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Beneficial effect of micronutrients on economics of broccoli (*Brassica oleracea* var. *italica*) cv. Green Magic

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Abstract
A field experiment was conducted to study of "Effect of different micronutrient on plant growth, yield and flower bud quality of broccoli (*Brassica oleracea* var. *Italica*) cv. Green Magic" during *rabi* season 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. The four micronutrients B, Mo, Mn and Zn were applied @ of (3:0.5:2:2.5 kg/ha) in which the application of micronutrients was found economically best treatment T_5 (B+Mn+Zn) with the benefit: cost ratio of (3.47:1 follow 1.42:1), respectively T_0 (control). Treatment T_5 (B + Mn +Zn) was recorded maximum gross return (Rs 277,080 ha^{-1}) followed by Rs. 239,180 ha^{-1} with T_7 **(**B + Mo + Mn+ Zn), while the minimum gross return (Rs 106,680) was recorded with (conrol).

Keywords: Plant, yield, broccoli, micronutrients, economics

Introduction
Broccoli (*Brassica oleracea* L. var. *italica* Plenck.) is one of the most nutritious vegetable amongst the cole crops grown for its tender heads. It belongs to the family brassicaceae and originated from the Mediterranean region (Thamburaj and Singh, 2001) [20]. Consumption of broccoli has been steadily increased due to its health promoting properties and conscious of human towards health. 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. 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) [8].

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 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 sulforaphane 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) [17]. 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) [2].

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) [3]. Broccoli contains indole-3-carbinol, which helps to fight breast and lung cancer. Its sprouts are rich source of glucosinolate, particularly glucoraphanin, the substance associated with reducing of cancer (Maurya *et al.*, 2008) [12]. Besides its anticarcinogenic properties, broccoli is a rich source of vitamins, minerals and proteins. It has about 130 times more vitamins A content than cauliflower and 22 times more than cabbage. It is richest source of sulphoraphane, a compound associated with reducing risk of cancer in human beings (Thamburaj and Singh, 2001) [20]. Consumption of 150 gm of broccoli helps in fulfilling the requirement of adult's for vitamins E, A, B1 and C and enhances the immune system (Michaud *et al.*, 2002) [13]. 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) [1]. 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) [1].

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 "Beneficial effect of micronutrients on economics 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*, 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

Economics of Cultivation

The economics of the treatments is the most important consideration for making any recommendation to the farmers for its wide adoption. For calculating economics, the average treatment yield along with prevailing market rates of the produce and cost of inputs were used. B: C ratio was computed by dividing gross returns with cost of cultivation for each treatment.

Cost of cultivation (Rs/ha)

The cost of the inputs that was prevailing at the time of their use was considered (Appendix) to work out the cost of cultivation which is given in rupees per hectare.

Gross income (Rs)

The income was calculated based on the prevailing market price for the broccoli.

Net Income (Rs)

The net income per hectare was calculated on the basis of gross income and coast of cultivation per hectare as follows-
Net income = Gross income – Cost of cultivation.

Benefit of Cost ratio

The benefit to cost ratio was worked out by using the following formula:-

$$\text{Benefit cost ratio} = \frac{\text{Gross income (Rs/ha)}}{\text{Cost of cultivation (Rs/ha)}}$$

Results and Discussion

Economics

The economics of different treatment *viz.*, yield (q ha-1), cost of cultivation, gross return and benefit cost ratio has been worked out and presented in table 1, 2 and 3. Treatment T_5 (B + Mn +Zn) was recorded maximum gross return (Rs 277,080

ha^{-1}) followed by Rs. 239,180 ha^{-1} with T_7 **(**B + Mo + Mn+ Zn), while the minimum gross return (Rs 106,680) was recorded with (Conrol). Treatment T_5 (B + Mn +Zn) was recorded maximum Net return (Rs 197,330 ha^{-1}) followed by Rs. 159,319 ha^{-1} with T_7 **(**B + Mo + Mn+ Zn) and minimum Net return (Rs 317,64.50 ha^{-1}) was recorded with (Control). Treatment T_5 (B + Mn +Zn) was recorded highest benefit cost ratio (3.47) followed by 2.99 with T_7 (B + Mn +Zn + Mo), while the minimum benefit cost ratio (1.42) was recorded with (Control). Above results clearly show that out of the 10 treatment tried in this experiment, treatment T_5 (B + Mn + Zn) maintained its superiority over all other treatment and proved to be the appropriate relation to growth, yielding attributes, yield and economics return for cultivation of broccoli under the agro-climatic condition of Allahabad.

