# EFFECT OF PLANT SPACING AND MICRONUTRIENTS ON GROWTH AND YIELD OF CAULIFLOWER

**MST. ESMOT ARA**

**DEPARTMENT OF HORTICULTURE**
**SHER-E-BANGLA AGRICULTURAL UNIVERSITY**
**DHAKA-1207**

**JUNE, 2016**

# EFFECT OF PLANT SPACING AND MICRONUTRIENTS ON GROWTH AND YIELD OF CAULIFLOWER

**BY**

**MST. ESMOT ARA**

**REG. NO. : 10-03931**

A Thesis
*Submitted to the Faculty of Agriculture*
*Sher-e-Bangla Agricultural University, Dhaka*
*in partial fulfillment of the requirements*
*for the degree*
*of*

**MASTER OF SCIENCE (MS)**
**IN**
**HORTICULTURE**

**SEMESTER: JANUARY-JUNE, 2016**

**Approved by:**

**Dr. Khaleda Khatun**
Associate Professor
Department of Horticulture
Sher-e-Bangla Agricultural University
Dhaka-1207
**Supervisor**

**Prof. Dr. Tahmina Mostarin**
Department of Horticulture
Sher-e-Bangla Agricultural University
Dhaka-1207
**Co-supervisor**

**Prof. Dr. Tahmina Mostarin**
Chairman
Examination Committee

# DEPARTMENT OF HORTICULTURE

Sher-e-Bangla Agricultural University

**Sher-e-Bangla Nagar, Dhaka-1207**

**Memo No: SAU/HORT/…………** **Date: ………………...**

## CERTIFICATE

This is to certify that the thesis entitled **'Effect of Plant Spacing and Micronutrients on Growth and Yield of Cauliflower**' submitted to the Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE in HORTICULTURE**, embodies the results of a piece of *bonafide* research work carried out by **MST. ESMOT ARA**, Registration No. **10-03931** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that any help or source of information, received during the course of this investigation has been duly acknowledged.

Dated: June, 2016
Dhaka, Bangladesh

**Dr. Khaleda Khatun**
Associate Professor
Department of Horticulture
Sher-e-Bangla Agricultural University
Dhaka-1207

**Supervisor**

**DEDICATED**

**TO**

**MY BELOVED ftARENTS**

## ACKNOWLEDGEMENTS

The author first wants to articulate her enormous wisdom of kindness to the Almighty Allah for His never ending blessing, protection, regulation, perception and assent to successfully complete of research and prepare thesis. Tthe author deems it a great pleasure to express her profound gratefulness to her respected parents, who entiled much hardship inspiring for prosecuting her studies, receiving proper education.

The authoress feels proud to express her heartiest sence of gratitude, sincere appreciation and immense indebtedness to her Supervisor Dr. Khaleda Khatun, Associate Professor, Department of Horticulture, Sher-e-Bangla Agricultural University (SAU), Dhaka, for her continuous scholastic and intellectual guidance, cooperation, constructive criticism and suggestions in carrying out the research work and preparation of thesis, without her intense co-operation this work would not have been possible.

The authoress feels proud to express her deepest respect, sincere appreciation and immense indebtedness to her Co-supervisor Dr. Tahmina Mostarin, Professor and Chairman, Department of Horticulture, SAU, Dhaka, for her scholastic and continuous guidance, constructive criticism and valuable suggestions during the entire period of course and research work and preparation of this thesis.

The author also expresses her heartfelt thanks to all the teachers of the Department of Horticulture, SAU, for their valuable teaching, suggestions and encouragement during the period of the study.

The authoress expresses her sincere appreciation to her brother, sisters, relatives, well wishers and friends for their inspiration, help and encouragement throughout the study.

**The Author**

# EFFECT OF PLANT SPACING AND MICRONUTRIENTS ON GROWTH AND YIELD OF CAULIFLOWER

**BY**

**MST. ESMOT ARA**

## ABSTRACT

The experiment was conducted in the Horticulture Farm, Sher-e-Bangla Agricultural University, Dhaka from November 2015 to February 2016. The experiment consisted of two factors, such as Factor A: Plant spacing (3 levels) as- $S_1$: 50 cm × 50 cm, $S_2$: 50 cm × 40 cm, $S_3$: 50 cm × 30 cm and Factor B: Levels of micronutrients (4 levels) as- $T_0$: $B_0Mo_0$ (control), $T_1$: $B_{1.0}Mo_{0.5}$ kg/ha, $T_2$: $B_{2.0}Mo_{1.0}$ kg/ha, $T_3$: $B_{3.0}Mo_{1.5}$ kg/ha. The two factorial experiment was laid out in Randomized Complete Block Design with three replications. Plant spacing and micronutrients influenced significantly at all the studied parameters. In case of plant spacing, the highest curd yield (39.89 t/ha) was found from $S_2$ and the lowest curd yield (35.00 t/ha) was found from $S_1$. For micronutrients, $T_2$ treatment produced the highest curd yield (46.85 t/ha) and the lowest (24.41 t/ha) was from control. For combined effect, the highest curd yield (51.56 t/ha) was obtained from $S_2T_2$ and the lowest curd yield (20.33 t/ha) from $S_1T_0$ .The highest benefit cost ratio (2.59) was noted from $S_2T_2$ treatment and the lowest 1.02 from $S_1T_0$. So 50 cm × 40 cm spacing and $B_{2.0}Mo_{1.0}$ kg/ha was best for growth and yield of cauliflower.

# TABLE OF CONTENTS

# LIST OF TABLES

## LIST OF FIGURES

## LIST OF APPENDICES

## SOME COMMONLY USED ABBREVIATIONS

| FULL WORD | ABBREVIATION |
|---|---|
| Agro-Ecological Zone | AEZ |
| and others | *et al.* |
| Bangladesh Bureau of Statistics | BBS |
| Bangladesh Rice Research Institute | BRRI |
| Centimeter | cm |
| Co-efficient of variation | CV |
| Days After Transplanting | DAT |
| Degree Celsius | $^0$C |
| Etcetera | etc |
| Food and Agriculture Organization | FAO |
| gram | g |
| Least Significance Difference | LSD |
| Millimeter | mm |
| Muriate of Potash | MOP |
| Sher-e-Bangla Agricultural University | SAU |
| Soil Resources Development Institute | SRDI |
| Square meter | $m^2$ |
| ton per hectare | t/ha |
| Triple Super Phosphate | TSP |

# CHAPTER I

# INTRODUCTION

Cauliflower (*Brassica oleraceae* var. *botrytis* L.) is a vegetable crop cultivated for its white curds as edible part. It represents the aristocrat of the family cruciferae for its delicate growing requires more devotion than broccoli, cabbage and its close cruciferous relative (Abdel-Razzak and El-Nasharty, 2008). It is being grown round the year for its white and tender curd vegetables and thrives best in a cool moist climate and it does not withstand very low temperature or too much heat (Din *et al.*, 2007). Cauliflower is a very tasty and much popular vegetable in Bangladesh as well as all over the world. 100 g edible part of cauliflower contains 89% moisture, 8.0 g carbohydrate, 2.3 g protein, 40 IU carotene, 0.13 mg B1, 0.11 mg B2, 50 mg vitamin C, 30 mg calcium and 0.8 mg iron and also contains 30 calorie (Rashid, 1999). In Bangladesh total of 21,472 acres of land are under cauliflower crop cultivation with per acre production is about 13068 kilograms (BBS, 2015).

Vegetable production in Bangladesh is far below of actual requirements. In 2010-2011, total vegetable (summer and winter season) production area was 645.04 thousand hectares of land with total production of 1.87 million tons (BBS, 2012). The per capita production of vegetable in Bangladesh is very low as compared to that of other countries. Due to low production of vegetables, the present consumption is only about 30 g, with potato and sweet potato it is 70g per day per person. The per capita consumption of vegetable in Nepal (42 g), Pakistan (69 g), Srilanka (120 g) and India (135 g) which are higher than that of Bangladesh (Yoldas *et al*., 2008). Due to increasing consumption of cauliflower products, the crop is becoming promising. At present Bangladesh is producing a good amount of cauliflower and it is using for the preparation of different delicious food. The average yield of cauliflower is low in Bangladesh compared to other developed countries of the world.

The low yield of cauliflower in Bangladesh however is not an indication of low yielding potentially of this crop but the fact that the low yield may be attributed to a number of reasons, viz. unavailability of quality seeds of high yielding varieties, land for production based on fertilizer management, pest infestation and improper irrigation facilities as well as improved management technology. Plant density as management practices and micronutrients is prerequisite for increasing the production of cauliflower in Bangladesh (Kannan *et al*., 2016). Plant spacing is an important aspect of crop production for maximizing the yield (Rahman *et al*., 2007). It helps to increase the number of leaves, branches and healthy foliage. Densely planted crop obstruct the proper growth and development. On the other hand, wider spacing ensures the basic requirements but decrease the total number of plants as well as total yield. Crop yield may be increased upto 25% by using optimum spacing. Vigorous development of the growth attributes (branches and leaves plant$^{-1}$) ultimately increased the dry matter accumulation per plant and higher plant density produced taller and lesser branched plants and their lower leaves had not received sufficient solar radiation to accelerate photosynthetic activities, thus become lower leaves parasitic due to high rate of respiration in which larger quantities of stored photosynthates were consumed than produced in photosynthesis. Closer spacing (60 cm × 50 cm) would be economically profitable for cauliflower seed production in North-Western part of Bangladesh (Hossain *et al*., 2015).

For optimal growth and development, 17 essential elements are required for plants. These minerals, when required in relatively high amounts, are called macronutrients or, in trace amounts are called micronutrients. While micronutrients are required in relatively smaller quantities for plant growth but they are very important (Hussain *et al*., 2012). Micronutrients play an important role in cauliflower production. Among the different micronutrients B and Mo are the most important and essential plant mineral nutrients in foliar fertilization method for growth and curd yield of cauliflower (Rahman *et al*., 2014). Boron (B) is one of the essential micronutrients required for normal growth and development of crop plants. Boron in plants is reported to function at membrane level (Shelp *et al.*, 1995) and is credited with maintaining membrane integrity (Cakmak *et al.*, 1995) and enhanced ability of membranes to transport vital nutrients. Molybdenum (Mo) is an essential micronutrient for plants, bacteria and animals. It is directly related to metabolic function of nitrogen in the plant through nitrate reductase enzyme that reduces the nitrate to nitrite and this the first step of the incorporation of nitrogen to phosphorus in the proteins (Marschner, 1995). Boron application increased plant height, number of leaves per plant, length and width of the leaf, plant spread, main head weight and head yield both per plant and per hectare (Moniruzzaman *et al*., 2007). Molybdenum is also an essential micronutrient for plants, animals and bacteria. It is directly related to reductase that reduces the nitrate to nitrite which is the first way towards incorporation of N to protein. It is also out as a co-factor of nitrogenase which is responsible for biological nitrogen fixation, as the deficiency and N-fixation (Bambara and Ndakidemi, 2010).

Considering the above all perspective, the present study was undertaken to investigate the effect of plant spacing and different levels of boron and molybdenum on cauliflower with the following objectives-

- to investigate the growth and yield of cauliflower as influence by different plant spacing;
- to identify the effective of micronutrient on the growth and yield of cauliflower; and
- to find out the suitable combined effects of plant spacing and micronutrients on the growth and yield parameters of cauliflower.

# CHAPTER II

# REVIEW OF LITERATURE

Cauliflower is an important vegetable crop with low in fat, but high in dietary fibre, folate, water, and vitamin C, possessing a high nutritional density which contributes mentionable shares of total vegetable production. Growth and curd development of cauliflower are greatly influenced by different management practices especially plant spacing and micronutrients but research works related to plant spacing and micronutrients on cauliflower are limited and not conclusive in the context of Bangladesh. Nevertheless, some of the important informative works and research findings related to plant spacing and combination of micronutrients on cauliflower and other related crops so far been done at home and abroad have been reviewed in this chapter under the following headings:

## 2.1 Effect of plant spacing on yield attributes and yield

Farzana *et al*. (2016) conducted an experiment to find out the effect of organic manures and spacing on the growth and yield of cauliflower in summer season. In this study, the treatment consisted of three organic manures viz. $F_0$: no organic manure, $F_1$: cowdung, $F_2$: vermicompost and three spacing viz. $S_1$ (60 × 30) cm, $S_2$ (60 × 40) cm, $S_3$ (60 × 50) cm. Significant variations in all parameter were observed due to spacing at different days after transplanting. For spacing, highest yield of cauliflower (11.25 t/ha) was obtained from 60 × 30 cm and lowest (10.57 t/ha) from 60 × 50 cm. It is found from the experiment that growth and yield of summer cauliflower were positively correlated with organic manure and spacing. However, white beauty cultivars can be cultivated in summer season and use of vermicompost with 60×50 cm spacing would be beneficial for the farmers.

A field trial comprising of different plant spacing's and boron on the productivity of cauliflower was conducted by Kannan *et al*. (2016) at Vegetable Research Station (VRC), G.B.P.U & T, Pantnagar, Uttarakhand. The treatments comprised of four different plant spacing with or without boron ($E_1$: 60 × 50 cm without boron, $E_2$: 60 × 50 cm with boron, $E_3$: 40 × 50 cm without boron and $E_5$: 40 × 50 cm with boron). The result revealed significant variation in all of the parameters, amongst various plant spacing's and boron. The treatment $E_1$ indicated that the cauliflower yield was mostly influenced by spacing rather than boron, while the treatment $E_2$ influenced days to curd formation and days to 50% maturity, however, the treatments $E_3$ and $E_4$ were favourable for vegetative growth. Maximum plant weight (731.53 g), curd weight (506.02 g), curd length (12.82 cm), curd breadth (6.94 cm), number of leaves (20.60), days to curd formation (99.79 days) and days to 50% maturity (129.77 days) were recorded due to the treatment $E_3$ where the plants were spaced 60 × 50 cm without boron.

Hossain *et al*. (2015) conducted field experiment at Regional Agricultural Research Station, Ishurdi, Pabna to find out the appropriate sowing date and optimum plant spacing for seed production of cauliflower (BARI Phulcopi-1). Four sowing dates viz. 20 September, 1 October, 10 October and 20 October and three plant spacing viz. 60 cm × 50 cm, 60 cm × 60 cm and 60 cm × 70 cm were used as treatment variables. Significant variation in seed yield and yield contributing characters of cauliflower were observed due to execution of different plant spacing. Closer spacing (60 cm × 50 cm) produced the highest seed yield (315.88 kg/ha) and the wider spacing (60 cm × 70 cm) produced the lowest seed yield (254.07 kg/ha). So, early sowing with closer spacing (60 cm × 50 cm) would be economically profitable for cauliflower seed production in North-Western part of Bangladesh.

Rahman *et al*. (2007) evaluate the effect of different plant spacing on the production of cauliflower was conducted at Horticulture Research Area, Faculty of Agriculture, Gomal University, Dera Ismail Khan, NWFP, Pakistan. Six different plant spacing viz., 30, 35, 40, 45, 50 and 55 cm were used. The results revealed significant variations in all the parameters and amongst various plant spacing, 45 cm spacing showed the best response for all the parameters.

Maximum plant height (49.33 cm), curd diameter (19.13 cm), maximum curd weight (1.23 kg/plant) and yield (30.77 t/ha) were recorded in the plots where the plants were spaced 45 cm apart.

Das *et al.* (2000) carried out a study to find out the effect of various N:P:K fertilizers and plat densities (45×45, 60×45 and 60×60 cm) on production of cauliflower cv. pusa Khtki and data revealed that the curd yield per plant of cauliflower was the highest at a spacing of 60×60 cm.

Pornsuriya *et al.* (1997) conducted an experiment to find out various cultural methods to increase yield and quality of broccoli in Thailand and reported the best spacing was 40×60 cm, which gave the highest yield of broccoli.

Sorensen and Grevsen (1994) planted broccoli at spacing of 40×50, 30×50, 20×50, 10×50 and 20×25 cm and had little effect on uniformity in maturity in the in different plant spacing, a higher variability in maturity index occurred at increased plant density.

Sharma and Rastogi (1992) were conducted at Horticultural Research Station, Kandaghat for two years to find out the response of cauliflower (PSB-1) to different levels of nitrogen (0, 50, 100, 150, 200 kglha) and plant spacing (60 × 30 cm, 60 × 45 cm and 60 × 60 cm). Maximum days to 50 per cent curd maturity, bolting and flowering were recorded when no nitrogen was applied for seed crop. However, maximum plant height and number of branches per plant were obtained at 200 kg N/ha. Maximum seed yield per plant as well as per hectare was obtained at 200 kg N/ha. It was noticed that plant spacing had no significant effect on days to 50 per cent curd maturity, bolting, flowering and plant height. However, highest number of branches per plant and maximum seed yield per plant was recorded at 60 × 60 cm, whereas maximum seed yield per hectare was recorded at 60 × 30 cm. It was concluded that an application of 200 kg N/ha and a plant spacing of 60 × 30 cm is best for obtaining maximum seed yield per hectare of cauliflower cv. PSB-1.

Griffith and Carling (1991) observed that the maximum yield of individual heads of broccoli for fresh market at a spacing of 45 cm ×30 cm using single plant transplants. At this spacing yields for Green Valiant and Emperor were 18.3 and 15.0 t/ha, respectively.

Soto (1991) reported in trials in Cartago were carried out in 2 years with the broccoli cultivar Green Valiant planted at densities of 70,000, 100,000 or 3000,000 plants/ha and receiving nitrogen at 200, 250, 300 , 350 or 400 kg/ha in the second year. The best combination with regard to yield (16.7 t/ha) and duality was 1000,000 plants/ha receiving 350 kg N/ha.

Khan *et al.* (1991) conducted field trials at Bixby, Oklahoma with Broccoli cv. Premium crop seedlings were planted at 15 or 30 cm apart and given 4 N rates in split applications before and after (side dressing) planting. The force required to shear the stalk was not affected by plant spacing and average stalk diameter was decreased only by 3 mm by reducing spacing. Although the 15 cm spacing sometimes produced the greatest total number of marketable heads, this spacing results in higher head production lower average marketable head weight, delayed maturity and lower percentage of field-planted transplants producing marketable heads stalk at the 30 cm spacing.

Broccoli is generally sown on bed like Cole crops. But more recently the seeds are drilled directly to soil in the USA. The spacing in such sowing is maintained at 30 cm × 75 cm between the plants and rows respectably. Crops grown in such close spacing yield more though main heads are smaller and these mature slightly later than when wide spacing is followed (Bose and Som, 1990).

Cuocolo and Duranti (1988) conducted a two-year trail to investigate the effects of nitrogen and plant density on production of cauliflower cv. Gigonte di Napoli in the Scale river plains. Seed yield was found to be increased linearly with increase in plants population, being more than 50% higher (over 800 kg/ha) at 2.5 that at 1.5 plant.

## 2.2 Effect of micronutrients on yield attributes and yield

Ribeiro *et al*. (2017) carried out an experiment to evaluate the influence of boron fertilization on the quality and yield of cauliflower growing under tropical conditions. The study was carried out in split plot design with the main plots four boron doses (0, 2, 4, 6 kg/ha) and subplots with 3 cauliflower genotypes (Verona CMS, Sarah and Sharon). In relation to boron doses, genotypes showed responsive to boron doses with maximum fresh curd mass of 1.378, 1.216 and 0.804 kg/plant with doses of 6, 4.18 and 4.06 kg B/ha. Total yield showed variation up to 307.96% positive with boron application.

Silva *et al*. (2016) reported that proper growth and development of broccoli may be affected by the application of N and B. Accordingly, the objective herein was to verify the effects of N and B application on growth and the nutritional status in the vegetative phase of broccoli. The experiment designed with four doses of B (0.25, 0.50, 1.00, and 2.00 mg $dm^{-3}$) and two doses of N (200 and 600 mg dm-3), and the check treatment (no B and no N), with four repetitions. The green color index, the accumulation of N and B in the plant aerial part, leaf area, and the aerial part dry matter content were evaluated. The interaction between nitrogen and boron was not important for the green color index, N and B accumulation, leaf area and dry matter production of broccoli in the vegetative phase. However, the isolated effects of nitrogen fertilization and boron doses were beneficial for broccoli development.

