EFFECT OF THE MAJOR MICRONUTRIENTS ON QUANTITY AND QUALITY TRAITS OF BROCCOLI UNDER THE KANPUR REGION (BRASSICA OLERACEA VAR. ITALICA L.)

**ABSTRACT**

A field experiment was conducted during rabi 2024 at Horticulture Research Farm, Faculty of Agricultural Sciences and Allied Industries, Rama University, Kanpur (U.P.), Kanpur. The experiment was laid out in Randomized Block Design with eight treatments each replicated thrice based on one year experimentation. The treatments are T1 (Control), T2 Zinc (3kg/ha) T3 Mo (1.5 kg/ha) T4 Mn (2 kg/ha) T5 Boron (2.5-3 kg) T6 (B+Mo) T7 (B+Mn+Zinc) T8 (Mo+Mn) T9 (B+Mo+Mn+Zinc). The unit plot size was 4.5 m2. The plants were spaced at 60 cm between the rows and 45 cm between the plants. There was a total of 10 plants in each plot. The treatments were allocated randomly to a unit plot in each replication. The results showed that the application of T9 (B+Mo+Mn+Zinc) was recorded highest plant growth, yield and quliaty of broccoli as compared to other treatments while T1 (control) was recorded lowest plant growth, yield and quliaty of broccoli as compared to other treatments. It also recorded highest gross return, net return (Rs. ha-1) and benefit cost ratio.

Key words: - Molybdenum, boron, yield, quality and broccoli

# Introduction

The "protective supplementary food" category includes vegetables since they are high in vitamins and minerals that are essential for the normal functioning of human metabolic systems. Since it can be done on small and marginal lands and produces big amounts of food quickly, growing vegetables is the most profitable enterprise. Of all the winter vegetables, the Cole group is important. The group ‘colecrop’is said to be derived from the wild cabbage, "colewort" (*Brassica oleracea* var*. sylvestris*). Broccoli (*Brassica*

*oleracea* var*. botrytis* L.) is one of the most important vegetables among all cole crops. It is the most popular

vegetable crop among cole crops belonging to the family Cruciferae. The main point develops into shortened shoot system whose apices make up the convex surface of curd. The edible part, i. e. curd is a ‘prefloral fleshy apical meristem’ and it is generally white in colour and maybe enclosed by inner leaves before its exposure. India is the world's second largest producer of vegetables next to China along with number of varieties,

grown in the country. According to an estimate, India produces 214.56 million tonne of vegetables which is a 3.6% increase from 2023-24 (Horticultural Statistics at a Glance, 2024-25). Thus, India holds estimated at around 10.6%, but productivity is very low as compared to developed countries. So, presently it does not meet even national need inspite of ample scope to increase in production per unit area. There is also equal scope for export and processing of vegetables.

Total requirement of vegetables in India, only 40 per cent is being met. However, for maintaining proper physique, recommendations have been made by the dieticians is. The ICMR (Indian Council of Medical Research) recommends consuming at least 300 grams of vegetables daily, including 50 grams of green leafy vegetables, 200 grams of other vegetables, and 50 grams of roots and tubers. The present production and consumption of vegetables in the country are very inadequate, being only about one-fourth to one-third of the requirement (ICMR, 2023).

However, the information about micronutrient requirements, especially boron and molybdenum of Broccoli under eastern Uttar Pradesh climatic conditions, is almost non- existent and very little research has been done on foliar application of

boron, Zinc, Mn, and molybdenum on Broccoli in this agro-climatic zone. Keeping in view the above discussed facts of sufficient information and space related research, the present investigation was undertaken to find out the **“Effect of the major Micronutrients on Quantity and Quality traits of Broccoli under the Kanpur region”** was initiated during winter season of 2024- 2025 at Vegetable Research Farm Department of Horticulture, Institute of Agricultural Sciences, Rama university, Kanpur, Uttar Pradesh with the following objectives:

1. To find out the impact of Application of micronutrients on Quntitative attributes of Broccoli
2. To study the impact of various micronutrients on qualitative attributes of Broccoli
3. To assess the economics of different treatment combinations.

