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Planting Date Affects Growth and Yield Performance of Cauliflower (*Brassica oleracea* var. *botrytis*)

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ABSTRACT

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A field experiment was conducted to investigate the effect of different planting time on the growth and yield of cauliflower (*Brassica oleracea* var. *botrytis*) at the Germplasm Centre of Agrotechnology Discipline, Khulna University, Khulna, from September, 2016 to March, 2017. There were four planting times included in the experiment viz., T_1: 15 October, T_2: 15 November, T_3: 15 December, and T_4: 15 January. Data were collected on plant height (cm), number of leaves per plant, leaf length and breadth (cm), curd size (cm), individual plant weight (kg) and yield (t/ha). The tallest plant (81.20 cm), maximum number of leaves (23.60), leaf length (64.40 cm), leaf breadth (24.60 cm) and also curd length (19.80 cm) and breadth (18.00 cm) were recorded from the treatment T_2 (November planting). The economic (67.08 t/ha) and biological yield (87.88 t/ha) were also found to be the highest in the treatment T_2 (November planting) followed by the highest benefit cost ratio (2.15). Therefore, the planting of cauliflower could be done during November in Khulna region to ensure better growth and yield with better economic return.

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INTRODUCTION

Cole crops such as cabbage, cauliflower and knol-khol are biennial crop that are grown as an annual, unless they are grown for seed production (Ryder, 1979; Pierce, 1987). The transition from vegetative to reproductive growth is triggered by temperature. Cole crops are cool season crops, and produces maximum yield when grown in areas of mild winters. The optimum temperature for growth of cole crops varies from 15-18^{o}C. Cole crops can tolerate freezing temperatures but is less tolerant to high temperatures. However, there are some varieties that have been bred for heat tolerance (Tindall, 1979; Hemy, 1984; Pierce, 1987).

Cauliflower (*Brassica oleracea* var. *botrytis*) belonging to the family brassicaceae is one among the most popular vegetable crops cultivated in all around the globe (Swarup, 2006). It enjoys first position among the different cole crops cultivated all over the world (Saravaiya and Patel, 2005). It is grown for its fleshy immature inflorescence which is known as curd and occupies the pride position among cole crops due to its delicious taste, flavour and nutritive value. One cup of boiled cauliflower is an excellent source of vitamin C, folate and dietary fiber. It is originated from wild cabbage (*Brassica oleracea* var. *sylvestris*) and its centre of origin is believed to be the Island of Cyprus (Kohli et al., 2008).

Bangladesh is one of the densely populated countries in the world and its population is increasing day by day. According to the FAO (1988) recommendation, amount of consumption of vegetables is 200g/day/person but the average intake of vegetables in Bangladesh is only 45g day^{-1} person^{-1}.

In Bangladesh cauliflower is generally grown as winter season crop and harvested from September to late-February or early-March. Cauliflower tends to be more exacting in its climatic requirement than the other member of the Brassicaceae. Therefore, it has been established that between 15^{o}C and 20^{o}C the growth would be optimum. Soil with rich humus is crucial because cauliflower tends to have weak root systems and soil with pH between 6.5 and 7.5 is important for best development (Peirce, 1987).

In Bangladesh, more than 30% of the total cultivable area is in the coastal belt. Out of 2.85 million hectares of the coastal and offshore areas, about 0.83 million hectares are affected by different degrees of salinity (Karim et al., 1990). Salinity occurs severely in winter season in which larger area of coastal region remain fallow and dry. Under salinity, plants face both osmotic and ionic stress that ultimately causes reduction in growth (Munns and Tester, 2008). Irrigation water contains soluble salts and in some instances as much as 20 metric tons of salts ha^{-1} are added in this way annually.

The salt affected area is increasing day by day in Bangladesh and about 2.8 million hectares of land under saline area remain fallow for about 4-7 months (middle of November-June) in each year (Karim et al., 1990). Brassica species at germination and early seedling growth stages are affected by salinity (Jamil et al., 2007). Salinity impairs seed germination, reduces nodule formation, retards plant development and reduces crop yield. Salinity is now recognized as a serious issue in south-west coastal region of Bangladesh and has a direct impact on ecological sustainability.