Influence of boron (B) application to cauliflower (*Brassica oleracea* var. botrytis) was investigated by Batabyal *et al*. (2015) in a pot experiment taking 15 Inceptisols with four levels of B. The critical levels of B for deficiency, adequacy and toxicity in soil and in cauliflower plant were also determined. Hot-calcium chloride ($CaCl_2$) extractable B in these soils varied from 0.33 to 0.78 mg/kg and its content for deficiency to cauliflower was 0.48 mg/kg. Boron application of 0.78 mg/kg significantly increased cauliflower yield, plant B concentration and uptake of B. The critical plant B concentrations for deficiency, sufficiency and toxicity varied with the growth stages and the values being 26, 31 and 48 mg/kg at 50 days of growth and 17, 24 and 35.5 mg/kg at harvest, respectively. The study also recommends application of fertilizer B at the rate 0.9-4.5 kg/ha for optimum B nutrition to cauliflower.

An experiment was conducted by Rahman *et al*. (2014) to investigate the effect of foliar fertilization on growth and yield of cauliflower under poultry manure condition at farmer's field Marghazar, Mansehra. The experimental treatments were $T_0$ = Control (Urea) 123.5 kg $ha^{-1}$, $T_1$ = N + Mo + Mg foliar spray [4%N + (Mo) 50 mg $L^{-1}$ + (B) 80 mg $L^{-1}$], $T_2$ = Urea + N foliar spray (123.5 kg $ha^{-1}$ + 2% N), $T_3$ = foliar spray 4% N and $T_4$ = foliar spray 8% N. The results revealed that $T_1$ [4% N + (Mo) 50 mg $L^{-1}$ + (B) 80 mg $L^{-1}$] significantly increased the root length, leaf length, plant fresh weight, curd weight, circumference of curd and curd yield. From these results it could be suggested and recommended that nitrogen in combination with micronutrients (Mo and B) are the most essential plant mineral nutrients in foliar fertilization method for growth and curd yield of cauliflower under poultry/chicken manure condition.

The experiment was conducted by Kamal *et al*. (2013) at permanent vegetable farm, Bihar Agricultural College, Sabour, Bhagalpur during two consecutive *Kharif* seasons. The treatments comprised of four basal dose of boron in form of borax (0, 5, 10 and 15 kg/ha) and Zinc in the form of zinc sulphate (0, 10, 20 and 30 kg/ha). The plant height, number of leaves per plant, biological yield, curd weight and marketable yield were found highest with combined soil application of 20 kg $ZnSO_4$ + 10 kg B/ha which showed statistical equality with 30 kg $ZnSO_4$ + 10 kg B/ha.

A field experiment was conducted by Hussain *et al*. (2012) at the Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, Bangladesh during winter season to determine the effects of N and B on the yield and hollow stem disorder of broccoli. Four levels of N as 0, 60, 120, 180 kg/ha and four levels of B as 0, 0.5, 1.0 and 1.5 kg/ha constituting sixteen treatments were applied in a split plot design with three replications. The highest curd yield of 15.14 t/ha was obtained by 180 kg N/ha. The incidence of hollow stem disorder was increased by increasing rate of N application and the highest value of hollow stem index of 1.38 was found with 180 kg N/ha. The curd yield of broccoli was significantly increased with boron application up to 1.0 kg $ha^{-1}$. This rate thus showed a remarkable impact on reduction of hollow stem disorder. A moderately high amount of B application (1.0 kg $ha^{-1}$) led to minimum incidence of hollow stem disorder, attaining considerably lowest value of hollow stem index of 1.0 as against the maximum value of 1.16 under no application of B. The interaction effect of N and B on yield and quality of broccoli was significant and the highest yield (16.68 t $ha^{-1}$) was recorded under 180 kg N and 1.0 kg B $ha^{-1}$, which might be recommended for farmer's practice in the Shallow-Red-Brown Terrace Soil of Madhupur Tract.

Ahmed *et al*. (2011) carried out an experiment to study the effect of foliar spraying with different concentrations of application of molybdenum (Mo) and magnesium (Mg) on the vegetative growth, chemical content and curds yield of cauliflower cv. Amshiry under field conditions. Plants were sprayed with 15, 30 and 45 µg/l Mo at 20, 40, 60 and 80 days after transplanting, whilst Mg was foliar sprayed at 0.25, 0.50 and 0.75% at 15, 35, 55 and 75 days after transplanting. Results showed that 30 and 45 µg/l Mo significantly improved vegetative growth parameters, curds yield and its components and chemical composition of leaves and curds. Likewise, using 0.50 and 0.75% Mg significantly enhanced foliar fresh weight, plant height, leaves fresh weight and leaves dry weight, total and marketable curds yield and chemical composition of leaves and curds. From these results, it could be recommended that molybdenum and magnesium individually or in combination are important and essential elements in the chemical fertilization management system for the cauliflower production cultivated under Egyptian soil conditions.

Firoz *et al*. (2008) carried out an experiment at the Hill Agricultural Research Station (HARS), Khagrachari. The treatment consisted of three broccoli varieties, viz., Green Commet, Green King and Green Harmony with three levels of boron viz., Control (0.0 kg/ha), l.0 kg/ha and 2.0 kg/ha. There was a significant and positive effect of boron application on the yield of the crop and 1.0 kg B/ha was found to be an optimum rate. The 1 .0 kg B/ha rate produced the highest yield (512.3 g/plant) followed by 2.0 kg B/ha showing 508.5 g/plant and the B control did the lowest (445.4 g/plant). All other characters remained unaffected by B application. However, the application of B at 1.0 kg/ha had the height curd weight (294.6 g) and 2.0 kg B showed the next result (270.2 g).

A field experiment was conducted by Moniruzzaman *et al*. (2007) to find out the suitable doses of B and N for higher yield and good quality head of broccoli comprising with six levels of boron (B) (0. 0.5, 1, 1.5, 2 and 2.5 kg/ha) and two levels of nitrogen (N) (100 and 200 kg/ha) was conducted at the Agricultural Research Station, Raikhali, Rangamati Hill District during the winter (rabi) seasons. Boron application increased plant height, number of leaves per plant, length and width of the leaf, plant spread, main head weight and head yield both per plant and per hectare significantly up to 1.5 kg/ha. Maximum yield per hectare was obtained at 2 kg B plus 200 kg N per hectare which was at par with 1.5 kg B plus 200 kg N per hectare and 1.5 kg B plus 100 kg N per hectare. The latter combination (1.5 kg B/ha + 100 kg N/ha) gave the lowest hollow stem in broccoli during both years. Response curve indicates 1.59 kg B/ha as optimum dose for this crop.

The effect of different levels of boron on cauliflower production was studied by Khadka *et al*. (2005) in a farmers' participatory on farm research approach at Sipadol, Bhaktapur district to identify appropriate and economic dose of boron for better cauliflower production in terms of both quality and quantity and thus increase the farmers' income. In the experimental site, cauliflower based cropping patterns. The experimental results revealed the better quality and quantity of cauliflower curd (14.3 and 13.9 t/ha) from the treatment with 20 kg borax in both the years, respectively. Similarly, the higher amount of soils B (0.730 and 0.768 ppm) was extracted in the same treatment (20 kg borax/ha) as a residual after cauliflower harvest. Response to boron was significant which indicated that the boron (B) is an essential micronutrient for the better quality and quantity of cauliflower production for the study area

A glass house experiments conducted by Annesar *et al.* (2004) with various macro and micro nutrients were carried out at Wiehenstephan, Bavaria. Broccoli was grown in plots with a black beltic peat substrate and reported that no deficiency symptoms were found for magnesium, iron, zinc, copper and manganese. Boron and Molybdenum deficiency and sodium chloride, boron, zinc and manganese over supplied caused severe damage.

Field experiments were conducted by Singh (2002) with cauliflower (cv. Snowball-16) during the Rabi seasons in Bihar, India. Four levels of B were applied at 0, 0.5, 1.0, and 2.0 kg/ha as Borax ($Na_2B_4O_7.10H_2O$), 11% (B) and band placed around each plant one week after transplanting. Soil application of B significantly produced higher marketable curd yields of cauliflower over the control in all three years. Application of B up to 1.0 kg/ha significantly increased the yields. Blackish curds appeared in the control plot. The highest B content in leaf tissue (23.77 mg/kg) and curds (19.31 mg/kg) was recorded upon treatment with 2.0 kg B/ha. B concentration in the leaf tissue was higher than that in the marketable curds. The mean hot water soluble B in soil increased significantly from 0.47 to 0.83 mg/kg with increased rates of B application in soil from 0.5 to 2.0 kg/ha over the control (0.21 mg/kg).

Mengel and Kirkby (2001) reported that the requirement of molybdenum in terms of dry matter is usually in the range from 0.1-1.0 ppm. Most plants are very tolerant of excessive amounts of molybdenum in the tissue with levels above 1000 ppm existing without any harmful effects. A unique feature of molybdenum nutrition is the wide variation between the critical deficiency and toxicity levels. These levels may differ by a factor of up to $10^4$ (e.g., 0.1 to 1000 ppm dry weight). Molybdenum is an essential component of two major enzymes in plants, nitrogenase and nitrate reductase. Nitrate reductase is the most well-studied molybdenum-containing enzyme.

Yang *et al.* (2000) studied the effects of B-Mo treatments on curd yield and active oxygen metabolism in broccoli. The concentrations of B were the same catalase (CAT) activity and antiscorbutic (ASA) content increased with increases in Mo concentration. Similar increased in CAT activity and ASA content were obtained with increases in B concentration at uniform Mo concentrations. The combination of B and Mo at 6 and 5g/litre, respectively, increased superoxide dismutase (SOD), peroxidase (POD), and nitrate rductase (NR) activity, decreased malondialdehyde content and autooxidation rate, inhibited membrane lipid peroxidation and increased curd yield.

The effects of eight B-Mo treatments on curd yield and active oxygen metabolism in broccoli were studied by Xian *et al. (*2000) in South China Agricultural University. There was a close relationship between B-Mo nutrition and curd yield as well as active oxygen nutrition. There was a marked interaction between B and Mo nutrition. The combination of B and Mo at 5g /liter respectively increased and yield.

In a field trials during the winter seasons Thakur *et al.* (1991) studied the effects of 5 rates of N application (80, 120, 160, 200 and 240 kg/ha), 4 rates of P application (100, 150, 200 and 250 kg/ha) and 2 rates of B application (0 and 20 kg/ha) on cauliflower cv. Pusa Snowball-1 were studied and reported that application of boron increased the number of leaves per plant, DM content and curd yield, and reduced leaf area, stalk length and incidence of stalk rot.

Shelp (1990) reported that Broccoli (cv. Premium Crop) seeds were germinated in soil, and the seedlings were transferred to vermiculite 3 weeks later and grown in a greenhouse; they were supplied continuously with B at concentration ranging from 0.0 to 12.5 mg/liter. At commercial maturity the partitioning of N into soluble (nitrate, ammonium, amino acids) and insoluble components of the foliage and the florets was investigated. Both B deficiency and toxicity increased the % soluble N, particularly as nitrate. Boron toxicity, but not deficiency consistently affected the concentration and relative amino acid composition, was dependent upon the developmental stage of the plant organs concerned, and upon whether B was present in deficient or toxic levels.

Two cultivars of cauliflower were grown by Blatt (1990) in two sand culture experiments in which arsenic (As) and molybdenum (Mo) were treatment variables. Generally, as As in solution increased, leaf As increased and leaf phosphorus (P), boron (B) and head weight decreased. The head weight response of each cultivar was different to increasing As and Mo in solution with c Idol Original reflecting increased tolerance to As at 0.2 mg $L^{-1}$ Mo in solution and cv Fortuna not responding to increased Mo. There was some plant stunting and off color appearance of leaves at 50 mg $L^{-1}$ As in solution, however there did not appear to be any P, B, or Mo deficiency symptoms in any cultivar. It did not appear that the typical whiptail Mo deficiency symptom of cauliflower could be induced by as toxicity.

From the above cited reviews, it may be concluded that optimum plant spacing and suitable amount of micronutrients are the prerequisite for attaining optimum growth and highest yield of cauliflower. The literature revealed that the influence of plant spacing, micronutrients have not been studied well and have no definite conclusion for the production of cauliflower under the agro climatic condition of Bangladesh.

# CHAPTER III

# MATERIALS AND METHODS

The experiment was carried out to study the effect of plant spacing and micronutrients on the growth and yield of cauliflower. The materials and methods that were used for conducting the experiment have been presented in this chapter. It includes a short description of the location, climate condition and soil of the experimental plot, materials used for the experiment, design of the experiment, data collection and data analysis procedure.

## 3.1 Description of the experimental site

### 3.1.1 Experimental period

The present experiment was conducted during the period of November 2015 to February 2016.

### 3.1.2 Description of experimental site

The experiment was conducted at the Horticulture farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh. The experimental site is situated between $23^0 74^/$N latitude and $90^0 35^/$E longitude and at an elevation of 8.4 m from sea level (Anon., 1989).

### 3.1.3 Climatic condition

The climate of the experimental site is subtropical, characterized by three distinct seasons, the monsoon from November to February and the pre-monsoon period or hot season from March to April and the monsoon period from May to October. The monthly average temperature, humidity, rainfall and sunshine hour during the study period were collected from Weather Yard, Bangladesh Meteorological Department, and presented in Appendix I. During these time, the maximum temperature ($27.1^0$C) and the highest rainfall (30 mm) was recorded in the month of February 2016, while the minimum temperature ($12.4^0$C) in the month of January 2016 and the highest humidity (78%) and longest sunshine hour (6.8 hour) was recorded in the month of November, 2015.

### 3.1.4 Characteristics of soil

The soil of the experimental field belongs to the Tejgaon series under the Agroecological Zone, Madhupur Tract (AEZ-28) and the General Soil Type is Deep Red Brown Terrace Soils. A composite sample was made by collecting soil from several spots of the field at a depth of 0-15 cm before the initiation of the experiment. The collected soil was air-dried, grind and passed through 2 mm sieve and analyzed at Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka for some important physical and chemical properties. The soil was having a texture of sandy loam with pH and organic matter 6.1 and 1.18%, respectively. The results showed that the soil composed of 27% sand, 43% silt, 30% clay, which has been presented in Appendix II.

## 3.2 Experimental details

### 3.2.1 Planting materials

The seeds of cauliflower ZAC-426 ($F_1$ hybrid) were used as planting materials for this experiment.

### 3.2.2 Treatment of the experiment

The experiment consisted of two factors:

Factor A: Plant spacing (3 levels) as

i $S_1$: 50 cm × 50 cm

ii. $S_2$: 50 cm × 40 cm

iii. $S_3$: 50 cm × 30 cm

Factor B: Levels of micronutrients (4 levels) as

i. $T_0$: $B_0Mo_0$ (control)

ii. $T_1$: $B_{1.0}Mo_{0.5}$ kg/ha

iii. $T_2$: $B_{2.0}Mo_{1.0}$ kg/ha

iv. $T_3$: $B_{3.0}Mo_{1.5}$ kg/ha

There were 12 (3 × 4) treatments combination such as $S_1T_0$, $S_1T_1$, $S_1T_2$, $S_1T_3$, $S_2T_0$, $S_2T_1$, $S_2T_2$, $S_2T_3$, $S_3T_0$, $S_3T_1$, $S_3T_2$ and $S_3T_3$.

### 3.2.3 Design and layout of the experiment

The two factorial experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The total area was divided into three equal blocks. Each block was divided into 12 plots where 12 treatments combination were allotted at random. There were 36 unit plots and the size of each plot was 2.0 m × 1.8 m. The distance between two blocks and two plots were 1.0 m and 0.5 m, respectively. The layout of the experimental field presented in Figure 1.

### 3.2.4 Preparation of the main field

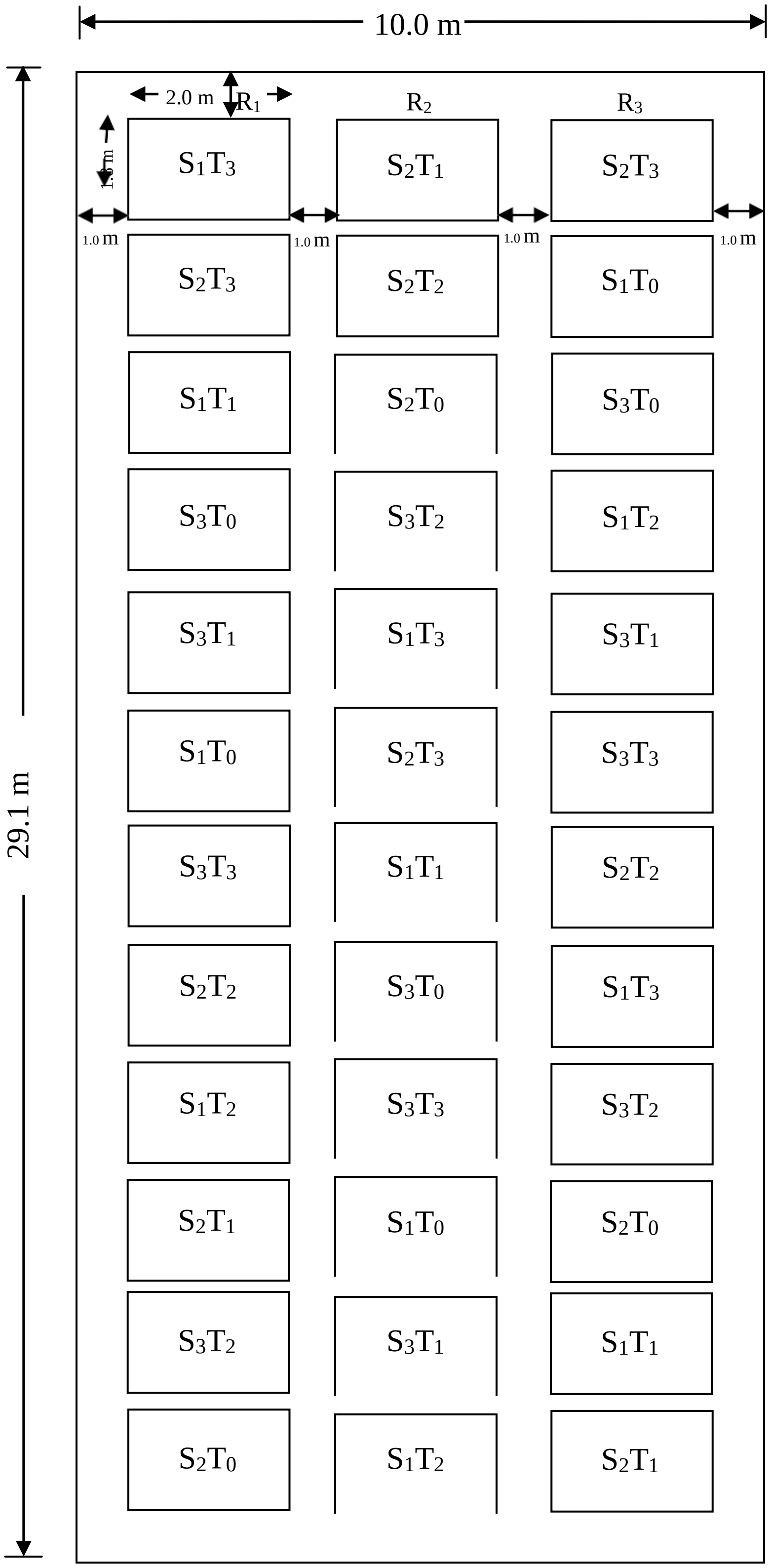
The selected plot of the experiment was opened in the 2$^{nd}$ week of November 2015 with a power tiller, and left exposed to the sun for a week. Subsequently cross ploughing was done five times with a country plough followed by laddering to make the land suitable for transplanting the seedlings. All weeds, stubbles and residues were eliminated from the field. Finally, a good tilth was achieved. The soil was treated with insecticides (Cinocarb 3G @ 4 kg/ha) at the time of final land preparation to protect young plants from the attack of soil inhibiting insects such as cutworm and mole cricket.

### 3.2.5 Application of manure and fertilizers

Manures and fertilizers were applied considering the recommended fertilizer doses of cauliflower. Boron as boric acid and molybedenum as ammonium molybdate were applied as per treatment.

