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# Effect of micronutrients on growth and yield of cauliflower (*Brassica oleracea* var. *botrytis* L.) under problematic soil environment

**B. M. Mahmudul Hasan*[1], Md. Hanjala Pipil[1], Israt Jahan Annee[2], Md. Nurul Alam[3], Ramjan Ali[4], Antu Chandra Karmokar[4]**

[1]*Department of Biochemistry and Molecular Biology, Trust University, Barishal, Bangladesh*

[2]*Department of Food and Nutrition, Barishal Home Economics College affiliated by University of Dhaka, Bangladesh*

[3]*Department of Crop Science and Technology, University of Rajshahi, Bangladesh*

[4]*Department of Public Health Nutrition, Primeasia University, Dhaka, Bangladesh*

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## Abstract

A field experiment was conducted to investigate the effects of micronutrients on the growth and yield of cauliflower (*Brassica oleracea* ar. *botrytis* v. Poushali) in Shampur, Rajshahi, Bangladesh. The study site had medium fertility, silty loam soil with a pH of 7.6, and belonged to AEZ 11 (High Ganges River Floodplain). The experiment followed a randomized complete block design (RCBD) with eleven micronutrient treatments, including a control (T1) and various combinations of Zn, B, Mo, Mn, Cu, and Cl (T2–T11), with three replications. The micronutrient application rates were Zn:B:Mo:Mn:Cu:Cl = 3:3:0.5:4:1:10 kg/ha, while N, P, K, and S were applied as a basal dose (150:100:50:20 kg/ha). Among the growth parameters, the highest plant height (48.73 cm) was recorded in T7 (Zn+B+Cu), while the greatest plant spread (62.72 cm) was observed in T5 (Zn+B+Mo), T9 (Zn+B+Mo+Mn) resulted in the highest number of leaves per plant (23.03), largest leaf dimensions, and superior yield components. Marketable curd yield was significantly increased by micronutrient application, with T9 producing the highest yield (35.44 t/ha), which was 48.47% greater than the control (23.78 t/ha). The findings indicate that micronutrient supplementation, particularly Zn, B, Mo, and Mn, significantly enhances cauliflower growth and yield, suggesting its potential for improved crop management and productivity in similar agro ecological zones.

* **Corresponding Author:** B. M. Mahmudul Hasan ✉ jewelgono @gmail.com

## Introduction

Crop production is closely related to soil fertility. Intensive cropping accompanied with modern varieties, low use of organic manure and improper soil management practices cause a marked depletion of plants nutrients in soils. As a result, crops suffer from inadequate supply of nutrients which is manifested through poor crop performances. To rescue the condition addition of concerned nutrients from external sources (manures and fertilizers) is needed. The crop production system with high yield targets cannot be sustainable unless nutrient inputs to soil are at least balanced against nutrient removal by crops (Jahiruddin and Rijpma, 2004). Proper identification and management of nutrient deficiency problems in soils are pre-requisites for sustenance of higher crop yield. The use of chemical fertilizers as a supplemental source of nutrients has been increasing steadily in Bangladesh, but usually they are not applied in balanced proportions by most of the farmers (BARC, 2005). The farmers of Bangladesh mainly use four fertilizers such as urea, TSP, MOP and gypsum, but they seldom use micronutrient fertilizers. The imbalance (deficiency or toxicity) of an element results in nutritional disorder or abnormality as retarded growth or lower yield. As a result, the benefit of NPKS fertilizers cannot be achieved fully if there remains deficiency of other elements like Zn, B, Cu, Mn, Mo, Fe, and Cl. So, to increase the production of vegetables application of micronutrients to the soil in the form of fertilizer is essential. High Ganges River Flood plain is one of the most important AEZs of Bangladesh bearing calcareous soil.

