**Effect of zinc and boron on the yield and quaity traits of the broccoli under the Kanpur agro climactic 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 with three replicates on the basis of one year experimentation. The treatments which are T0Control, T1RDF+ Zinc foliar @0.5%, T2RDF+ Zinc soil application @ 25kg/ha,T3 RDF+ Zinc soil application @ 25kg/ha; + zinc foliar @0.5%, T4 RDF+ Boron foliar application @ 0.5%, T5 RDF + Boron soil application @2 kg/ha, T6 RDF + Boron soil application @2 kg/ha; + foliar application @ 0.5% and T7 RDF + Combined application of boron foliar @0.5% and Zinc foliar @0.5%. 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 were total of 10 plants in each plot. The treatments were allocated randomly to a unit plot in each replication. The results showed that application of T7 RDF + Combined application of boron foliar @0.5% and Zinc foliar @0.5% was recorded the highest plant growth, yield and quality of broccoli as compared to other treatments. It also recorded highest gross return, net return (Rs. ha-1) and benefit cost ratio.

**Key words:** Zinc, boron broccoli growth, yield, quality and broccoli

**INTRODUCTION**

Broccoli (*Brassica oleracea* L. var. italica) Cv. Phule Ganesh” belongs to the genus Brassica, and family Brassicaceae which includes a wide range of crop plants derived from the Mediterranean Sea and modified over the years by selection and breeding **(Decoteau, 2000).** Plants in the Cruciferae family have flowers with four equal-sized petals in the shape of ‘crucifer’ cross. “Brassica” is the Latin term for cabbage **(Lee *et al.,* 2008).** Cole crops are among the most widely grown vegetables in the temperate zones. The word cole has been taken from the Latin word ‘caulis’ meaning stem **(Bose, 1993).** The wild species from which the now cultivating varieties are originated is *Brassica oleraceace* var. *sylvastris*. The Mediterranean region is supposed to be the centre of origin of cole crops. Vegetables in the Brassicaceae family are rich source of glucosinolates and their hydrolysis products, including indoles and isothiocyanates and the high intake of these vegetables can help to lower the risk of colon, stomach and lung cancer **(Lee *et al.,* 2008).** The *Brassica* genus includes various crops such as Broccoli, Brussel’s sprouts, cauliflower, cabbage, collard greens, kale, kohlrabi, mustard, rutabaga, turnips, bok choy and Chinese cabbage. Although not in the *Brassica* genus, argula, horseradish, radish, wasabi and watercress are also cruciferous vegetables **(Lee *et al.,* 2008).** Micronutrient has specific role to play in the plant and its presence in optimum concentration is a must for the plant to complete its life cycle which ends with maturity and harvesting of the economic produce. Zinc is an indispensable micronutrient for proper plant growth and development **Mondal *et al.,* (2023).** Zinc plays an important role in different plant metabolic processes such as enzyme activity, development of cell wall, respiration, photosynthesis, chlorophyll formation and other biochemical functions whereas Boron is required for the translocation of sugars, root extension and growth of meristematic tissues, the pyrimidine biosynthetic pathway and the ATPase. Foliar application of micronutrient is beneficial during active growth phase of crop. Both B and Zn are two most important micro-nutrients essential for cell division, nitrogen and carbohydrate metabolism as well as water relation in plant growth. Application of B significantly helps in increasing the vegetative growth and head yield in broccoli. Similarly, Zn helps in many enzymatic activities in plant, chlorophyll synthesis and carbohydrate formation accelerates the plant growth **Ranjita *et al.,* (2020).** It is also a rich source of sulforaphane, a compound associated with reducing risk of cancer. It contains vitamin A (9000 mg-l00 g), vitamin B (33 mg-l00 g), vitamin C (137 mg-l00g), minerals viz; Ca (1.29%), P (0.79%), K (3.5%), S (1.26%), Fe (205ppm), I (1.965 ppm), Cu (24 ppm), protein (3.3%), total carbohydrates (5.5%), fat (0.2%), water (89.9%) and calories (36-l00g) **(Thamburaj and Singh, 2003).** World area and production of broccoli (combined for production reports with cauliflowers) are 1.37 mha-1 and 25.53MT India ranks second in area (0.36 mha-1) and production (9.57 MT) of broccoli **(FAO stat, 2021).**

