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Influence of different micronutrient on vegetative growth of broccoli (*Brassica oleracea* var. *italica*) cv. green magic

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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 (17 September to 25 January) 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. The maximum plant height was found in T_5 (B + Mn + Zn) with 14.80 cm, 36.06 cm followed by T_7 (B + Mo + Mn +Zn) with 13.70 cm T_6 (Mo + Mn) with 34.82 cm, at 20 DAT, 40 DAT respectively as compare to control. At 60 DAT the maximum plant height was significantly recorded in T_5 (B + Mn + Zn) with 52.23 cm. followed by T_7 (B + Mo + Mn + Zn) with 49.89. The maximum number of leaves were found in T_5 (B + Mn +Zn) with 7.83/plant, 13.25 /plant and 26.06/plant followed by T8 (B +Zn) with 6.83/plant, T_6 (Mo +Mn) with 13.25 /plant and T_9 (Zn) with 23.09/plant at 20 DAT, 40 DAT and 60 DAT, respectively as compare to control. The maximum plant spread was found in T_5 (B + Mn + Zn) 14.98 cm, 36.20 cm and 55.25 cm followed by T_6 (Mo +Mn) with 14.25 cm, T_9 (Zn) with 34.15 cm, T_9 (Zn) with 50.03 cm at 20 DAT, 40 DAT and 60 DAT respectively as compare to control during the crop season.

Keywords: Broccoli, micronutrients, vegetative growth

Introduction
Broccoli probably evolved in Roman times from wild or primitive cultivated forms of (*Brassica oleracea*) from the Mediterranean region. 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 is often boiled or steamed but may be eaten raw. 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].

Broccoli is the most nutritive vegetable among cole crops, especially in calcium and iron (103 mg/gm.) of edible portion. It has 130 times more vitamin A than cauliflower and 22 times more than cabbage. Broccoli rich source of sulphoraphane compound associated with reducing risk of cancer. Broccoli also contain amount of goitrogens, the naturally occurring substances that can interfere with functioning of thyroid gland. Broccoli is an excellent source of vitamin C and dietary fiber. It is a good source of potassium. It is free from fat and cholesterol. Broccoli contain the phytonutrient (plant nutrient) sulforaphane it has been shown in some studies to reduce risk of breast and lung cancer. Broccoli can be mixed with a variety of foods. It can be used as a soup, salad, flavouring for grains, or even as a main dish. Broccoli is also known as harigobhi, in the world market about 40% is marketed as fresh and remaining 60% as frozen (Sharma, 2003) [16]. 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) [3]. 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) [4].

Broccoli is a rich source of vitamin C. Vitamin C, also known as ascorbic acid; it is needed for growth and repair of body tissue. Vitamin C help the body make collagen, a tissue needed for healthy bones, teeth, gum and blood vessels (Annonymous, 2007) [2]. Horticultural crops suffer widely by zinc deficiency followed by boron, manganese, copper, iron (mostly induced) and Mo deficiencies. Manganese is necessary for chlorophyll formation for photosynthesis, respiration, and nitrate assimilation and for the activity of several enzymes. The concentration of manganese in leaves can range widely from (10-15ppm) when deficient and in thousands of ppm when it is toxic.Most manganese in soils is precipitated as manganese oxide or hydroxide. Boron is much required for cell division and development in the growth regions of the plant near the tips of shoots and roots. 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^-. Function of Molybdenum is 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. Deficiencies may occur on acid sandy soils and acid peats. Certain vegetable crops such as cauliflower are particularly susceptible to molybdenum deficiency. 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 (Lucas and Knezek, 1973) [9].

Materials and Methods

The present research work entitled "Influence of different micronutrient on vegetative growth of broccoli (*Brassica oleracea var. italica*) cv. Green Magic" 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

In this experiment plant height (cm), Plant spread (cm), Number of leaves/plant was observed during the crop season. Growth observations on the following characters were recorded at an interval of 20 days till they complete vegetative maturity.

I. Plant Height (cm)

The height of four randomly selected plant from each plot were measured with the help of measuring tape from soil surface up to the leaf peak, in cm, in natural condition at 20, 40 and 60 days after transplanting. The average height of plant of each replication was recorded and subjected to statistical analysis.