This type of soil contains large amount of $CaCO_3$. The pH generally ranges from 7.0 to 8.5 but in most of the upland soils it laid between 8.0-8.5 (Alam, 2006). There is a lot of evident that cauliflower responds significantly to major essential elements like NPK in respect of their growth and yield (Thompson and Kelly, 1957; Mital *et al.*, 1999). In the objective of our study, various effects of micronutrients on the growth and yield of cauliflower (Brassica oleracea var. botrytis l.) under a problematic soil environment. Furthermore, while various researchers have investigated the individual effects of micronutrients, the combined effects of these nutrients have yet to be examined.

## Materials and methods

To assess the effect of micronutrients on the growth and yield of cauliflower the investigations were carried out at a field plot of Shampur, Rajshahi, during the period from November, 2008 to February, 2009. The soil of the experimental plots was silty loam in texture belonging to High Gangaje River flood plain. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. N (urea), P (TSP), K (potassium sulfate) and S (gypsum) were applied to the plots as basal dose at the rate of 150, 100, 50 and 20 kg/ha respectively. 11 different treatments of 6 micronutrients (Zn, B, Mn, Mo, Cu and Cl) were applied. Healthy and 3 weeks old seedlings were transplanted on 13 November, 2008 with a spacing of 45 cm × 50 cm. Soil was irrigated, weeding and earthing up were also done regularly wherever necessary. Harvesting was done when the plants formed compact head during the period of 30 January to 05 February, 2009.

Data on plant height, plant spread, number of leaves per plant, length of largest leaf, breadth of largest leaf, length of stem were collected at 30, 45, 60 days after transplanting (DAT). Other parameters were recorded at harvest. The collected data were statistically analyzed with MSTAT-C. After statistical analysis, correlation analysis was also performed to find out there was relation between different parameters or not.

## Results and discussion

*Plant height*

The plant height is significantly influenced by the micronutrients. The height of the plant ranged from 23.83 cm to 30.81 cm (at 30 DAT), 34.75 cm to 45.33 cm (at 45 DAT) and 39.51 to 48.73 cm (at 60 DAT). In all dates of observation, the height of plant was maximum when the plot was treated with treatment $T_7$ (Table. 2).

**Table 1.** The treatments of micronutrients.

| Treatments | Rates (kg/ha) | | | | | |
|---|---|---|---|---|---|---|
| | Zn | B | Mo | Mn | Cu | Cl |
| $T_1$ = Control | - | - | - | - | - | - |
| $T_2$ = Zn | 3 | - | - | - | - | - |
| $T_3$ = B | - | 3 | - | - | - | - |
| $T_4$ = Zn+B | 3 | 3 | - | - | - | - |
| $T_5$ = Zn+B+Mo | 3 | 3 | 0.5 | - | - | - |
| $T_6$ = Zn+B+Mn | 3 | 3 | - | 4 | - | - |
| $T_7$ = Zn+B+Cu | 3 | 3 | - | - | 1 | - |
| $T_8$ = Zn+B+Cl | 3 | 3 | - | - | - | 20 |
| $T_9$ = Zn+B+Mo+Mn | 3 | 3 | 0.5 | 4 | - | - |
| $T_{10}$ = Zn+B+Mo+Mn+Cu | 3 | 3 | 0.5 | 4 | 1 | - |
| $T_{11}$ = Zn+B+Mo+Mn+Cu+Cl | 3 | 3 | 0.5 | 4 | 1 | 20 |

This effect was statistically similar to $T_4$ (at 30 DAT) and $T_9$, $T_4$ (at 45 DAT). At 30 DAT the lowest height of plant was found for $T_1$, but in case of rest two days of observation it was for treatment $T_{11}$. Sharma (2002) reported that maximum plant height was observed when 10 kg Borax/ha was applied. Adhikary *et al.* (2004) reported that maximum plant height (42.05 cm) was observed when the crop was supplied with 25 kg borax/ha.

*Plant spread*

Canopy spread ranged from 28.67 to 31.26 cm ((at 30 DAT), 47.5 to 54.51 cm (at 45 DAT) and 57.27 to 62.72 cm (at 60 DAT). In case of plant spread, though the effects of different micronutrient treatments were significant, the variations among them were not widely extended (Table 2). At first two days of observation (30 and 45 DAT) the maximum plant canopy was recorded for the treatment $T_7$. This effect is statistically similar to all other treatments except $T_1$ at 30 DAT and $T_5$ and $T_9$ at 45 DAT. But at 60 DAT it was found maximum for treatment $T_5$. Statistically this effect was similar to $T_7$ and $T_9$. At all the three days of observation the minimum plant canopy was observed for the treatment $T_1$ (control).

