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RESEARCH ARTICLE

Effect of different micronutrients on plant growth, yield and flower bud quality of broccoli (*Brassica oleracea var. Italica*) cv. Green Bud

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Abstract

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.

Introduction:-

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. **(Indian Horticulture Database, 2012-2013).** 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 tones and 369 thousand hectares. **(Vegetable statistics 2013).** 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 (Pandey and Mathura Rai, 2005). 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). Broccoli

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commonly known as harigobhi or broccoli in Hindi is gainig popularity in India also. In the world market about 40 percent is marketed as fresh and remaining 60 percent as frozen. It is used salad, cooked in curries, boiled and also processed (Sharma, 2003). The name 'Broccoli' refers to the young shoots which develop in spring on some species of the genus Brassica ('brocco' is Italian for shoot) (Bose, 2002). Broccoli is of two types, heading and sprouting, sprouting broccoli is more popular in India. Heading broccoli forms curd like cauliflower, while sprouting broccoli contains a group of green immature bud and thick fleshy flower stalk forming a head. The cultivation was initially restricted to hill areas of Jammu and Kashmir, Himachal Pradesh, and Uttar Pradesh but now successfully grown under North Indian plain condition (Nirmal et al. 2004). 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). 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 fiber 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. 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. Horticultural crops suffer widely by 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. 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. The form available to plants is the Mn^{++} ion. Manganese availability is related more to soil pH than soil test manganese levels. Manganese recommendations are based on the crop being grown and soil pH. On low pH mineral soils (pH less than 4.8), manganese can be toxic to plants. A few suspected deficiencies have been reported in fruit and vegetable crops grown on alkaline mineral soils. Manganese deficiency problems are most likely to occur on organic soils with a pH greater than 5.8. If crops grown on mineral soils show signs of manganese deficiency or have low tissue manganese levels, a foliar application at the rate of 0.2 lb Mn/A is recommended. Two or three applications are usually required. Apply with 50 to 100 gallons of water per acre. Chelated sources of manganese are recommended for foliar spays. 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^-. Deficiency of boron is most likely on sandy soils low in organic matter. Excessive rainfall or irrigation may leach boron from sandy soils. A suspected boron deficiency should be confirmed by soil and plant analyses before a boron fertilizer is applied since excessive boron can be highly toxic to plants. For in season correction of boron deficiency, foliar sprays at the rate of 0.2 to 0.4 lb B/A are recommended. Multiple applications are usually required. 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. Soil tests for molybdenum are not reliable for making molybdenum fertilizer recommendations. Liming soils to a pH of 6.0-6.5 is the best method to correct molybdenum deficiency; however, some cauliflower cultivars seem to be susceptible to molybdenum deficiency even in limed soils. Soil applications of 0.25-0.5 pounds per acre of actual molybdenum can be used if molybdenum deficiency is a problem. Foliar applications of 1-2 oz/A of actual molybdenum are suggested for Cole crops where a deficiency is known or expected. Do not over apply molybdenum as high rates can be toxic to animals. 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. High levels of phosphorus coupled with low levels of soil zinc may induce zinc deficiency. If zinc deficiency is known or suspected, zinc sulfate can be blended with a dry bulk fertilizer. 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. (R. F. Lucas and B. D. Knezek. 1973).

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 the growth, yield and flower bud quality of broccoli (*Brassica oleracea var. Italica*) c.v. – Green Bud" was carried out at Horticulture Experimental field, Department of Horticulture, Allahabad School of Horticulture, Sam Higginbottom Institute of Agriculture Technology and Sciences (formerly known as Allahabad Agriculture Institute Deemed University, AAI-DU) during rabi season of 2014-2015.

Experimental site:-The experiment was conducted during rabi season of 2014-2015 at Vegetable Unit of Department of Horticulture, SHIATS, Allahabad 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).

Climatic conditions of the experimental area:- The area of Allahabad District comes under sub tropical belt in the south eastern Uttar Pradesh, which experience extremely hot summer and fairly cold winter. The maximum temperature of the location reaches up to 460 C to 480 and seldom falls as low as 40 C to 50 C. The Relative humidity ranged between 20 to 94 %. The average rainfall in this area is around 850-1100 mm annually. The meteorology data (October, 2014 to February, 2015) with respect to total rainfall, maximum and minimum temperature, relative humidity is presented in Table 1.1 and fig 1.1

Table:-1.1 Average weekly meteorological data during cropping period (October, 2014 to February, 2015).

Weeks	Temperature^{0}C		Rainfall (mm)	Relative humidity (%)	
	Maximum	Minimum		Maximum	Minimum
October 2014					
2nd Week	32.3	22.3	15.85	86.57	62.28
3rd Week	33.34	20.4	0	86.42	60.71
4th Week	32.6	20.3	0	86.00	53.85
November 2014					
1st Week	33.51	23.66	0	86.14	62.00
2nd week	33.14	20.64	0.00	86.43	52.86
3rd week	32.60	20.31	0.00	86.00	53.86
4th week	33.51	23.66	0	86.14	62.00
December 2014					
1st Week	30.26	11.86	1.29	83.57	44.71
2nd week	28.26	9.46	0	86.43	55.00
3rd week	22.26	7.84	0.00	92.71	58.57
4th week	17.20	8.20	0.00	93.00	62.71
January 2015					
1st Week	21.83	13.26	4.71	91.71	56.00
2nd week	16.74	7.90	0	92.57	73.14
3rd week	18.40	8.50	0.29	94.00	63.57
4th week	19.66	13.04	4.51	91.14	63.14
February 2015					
1st Week	28.6	14	2.00	88	43.55
2nd week	26.48	12	0	89.14	48
3rd week	29.2	11.8	0	85.0	48

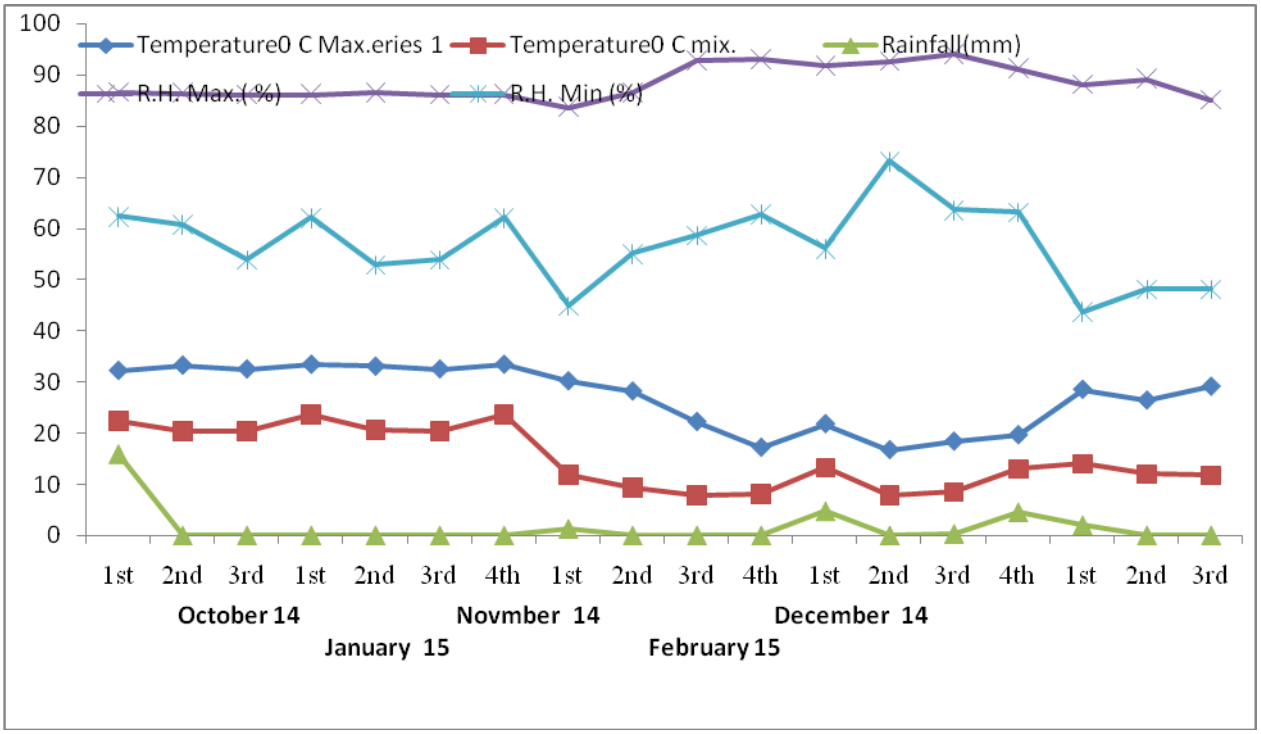


Figure:-1.1 Average weekly meteorological data during cropping period (October, 2014 to February, 2015).

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 1.2.

Table:- 1.2:- Physical and chemical properties of soil at experimental site (SHIATS, Allahabad)

S. No.	Particulars	Value(0-30 cm depth)	Method followed
Physical properties			
1.	Sand	48.15%	Bouyoucos hydrometer method **(Bouycoucos, 1952)**
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 **(Walkely and Black's,1934)**
4.	Available nitrogen (k $ha^{-1)}$	214.6	Alkaline permangananate method **(Subbaiah and Asija,1956)**
5.	Available phosphorus (k ha^{-1})	36.64	Olsen's Colorimetric method **(Olsen *et al.*, 1954)**
6.	Available potassium (k ha^{-1})	212.05	Flame Photometric method **(Jackson,1958)**

Table:- 1.3 Pre- transplanting operations

Date	Operations	Remark
25-09-2014	Ploughing of land	By tractor
02-10-2014	Weeding and levelling	By manual labour
04-10-2014	Demarcation of layout	By manual labour
05-10-2015	Application of manures by raking	By manual labour
19-10-2014	Application of micronutrients	By manual labour
20-10-2014	Transplanting	By manual labour

Experimental details:-The experiment entitled **"Effect of different micronutrient on the growth, yield and flower bud quality of broccoli (Brassica oleracea var. Italica) c.v. – Green Bud"** was conducted as per following details:

Design and layout of experiment:-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.

Table:- 1.4:- Treatments Combination

Treatments	Treatment Combination
T_1	Control
T_2	Boron (B)
T_3	Molybdenum (Mo)
T_4	Manganese (Mn)
T_5	Boron + Molybdenum
T_6	Boron + Manganese + Zinc
T_7	Molybdenum + Magnesium
T_8	Boron + Molybdenum + Manganese + Zinc
T_9	Boron + Zinc
T_{10}	Zinc (Zn)

Table:- 1.5 Micronutrients combinations

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

Table:- 1.5:- Details of crop cultivation

Cultivation variety	Seed source	Date of sowing in Nursery
Green Bud	- kraft seed company ltd.	16th October
Crop	Date of transplanting	
Broccoli	3rd, 5th, 8th and 11th February 2015	

'Green bud'- (F1, 63-68 days) produces uniform, Early maturity, small-beaded green heads, each 5-6" (13-15 cm) across. Strong cold tolerance makes this one of the best types of broccoli for fall and winter production. Resists head rot, downy mildew, and brown bead. Crops are ready for harvesting in 65-70 days after transplanting. About 100-150 q yield /ha may be obtained.

