Journal of Agriculture and Ecology Research International

16(1): 1-10, 2018; Article no.JAERI.44192
ISSN: 2394-1073

Growth and Yield Attributes of Cauliflower as Influenced by Micronutrients and Plant Spacing

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Authors' contributions

This work was carried out in collaboration between all authors. Authors MNHS, ET and JA designed the study, performed the statistical analysis, wrote the protocol and first draft of the manuscript. Authors MNI and ET managed the analyses of the study. Author MRH managed the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JAERI/2018/44192
Editor(s):
(1) Dr. N. Karunakaran, Department of Economics and Vice-Principal, EK Nayanar Memorial Govt. College, Elerithattu, India.
(2) Dr. Chandra Shekhar Kapoor, Department of Environmental Sciences, University College of Science, Mohan Lal Sukhadia University, India.
Reviewers:
(1) R. K. Mathukia, College of Agriculture, Junagadh Agricultural University, Junagadh, Gujarat, India.
(2) Nebi Bilir, Forestry Faculty of Suleyman Demirel University, Turkey.
Complete Peer review History: http://www.sciencedomain.org/review-history/26716

Original Research Article

Received 19 July 2018
Accepted 09 October 2018
Published 20 October 2018

ABSTRACT

The experiment was conducted in the Central Farm, Sher-e-Bangla Agricultural University, Dhaka from November 2015 to February 2016 with the aim of investigating the growth and yield attributes of cauliflower as influenced by different micronutrients and plant spacing. 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 experiment was laid out in Randomized Complete Block Design with three replications. All the studied parameters were significantly influenced by micronutrients and plant spacing. 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. In case of combined effect, the highest curd yield (51.56 t/ha) was obtained from

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S_2T_2 and the lowest curd yield (20.33 t/ha) from S_1T_0. Therefore, it can be suggested that the highest curd yield and good shape cauliflower curd can be obtained in plant spacing 50 cm × 40 cm with the combined application of B 2.0 kg/ha and Mo 1.0 kg/ha.

Keywords: Growth; yield; micronutrients; spacing; cauliflower.

1. INTRODUCTION

Cauliflower (*Brassica oleraceae* var. *botrytis* L.) is one of the most popular cruciferous vegetable crops cultivated for its white curds as edible part. 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 [1]. Cauliflower is a very tasty and much popular vegetable in Bangladesh as well as all over the world. Due to the increasing consumption of cauliflower products, the crop is becoming promising. Although Bangladesh is producing a good amount of cauliflower and it is using for the preparation of different delicious food but the average yield of cauliflower is low in Bangladesh compared to other countries. Plant density as management practices and micronutrients is prerequisite for increasing the production of cauliflower in Bangladesh [2]. Plant spacing is an important aspect of crop production for maximising the yield [3]. 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 up to 25% by using optimum spacing [4]. Cauliflower responds well to macronutrients–nitrogen, phosphorus and potassium. However, micronutrients are also essential for its proper growth and yield especially boron and molybdenum [3]. 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 [5]. On the other hand, due to boron deficiency water soaked areas appear on the stem and head surface, gradually the stem becomes hollow and curd turns brown. Again the molybdenum deficiency appears on young plant with chlorosis of leaf margins and gradually the whole leaf turns white. They also become cupped and wither, eventually. The leaf dies and the growing point also collapses [6]. It was known that there could be many genetic and environmental effects on the yield [7]. 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 to find out the suitable combination of plant spacing and micronutrients which can ameliorate the growth and yield attributes of cauliflower.

2. MATERIALS AND METHODS

2.1 Experimental Site

The experiment was conducted at the Central farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh from November 2015 to February 2016. The location of the experimental site was $23^0 74^/$N latitude and $90^0 35^/$E longitude and at an elevation of 8.2 m from sea level. The climate of experimental site was under the subtropical climate, characterised by three distinct seasons, the winter season from November to February and the pre-monsoon or hot season from March to April and the monsoon period from May to October. The soil of the experimental area belongs to the Modhupur Tract (AEZ No 28). It had shallow red brown terrace soil. The selected plot was medium high land, and the soil series was Tejgaon.