These finding are also closely to Singh, (2016) [18] observed that the economics of different treatment *viz.*, yield (q ha-1), cost of cultivation, gross return and benefit cost ratio revealed that the treatment T6 (B + Mn +Zn) was recorded maximum gross return (Rs 303700 ha-1) followed by Rs. 287600 ha-1 with T8 (B + Mo + Mn+ Zn), while the minimum gross return (Rs 182150) was recorded with (control). Treatment T6 (B + Mn +Zn) was recorded maximum Net return (Rs 212433 ha-1) followed by Rs. 195821 ha-1 with T8 (B + Mo + Mn+ Zn) and minimum Net return (Rs 93058) was recorded with (control). Treatment T6 (B + Mn +Zn) was recorded highest benefit cost ratio (3.32) followed by 3.13 with T8 (B + Mo + Mn+ Zn), while the minimum benefit cost ratio (2.02) was recorded with (control). Above results clearly show that out of the 10 treatment tried in this experiment, treatment T6 (B + Mn + Zn) maintained its superiority over all other treatment and proved to be the appropriate relation to growth, yielding attributes, yield and economics return for cultivation of broccoli under the agro-climatic condition of Allahabad.

Singh and Singh (2004) [19] 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. Sharma, (2000) [16] reported that the combined application of organic fertilizer (farmyard manure) and inorganic fertilizer (NPK) increased the head yield of broccoli compared with the supply of inorganic fertilizer alone. The treatment N: P: K at 175: 75: 60 kg/ha + farmyard manure at 12.5 t/ha recorded the highest broccoli yield and net profit. Choudhary *et al.* (2012) [6] conducted a study to evaluate the effect of different organic sources and fertility levels on the growth, yield, quality and economics of sprouting broccoli under semi-arid conditions of Rajasthan. Significant increase in plant height, number of leaves, leaf area, volume and diameter of head, total head yield, crude protein and chlorophyll content in head was recorded under various levels of organic sources and fertility levels. Growth, yield and quality attributes were recorded maximum under treatment combination of vermicompost 5.0 t/ha along with recommended dose of fertilizers (NPK, 100, 80 and 60 kg/ ha), which was at par with poultry manure 5.0 t/ha and recommended dose of fertilizers, respectively. Further, it also registered maximum net return and B: C ratio of 4.09:1.

Kachari and Korla (2012) [9] carried out a field experiment on cauliflower to know the influence of bio-fertilizers (Azotobacter, Azospirillum and PSB-1) and inorganic fertilizers on curd quality and economics of cauliflower. The results indicated that bio-fertilizers in combinations with inorganic fertilizers performed better as compared to control (FYM), recommended dose of NPK and bio-fertilizers alone. The application of PSB + 50 or 75 or 100 per cent of phosphorus + recommended dose of nitrogen and potassium performed significantly better than other treatments including control. The inoculation with PSB-1 + 100 per cent phosphorus + recommended dose of nitrogen and potassium recorded highest yield (33.94 t/ha). Negi (2016) [14] reported that the economics of treatments and maximum cost: benefit ratio of was found in treatment T_9 (Biofertilizer + Biovita granules) 1:4.16 with a total net returns of Rs. 220383.73 and minimum C:B ratio was found in T_{10} (control) 1:1.01. Cost: benefit ratio revealed that maximum cost: benefit ratio was obtained in that treatment, which fetched highest gross return. Treatment combination T_7 (Vermicompost+ Biofertilizers) registered maximum cost:benefit ratio closely followed by the treatment combination, which received organic and biofertilizers in combination treatment T_9 (Biovita granules + Biofertilizers) due to higher yield and lesser cost of Biovita Granules.