1.6 Details of Cultivation:-The details regarding the various cultural operations carried out during the course of investigation are furnished below:

1.6.1 Preparation of Nursery:- A normal sized nursery bed (1.0 m x 1.0 m) was raised 15cm above the soil surface in the department nursery in the month of October 2014. While leveling, a slope of 2.0 cm was maintained from the centre to all sides for efficient drainage. Then the prepared bedding mixture was evenly spread in form of 5.0 cm thick layer over the nursery. Rows were made 1.5 to 2.0 cm deep at 10.0 cm apart and seeds were sown, covered and watered. The seedlings became ready for transplanting within a month and transplanted.

1.6.2 Field Preparation:-Land was thoroughly prepared 25 days prior to transplanting by deep ploughing, harrowing thrice and weeds and stubbles were removed completely. The land was brought to a fine tilth by thorough tillage. On 04 Nov. 2014 the experimental area laid out into ridge bed of size 1.5 x 1.0 m. A spacing of 0.40 between to replications was maintained for lying of irrigation channels and bunds, respectively.

1.6.3 Application of Manures and fertilizers:-The organic manure applied was FYM 25 t/ha were well incorporated in the experimental field 20 days before transplanting of seedling. Half dose of nitrogen, total phosphorus and potash were well mixed and applied as basal dose before transplanting. According to the treatment the micronutrients (B: Mo: Mn: Zn – 2: 0.5: 2.5: 3 kg/ha) are applied before transplanting. Balance half quantity of nitrogen was applied as top dressing at 30 days after transplanting.

1.6.4 Transplanting:- Irrigation was given to the plots two day transplanting of the seedling. So that seedling could be transplanted in well moist soil. 35 days old seedlings were transplanting in the main field in the month of November, 2014. During the transplanting soil was pressed firmly around the seedling will not be disturbed by irrigation water immediately after transplanting.

After care:-

1.7.1. Gap filling;- In order to maintain uniform stand of the crop in each plot, the dead seedling were located 10 days after transplanting and replaced with new ones of the same age.

1.7.2 Weeding and hoeing:-The plot were kept weed free throughout the growth period by weeding at regular intervals. First weeding and hoeing was done 25 days after transplanting and second weeding and hoeing was done 50 days after transplanting.

1.7.3 Ear-thing –up:- Ear-thing-up of seedling was done 30 days after transplanting by covering the base of the plant with the surrounding soil.

1.7.4 Irrigation:-Immediately after transplanting a light irrigation was done depending upon the moisture requirement of the soil. During the entire period of growth total irrigations were mentioned in table of cost of cultivation.

1.7.5. Plant protection measures:-At the nursery bed, Carboryl 3% @ 2 gm/lit of water and Bavistin @ 2ml /lit were sprayed at 13 and 23 day after sowing, respectively , to protect the plant plants from insects and fungal diseases.(29 Oct. and 09 Nov. 2014)**.** After transplanting, the seedlings attacked by insects and pests were controlled by spraying as well as non- systemic insecticides as per requirement. To prevent the termite attack on plants, chloropyriphos 20 EC @ 0.75 kg ha-1 was applied to entire field immediately after transplanting with irrigation. To check the attack of cabbage butterfly, hopper and aphids, prophylactic measures were taken i.e. the sprouting broccoli plants were sprayed with malathion 50 EC (0.05%) at an interval of 20 days from 40 days after transplanting and up to a week before the maturity of the crop.

Table 1.6 Post – transplanting field Operations

Date	Operations	Remarks
18-11-2014	chloropyriphos 20 EC @ 0.75 kg ha-1	By manual labour
21-11-2014	Irrigation by hose	By manual labour
22-11-2014	Irrigation by hose	By manual labour
23-11-2014	Irrigation by slight flooding	By manual labour
30-11-2014	Gap filling and irrigation by can	By manual labour
06-12-2014	Flood irrigation	By manual labour
10-12-2014	First reading	
11-12-2014	Application of malathion 50 EC (0.05%)	By manual labour
15-12-2014	First weeding	By manual labour
17-12-2014	Flood irrigation	By manual labour
20-12-2014	Ear-thing-up	By manual labour
27-12-2014	Flood irrigation	By manual labour
30-12-2014	Second reading	
31-12-2014	Application of malathion 50 EC (0.05%)	By manual labour
10-01-2015	Second weeding	By manual labour
13-01-2015	Flood irrigation	By manual labour
20-01-2015	Third reading	By manual labour
20-01-2015	Bud initiation stage	
25-01-2015	Flood irrigation	By manual labour
03-02-2015	First Harvest	By manual labour
05-02-2015	Second Harvest	By manual labour
05-02-2015	Flood irrigation	By manual labour
08-02-2015	Third Harvest	By manual labour
11-02-2015	Fourth Harvest	By manual labour

1.9. Observations recorded:- The parameters relating to growth, yielding attribute and yield were measured to make a critical analysis of the crop as affected by different treatments under different micronutrient. The technique of representative sample was adopted for recording the observations on various morphological characters in Broccoli. At every observation, four plants from each plot were randomly selected and tagged. The observations were recorded from these samples. The following observations were recorded at various successive growth stages:

1.9.1 Pre- Harvest observations:-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 forms 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, with the help of a statically analyzed.

1.9.2:-Post-Harvest Observations:-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 harvesting was done in the plot on 02 February 2015. The whole plants (except root) were cut just above the ground level. Fresh weights of the selected plants were recorded data wise separately for each plot. 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. Fresh weight of plant (g):-Fresh weights of the four selected plants were recorded in each plot and average fresh weight is calculated. This calculated value was assumed as average weight of the rest of remaining plant per-plot.

V. Dry weight of plant (g):-We have taken the same plant taken for fresh weight form every treatment for dry weight and dried in the drier for dehydration. It was dried for 5-6 hours at the temperature of 50-60^{0}C. The dry weights of all randomly selected plant in each plot were added together and average calculated.

VI. 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.

VII. 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 (A.O.A.C., 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% metaphosphoric 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.
Vitamin C mg/100 g of broccoli fresh tissue.
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.

VIII. Total Soluble Solid (T.S.S.^{0} Brix):-Percentage of total Soluble Solid was determined with the help of Erma Hand Refract meter (range 0-32) in Brix^0. Averaged and Analysed.

IX. Root weight (g):-Root weights of the four selected plants were recorded in each plot and average weight is calculated. Before weight root are wash in fresh water. This calculated value was assumed as average weight of the rest of remaining plant per-plot.

X. Dry Root weight (g):-We have taken the same plant taken for root weights form every treatment for dry weight and dried in the drier for dehydration. It was dried for 5-6 hours at the temperature of 50-60^{0}C. The dry weights of all randomly selected plant in each plot were added together and average calculated.

Economics of Cultivation:-

1.10.1 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.

1.10.2 Gross income (Rs):-The income was calculated based on the prevailing market price for the broccoli.

1.10.3 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

1.10.4 Benefit of Cost ratio :-The benefit to cost ratio was worked out by using the following formula:-

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

1.11 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.

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.

Table 3.7:- 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.	R.S.S. / r-1	R.S.S. / M.E.S.S.	
Due to treatment	(t-1)	T.S.S.	T.S.S / t-1	M.T.S.S. / M.E.S.S.	(r-1) (t-1)
Due to error	(r-1) (t-1)	E.S.S.	E.S.S. / (r-1) (t-1)	M.E.S.S.	F(t-1) (r-1)(t-1)
Total	(rt-1)	TSS	-	-	-

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

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

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. 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.

Results and Discussion:-The present field experiment **Effect of different micronutrient on the growth, yield and flower bud quality of broccoli (*Brassica oleracea var. Italica*) c.v. – Green Bud"** was aimed at identifying suitable treatment combination of different micronutrient for production and bud quality in broccoli cultivation. Ten treatment combinations, including control were evaluated during rabi season, 2014-2015 in the experimental unit of Department of Horticulture, Sam Higginbottom Institute of Agriculture, Technology and Sciences, Allahabad. The results of the experiments are presented separately under the following heading.

2.1. Plant Height (cm):-The results pertaining of the effect RDF applied through different micronutrient on plant height of Broccoli at 20, 40 and 60 DAT are graphically presented in Table 2.1 and Fig 2.1 At 20 DAT table 2.1 and Fig. 2.1 shows that the plant height was maximum (14.30 cm) in T_6 (Boron + Manganese + Zinc) followed by T_8 (B + Mo + Mn + Zn) in (13.38 cm). The lowest plant height found in T_1 (control) 11.98 cm. Plant height at 40 DAT is shows table 2.1 and Fig. 2.1 differed significantly due to various treatment combinations and considerably increased up to 60 DAT due to micronutrient. At 40 DAT T_6 (B + Mn + Zn) gave maximum height (33.99 cm).

Table 2.2:- Effect of different Micronutrient number of Leaves per Plant

Treatments	Treatment Combination	Number of Leaves		
		20DAT	40DAT	60DAT
T_1	Control	4.00	8.67	19.00
T_2	B	4.83	9.08	20.42
T_3	Mo	5.42	11.50	21.33
T_4	Mn	5.25	11.67	21.58
T_5	B + Mo	5.25	11.92	21.83
T_6	B + Mn + Zn	6.58	12.92	24.25
T_7	Mo + Mn	5.17	12.17	22.08
T_8	B + Mo + Mn + Zn	4.83	11.17	22.92
T_9	B + Zn	5.33	11.42	22.33
T_{10}	Zn	5.17	12.00	22.50
F-test		S	S	S
$S.E_d(\pm)$		0.35	0.33	0.32
C.D at 5%		0.74	0.68	0.67

Followed by T_7 (Mo + Mn) is 34.33 cm. The lowest plant height (32.35 cm) was found in T_1 (control). The plant height at 60 DAT maximum found in T_6 (B + Mn + Zn) is 51.30 cm. followed by 48.99 in T_8 (B + Mo + Mn + Zn). Minimum found in T_1 (control) 42.84 cm. These results are similar recorded by **Alam MN, Abedin MJ, and Azad MAK (2010)** on onion and **Naga Sivaiah, K.,Swain (2013)** in tomato.

2.2 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 Day after transplanting are presented in table and fig 2.2 It's seen from results in table and fig. 2.2 that, there was heights number of leaves at 20 DAT in T_6 (B +Mn +Zn) 6.58 followed by 5.42 per plant in T_3 (Mo) and lowest number of leaves was found in T_1 (control) is 4.00. The number of leaves at 40 DAT and 60 DAT maximum found in same treatment T_6 (B + Mn +Zn) is 12.92 and 24.25 followed by respectively T_{10} (Zn) and T_8 (B + Mo + Mn + Zn) is 12.00 and 22.92 per plant. The lowest number of leaves found in T_1 (control) is 8.67 and 19.00. These results are similar recorded by **Alam MN, Abedin MJ, and Azad MAK (2010)** on onion and **Naga Sivaiah, K.,Swain (2013)** in tomato.