2.2 Planting Material

The seeds of cauliflower *cv.* Snowball were collected from the Seed Wing, BADC (Bangladesh Agriculture Development Corporation), Dhaka.

2.3 Experimental Design and Treatments

The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. 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. 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 soil was having a texture of sandy loam with pH and organic matter 6.1 and 1.18%, respectively. Total

N (%), available P (µg/g), exchangeable K (meq/100g) were 0.091, 16.0 and 0.32 respectively. The micronutrients i.e. boron and molybdenum were applied as three consecutive foliar spray at 30, 40 and 50 days after transplanting (DAT) as per treatments. The sources of micronutrients boron and molybdenum were obtained from Borax (contain 11% boron) and Ammonium molybdate (contain 98.99% tracer element).

2.4 Growth Condition of Cauliflower & Measurements of Parameters

Seedlings were grown following proper methods and all of the cultural practices were done properly. Seeds (5g) were sown in the well prepared seedbed (3×1) m^2 on November 01, 2015. Application of manure and fertilisers were applied as per treatment. The crop was grown with the recommended dose of N: P: K (138:96:150 kg/ha) and FYM@ 20 ton/ha. Full dose of phosphorus, potash and half dose of nitrogen were applied as soil application before transplanting. The remaining half dose of nitrogen was applied at 30 days after transplanting (DAT). Healthy and uniform seedlings of 20 days old seedlings were transplanting in the experimental plots on 20 November, 2015. Intercultural practices *viz.* gap filling, weeding, earthing up, irrigation, pest and disease control etc. were done as per requirements. The hand weeding was done 15, 30 and 45 days after transplanting to keep the plots free from weeds. For controlling leaf caterpillars Nogos @ 1 ml/L water were applied two times at an interval of 10 days starting soon after the appearance of infestation. All cauliflower curd was not matured at a same time, harvesting was done at 15 February to 02 March. Different yield contributing data have been recorded from the mean of five harvested plants which was selected at random of each unit plot of every harvesting stage.

2.5 Data Collection and Analysis

Five plants were randomly selected from each unit plot for the collection of data. The plants in the outer rows and the extreme end of the middle rows were excluded from the random selection to avoid the border effect. The height of the plants was measured from the ground level to the tip of the highest leaves using a meter scale. Dry matter content of leaves and curd was measured with the formula -Dry matter content of (leaves/curd) = [Dry weight /Fresh weight] × 100. At first leaves and curd were cut into pieces and was dried under sunshine for 3 days and then dried in an oven at 70°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 and then measured with the above formula. The data obtained for different parameters were statistically analysed to find out the significance difference of variety and different fertiliser application on yield and yield contributing characters of cabbage. The mean values of all the characters were calculated, and analysis of variance was performing by the 'f' (variance ratio) test. The significance of the difference among the treatment combinations means was estimated by the duncan's multiple range test (dmrt) at 5% level of probability [8].

3. RESULTS AND DISCUSSION

3.1 Plant Height

Plant height of cauliflower showed significant influence due to different plant spacing at 30, 40, 50, 60 DAT and at harvest (Fig. 1). The significantly superior 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 (Fig.1). The variation in plant height as influenced by spacing was perhaps due to proper utilisation of nutrient, moisture and light. Rahman et al. [3] reported the maximum plant height (49.33 cm) where the plants were spaced 45×50 cm apart.

During the 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 (Fig. 2). At the time of harvest, 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) treatments and they were statistically similar, whereas the shortest plant (45.00 cm) was recorded from T_0 (B_0Mo_0 i.e. control) treatment (Fig. 2). The results indicate that the increasing rate of micronutrients significantly increase the plant height. Thakur et al. [9] reported that application of boron increased the plant height of cauliflower and our finding is in agreement with their findings.