The results obtained with respect to cost: benefit ratio are in line with the findings of Chaterjee *et al.* (2005) [5] in broccoli, Bhardwaj *et al.* (2000) [4] in cauliflower and cabbage, Sharma (2000) [16], Sharma *et al.* (2008) [15] and Khan *et al.* (2010) [10] in cauliflower, whereas, minimum benefit: cost ratio was obtained in the treatment T_{10} *i.e.* (control) due to lesser yield, ultimately lesser gross income and lesser net return, taking into consideration all aspect, it can be concluded that application of organic, and biofertilizers in combination gave higher cost: benefit ratio as compare to sole application of different nutrient sources and biofertilizers. Therefore, balance nutrition in integration is essential to enhance the cost: benefit ratio in broccoli Dass *et al.* (2008) [7] and Maurya *et al.* (2008) [12].

Table 1: Cost of cultivation of crop (fixed cost for all treatment) per hectare

S. No	Particulars	Unit	Qty.	Rate/Unit (Rs)	Cost (Rs/Ha^{-1})
A.	Nursery preparation				
1	Preparation of seed bed and sowing	Labour	1	200	200
B.	Land Preparation				
1.	Ploughing with M.B. Plough	Hrs.	3		1,800
2.	Disc harrowing	Hrs.	3		1,800
3.	Planking and leveling	Hrs.	5		3,000
4.	Layout of field	Labour	10	2 days	4,000
C.	Manures and				
1.	FYM	Tones	15	1500	22,500
D.	Seed and sowing				
1.	Cost of seeds	gm	250	100	500
2.	Labour for seed sowing, transplanting and fertilizer application	Labour	30	200	6,000
E.	Plant protection				

1.	Carboryl 3%	gm	20		60
2.	Hand weeding and ear-thing up	Labour	20	200	4,000
3.	Chloropyriphos 35 EC	Liter	1	350	350
4.	Dimethoate 35 EC	ml	300	165	165
5.	Labour for spraying of chemicals	Labour	4	200	800
F.	Irrigation				
1.	Tube well Charges 5 irrigation		5	250	1,500
2.	Labour for irrigation (2 labour/irrigation)	Labour	10	200	2,000
G.	Harvesting and other operation	Labour	15	200	3,000
H.	Transportation charges	L.S.			5,000
I.	Supervision charges	Month	3	3,000	9,000
J.	Rental value of land	Month	3	1,000	3,000
K.	Total				70,675
L.	Interest working 12% @ 6 month				4,240.50
M.	Total fixed cost (Rs/ha)				74,915.50

Table 2: Total cost for different micronutrients combination.

S. N	Fertilizer	Unit	Qty. kg^{-1}	Rs /unit	Rs/ha^{-1}	Fixed cost	Total cost of cultivation
1.	Borax	Kg	10.5	78	819	74,915.5	75,737.5
2.	Sodium	Kg	2.5	400	1000	74,915.5	75,915.5
	Molybdenum						
3.	Manganese sulfate	Kg	9.5	30	285	74,915.5	75,200.5
4.	Zinc Sulfate heptahydrate	Kg	15.65	40	626	74,915.5	75,541.5

Table 3: Economics of different treatment combination.

Treatment	Treatment combination	Yield Q ha^{-1}	Selling Rate (Rs) Rs. Q-1	Gross Return Rs.ha^{-1}	Cost of cultivation Rs.ha^{-1}	Net return Rs.ha^{-1}	Benefit ratio
T_0	Control	71.12	2,000	106,680	74,915.50	31,764.50	1.42
T_1	B	96.24	2,000	192,480	75,734.50	116,745.50	2.54
T_2	Mo	94.31	2,000	188,620	75,915.50	112,704.50	2.48
T_3	Mn	95.25	2,000	190,560	75,200.50	165.359.5	2.53
T_4	B + Mo	115.98	2,000	231,960	78,338	153,622	2.56
T_5	B + Mn + Zn	138.54	2,000	277,080	702,750	197,330	3.47
T_6	Mo + Mn	110.54	2,000	221,080	77,462	143,618	2.85
T_7	B + Mo + Mn +Zn	119.59	2,000	239180	79,861	159,319	2.9
T_8	B + Zn	116.25	2,000	232,500	78,223	154,277	2.97
T_9	Zn	114.5	2,000	229,000	77,416	151,584	2.95

Conclusion

The four micronutrients B, Mo, Mn and Zn were applied @ of (3:0.5:2:2.5 kg/ha) in which the application of micronutrients was found economically best treatment T_5 (B+Mn+Zn) with the benefit: cost ratio of (3.47:1 follow 1.42:1), respectively T_0 (control).

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