# GROWTH ATTRIBUTES

**Swiatkiewies and Sandy (2023)** assessed the impact of a 1% foliar zinc spray on broccoli, finding that the highest plant height and spread were achieved.

**Singh *et al.* (2018**) carried out a field trial they applied foliar applications of boron at 100 ppm and molybdenum at 50 ppm both separately and in combination with two levels of borax at 10 and 20 kg/ha and sodium molybdate at 1 and 2 kg/ha. both by itself and in combination.

Provided the plant's maximum height, leaf length, leaf breadth, total plant weight, and curd width.

**Nagda, A. (2021)** carried out a field study to examine the effects of boron and molybdenum on cauliflower growth, yield, and quality. They applied foliar boron at 100 parts per million and molybdenum at 50 parts per million, both separately and in combination, along with two levels of borax at 10 and 20 kilograms per hectare and sodium molybdate at 1 and 2 kilograms per

hectare.

# YIELD ATTRIBUTES

**Mm *et al.* (2016)** examined how broccoli responded to foliar applications of boron and zinc concentrations and found that, under the agroclimatic conditions of Peshawar, broccoli yield increased when boron and zinc were applied at a rate of 0.5% each.

**Chaudhari *et al.* (2023)** conducted an experiment during *rabi*, 2016-2017 at Navsari Agricultural University, Gujarat. Application of micronutrients (Fe 2.0%, Mn 0.5%, Zn 4.0%, Cu 0.3% and B 0.5%) + (Ammonium molybdate) which show significantly maximum growth characters *viz.* plant height (74.93 cm), length of stalk (16.59 cm), number of leaves plant-1 (23.39) and plant spread (N-S: 76.81 cm and E-W: 77.79 cm). The yield parameter *viz.* marketable curd yield (28.64 t ha-1), curd width (19.16 cm), gross weight (2.65 kg plant-1) and net weight (883.33 g plant-1) of Broccoli.

**Sharma *et al.* (2018)** conducted field study to investigate the effect of micronutrients on broccoli yield (cv. Palam Samridhi). They discovered that the primary curd diameter, average curd weight of plant-1, and yield were all considerably raised by adding B in the form of borax @ 15.0 kg ha-1.

**Kumar *et al.* (2021)** studied that, the foliar spraying of boron 0.5% in Broccoli was the best treatment for maximum weight of curd

(930.50 g) and highest (310.70 q ha-1) marketable yield. However, Swain *et al.* (2015) was concluded that dose of B (1.5-4.0 kg ha-1) gave significantly larger, heavier fruits and higher curd yield.

**Hassan *et al.* (2018)** were studied the role of micronutrients on growth and yield traits of Broccoli. The experimental findings suggested that significant enhance ingrowth traits *viz*., length of leaf (32.26 cm) and total biomass (2849.20 g) were observed at borax 0.2% + ZnSO40.5%. The total yield plot-1 (34.80 kg) was also observed by similar concentration of borax @ 0.2% + ZnSO4@ 0.5%.

**Panda (2024)** reported that the highest curd diameter (18.41 cm), fresh- weight of curd (1.24 kg), yield ha-1 (400.29 q) and dry matter of curd (11.37 %) were recorded with application of ammonium molybdate 1 kg ha-1 as soil application.

**Pankaj *et al.* (2018)** looked into how different micronutrients affected broccoli cv. Green Magic. Following that, the researchers added four micronutrients: B, Mo, Mn, and Zn @ (3:0.5:2:2.5 kg/ha), which significantly raised the amount of vitamin C and TSS.

**Nagda *et al.* (2021)** investigated the impact of bio fertilizers and micronutrients on broccoli quality traits. They found that the lowest TSS was obtained when 0.5% boric acid was used. Zinc sulfate at

0.5%, however, produced the largest amount of vitamin C.

**Shivran *et al.* (2017)** investigated the effect of zinc on biochemical parameters in sprouting broccoli and discovered that applying 30 kg of zinc ha-1 resulted in the highest and significantly better values for quality attributes such as total soluble solids and ascorbic acid.