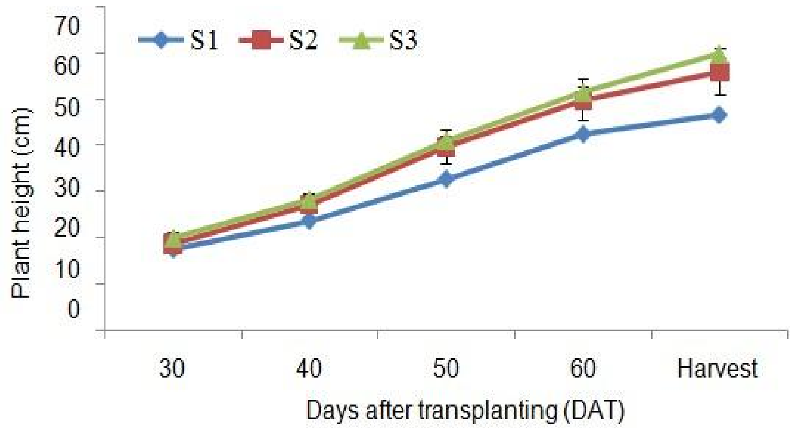

Fig. 1. Effect of different plant spacing on plant height of cauliflower at different DAT

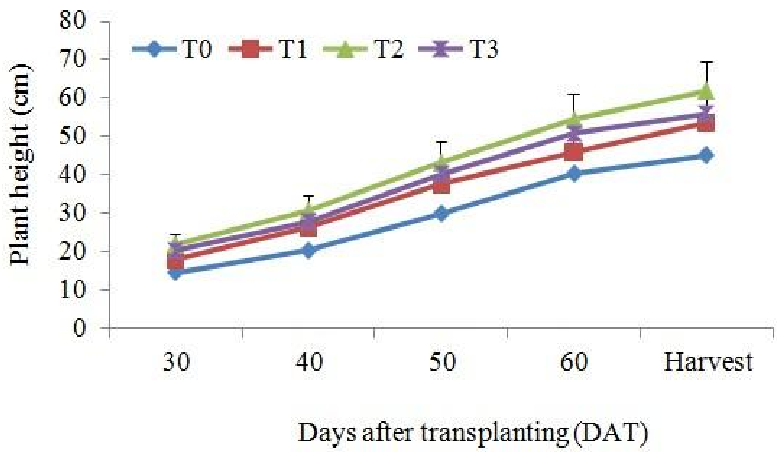

Fig. 2. Effect of micronutrients on plant height of cauliflower at different DAT

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 (Table 1). 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 1).

3.2 Number of Leaves per Plant

The number of leaves per plant of cauliflower was significantly influenced by the different plant spacing at 30, 40, 50, 60 DAT and at harvest (Fig. 3). An increasing trend in the number of leaves per plant was found up to harvest for all the 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 (Fig.3) 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 reported by Kannan et al. [2].

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 (Fig. 4). 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 (Fig 4). Thakur et al. [9] reported that application of boron increased the number of leaves per plant of cauliflower. Sharma [10] in cauliflower, who stated that the probable reasons for enhanced plant height and the number of leaves, may be due to promoting effects of molybdenum on vegetative growth which ultimately lead to more photosynthetic activities. Similar findings were also reported by Singh and Rajput [11], Muthoo et al. [12], Rahman et al. [13].

The 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 (Table 2). At harvest, the highest number of leaves per plant (20.27) was recorded from S_2T_2 whereas the lowest number of leaves per plant (13.53) was found from S_1T_0 treatment combination (Table 2). Ningawale et al. [6] reported that the number of leaves/plant increased significantly with the different treatments of boron and molybdenum at every stage of observations and our findings is in conformity with their findings.

3.3 Days to Curd Initiation

Days to curd initiation of cauliflower showed significant differences due to different plant spacing (Table 3). 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 3). The maximum days required for curd initiation in wider spacing might be attributed due to the less interplant competition, which resulted in the better vegetative growth of plants. Similar result was observed by Kannan et al. [2].