**MATERIALS AND METHODS**

The present study, titled " **Effect of zinc and boron on the yield and quality traits of the broccoli under the kanpur agro climactic region *(Brassica oleracea L. var. Italica)***” was conducted at the Horticulture Research Farm, Faculty of Agricultural Sciences and Allied Industries, Rama University, Kanpur (U.P.), Kanpur. The experimental site for this study is located at the Horticulture Research Farm, Faculty of Agricultural Sciences and Allied Industries, Rama University, Kanpur (U.P.) during the *rabi* season of 2024 positioned approximately 25 km from the district headquarters of Uttar Pradesh 208024. The farm is situated at 20°16' North latitude and 80°08' East longitude in the southwestern plains of Uttar Pradesh. The experiment consisted of 8 treatments of zinc and boron combination with different doses and application method and was laid out in randomized block design replicated thrice. The treatments were as follows T0:Control, T1:RDF+ Zinc foliar @0.5%, T2:RDF+ Zinc soil application @ 25kg/ha, T3:RDF+ Zinc soil application @ 25kg/ha; + zinc foliar @0.5%, T4:RDF+ Boron foliar application @ 0.5%, T5:RDF + Boron soil application @2 kg/ha, T6:RDF + Boron soil application @2 kg/ha; + foliar application @ 0.5% and T7:RDF + Combined application of boron foliar @0.5% and Zinc foliar @0.5%. Broccoli was planted (spacing of 50 cm x 45 cm), fertilized with (N: P2O5: K2O; at a ratio 150:100:100). Broccoli seedlings was transplanted into the main field on 15th October 2024. Thirty days old healthy seedling having two pairs of leaves with a height of 10 to 15 cm were selected from the nursery and roots of the plant were treated first with 0.1% carbendazim before transplanting and transplanted at the experimental plot and given light irrigation. Data on growth and yield parameters were collected from plants from the different experimental plots at 15, 30, 45 and 60 days after transplanting and at harvesting as the case may be. These include plant height (cm), leaves per plant, plant spread (cm), days to first curd formation, duration from transplanting to harvesting (days), curd diameter (cm), weight of untrimmed curd (g), weight of trimmed curd (g), curd yield per plot (kg), curd yield (q ha-1), total soluble solid (°brix) and ascorbic acid (mg / 100 g edible portion). The data on growth and yield parameters were subjected to Fisher’s method of analysis of variance (ANOVA) as outlined by Sundararaj *et al*. (1972) where the ‘F’ test was significant for comparison of the treatment means, CD values were worked out at 5% probability level.