**Table 1. Dose and method of application of fertilizers in cauliflower field**

| Fertilizers and Manures | Dose/ha | Amount of nutrients (kg/ha) | Sources |
|---|---|---|---|
| Cowdung | 20 tonnes | | |
| Urea | 300 kg | 138 kg N | $CO (NH_2)_2$ |
| TSP | 200 kg | 96 kg $P_2O_5$ | $Ca(H_2PO_4)2$ |
| MOP | 250 kg | 150 kg $K_2O$ | KCL |
| Boric Acid | As per treatment | 0, 1, 2 and 3 kg B | $H_3BO_3$ |
| Ammonium Molybdate | As per treatment | 0, 0.5, 1.0 and 1.5 kg Mo | $(NH_4)_2MoO_4$ |




N

W E

S

Plot size: 2.0 m × 1.8 m

Plot spacing: 0.50 m

Between block: 1.00 m

**Factor A:** Plant spacing (3 levels) as

i. $S_1$: 50 cm × 50 cm

ii. $S_2$: 50 cm × 40 cm

iii. $S_3$: 50 cm × 30 cm

**Factor B:** Levels of micronutrients (4 levels) as

i. $T_0$: $B_0Mo_0$ (control)

ii. $T_1$: $B_{1.0}Mo_{0.5}$ kg/ha

iii. $T_2$: $B_{2.0}Mo_{1.0}$ kg/ha

iv. $T_3$: $B_{3.0}Mo_{1.5}$ kg/ha

Figure 1. Layout of the experimental plot

The total amount of cowdung, TSP, boric acid and ammonium molybdate was applied as basal dose at the time of final land preparation maintaining doses as per Table 1. The total amount of urea and MoP was applied in three equal installments at 10, 30 and 50 day after transplanting (DAT).

## 3.3 Growing of crops

### 3.3.1 Collection of seeds

The seeds of cauliflower ZAC-426 ($F_1$ hybrid) were collected from Siddique Bazar market, Dhaka.

### 3.3.2 Raising the seedlings

The seedlings were raised at the Horticultural Farm, SAU, Dhaka under special care in a 3 m × 1 m size seed bed. The soil of the seed bed was well ploughed with a spade and prepared into loose friable dried masses and to obtain good tilth to provide a favorable condition for the vigorous growth of young seedlings. Weeds, stubbles and dead roots of the previous crop were removed. The seedbed was dried in the sun to destroy the soil insect and protect the young seedlings from the attack of damping off disease. To control damping off disease Cupravit fungicide were applied. Decomposed cowdung was applied to the prepared seedbed at the rate of 10 t/ha. Five (5) grams of seeds were sown in seedbed on November 01, 2015. After sowing, the seeds were covered with the finished light soil. At the end of germination shading was done by bamboo mat (chatai) over the seedbed to protect the young seedlings from scorching sunshine and heavy rainfall. Light watering, weeding was done as and when necessary to provide seedlings with ideal condition for growth.

### 3.3.3 Transplanting the seedlings

Healthy and uniform seedlings of 20 days old seedlings were transplanting in the experimental plots on 20 November, 2015. The seedlings were uploaded carefully from the seed bed to avoid damage to the root system. To minimize the damage to the roots of seedlings, the seed beds were watered one hour before uprooting the seedlings. Transplanting was done in the afternoon. The seedlings were watered immediately after transplanting. Seedlings were sown in the plot with maintaining distance as per the treatment of plant spacing. In case of $S_1$ (50 cm × 50 cm), $S_2$: (50 cm × 40 cm) and $S_3$ (50 cm × 30 cm) plant spacing total 12, 16 and 24 seedlings, respectively transplanted in each plot. The young transplanted seedlings were shaded by banana leaf sheath during day to protect them from scorching sunshine up to 7 days until they were set in the soil. Transplanted seedlings were kept open at night to allow them receiving dew. A number of seedlings were also planted in the border of the experimental plots for gap filling.

### 3.3.4 Intercultural operations

After raising seedlings, various intercultural operations such as gap filling, weeding, earthing up, irrigation pest and disease control etc. were accomplished for better growth and development of the cauliflower seedlings.

#### 3.3.4.1 Gap filling

The transplanted seedlings in the experimental plot were kept under careful observation. Very few seedlings were damaged after transplanting and such seedling were replaced by new seedlings from the same stock. Replacement was done with healthy seedling having a boll of earth which was also planted on the same date by the side of the unit plot. The transplants were given shading and watering for 7 days for their proper establishment.

#### 3.3.4.2 Weeding

The hand weeding was done 15, 30 and 45 days after transplanting to keep the plots free from weeds.

#### 3.3.4.3 Earthing up

Earthing up was done at 15 and 30 days after transplanting on both sides of rows by taking the soil from the space between the rows by a small spade.

#### 3.3.4.4 Irrigation

Light watering was given by a watering can at every morning and afternoon after transplanting. Following transplanting and it was continued for a week for rapid and well establishment of the transplanted seedlings. Beside this a routine irrigation was given at 3 days intervals.

#### 3.3.4.5 Pest and disease control

Insect infestation was a serious problem during the period of establishment of seedling in the field. In spite of Cirocarb 3G applications during final land preparation, few young plants were damaged due to attack of mole cricket and cut worm. Cut worms were controlled both mechanically and spraying Darsban 29 EC @ 3%. Some plants were infected by *Alternaria* leaf spot diseases caused by *Alternaria brassicae*. To prevent the spread of the disease Rovral @ 2 g per liter of water was sprayed in the field. The diseased leaves were also collected from the infested plant and removed from the field. Birds pest such as nightingales (common Bulbuli) were seen visiting the cauliflower field very frequently. The nightingale visited the fields in the morning and afternoon. The birds found to puncture the newly initiated curd and were controlled by striking a kerosene tin of metallic container frequently during day time.

## 3.4 Harvesting

Harvesting of the cauliflower was not possible on a certain or particular date because the curd initiation as well as curd at marketable size in different plants were not uniform. Only the marketable size curds were harvested with fleshy stalk by using as sharp knife. Before harvesting of the cauliflower curd it compactness was tested by pressing with thumbs.

## 3.5 Data collection

Five plants were randomly selected from the middle rows of each unit plot for avoiding border effect, except yields of curds, which was recorded plot wise. Data were collected in respect of the following parameters to assess plant growth; yield attributes and yields as affected by different treatments of this experiment. Data on plant height, number of leaves and length of largest leaf were collected at 30, 40, 50 and 60 days after transplanting (DAT) and at harvest. All other yield contributing characters and yield parameters were recorded during harvest and after harvest.

### 3.5.1 Plant height (cm)

Plant height was measured from five randomly selected plants by using meter scale in centimeter from the ground level to the tip of the longest leaf at 30, 40, 50, 60 DAT and at harvest and their mean value was calculated.

### 3.5.2 Number of leaves per plant

Number of leaves per plant was counted from five randomly selected plants. Data were recorded at 30, 40, 50, 60 DAT and at harvest and their mean value was calculated.

### 3.5.3 Length of longest leaf (cm)

The length of longest leaf was counted from each selected plant. Data were recorded as the average of 5 leaves selected at random of each plot at 10 days interval starting from 30 DAT and continued upto 60 DAT and it was also recorded at the time of curd harvest.

### 3.5.4 Days to curd initiation

Each plant of the experiment plot was kept under close observation to assess date of first visible curd. Total number of days from the date of transplanting to the first visible of curd was calculated and recorded.

### 3.5.5 Length of stem (cm)

The length of stem was taken from the ground level to base of the curd of plant during harvesting. A meter scale used to measure the length of stem and was expressed in centimeter (cm).

### 3.5.6 Diameter of stem (cm)

The diameter of the stem was measured at the point where the central stem was cut off. The diameter of the stem was recorded in three dimensions with scale and the average of three figures was taken into account in centimeter (cm).

### 3.5.7 Fresh weight of leaves per plant (g)

The fresh weight of leaves per plant was recorded from the average of five (5) selected plants in grams (gm) with a beam balance after harvest after detached from plant.

### 3.5.8 Length of root (cm)

The length of root was taken from the after harvest by cleaning. A meter scale used to measure the length of stem and was expressed in centimeter (cm).

### 3.5.9 Fresh weight of roots per plant (g)

The fresh weight of roots per plant was recorded from the average of five (5) selected plants in grams (gm) with a beam balance after harvest after detached from plant.

### 3.5.10 Dry matter content of leaves (%)

At first leaf of selected plant were collected, cut into pieces and was dried under sunshine for a 3 days and then dried in an oven at $70^0$C for 72 hours. The sample was then transferred into desiccators and allowed to cool down at room temperature. The final weight of the sample was taken. The dry matter contents of leaves were computed by simple calculation from the weight recorded by the following formula:

$$\text{Dry matter content of leaves (\%)} = \frac{\text{Dry weight}}{\text{Fresh weight}} \times 100$$

### 3.5.11 Dry matter content of curd (%)

At first curd of selected plant were collected, cut into pieces and was dried under sunshine for a 3 days and then dried in an oven at $70^0$C for 72 hours. The sample was then transferred into desiccators and allowed to cool down at room temperature. The final weight of the sample was taken. The dry matter contents of curd were computed by simple calculation from the weight recorded by the following formula:

$$\text{Dry matter content of curd (\%)} = \frac{\text{Dry weight}}{\text{Fresh weight}} \times 100$$

### 3.5.12 Diameter of curd (cm)

The curds from sample plants were sectioned vertically at the middle position with a sharp knife. The diameter of the curd was measured in centimeter (cm) with a meter scale as the horizontal distance from one side to another side of the widest part of the sectioned curd and mean value was recorded.

### 3.5.13 Curd yield per plant (kg)

Curd yield per plant was recorded by multiplying average curd yield per plant with total number of plant within a plot and was expressed in kilogram and recorded plot wise

### 3.5.14 Curd yield per plot (kg)

Curd yield per plot was recorded by multiplying average curd yield per plant with total number of plant within a plot and was expressed in kilogram and recorded plot wise

### 3.5.15 Curd yield per hectare (ton)

The curd yield per hectare was calculated by converted total curd yield per plot into yield per hectare and was expressed in ton.

## 3.6 Statistical analysis

The data obtained for different characters were statistically analyzed to find out the significance of the difference for different plant spacing and levels of boron and molybdenum on the growth and yield of cauliflower. The mean values of all the recorded yield contributing characters and yield were estimated and analysis of variance of theses parameter was performed by the ‘F’ (variance ratio) test using MSTAT-C software. The significance of the difference among the treatment combinations of means was estimated by Duncan’s Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

### 3.7 Economic analysis

The cost of production was analyzed in order to find out the most economic combination of different plant spacing and levels of boron and molybdenum. All input cost included the cost for lease of land and interests on running capital in computing the cost of production. The interests were calculated @ 12% in simple rate. The market price of cauliflower was considered for estimating the cost and return. Analyses were done according to the procedure of Alam *et al*. (1989). The benefit cost ratio (BCR) was calculated as follows:

$$\text{Benefit cost ratio (BCR)} = \frac{\text{Gross return per hectare (Tk.)}}{\text{Total cost of production per hectare (Tk.)}}$$

# CHAPTER IV

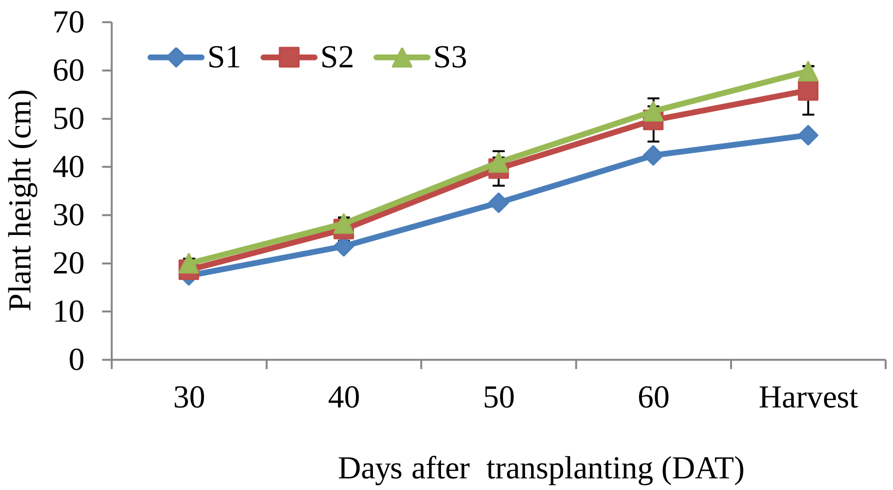
# RESULTS AND DISCUSSION

The experiment was carried out to find out the effect of plant spacing and micronutrients on the growth and yield of cauliflower. The analysis of variance (ANOVA) of the data on different growth and yield parameters are presented in Appendices III-VII. The results have been presented with the help of table and graphs and possible interpretations given under the following headings:

## 4.1 Plant height

Plant height of cauliflower showed significant influence due to different plant spacing at 30, 40, 50, 60 DAT and at harvest (Appendix III). The maximum plant height (59.84 cm) was observed from $S_3$ (50 cm × 30 cm) treatment at harvest which was statistically similar (55.87 cm) to $S_2$ (50 cm × 40 cm) treatment, while the shortest plant (46.56 cm) was found from $S_1$ (50 cm × 50 cm) treatment at the same growth stage (Figure 2). The variation in plant height as influenced by spacing was perhaps due to proper utilization of nutrient, moisture and light. Rahman *et al*. (2007) reported the maximum plant height (49.33 cm) where the plants were spaced 45 cm apart.

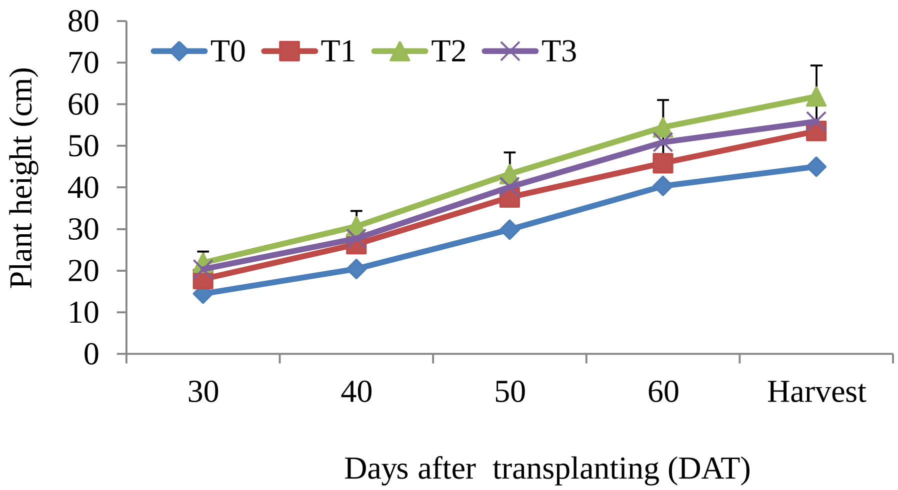
During growing period plant height gradually increased with time and reached to the maximum at harvest. Plant height was significantly influenced by micronutrients at 30, 40, 50, 60 DAT and at harvest (Appendix III). At harvest time, the tallest plant (61.89 cm) was found from $T_2$ ($B_{2.0}Mo_{1.0}$ kg/ha) treatment which was followed (55.89 cm and 53.57 cm) by $T_3$ ($B_{3.0}Mo_{1.5}$ kg/ha) and $T_1$ ($B_{1.0}Mo_{0.5}$ kg/ha) treatment and they were statistically similar, whereas the shortest plant (45.00 cm) was recorded from $T_0$ ($B_0Mo_0$ i.e. control) treatment (Figure 3). The results indicate that the increasing rate of micronutrients significantly increase the plant height. It may be that the applied micronutrients combindely influenced the absorption of plant nutrients and provided better growing conditions, which lead to the proper vegetative growth of plants resulting maximum plant height. Thakur *et al.* (1991) reported that application of boron increased the plant height of cauliflower.




$S_1$: 50 cm × 50 cm $S_2$: 50 cm × 40 cm

$S_3$: 50 cm × 30 cm

Figure 2. Effect of different plant spacing on plant height of cauliflower. Vertical bars represent LSD value at 5% level of probability




$T_0$: $B_0Mo_0$ kg/ha $T_1$: $B_{1.0}Mo_{0.5}$ kg/ha

$T_2$: $B_{2.0}Mo_{1.0}$ kg/ha $T_3$: $B_{3.0}Mo_{1.5}$ kg/ha

Figure 3. Effect of micronutrients on plant height of cauliflower. Vertical bars represent LSD value at 5% level of probability

Combined effect of different plant spacing and micronutrients showed statistically significant variation on plant height of cauliflower at 30, 40, 50, 60 DAT and at harvest (Appendix III). The maximum plant height (69.23 cm) was recorded from $S_1T_2$ (50 cm × 50 cm plant spacing with $B_{2.0}Mo_{1.0}$ kg/ha) treatment at harvest which was statistically similar (66.73 cm) to $S_2T_2$ (50 cm × 40 cm plant spacing with $B_{2.0}Mo_{1.0}$ kg/ha), while the shortest plant (36.43 cm) was observed from $S_1T_0$ (50 cm × 50 cm plant spacing with $B_0Mo_0$ kg/ha) treatment (Table 2).

### 4.2 Number of leaves per plant

The number of leaves per plant of cauliflower was found to be significantly influenced by the different plant spacing at 30, 40, 50, 60 DAT and at harvest (Appendix IV). An increasing trend in number of leaves per plant was found up to harvest for all treatments. The highest number of leaves per plant (18.00) was recorded from $S_2$ treatment at harvest time which was statistically similar (17.67) to $S_1$ treatment, whereas the lowest number of leaves per plant (16.53) was found from $S_3$ (Figure 4) treatment at the same growth stage of plant. It was observed that the number of leaves was higher in plants with wider spacing and lower in closely plants. It is probably, due to reduce inter plant competition for access to nutrients, moisture and other resources. Similar trend was obtained by Kannan *et al*. (2016).

The number of leaves per plant was found to be significantly influenced by the application of micronutrients at 30, 40, 50, 60 DAT and at harvest (Appendix IV). At harvest, the highest number of leaves per plant (19.27) was recorded from $T_2$ treatment which was followed (18.62 and 17.71) by $T_3$ and $T_1$ treatment and they were statistically similar, while the lowest number of leaves per plant (14.00) was found from $T_0$ (Figure 5). From the results of the present study indicated that optimum levels of micronutrients might have influence better growing condition perhaps due to supply of adequate plant nutrients which ultimately produced more No. of leaves of cauliflower plant. Thakur *et al.* (1991) also obtained that application of boron increased the number of leaves per plant of cauliflower.