Statistically significant variation was recorded for micronutrients in terms of days to curd initiation of cauliflower (Table 3). The maximum days to curd initiation (59.22) was found from T_0 treatment whereas the minimum days to curd initiation (48.00) was recorded from T_2 treatment (Table 3). The combined effect of different plant spacing and micronutrients combination showed a significant variation on days to curd initiation of cauliflower (Table 4). 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 4). It was observed that the curd initiation period required in plants decreased with the increasing levels of micronutrients application.; This might be due to the positive role played by the regulating micronutrients in the balanced absorption of nutrients might improve physiological activities, which resulted in the

Table 1. Combined effect of different plant spacing and micronutrients on plant height at different days after transplanting (DAT) and harvest of cauliflower

Treatments	Plant height 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 b-d	40.22 cd	49.81 c	58.28 c-e
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
CV (%)	8.64	7.17	5.15	6.51	5.27

In a column, means followed by same letter (s) do not differ significantly at 5% level of probability, 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

Table 2. Combined effect of different plant spacing and micronutrients on number of leaves per plant at different 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 c-e	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
CV (%)	9.57	8.09	5.13	9.46	6.58

In a column, means followed by same letter (s) do not differ significantly at 5% level of probability, 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.

Table 3. Effect of different plant spacing on yield attributes and yields of cauliflower

Treatments	Days to curd initiation	Dry matter content of leaves (%)	Dry matter content of curd (%)	Diameter of curd (cm)	Curd yield/plant (kg)	Curd yield hectare (ton)
S_1	57.50 a	12.24 ab	13.29 ab	9.07 a	1.05 a	35.00 b
S_2	53.75 b	12.57 a	13.93 a	8.21 b	0.90 b	39.89 a
S_3	49.42 c	11.90 b	12.69 b	8.10 b	0.55 c	36.39 b
LSD(0.05)	3.812	0.379	0.703	0.390	0.038	1.840
CV (%)	8.16	4.39	6.75	4.87	5.31	5.86
			Treatments			
T_0	59.22 a	10.84 c	12.56 c	7.56 c	0.53 d	24.41 d
T_1	53.78 b	12.37 b	13.24 b	8.43 b	0.80 c	35.67 c
T_2	48.00 c	12.94 a	14.10 a	9.00 a	1.05 a	46.85 a
T_3	53.89 b	12.79 ab	13.31 ab	8.85 ab	0.94 b	41.44 b
LSD(0.05)	4.402	0.439	0.811	0.449	0.044	2.125
CV (%)	8.16	4.39	6.75	4.87	5.31	5.86

In a column, means followed by same letter (s) do not differ significantly at 5% level of probability, 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.

endogenous growth hormone synthesis responsible for early curd formation in plants. The present result is in agreement with the findings of Kumar and Choudhary [14].

3.4 Dry Matter Content of Leaves

Dry matter content of leaves of cauliflower showed significant differences due to different plant spacing (Table 3). 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 3). Statistically, significant variation was recorded for micronutrients in terms of dry matter content of leaves of cauliflower (Table 3). The highest dry matter content of leaves (12.94%) was found from T_2 treatment whereas the lowest dry matter content of leaves (10.84 g) was recorded from T_0 treatment (Table 3). Mengel and Kirkby [15] reported similar kind or of results. The combined effect of different plant spacing and micronutrients showed a significant variation on dry matter content of leaves of cauliflower

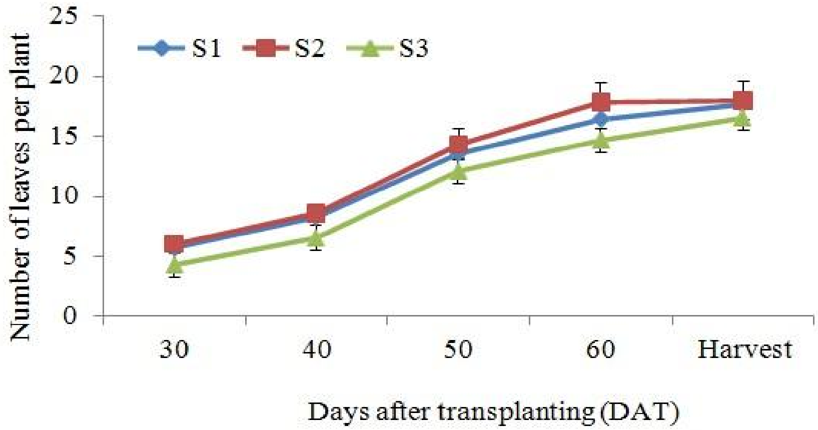

Fig. 3. Effect of plant spacing on number of leaves per plant at different DAT and harvest of cauliflower