II. Number of leaves per plant

All the open leaves from four selected plant from each replication of all the treatments were counted at 20, 40 and 60 days after transplanting. The average number of leaves per plant of each replication was recorded and subjected to statistical analysis.

III. Plant Spread (cm)

Spread of four randomly selected plants from each plot was measured from East to west and north to south, and recorded with the help of a statically analyzed.

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

Plant height (cm)

The results pertaining of the effect applied through different micronutrients on plant height of Broccoli at 20, 40 and 60 DAT are graphically presented in Table 1 and Fig 1. At 20 DAT data presented in table 1 and graphically depicted in Fig. 1 shows that the plant height was maximum (14.80 cm) in T_5 (B + Mn + Zn) followed by T_7 (B + Mo + Mn + Zn) in (13.70 cm). The lowest plant height 12.32 cm. found in T_0 (control). Plant height at 40 DAT differed significantly due to various treatment combinations and considerably increased up to 60 DAT due to micronutrient. Treatment T_5 (B + Mn + Zn) gave the maximum height (36.06 cm) followed by T_6 (Mo + Mn) i.e. 34.82 cm. However lowest plant height (31.97 cm) was found in T_0 (control). The plant height at 60 DAT found maximum in T_5 (B + Mn + Zn) is 52.23 cm. followed by 49.89 in T_6 (B + Mo + Mn + Zn). The minimum was found in T_0 (control) 43.10.This variations might be due to the availability of micronutrients enhances soil aggregation, aeration, water holding capacity and plant height So, the combination of different micronutrients.

Number of leaves per plant

The data respect of mean number of leaves per plant observed at different intervals i.e. 20, 40 and 60 Days after transplanting are presented in table 1 and fig. 2. It's seen from results in table and fig. 4.2 that, there was highest number of leaves at 20 DAT in T_5 (B +Mn +Zn) 7.83 followed by 5.56 per plant in T_2 (Mo) and lowest number of leaves was found in T_0 (control) is 4.08. The number of leaves at 40 DAT and 60 DAT maximum found in same treatment T_5 (B + Mn +Zn) is 13.25 and 26.06 respectively followed by T_9 (Zn) and T_7 (B + Mo + Mn + Zn) is 12.80 and 23.07 per plant. The lowest number of leaves found in T_0 (control) is 8.67 and 19.00. This variations might be due to the availability of micronutrients enhances soil aggregation, aeration, water holding capacity so, the combination of different micronutrients.

Plant Spread (cm)

The data of the mean plant spread of the plant as influenced by different treatment observed at different intervals i.e. 20, 40 and 60 Day after transplanting are presented in the table 1 and fig 3 At 20 DAT the maximum plants spread was found 14.98 cm in T_5 (B + Mn +Zn) followed by T_4 (B + Mo) is 14.00 cm and minimum plant spread was found (11.85 cm) in T_0 (control). At 40 DAT and 60 DAT maximum plant spread was found in T_5 (B + Mn + Zn) is 36.20 cm and 55.25 cm followed by 34.15 cm and 50.03 cm in T_9 (Zn). The minimum plant spread 29.76 cm and 43.89 cm was found T_0 (control).