*Leaves number*

Number of leaves per plant is one of the important growth characters which significantly contribute in both plant growth and yield.

**Table 2.** Effects of micronutrients on growth parameters of cauliflower.

| Treatments | Plant height at | | | Plant spread at | | |
|---|---|---|---|---|---|---|
| | 30 DAT | 45 DAT | 60 DAT | 30 DAT | 45 DAT | 60 DAT |
| $T_1$ = Control | 23.83 c | 36.58 cd | 41.04 cd | 28.67 b | 47.50 e | 57.27 d |
| $T_2$ = Zn | 27.04 b | 37.25 cd | 40.92 cd | 30.28 ab | 50.28 cd | 59.94 c |
| $T_3$ = B | 28.15 b | 36.79 cd | 43.73 b | 29.68 ab | 49.64 cde | 60.13 bc |
| $T_4$ = Zn + B | 28.19 b | 42.94 a | 46.99 a | 29.69 ab | 48.79 de | 59.90 c |
| $T_5$ = Zn + B + Mo | 24.32 c | 39.29 bc | 43.12 bc | 31.24 a | 53.17 ab | 62.72 a |
| $T_6$ = Zn + B + Mn | 24.41 c | 38.48 cd | 43.00 bc | 29.40 ab | 50.99 bcd | 59.46 c |
| $T_7$ = Zn + B + Cu | 30.81 a | 45.33 a | 48.73 a | 31.26 a | 54.51 a | 61.85 ab |
| $T_8$ = Zn + B + Cl | 28.60 b | 38.90 bc | 43.50 b | 30.53 ab | 51.59 bc | 60.15 bc |
| $T_9$ = Zn + B + Mo + Mn | 28.54 b | 42.27 ab | 47.30 a | 31.08 a | 52.95 ab | 61.28 abc |
| $T_{10}$ = Zn + B + Mo + Mn + Cu | 25.35 c | 37.22 cd | 41.62 bcd | 30.78 a | 50.39 cd | 59.74 c |
| $T_{11}$ = Zn + B + Mo + Mn + Cu + Cl | 24.36 c | 34.78 d | 39.51 d | 29.89 ab | 51.71 bc | 59.68 c |
| Level of significance | ** | ** | ** | NS | ** | ** |
| CV (%) | 3.15 | 5.11 | 2.94 | 3.46 | 2.57 | 1.61 |

In a column, figure(s) having common letter(s) do not differ significantly by DMRT at 5% level.

* = Significant at 5% ** = Significant at 1% NS = Non-significant DAT: Days after transplant.

In this study the maximum number of leaves was found in the plot treated with $T_9$ in all the days of observation (Table 3). This effect was statistically similar to all other treatment except $T_6$, $T_5$ and $T_1$ (at 30 DAT), except $T_2$, $T_6$ and $T_1$ (at 45 DAT) and excluding $T_{11}$, $T_8$, $T_6$ and $T_1$ (at 60 DAT). In all three days of observation the lowest number of leaves was observed for the treatment $T_1$ (control).

Adhikary *et al.* (2004) reported that maximum leaf number was observed when the plant was fertilized with 10 kg borax/ha.