The need to develop crops with higher salt tolerance has increased greatly within the last decade due to increased salinity problem throughout the world. However, in Bangladesh salinity problem is severe in winter though during summer the salt concentration decreases. The yields of winter vegetables are greatly reduced due to the presence of higher soluble salt in soil (Karim et al., 1990). There is ample scope to increase the productivity by planting early when there will be sufficient soil moisture and tolerable level of salinity. Each crop has its own set of optimum planting time under which it can grow efficiently. Knowledge about the relationships between crop growth stages and planting time is very important to maximize the production. For a crop to be successful in a given region, it is very much important to select appropriate planting time to ensure the presence of optimum level of moisture and salinity. In this context, the present study was planned to determine the optimum planting date for maximum growth and yield of the cauliflower for successful cultivation in South-west coastal regions of Bangladesh.

MATERIALS AND METHODS

Experimental site:

The field experiment was conducted at the Germplasm Center of Agrotechnology Discipline, Khulna University, Khulna, during the period from September 2016 to March 2017. Experimental field was located at 89°34' E longitudes and 22°47' N latitude at an altitude of 8 meters above the sea level (FAO, 1988). The site is under the sub-tropical monsoon climate, which is characterized by heavy rainfall during Kharif season (April to September) and scanty of rainfall during rest of the months. Plenty of sunshine and moderately low temperature prevails during Rabi season (October to March), which is suitable for growing cauliflower in Bangladesh.

Experimental materials, design of experiment and treatments:

Cauliflower seed of snowball variety was collected from local market of Khulna, Bangladesh and seedlings were raised in 3m x 1m seedbed at the Germplasm Center, Agrotechnology Discipline, Khulna University, Khulna. Seeds were sown in line at a depth of 1.5-2.0 cm on 15th September, 15th October, 15th November and 15th December, 2016 respectively. Proper care was taken to ensure better germination of the seeds. Seedlings of 4 weeks old were transplanted at the main field. This experiment was laid out in a randomized complete block design (RCBD) with five replications for each treatment. The treatments included four planting times at an interval of 30 days from 15th October to 15th January as follows-

T_1 = planting on: 15th October T_2 = planting on: 15th November T_3 = planting on: 15th December and T_4 = planting on: 15th January

The experimental area was first divided into five blocks which were again divided into 4 unit plots and thus the experiment consists of a total of 20 (4 x 5) unit plots. The size of a unit plot was 2.0 m x 4.0 m. The distance between two plots was 50 cm and a gap between two blocks was maintained as 75 cm.

A spacing of 50cm x 75cm was maintained during transplanting the seedlings. After transplanting of seedlings, various intercultural operations were accomplished for better growth and development of the plants. A few of gaps were filled by healthy seedlings of the same stock where initially planted seedlings failed to survive. Weeding and mulching were accomplished as and when necessary to keep the crop free from weeds and to conserve soil moisture. Irrigation was done daily until the plants were fully established and then every 2 days interval for 2 weeks. It was continued during curd initiation and also in curd enlargement stage.

Harvesting, sampling and data collection:

Harvesting of curds was started at 105 days after transplanting. Data were recorded during harvesting from randomly selected five plants of each plot. Yields were recorded from the whole plot basis. Data were collected on plant height (cm), number of leaves/plant, leaf size (length and breadth) (cm), curd size (length and breadth), and yield (ton/ha). A cost-benefit analysis was made too from the collected data.

Plant height:

Plant height was measured from ground level to the tip of the largest leaf of an individual plant. Mean value of the five selected plants per plot was considered as the height of the plant and was expressed in centimeter.

Number of leaves, leaf length and breadth:

Number of leaves per plant was counted from five randomly selected plants. Length of the leaf was measured from the base of the petiole to the tip of leaf with a scale and was recorded in centimeter. Breadth of the leaf was measured at three positions of the lamina by a meter scale and the average value was recorded.

Size of curd:

Length and breadth of the curd was estimated by slide callipers. The values of these parameters were taken in centimetre (cm).

Yield (ton/ha):

Total curd yield/plot was recorded from each plot. The gross (biological) yield and marketable (economic) yield were calculated from each plot and then converted to t/ha. Yield of whole plot with leaves, curds and stems was considered as biological yield. However yield of edible parts (curd) only was considered as economic yield.

Harvest Index:

Harvest index is the proportion of economic yield with biological yield. It was expressed in percentage.