These findings are in conformity with Moniruzzaman *et al.*, (2007) [11] reported that increasing levels of boron (0. 0.5, 1, 1.5, 2 and 2.5 kg/ha) and nitrogen (100 and 200 kg/ha) significantly increased plant height, number of leaves per plant, length and width of the leaf, plant spread in sprouting broccoli. Singh, (2014) [17] also reported that the plant height was maximum (14.30) in T_5 (B + Mn +Zn) followed by T_7 (B + Mo + Mn +Zn) in (13.38 cm) at 20 DAT. The lowest plant height 11.98 cm. found in T_0 (control). Plant height at 40 DAT differed significantly due to various treatment combinations and considerably increased up to 60 DAT due to micronutrient. Treatment T_5 (B + Mn + Zn) gave the maximum height (33.99 cm) followed by T_6 (Mo + Mn) i.e. 34.33 cm. However lowest plant height (32.35 cm) was found in T_0 (control). The plant height at 60 DAT found maximum in T6 (B + Mn + Zn) is 51.30 cm. followed by 48.99 in T6 (B + Mo + Mn + Zn). The minimum was found in T0 (control) 42.84. There was highest number of leaves at 20 DAT in T_5 (B +Mn +Zn) 6.58 followed by 5.42 per plant in T2 (Mo) and lowest number of leaves was found in T0 (control) is 4.00. The number of leaves at 40 DAT and 60 DAT maximum found in same treatment T_5 (B + Mn +Zn) is 12.92 and 24.25 respectively followed by T9 (Zn) and T7 (B + Mo + Mn + Zn) is 12.00 and 22.92 per plant. The lowest number of leaves found in T_0 (control) is 8.67 and 19.00. At 20 DAT the maximum plants spread was found 14.23 cm in T5 (B + Mn +Zn) followed by T4 (B + Mo) is 13.53 cm and minimum plant spread was found (11.37 cm) in T0 (control). At 40 DAT and 60 DAT maximum plant spread was found in T5 (B + Mn + Zn) is 35.15 cm and 52.83 cm followed by 33.53 cm and 49.15 cm in T_9 (Zn). The minimum plant spread 29.76 cm and 43.89 cm was found T_0 (control).

These finding are also closely to Rahman, *et al.*, (2013) [15] in cauliflower and Narayanamma *et al.*, (2007) [13] in cabbage. Lashkari, *et al.*, (2008) [8] reported that the cultivation of cauliflower cv. Snowball-16 was found to be more beneficial and economical with foliar sprays of zinc ($ZnSO_4$) and iron ($FeSO_4$). Treatment T_5 (B + Mn +Zn) were found superior over all other treatment growth, flower bud quality and economic return for cultivation of broccoli. Alam, *et al.*, (2010) reported that the onion growth and yield in increased to use micronutrient by this following order (Zn+B)>Zn>B>Mo. These results are similar recorded by Naga *et al.*, (2013) [12] in tomato. Suresh *et al.*, (2010) [19] also found that both boron and molybdenum has profound effect on vegetative growth either applied individually or in combination. However, the plant height and more number of leaves per plant was highest with 2 kg soil application of ammonium molybdate + 3 kg soil application of borax + 0.3% each of foliar application of borax and ammonium molybdate over control. The same treatment recorded more curd weight, width, length and curd yield.

Kumar *et al.*, (2010) [7] 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. 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.

Bishnu *et al.*, (2004) [5] 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. Maximum leaf numbers (12.73 $plant^{-1}$) and leaf length (38.91 cm) were observed when the crop was fertilized with 10 kg borax ha^{-1}. Raghav and Singh (2004) [14] 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 (2004a) 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.

Table 1: Effect of micronutrient on vegetative growth (plant height (cm), number of leaves/plant, plant spread (cm)) of broccoli

Treatments	Treatment combination	Effect of micronutrient on plant height (cm)			Effect of micronutrient on number of leaves/plant			Effect of micronutrient on plant spread (cm)		
		20 DAT	**4 DAT**	**60 DAT**	20 DAT	40 DAT	60 DAT	20 DAT	40 DAT	60 DAT
T_0	Control	12.32	31.97	43.10	4.08	8.87	20.02	11.85	30.02	44.03
T_1	B	12.99	33.82	47.23	5.02	9.98	20.89	13.12	32.3	46.98
T_2	Mo	13.11	33.94	46.11	5.56	11.99	21.98	12.87	31.98	44.83
T_3	Mn	13.43	34.12	48.23	5.79	12.03	22.03	14.02	33.09	48.26
T_4	B + Mo	13.52	34.26	46.04	5.73	12.67	22.58	14.00	33.40	46.83
T_5	B + Mn + Zn	14.80	36.06	52.23	7.83	13.25	26.06	14.98	36.20	55.25
T_6	Mo + Mn	13.22	34.82	48.26	6.02	13.25	22.86	14.25	33.98	50.01
T_7	B + Mo + Mn +Zn	13.70	33.74	49.89	6.23	12.03	23.07	13.87	33.23	48.96
T_8	B + Zn	12.92	34.03	47.29	6.83	12.16	22.93	13.87	33.23	48.96
T_9	Zn	13.55	33.74	48.05	6.32	12.8	23.09	13.12	34.15	50.03
	C.D At 5%	0.54	0.54	0.95	0.54	0.80	0.79	1.31	1.31	1.43
	S. Ed (±)	0.25	0.25	0.45	0.26	0.38	0.37	0.62	0.62	0.68
	F test	S	S	S	S	S	S	S	S	S