**RESULTS AND DISCUSSION**

The findings of the present study as depicted in Table 1 revealed significant effect of zinc and boron on plant height (cm), leaves per plant and plant spread (cm) at 15, 30, 45 and 60 days after transplanting. The data showed significant effect of foliar application and soil application of zinc and boron on plant height of broccoli at 15, 30, 45 and 60 days after transplanting. At 15, 30, 45 and 60 days after transplanting, T7 RDF + Combined application of boron foliar @0.5% and Zinc foliar @0.5% recorded maximum plant height (15.51, 36.44, 47.48 and 55.50) followed by T6 RDF + Boron soil application @2 kg/ha; + foliar application @ 0.5%, whereas the minimum plant height (11.22, 26.27, 36.17 and 40.67) was recorded in treatment T0Control. The data showed significant effect of foliar application and soil application of zinc and boron on number of leaves per plants of broccoli at 15, 30, 45 and 60 days after transplanting. At 15, 30, 45 and 60 days after transplanting, T7 RDF + Combined application of boron foliar @0.5% and Zinc foliar @0.5% recorded maximum number of leaves per plant (6.47, 14.09, 27.57 and 36.06) followed by T6 RDF + Boron soil application @2 kg/ha; + foliar application @ 0.5%, whereas the minimum number of leaves per plant (4.25, 8.78, 18.28 and 27.14) was recorded in treatment T0Control. The data showed significant effect of foliar application and soil application of zinc and boron on plant spread (cm) of broccoli at 15, 30, 45 and 60 days after transplanting. At 15, 30, 45 and 60 days after transplanting, T7 RDF + Combined application of boron foliar @0.5% and Zinc foliar @0.5% recorded maximum plant spread (cm) (22.10, 46.39, 65.88 and 73.68) followed by T6 RDF + Boron soil application @2 kg/ha; + foliar application @ 0.5%, whereas the minimum number of leaves per plant (14.03, 31.46, 46.67 and 57.11) was recorded in treatment T0Control. The findings are similar to those reported by **Prasad *et al.* (2021)** and **Parmar *et al.* (2023)** in their experiment on effect of micronutrient in broccoli where plant growth was influenced by combined application of zinc and boron. **Quratul *et al.* (2021)** found similar response in his experiment where 0.5% application of zinc sulphate and borax increased plant height. **Chowdhury *et al.* (2019)** in the research of effect of boron, zinc and molybdenum on broccoli (cv-green magic) with sole doses of these three micronutrients found 0.5% application of zinc sulphate in promoting growth of broccoli plant had similar results. The results pertaining to days to first curd formation stage and duration from transplanting to harvesting (days)as influenced with soil application and foliar application of zinc and boron are present in table 2. The findings revealed significant effect of zinc and boron on days to first curd formation stage at curd formation stage and duration from transplanting to harvesting (days). Minimum days to first curd formation i.e. 44.33 was found with treatment T7 RDF + Combined application of boron foliar @0.5% and Zinc foliar @0.5% which was statiscally at par wth treatment T6 RDF + Boron soil application @2 kg/ha; + foliar application @ 0.5%. Where as the maximum Days to first curd formation stage (56.55) was found in T0 Control. Minimum duration from transplanting to harvest i.e. 63.26 days were taken under treatment T7 RDF + Combined application of boron foliar @0.5% and Zinc foliar @0.5%. It was followed by T6 RDF + Boron soil application @2 kg/ha; + foliar application @ 0.5%, T1 RDF+ Zinc foliar @0.5% and T2 RDF+ Zinc soil application @ 25kg/ha. Whereas the maximum duration from transplanting to harvest (73.08) were taken under treatment T0 Control. This might be due to the stimulating influence of boron enhancing the rate of absorption of N, P and K and other nutrients. **Moniruzzaman *et al.* (2007),** Moreover, boron took part in sugar translocation which might be lead to the increased height of plant. This is in accordance with the findings of similar results observed **Saha *et al.* (2010), Naher *et al.* (2014)** on cabbage. **Singh *et al.* (2015)** on broccoli. The plant which treated with nitrogen (N) grows quickly and retain maximum vegetative growth by means of higher canopy area development, CO2 exchange rate and photosynthetic activity. **Yasir *et al.* (2016)** reported that potassium gives role on carbohydrate metabolism and enzyme activation in plant body and boron enhances proper translocation of sugars, starch and nitrogen compound in plant body these finding are in close conformity with earlier results obtained by **Alam *et al.