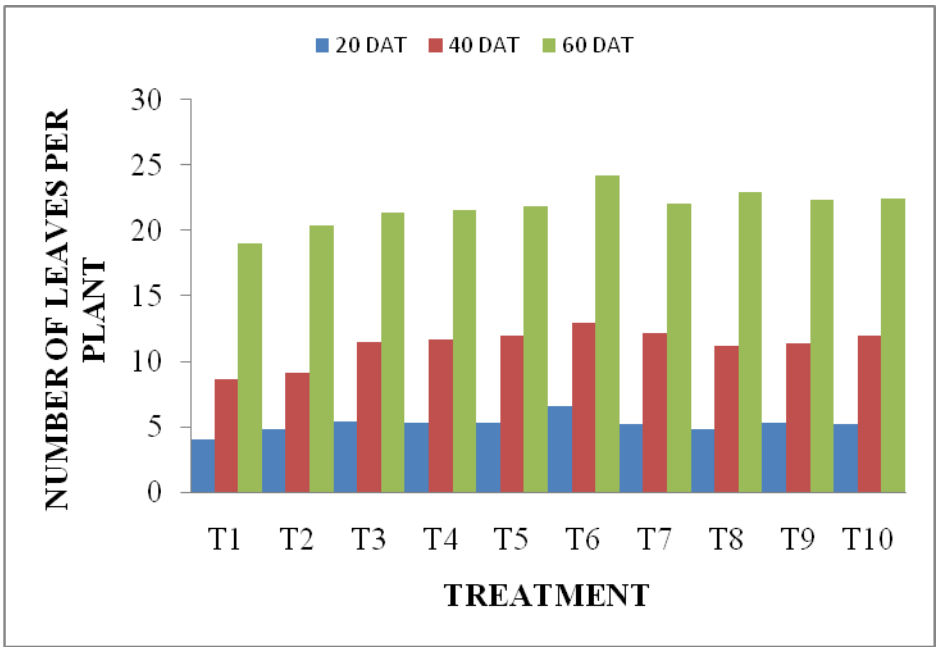
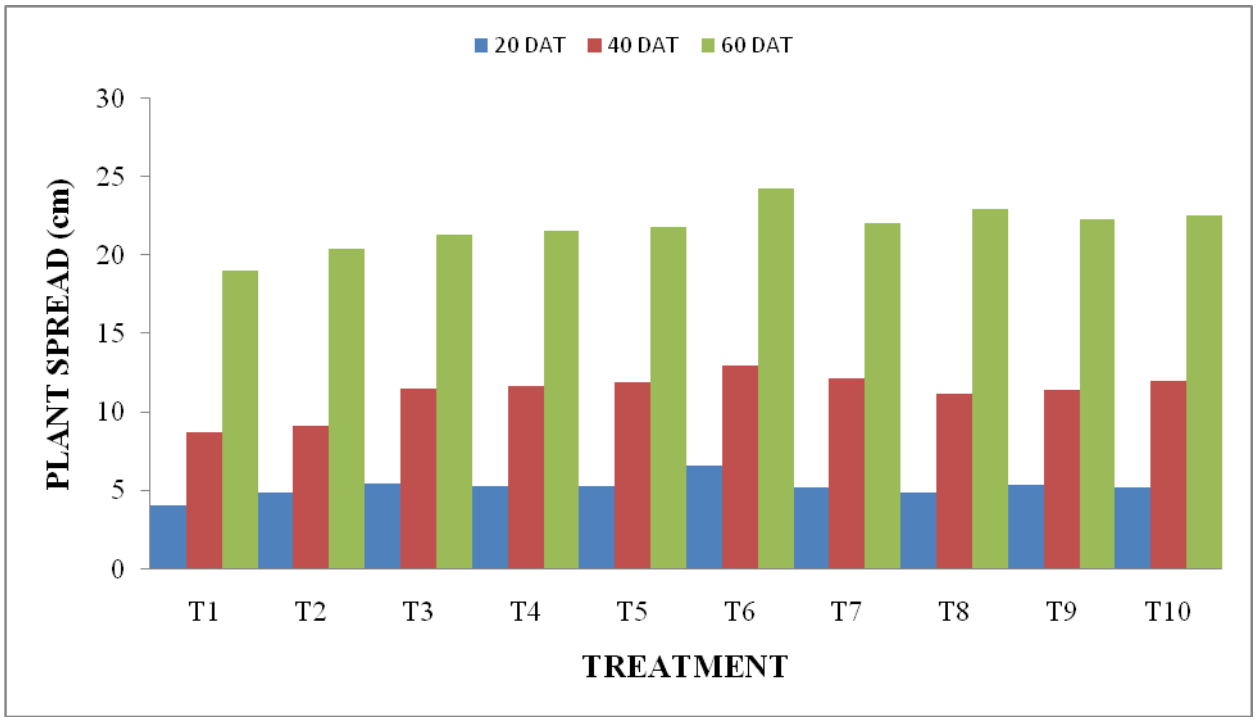


Fig.2.2:- Effect of different Micronutrient number of Leaves per Plant

2.3 Plant Spread (cm):-The data of the mean plant spread of the plant as influenced by different treatments observed at different intervals i.e. 20, 40 and 60 Day after transplanting are presented in the table and fig 2.3. At 20 DAT maximum plants spread was found 14.23 cm in T_6 (B + Mn +Zn) followed by T_5 (B + Mo) is 13.53 cm and minimum plant spread was found (11.37 cm) in T_1 (control). At 40 DAT and 60 DAT maximum plant spread was found in T_6 (B + Mn + Zn) is 35.15 cm and 52.83 cm followed by 33.53 cm and 49.15 cm in T_{10} (Zn). The minimum plant spread 29.76 cm and 43.89 cm was found T_1 (control). These results are found closely by **Inayat Ur Rahman, Aftab Afza et. al(2013)** in cauliflower and **M Narayanamma, Ch Chiranjeevi And S Riazuddin Ahmed(2007)** in cabbage.

Table 2.3:- Effect of different Micronutrient on Plant Spread (cm)

Treatments	Treatment Combination	Plant Height		
		20DAT	40DAT	60DAT
T_1	Control	11.98	32.35	42.84
T_2	B	12.67	33.26	46.81
T_3	Mo	13.06	33.50	45.53
T_4	Mn	13.18	33.74	47.89
T_5	B + Mo	13.29	34.02	45.37
T_6	B + Mn + Zn	14.30	35.99	51.30
T_7	Mo + Mn	12.97	34.33	48.03
T_8	B + Mo + Mn + Zn	13.38	33.60	48.99
T_9	B + Zn	12.86	33.89	47.05
T_{10}	Zn	13.35	33.07	47.47
F-test		S	S	S
S. E_d(±)		0.33	0.30	0.36
C.D at 5%		0.69	0.64	0.75



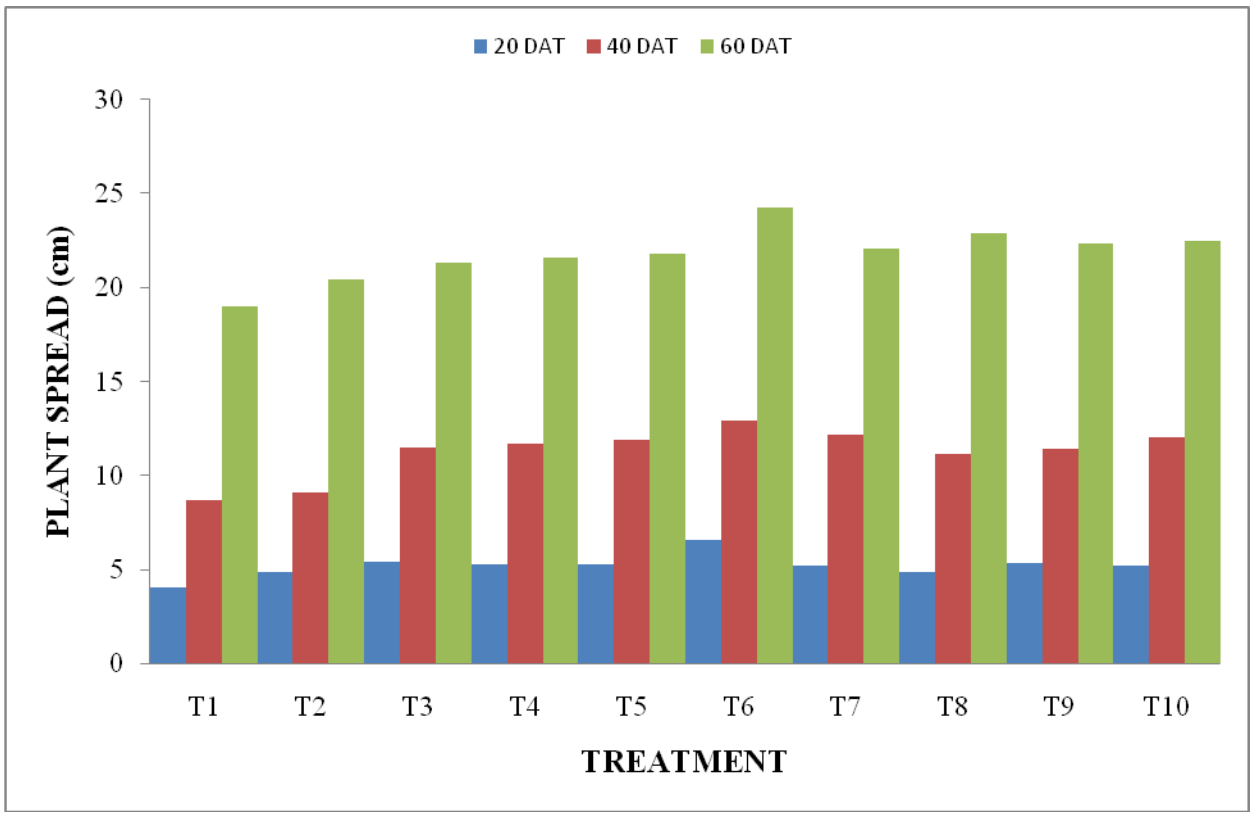


Fig. 2.3:- Effect of different Micronutrient on Plant Spread (cm) (20, 40 AND 60 DAT)

2.4 Bud or Head Diameter (cm):-Different micronutrient application significantly influenced the bud or head diameter over control. Table and fig 2.4 reveals that the maximum bud diameter 16.90 cm was recorded with T_6 (B + Mn +Zn) followed by 16.28 cm in T_9 (B +Zn) and T_8 (B + Mo + Mn + Zn) i.e. 15.73 cm, which were significantly higher than other treatment. The lowest bud diameter (14.04 cm) was observed in treatment T_1 (control). These results are found similar to **M. Moniruzzaman and S. M. L. Rahman *et al.* (2007)** in broccoli and **Md. Joynul Abedin, Md. Nurul. Alam *et al* (2010)** on onion.