**Singh *et al.* (2018)** evaluated the effect of foliar micronutrient sprays on the quality of broccoli (Pusa KTS-1) in the field and discovered that applying boric acid at 0.4% resulted in the highest TSS concentration.

**Xu *et al.* (2015)** conducted a field investigation on broccoli and discovered that the highest vitamin-C content was obtained by foliar application of zinc 0.25 percent and boron 3.50 percent.

**2.1.1 Effect on relative economics**

**Singh *et al.* (2022)** reported that, application of 100 ppm Mo ha-1 in Broccoli gave maximum plant height (63.00 cm), number of leaves (16.44), leaf length (49.11), leaf width (16.87), plant spread (52.72 cm2) and stem diameter (4.24 cm).

# Experimental Site:-

The experimental site lies approximately in the center of north Gangetic alluvial plain, on the left of bank of river Ganga at the distant of about 20 km away from Kanpur Railway Station in the South-East direction. Geographically, Kanpur city is situated at about 25o10' North and 83o03' East longitudes with an elevation of 86 meters above the mean sea level. The altitude of location is 128.93 meters above the

Mean Sea Level. The location of the experimental field was the same for both the years of investigation. The field of the experimental site represented an ideal spatial unit in respect of texture, make up and fertility status. The winter mo n t h are cold and dry and occasional frost occurring during the period. The temperature starts during the month of February on wards and continues to rise up to June.

**Table :-1 Effect of major micronutrients on Growth Attributes of Broccoli**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **plant height (cm) of Broccoli** | | | | | **Number of leaves** | | | | **leaf length of Broccoli** | | | | **Effect of major micronutrient s on Girth of stem of Broccoli** |
| **Treatment** | **15DA T** | **30DA T** | **45DA T** | **At harves t** | **15DA T** | **30DA T** | **45DA T** | **At harves t** | **15DA T** | **30**  **DAT** | **45**  **DA T** | **At harves t** | **Stem Girth** |
| **T1** | 7.67 | 12.92 | 15.58 | 22.75 | 6.55 | 13.38 | 19.52 | 19.45 | 4.6 | 7.27 | 12.4  4 | 14.79 | 3.697 |
| **T2** | 11.6 | 18.71 | 22.35 | 27.98 | 7.48 | 13.62 | 20.01 | 20.69 | 5.26 | 8.3 | 14.6  6 | 18.08 | 5.38 |
| **T3** | 12.76 | 19.19 | 23.18 | 28.33 | 7.66 | 13.38 | 19.53 | 21.02 | 5.67 | 8.17 | 15.3  9 | 18.41 | 5.733 |
| **T4** | 12.55 | 21.14 | 24.02 | 28.82 | 7.8 | 13.94 | 19.32 | 21.17 | 5.38 | 8.96 | 15.0  6 | 18.66 | 5.487 |
| **T5** | 13.03 | 19.08 | 22.94 | 29.64 | 6.26 | 13.86 | 17.66 | 21.25 | 5.29 | 9.52 | 13.9  1 | 18.92 | 7.99 |
| **T6** | 12.5 | 21.59 | 23.83 | 29.95 | 7.55 | 14.13 | 18.73 | 21.27 | 6.23 | 10.0  9 | 15.8  3 | 19.12 | 6.617 |
| **T7** | 12.9 | 21.68 | 23.85 | 31.11 | 8.35 | 14.24 | 20.49 | 22.14 | 5.77 | 8.6 | 15.1 | 19.45 | 6.57 |
| **T8** | 13.05 | 21.67 | 26.24 | 31.49 | 8.02 | 14.36 | 20.21 | 22.47 | 6.37 | 10.8  9 | 16.1  2 | 20.05 | 6.753 |
| **T9** | 14.35 | 23.01 | 25.98 | 32.04 | 9.41 | 15.38 | 22.41 | 22.78 | 6.67 | 11.6  2 | 17.5  2 | 20.4 | 7.07 |
| **SE±** | 0.16 | 0.17 | 0.18 | 0.2 | 0.09 | 0.19 | 0.2 | 0.14 | 0.15 | 0.19 | 0.22 | 0.19 | 0.09 |
| **CD(P=0.0**  **5)** | 0.47 | 0.47 | 0.59 | 0.56 | 0.34 | 0.38 | 0.46 | 0.4 | 0.39 | 0.49 | 0.64 | 0.54 | 0.24 |

