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Effect of different micronutrient on plant quality of broccoli (*Brassica oleracea* var. *italica*) CV green magic

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Abstract
A field experiment was conducted to study the Effect of different micronutrient on plant quality of broccoli (*Brassica oleracea* var. *Italica*) CV. Green Magic during *rabi* season (17 September to 25 January) 2015-16 at Vegetable Research Field, Central Orchard, Department of Horticulture, Allahabad School of Agriculture, Sam Higginbottom Institute of Agriculture Technology & Sciences, Allahabad (U. P.) India. The experiment was laid out in Randomized Block Design (RBD) with 10 treatments and each replicated thrice. Results of the experiment showed that there was a significant difference among various treatment combinations. The maximum T.S.S (^{0}Brix) value T_5 (B + Mn + Zn) 8.80, followed by T_9 (Zn) with 7.90. The lowest T.S.S (^{0}Brix) value was recorded in T_0 (control) 6.45. The maximum vitamin 'C' mg/100gm recorded (94.80 mg) in T_5 (B + Mn + Zn) followed by T_6 (Mo + Mn) with 88.73 mg. The lowest vitamin C was found in case of T_0 (control) 79.02 followed by T_2 (Mo) with (82.23 mg). The four micronutrients B, Mo, Mn and Zn were applied @ of (3:0.5:2:2.5 kg/ha) which shows significantly increase in vitamin 'C' (94.80 mg/100g), TSS (8.80 ^{0}Brix) during research.

Keywords: Broccoli, Micronutrients, TSS, and Vitamin 'C'.

Introduction
Broccoli *(Brassica oleracea* L. var. *Italica* Plenck*)* is an important cole crop vegetable. The word *broccoli* comes from the Latin word *brachium* and Italian word *brocco* meaning "arm", or "branch". It is a new crop in India which is nutritious among cole crops being rich in vitamins and minerals. It is also a rich source of sulphoraphane compound which is associated with reducing the risk of cancer (Kalia, 1995). Broccoli also contains the compound glucoraphanin, leading to an anticancer compound. It provides substantial amounts of nutrients such as pro-vitamins a (567IU), C (81.2mg) and E, magnesium, selenium which are important for human health (Munger, 1999). The name "broccoli "refers to the young shoots which develop in spring on some species of the genus brassica. In Italy, these have been used as vegetable from early times but their economic importance becomes appreciable only since the thirties of last century when this vegetable become popular in the USA. The Brassicaceae family was formerly called the Cruciferae family, due to the fact that these plants often have four petals which can look like crosses. Broccoli possesses abundant fleshy green flower heads arranged in a tree-like fashion on branches sprouting from a thick, edible stalk. The large mass of flower heads is surrounded by leaves. Broccoli most closely resembles its close relative cauliflower, but is green rather than white and the flower stalks are longer than cauliflower. It can be easily distinguished from cauliflower by having a head composed of differentiated flower buds rather than a curd (Gray, 1982).
Broccoli was grown mainly in Italy since the Roman Empire until the 16th century when a royal marriage brought the vegetable to France. Cultivation of the vegetable spread throughout Europe and was first grown on this side of the Atlantic in Virginia in the late 1700s. Today, broccoli is enjoyed through much of the world, in creamed soups, nouvelle cuisine vegetable purées, crisp Italian sautés, salads, Chinese stir-fries, as well as steamed and tossed with butter and lemon or paired with hollandaise Broccoli was grown in Italy and France since the 16th century. It was commonly grown in United States in the 1920s. 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 (Dhurwey, 2015).
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 (Anonymous, 2007). 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^-. A molybdenum function in 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).

Broccoli (*Brassica oleracea* L. var *italica* Plenck) is an important winter season exotic vegetable from the Brassicaceae family as well as heavy feeder of plant nutrients. Plant nutrition is one of the prime considerations for getting higher yield of any crop. 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. Plants differ widely in their requirements, but the ranges of deficiency and toxicity are narrow. Boron and molybdenum deficiencies are very common in Cole crops. Deficiency causes many anatomical, physiological, and biological changes. The deficiency of boron and molybdenum has threatened the ever increasing areas of broccoli. The effected heads become irregular in shape, smaller in size and bitter in taste which adversely affects the market demand of the crop. No systematic work so far has been done in production technology of sprouting broccoli in relation to response of nutrients in the gangetic plains of West Bengal (Thapa, *et al*. 2016.).