Table 2.4:- Effect of different Micronutrient on Bud Diameter (cm)

Treatments	**Treatment Combination**	**Bud Diameter**
T_1	Control	14.04
T_2	B	14.53
T_3	Mo	14.98
T_4	Mn	15.35
T_5	B + Mo	14.39
T_6	B + Mn + Zn	16.90
T_7	Mo + Mn	15.58
T_8	B + Mo + Mn + Zn	15.73
T_9	B + Zn	16.28
T_{10}	Zn	15.95
F-test		S
$S.E_d(\pm)$		0.50
C.D at 5%		1.05

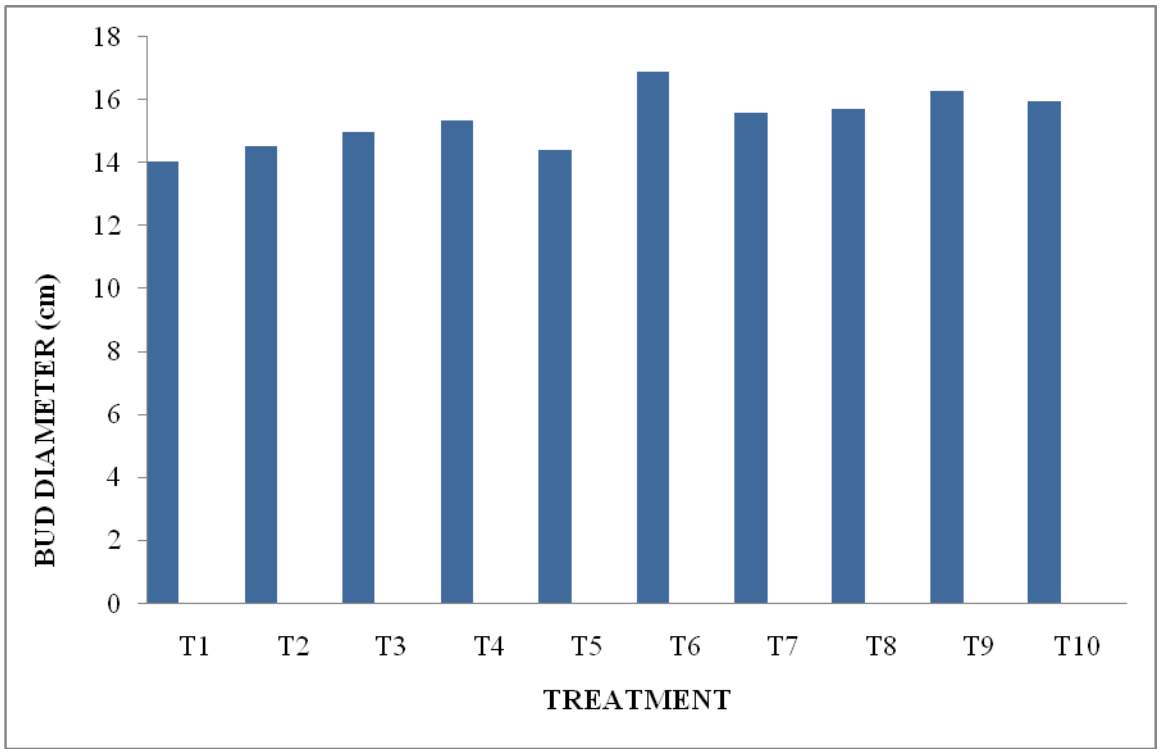


Fig.2.4:- Effect of different Micronutrient on Bud Diameter (cm)

2.5 Bud or Head Weight (g):-Table and fig. 2.5 shows that the bud weight was significantly influenced by the different treatment combination tried. The treatment T_6 (B + Mn + Zn) had significantly the highest bud weight (303.69 gm) followed by T_8 (B + Mo + Mn +Zn) is 287.61 gm. Lowest bud weight 182.15 gm was observed in T_1 (control). These results are closely recorded by **M. Moniruzzaman and S. M. L. Rahman *et al.* (2007) and Sohan Lal and Singh S.P. (2012)** in broccoli table and fig 2.5.

Table 2.5:- Effect of different Micronutrient on Head or Bud Weight per Plant (g)

Treatments	**Treatment Combination**	**Bud Weight per Plant (g)**
T_1	Control	182.15
T_2	B	238.32
T_3	Mo	242.47
T_4	Mn	241.77
T_5	B + Mo	285.98
T_6	B + Mn + Zn	303.69
T_7	Mo + Mn	260.57
T_8	B + Mo + Mn + Zn	287.61
T_9	B + Zn	261.82
T_{10}	Zn	265.17
F-test		S
$S.E_d(\pm)$		6.37
C.D at 5%		13.38

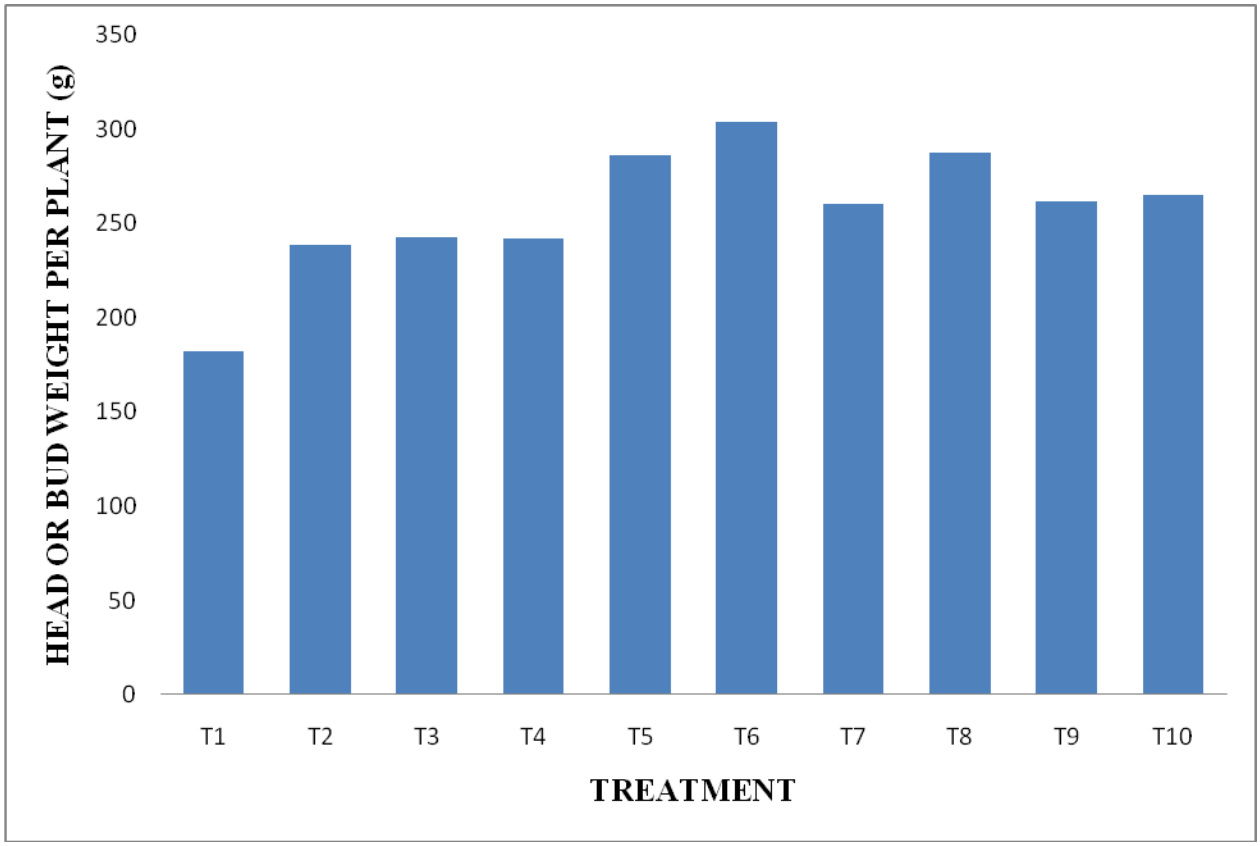


Fig. 2.5:- Effect of different Micronutrient on Head or Bud Weight per Plant (g)

2.6. Number of Frouds per Head or Bud:-On observing the data, table and fig. 2.6 shows that there was significant difference among various treatment combinations regarding number of frouds/bud. Maximum number of frouds (15.67) was observed in T_6 (B + Mn + Zn) followed by 14.08 T_3 (Mo) and minimum (12.75) were found in T_0 (control).

Table 2.6:- Effect of different Micronutrient on Number of Frouds per Head or Bud.

Treatments	**Treatment Combination**	**Number of Frouds per Bud**
T_1	Control	12.75
T_2	B	13.42
T_3	Mo	14.08
T_4	Mn	13.33
T_5	B + Mo	13.67
T_6	B + Mn + Zn	15.67
T_7	Mo + Mn	12.92
T_8	B + Mo + Mn + Zn	12.92
T_9	B + Zn	13.58
T_{10}	Zn	13.00
F-test		S
$S.E_d(\pm)$		0.46
C.D at 5%		0.96

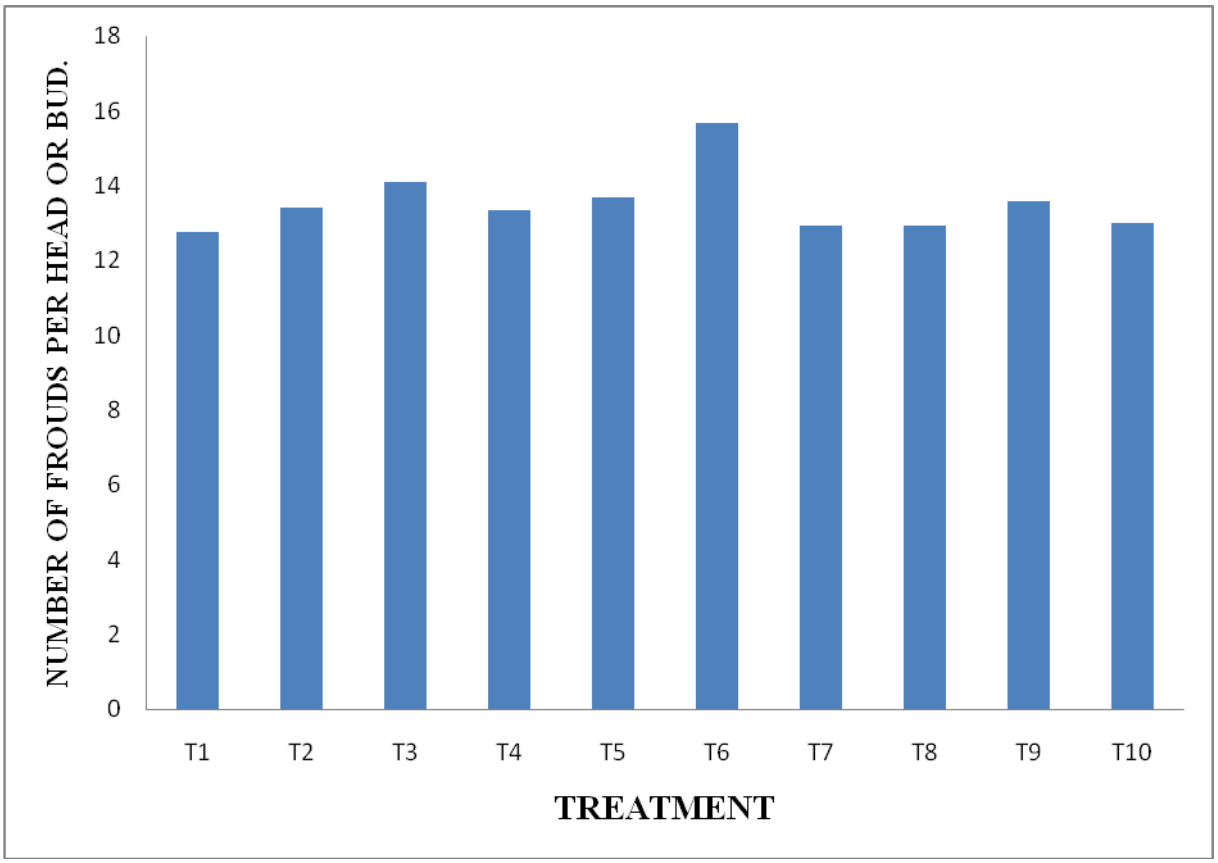


Fig. 2.6:- Effect of different Micronutrient on Number of Frouds per Head or Bud.