**Fig 1. Effect of micronutrients on plant height (cm) of Broccoli**

40.00

30.00

20.00

10.00

0.00

T1

T2

T3

T4

T5

T6

T7

T8

T9

Effect of micronutrients on plant height (cm) of Broccoli 15DAT

Effect of micronutrients on plant height (cm) of Broccoli 30DAT

Effect of micronutrients on plant height (cm) of Broccoli 45DAT

Effect of micronutrients on plant height (cm) of Broccoli At harvest

Effect of micronutrients on Number of leaf of Broccoli 15DAT

Effect of micronutrients on Number of leaf of Broccoli 30DAT Effect of micronutrients on Number of leaf of Broccoli 45DAT Effect of micronutrients on Number of leaf of Broccoli At harvest

T9

T8

T7

T6

T5

T4

T3

T2

T1

25.00

20.00

15.00

10.00

5.00

0.00

**Fig 2. Effect of micronutrients on Number of leaf of Broccoli**

**Fig 3. Effect of micronutrients on leaf length of Broccoli**

25.00

20.00

15.00

10.00

5.00

0.00

T1

T2

T3

T4

T5

T6

T7

T8

T9

Effect of micronutrients on leaf length of Broccoli 15DAT

Effect of micronutrients on leaf length of Broccoli 30 DAT

Effect of micronutrients on leaf length of Broccoli 45 DAT

Effect of micronutrients on leaf length of Broccoli At harvest

T9

T8

T7

T6

T5

T4

T3

T2

T1

9.000

8.000

7.000

6.000

5.000

4.000

3.000

2.000

1.000

0.000

**Fig 4. Effect of micronutrients on Girth of stem of Broccoli Girth**

**Table :-2 Effect of major micronutrients on Yield Attributes of Broccoli**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Effect of micronutrients on Days required to head initiation of stem of Broccoli** | | | **Effect of micronutrients on diameter of head (cm) of Broccoli** | **Effect of Application of micronutrients on curd yield, curd weight and gross weight** | | |
| **Treatment** | **Days to head initiation** | **Days to 50%**  **head initiation** | **Diameter of head** | **Gross weight (g)** | **Net curd weight (g)** | **Curd yield (q/ha)** |
| **T1** | 50 | 75.89 | 9.81 | 885.23 | 298.19 | 98.17 |
| **T2** | 45 | 68.94 | 11.9 | 977.84 | 363.14 | 132.68 |
| **T3** | 43 | 64.31 | 12.1 | 981.47 | 374.24 | 164.43 |
| **T4** | 42 | 60.99 | 12.18 | 968.21 | 307.55 | 158.28 |
| **T5** | 42 | 58.82 | 12.86 | 953.09 | 295.49 | 148.69 |
| **T6** | 43 | 56.7 | 13.59 | 954.56 | 256.98 | 154.89 |
| **T7** | 41 | 54.04 | 13.66 | 975.26 | 323.46 | 198.72 |
| **T8** | 40 | 49.45 | 13.92 | 972.32 | 317.46 | 190.42 |
| **T9** | 38 | 45.96 | 14.74 | 983.15 | 376.22 | 216.69 |
| **SE±** | 1.15 | 0.26 | 0.07 | 0.81 | 0.62 | 0.86 |
| **CD(P=0.05)** | 0.41 | 0.75 | 0.19 | 2.37 | 1.79 | 2.31 |

Fig 5. Effect of micronutrients on Days required to head initiation of stem of Broccoli