Cost–benefit analysis and benefit cost ratio:

The cost–benefit analysis was done based on gross returns and cost of production to compare the profitability among the treatments. The benefit cost ratio (BCR) was calculated using following formula-

$$\text{BCR} = \frac{\textit{Gross Return}}{\textit{Cost of Production}}$$

Statistical analysis:
Calculated data on various parameters under study were statistically analyzed using STAR statistical programme. Means for all the treatments were calculated and analyses of variances for all the characters under consideration were performed by F test. Significance of differences between pairs of treatment means were evaluated by New Duncan's Multiple Range Test (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Plant height:
The variation in plant height due to different planting time was statistically significant in cauliflower at harvest stage (Table 1). Maximum plant height was found in the treatment T_2 (November planting) (81.20 cm) that was statistically similar to treatment T_3 (December planting) (78.2 cm). On the other hand, the early (October) or late (January) planting gave minimum and significantly similar plant height (73.6 cm and 69.40 cm respectively). Plant height is one of the important growth contributing characters for cauliflower plant. It depends on several factors like genetic makeup, nutrient availability, planting time, climate, soil, etc. Among those, planting time is one of the important factors for desirable plant height. From the result of the present study it could be said that November planting provide appropriate growing conditions (sufficient soil moisture and optimum ambient temperature) for proper vegetative growth of cauliflower plants which ultimately influenced the plant height. A similar observation was reported by Singh et al. (1999) while they carried out an experiment during winter season to study the effect of transplanting dates in cauliflower at Himachal Pradesh, India. They recorded maximum plant height (79.60 cm) when transplanted on 20th November.

Number of leaves per plant:
The number of leaves produced per plant under different planting time was statistically similar for treatment T_1 (17.00) and T_3 (18.00) (Table 1). The maximum number of leaves per plant was recorded from the treatment T_2 (November planting) (23.60) and the minimum was found from T_4 (January planting) (14.40). Maximum number of leaves was recorded from November planting because, sufficient moisture was present in soil during December to January and the temperature was also optimum to accelerate their vegetative growth. Similar result was also reported by Hossain et al. (2011) where they stated that cauliflower when sown on 15th October produced maximum number of leaves per plant (20.0).

Length of the leaf:
The length of the largest leaf was recorded from the treatment T_2 (November planting) (64.4 cm) and the lowest was found from the treatment T_4 (January planting) (47.2 cm) which was statistically similar to the treatment T_1 (50.20 cm) and T_3 (47.20 cm) (Table 1). From this result it could be revealed that November planting favored the development of leaves which in turn resulted in largest leaf length due to the presence of optimum temperature and moisture in soil. Minimum leaf length was resulted from January planting as the vegetative growth of cole crops was affected from high temperature during vegetative growth.

Breadth of leaf per plant:
The maximum breadth of the leaf was observed from the treatment T_2 (November planting) (24.6 cm) and the minimum was found from the T_4 (January planting) (17.2 cm) which was statistically similar to the treatment T_1 (18.60 cm) and T_3 (15.00 cm) (Table 1). Sufficient moisture was present in soil from December to January and the temperature was also low that favored the November planting cole crops to develop broader leaf. During February to March the temperature gradually increased which affected the vegetative growth of cauliflower that was planted during January.

Length of curd:
Average length of the curd was found to be significantly different for different planting time (Table 1). Largest length of the curd was found in treatment T_2 (November planting) (19.80 cm) which was statistically similar to the treatment T_3 (December planting) (17.00 cm) and the lowest length was recorded from the treatment T_4 (12.60 cm) which was statistically similar for the treatment T_1 (13.60 cm). The development of curd in cauliflower was maximum during November planting as low temperature along with sufficient soil moisture was present during curd formation. While early planting affected from excess moisture and late planting suffered from high temperature.

Breadth of curd:
Average breadth of the curd was found to be significantly different for different planting time (Table 1). Broader breadth of the curd was recorded from treatment T_2 (November planting) (18.00 cm) and the lowest breadth was found in the treatment T_4 (January planting) (11.80 cm) that was statistically similar to treatment T_1 (12.60 cm) and T_3 (15 cm). Broader curd breadth resulted from November planting because, the plant exposed to low temperature at the time of curd formation with adequate soil moisture which favored the development of curd. This data was supported by a study conducted by Thapa and Pati (2003) who recorded maximum curd weight (440.95g) from 5th November planting followed by 20th November in cauliflower.