Materials and Methods

The details of materials used, experimental procedure followed and techniques adopted during the course of investigation have been described in this chapter. The present research work entitled effect of different micronutrient on plant quality of broccoli (*Brassica oleracea* var. *Italica*) cv. Green Magic was conducted at Vegetable Research Field, Central Orchard, Department of Horticulture, Allahabad School of Agriculture, Sam Higginbottom Institute of Agriculture Technology & 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 78 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. The experiment consists of 10 treatment *viz*, 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	Texture class	Soil pH	EC(dsm^{-1} at25^0 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

Measured plant quality parameters

Quality Parameters- Total soluble solid (^{0}B) by-Hand Refractor meter, Vitamin 'C' mg/100gm. V (Colorimetric method).

Total Soluble Solid (T.S.S. Brix^0)

Percentage of total Soluble Solid was determined with the help of Erma Hand Refract meter (range 0-32) in Brix^0. Averaged and Analysed.

Vitamin-C content in head (mg/100 g)

Ascorbic acid content of head was determined by diluting the known volume of juice with 3% meta-phosphoric acid and titrating with 2, 6- dichlorophenol-indo-phenol solution (Anonymous, 1960), till the faint pink colour was obtained.

Standardization

Standardization of the dye 2, 6-dichlorophenol-indo-phenol solution was done by titrating it against standard ascorbic acid solution for the purpose 100 mg of pure ascorbic acid was dissolve in 3% meta -phosphoric acid and volume made to 100 ml from this 10 ml ascorbic acid solution was used for titration. The results were expressed as ascorbic acid in mg/100 g of juice.

Where,

Y= ml of dye indicator used in the titration.

V_1= Volume to which the juice is diluted.

T= Titrate volume of day with standard solution of Vitamin C

V_2= Volume of filtrate taken for titration.

W= Volume of the juice initially taken for the determination.

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

Total soluble solid (^{0}BRIX)

Table 1 and fig. 1 showed that there was a significant difference among various treatment combinations. The maximum T.S.S (^{0}Brix) value (8.80) was found in T_5 (B + Mn + Zn), followed by T_9 (Zn) with 7.90, T_4 (B + Mo) with 7.83, T_8 (B + Zn) with 7.73 and T_7 (B + Mo + Mn + Zn) with 7.58. The lowest T.S.S (^{0}Brix) value was recorded in T_0 (control) 6.45. Similar results were recorded by Valeria, *et al.* (2011) who reported that the influence of the presence and the absence of the sulphuric fertilization on leaves samples quality, in terms of nitrate and chlorophyll contents, colour, pH, TSS, and dry matter were assessed. Edward and Iyengar (1987) also found that foliar and soil applied zinc increased maximum yield of capsicum and leaf size in 0.5 per cent + 0.3 per cent ZnSO4 treatment. Kumar, *et al*. 2012 studied the impact of foliar spray of urea (1%), micronutrients (B, Zn, Mn, Cu and Fe each 0.2%) and GA3 (0.01%) on production productivity, earliness in curd production and quality of broccoli cv. FIESTA under Ranchi condition were carried out at the Department of Horticulture, Birsa Agricultural University, Ranchi, Jharkhand during winter season of 2008-2009. The physicochemical properties particularly TSS (10.53° brix), total sugar (2.61%) and soluble protein (40.49 mg/100g) content were registered highest with urea 1 per cent spray but ascorbic acid decreased and it was in the favour of zinc sulphate as well as boric acid 0.2 per cent spray whereas lowest phenol recorded under copper sulphate 0.2 per cent spray. Regarding the economics of broccoli production, urea spray resulted into higher net profit per hectare. Srivastava *et al.* (2005) recorded maximum TSS content of 36.07 and 36.33^O brix with $ZnSO_4$ and 1.0 per cent boric acid, respectively as foliar spray in garlic. Shah *et al.* (2010) observed that foliar application either of Zn and B 15 kg/ha and their combination improving the knob quality of knol-khol in respect of TSS and ascorbic acid content.

Vitamin C (mg/100gm Broccoli fresh tissue)

Table 2 and fig 2 shows that the maximum vitamin 'C' mg/100 gm recorded (94.80 mg) in T_5 (B + Mn + Zn) followed by T_6 (Mo + Mn) with 88.73 mg, T_4 (B + Mo) with 87.68, T_9 (Zn) with 85.93, T_3 (Mn) with 85.48 and T_7 (B + Mo + Mn + Zn) with 83.82. The lowest vitamin was found in case of T_0 (Control) 79.02 followed by T_2 (Mo) with 82.23 mg (mg/100 gm broccoli fresh tissue). The present studies are corroborated with Mohamed *et. al.* (2011), who reported that the 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, Saha *et al.* (2010) reported that combined application of borax @ 0.3% at 30 and 45 DAT and ammonium molybdate @ 0.05 % at 45 DAT were found better in terms of total yield per plant along with ascorbic acid and chlorophyll content of head than their individual application over the control.