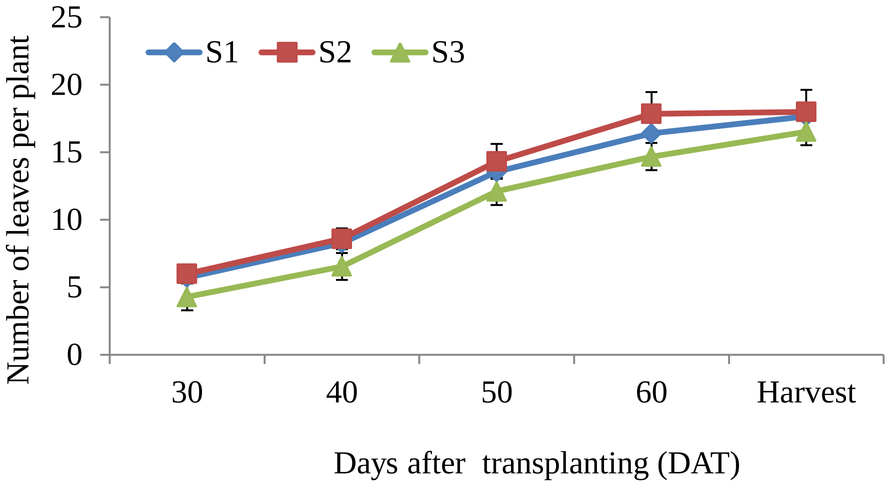
**Table 2. Combined effect of different plant spacing and micronutrients on plant height at different days after transplanting (DAT) and harvest of cauliflower**

| Treatments | Plant height (cm) at | | | | |
|---|---|---|---|---|---|
| | **30 DAT** | **40 DAT** | **50 DAT** | **60 DAT** | **Harvest** |
| $S_1T_0$ | 15.24 g | 19.25 h | 23.46 i | 31.57 g | 36.43 g |
| $S_1T_1$ | 18.19 ef | 22.80 fg | 27.59 h | 35.95 fg | 39.02 fg |
| $S_1T_2$ | 27.42 a | 34.81 a | 46.26 a | 57.80 a | 69.23 a |
| $S_1T_3$ | 21.01 de | 25.30 ef | 32.93 fg | 44.18 de | 41.56 f |
| $S_2T_0$ | 16.57 fg | 21.37 gh | 30.69 gh | 39.12 ef | 42.70 f |
| $S_2T_1$ | 20.80 de | 29.65 bcd | 40.22 cd | 49.81 c | 58.28 cde |
| $S_2T_2$ | 26.02 ab | 34.45 ab | 45.25 ab | 56.14 ab | 66.73 ab |
| $S_2T_3$ | 23.17 bcd | 30.94 bc | 42.51 bc | 53.91 abc | 59.38 cd |
| $S_3T_0$ | 20.62 de | 26.64 de | 35.43 ef | 50.38 bc | 55.88 de |
| $S_3T_1$ | 24.08 bc | 32.68 ab | 45.06ab | 51.85 bc | 63.42 bc |
| $S_3T_2$ | 21.34 cd | 28.82 cd | 38.22de | 49.45 cd | 53.32 e |
| $S_3T_3$ | 25.88 ab | 32.91 ab | 44.95 ab | 54.56 abc | 63.12 bc |
| **$LSD_{(0.05)}$** | **2.735** | **3.193** | **3.286** | **5.279** | **4.825** |
| **Level of significance** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** |
| **CV(%)** | **8.64** | **7.17** | **5.15** | **6.51** | **5.27** |

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

$S_1$: 50 cm × 50 cm
$S_2$: 50 cm × 40 cm
$S_3$: 50 cm × 30 cm

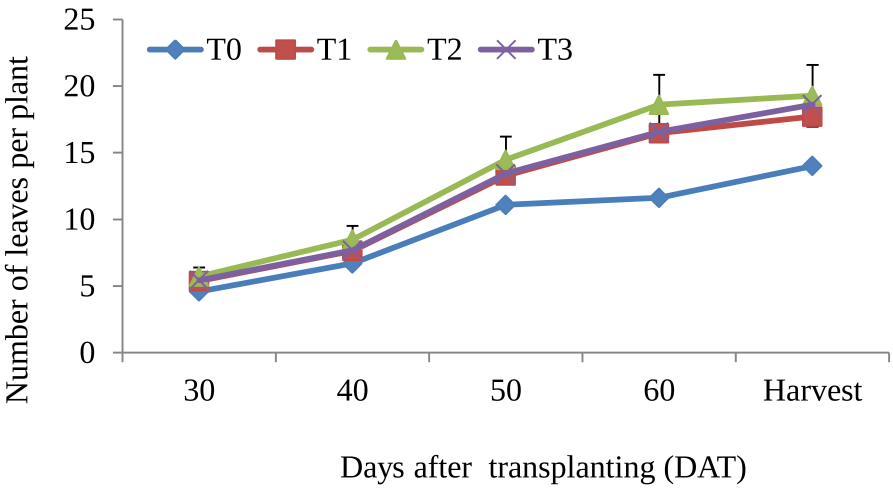
$T_0$: $B_0Mo_0$ kg/ha
$T_1$: $B_{1.0}Mo_{0.5}$ kg/ha
$T_2$: $B_{2.0}Mo_{1.0}$ kg/ha
$T_3$: $B_{3.0}Mo_{1.5}$ kg/ha




$S_1$: 50 cm × 50 cm  $S_2$: 50 cm × 40 cm

$S_3$: 50 cm × 30 cm

Figure 4. Effect of different plant spacing on number of leaves per plant of cauliflower. Vertical bars represent LSD value at 5% level of probability




$T_0$: $B_0Mo_0$ kg/ha  $T_1$: $B_{1.0}Mo_{0.5}$ kg/ha

$T_2$: $B_{2.0}Mo_{1.0}$ kg/ha  $T_3$: $B_{3.0}Mo_{1.5}$ kg/ha

Figure 5. Effect micronutrients on number of leaves per plant of cauliflower. Vertical bars represent LSD value at 5% level of probability

Combined effect of different plant spacing and micronutrients showed statistically significant variation on number of leaves per plant of cauliflower at 30, 40, 50, 60 DAT and at harvest (Appendix IV). At harvest, the highest number of leaves per plant (20.27) was recorded from $S_2T_2$ treatment which was statistically similar (19.93) to $S_1T_2$ treatment, whereas the lowest number of leaves per plant (13.53) was found from $S_1T_0$ treatment combination (Table 3).

### 4.3 Length of largest leaf

Different plant spacing significantly influenced length of largest leaf of cauliflower at 30, 40, 50, 60 DAT and at harvest (Appendix V). At harvest, the maximum leaf length (45.36 cm) was recorded from $S_1$ treatment in all stages of plant growth which was statistically similar (42.75 cm) to $S_2$ and the shortest leaf (37.47 cm) was found from $S_3$ (Figure 6) treatment at harvest time. It was revealed that with the increases of spacing length of leaf showed increasing trend. In case of closer spacing plant compete for light and other macro and micro nutrients than closer spacing which greatly effect plant growth that produced comparatively shorter leaf than wider spacing.

The leaf length of per plant was significantly influenced with treatments of micronutrients at 30, 40, 50, 60 DAT and at harvest (Appendix V). At harvest, the maximum length of leaf (47.57 cm) was found from $T_2$ treatment which was statistically similar (44.85 cm) to $T_3$ treatment and closely followed (41.93 cm) by $T_1$ treatment, while the shortest leaf (32.10 cm) was observed from $T_0$ (Figure 7) treatment. The longer leaf per plant was obtained from $T_2$ treatment due to vigours vegetative growth of plant. These result indicated that and Mo micronutrients combindly used which supplied balanced plant nutrients which helped proper vegetative growth as well as maximum length of leaf. Plants require B a number of growth process such as new development in meristamatic tissue, translocation of sugars, nitrate, phosphorus and synthesis of amino acids and protein (Tisdale *et al*., 1984).

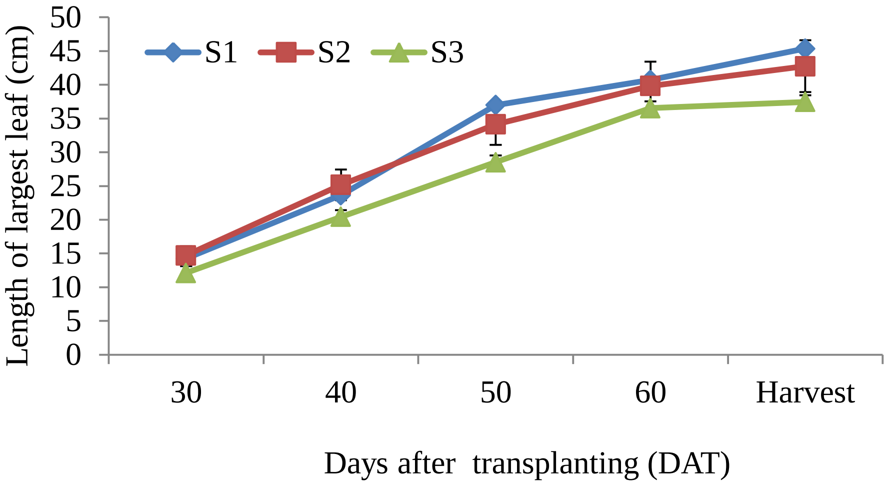
**Table 3. Combined effect of different plant spacing and micronutrients on number of leaves per plant at different days after transplanting (DAT) and harvest of cauliflower**

| Treatments | Number of leaves per plant at | | | | |
|---|---|---|---|---|---|
| | **30 DAT** | **40 DAT** | **50 DAT** | **60 DAT** | **Harvest** |
| $S_1T_0$ | 3.67 d | 6.13 d | 10.53 g | 10.93 g | 13.53 e |
| $S_1T_1$ | 6.00 ab | 9.30 ab | 14.73 bc | 18.13 bc | 19.20 ab |
| $S_1T_2$ | 6.60 ab | 9.53 a | 15.27 ab | 19.93 ab | 19.93 a |
| $S_1T_3$ | 5.87 b | 8.00 c | 13.67 cd | 16.60 cde | 18.00 c |
| $S_2T_0$ | 4.80 c | 6.93 d | 11.53 fg | 12.33 fg | 14.20 e |
| $S_2T_1$ | 6.20 ab | 9.30 b | 15.13 b | 19.80 b | 19.27 b |
| $S_2T_2$ | 6.87 a | 9.80 a | 16.13 a | 21.40 a | 20.27 a |
| $S_2T_3$ | 6.13 ab | 8.33 bc | 14.47 bc | 17.87 bc | 18.27 bc |
| $S_3T_0$ | 4.60 c | 6.87 d | 11.20 fg | 11.60 g | 14.27 e |
| $S_3T_1$ | 4.53 cd | 6.57 d | 13.00 de | 17.47 bcd | 17.40 cd |
| $S_3T_2$ | 4.40 cd | 6.27 d | 12.00 ef | 14.47 ef | 17.60 cd |
| $S_3T_3$ | 4.33 cd | 6.60 d | 12.20 ef | 15.20 de | 16.87 d |
| **$LSD_{(0.05)}$** | **0.799** | **1.015** | **1.069** | **2.453** | **0.994** |
| **Level of significance** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** |
| **CV(%)** | **9.57** | **8.09** | **5.13** | **9.46** | **6.58** |

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

$S_1$: 50 cm × 50 cm
$S_2$: 50 cm × 40 cm
$S_3$: 50 cm × 30 cm

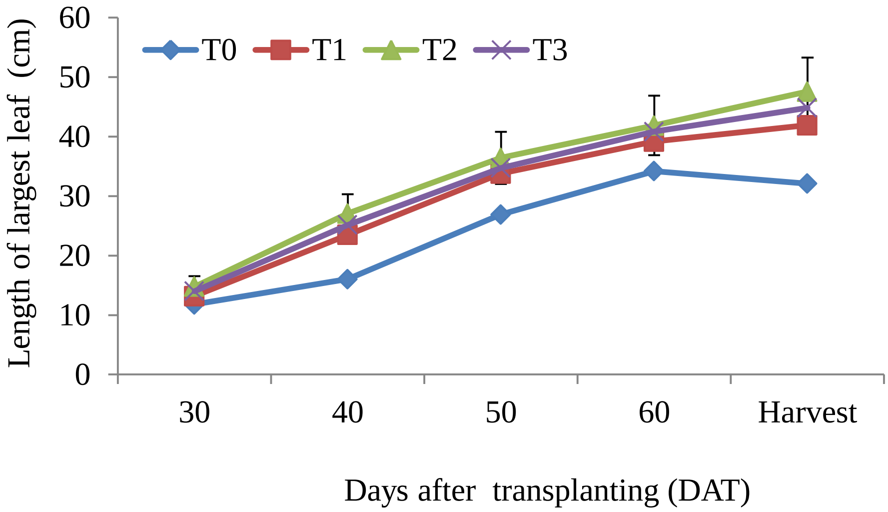
$T_0$: $B_0Mo_0$ kg/ha
$T_1$: $B_{1.0}Mo_{0.5}$ kg/ha
$T_2$: $B_{2.0}Mo_{1.0}$ kg/ha
$T_3$: $B_{3.0}Mo_{1.5}$ kg/ha




$S_1$: 50 cm × 50 cm  $S_2$: 50 cm × 40 cm

$S_3$: 50 cm × 30 cm

Figure 6. Effect of different plant spacing on length of largest leaf of cauliflower. Vertical bars represent LSD value at 5% level of probability




$T_0$: $B_0Mo_0$ kg/ha  $T_1$: $B_{1.0}Mo_{0.5}$ kg/ha

$T_2$: $B_{2.0}Mo_{1.0}$ kg/ha  $T_3$: $B_{3.0}Mo_{1.5}$ kg/ha

Figure 7. Effect of micronutrients on length of largest leaf of cauliflower. Vertical bars represent LSD value at 5% level of probability

Combined effect of different plant spacing and micronutrients showed statistically significant variation on length of largest leaf of cauliflower at 30, 40, 50, 60 DAT and at harvest (Appendix V). At harvest, the longest largest leaf (54.21 cm) was recorded from $S_2T_2$ treatment which was statistically similar (51.39 cm) to $S_1T_2$ treatment and the shortest leaf (33.31 cm) was found from $S_1T_0$ treatment combination (Table 4).

### 4.4 Days to curd initiation

Days to curd initiation of cauliflower showed significant differences due to different plant spacing (Appendix VI). The maximum days to curd initiation (57.50) was observed from $S_1$ treatment which was closely followed (53.75) by $S_2$ treatment, while the minimum days to curd initiation (49.42) was found from $S_3$ treatment (Table 5). The maximum days required for curd initiation in wider spacing might be attributed due to the less interplant competition, which resulted in better vegetative growth of plants. Similar result was observed by Kannan *et al*. (2016) that the highest days to curd formation (99.79 days) from plant spaced 60 × 50 cm.

Statistically significant variation was recorded for micronutrients in terms of days to curd initiation of cauliflower (Appendix VI). The maximum days to curd initiation (59.22) was found from $T_0$ treatment which was closely followed (53.89 and 53.78) by $T_3$ and $T_1$ treatment and they were statistically similar, whereas the minimum days to curd initiation (48.00) was recorded from $T_2$ treatment (Table 6).

Combined effect of different plant spacing and micronutrients combination showed statistically significant variation on days to curd initiation of cauliflower (Appendix VI). The maximum days to curd initiation (65.33) was recorded from $S_1T_0$ which was statistically similar (62.00 and 61.67) to $S_1T_3$ and $S_1T_1$, while the minimum days to curd initiation (41.00) was found from $S_1T_2$ treatment combination (Table 7). It was observed that the curd initiation period required in plants decreased with the increasing levels of micronutrients application, while

**Table 4. Combined effect of different plant spacing and micronutrients on length of largest leaf at different days after transplanting (DAT) and harvest of cauliflower**

| Treatments | Length of largest leaf (cm) at | | | | |
|---|---|---|---|---|---|
| | **30 DAT** | **40 DAT** | **50 DAT** | **60 DAT** | **Harvest** |
| $S_1T_0$ | 11.36 c | 14.88 g | 24.67 d | 32.90 e | 33.31 e |
| $S_1T_1$ | 14.41 b | 24.26 cde | 34.40 bc | 39.97 bc | 42.25 c |
| $S_1T_2$ | 16.04 ab | 29.47 ab | 39.33 ab | 43.97 a | 51.39 ab |
| $S_1T_3$ | 15.20 ab | 25.96 bc | 38.20 ab | 42.50 ab | 46.08 c |
| $S_2T_0$ | 12.18 c | 17.22 fg | 28.27 d | 34.80 de | 33.98 de |
| $S_2T_1$ | 15.06 ab | 25.80 bc | 37.67 ab | 40.67 b | 45.55 c |
| $S_2T_2$ | 16.63 a | 30.91 a | 42.27 a | 44.73 a | 54.21 a |
| $S_2T_3$ | 15.03 ab | 26.79 bc | 39.73 ab | 42.67 ab | 47.71 bc |
| $S_3T_0$ | 11.87 c | 16.03 g | 27.80 d | 34.90 de | 32.01 de |
| $S_3T_1$ | 12.57 c | 20.37 ef | 29.33 cd | 36.93 cd | 37.00 d |
| $S_3T_2$ | 11.66 c | 20.80 def | 27.67 d | 36.93 cd | 37.12 d |
| $S_3T_3$ | 12.38 c | 24.54 cd | 29.27 cd | 37.37 cd | 43.76 c |
| **$LSD_{(0.05)}$** | **1.530** | **3.828** | **5.591** | **3.014** | **5.016** |
| **Level of significance** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** |
| **CV(%)** | **7.12** | **10.72** | **10.58** | **4.45** | **7.25** |

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

$S_1$: 50 cm × 50 cm
$S_2$: 50 cm × 40 cm
$S_3$: 50 cm × 30 cm

$T_0$: $B_0Mo_0$ kg/ha
$T_1$: $B_{1.0}Mo_{0.5}$ kg/ha
$T_2$: $B_{2.0}Mo_{1.0}$ kg/ha
$T_3$: $B_{3.0}Mo_{1.5}$ kg/ha

**Table 5. Effect of different plant spacing on yield attributes of cauliflower**

| Treatments | Days to curd initiation | Diameter of stem (cm) | Fresh weight of leaves per plant (g) | Length of root (cm) | Fresh weight of roots per plant (g) |
|---|---|---|---|---|---|
| $S_1$ | 57.50 a | 2.80 a | 238.88 a | 22.99 a | 25.14 a |
| $S_2$ | 53.75 b | 2.76 ab | 234.15 a | 23.82 a | 24.72 a |
| $S_3$ | 49.42 c | 2.27 b | 205.76 b | 20.77 b | 21.05 b |
| **$LSD_{(0.05)}$** | **3.812** | **0.241** | **14.12** | **1.379** | **1.477** |
| **Level of significance** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** |
| **CV(%)** | **8.16** | **7.86** | **7.64** | **6.93** | **8.07** |

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

$S_1$: 50 cm × 50 cm    $S_2$: 50 cm × 40 cm

$S_3$: 50 cm × 30 cm

**Table 6. Effect of micronutrients on yield attributes of cauliflower**

| Treatments | Days to curd initiation | Diameter of stem (cm) | Fresh weight of leaves per plant (g) | Length of root (cm) | Fresh weight of roots per plant (g) |
|---|---|---|---|---|---|
| $T_0$ | 59.22 a | 2.07 c | 185.97 c | 19.47 c | 21.38 b |
| $T_1$ | 53.78 b | 2.43 b | 222.01 b | 22.62 b | 23.35 a |
| $T_2$ | 48.00 c | 3.07 a | 254.23 a | 24.32 a | 25.03 a |
| $T_3$ | 53.89 b | 2.87 ab | 234.84 ab | 23.68 ab | 24.80 a |
| **$LSD_{(0.05)}$** | **4.402** | **0.276** | **16.30** | **1.594** | **1.706** |
| **Level of significance** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** |
| **CV(%)** | **8.16** | **7.86** | **7.64** | **6.93** | **8.07** |

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

$T_0$: $B_0Mo_0$ kg/ha    $T_1$: $B_{1.0}Mo_{0.5}$ kg/ha

$T_2$: $B_{2.0}Mo_{1.0}$ kg/ha    $T_3$: $B_{3.0}Mo_{1.5}$ kg/ha

**Table 7. Combined effect of different plant spacing and micronutrients on yield attributes of cauliflower**

| Treatments | Days to curd initiation | Diameter of stem (cm) | Fresh weight of leaves per plant (g) | Length of root (cm) | Fresh weight of roots per plant (g) |
|---|---|---|---|---|---|
| $S_1T_0$ | 65.33 a | 1.57 f | 179.21 e | 18.42 e | 20.33 d |
| $S_1T_1$ | 61.67 ab | 1.97 ef | 232.79 bc | 24.46 abc | 25.69 ab |
| $S_1T_2$ | 41.00 f | 2.87 abc | 281.10 a | 26.85 a | 27.38 a |
| $S_1T_3$ | 62.00 ab | 2.67 bcd | 262.43 ab | 22.22 cd | 27.17 a |
| $S_2T_0$ | 53.67 bcde | 2.20 de | 188.54 de | 20.50 de | 22.14 cd |
| $S_2T_1$ | 55.33 bcd | 2.63 bcd | 236.18 bc | 23.53 bc | 23.85 bc |
| $S_2T_2$ | 47.67 def | 3.23 a | 263.60 ab | 26.55 ab | 26.63 ab |
| $S_2T_3$ | 54.33 bcde | 3.13 ab | 248.30 bc | 24.68 abc | 26.27 ab |
| $S_3T_0$ | 46.00 ef | 2.43 cde | 190.18 de | 19.49 de | 21.66 cd |
| $S_3T_1$ | 50.33 cde | 2.70 abcd | 197.07 de | 19.86 de | 20.51 d |
| $S_3T_2$ | 55.33 bcd | 3.10 ab | 218.00 cd | 19.57 de | 21.08 cd |
| $S_3T_3$ | 58.00 abc | 2.80 abc | 217.80 cd | 24.15 bc | 20.95 cd |
| **$LSD_{(0.05)}$** | **7.625** | **0.478** | **28.24** | **2.758** | **2.956** |
| **Level of significance** | **0.01** | **0.05** | **0.05** | **0.01** | **0.01** |
| **CV(%)** | **8.16** | **7.86** | **7.64** | **6.93** | **8.07** |