**Table 3.** Effects of micronutrients on number and Length of leaves of cauliflower.

| Treatments | Number of leaves per plant at | | | Length of largest leaf at | | |
|---|---|---|---|---|---|---|
| | 30 DAT | 45 DAT | 60 DAT | 30 DAT | 45 DAT | 60 DAT |
| $T_1$ = Control | 10.83 c | 19.22 d | 19.69 d | 20.93 e | 30.56 c | 32.42 c |
| $T_2$ = Zn | 12.11 ab | 19.94 bcd | 20.31 cd | 23.08 bcde | 32.75 bc | 35.63 bc |
| $T_3$ = B | 12.56 ab | 21.03 abc | 21.58 abc | 24.90 abcd | 34.73 abc | 37.11 abc |
| $T_4$ = Zn + B | 12.58 ab | 21.17 abc | 21.56 abc | 25.73 abc | 36.53 ab | 38.75 ab |
| $T_5$ = Zn + B + Mo | 11.67 bc | 21.42 ab | 21.97 ab | 21.87 de | 35.49 abc | 38.15 ab |
| $T_6$ = Zn + B + Mn | 11.92 b | 19.56 cd | 20.17 cd | 21.55 e | 35.88 ab | 38.02 ab |
| $T_7$ = Zn + B + Cu | 12.33 ab | 21.28 abc | 21.58 abc | 26.33 ab | 36.83 ab | 38.64 ab |
| $T_8$ = Zn + B + Cl | 12.31 ab | 20.86 abcd | 21.17 bcd | 24.97 abcd | 32.51 bc | 34.63 bc |
| $T_9$ = Zn + B + Mo + Mn | 13.17 a | 22.22 a | 23.03 a | 27.32 a | 38.14 a | 40.66 a |
| $T_{10}$ = Zn + B + Mo + Mn + Cu | 12.67 ab | 21.72 ab | 22.33 ab | 22.73 cde | 32.19 bc | 34.80 bc |
| $T_{11}$ = Zn + B + Mo + Mn + Cu + Cl | 12.33 ab | 20.64 abcd | 21.33 bc | 23.41 bcde | 33.02 bc | 35.58 bc |
| Level of significance | * | * | ** | ** | * | * |
| CV (%) | 4.95 | 4.44 | 3.92 | 7.31 | 7.58 | 6.71 |

In a column, figure(s) having common letter(s) do not differ significantly by DMRT at 5% level.

* = Significant at 5% ** = Significant at 1% NS = Non-significant DAT: Days after transplant.

*Leaf length*

Length of largest leaf is also an important phenomenon that contributes in yield significantly. The maximum leaf length was observed for the treatment $T_9$ (Table 3). This effect was statistically similar to $T_7$, $T_4$, $T_8$, $T_3$ at 30 DAT, $T_7$, $T_4$, $T_6$, $T_5$, $T_3$ at 45 DAT and $T_4$, $T_7$, $T_5$, $T_6$, $T_3$ at 60 DAT. In all days of observation length of the largest leaf was minimum at the treatment $T_1$. Adhikary *et al.* (2004) reported that maximum leaf length was observed when the plant was treated with 10 kg borax/ha.

*Leaf breadth*

The breadth of largest leaf ranged between 9.10-11.57 cm, 11.77-14.37 cm and 13.46-16.11 cm at 30, 45 and 60 DAT respectively. The highest breadth of largest leaf was observed for the treatment $T_9$, which was significantly similar to $T_3$ at 45 DAT and $T_4$ at 60 DAT (Table 4). The lowest value of largest leaf was recorded in treatment combination $T_1$ for all the days of observation.

*Stem length*

Length of stem is an important indicator for the strength of the plant. The more the length, the weak the plant will be. The maximum stem length was recorded for the treatment $T_3$, which was statistically similar with $T_1$ (Table 4).

However, the shortest stem was found in the plot treated with $T_5$, which was statistically similar to $T_7$, $T_2$ and $T_{10}$ combinations.

*Days to curd formation*

The number of days required for curd formation ranged from 46.69 to 50.56 days (Table 5). The maximum day (50.56 days) was required when the plant was treated with treatment $T_{11}$.

The effects of $T_9$, $T_5$, $T_1$ and $T_3$ were statistically similar to that of $T_{11}$. However, the minimum day requirement for curd formation was observed in $T_6$ which was statistically similar to $T_2$.