2.7 Bud or Head Yield per Hectare (q):-The table and fig 2.7 shows that the treatment T_6 (B + Mn + Zn) and T_8 (B + Mo + Mn +Zn) had significantly more yield per hectare than other treatment (121.48 q/ha and 115.04 q/ha. The yield of treatment T_3 (Mo) and T_4 (Mn) was almost similar (96.99q/ha and 96.71 q/ha) respectively. The treatment T_1 (control) recorded lowest yield per hectare (72.86 q/ha). These results are similar recorded by **Alam MN, Abedin MJ, and Azad MAK (2010)** and **Naga Sivaiah, K.,Swain (2013)** in tomato.

Table 2.7:- Effect of different Micronutrient on Head Yield per Hectare (q)

Treatments	**Treatment Combination**	**Head Yield per Hectare(q)**
T_1	Control	72.86
T_2	B	95.33
T_3	Mo	96.99
T_4	Mn	96.71
T_5	B + Mo	114.39
T_6	B + Mn + Zn	121.48
T_7	Mo + Mn	104.23
T_8	B + Mo + Mn + Zn	115.04
T_9	B + Zn	104.73
T_{10}	Zn	72.86
F-test		S
$S.E_d(\pm)$		2.55
C.D at 5%		5.35

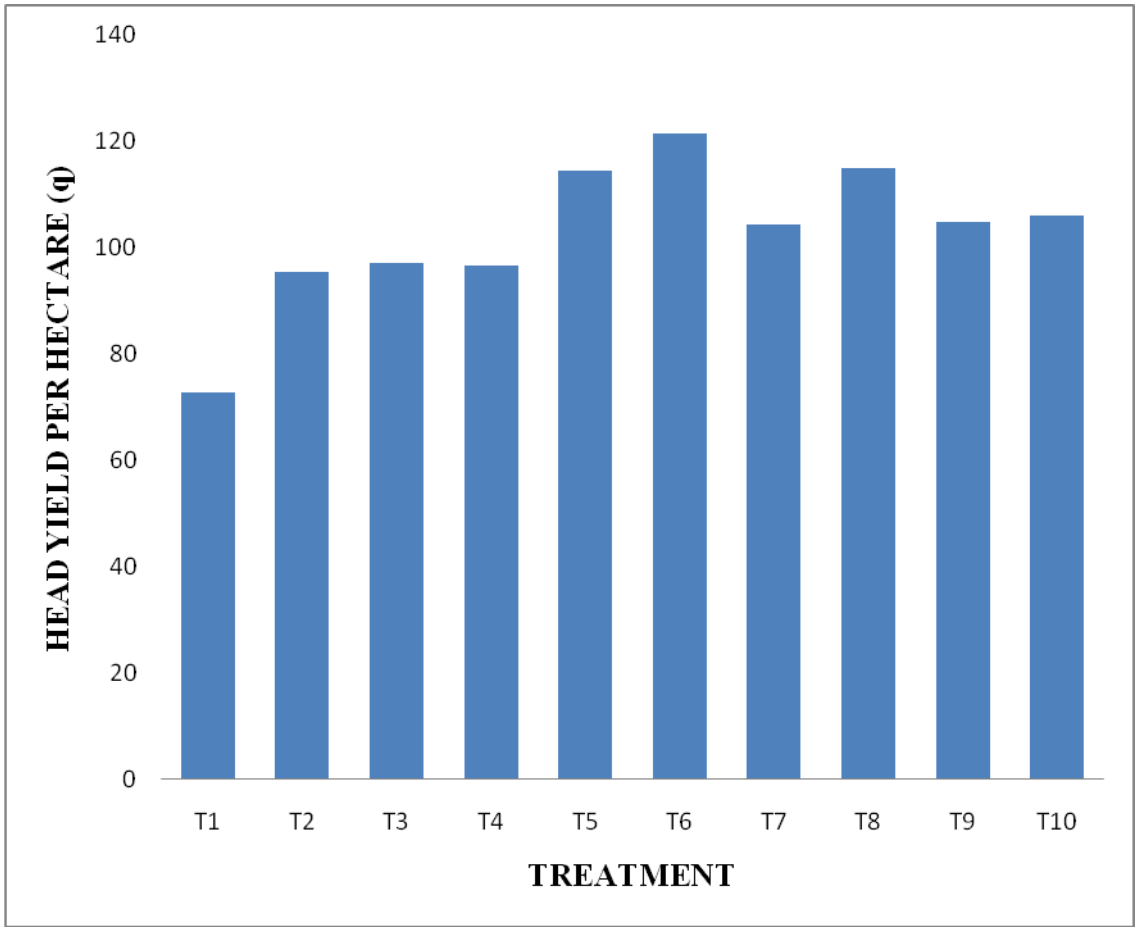


Fig. 2.7:- Effect of different Micronutrient on Head Yield per Hectare (q)

2.8 Total Soluble Solid (BRIX^0):-Table and fig. 2.8 shows that there was a significant difference among various treatment combinations. The maximum T.S.S (Brix^0) value T_6 (B + Mn + Zn) 8.37, followed by T_{10} (Zn) 7.89. The lowest T.S.S (Brix^0) value was recorded in T_1 (control) 6.46. These result recorded by **Raja Edward, M. and Lyengar, B.R.V. (1987).**

Table 2.8:- Effect of different Micronutrient on Bud TSS (^{0}BRIX)

Treatments	**Treatment Combination**	**TSS (^{0}BRIX)**
T_1	Control	6.46
T_2	B	6.67
T_3	Mo	7.28
T_4	Mn	7.00
T_5	B + Mo	7.60
T_6	B + Mn + Zn	8.37
T_7	Mo + Mn	7.38
T_8	B + Mo + Mn + Zn	7.53
T_9	B + Zn	7.68
T_{10}	Zn	7.89
F-test		S
S.E$_d$(±)		0.15
C.D at 5%		0.31

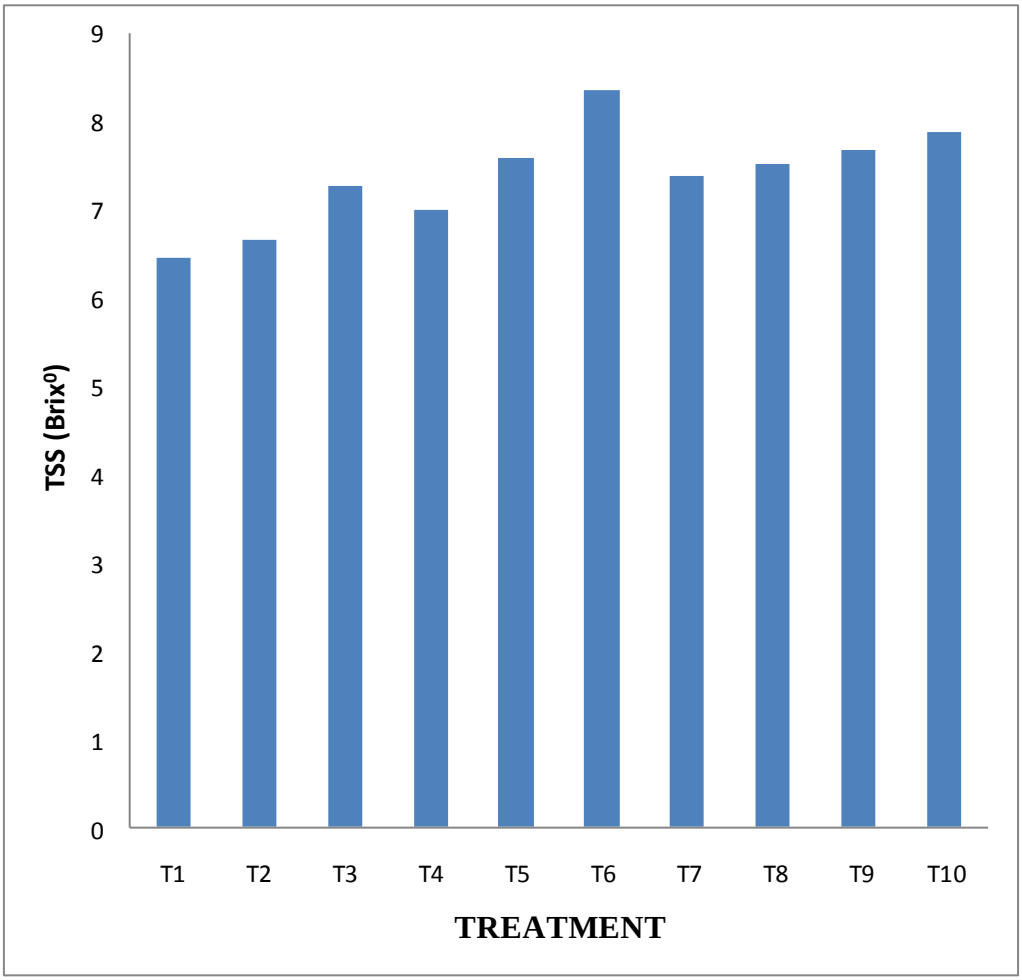


Fig. 2.8:- Effect of different Micronutrient on Bud TSS (^{0}BRIX)

2.9. Vitamin 'C' (mg/100gm Broccoli fresh tissue):-Table and fig 2.9 shows that the maximum vitamin 'C' mg/100gm recorded (93.92 mg) in T_6 (B + Mn + Zn) followed by T_7 (Mo + Mn) 88.43. The lowest vitamin was found in case of T_1 (control) 78.81 followed by (80.22) T_3 (Mo). These result was recorded to closely by **Mohamed El-Sayed Ahmed, Abdelnaser, Abdelghany Elzaawely and Mohamed Basiouny El-Sawy (2011) and Nadia Gad and M.R. Abd El-Moez(2011)** in broccoli.