80.00

70.00

60.00

50.00

40.00

30.00

20.00

10.00

0.00

T1

T2

T3

T4

T5

T6

T7

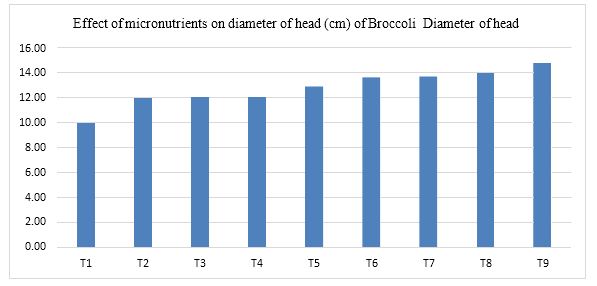
T8

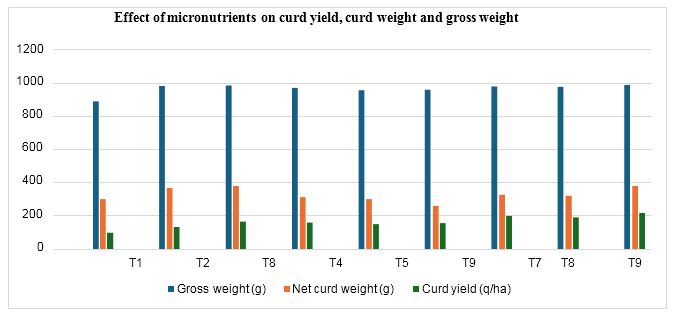
T9

Days to head initiation

Days to 50% head initiation

Fig 6.

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Fig 7.

**Table 3:- Effect of major micronutrients on Yield Attributes of Broccoli**

Effect of major micronutrients on number of days for marketable maturity, ascorbic acid (mg/100g) and TSS (ºBrix)

|  |  |  |
| --- | --- | --- |
| **Treatment Code** | **Ascorbic acid (mg/100g)** | **TSS (() Brix)** |
| **T1** | 56.27 | 2.89 |
| **T2** | 59.48 | 2.98 |
| **T3** | 62.28 | 3.9 |
| **T4** | 62.79 | 3.98 |
| **T5** | 66.06 | 3.24 |
| **T6** | 67 | 3.09 |
| **T7** | 67.8 | 3.29 |
| **T8** | 76.8 | 2.68 |
| **T9** | 70.06 | 3.45 |
| **SE±** | 3.51 | 3.81 |
| **CD(P=0.05)** | 8.19 | 10.8 |

fig 8.



# Crop growth characters

Data on periodic plant height recorded at 15,30, 45 and at Harvest after transplanting (DAT) are presented in Table: -1

# Plant Height

Perusal of the data showed that plant height continued to increase with the advancement of crop age and this increase was rapid during early crop growth period and thereafter, a slow rate of increase in plant height was observed at harvest. In general, higher plant height at all the growth stages were recorded. The performance indicated that the highest plant height, 28.56 cm in was noticed with Application (T9) B+Mo+Mn+Zinc which was statistically at par with Application (T8) Mo+ Mn and (T6) B+Mo while minimum plant height was recorded in T1 (Control) was also observed at harvest. This perceptible increase in plant height is due to an enhancement in cell multiplication and cell elongation in the presence of boron. It might be due to the supply of micronutrients and availability of uptake nutrients in soil due to favorable conditions. The increase in plant height also may be attributed to improved root system of plants resulting in absorption of water and nutrients from soil and utilization of more nutrients through foliar spray of micronutrients (B and Mo) and consequently they

improved different plant organs and entire plant. These results are close conformity with findings of Moniruzzaman *et al.* (2007) in broccoli, Singh *et al.* (2015) in Broccoli, Kumar *et al.* (2013) in also Broccoli and Devi *et al.* (2012) in cabbage.

# Number of leaves plant-1

Different applications of micronutrients significantly influenced the number of Broccoli leaves. At 15, 30 DAT the Minimum leaves plant- 1 was recorded in T1(Control). At harvest the number of leaves significantly varied from 21.25 to 22.14. The highest number of leaves per were noticed in treatment (T9) B+Mo+Mn+Zinc which was statistically at par with Application (T8) Mo+ Mn and (T6) B+Mo while minimum number of leaves plant-1 was recorded in T1(Control) as well as basis. The positive influence of boron and molybdenum on number of leaves could be the result of availability of required quantity of essential plant nutrients at various growth stages leading to hastening the metabolic processes of plant and sugar metabolism, translocation of solutes and protein synthesis that might have resulted in production of more number of leaves, similar result was also reported by Gupta *et al.* (2021) in Broccoli.