**Table 4.** Effects of micronutrients on leaf breadth and stem length of cauliflower.

| Treatments | *Breadth of largest leaf at* | | | Length of stem at | | |
|---|---|---|---|---|---|---|
| | 30 DAT | 45 DAT | 60 DAT | 30 DAT | 45 DAT | 60 DAT |
| $T_1$ = Control | 9.10 g | 11.77 e | 13.46 d | 6.050 ab | 6.720 b | 6.970 b |
| $T_2$ = Zn | 10.39 cde | 13.20 c | 15.01 c | 5.357 cd | 5.680 ef | 5.900 d |
| $T_3$ = B | 11.08 b | 13.96 ab | 15.22 bc | 6.583 a | 7.180 a | 7.427 a |
| $T_4$ = Zn + B | 10.44 cde | 13.64 bc | 15.81 ab | 5.630 bc | 6.170 c | 6.017 d |
| $T_5$ = Zn + B + Mo | 10.06 ef | 13.15 c | 15.04 c | 4.757 d | 5.140 g | 5.360 e |
| $T_6$ = Zn + B + Mn | 10.51 cd | 13.51 bc | 15.21 bc | 5.417 bc | 5.860 d | 6.100 d |
| $T_7$ = Zn + B + Cu | 10.36 cde | 13.60 bc | 15.11 bc | 5.167 cd | 5.580 f | 5.853 d |
| $T_8$ = Zn + B + Cl | 9.89 f | 12.60 d | 14.55 c | 5.783 bc | 6.270 c | 6.420 c |
| $T_9$ = Zn + B + Mo + Mn | 11.57 a | 14.37 a | 16.11 a | 5.550 bc | 5.920 d | 6.080 d |
| $T_{10}$ = Zn + B + Mo + Mn + Cu | 10.59 c | 13.33 c | 15.11 c | 5.380 cd | 5.810 de | 6.050 d |
| $T_{11}$ = Zn + B + Mo + Mn + Cu+ Cl | 10.15 def | 13.27 c | 14.96 c | 5.790 bc | 6.260 c | 6.480 c |
| Level of significance | ** | ** | ** | ** | ** | ** |
| CV (%) | 2.03 | 2.36 | 2.51 | 6.16 | 1.23 | 2.89 |

In a column, figure(s) having common letter(s) do not differ significantly by DMRT at 5% level.

* = Significant at 5% ** = Significant at 1% NS = Non-significant DAT: Days after transplant.

*Fresh weight of plant*

In cauliflower, the fresh weight of plant ranged from 801.7 g to 1072 g (Table 5). The maximum fresh weight of plant (1072 g) was recorded when the plant was treated with the treatment $T_9$. However, the lowest value of plant weight was observed in treatment $T_1$.

*Fresh weight of curd*

For cauliflower, the fresh weight of curd without leaves was taken and was found to be significance for different nutrient combination. The weight of curd ranged from 333.3 to 471.7 g (Table 5). The maximum curd weight (471.7 g) was observed on the plot treated with $T_9$ combination. However, the minimum curd weight was found in case of treatment $T_1$.

*Curd diameter*

The maximum curd diameter (13.23 cm) was observed in $T_9$ which is statistically similar to $T_{10}$ (Table 5). On the other hand, the minimum curd diameter (10.07 cm) was found in $T_1$ which is statistically similar to $T_8$. Sanjay (2002) found that molybdenum and boron application significantly increased curd diameter. Adhikary *et al.* (2004) noticed that curd size was increased with the increasing levels of borax and maximum curd diameter (10.26 cm) was produced when the crop was supplied with 25 kg borax/ha.

*Marketable curd weight*

In cauliflower the marketable curd weight per plant ranged from 535 to 790 g. The maximum curd weight (790 g) was found in the plot treated with $T_9$, while the lowest weight (535 g) was observed for the treatment $T_1$. Sanjay (2002) reported that molybdenum and boron application significantly increased curd weight.

*Marketable curd yield*

Application of micronutrients significantly increased the curd yield of cauliflower. Marketable curd yield of cauliflower per hectare ranged from 23.78 to 35.44 tons. Maximum marketable curd yield (35.44 t/ha) was observed for the treatment $T_9$, which was 48.47 % higher than that of control treatment $T_1$ (23.78 t/ha).