Table 2.9:- Effect of Different Micronutrient on Vitamin 'C' (mg/100gm Broccoli fresh tissue)

Treatments	**Treatment Combination**	**Vitamin 'C' (mg)**
T_1	Control	78.81
T_2	B	81.81
T_3	Mo	80.22
T_4	Mn	84.74
T_5	B + Mo	87.67
T_6	B + Mn + Zn	93.92
T_7	Mo + Mn	88.43
T_8	B + Mo + Mn + Zn	80.83
T_9	B + Zn	81.24
T_{10}	Zn	85.01
F-test		S
S.E$_d$(±)		0.97
C.D at 5%		2.04

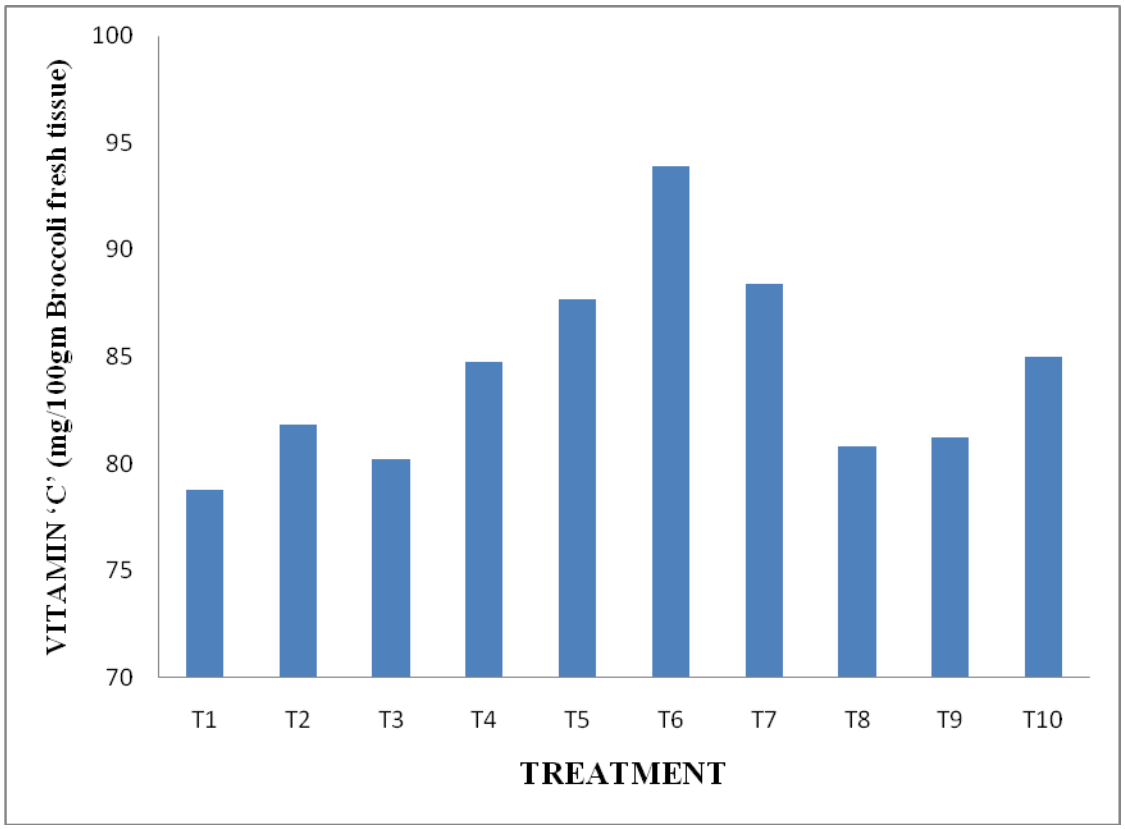


Fig 2.9:- Effect of different Micronutrient on Vitamin'C' (mg/100gm Broccoli fresh tissue)

2.10 Tritable Acidity %:- Table and fig 2.9 shows that the maximum Tritable acidity recorded (0.44 %) in T_6 (B + Mn + Zn) followed by nearly 0.43 % T_8 (B + Mo + Mn + Zn) and T_3 (Mo). The lowest treatable acidity was found in T_1 (control) 0.33% followed by T_9 (B +Zn) 0.37. The tritable acidity in T_7 (Mo +Mn) and T_{10} (Zn) was found the similar 0.39 %. These results were similar recorded by **Nadia Gad and M.R. Abd El-Moez (2011)** and **Suresh Kumar P, Bhagawati R, Choudhary Vk, Preema Devi And Ronya T (2010)** in cauliflower.

Table 2.10:- Effect of different Micronutrient on Tritable Acidity (%)

Treatments	**Treatment Combination**	**Tritable Acidity (%)**
T_1	Control	0.33
T_2	B	0.38
T_3	Mo	0.43
T_4	Mn	0.40
T_5	B + Mo	0.41
T_6	B + Mn + Zn	0.44
T_7	Mo + Mn	0.39
T_8	B + Mo + Mn + Zn	0.43
T_9	B + Zn	0.37
T_{10}	Zn	0.39
F-test		S
S.E$_d$(±)		0.01
C.D at 5%		0.02

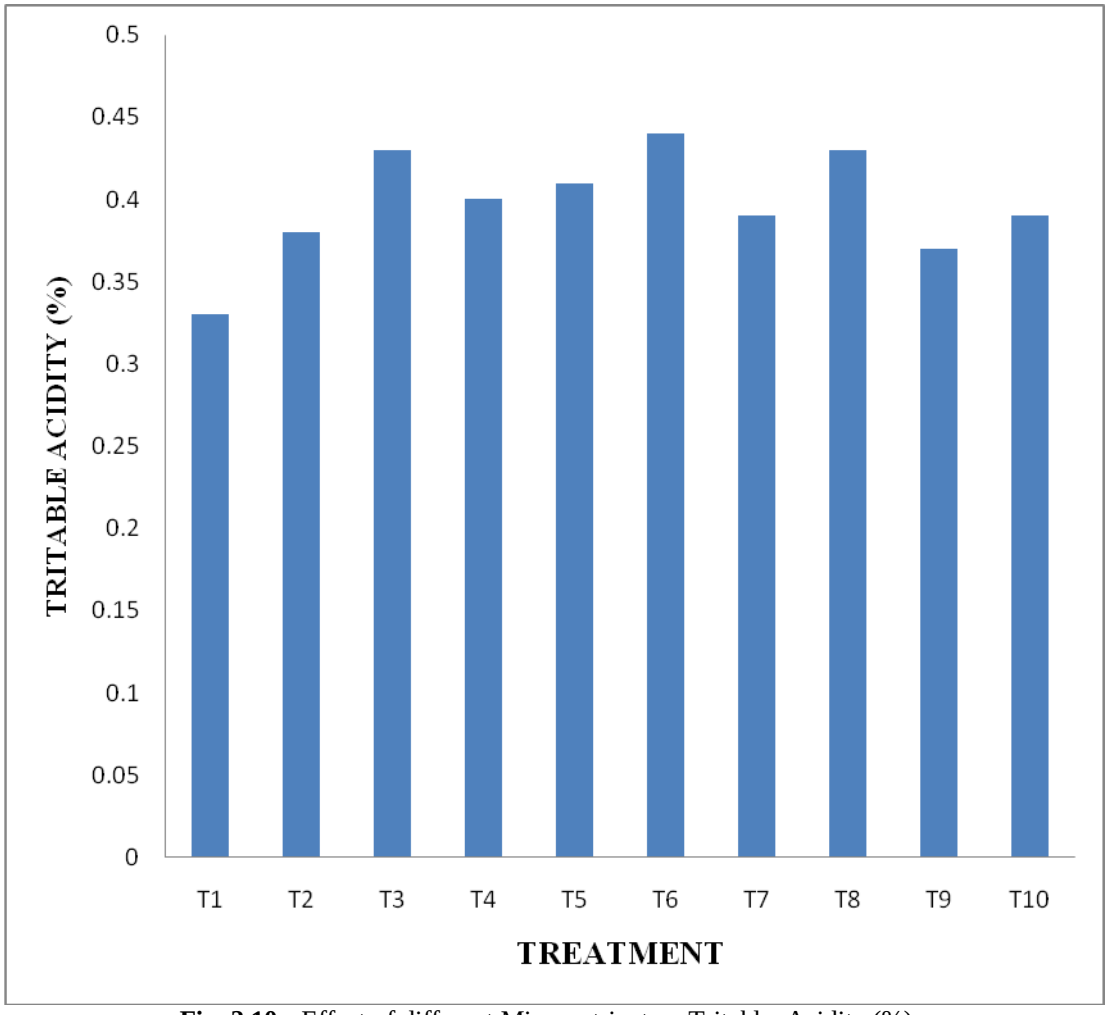


Fig 2.10:- Effect of different Micronutrient on Tritable Acidity (%)

2.11 Fresh Weight of Plant (g):-Table and fig. 2.11 shows that various treatment combinations significantly influenced the fresh weight of plant. In treatment T_6 (B + Mn +Zn) fresh weight of plant was highest (908.28 gm) followed by (867.65 gm) T_8 (B + Mo + Mn +Zn). The lowest fresh plant weight found in T_0 (control) 725.92 gm. These results were recorded closely by **Md. Joynul Abedin, Md. Nurul. Alam *et al* (2010)** on onion and **Suresh Kumar P, Bhagawati R, Choudhary Vk, Preema Devi And Ronya T (2010)** in cauliflower.

Table 2.11:- Effect of different Micronutrient on Fresh Weight per Plant (g)

Treatments	**Treatment Combination**	**Fresh Weight per Plant (g)**
T_1	Control	725.92
T_2	B	754.12
T_3	Mo	728.78
T_4	Mn	835.77
T_5	B + Mo	839.79
T_6	B + Mn + Zn	908.28
T_7	Mo + Mn	741.23
T_8	B + Mo + Mn + Zn	867.65
T_9	B + Zn	826.00
T_{10}	Zn	826.74
F-test		S
$S.E_d(\pm)$		18.51
C.D at 5%		38.88

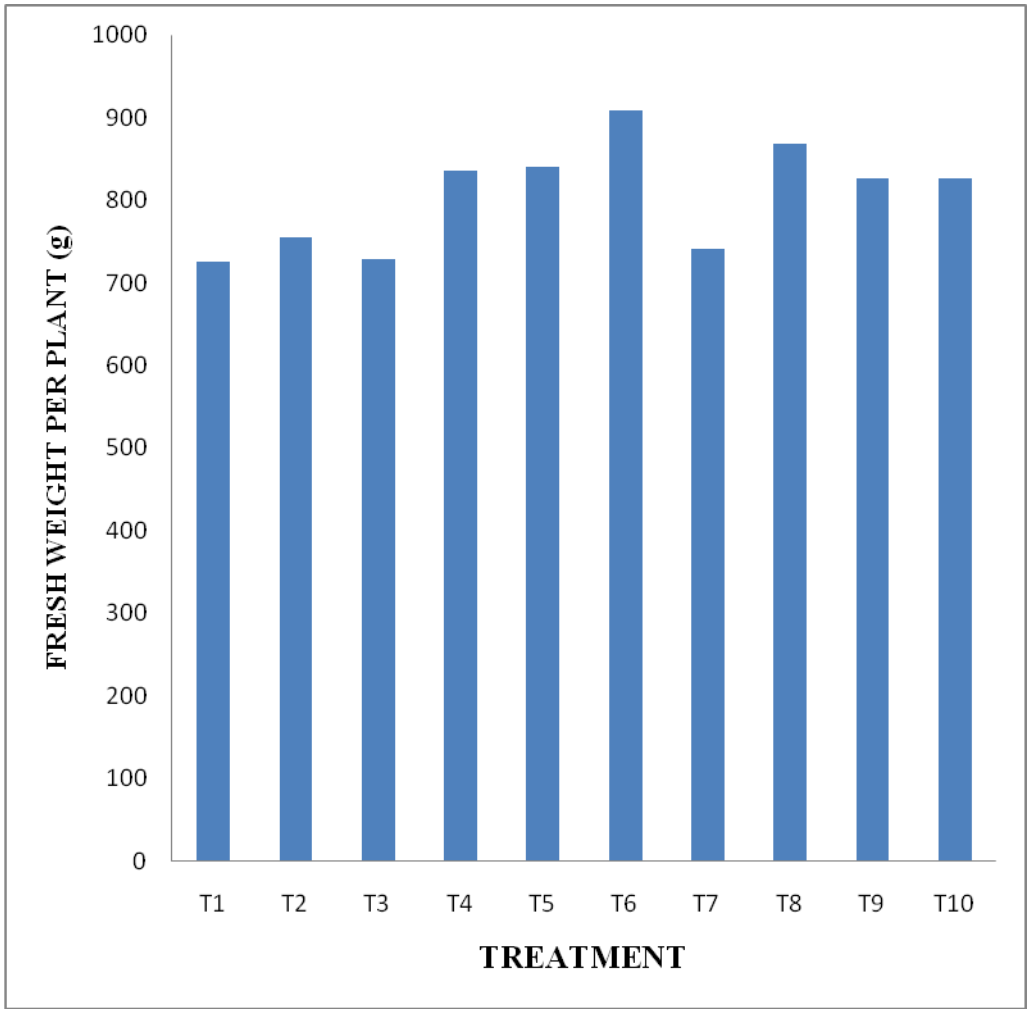


Fig. 2.11:- Effect of different Micronutrient on Fresh Weight per Plant (g)