* (2007)** and **Singh *et al.* (2015).** The data given in table 2 revealed that curd diameter (cm), weight of untrimmed curd (g), weight of trimmed curd (g), curd yield per plot (kg), curd yield (q ha-1) was affected significantly with soil and foliar application of zinc and boron. Maximum curd diameter (16.21cm) was recorded with treatment T7 RDF + Combined application of boron foliar @0.5% and Zinc foliar @0.5% which is significantly superior over all the treatment. It was followed by T6 RDF + Boron soil application @2 kg/ha; + foliar application @ 0.5% respectively. While minimum curd diameter (11.07) was observed under treatment T0 Control. Maximum weight of untrimmed curd (g) (894.00) was recorded with treatment T7 RDF + Combined application of boron foliar @0.5% and Zinc foliar @0.5% which is significantly superior over all the treatment. It was followed by T6 RDF + Boron soil application @2 kg/ha; + foliar application @ 0.5% respectively. While minimum weight of untrimmed curd (g) (636.72) was observed under treatment T0 Control. Maximum weight of trimmed curd (g) (428.51) was recorded with treatment T7 RDF + Combined application of boron foliar @0.5% and Zinc foliar @0.5% which is significantly superior over all the treawtment. It was followed by T6 RDF + Boron soil application @2 kg/ha; + foliar application @ 0.5% respectively. While minimum weight of trimmed curd (g) (334.48) was observed under treatment T0 Control. Maximum curd yield per plot (kg) (4.29) was recorded with treatment T7 RDF + Combined application of boron foliar @0.5% and Zinc foliar @0.5% which is significantly superior over all the treawtment. It was followed by T6 RDF + Boron soil application @2 kg/ha; + foliar application @ 0.5% respectively. While minimum curd yield per plot (kg) (3.34) was observed under treatment T0 Control. Maximum curd yield (q ha-1) (95.12) was recorded with treatment T7 RDF + Combined application of boron foliar @0.5% and Zinc foliar @0.5% which is significantly superior over all the treatment. It was followed by T6 RDF + Boron soil application @2 kg/ha; + foliar application @ 0.5% respectively. While minimum curd yield (q ha-1) (74.23) was observed under treatment T0 Control. The findings are similar to **Singh *et al.* (2017) and Sidhu *et al.* (2022)** concluded that the application of boron with zinc promoted head weight, head diameter and plant weight. **Mahmoud et al. (2019)** reported that combined foliar application of zinc and boron recorded highest yield. The increase in yield could be attributed to combined effect of zinc and boron at the same time for particular treatments which boosted the plant metabolism and translocated sugar and carbohydrates from site of synthesis to storage tissue in broccoli. However, there was no significant differences on head length, width and stem girth with combined application of zinc and boron. Lowest value was recorded for control plots. The data given in Table 1 revealed that total soluble solid (°Brix) and **ascorbic acid (mg / 100 g edible portion)** was affected significantly with soil and foliar application of zinc and boron. Application of zinc and boron exhibited positive effect on total soluble solid (°Brix) and **ascorbic acid (mg / 100 g edible portion)**. Maximum total soluble solid (°Brix) (5.16) was recorded with treatment T7 RDF + Combined application of boron foliar @0.5% and Zinc foliar @0.5% which is significantly superior over all the treawtment. It was followed by T6 RDF + Boron soil application @2 kg/ha; + foliar application @ 0.5% respectively. While minimum total soluble solid (°Brix) (3.15) was observed under treatment T0 Control. Maximum ascorbic acid (mg / 100 g edible portion) (121.40) was recorded with treatment T7 RDF + Combined application of boron foliar @0.5% and Zinc foliar @0.5% which is significantly superior over all the treawtment. It was followed by T6 RDF + Boron soil application @2 kg/ha; + foliar application @ 0.5% respectively. While minimum ascorbic acid (mg / 100 g edible portion) (108.37) was observed under treatment T0 Control. Boron being in xylem tissue, adsorbed from soil as neutral molecules and accumulates in broccoli head. Combined application of boron and zinc resulted in enhanced vegetative growth, improved physical quality, and increased nutritional value of the broccoli heads **Mahmoud *et al.,* (2019).**