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

$S_1$: 50 cm × 50 cm
$S_2$: 50 cm × 40 cm
$S_3$: 50 cm × 30 cm

$T_0$: $B_0Mo_0$ kg/ha
$T_1$: $B_{1.0}Mo_{0.5}$ kg/ha
$T_2$: $B_{2.0}Mo_{1.0}$ kg/ha
$T_3$: $B_{3.0}Mo_{1.5}$ kg/ha

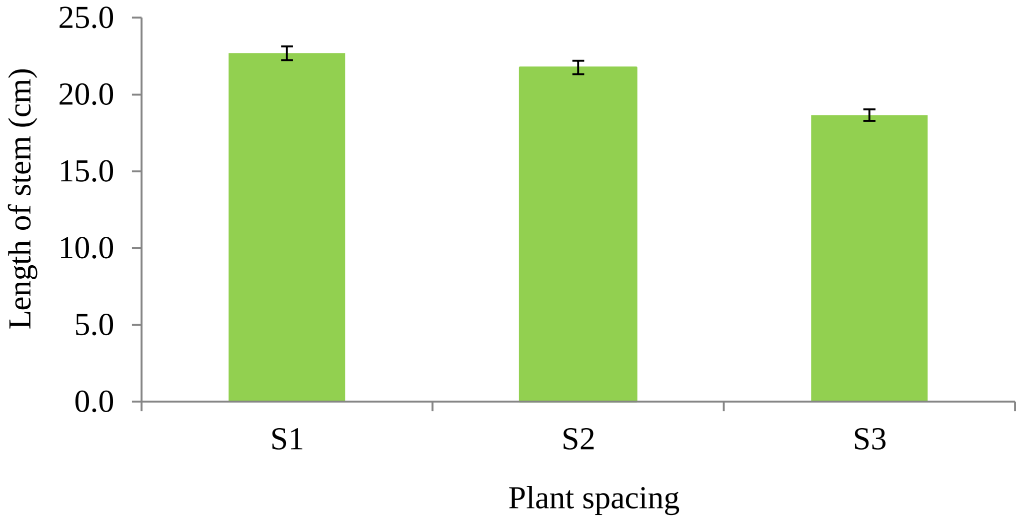
the period was maximum when micronutrients were not applied. This might be due to the positive role played by the regulating micronutrients in balanced absorption of nutrients might improve physiological activities, which resulted the endogenous growth hormone synthesis responsible for early curd formation in plants. The present result is in agreement with the findings of (Rouf, 2006) who reported that maximum days required to curd initiation of cauliflower in the control plot and minimum days was observed in plant which receiving Boron (3 kg/ha) and molybdenum (1.5 kg/ha).

### 4.5 Length of stem

Length of stem of cauliflower showed significant differences due to different plant spacing (Appendix VI). The longest stem (22.69 cm) was recorded from $S_1$ treatment which was statistically similar (21.76 cm) to $S_2$ treatment, whereas the shortest stem (18.66 cm) was observed in $S_3$ treatment (Figure 8).

Statistically significant variation was recorded for micronutrients in terms of length of stem of cauliflower (Appendix VI). The longest stem (24.21 cm) was found from $T_2$ treatment which was statistically similar (22.73 cm) to $T_3$ treatment and closely followed (21.83 cm) by $T_1$ treatment and the shortest stem (14.39 cm) was found from $T_0$ treatment (Figure 9). Plants from wider spacing reclined more nutrients, water, light and other resources and produced more vegetative growth with maximum length of stem.

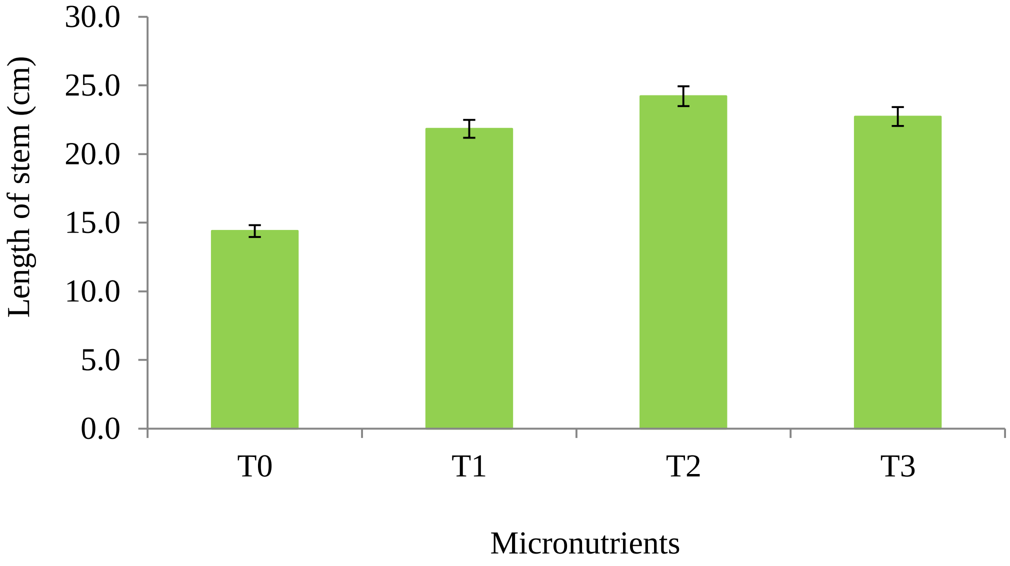
Combined effect of different plant spacing and micronutrients showed significant variation on length of stem of cauliflower (Appendix VI). The longest stem (27.82 cm) was recorded from $S_2T_2$ which was statistically similar (26.56 cm, 25.42 cm, 24.56 cm and 24.41 cm) to $S_1T_2$, $S_2T_1$, $S_2T_3$ and $S_1T_3$, while the shortest stem (12.80 cm) from $S_1T_0$ treatment combination (Figure 10).




$S_1$: 50 cm × 50 cm $S_2$: 50 cm × 40 cm

$S_3$: 50 cm × 30 cm

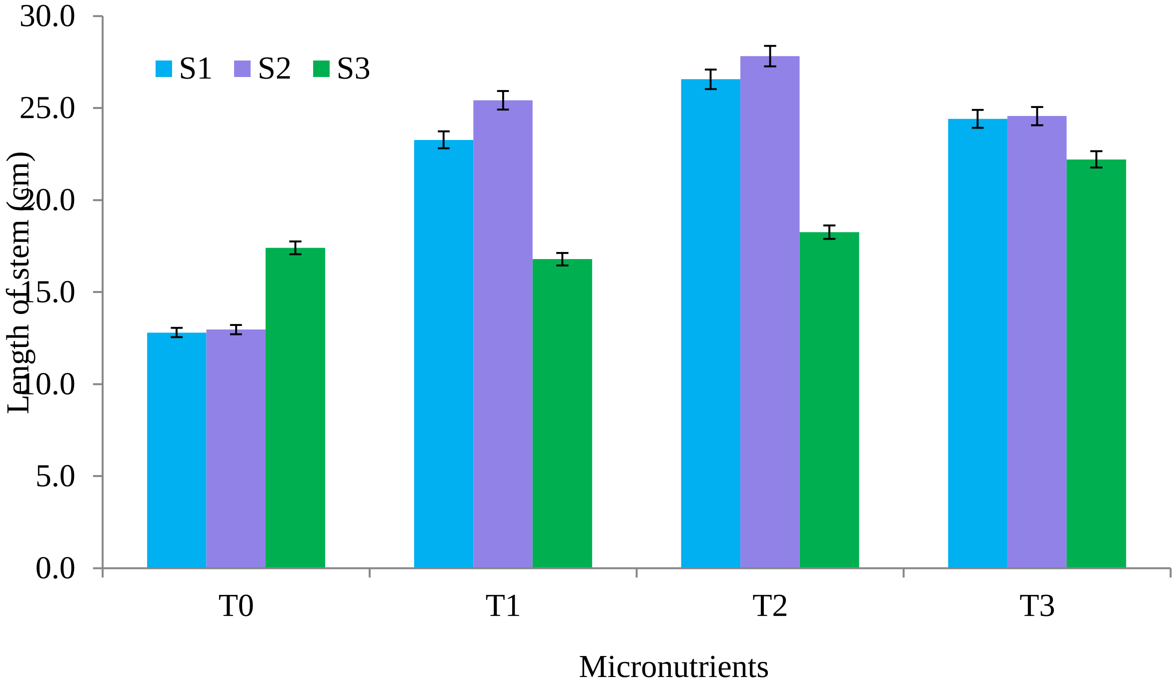
Figure 8. Effect of different plant spacing on length of stem of cauliflower. Vertical bars represent LSD value at 5% level of probability




$T_0$: $B_0Mo_0$ kg/ha $T_1$: $B_{1.0}Mo_{0.5}$ kg/ha

$T_2$: $B_{2.0}Mo_{1.0}$ kg/ha $T_3$: $B_{3.0}Mo_{1.5}$ kg/ha

Figure 9. Effect of micronutrients on length of stem of cauliflower ertical bars represent LSD value at 5% level of probability




$S_1$: 50 cm × 50 cm
$S_2$: 50 cm × 40 cm
$S_3$: 50 cm × 30 cm

$T_0$: $B_0Mo_0$ kg/ha
$T_1$: $B_{1.0}Mo_{0.5}$ kg/ha
$T_2$: $B_{2.0}Mo_{1.0}$ kg/ha
$T_3$: $B_{3.0}Mo_{1.5}$ kg/ha

Figure 10. Combined effect of differnt plant spacing and micronutrients on length of stem of cauliflower. Vertical bars represent LSD value at 5% level of probability

### 4.6 Diameter of stem

Diameter of stem of cauliflower showed significantly significant differences due to different plant spacing (Appendix VI). The highest diameter of stem (2.80 cm) was observed from $S_1$ treatment which was statistically similar (2.76 cm) to $S_2$ treatment and the lowest diameter of stem (2.27 cm) was found from $S_3$ treatment (Table 5).

Significant variation was recorded for micronutrients in terms of diameter of stem of cauliflower (Appendix VI). The highest diameter of stem (3.07 cm) was found from $T_2$ treatment which was statistically similar (2.87 cm) to $T_3$ treatment and closely followed (2.43 cm) by $T_1$ treatment, while the lowest diameter (2.07 cm) was from $T_0$ treatment (Table 6).

Combined effect of different plant spacing and micronutrients showed statistically significant variation on diameter of stem of cauliflower (Appendix VI). The highest diameter of stem (3.23 cm) was recorded from $S_2T_2$ which was statistically similar (3.13 cm, 3.10 cm, 2.87 cm, 2.80 cm and 2.70 cm) to $S_2T_3$, $S_3T_2$, $S_1T_2$, $S_3T_3$ and $S_3T_1$, whereas the lowest diameter of stem (1.57 cm) was observed from $S_1T_0$ treatment combination (Table 7).

### 4.7 Fresh weight of leaves per plant

Fresh weight of leaves per plant of cauliflower showed significantly significant differences due to different plant spacing (Appendix VI). The highest fresh weight of leaves per plant (238.88 g) was observed from $S_1$ treatment which was statistically similar (234.15 g) to $S_2$ treatment, while the lowest fresh weight of leaves per plant (205.76 g) was found from $S_3$ treatment (Table 5). Wider spacing resulted in increase number and size of leaves, which contributed maximum fresh weight of leaves per plant.

Statistically significant variation was recorded for micronutrients in terms of fresh weight of leaves per plant of cauliflower (Appendix VI). The highest fresh weight of leaves per plant (254.23 g) was found from $T_2$ treatment which was statistically similar (234.84 g) to $T_3$ treatment and closely followed (222.01 g) by $T_1$ treatment, whereas the lowest fresh weight of leaves per plant (185.97 g) was found from $T_0$ treatment (Table 6). Fresh weight of leaves per plant is important yield contributing factor in this vegetable crop. The optimum micronutrients might have regulate some important physiological process, which occurs influenced better vegetative performance of the crop and ultimately produced more leaf fresh weight.

Combined effect of different plant spacing and micronutrients showed statistically significant variation on fresh weight of leaves per plant of cauliflower (Appendix VI). The highest fresh weight of leaves per plant (281.10 g) was recorded from $S_1T_2$ which was statistically similar (263.60 g and 262.43 g) to $S_2T_2$ and $S_1T_3$, while the lowest fresh weight of leaves per plant (179.21 g) was observed from $S_1T_0$ treatment combination (Table 7).

**4.8 Length of root**

Length of root of cauliflower showed significantly significant differences due to different plant spacing (Appendix VI). The longest root (23.82 cm) was observed from $S_2$ treatment which was statistically similar (22.99 cm) to $S_1$ treatment, while the shortest root (20.77 cm) from $S_3$ treatment (Table 5).

Statistically significant variation was recorded for micronutrients in terms of length of root of cauliflower (Appendix VI). The longest root (24.32 cm) was found from $T_2$ treatment which was statistically similar (23.68 cm) to $T_3$ treatment and closely followed (22.62 cm) by $T_1$ treatment, whereas the shortest root (19.47 cm) was recorded from $T_0$ treatment (Table 6).

Combined effect of different plant spacing and micronutrients showed statistically significant variation on length of root of cauliflower (Appendix VI). The longest root (26.85 cm) was recorded from $S_1T_2$ which was statistically similar (26.55 cm, 24.68 cm and 24.46 cm) to $S_2T_2$, $S_2T_3$ and $S_1T_1$, while the shortest root (18.42 cm) was found from $S_1T_0$ treatment combination (Table 7).

### 4.9 Fresh weight of roots per plant

Fresh weight of roots per plant of cauliflower showed significant variation due to different plant spacing (Appendix VI). The highest fresh weight of roots per plant (25.14 g) was observed from $S_1$ treatment which was statistically similar (24.72 g) to $S_2$ treatment, whereas the lowest fresh weight of roots per plant (21.05 g) was found from $S_3$ treatment (Table 5).

Statistically significant variation was recorded for micronutrients in terms of fresh weight of roots per plant of cauliflower (Appendix VI). The highest fresh weight of roots per plant (25.03 g) was found from $T_2$ treatment which was statistically similar (24.80 g and 23.35 g) to $T_3$ and $T_1$ treatment, while the lowest fresh weight of roots per plant (21.38 g) was recorded from $T_0$ treatment (Table 6).

Combined effect of different plant spacing and micronutrients showed statistically significant variation on fresh weight of roots per plant of cauliflower (Appendix VI). The highest fresh weight of roots per plant (27.38 g) was recorded from $S_1T_2$ treatment combination which was statistically similar (27.17 g, 26.63 g, 26.27 g and 25.69 g) to $S_1T_3$, $S_2T_2$, $S_2T_3$ and $S_1T_1$, whereas the lowest fresh weight of roots per plant (20.33 g) was observed from $S_1T_0$ treatment combination (Table 7).

### 4.10 Dry matter content of leaves

Dry matter content of leaves of cauliflower showed significant differences due to different plant spacing (Appendix VII). The highest dry matter content of leaves (12.57 %) was observed from $S_2$ treatment which was statistically similar (12.24%) to $S_1$ treatment, while the lowest dry matter content of leaves (11.90 %) was found from $S_3$ treatment (Table 8).

**Table 8. Effect of different plant spacing on yield attributes and yield of cauliflower**

| Treatments | Dry matter content of leaves (%) | Dry matter content of curd (%) | Diameter of curd (cm) | Curd yield per plant (kg) | Curd yield per hectare (ton) |
|---|---|---|---|---|---|
| $S_1$ | 12.24 ab | 13.29 ab | 9.07 a | 1.05 a | 35.00 b |
| $S_2$ | 12.57 a | 13.93 a | 8.21 b | 0.90 b | 39.89 a |
| $S_3$ | 11.90 b | 12.69 b | 8.10 b | 0.55 c | 36.39 b |
| **$LSD_{(0.05)}$** | **0.379** | **0.703** | **0.390** | **0.038** | **1.840** |
| **Level of significance** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** |
| **CV(%)** | **4.39** | **6.75** | **4.87** | **5.31** | **5.86** |

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

$S_1$: 50 cm × 50 cm $S_2$: 50 cm × 40 cm

$S_3$: 50 cm × 30 cm

**Table 9. Effect of micronutrients on yield attributes and yield of cauliflower**

| Treatments | Dry matter content of leaves (%) | Dry matter content of curd (%) | Diameter of curd (cm) | Curd yield per plant (kg) | Curd yield per hectare (ton) |
|---|---|---|---|---|---|
| $T_0$ | 10.84 c | 12.56 c | 7.56 c | 0.53 d | 24.41 d |
| $T_1$ | 12.37 b | 13.24 b | 8.43 b | 0.80 c | 35.67 c |
| $T_2$ | 12.94 a | 14.10 a | 9.00 a | 1.05 a | 46.85 a |
| $T_3$ | 12.79 ab | 13.31 ab | 8.85 ab | 0.94 b | 41.44 b |
| **$LSD_{(0.05)}$** | **0.439** | **0.811** | **0.449** | **0.044** | **2.125** |
| **Level of significance** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** |
| **CV(%)** | **4.39** | **6.75** | **4.87** | **5.31** | **5.86** |

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

$T_0$: $B_0Mo_0$ kg/ha $T_1$: $B_{1.0}Mo_{0.5}$ kg/ha

$T_2$: $B_{2.0}Mo_{1.0}$ kg/ha $T_3$: $B_{3.0}Mo_{1.5}$ kg/ha

Statistically significant variation was recorded for micronutrients in terms of dry matter content of leaves of cauliflower (Appendix VII). The highest dry matter content of leaves (12.94%) was found from $T_2$ treatment which was statistically similar (12.79 %) to $T_3$ treatment and closely followed (12.37 %) by $T_1$ treatment, whereas the lowest dry matter content of leaves (10.84 g) was recorded from $T_0$ treatment (Table 9). Mengel and Kirkhy (2001) reported that, requirement of molybdenum in terms of dry matter is usually in the range of 0.1-1.0 ppm.

Combined effect of different plant spacing and micronutrients showed significant variation on dry matter content of leaves of cauliflower (Appendix VII). The highest dry matter content of leaves (13.62 %) was recorded from $S_2T_2$ which was statistically similar (13.46 % and 12.97 %) to $S_1T_2$ and $S_2T_3$, while the lowest dry matter content of leaves (10.49 %) was observed from $S_1T_0$ treatment combination (Table 10).

### 4.11 Dry matter content of curd

Dry matter content of curd of cauliflower showed significant differences due to different plant spacing (Appendix VII). The highest dry matter content of curd (13.93%) was observed from $S_2$ treatment which was statistically similar (13.29 %) to $S_1$ treatment, while the lowest dry matter (12.69 %) from $S_3$ treatment (Table 8).

Statistically significant variation was recorded for micronutrients in terms of dry matter content of leaves of cauliflower (Appendix VII). The highest dry matter content of curd (14.10 %) was found from $T_2$ treatment which was statistically similar (13.31 %) to $T_3$ treatment and closely followed (13.24 %) by $T_1$ treatment, whereas the lowest dry matter content of curd (12.56 %) from $T_0$ treatment (Table 9). Thakur *et al.* (1991) reported that application of boron increased the DM content of cauliflower.