2.12 Root Weight (g):-Table and fig. 2.12 shows that various treatment combinations significantly influenced the weight of plant root. In treatment T_6 (B + Mn +Zn) weight of root was highest (45.02 gm) followed by (43.91 gm) T_8 (B + Mo + Mn +Zn). The lowest fresh plant weight found in T_0 (control) 35.43 gm. The root weight in T_7 (Mo + Mn) and T_9 (B + Zn) had almost similar (43.19 gm and 43.52 gm respectively). This result was similar found by **Inayat Ur Rahman *et al.* (2014)** in cauliflower and **Nadia Gad and M.R. Abd El-Moez (2011).**

Table 2.12:- Effect of different Micronutrient on Root Weight per Plant (g)

Treatments	**Treatment Combination**	**Root Weight per Plant (g)**
T_1	Control	35.43
T_2	B	42.09
T_3	Mo	39.22
T_4	Mn	41.62
T_5	B + Mo	42.57
T_6	B + Mn + Zn	45.02
T_7	Mo + Mn	43.91
T_8	B + Mo + Mn + Zn	43.19
T_9	B + Zn	43.52
T_{10}	Zn	42.88
F-test		S
$S.E_d(\pm)$		0.46
C.D at 5%		0.97

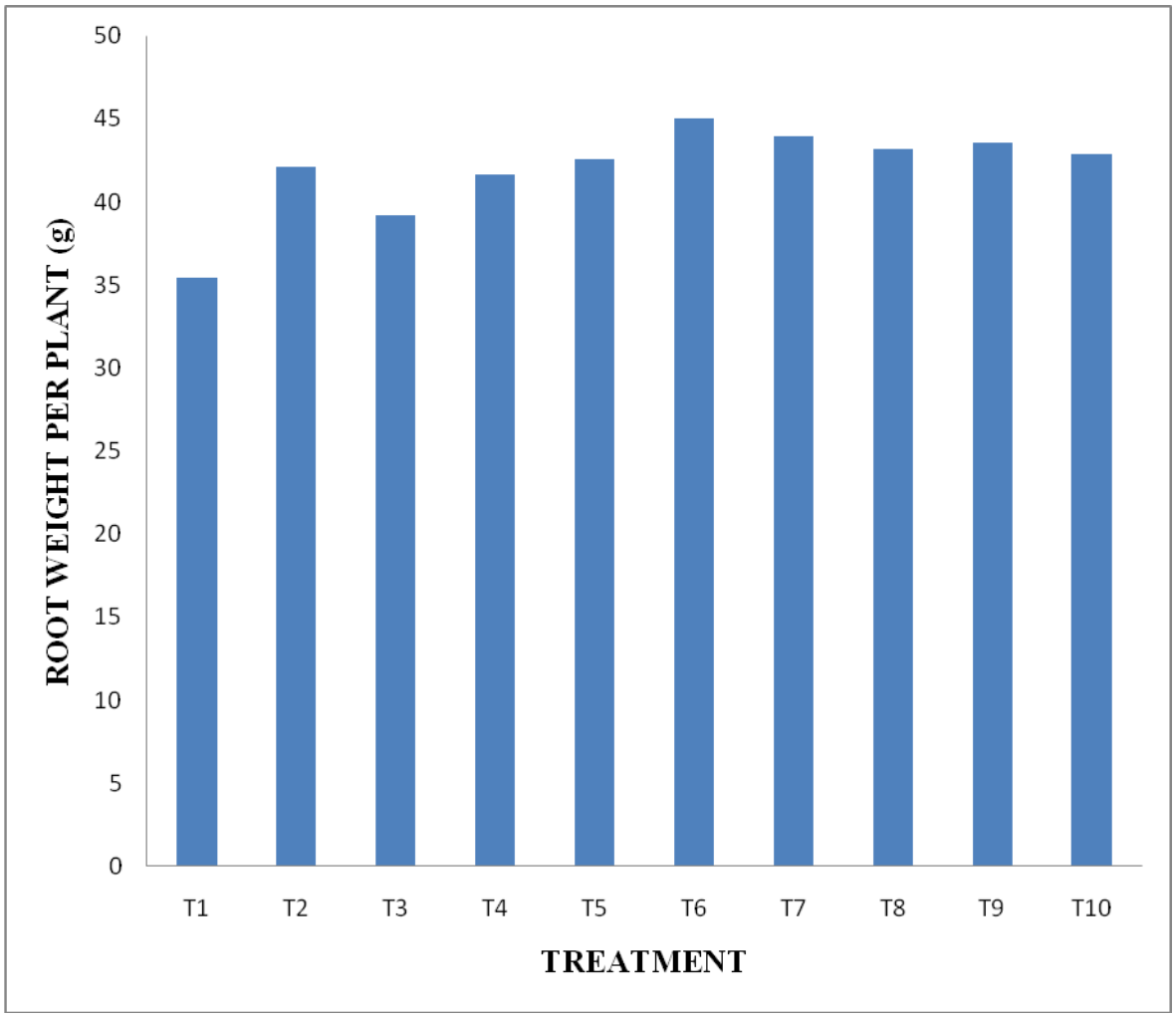


Fig. 2.12:- Effect of different Micronutrient on Root Weight per Plant (g)

2.13 Dry Weight of Plant (g):-The data presented in table and fig. 2.13 shows that various treatment combinations significantly influence the dry weight of plant. The treatment T_6 (B + Mn +Zn) recorded the maximum dry matter (95.61 gm) followed by T_8 (B+ Mo+ Mn+ Zn) with 91.33 gm. The lowest dry matter found in T_1 (control) 76.41 gm. These results were recorded closely by **Md. Joynul Abedin, Md. Nurul. Alam *et al.* (2010)** in onion.

Table 2.13:- Effect of different Micronutrient on Dry Weight per Plant (g)

Treatments	**Treatment Combination**	**Dry Weight per Plant (g)**
T_1	Control	76.41
T_2	B	79.38
T_3	Mo	76.71
T_4	Mn	87.98
T_5	B + Mo	88.40
T_6	B + Mn + Zn	95.61
T_7	Mo + Mn	78.02
T_8	B + Mo + Mn + Zn	91.33
T_9	B + Zn	86.95
T_{10}	Zn	87.03
F-test		S
$S.E_d(\pm)$		1.95
C.D at 5%		4.09

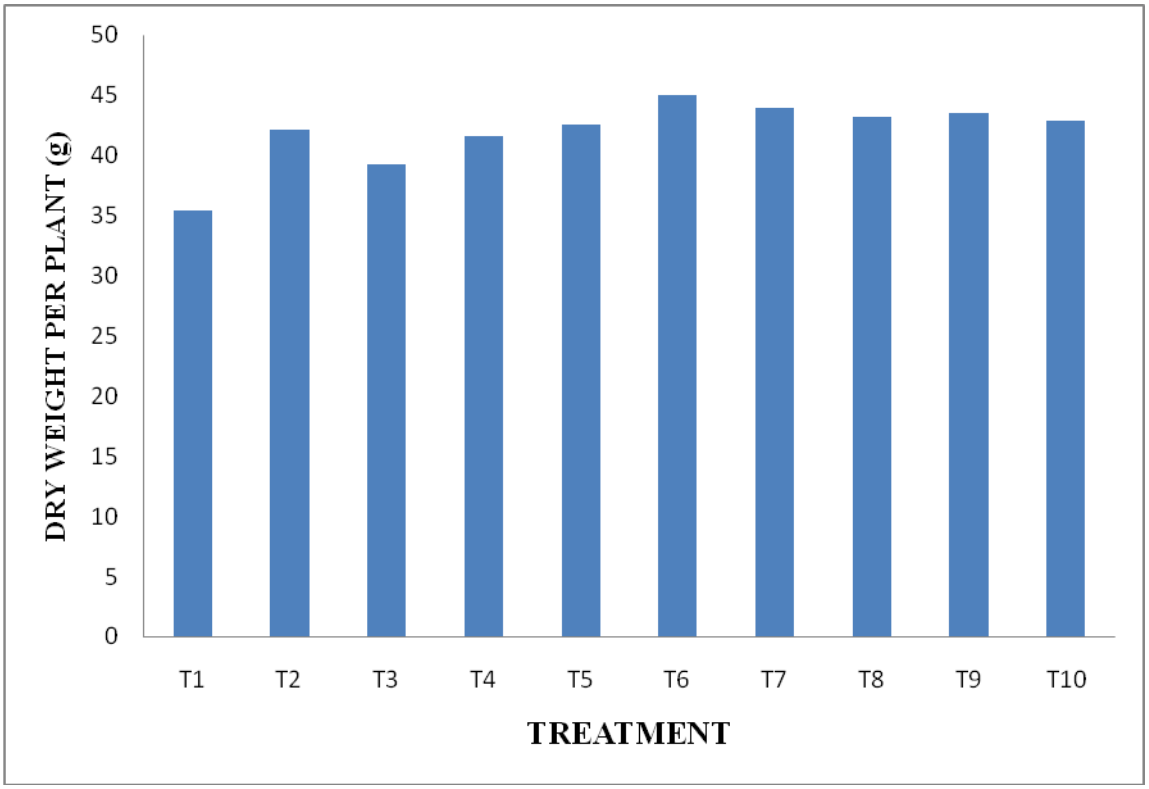


Fig. 2.13:- Effect of different Micronutrient on Dry Weight per Plant (g)

2.14 Dry Root Weight (g):-Table and fig. 2.14 shows that various treatment combinations significantly influence the dry weight of root. The treatment T_6 (B + Mn +Zn) recorded the maximum dry root weight (11.65 gm) followed by T_7 (Mo+ Mn) with 11.36 gm. The lowest dry root weight found in T_1 (control) 9.17 gm. The dry root weight in T_5 (B + Mo) and T_{10} (Zn) had almost similar (11.01 gm and 11.09 gm respectively). This result was similar found by **Inayat Ur Rahman *et al.* (2014)** in cauliflower and **Nadia Gad and M.R. Abd El-Moez(2011).**

Table 2.14:- Effect of different Micronutrient on Dry Root Weight of per Plant (g)