**CONCLUSION**

The present findings have clearly indicated that the combined soil and foliar application of NPK, boron and zinc at RDF (150:100:100) + Combined application of boron foliar @0.5% and Zinc foliar @0.5% may be suggested as the optimum level for improving growth, yield and quality of broccoli.

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**Table 1: Effect of zinc and boron on growth parameters of the broccoli under the kanpur agro climactic region *(Brassica oleracea L. var. Italica)***

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S. No.** | **Treatments Notation** | **Plant height (cm)** | **Number of leaves per plant** | **Plant spread (cm)** |
| **15 DAT** | **30 DAT** | **45 DAT** | **60 DAT** | **15 DAT** | **30 DAT** | **45 DAT** | **60 DAT** | **15 DAT** | **30 DAT** | **45 DAT** | **60 DAT** |
| 1 | T0 | 11.22 | 26.27 | 36.17 | 40.67 | 4.25 | 8.78 | 18.28 | 27.14 | 14.03 | 31.46 | 46.67 | 57.11 |
| 2 | T1 | 15.57 | 33.26 | 42.74 | 50.44 | 5.28 | 11.17 | 24.05 | 33.05 | 17.67 | 42.97 | 61.25 | 69.92 |
| 3 | T2 | 13.74 | 31.07 | 41.22 | 47.49 | 4.74 | 10.28 | 22.02 | 30.54 | 16.89 | 38.17 | 57.98 | 66.59 |
| 4 | T3 | 13.93 | 31.71 | 42.00 | 48.88 | 4.91 | 10.35 | 22.25 | 30.14 | 16.73 | 39.16 | 61.83 | 69.67 |
| 5 | T4 | 13.57 | 29.66 | 38.62 | 45.06 | 4.47 | 9.97 | 21.17 | 28.77 | 15.85 | 36.72 | 57.35 | 64.28 |
| 6 | T5 | 13.80 | 30.49 | 38.61 | 46.06 | 4.67 | 10.21 | 21.51 | 29.85 | 16.12 | 36.23 | 57.70 | 65.91 |
| 7 | T6 | 15.15 | 34.40 | 45.53 | 52.89 | 6.15 | 12.26 | 25.36 | 34.51 | 21.10 | 44.53 | 62.98 | 71.00 |
| 8 | T7 | 15.51 | 36.44 | 47.48 | 55.50 | 6.47 | 14.09 | 27.57 | 36.06 | 22.10 | 46.39 | 65.88 | 73.68 |
|  | **F-Test** | **S** | **S** | **S** | **S** | **S** | **S** | **S** | **S** | **S** | **S** | **S** | **S** |
|  | **S.Ed (+)** | **0.761** | **0.470** | **0.337** | **0.469** | **0.225** | **0.222** | **0.449** | **0.602** | **1.330** | **0.706** | **0.802** | **0.718** |
|  | **C.D. at 0.5%** | **1.632** | **1.009** | **0.722** | **1.005** | **0.482** | **0.475** | **0.963** | **1.290** | **2.852** | **1.514** | **1.720** | **1.541** |

**Table 2: Effect of zinc and boron on the yield and nutritive quality of the broccoli under the kanpur agro climactic region *(Brassica oleracea L. var. Italica)***

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **S. No.** | **Treatments Notation** | **Curd diameter (cm)** | **Weight of untrimmed curd (g)** | **Weight of trimmed curd (g)** | **Curd yield per plot (kg)** | **Curd yield (q ha-1)** | **Total soluble solid (°Brix)** | **Ascorbic acid (mg / 100 g edible portion)** |
| 1 | T0 | 11.07 | 636.72 | 334.48 | 3.34 | 74.23 | 3.15 | 108.37 |
| 2 | T1 | 14.21 | 674.21 | 409.32 | 4.09 | 91.00 | 4.11 | 117.04 |
| 3 | T2 | 13.37 | 746.48 | 359.45 | 3.59 | 79.94 | 3.55 | 114.34 |
| 4 | T3 | 13.93 | 730.34 | 363.84 | 3.64 | 80.93 | 3.73 | 115.17 |
| 5 | T4 | 12.69 | 719.24 | 346.48 | 3.46 | 76.67 | 3.35 | 109.88 |
| 6 | T5 | 13.26 | 730.62 | 355.25 | 3.55 | 79.39 | 3.44 | 111.04 |
| 7 | T6 | 15.02 | 819.73 | 418.27 | 4.18 | 93.14 | 4.76 | 119.66 |
| 8 | T7 | 16.21 | 894.00 | 428.51 | 4.29 | 95.15 | 5.16 | 121.40 |
|  | **F-Test** | **S** | **S** | **S** | **S** | **S** | **S** | **S** |
|  | **S.Ed (+/-)** | **0.535** | **3.083** | **3.308** | **0.033** | **0.581** | **0.051** | **0.820** |
|  | **C.D. at 0.5%** | **1.148** | **6.612** | **7.096** | **0.071** | **1.247** | **0.110** | **1.759** |