Abd, *et al.* (2014) studied on two levels of potassium (72 and 96kg K2O/fed.), sulphur (75 and 150kg S/fed.), zinc (100 and 200 ppm) and boron (50 and 100 ppm) on growth, head yield, yield components and quality of broccoli (*Brassica aleracea* L. *var. Italica*. cv. Marathon F1). Islam, *et al.* (2015) reported that a significant and positive effect of boron application on the yield and quality of broccoli and 2.0 kg B/ha was found to be an optimum rate. The genotype Early Green yielded the highest (32.19 t/ha) when boron was applied @ 2 kg/ha. Dry matter, ascorbic acid, and potassium content were increased with the increase of boron level up to 2.0 kg/ha and then declined with further increase of boron. On the other hand, iron and β-carotene content increases with the increase of boron level up to 3.0 kg/ha. Calcium content was found to be decreased with the increase of boron level. Nadia and Abd (2011) also reported broccoli growth, yield quantity and quality as affected by cobalt nutrition. The obtained results showed that the addition of 6 ppm cobalt had a significant positive effect on broccoli growth, head yield and quality. Higher concentrations exerted hazards effect.

Conclusion

From the present investigation it is concluded that treatment T_5 (B 2kg+ Mn 2.5kg +Zn 3kg) was found to be the best treatment combination in terms of quality for broccoli cv. Green Magic cultivation.

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Table 1: Effect of different micronutrients on bud TSS (^{0}Brix) of broccoli

Treatment Symbol	Treatment Combination	Bud Tss (^{0}BRIX)
T_0	Control	6.45
T1	B	6.68
T_2	Mo	7.32
T3	Mn	7.13
T_4	B + Mo	7.83
T_5	B + Mn + Zn	8.8
T_6	Mo + Mn	7.42
T_7	B + Mo + Mn + Zn	7.58
T_8	B + Zn	7.73
T_9	Zn	7.9
F-test		S
SE $_d$(±)		0.51
C.D at 5%		1.07

Table 2: Effect of different micronutrients on vitamin C (mg/100gm broccoli fresh tissue) of broccoli

Treatment symbol	Treatment combination	Vitamin c (mg/100gm broccoli fresh tissue
T_0	Control	79.02
T1	B	82.23
T_2	Mo	82.89
T3	Mn	85.48
T_4	B + mo.	87.68
T_5	B + mn + zn	94.8
T_6	Mo + mn	88.79
T_7	B + mo. + mn + zn	83.82
T_8	B + zn	82.29
T_9	Zn	85.93
F-test		S
S.e$_d$(±)		0.49
Cd at 5%		1.04

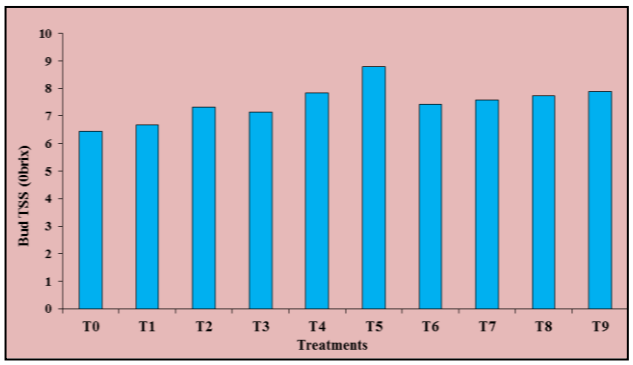

Fig 1: Effect of different micronutrients on bud TSS (^{0}Brix) of broccoli

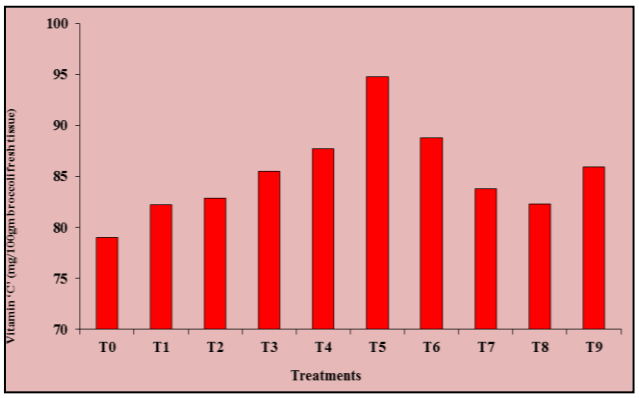

Fig 2: Effect of different micronutrients on vitamin C (mg/100gm broccoli fresh tissue) of broccoli

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