Treatments	**Treatment Combination**	**Dry Root Weight of per Plant (g)**
T_1	Control	9.17
T_2	B	10.88
T_3	Mo	10.14
T_4	Mn	10.77
T_5	B + Mo	11.01
T_6	B + Mn + Zn	11.65
T_7	Mo + Mn	11.36
T_8	B + Mo + Mn + Zn	11.17
T_9	B + Zn	11.26
T_{10}	Zn	11.09
F-test		S
S.E$_d$(±)		0.12
C.D at 5%		0.25

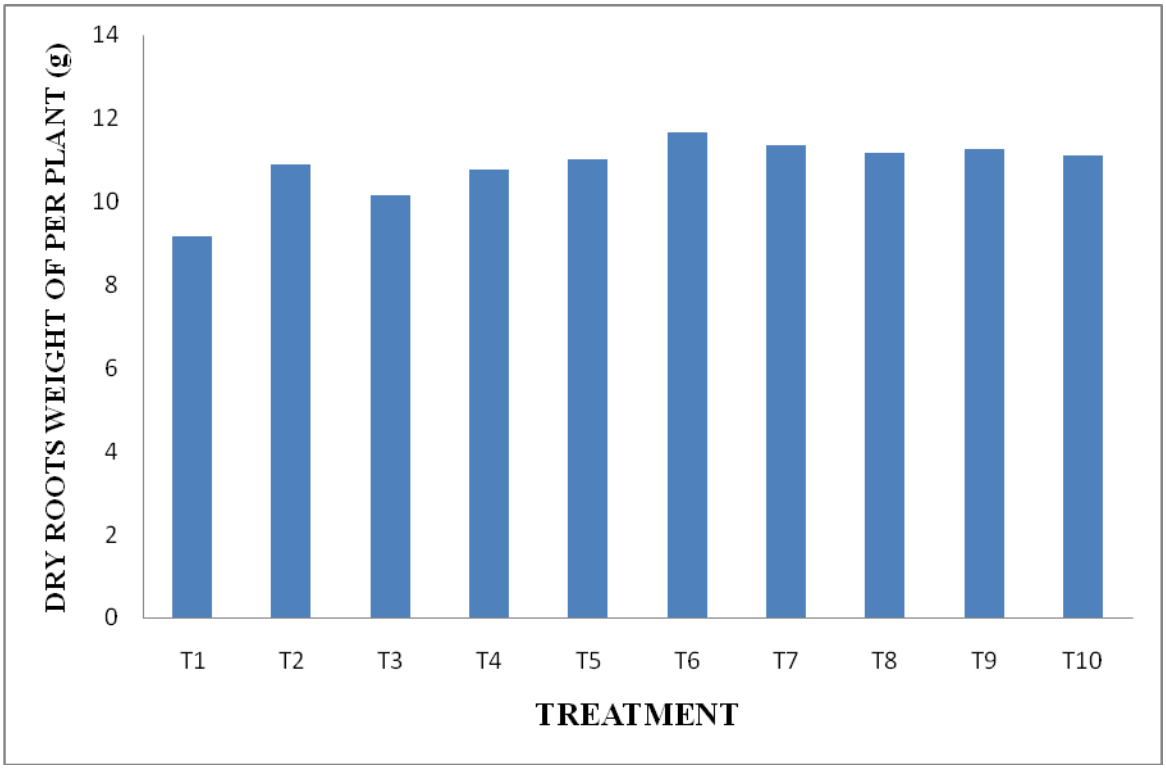


Fig. 2.14:- Effect of different Micronutrient on Dry Root Weight of per Plant (g)

2.15 Economics of different Treatment:-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 2.15 and 2.16. Treatment T_6 (B + Mn +Zn) was recorded maximum gross return (Rs 303700 ha^{-1}) followed by Rs. 287600 ha^{-1} with T_8 **(**B + Mo + Mn+ Zn), while the minimum gross return (Rs 182150) was recorded with (control). Treatment T_6 (B + Mn +Zn) was recorded maximum Net return (Rs 212433 ha^{-1}) followed by Rs. 195821 ha^{-1} with T_8 **(**B + Mo + Mn+ Zn) and minimum Net return (Rs 93058) was recorded with (control). Treatment T_6 (B + Mn +Zn) was recorded highest benefit cost ratio (3.32) followed by 3.13 with T_8 **(**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 T_6 (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.

Table 2.15:- 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	2	200	400
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	15		3,000
C.	**Manures and fertilizers**				
1.	FYM	Tones	20	1500	40,000
2.	Borax	Kg	18.18	78	1418
3.	Sodium Molybdenum	Kg	1.28	400	512
4.	Manganese sulfate	Kg	7.81	30	235
5.	Zinc Sulfate	Kg	13.04	40	522

D.	**Seed and sowing**				
1.	Cost of seeds	g	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
3.	malathion 50 EC (0.05%)	Liter	1	350	350
4.	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**				88,247
L.	**Interest working 12% @ 6 month**				3,532
M.	**Total fixed cost (Rs/ha)**				91,779

Table 2.16:- Economics of different Treatment Combination

Treatment No.	**Treatment combinations**	**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**
1.	Control	70.74	2,500	182150	89092	93058	2.044516
2.	B	95.33	2,500	238325	90510	147815	2.633134
3.	Mo	96.99	2,500	242475	89604	152871	2.706073
4.	Mn	96.71	2,500	241775	89327	152448	2.706628
5.	B + Mo	114.39	2,500	285975	91022	194953	3.141823
6.	B + Mn + Zn	121.48	2,500	303700	91267	212433	3.327599
7.	Mo + Mn	104.23	2,500	260575	89839	170736	2.900466
8.	B + Mo + Mn +Zn	115.04	2,500	287600	91779	195821	3.133614
9.	B + Zn	104.73	2,500	261825	90510	171315	2.892774
10	Zn	106.07	2,500	265175	89614	175561	2.95908

Summary and Conclusion:-The present experiment entitled "**Effect of different micronutrients on the growth, yield and flower bud quality of broccoli (*Brassica oleracea var.italica*) c.v- Green bud"** was carried out at the crop research Unit of the Department of Horticulture, Allahabad School of Horticulture, Sam Higginbottom Institute of Agriculture Technology and Sciences (formerly known as Allahabad Agriculture Institute Deemed University, AAI-DU) during rabi season of 2014-2015. The experiment was laid out in the Randomized Block Design with 10 treatments and 3 replications. The experiment included use different micronutrient in various combinations. Net plot size was kept 1.2 m^2 and spacing 60 x 45 cm. the results obtained are briefly summarized below.

- At 40 DAT T_6 (B + Mn + Zn) gave maximum height (33.99 cm) followed by T_7 (Mo + Mn) is 34.33 cm. The lowest plant height (32.35 cm) was found in T_1 (control). The plant height at 60 DAT maximum found in T_6 (B + Mn + Zn) is 51.30 cm. followed by 48.99 in T_8 (B + Mo + Mn + Zn) and minimum found in T_1 (control) 42.84 cm.
- The number of leaves at 40 DAT and 60 DAT maximum found in same treatment T_6 (B + Mn +Zn) is 12.92 and 24.25 followed by respectively T_{10} (Zn) and T_8 (B + Mo + Mn + Zn) is 12.00 and 22.92 per plant. The lowest number of leaves found in T_1 (control) is 8.67 and 19.00.
- At 40 DAT and 60 DAT maximum plant spread was found in T_6 (B + Mn + Zn) is 35.15 cm and 52.83 cm followed by 33.53 cm and 49.15 cm in T_{10} (Zn). The minimum plant spread 29.76 cm and 43.89 cm was found T_1 (control).

- The maximum bud diameter 16.90 cm was recorded with T_6 (B + Mn +Zn) followed by 16.28 cm in T_9 (B +Zn) and T_8 (B + Mo + Mn + Zn) i.e. 15.73 cm, which were significantly higher than other treatment. The lowest bud diameter (14.04 cm) was observed in treatment T_1 (control).
- The treatment T_6 (B + Mn + Zn) had significantly the highest bud weight (303.69 gm) followed by T_8 (B + Mo + Mn +Zn) is 287.61 gm. Lowest bud weight 182.15 gm was observed in T_1 (control).
- Maximum number of frouds (15.67) was observed in T_6 (B + Mn + Zn) followed by 14.08 T_3 (Mo) and minimum (12.75) were found in T_0 (control).
- The treatment T_6 (B + Mn + Zn) and T_8 (B + Mo + Mn +Zn) had significantly more yield per hectare than other treatment (121.48 q/ha and 115.04 q/ha. The treatment T_1 (control) recorded lowest yield per hectare (72.86 q/ha).
- The maximum T.S.S ($Brix^0$) value T_6 (B + Mn + Zn) 8.37, followed by T_{10} (Zn) 7.89. The lowest T.S.S ($Brix^0$) value was recorded in T_1 (control) 6.46.
- The maximum vitamin 'C' mg/100gm recorded (93.92 mg) in T_6 (B + Mn + Zn) followed by T_7 (Mo + Mn) 88.43. The lowest vitamin was found in case of T_1 (control) 78.81 followed by (80.22) T_3 (Mo).
- The maximum Tritable acidity recorded (0.44 %) in T_6 (B + Mn + Zn) followed by nearly 0.43 % T_8 (B + Mo + Mn + Zn) and T_3 (Mo). The lowest treatable acidity was found in T_1 (control) 0.33% followed by T_9 (B +Zn) 0.37.
- In treatment T_6 (B + Mn +Zn) fresh weight of plant was highest (908.28 gm) followed by (867.65 gm) T_8 (B + Mo + Mn +Zn). The lowest fresh plant weight found in T_0 (control) 725.92 gm.
- In treatment T_6 (B + Mn +Zn) weight of root was highest (45.02 gm) followed by (43.91 gm) T_8 (B + Mo + Mn +Zn). The lowest fresh plant weight found in T_0 (control) 35.43 gm.
- The treatment T_6 (B + Mn +Zn) recorded the maximum dry matter (95.61 gm) followed by T_8 (B+ Mo+ Mn+ Zn) with 91.33 gm. The lowest dry matter found in T_1 (control) 76.41 gm.
- The treatment T_6 (B + Mn +Zn) recorded the maximum dry root weight (11.65 gm) followed by T_7 (Mo+ Mn) with 11.36 gm. The lowest dry root weight found in T_1 (control) 9.17 gm.
- Treatment T_6 (B + Mn +Zn) was recorded maximum gross return, Net return and benefit cost ratio (Rs 303700 ha^{-1}, Rs 212433 ha^{-1} and 3.32) while the minimum gross return, Net return and Benefit cost ratio (Rs 182150 ha^{-1}, 195821 ha^{-1} and 2.02) was recorded with T_1 (control).
- Treatment T_6 (B + Mn +Zn) were found superior over all other treatment growth, flower bud quality and economic return for cultivation of broccoli.

From the present investigation it was concluded that treatment T_6 (B + Mn +Zn) was found the best out of 10 micronutrient combinations treatment in terms growth, yield, flower bud quality and economics return. The highest B:C ratio (1:3.32)was found for treatment T_6 (B + Mn +Zn) for broccoli c.v-green bud, However since this is based on one season experiment therefore further trials may be needed to substantiate the results.

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