**Table 10. Combined effect of different plant spacing and micronutrients on yield attributes and yield of cauliflower**

| Treatments | Dry matter content of leaves (%) | Dry matter content of curd (%) | Diameter of curd (cm) | Curd yield per plant (kg) | Curd yield per hectare (ton) |
|---|---|---|---|---|---|
| $S_1T_0$ | 10.49 f | 11.00 d | 8.10 de | 0.61 de | 20.33 e |
| $S_1T_1$ | 12.36 cd | 13.69 bc | 9.06 abc | 0.99 c | 33.00 d |
| $S_1T_2$ | 13.46 ab | 14.97 ab | 9.90 a | 1.33 a | 44.33 b |
| $S_1T_3$ | 12.64 bc | 13.48 bc | 9.22 abc | 1.27 a | 42.33 b |
| $S_2T_0$ | 11.12 ef | 11.67 d | 7.50 ef | 0.53 fg | 23.56 e |
| $S_2T_1$ | 12.57 c | 14.41 ab | 8.44 cd | 0.94 c | 41.78 bc |
| $S_2T_2$ | 13.62 a | 15.63 a | 9.41 ab | 1.16 b | 51.56 a |
| $S_2T_3$ | 12.97 abc | 15.00 ab | 7.91 def | 0.96 c | 42.67 bc |
| $S_3T_0$ | 10.91 f | 14.01 b | 7.07 f | 0.44 h | 29.33 d |
| $S_3T_1$ | 12.18 cd | 11.62 d | 7.81 def | 0.48 gh | 32.22 d |
| $S_3T_2$ | 11.73 de | 11.70 d | 8.11 de | 0.67 d | 44.67 b |
| $S_3T_3$ | 12.77 bc | 12.45 cd | 8.98 bc | 0.59 ef | 39.33 c |
| **$LSD_{(0.05)}$** | **0.758** | **1.407** | **0.779** | **0.076** | **3.681** |
| **Level of significance** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** |
| **CV(%)** | **4.39** | **6.75** | **4.87** | **5.31** | **5.86** |

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

$S_1$: 50 cm × 50 cm
$S_2$: 50 cm × 40 cm
$S_3$: 50 cm × 30 cm

$T_0$: $B_0Mo_0$ kg/ha
$T_1$: $B_{1.0}Mo_{0.5}$ kg/ha
$T_2$: $B_{2.0}Mo_{1.0}$ kg/ha
$T_3$: $B_{3.0}Mo_{1.5}$ kg/ha

Combined effect of different plant spacing and micronutrients showed statistically significant variation on dry matter content of curd of cauliflower (Appendix VII). The highest dry matter content of curd (15.63 %) was recorded from $S_2T_2$ which was statistically similar (15.00 %, 14.97 % and 14.41 %) to $S_2T_3$, $S_1T_2$ and $S_2T_1$, while the lowest dry matter content of curd (11.00 %) was observed from $S_1T_0$ treatment combination (Table 10).

### 4.12 Diameter of curd

Diameter of curd of cauliflower showed significant differences due to different plant spacing (Appendix VII). The highest diameter of curd (9.07 cm) was observed from $S_1$ treatment, while the lowest diameter of curd (8.10 cm) was found from $S_3$ treatment which was statistically similar (8.21 cm) to $S_2$ treatment (Table 8). Formation of bigger curd at the widest spacing was probably due to the availability of more nutrients, light, moisture to the plants. On the other hand, in closer spacing plants inter plants competition resulted in formation of small curd. Kannan *et al*. (2016) observed the highest curd breadth (6.94 cm) from plant spaced 60 × 50 cm. Rahman *et al*. (2007) reported the maximum curd diameter (19.13 cm) where the plants were spaced 45 cm apart.

Statistically significant variation was recorded for micronutrients in terms of diameter of curd of cauliflower (Appendix VII). The highest diameter of curd (9.00 cm) was found from $T_2$ treatment which was statistically similar (8.85 cm) to $T_3$ treatment and closely followed (8.43 cm) by $T_1$ treatment, whereas the lowest diameter of curd (7.56 cm) from $T_0$ treatment (Table 9). This result also supported by Rouf (2006) who reported that the greatest curd diameter of cauliflower was obtained with combined application of B (3 kg/ha) and Mo (1.5 kg/ha) and the smallest in control plot. Kumar *et al*. (2002) reported that B and Mo application significantly increased curd diameter of cauliflower. The formation of bigger curd with the application of higher levels of micronutrients might be done to higher synthesis of carbohydrate and their translocation to the curd, which subsequently helped in the formation of higher curd of cauliflower.

Combined effect of different plant spacing and micronutrients showed statistically significant variation on diameter of curd of cauliflower (Appendix VII). The highest diameter of curd (9.90 cm) was recorded from $S_1T_2$ treatment combination which was statistically similar (9.41 cm, 9.22 cm and 9.06 cm) to $S_2T_3$, $S_1T_3$ and $S_1T_1$, while the lowest diameter of curd (7.07 cm) was observed from $S_3T_0$ treatment combination (Table 10).

## 4.13 Weight of curd per plant

Weight of curd per plant of cauliflower showed significantly significant differences due to different plant spacing (Appendix VII). The highest weight of curd per plant (1.05 kg) was observed from $S_1$ treatment which was closely followed (0.90 kg) to $S_2$ treatment, while the lowest weight of curd per plant (0.55 kg) was found from $S_3$ treatment (Table 8). Kannan *et al*. (2016) observed the highest curd weight (506.02 g) from plant spaced 60 × 50 cm. Rahman *et al*. (2007) reported the maximum curd weight (1.23 kg $plant^{-1}$) where the plants were spaced 45 cm apart.

Statistically significant variation was recorded for micronutrients in terms of weight of curd per plant of cauliflower (Appendix VII). The highest weight of curd per plant (1.05 kg) was found from $T_2$ treatment which was closely followed (0.94 kg) by $T_3$ treatment, whereas the lowest weight (0.53 kg) from $T_0$ treatment which was followed (0.80 kg) by $T_1$ treatment (Table 9). Thakur *et al.* (1991) reported that application of boron increased the curd yield of cauliflower.

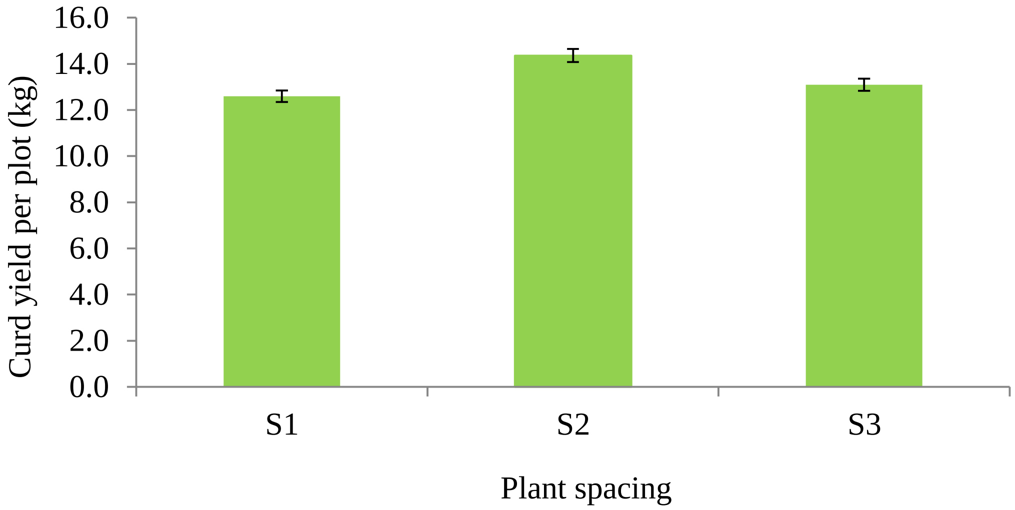
Combined effect of different plant spacing and micronutrients showed statistically significant variation on weight of curd per plant of cauliflower (Appendix VII). The highest weight of curd per plant (1.33 kg) was recorded from $S_1T_2$ which was statistically similar (1.27 kg) to $S_1T_3$, while the lowest weight of curd per plant (0.44 kg) was observed from $S_3T_0$ treatment combination (Table 10).

### 4.14 Curd yield per plot

The curd yield per plot of cauliflower was found to be statistically significant due to different plant spacing (Appendix VII). The highest curd yield per plot (14.36 kg) was observed from $S_2$ treatment and the lowest curd yield per plot (13.10 kg) was found from $S_3$ treatment which was statistically similar (12.60 kg) to $S_1$ treatment (Figure 11). The increase in yield per plot with closer spacing than wider spacing was due to the accommodation of higher number of plant per unit. Rahman *et al*. (2007) reported that 45 cm plant to plant spacing showed the best performance for all the parameters. Maximum plant height, maximum curd weight and yield were recorded in plants where plants were spaced 45 cm apart. The crops grow in such close spacing yield more through main heads are smaller and these mature slightly letter that case optimum spacing is followed. The present result is in agreement with the findings of Bose and Som (1990).

Statistically significant variation was recorded for micronutrients in terms of curd yield per plot of cauliflower (Appendix VII). The highest curd yield per plot (16.87 kg) was found from $T_2$ treatment which was closely followed (14.92 kg) by $T_3$ treatment, while the lowest curd yield per plot (8.79 kg) was recorded from $T_0$ treatment which was followed (12.84 kg) by $T_1$ treatment (Figure 12). Kumar *et al*. (2002) reported that B and Mo application significantly increased curd diameter, weight and yield of cauliflower. Xian *et al*. (2000) reported that the combination of B and Mo at 5 g/L respectively increased the growth and yield of broccoli.

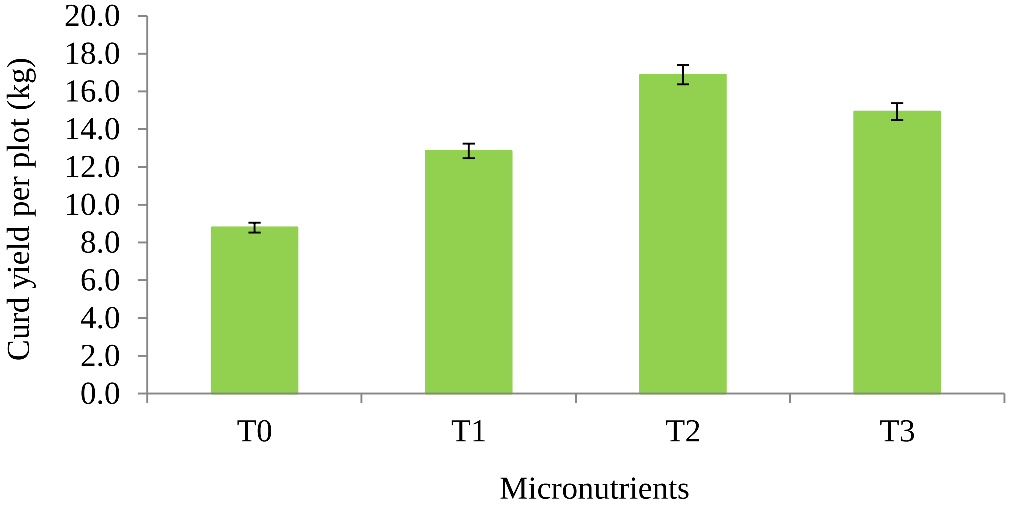
Combined effect of different plant spacing and micronutrients showed statistically significant variation on curd yield per plot of cauliflower (Appendix VII). The highest curd yield per plot (18.56 kg) was recorded from $S_2T_2$, whereas the lowest curd yield per plot (7.32 kg) was observed from $S_1T_0$ treatment combination (Figure 13).




$S_1$: 50 cm × 50 cm     $S_2$: 50 cm × 40 cm

$S_3$: 50 cm × 30 cm

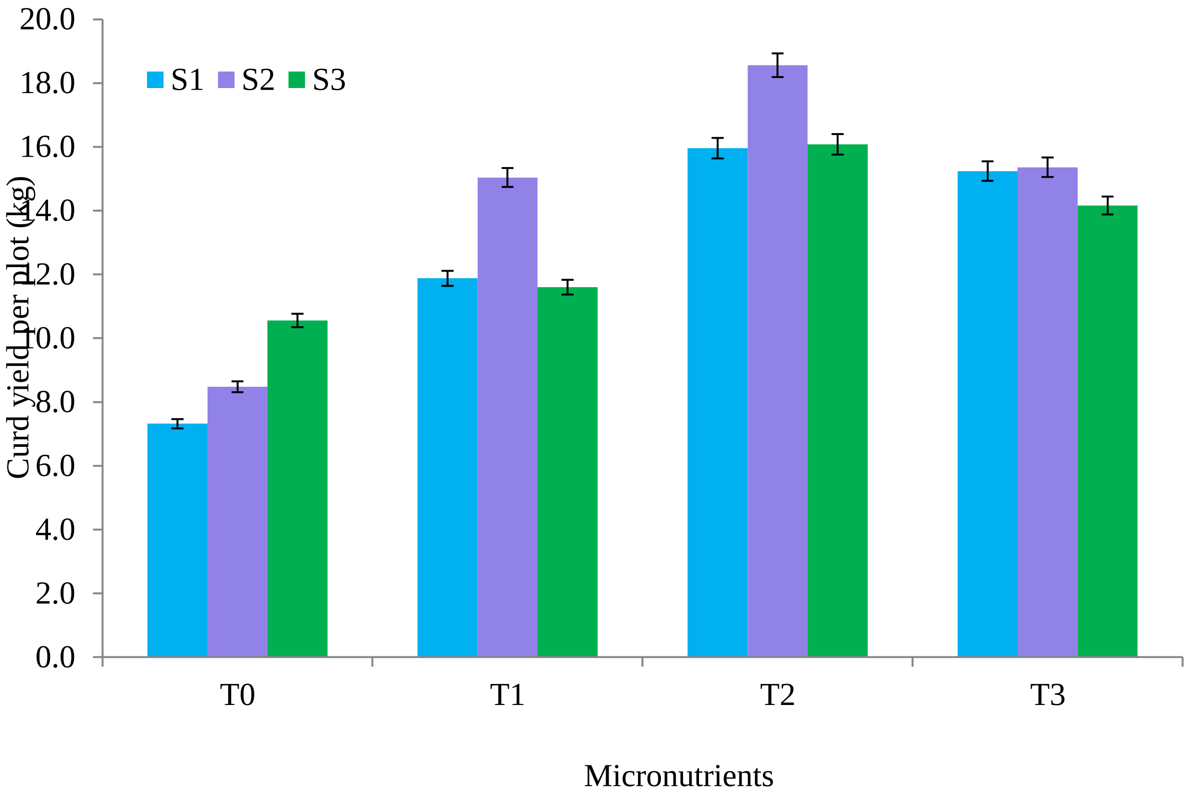
Figure 11. Effect of different plant spacing on curd yield per plot of cauliflower. Vertical bars represent LSD value at % level of probability




$T_0$: $B_0Mo_0$ kg/ha     $T_1$: $B_{1.0}Mo_{0.5}$ kg/ha

$T_2$: $B_{2.0}Mo_{1.0}$ kg/ha     $T_3$: $B_{3.0}Mo_{1.5}$ kg/ha

Figure 12. Effect of micronutrients on curd yield per plot of cauliflower. Vertical bars represent LSD value at 5% level of probability




$S_1$: 50 cm × 50 cm
$S_2$: 50 cm × 40 cm
$S_3$: 50 cm × 30 cm

$T_0$: $B_0Mo_0$ kg/ha
$T_1$: $B_{1.0}Mo_{0.5}$kg/ha
$T_2$: $B_{2.0}Mo_{1.0}$ kg/ha
$T_3$: $B_{3.0}Mo_{1.5}$ kg/ha

Figure 13. Combined effect of different plant spacing and micronutrients on curd yield per plot of cauliflower. Vertical bars represent LSD value at 5% level of probability

## 4.15 Curd yield per hectare

Curd yield per hectare of cauliflower showed significantly significant differences due to different plant spacing (Appendix VII). The highest curd yield per hectare (39.89 t/ha) was observed from $S_2$ treatment, while the lowest curd yield per hectare (35.00 t/ha) was found from $S_1$ treatment which was statistically similar (36.39 t/ha) to $S_3$ treatment (Table 8). The crops grow in such close spacing yield more through main heads are smaller and these mature slightly letter that case optimum spacing is followed. Farzana *et al*. (2016) observed the highest yield of cauliflower (11.25 t/ha) from 60 × 30 cm and lowest (10.57 t $ha^{-1}$) from 60 × 50 cm. Rahman *et al*. (2007) reported the maximum yield (30.77 t $ha^{-1}$) were where the plants were spaced 45 cm apart.

Statistically significant variation was recorded for micronutrients in terms of curd yield per hectare of cauliflower (Appendix VII). The highest curd yield (46.85 t/ha) was found from $T_2$ treatment which was closely followed (41.44t/ha) by $T_3$ treatment, whereas the lowest curd yield (24.41 t/ha) was recorded from $T_0$ treatment which was followed (35.67 ton) by $T_1$ treatment (Table 9). Kumar *et al*. (2002) reported that B and Mo application significantly increased curd diameter, weight and yield of cauliflower. Khadka *et al*. (2005) reported the better cauliflower curd (13.9 t $ha^{-1}$) from the treatment with 20 kg borax.

Combined effect of different plant spacing and micronutrients showed statistically significant variation on curd yield 0000of cauliflower (Appendix VII). The highest yield (51.56 t/ha) was recorded from $S_2T_2$, while the lowest curd yield (20.33 t/ha) was observed from $S_1T_0$ treatment combination (Table 10).

### 4.16 Economic analysis

Input costs for land preparation, fertilizers, seeds and manpower for all operations from sowing to harvesting of cauliflower were recorded as per plot and converted into hectare. Price of cauliflower was considered as per present market price. The economic analysis presented under the following headings-

#### 4.16.1 Gross return

The combination of different plant spacing and micronutrients showed different value in terms of gross return under the trial (Table 11). The highest gross return (Tk. 773,400/ha) was obtained from the treatment combination $S_2T_2$ and the second highest gross return (Tk. 670,050/ha) was found in $S_3T_2$. The lowest gross return (Tk. 304,950/ha) was obtained from $S_1T_0$.

#### 4.16.2 Net return

In case of net return, different plant spacing and micronutrients showed different levels of net return under the present trial (Table 11). The highest net return (Tk. 475,212/ha) was found from the treatment combination $S_2T_2$ and the second highest net return (Tk. 371,862/ha) was obtained from the combination $S_3T_2$. The lowest (Tk. 7,413/ha) net return was obtained $S_1T_0$.

#### 4.16.3 Benefit cost ratio

In the different plant spacing and micronutrients the highest benefit cost ratio (2.59) was noted from the combination of $S_2T_2$ and the second highest benefit cost ratio (2.25) was estimated from the combination of $S_3T_2$. The lowest benefit cost ratio (1.02) was obtained from $S_1T_0$ (Table 11). From economic point of view, it is apparent from the above results that the combination of $S_2T_2$ was better than rest of the combination in cauliflower cultivation.