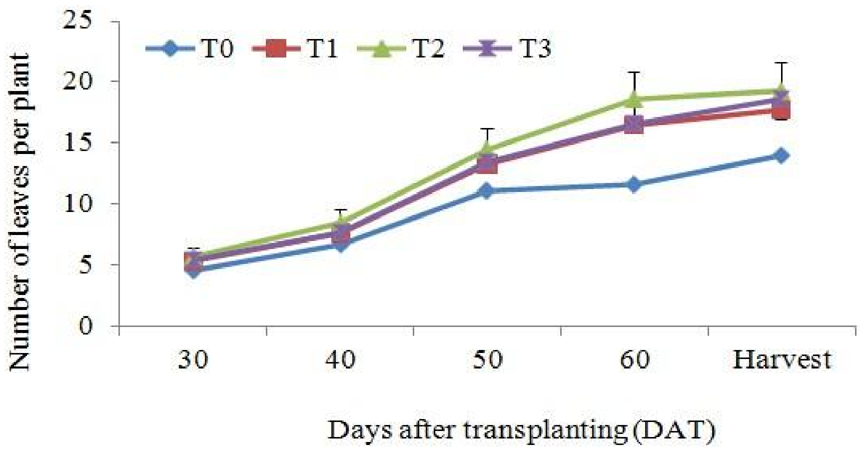

Fig. 4. Effect of micronutrients on number of leaves per plant at different DAT and harvest of cauliflower

(Table 4). The highest dry matter content of leaves (13.62 %) was recorded from S_2T_2 while the lowest dry matter content of leaves (10.49%) was observed from S_1T_0 treatment combination (Table 4).

3.5 Dry Matter Content of Curd

It is obvious from the Table 3 that the dry matter content of curd significantly influenced by the different plant spacing. The maximum 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 3). Statistically significant variation was recorded for micronutrients in terms of dry matter content of leaves of cauliflower (Table 3). The highest dry matter content of curd (14.10%) was found from T_2 treatment whereas the lowest dry matter content of curd (12.56%) from T_0 treatment (Table 3). Thakur et al. [9] reported that application of boron increased the dry matter content of cauliflower.

Combined effect of different plant spacing and micronutrients showed statistically significant variation on dry matter content of curd of cauliflower (Table 4). 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 4). This increase might be due to the collective effect of boron and molybdenum.

Boron plays role in enhancing the translocation of carbohydrates from the site of synthesis to reproductive tissues in the curd, whereas, molybdenum stimulates the photosynthesis and enhance the metabolic process. Such a significant response of micronutrients has also been reported by Kotur [16], Farag et al. [17], Singh [18], Chattopadhyay and Mukhopadhyay [19].

3.6 Diameter of Curd

The diameter of curd of cauliflower showed significant differences due to different plant spacing (Table 3). 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. 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 the formation of small curd. Kannan et al. [2], Rahman et al. [3] reported similar kind or result and our findings is in corroboration with their findings. Statistically, significant variation was recorded for micronutrients in terms of diameter of curd of cauliflower (Table 3). The highest diameter of curd (9.00 cm) was found from T_2 treatment whereas the lowest diameter of curd (7.56 cm) from T_0 treatment (Table 3). Kumar and Choudhary [14] reported that B and Mo application significantly increased curd diameter of cauliflower. Combined effect of different plant spacing and micronutrients showed statistically significant variation on diameter of curd of cauliflower (Table 4). The highest diameter of curd (9.90 cm) was recorded from S_1T_2 treatment combination while the lowest diameter of curd (7.07 cm) was observed from S_3T_0 treatment combination (Table 4). 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. Similar results have been reported by Kotur [16], Singh [18], Kumar and Choudhary [14], Prasad and Yadav [20].