Result suggested that Zn along with B, Mo and Mn is suitable for yield of cauliflower in calcareous soils of Bangladesh. Sharma *et al.* (1988) reported that

molybdenum had the effect to increase yield significantly. Significant effect of zinc was also observed by Singh and Balyan (1994). Adhikary *et al.* (2004) found that boron significantly increases the yield of cauliflower and maximum yield (10.9 t/ha) was reported at 25 kg borax/ha. Kotur (1998) reported that combined application of Boron (1.5 kg B/ha) and Mo (1% ammonium molybdate) on soil synergistically increased crud yield by 12% and 17% compared with single application of B and Mo respectively. Batel *et al.* (1996) noticed maximum curd yield at 4.4 kg B/ha on sandy loam soil. Sanjay (2002) found that molybdenum and boron application significantly increased curd yield. Boron at 10 kg/ha and molybdenum at 0.5 kg/ha increased the yield by 32 and 14%, respectively.

**Table 5.** Effects of micronutrients on yield parameters of cauliflower.

| Treatments | Days to curd formation | Fresh weight of plant (g) | Fresh weight of curd (g) | Curd diameter (cm) | Marketable curd weight (g) | Marketable Curd yield (t/ha) | % yield change over control |
|---|---|---|---|---|---|---|---|
| $T_1$ = Control | 49.42 abc | 775 h | 333.3 f | 10.05 e | 535.0 f | 23.78 f | - |
| $T_2$ = Zn | 47.67 ef | 881.7cde | 391.7 c | 11.73 bc | 630.0 c | 28.00 c | 17.75 |
| $T_3$ = B | 49.42 abc | 868.3 de | 386.7 cd | 11.63 c | 623.3 c | 27.70 cd | 16.48 |
| $T_4$ = Zn + B | 49.00 bc | 890.0 cd | 395.0 c | 11.63 c | 635.0 c | 28.21 c | 18.63 |
| $T_5$ = Zn + B + Mo | 49.58 abc | 896.7 c | 396.7 c | 11.68 bc | 638.3 c | 28.37 c | 19.30 |
| $T_6$ = Zn + B + Mn | 46.69 f | 861.7 ef | 376.7 cd | 11.23 cd | 611.7 cd | 27.19 cd | 14.34 |
| $T_7$ = Zn + B + Cu | 48.58 cde | 858.3 ef | 380.0 cd | 11.38 c | 608.3 cd | 27.04 cd | 13.71 |
| $T_8$ = Zn + B + Cl | 48.92 bcd | 801.7 g | 350.0 ef | 10.45 de | 566.7 e | 25.19 e | 5.93 |
| $T_9$ = Zn + B + Mo + Mn | 49.83 ab | 1072 a | 471.7 a | 13.23 a | 790.0 a | 35.44 a | 49.03 |
| $T_{10}$ = Zn + B + Mo + Mn + Cu | 47.83 de | 968.3 b | 423.3 b | 12.52 ab | 689.3 b | 30.65 b | 28.89 |
| $T_{11}$ = Zn + B + Mo + Mn + Cu + Cl | 50.56 a | 836.7 f | 368.3 de | 10.98 cd | 588.3 de | 26.44 d | 11.19 |
| Level of significance | ** | ** | ** | ** | ** | ** | |
| CV (%) | 1.24 | 1.70 | 2.85 | 4.06 | 2.79 | 2.62 | |

In a column, figure(s) having common letter(s) do not differ significantly by DMRT at 5% level.
* = Significant at 5% ** = Significant at 1% NS = Non-significant DAT: Days after transplant.

*Correlation analysis*

Being a quantitative character yield is the expression of the interaction of many growth and yield components. In order to develop the interrelationship among plant characters, correlation study was performed.