**Table 11. Cost and return of cauliflower cultivation as influenced by different plant spacing and micronutrients**

| Treatment Combination | Cost of production (Tk./ha) | Yield of cauliflower (t/ha) | Gross return (Tk./ha) | Net return (Tk./ha) | Benefit cost ratio |
|---|---|---|---|---|---|
| $S_1T_0$ | 297,537 | 20.33 | 304,950 | 7,413 | 1.02 |
| $S_1T_1$ | 297,904 | 33.00 | 495,000 | 197,096 | 1.66 |
| $S_1T_2$ | 298,188 | 44.33 | 664,950 | 366,762 | 2.23 |
| $S_1T_3$ | 298,472 | 42.33 | 634,950 | 336,478 | 2.13 |
| $S_2T_0$ | 297,537 | 23.56 | 353,400 | 55,863 | 1.19 |
| $S_2T_1$ | 297,904 | 41.78 | 626,700 | 328,796 | 2.10 |
| $S_2T_2$ | 298,188 | 51.56 | 773,400 | 475,212 | 2.59 |
| $S_2T_3$ | 298,472 | 42.67 | 640,050 | 341,578 | 2.14 |
| $S_3T_0$ | 297,537 | 29.33 | 439,950 | 142,413 | 1.48 |
| $S_3T_1$ | 297,904 | 32.22 | 483,300 | 185,396 | 1.62 |
| $S_3T_2$ | 298,188 | 44.67 | 670,050 | 371,862 | 2.25 |
| $S_3T_3$ | 298,472 | 39.33 | 589,950 | 291,478 | 1.98 |

Market price of cauliflower @ 15.0 Tk/kg

$S_1$: 50 cm × 50 cm
$S_2$: 50 cm × 40 cm
$S_3$: 50 cm × 30 cm

$T_0$: $B_0Mo_0$ kg/ha
$T_1$: $B_{1.0}Mo_{0.5}$ kg/ha
$T_2$: $B_{2.0}Mo_{1.0}$ kg/ha
$T_3$: $B_{3.0}Mo_{1.5}$ kg/ha

# CHAPTER V

# SUMMARY AND CONCLUSIONS

The experiment was carried out at the Horticulture farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh during the period of November 2015 to February 2016 to study the effect of plant spacing and micronutrients on the growth and yield of cauliflower. The seeds of cauliflower ZAC-426 ($F_1$ hybrid) were used as planting materials for this experiment. The experiment consisted of two factors: Factor A: Plant spacing (3 levels) as- $S_1$: 50 cm × 50 cm, $S_2$: 50 cm × 40 cm, $S_3$: 50 cm × 30 cm and Factor B: Levels of micronutrients (4 levels) as- $T_0$: $B_0Mo_0$ (control), $T_1$: $B_{1.0}Mo_{0.5}$ kg/ha, $T_2$: $B_{2.0}Mo_{1.0}$ kg/ha, $T_3$: $B_{3.0}Mo_{1.5}$ kg/ha. The two factorial experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Data on different growth and yield parameters were recorded and statistically significant variation was recorded for different treatment.

For different plant spacing, at harvest, the tallest plant (59.84 cm) was observed from $S_3$, while the shortest plant (46.56 cm) from $S_1$. At harvest, the highest number of leaves per plant (18.00) was recorded from $S_2$, whereas the lowest number (16.53) from $S_3$. At harvest, the longest largest leaf (45.36 cm) was recorded from $S_1$ and the shortest leaf (37.47 cm) from $S_3$. The maximum days to curd initiation (57.50) was observed from $S_1$, while the minimum days (49.42) from $S_3$. The longest stem (22.69 cm) was recorded from $S_1$, whereas the shortest leaf (18.66 cm) from $S_3$. The highest diameter of stem (2.80 cm) was observed from $S_1$ and the lowest (2.27 cm) from $S_3$. The highest fresh weight of leaves per plant (238.88 g) was observed from $S_1$, while the lowest (205.76 g) from $S_3$. The longest root (23.82 cm) was observed from $S_2$, while the shortest root (20.77 cm) from $S_3$. The highest fresh weight of roots per plant (25.14 g) was observed from $S_1$, whereas the lowest (21.05 g) from $S_3$. The highest dry matter content of leaves (12.57 %) was observed from $S_2$, while the lowest

(11.90 %) from $S_3$. The highest dry matter content of curd (13.93 %) was observed from $S_2$, while the lowest (12.69 %) from $S_3$. The highest diameter of curd (9.07 cm) was observed from $S_1$, while the lowest (8.10 cm) from $S_3$. The highest curd yield per plant (1.05 kg) was observed from $S_1$, while the lowest (0.55 kg) from $S_3$. The highest curd yield per plot (14.36 kg) was observed from $S_2$ and the lowest (13.10 kg) from $S_3$. The highest curd yield per hectare (39.89 ton) was observed from $S_2$, while the lowest (36.39 ton) from $S_3$.

In case of micronutrients, at harvest, the tallest plant (61.89 cm) was found from $T_2$, whereas the shortest plant (45.00 cm) from $T_0$. At harvest, the highest number of leaves per plant (19.27) was recorded from $T_2$, while the lowest number (14.00) from $T_0$. At harvest, the longest largest leaf (47.57 cm) was found from $T_2$, while the shortest leaf (32.10 cm) from $T_0$. The maximum days to curd initiation (59.22) was found from $T_0$, whereas the minimum days (48.00) from $T_2$. The longest stem (24.21 cm) was found from $T_2$ and the shortest leaf (14.39 cm) from $T_0$. The highest diameter of stem (3.07 cm) was found from $T_2$, while the lowest (2.07 cm) from $T_0$. The highest fresh weight of leaves per plant (254.23 g) was found from $T_2$, whereas the lowest (185.97 g) from $T_0$. The longest root (24.32 cm) was found from $T_2$, whereas the shortest (19.47 cm) from $T_0$. The highest fresh weight of roots per plant (25.03 g) was found from $T_2$, while the lowest (21.38 g) from $T_0$. The highest dry matter content of leaves (12.94 %) was found from $T_2$ and the lowest (10.84%g) from $T_0$. The highest dry matter content of curd (14.10 %) was found from $T_2$, whereas the lowest (12.56 %) from $T_0$. The highest diameter of curd (9.00 cm) was found from $T_2$ and the lowest (7.56 cm) from $T_0$. The highest curd yield per plant (1.05 kg) was found from $T_2$, whereas the lowest (0.53 kg) from $T_0$. The highest curd yield per plot (16.87 kg) was found from $T_2$ and the lowest (8.79 kg) from $T_0$. The highest curd yield (46.85 t/ha) was found from $T_2$, while the lowest (24.41 t/ha) from $T_0$.

Due to the combined effect of different plant spacing and micronutrients at harvest, the tallest plant (69.23 cm) was recorded from $S_1T_2$, while the shortest plant (36.43 cm) from $S_1T_0$. At harvest, the highest number of leaves per plant (20.27) was recorded from $S_2T_2$, whereas the lowest number (13.53) was found from $S_1T_0$ treatment combination. At harvest, the longest largest leaf (54.21 cm) was recorded from $S_2T_2$ and the shortest leaf (33.31 cm) was found from $S_1T_0$ treatment combination. The maximum days to curd initiation (65.33) was recorded from $S_1T_3$, while the minimum days (41.00) was found from $S_1T_0$ treatment combination. The longest stem (27.82 cm) was recorded from $S_2T_2$, while the shortest stem (12.80 cm) from $S_1T_0$ treatment combination. The highest diameter of stem (3.23 cm) was recorded from $S_2T_2$, whereas the lowest diameter (1.57 cm) from $S_1T_0$ treatment combination. The highest fresh weight of leaves per plant (281.10 g) was recorded from $S_1T_2$, while the lowest (179.21 g) from $S_1T_0$. The longest root (26.85 cm) was recorded from $S_1T_2$, while the shortest root (18.42 cm) from $S_1T_0$ treatment combination. The highest fresh weight of roots per plant (27.38 g) was recorded from $S_1T_2$, whereas the lowest (20.33 g) from $S_1T_0$ treatment combination. The highest dry matter content of leaves (13.62 g) was recorded from $S_2T_2$, while the lowest (10.49 g) from $S_1T_0$ treatment combination. The highest dry matter content of curd (15.63 g) was recorded from $S_2T_2$, while the lowest (10.49 g) from $S_1T_0$ treatment combination. The highest diameter of curd (9.90 cm) was recorded from $S_1T_2$, while the lowest (7.07 cm) from $S_3T_0$ treatment combination. The highest curd yield per plant (1.33 kg) was recorded from $S_1T_2$, while the lowest (0.44 kg) from $S_3T_0$ treatment combination. The highest curd yield per plot (18.56 kg) was recorded from $S_2T_2$, whereas the lowest (7.32 kg) from $S_1T_0$ treatment combination. The highest curd yield per hectare (51.56 ton) was recorded from $S_2T_2$, while the lowest (20.33 ton) from $S_1T_0$ treatment combination.

The combination of different plant spacing and micronutrients, the highest gross return (Tk. 773,400/ha) was obtained from the treatment combination $S_2T_2$ and the lowest gross return (Tk. 304,950/ha) from $S_1T_0$. In case of net return, the highest value (Tk. 475,212/ha) was found from the treatment combination $S_2T_2$ and the lowest (Tk. 7,413/ha) from $S_1T_0$. The highest benefit cost ratio (2.59) was noted from the combination of $S_2T_2$ and the lowest (1.02) from $S_1T_0$. From economic point of view, it is apparent from the above results that the combination of $S_2T_2$ was better than rest of the combination in cauliflower cultivation.

**Conclusion and recommendation:**

Considering the above results of this experiment, the following conclusion and recommendation can be drawn:

- In the experiment plant spacing $S_1$ (50 cm × 50 cm) treatment gave higher curd yield per plant but plant spacing $S_2$ (50 cm × 40 cm) treatment gave maximum curd yield per hectare.
- Micronutrients combination $T_2$ (2.0 kg B/ha and Mo 1.0 kg/ha) was more effective than control $T_0$.
- The results of the investigation suggested that highest curd yield and good shape cauliflower curd can be obtained, in plant spacing 50 cm × 40 cm with the combined application of 2.0 kg B /ha and Mo 1.0 kg/ha.
- Based on the findings of the study, trial may be given in different agro-ecological zones of Bangladesh before final recommendation.

# REFERENCES

Abdel-Razzak, H.S. and El-Nasharty, A.B. (2008). Vegetative growth and yield potential of cauliflower (*Brassica oleraceae* var. *botrytis,* L.) plants as affected by inorganic and organic nitrogen fertilization. *Alex. Sci. Exch. J*., **29**: 325-339.

Ahmed, M.E., Elzaawely, A.A. and El-sawy, M.B.( 2014). Effect of boron on cauliflower production. Effect of the Foliar Spraying with Molybdenum and Magnesium on Vegetative Growth and Curd Yields in Cauliflower (*Brassica oleraceae* var. *botrytis* L.). *World J. Agril. Sci*., **7**(2): 149-156.

Alam, M.S., Iqbal, T.M.T., Amin, M. and Gaffar, M.A. (1989). Krishitattic Fasaler Utpadan O Unnayan (in Bengali). T.M. Jubair Bin Iqbal, Sirajgonj. pp. 231-239.

Anneser, K., Fischer, P. and Seling, S. (2004). Nutritional disorders in broccoli. *Gemuse Munchen*. **40**(12): 24-27.

Anonymous. (1989). Annual Report 1987-88. Bangladesh Agricultural Research Institute. Joydebpur, Gazipur. p. 133.

Bambara, S. and Ndakidemi, P.A.( 2010). The potential roles of lime and molybdenum on the growth, nitrogen fixation and assimilation of matabolites in nodulated legume: A special reference to *Phaseolus vulgaris*. *African J. Biotech*., **8**: 2482-2489.

Batabyal, K., Sarkar, D. and Mandal, B. (2015). Effect of plant spacing and different levels of boron and molybdenum on plant height at different days after transplanting (DAT) of cauliflower. *J. Plant Nutri.*, **38**(12): 1822-1835.

BBS. (2012). Monthly Statistical Bulletin of Bangladesh. Bangladesh Bureau of Statistics, Ministry of Planning. Government of the People's Republic of Bangladesh, Dhaka. p. 51.

BBS. (2015). Report on the productivity survey of cauliflower crop. Bangladesh Bureau of statistics. Statistics and Informatics division, Ministry of planning. Government of the People's Republic of Bangladesh, Dhaka. P. 108.

Blatt, C.R.(1990). Effect of arsenic and molybdenum on plant response of cauliflower (*Brassica oleracea*) grown in sand culture. *Dev. Plant and Soil Sci*., **12**: 303-306.

Bose, T.K. and Som, M.G. (1990). Vegetable Crops in India.NayaProkash, Calcutta-Six, India. pp. 408-442.

Cakmak, I., Kurtz, H. and Marschner, H. (1995). Short-term effects of boron, germanium and high light intensity on membrane permeability in boron deficient leaves of sunflower. *Physiologia Plantarum.* **95**: 11-18.

Cuocolo, L. and Duranti, A. (1988). The effect of nitrogen fertilization and plant density on seed yield of cauliflower (*Brassica oleracea var.* botrytis). *Rivistadi Agron*., **22**(3): 124-129.

Das, J., Phookan D.B. and Gautam, B.P. (2000). Effect of levels of NPK and plant densities for curd productionof early cauliflower (*Brassica oleracea var botrytis)* cv. Pusa Katki. *Haryana J. Hort. Sci*., **29**(3-4): 265-266.

Din, F., Qasim, M., Elahi, N. and Faridullah. (2007)

. Response of different sowing dates on the growth and yield of cauliflower. *Sarhad J. Agric.* **23**(2): 289-291.

Farzana, L., Solaiman, A.H.M. and Amin, M.R.( 2016). Potentiality of producing summer cauliflower as influenced by organic manures and spacing. *Asian J. Med. Biol. Res*., **2**(2): 304-317.

Firoz, Z.A., Jaman, M.S. and Alam, M.K. (2008). Effect of boron application on the yield of different varieties of broccoli in hill valley. *J. Agril. Res.* **33**(3): 655-657.

Gomez, K.A. and Gomez, A.A. (1984). Statistical Procedure for Agricultural Research (2nd edn.). *Intl. Rice Res. Inst., A Willey Int. Sci*., pp. 28-192.

Griffith, M. and Carling, D.E.)(1991). Effect of plant spacing on broccoli yield and hollow stem in Alaska. *Canadian J. Plant Sci*., **71**(2): 579-585.

Hossain, M.F., Ara, N., Uddin, M.R., Islam, M.R. and Azam, M.G.( 2015). Effect of sowing date and plant spacing on seed production of cauliflower**.** *Bangladesh J. Agril. Res*., **40**(3): 491-500.

Hussain, M.J., Karim, A.J.M.S., Solaiman, A.R.M. and Haque, M.M.( 2012). Effects of Nitrogen and Boron on the Yield and Hollow Stem Disorder of Broccoli (*Brassica oleracea var. italica*). *The Agriculturists*. **10**(2): 36-45.

Kamal, K.. Singh, K.P., Singh, V.K. and Ranjan, A. (2013). Effect of boron, zinc and their combinations on the yield of cauliflower (*Brassica oleracea var. Botrytis* Linn.) hybrid cultivar-Himani, *Asian J. Hort.*, **8**(1): 238-240.

Kannan, D., Kumar, S.D. and Kumar, J.S.( 2016). Effect of Spacing, Boron and Their Combinations on Yield and Yield Attributing Characters of Cauliflower (*Braccica Oleraceae* Var. *Botrytis* L.). *J. Life Sci*., **13**(3): 524-526.

Khadka, Y.G., Rai, S.K. and Raut, S. (2005). Effect of Boron on Cauliflower Production. *Nepal J. Sci. & Tech*., **6**: 103-108.

Khan, B.A., Shillin, P.G., Brusewitz, G.H. and McNew, R.W. (1991). Force to shear the stalk, stalk diameter and yield of broccoli in response to nitrogen fertilizer and within row spacing. *J. Amer. Soc. Hort. Sci*., **116**(2): 222-227.

Kumar, S., Chaudhury, D.R. and Kumar, S. (2002). Effect of FYM, molybdenum and boron application on yield attributes and yields of cauliflower. *Cop Res. Hisar*., **24**(3): 494-496.

Marschner, H. (1995). Mineral nutrition of higher plants, 2nd ed. Academic press, New York, USA.

Mengel, K., and Kirkby, E.A.( 2001). Principles of Plant Nutrition (5th ed.) Dordrecht: Kluwer Academic Publishers. p. 480.

Moniruzzaman, M., Rahman, S.M.L., Kibria, M.G., Rahman, M.A. and Hossain, M.M.( 2007). Effect of boron and nitrogen on yield and hollowstem of broccoli. *J. Soil. Nature*. **1**(3): 24-29.

Pornsuriya, P., Pornsuriya, P. and Teeraskulchon, S.( 1997). Studies on broccoli production in Chonburi Provience, Thailand. *Kasesart J. Natural Sci*., **32**(4): 81-85.

Rahman, I.U., Afzal, A., Iqbal, Z., Ijaz, S.F., Manan, S., Niaz, S., Shah, A.H. and Waheed, A.U.A.(2012). Response of cauliflower (*Brassica oleraceae* var. *botrytis* L.) to N, Mo and Mg fertilization under poultry manure condition. *Intl. J. Bio. Sci*., **4**(8): 215-221.

Rahman, I.U., Afzal, A., Sohail, Z.I., Ijaz, F., Manan, S., Niaz, S., Shah, A.H., Ullah, A. and Waheed, A. (2014). Response of cauliflower (*Brassica oleraceae* var. botrytis L.) to N, Mo and Mg fertilization under poultry manure condition. *Intl. J. Bio. Sci*., **4**(8): 215-221.

Rahman, M., Iqbal, M., Jilani, M.S. and Waseem, K.( 2007). Effect of different plant spacing on the production of cauliflower (Brassica oleraceae var. Botrytis) under the agro-climatic conditions of D.I. Khan. *Pakistan J. Biol. Sci.* **10**(24): 4531-4534.

Rashid, M.M. (1999). Shabjeer chash (Vegetable cultivation). Begum Shehala Rashid. BARI Residential Area, Joydebpur, Dhaka. p. 97.

Ribeiro, L.M.P., Zanuzo, M.R., Vieira, C.V.V., Junior, S.S. and Junior, F.F. (2017). Cauliflower quality and yield under tropical conditions are influenced by boron fertilization. *African J. Agril. Res*., **12**(12): 1045-1053.

Rouf, M.A. (2006). Effects of growing conditions and management practices and seed production of cauliflower, Ph.D thesis, Department of Horticulture, BAU, Mymensingh. P. 20.

Sharma, P.K. and Rastogi, D.A.( 1992). Response of cauliflower (PSB-1) to different levels of nitrogen and plant spacing. *Dev. Plant and Soil Sci*., **14**: 123-129.

Shelp, B.J. (1990). The influence of boron nutrition on nitrogen partitioning in broccoli plants. *Com. Soil Sci. & Plant Anal*., **21**(1-2): 49-60.

Shelp, B.J., Marentes, E., Kitheka, A.M. and Vivekanandan, P. (1995). Boron mobility in plants. *Physiologia Plantarum*. **94**: 356-361.

Silva, D.P., Prado, R.M., Barbosa, G., Oliveira, S.L., Fabio Tiraboschi Leal F.T., Leonardo Correia Costa, L.C. and Carmona, V.M.V. (2016). Broccoli growth and nutritional status as influenced by doses of nitrogen and boron. *African J. Agril Res*. **11**(20): 1858-1861.

Singh, D.N.( 2002). Effects of boron on the growth and yield of cauliflower in lateric soil on Western Orissa. *Indian J. Hort. Sci*., **60**(3): 283-286.

Sorensen, L. and Grevsen, K. (1994). Effect of planting spacing on uniformity in broccoli for once over harvest. *Gartenbau Wissenschaft*. **59**(3): 102-105.

Soto, J.A. (1991). Effect of nitrogen fertilization and spacing on the yield and quality of broccoli during two growing cycles in Cartago. *Agron. Costarricense*, **15**(1-2): 19-27.

Thakur, O.P., Sharma, P.P. and Sing, K.K. (1991). Effect of nitrogen and phosphorus with and without boron on curd yield and stalk rot incidence in cauliflower. *Veg. Sci*., **18**(2): 115-121.

Xian, O.Y., Peng, F. and Cao, L. (2000). Response to cauliflower to B, Mo and the application technique in soil. *Zeszyty Problemowe Postepow Nauk Rolniczych*, **23**(5): 673-679.

Y.G. Khadka, Rai, S.K. and Raut, S. (2005). Effect of boron on cauliflower production. *Nepal J. Sci. & Tech*., **6**: 103-108**.**

Yang, X., Chen, X.Y., Liu, Z.C., Yang, X., Chen, X.Y. and Liu, Z.C.( 2000). Effects of boron and molybdenum nutrition on curd yield and active oxygen metabolism in broccoli (*Brassica oleracea* L. var. *italica*). *Acta Hort.*, **27**(2): 112-116.

Yoldas, F., Ceylan, S., Yagmur, B., Mordogan, N. (2008). Effect of nitrogen fertilizer on yield quality and nutrient content in broccoli. *J. Plant Nutr*., **31**: 1333-1343.