3.7 Curd Yield per Plant

Weight of curd per plant of cauliflower showed significant differences due to different plant spacing (Table 3). 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 3). Similar kind or result was reported by Kannan et al. [2], Rahman et al. [3]. Statistically significant variation was recorded for micronutrients in terms of weight of curd per plant of cauliflower (Table 3). The highest weight of curd per plant (1.05 kg) was found from T_2 treatment whereas the lowest weight (0.53 kg) from T_0 treatment which was followed (0.80 kg) by T_1 treatment (Table 3). Thakur et al. [9] reported that the application of boron increased the curd yield of cauliflower. In case of combined effect of different plant spacing and micronutrients, statistically significant variation on curd yield per plant of cauliflower was found (Table 4). 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 4). Increase in yield might be due to the combined application of boron and molybdenum at optimum levels under deficient condition increased uptake of major nutrients which resulted in sturdy plant growth and increased yield and quality. Present result confirms findings of Singh [18] who found maximum yield with the combined foliar application of boron and molybdenum in cauliflower.

3.8 Curd Yield per Hectare

Curd yield per hectare of cauliflower showed significantly significant differences due to different plant spacing (Table 3). 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 (Table 3). The crops grow in such close spacing yield more though main heads are smaller and these mature slightly later that case optimum spacing is followed. Rahman et al. [3], Farzana et al. [21] reported the maximum yield of cauliflower where the plants were spaced 45×50 cm apart.

Statistically significant variation was recorded for micronutrients in terms of curd yield per hectare of cauliflower (Table 3). The highest curd yield (46.85 t/ha) was found from T_2 treatment which was closely followed by (41.44 t/ha) T_3 treatment, whereas the lowest curd yield (24.41 t/ha) was recorded from T_0 treatment (Table 3). Kumar and Choudhary [14] reported that B and Mo application

Table 4. Combined effect of different plant spacing and micronutrients on yield attributes and yield of cauliflower

Treatments	Days to curd initiation	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	65.33 a	10.49 f	11.00 d	8.10 de	0.61 de	20.33 e
S_1T_1	61.67 ab	12.36 cd	13.69 bc	9.06 abc	0.99 c	33.00 d
S_1T_2	41.00 f	13.46 ab	14.97 ab	9.90 a	1.33 a	44.33 b
S_1T_3	62.00 ab	12.64 bc	13.48 bc	9.22 a-c	1.27 a	42.33 b
S_2T_0	53.67 b-e	11.12 ef	11.67 d	7.50 ef	0.53 fg	23.56 e
S_2T_1	55.33 b-d	12.57 c	14.41 ab	8.44 cd	0.94 c	41.78 bc
S_2T_2	47.67 def	13.62 a	15.63 a	9.41 ab	1.16 b	51.56 a
S_2T_3	54.33 b-e	12.97 a-c	15.00 ab	7.91 def	0.96 c	42.67 bc
S_3T_0	46.00 ef	10.91 f	14.01 b	7.07 f	0.44 h	29.33 d
S_3T_1	50.33 c-e	12.18 cd	11.62 d	7.81 def	0.48 gh	32.22 d
S_3T_2	55.33 b-d	11.73 de	11.70 d	8.11 de	0.67 d	44.67 b
S_3T_3	58.00 a-c	12.77 bc	12.45 cd	8.98 bc	0.59 ef	39.33 c
LSD(0.05)	7.625	0.758	1.407	0.779	0.076	3.681
CV (%)	8.16	4.39	6.75	4.87	5.31	5.86

In a column, means followed by same letter (s) do not differ significantly at 5% level of probability, 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.

significantly increased curd diameter, weight and yield of cauliflower. Khadka et al. [22] reported the better cauliflower curd from the application of boron.

Combined effect of different plant spacing and micronutrients showed statistically significant variation on curd yield of cauliflower (Table 4). 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 4). These findings are in confirmation with the findings of Kotur [16], Singh [18], Kumar and Choudhary [18], Prasad and Yadav [20], Mahmud et al. [23].

4. CONCLUSION

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 1.0 kg Mo/ha) was more effective than control T_0. Therefore, the results of the investigation suggest that the highest curd yield and good shape cauliflower curd can be obtained, in plant spacing 50 cm × 40 cm with the combined application of B 2.0 kg /ha and Mo 1.0 kg/ha.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sciencedomain.org/review-history/26716