**Table 6.** Correlation matrix among the parameters of cauliflower.

| *Parameters* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Plant height | 1.00 | | | | | | | | | | | |
| 2. Plant spread | $0.527^{NS}$ | 1.00 | | | | | | | | | | |
| 3. Number of leaves per plant | $0.476^{NS}$ | 0.669* | 1.00 | | | | | | | | | |
| 4. Length of largest leaf | 0.753** | 0.713* | $0.590^{NS}$ | 1.00 | | | | | | | | |
| 5. Breadth of largest leaf | $0.565^{NS}$ | $0.583^{NS}$ | 0.700* | 0.875*** | 1.00 | | | | | | | |
| 6. Length of stem | $-0.199^{NS}$ | -0.654* | $-0.278^{NS}$ | $-0.396^{NS}$ | $-0.314^{NS}$ | 1.00 | | | | | | |
| 7. Days to curd formation | $0.017^{NS}$ | $0.141^{NS}$ | $0.371^{NS}$ | $0.032^{NS}$ | $-0.028^{NS}$ | $0.277^{NS}$ | 1.00 | | | | | |
| 8. Fresh weight of plant | $0.383^{NS}$ | $0.455^{NS}$ | 0.789** | 0.640* | 0.772** | $-0.367^{NS}$ | $0.011^{NS}$ | 1.00 | | | | |
| 9. Fresh weight of curd | $0.408^{NS}$ | $0.504^{NS}$ | 0.802** | 0.681* | 0.814** | $-0.372^{NS}$ | $0.020^{NS}$ | 0.995*** | 1.00 | | | |
| 10. Diameter of curd | $0.373^{NS}$ | $0.510^{NS}$ | 0.782** | 0.656* | 0.816** | $-0.371^{NS}$ | $-0.056^{NS}$ | 0.975*** | 0.987*** | 1.00 | | |
| 11. Marketable curd weight | $0.409^{NS}$ | $0.472^{NS}$ | 0.790** | 0.668* | 0.792** | $-0.347^{NS}$ | $0.022^{NS}$ | 0.997*** | 0.996*** | 0.973*** | 1.00 | |
| 12. Marketable curd yield | $0.400^{NS}$ | $0.467^{NS}$ | 0.792** | 0.666* | 0.791** | $-0.340^{NS}$ | $0.045^{NS}$ | 0.997*** | 0.994*** | 0.968*** | 0.999*** | 1.00 |

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$, NS = Non signifiant.

The values of correlation coefficient (Table 6) indicated that marketable curd yield was significantly and positively correlated with number of leaves per plant (r = 0.792), length of largest leaf (r = 0.666), breadth of largest leaf (r= 0.791), fresh weight of plant (r = 0.997), fresh weight of curd (r = 0.994), diameter of curd (r = 0.968), marketable curd weight (r = 0.999). However, plant height, plant spread, length of stem, days to curd formation showed no association with yield of cauliflower in the present study.

It was observed that number of leaves per plant (r = 0.792) and breadth of leaves (r= 0.791) showed highly significant and positive correlation with yield of cauliflower. This might be due to the greater surface of leaves which resulted in higher photosynthesis that might have contributed to the higher yield of individual cauliflower curd. These two parameters also showed highly significant and positive correlation to most of the yield contributing parameters. Negative significant correlation (r = -0.654) was observed between plant spread and length of stem which indicated that plant spread decreased with corresponding increase of stem length.

## Conclusion

Plant height and canopy spread were found to be maximum for the treatment $T_7$ (Zn+ B+Cu) and $T_5$ (Zn+B+Mo) respectively. Number of leaves per plant, length of largest leaf and breadth of largest leaf were found maximum in $T_9$ (Zn+B+Mo+Mn), but length of stem was highest at $T_3$ (B). Among the yield contributing parameters except days to curd formation all other characters (fresh weight of plant, fresh weight of curd, curd diameter, marketable curd weight and marketable curd yield) showed their maximum value for treatment $T_9$ (Zn+B+Mo+ Mn). The maximum marketable curd yield (35.44 t/ha) was observed for the treatment $T_9$, which was 48.47 % higher than that of control treatment $T_1$ (23.78 t/ha). Result suggested that Zn along with B, Mo and Mn is suitable for better growth and yield of cauliflower in calcareous soils of Bangladesh.

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