# Leaf Length (cm)

The data revealed that the Application of micronutrients had shown a significant influence on the number of leaves of Broccoli plant at 15,30, 45 and at Harvest after transplanting. This examination of data in Table 1 and Fig. 3 revealed that leaf length increased exponentially from 15, 30 DAT to at harvest of the crop. Significant difference in leaf length was noticed under the Application of micronutrients. At 15,30 DAT,45 DAT and at Harvest performance leaf length ranged from 4.60 to 6.37 cm and 7.27 to 10.89. The maximum leaf length was found in Application of (T9) B+Mo+Mn+Zinc which was statistically at par with Application (T8) Mo+ Mn and (T6) B+ Mo while minimum leaf length was recorded in T1(Control). The positive influence of boron and molybdenum on number of leaves could be the result of availability of required quantity of essential plant nutrients at various growth stages leading to hastening the metabolic processes of plant and sugar metabolism, translocation of solutes and protein synthesis that might have resulted in production of more number of leaves, similar result was also reported by Gupta *et al.* (2017) in Broccoli.

# Girth of stem(cm)

The data regarding stem diameter recorded performance have been presented along with in Table 1 and graphically shown in Figure

4. The analysis of variance indicated that data on stem girth data on stem girth was significantly observed with Application (T9) B+Mo+Mn+Zinc which was statistically at par with Application (T8) Mo+Mn and Application of (T7) B+Mn+Zinc over rest of the treatments. However, minimum stem girth was observed under control treatment of experimentation.

# Yield Attributes

**Days to head initiation**

The data pertaining to the effect of various treatments on days to head initiation are presented in Table 2 and depicted in Fig. 5. It was observed from the results that the effect of Application of micronutrients on days to head initiation was found maximum and soon (39 days) and significant in Application of (T9) B+Mo+Mn+Zinc. The minimum days to 50 per cent head initiation found in T1 (Control).

# Days to 50 % percent head initiation

The data pertaining to the effect of various treatments on days to 50

% head initiation are presented in Table 2 and depicted in Fig. 6 It was observed from the results that the effect of Application of micronutrients on days to 50 % head initiation was found maximum

and soon (46 days) and significant in Application of (T9) B+Mo+Mn+Zinc. The minimum and late days to 50 per cent head initiation found in T1 (Control). Minimum days required to 50% head maturity under Application (T9) B+Mo+Mn+Zinc. This might be due to boron acts as the key element for increasing the translocation of carbohydrates from the site of formation to reproductive tissues in head in the Broccoli, whereas molybdenum promoted the photosynthetic activities and increase the metabolic process. Such significant responses of micronutrients have also been recorded by Singh (2015) and Chattopadhyay and Mukhopadhyay (2010) in Broccoli.

# Head Diameter (cm)

The data about the diameter of broccoli as influenced by different treatments are presented in Table 2 and depicted in Fig. 6. It is seen from the data that differences among the different treatments in diameter of head are significant. It was observed from the results that the effect of Application of micronutrients on Head diameter was found maximum on T9 (B+Mo+Mn+Zinc) and the minimum Head Diameter (cm) found in T1 (Control).

# Effect of Application of micronutrients on ascorbic acid

The perusal of data represented in Table 3 clearly revealed that there was significant increase in ascorbic acid content with the application of micronutrients, liquid inputs and inorganic fertilizers. The maximum ascorbic acid content (70.06 mg/ 100g) was recorded under Control which was found statistically at par with T8 (B+Mn+Zinc). The minimum (56.27 mg/ 100g) content was recorded under T1 Control. The results of present investigations are in conformity with those of Sharma *et al.,* (2018) who found that the micronutrients grown spinach recorded 14.42 percent. All integrated treatments that included B+Mo+Mn+Zinc reported the higher ascorbic acid contents. These results are quite like those obtained by Guo *et al.* (2013) in cabbage, Singh (2014) in cauliflower, Thapa *et al.* (2013) in cabbage, and Thakur (2018) in cabbage.

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