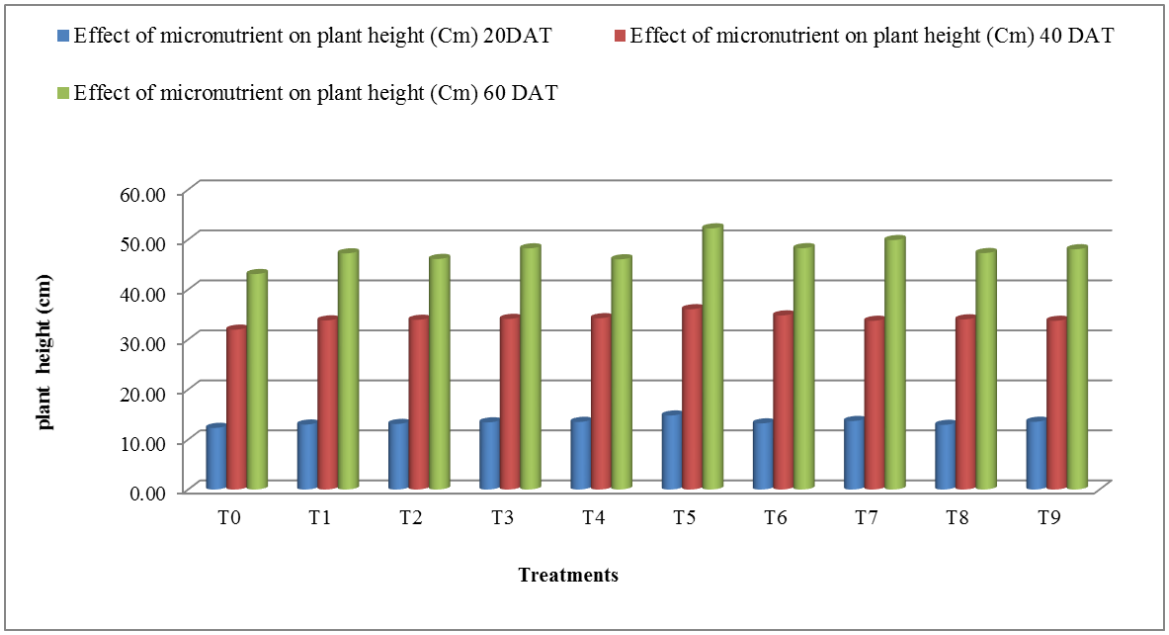

Fig 1: Effect of micronutrient on vegetative growth [plant height (cm)] of broccoli plant