Economic yield:
Effects of different planting time on economic yields of cauliflower per hectare revealed statistically significant variations. The maximum marketable yield (67.08 t/ha) was found from treatment T_2 (November planting) while the minimum was found from the treatment T_4 (January planting) (43.84 t/ha) (Table 1). From the result of the present study it could be said that November planting provide appropriate growing conditions for both vegetative as well as reproductive growth phases of cauliflower plants due to the presence of sufficient moisture in soil along with low temperature. High temperature and excess moisture reduced the economic yield of cabbage in case of early and late planting. Ajithkumar (2005) conducted a study on cauliflower with three dates of planting at Anand, Gujarat and observed that the 1st November planted crop resulted in more curd yield and biomass compared to the crops planted on 1st December.

Table 1. Effect of different planting time on growth and yield of cauliflower

Treatment (planting date)	Plant Height (cm)	Leaves			Curd		Economic Yield (ton/ha)	Gross Yield (ton/ha)	Harvest Index (%)
		No. of Leaves	Length (cm)	Breadth (cm)	Length (cm)	Breadth (cm)			
T_1	73.60bc	17.00b	50.20b	18.60b	13.60b	12.60bc	50.24c	70.24c	71.37bc
T_2	81.20a	23.60a	64.40a	24.60a	19.80a	18.00a	67.08a	87.88a	76.27a
T_3	78.20ab	18.80b	54.20b	20.20b	17.00a	15.00b	59.92b	81.12b	73.82ab
T_4	69.40c	14.40c	47.20b	17.20b	12.60b	11.80c	43.84d	63.84d	68.48c
LS	**	**	**	**	**	**	**	**	**

**= Significant at 1% level of significance, LS= Level of Significance; T_1- October planting, T_2- November planting, T_3- December planting, T_4- January planting; Means followed by common letter(s) in a column do not differ significantly by DMRT

Table 2. Cost and return analysis in cauliflower production as influenced by different planting time

Treatment	Yield (t/ha)	Gross return ('000 tk/ha)	Total cost of production ('000 tk/ha)	Net income ('000 tk/ha)	Benefit Cost Ratio (BCR)
T_1	50.24	502.4		191.475	1.61
T_2	67.08	670.8	310.925	359.875	2.15
T_3	59.92	599.2		288.275	1.92
T_4	43.84	438.4		127.475	1.40

The price of head @ Tk. 10000 per ton at harvest; T_1- October planting, T_2- November planting, T_3- December planting, T_4- January planting

Biological yield:
Effects of different planting time on biological yields of cauliflower per hectare revealed that variation among different planting time were statistically significant. The maximum biological yield was resulted from T_2 (November planting) (87.88 t/ha) and minimum was from the treatment T_3 (December planting) (63.84 t/ha) (Table 1). From this result it could be said that, besides maximum economic yield November planting also resulted in maximum biological yield as the growing conditions during this period was favorable for cauliflower cultivation in the study area.

Harvest index:
In respect of harvest index the variations among different planting time were statistically significant. The highest harvest index was found in treatment T_2 (November planting) (76.27) that was statistically similar to treatment T_3 (73.82) and minimum harvest index was found from the treatment T_4 (January planting) (68.48) that was statistically similar to treatment T_1 (71.37) (Table 1). Maximum economic and biological yield from November planting resulted in highest harvest index for this treatment.

Economic analysis:
The highest gross return was obtained from the treatment T_2 (November planting) (Tk. 6,70,800.00/ha). The lowest gross return was obtained from treatment T_4 (January planting) (Tk. 4,38,400.00/ha). Maximum net return was Tk. 3,59,875/ha having a benefit cost ratio of 2.15 in the treatment T_2 (November planting). On the other hand, the lowest net return Tk. 1,27,475/ha and benefit cost ratio (1.40) were obtained from the treatment T_4 (January planting). Thus, it was clear that the November planting gave the highest net return in the cauliflower cultivation (Table 2).

CONCLUSION

From the present study it could be concluded that higher yield of cauliflower in Khulna region may be obtained by planting the crop in the month of November.

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