# APPENDICES

**Appendix I. Monthly record of air temperature, relative humidity, rainfall and sunshine hour of the experimental site during the period from November 2015 to February 2016**

| Month | *Air temperature (ºc) | | *Relative humidity (%) | Total Rainfall (mm) | *Sunshine (hr) |
|---|---|---|---|---|---|
| | Maximum | Minimum | | | |
| November, 2015 | 25.8 | 16.0 | 78 | 00 | 6.8 |
| December, 2015 | 22.4 | 13.5 | 74 | 00 | 6.3 |
| January, 2016 | 24.5 | 12.4 | 68 | 00 | 5.7 |
| February, 2016 | 27.1 | 16.7 | 67 | 30 | 6.7 |

* Monthly average,

* Source: Bangladesh Meteorological Department (Climate & weather division) Agargoan, Dhaka-1207

**Appendix II. Soil characteristics of experimental field as analyzed by Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka**

**A. Morphological characteristics of the experimental field**

| Morphological features | Characteristics |
|---|---|
| Location | Horticulture farm field , SAU, Dhaka |
| AEZ | Madhupur Tract (28) |
| General Soil Type | Shallow red brown terrace soil |
| Land type | High land |
| Soil series | Tejgaon |
| Topography | Fairly leveled |

**B. Physical and chemical properties of the initial soil**

| Characteristics | Value |
|---|---|
| % Sand | 27 |
| % Silt | 43 |
| % clay | 30 |
| Textural class | Sandy loam |
| pH | 6.1 |
| Catayan exchange capacity | 2.64 meq 100 g soil$^{-1}$ |
| Organic matter (%) | 1.18 |
| Total N (%) | 0.03 |
| Available P (ppm) | 20.00 |
| Exchangeable K (me/100 g soil) | 0.10 |
| Available S (ppm) | 45 |

**Appendix III. Analysis of variance of the data on plant height of cauliflower as influenced by different plant spacing and micronutrients**

| Source of variation | Degrees of freedom | Mean square | | | | |
|---|---|---|---|---|---|---|
| | | Plant height (cm) at | | | | |
| | | 30 DAT | 40 DAT | 50 DAT | 60 DAT | Harvest |
| Replication | 2 | 0.037 | 0.001 | 0.284 | 2.403 | 4.941 |
| Plant spacing (A) | 2 | 19.003** | 72.678** | 243.777** | 283.932** | 557.418** |
| Micronutrients (B) | 3 | 94.318** | 167.666** | 294.328** | 338.981** | 440.743** |
| Interaction (A×B) | 6 | 26.321** | 42.758** | 95.992** | 123.138** | 310.137** |
| Error | 22 | 2.609 | 3.555 | 3.766 | 9.718 | 8.120 |

** Significant at 0.01 level of probability

**Appendix IV. Analysis of variance of the data on number of leaves per plant of cauliflower as influenced by different plant spacing and micronutrients**

| Source of variation | Degrees of freedom | Mean square | | | | |
|---|---|---|---|---|---|---|
| | | Number of leaves per plant at | | | | |
| | | 30 DAT | 40 DAT | 50 DAT | 60 DAT | Harvest |
| Replication | 2 | 0.030 | 0.220 | 0.121 | 0.023 | 0.381 |
| Plant spacing (A) | 2 | 5.986** | 8.344** | 12.309** | 17.133** | 34.226** |
| Micronutrients (B) | 3 | 2.453** | 7.156** | 23.134** | 22.456** | 67.314** |
| Interaction (A×B) | 6 | 1.687** | 2.456** | 2.689** | 1.893** | 7.675** |
| Error | 22 | 0.224 | 0.361 | 0.397 | 0.343 | 2.096 |

** Significant at 0.01 level of probability; * Significant at 0.05 level of probability

**Appendix V. Analysis of variance of the data on length of largest leaf of cauliflower as influenced by different plant spacing and micronutrients**

| Source of variation | Degrees of freedom | Mean square | | | | |
|---|---|---|---|---|---|---|
| | | Length of largest leaf (cm) at | | | | |
| | | 30 DAT | 40 DAT | 50 DAT | 60 DAT | Harvest |
| Replication | 2 | 0.269 | 1.272 | 1.424 | 0.201 | 1.274 |
| Plant spacing (A) | 2 | 11.366** | 27.435** | 42.345** | 34.288** | 55.234** |
| Micronutrients (B) | 3 | 8.134** | 22.166** | 88.156** | 67.156** | 196.134** |
| Interaction (A×B) | 6 | 5.512** | 9.345** | 32.122** | 38.344** | 38.234** |
| Error | 22 | 1.175 | 1.836 | 6.252 | 8.854 | 8.170 |

** Significant at 0.01 level of probability; * Significant at 0.05 level of probability

**Appendix VI. Analysis of variance of the data on yield attributes of cauliflower as influenced by different plant spacing and levels of micronutrients**

| Source of variation | Degrees of freedom | Mean square | | | | | |
|---|---|---|---|---|---|---|---|
| | | Days to curd initiation | Length of stem (cm) | Diameter of stem (cm) | Fresh weight of leaves per plant (g) | Length of root (cm) | Fresh weight of roots per plant (g) |
| Replication | 2 | 0.778 | 1.308 | 0.062 | 101.553 | 0.932 | 0.993 |
| Plant spacing (A) | 2 | 26.267* | 58.228** | 1.234** | 2389.334** | 32.155** | 64.234** |
| Micronutrients (B) | 3 | 97.134** | 112.459** | 1.978** | 6395.06** | 46.456** | 27.567** |
| Interaction (A×B) | 6 | 64.345** | 39342** | 0.145* | 808.133* | 15.345** | 12.455** |
| Error | 22 | 6.565 | 3.564 | 0.081 | 278.048 | 2.653 | 3.048 |

** Significant at 0.01 level of probability; * Significant at 0.05 level of probability

**Appendix VII. Analysis of variance of the data on yield attributes and yield of cauliflower as influenced by different plant spacing and micronutrients**

| Source of variation | Degrees of freedom | Mean square | | | | | |
|---|---|---|---|---|---|---|---|
| | | Dry matter content of leaves (%) | Dry matter content of curd (%) | Diameter of curd (cm) | Curd yield per plant (kg) | Curd yield per plot (kg) | Curd yield per hectare (ton) |
| Replication | 2 | 0.138 | 0.028 | 0.136 | 0.000 | 0.042 | 0.325 |
| Plant spacing (A) | 2 | 1.455** | 4.567** | 3.435** | 0.856** | 9.986** | 72.455** |
| Micronutrients (B) | 3 | 8.456** | 3.897** | 3.897** | 0.495** | 107.544** | 831.234** |
| Interaction (A×B) | 6 | 0.956** | 10.355** | 0.998** | 0.057** | 4.967** | 43.454** |
| Error | 22 | 0.202 | 0.688 | 0.211 | 0.002 | 0.611 | 4.727 |

** Significant at 0.01 level of probability; * Significant at 0.05 level of probability

## Appendix VIII. Per hectare production cost of cauliflower

### A. Input cost

| Treatment Combination | Labour cost | Ploughing cost | Seed Cost | Water for plant Establishment | Manure and fertilizers | | | | | Insecticide/ pesticides | Sub total (A) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Cowdung | Urea | TSP | MP | B and Mo | | |
| $S_1T_0$ | 52,000 | 35,000 | 16,000 | 28,000 | 25,000 | 1,200 | 3,000 | 2,700 | 0.00 | 13,000 | 175,900 |
| $S_1T_1$ | 52,000 | 35,000 | 16,000 | 28,000 | 25,000 | 1,200 | 3,000 | 2,700 | 330.00 | 13,000 | 176,230 |
| $S_1T_2$ | 52,000 | 35,000 | 16,000 | 28,000 | 25,000 | 1,200 | 3,000 | 2,700 | 585.00 | 13,000 | 176,485 |
| $S_1T_3$ | 52,000 | 35,000 | 16,000 | 28,000 | 25,000 | 1,200 | 3,000 | 2,700 | 840.00 | 13,000 | 176,740 |
| $S_2T_0$ | 52,000 | 35,000 | 16,000 | 28,000 | 25,000 | 1,200 | 3,000 | 2,700 | 0.00 | 13,000 | 175,900 |
| $S_2T_1$ | 52,000 | 35,000 | 16,000 | 28,000 | 25,000 | 1,200 | 3,000 | 2,700 | 330.00 | 13,000 | 176,230 |
| $S_2T_2$ | 52,000 | 35,000 | 16,000 | 28,000 | 25,000 | 1,200 | 3,000 | 2,700 | 585.00 | 13,000 | 176,485 |
| $S_2T_3$ | 52,000 | 35,000 | 16,000 | 28,000 | 25,000 | 1,200 | 3,000 | 2,700 | 840.00 | 13,000 | 176,740 |
| $S_3T_0$ | 52,000 | 35,000 | 16,000 | 28,000 | 25,000 | 1,200 | 3,000 | 2,700 | 0.00 | 13,000 | 175,900 |
| $S_3T_1$ | 52,000 | 35,000 | 16,000 | 28,000 | 25,000 | 1,200 | 3,000 | 2,700 | 330.00 | 13,000 | 176,230 |
| $S_3T_2$ | 52,000 | 35,000 | 16,000 | 28,000 | 25,000 | 1,200 | 3,000 | 2,700 | 585.00 | 13,000 | 176,485 |
| $S_3T_3$ | 52,000 | 35,000 | 16,000 | 28,000 | 25,000 | 1,200 | 3,000 | 2,700 | 840.00 | 13,000 | 176,740 |

$S_1$: 50 cm × 50 cm
$S_2$: 50 cm × 40 cm
$S_3$: 50 cm × 30 cm

$T_0$: $B_0Mo_0$ kg/ha
$T_1$: $B_{1.0}Mo_{0.5}$ kg/ha
$T_2$: $B_{2.0}Mo_{1.0}$ kg/ha
$T_3$: $B_{3.0}Mo_{1.5}$ kg/ha

**Appendix VIII. Per hectare production cost of cauliflower (contd')**

**B. Overhead cost (Tk./ha)**

| Treatment Combination | Cost of lease of land (12% of value of land Tk. 16,00000/year | Miscellaneous cost (Tk. 5% of the input cost | Interest on running capital for 6 months (Tk. 12% of | Sub total (Tk) (B) | Total cost of production (Tk./ha) [Input cost (A)+ overhead cost (B)] |
|---|---|---|---|---|---|
| $S_1T_0$ | 96,000 | 8,795 | 16,842 | 121,637 | 297,537 |
| $S_1T_1$ | 96,000 | 8,812 | 16,862 | 121,674 | 297,904 |
| $S_1T_2$ | 96,000 | 8,824 | 16,879 | 121,703 | 298,188 |
| $S_1T_3$ | 96,000 | 8,837 | 16,895 | 121,732 | 298,472 |
| $S_2T_0$ | 96,000 | 8,795 | 16,842 | 121,637 | 297,537 |
| $S_2T_1$ | 96,000 | 8,812 | 16,862 | 121,674 | 297,904 |
| $S_2T_2$ | 96,000 | 8,824 | 16,879 | 121,703 | 298,188 |
| $S_2T_3$ | 96,000 | 8,837 | 16,895 | 121,732 | 298,472 |
| $S_3T_0$ | 96,000 | 8,795 | 16,842 | 121,637 | 297,537 |
| $S_3T_1$ | 96,000 | 8,812 | 16,862 | 121,674 | 297,904 |
| $S_3T_2$ | 96,000 | 8,824 | 16,879 | 121,703 | 298,188 |
| $S_3T_3$ | 96,000 | 8,837 | 16,895 | 121,732 | 298,472 |

$S_1$: 50 cm × 50 cm
$S_2$: 50 cm × 40 cm
$S_3$: 50 cm × 30 cm

$T_0$: $B_0Mo_0$ kg/ha
$T_1$: $B_{1.0}Mo_{0.5}$ kg/ha
$T_2$: $B_{2.0}Mo_{1.0}$ kg/ha
$T_3$: $B_{3.0}Mo_{1.5}$ kg/ha

**Appendix IX. Effect of different plant spacing and levels of micronutrients on plant height at different days after transplanting (DAT) and harvest of cauliflower**

| Treatment | Plant height (cm) at | | | | |
|---|---|---|---|---|---|
| | 15 DAT | 30 DAT | 45 DAT | 60 DAT | Harvest |
| **Different plant spacing** | | | | | |
| $S_1$ | 20.47 b | 25.54 b | 32.56 b | 42.38 b | 46.56 c |
| $S_2$ | 21.64 ab | 29.10 a | 39.67 a | 49.74 a | 55.87 b |
| $S_3$ | 22.98 a | 30.26 a | 40.92 a | 51.56 a | 59.84 a |
| **$LSD_{(0.05)}$** | **1.368** | **1.596** | **1.643** | **2.639** | **2.413** |
| **Level of significance** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** |
| **Levels of micronutrients** | | | | | |
| $T_0$ | 17.48 c | 22.42 c | 29.86 d | 40.36 d | 45.00 c |
| $T_1$ | 21.02 b | 28.38 b | 37.62 c | 45.87 c | 53.57 b |
| $T_2$ | 24.93 a | 32.69 a | 43.24 a | 54.46 a | 61.89 a |
| $T_3$ | 23.35 a | 29.72 b | 40.13 b | 50.88 b | 55.89 b |
| **$LSD_{(0.05)}$** | **1.579** | **1.843** | **1.897** | **3.048** | **2.786** |
| **Level of significance** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** |
| **CV(%)** | **8.64** | **7.17** | **5.15** | **6.51** | **5.27** |

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

$S_1$: 50 cm × 50 cm
$S_2$: 50 cm × 40 cm
$S_3$: 50 cm × 30 cm

$T_0$: $B_0Mo_0$ kg/ha
$T_1$: $B_{1.0}Mo_{0.5}$ kg/ha
$T_2$: $B_{2.0}Mo_{1.0}$ kg/ha
$T_3$: $B_{3.0}Mo_{1.5}$ kg/ha

**Appendix X. Effect of different plant spacing and levels of on nu micronutrients number of leaves per plant at different days after transplanting (DAT) and harvest of cauliflower**

| Treatment | Number of leaves per plant at | | | | |
|---|---|---|---|---|---|
| | 30 DAT | 40 DAT | 50 DAT | 60 DAT | Harvest |
| **Different plant spacing** | | | | | |
| $S_1$ | 5.72 ab | 8.28 ab | 13.55 ab | 16.40 ab | 17.67 a |
| $S_2$ | 6.00 a | 8.59 a | 14.32 a | 17.85 a | 18.00 a |
| $S_3$ | 4.28 b | 6.54 b | 12.10 c | 14.68 c | 16.53 b |
| **$LSD_{(0.05)}$** | **0.400** | **0.508** | **0.535** | **1.226** | **0.497** |
| **Level of significance** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** |
| **Levels of micronutrients** | | | | | |
| $T_0$ | 4.60 c | 6.69 c | 11.09 c | 11.62 c | 14.00 d |
| $T_1$ | 5.38 b | 7.64 b | 13.29 b | 16.47 b | 17.71 c |
| $T_2$ | 5.71 a | 8.49 a | 14.47 a | 18.60 a | 19.27 a |
| $T_3$ | 5.44 a | 7.69 b | 13.44 b | 16.56 b | 18.62 b |
| **$LSD_{(0.05)}$** | **0.461** | **0.587** | **0.618** | **1.416** | **0.574** |
| **Level of significance** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** |
| **CV(%)** | **9.57** | **8.09** | **5.13** | **9.46** | **6.58** |

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

$S_1$: 50 cm × 50 cm
$S_2$: 50 cm × 40 cm
$S_3$: 50 cm × 30 cm

$T_0$: $B_0Mo_0$ kg/ha
$T_1$: $B_{1.0}Mo_{0.5}$ kg/ha
$T_2$: $B_{2.0}Mo_{1.0}$ kg/ha
$T_3$: $B_{3.0}Mo_{1.5}$ kg/ha

**Appendix XI. Effect of different plant spacing and levels of micronutrients on length of largest leaf at different days after transplanting (DAT) and harvest of cauliflower**

| Treatment | Length of largest leaf (cm) at | | | | |
|---|---|---|---|---|---|
| | 30 DAT | 40 DAT | 50 DAT | 60 DAT | Harvest |
| **Different plant spacing** | | | | | |
| $S_1$ | 14.25 a | 23.64 a | 36.98 a | 40.72 a | 45.36 a |
| $S_2$ | 14.72 a | 25.18 a | 34.15 a | 39.83 a | 42.75 a |
| $S_3$ | 12.12 b | 20.43 b | 28.52 b | 36.53 b | 37.47 b |
| **$LSD_{(0.05)}$** | **0.766** | **1.914** | **2.796** | **1.507** | **2.507** |
| **Level of significance** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** |
| **Levels of micronutrients** | | | | | |
| $T_0$ | 11.80 b | 16.04 c | 26.91 b | 34.20 c | 32.10 c |
| $T_1$ | 13.20 ab | 23.48 b | 33.80 a | 39.19 b | 41.93 b |
| $T_2$ | 14.78 a | 27.06 a | 36.42 a | 41.88 a | 47.57 a |
| $T_3$ | 14.02 a | 25.16 ab | 34.73 ab | 40.84 ab | 44.85 ab |
| **$LSD_{(0.05)}$** | **0.884** | **2.210** | **3.228** | **1.741** | **2.895** |
| **Level of significance** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** |
| **CV(%)** | **7.12** | **10.72** | **10.58** | **4.45** | **7.25** |

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

$S_1$: 50 cm × 50 cm
$S_2$: 50 cm × 40 cm
$S_3$: 50 cm × 30 cm

$T_0$: $B_0Mo_0$ kg/ha
$T_1$: $B_{1.0}Mo_{0.5}$ kg/ha
$T_2$: $B_{2.0}Mo_{1.0}$ kg/ha
$T_3$: $B_{3.0}Mo_{1.5}$ kg/ha

**Appendix XII. Effect of different plant spacing and levels of on length of stem and curd micronutrients yield per plot of cauliflower**

| Treatment | Length of stem (cm) | Curd yield per plot (kg) |
|---|---|---|
| **Different plant spacing** | | |
| $S_1$ | 22.69 a | 12.60 b |
| $S_2$ | 21.76 ab | 14.36 a |
| $S_3$ | 18.66 b | 13.10 b |
| **$LSD_{(0.05)}$** | **1.599** | **0.662** |
| **Level of significance** | **0.01** | **0.01** |
| **Levels of micronutrients** | | |
| $T_0$ | 14.39 c | 8.79 d |
| $T_1$ | 21.83 b | 12.84 c |
| $T_2$ | 24.21 a | 16.87 a |
| $T_3$ | 22.73 ab | 14.92 b |
| **$LSD_{(0.05)}$** | **1.844** | **0.765** |
| **Level of significance** | **0.01** | **0.01** |
| **Combined effect of different plant spacing and micronutrients** | | |
| $S_1T_0$ | 12.80 e | 7.32 e |
| $S_1T_1$ | 23.27 bc | 11.88 d |
| $S_1T_2$ | 26.56 ab | 15.96 b |
| $S_1T_3$ | 24.41 abc | 15.24 bc |
| $S_2T_0$ | 12.96 e | 8.48 e |
| $S_2T_1$ | 25.42 abc | 15.04 bc |
| $S_2T_2$ | 27.82 a | 18.56 a |
| $S_2T_3$ | 24.56 abc | 15.36 bc |
| $S_3T_0$ | 17.40 d | 10.56 d |
| $S_3T_1$ | 16.79 d | 11.60 d |
| $S_3T_2$ | 18.25 d | 16.08 b |
| $S_3T_3$ | 22.21 c | 14.16 c |
| **$LSD_{(0.05)}$** | **3.197** | **1.325** |
| **Level of significance** | **0.01** | **0.01** |
| **CV(%)** | **8.19** | **5.86** |

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

$S_1$: 50 cm × 50 cm
$S_2$: 50 cm × 40 cm
$S_3$: 50 cm × 30 cm

$T_0$: $B_0Mo_0$ kg/ha
$T_1$: $B_{1.0}Mo_{0.5}$ kg/ha
$T_2$: $B_{2.0}Mo_{1.0}$ kg/ha
$T_3$: $B_{3.0}Mo_{1.5}$ kg/ha