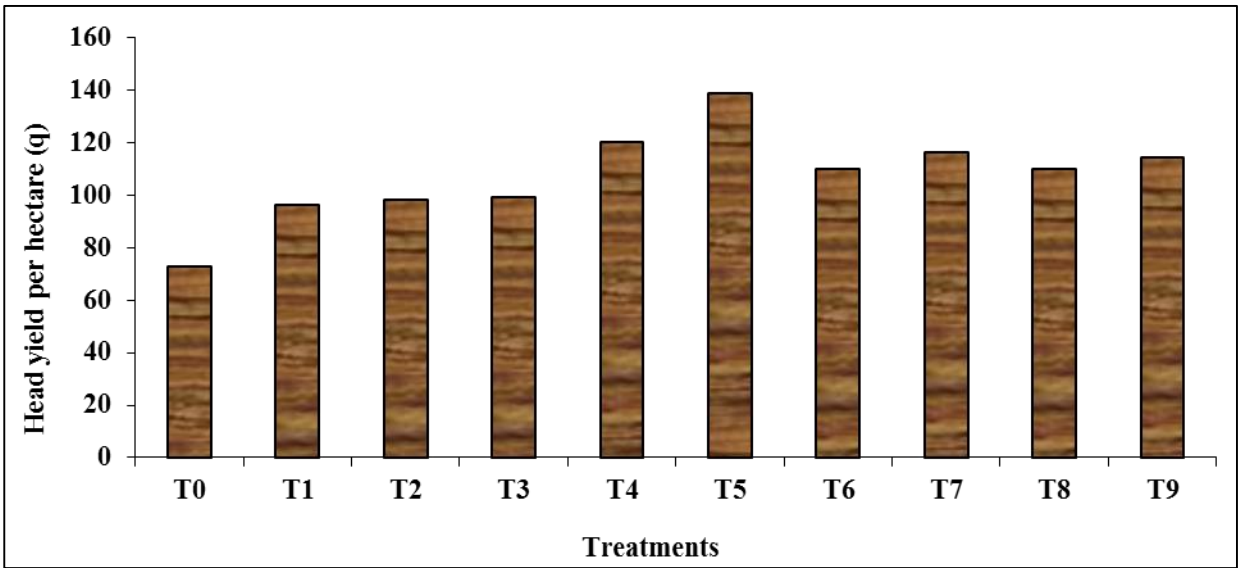

Fig 4: Effect of different micronutrients on head yield per hectare (q) of broccoli

Table 1: Effect of different micronutrients on Head yield per hectare (q), Number of frouds per head or bud, Head or bud weight per plant (g) and bud diameter (cm) of broccol

Treatment	Treatment combination	Head yield per hectare (q)	Number of frouds per head or bud	Head or bud weight per plant (g)	Bud diameter (cm)
T_0	Control	72.98	12.98	198.02	14.8
T_1	B	96.27	14.02	340.38	15.3
T_2	Mo	98.03	14.96	283.58	16.23
T_3	Mn	98.99	14.98	290.98	15.83
T_4	B + Mo	120.01	15.89	300.8	15.87
T_5	B + Mn + Zn	138.58	18.32	511.5	18.02
T_6	Mo + Mn	110.07	14.09	267.5	16.34
T_7	B + Mo + Mn +Zn	116.23	13.67	343	16.87
T_8	B + Zn	109.92	14.43	267.02	16.22
T_9	Zn	114.32	14.09	320.83	15.97
	F test	S	S	S	S
	S. Ed (±)	2.59	0.38	3.60	0.39
	C.D At 5%	5.45	0.80	7.56	0.82

Conclusion

From the present investigation it is concluded that the maximum bud diameter (18.02 cm), the highest bud weight (511.50 gm), Maximum number of frouds (18.32) and more yield per hectare (138.58 q/ha) was found in T_5 (B + Mn + Zn) as compare to control during the crop season. Lowest response was observed in T_0 (control). Micronutrient significantly enhanced bud diameter, bud weight, number of frouds and yield per hectare.

Acknowledgement
Authors are very much thankful to the Department of Horticulture for providing all the essential facilities and moral support to conduct the whole research programme and to obtain its significant findings. Authors are also very much greatly privileged to the Department of Soil Science and Department of Forestry and Environmental sciences to providing all the necessary and required information, technology and moral support.

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