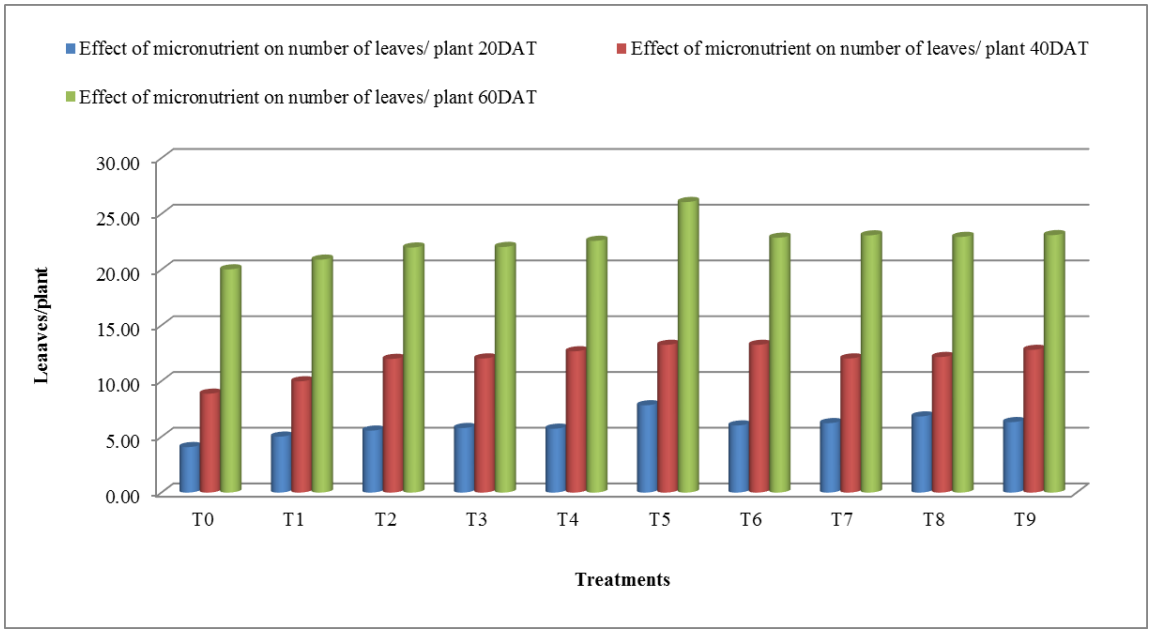

Fig 2: Effect of micronutrient on vegetative growth [number of leaves/plant] of broccoli plant

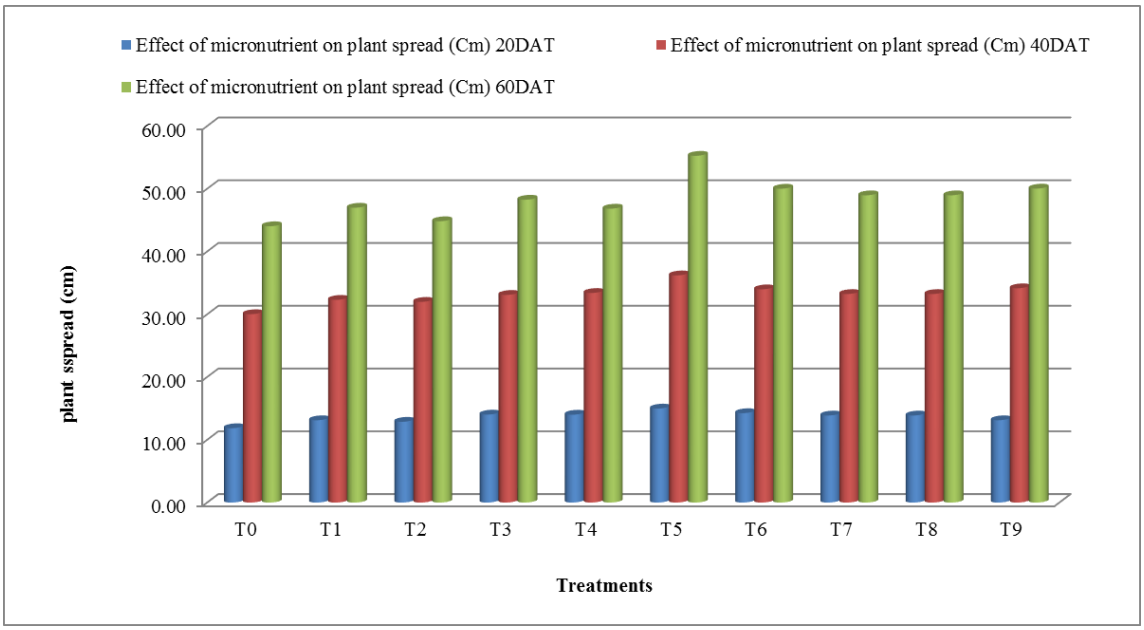

Fig 3: Effect of micronutrient on vegetative growth [plant spread (cm)] of broccoli plant

Conclusion

From the present investigation it is concluded that the maximum plant height (52.23 cm), plant spread (55.25 cm) and number of leaves/plant (26.06/plant) was found in T_5 (B + Mn + Zn) as compare to control during the crop season. The lowest plant height (31.97 cm) was found in T_0 (control). Micronutrient significantly enhanced plant height, Number of leaves per plant, leaves fresh weight and leaves dry weight.

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