Effect of Planting Time on Growth and Yield of Garlic (*Allium sativum* L.) genotypes

Abstract

A field experiment was conducted at field Laboratory, Horticulture farm, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh during dry season (Ocober to April) to evaluate the effect of planting time on growth and yield of two garlic varieties. The experiment was laid-out with two factors, dates of planting (21 October, 6 November, 21 November and 06 December) and variety (BAU garlic-1 and BAU garlic-2) in RCB design with three replications. Planting time had significant influence on growth, yield attributes and yield of garlic. Plant height, leaf length, leaf number, leaf and root dry weight, bulb diameter, number of cloves per bulb and bulb yield decreased with delay planting. The highest plant height (52.38 cm), leaf length (37.66 cm, number of leaves per plant (7.15), leaf dry weight (1.75 g), bulb diameter (3.89 cm), number of cloves per bulb (22.31) , bulb yield per plant (16.42 g) and per hectare (8.13 t ha^{-1}) obtained from 21 October planting . BAU garlic-2 was relatively better than BAU garlic-1 in terms of yield and yield attributes . Combined effect of planting time and variety showed the highest bulb yield of both varieties from 21 October planting. Early planting of both varieties is better to get maximum yield of garlic.

Key Words: Garlic, growth, plant dry matter, planting time, yield components.

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Introduction

Garlic (*Allium sativum* L.), a member of the Alliaceae family, is one of the most important aromatic herbaceous annual spices (Kurian, 1995). It is the second most widely used spice crop of the cultivated *Allium* crops, next to onion in the world (Purseglove, 1975, Lanzotti 2006) with a characteristic pungent smell. Garlic originated in central Asia (Vvedensky, 1946, Turan *et al*., 2017) from where it was extended to the Mediterranean region in the pre-historic times (Thompson and Kelly, 1957, Turan *et al*., 2017). Garlic is also growing extensively as a spice crop in Bangladesh, but the yield is very low in comparison with the yield of many other countries. The average production of garlic in Bangladesh was about 224 thousand metric tons of garlic from 105 thousand acres of land (BBS, 2013). The yield of garlic

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is relativley lower due to the lack of inadequate cultural management practices in respect of soil water shortage in the soil profile, and due to delay planting (Kabir *et al*., 2016). Moreover, the demand of garlic is increasing day by day in Bangladesh due to its pungent materials and medicinal values or condiment (Shuvra *et al*., 2017). Therefore, the emphasis should be given to increase the production of garlic adopting improved methods of cultivation such as appropriate planting time, growing condition and stress or disease tolerant variety. In this regard planting time plays an important role on the growth, yield attributes and yield of garlic (Shuvra *et al*., 2017).

Garlic is popular globally as a valuable spice for cooking different dishes. Besides, it is also used in preparing the pickles, curry powder, vegetables, tomato ketchup, etc. According to the Unani and Ayurvedic medicines in the treatments of disease like chronic infection of the stomach and intestine, dysentery, typhoid, cholera and lungs disease, garlic is successfully used (Chopra *et al*., 1958; Londhe *et al*., 2011). It contains amino acids which reduce cholesterol levels in human blood. Garlic is known to be thermo and photo-sensitive crop (Jones and Mann, 1963, Shuvra *et al*., 2017) and its vegetative growth and bulb formation are greatly influenced by growing environment (Jones and Mann, 1963; Rahim and Fordham, 1988). Garlic prefers cool weather and grow in a well-drained, moderately clay loam at higher elevation (900 to 1200 meters). In Bangladesh, the growth period of garlic is centered in the cool season. As a result, only early planted crops can utilize full advantages of the cool period. But the farmers of Bangladesh cannot always adopt early planting due to climatic limitations and cropping pattern. For this reason, plants are exposed to increasing high temperature before initiation of clove and during the period of growth and development. So, the yield becomes low and sometimes a percentage of plants fail to initiate bulb at all. Considering the effect of planting time and varieties of garlic the present study was undertaken to find out the appropriate planting time of the two newly released garlic varieties.

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Materials and Methods

Experimental Site

The research experiment was conducted at Field Laboratory in Horticulture Farm, Bangladesh Agricultural University, Mymensingh during October to March to

investigate the effect of planting time on growth and yield of two newly released garlic varieties. The soil of the experimental area was sandy loam and belongs to the old Brahmaputraputra flood plain alluvial tract of agro ecological zone 9 (AEZ-9) having non-calcarious soil. The selected site was a medium high land and the pH of the soil was 6.3 with organic matter content of 1.21 %. Garlic varieties were collected from the Department of Horticulture, Bangladesh Agricultural University, Mymensingh-2202.

Land preparation

The selected experimental plot was first opened in the month of October, by a power tiller. It was then thoroughly prepared by ploughing and cross ploughing with power tiller followed by laddering. During the land preparation, weeds and stubbles of previous were collected and removed. The plot was finally prepared after applying the basal doses of manure and fertilizers. Irrigation and drainage channels were installed around the plots. Recommended doses of manure and fertilizers were applied to the experimental plots for bulb production (Rahim *et al*., 1984). Total amount of well decomposed cowdung (12 ton), Mustard oil cake (2 ton), Urea (130kg), TSP (110 kg) and MP (210 kg) per hectare were applied to the plot during final land preparation of 7 days before planting. Urea and MoP were top dressed in two equal splits at 30 and 60 days after planting.

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3.7 Treatments of the experiment

The research study consisted of the following 3 sets of factors. The treatments are as follows:

Factor A: Planting time:

i) October 21, 2009 (T_1)

ii) November 06, 2009 (T_2)

iii) November 21, 2009 (T3)

iv) December 06, 2009 (T4)

Factor B: (Varieties)

V_1 = BAU garlic -1

V_2 = BAU garlic-2

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Design of the experiment

The experiment was laid out in Randomized complete dock Design (RCBD) with three replications. The treatment combinations were accommodated in individual unit

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plot among the total plots. The size of each unit plot was l m × l.5 m. The spacing between plant to plant 10 cm x 10 cm and row to row ?. The treatment combinations were assigned randomly to the unit plot of each block. The two outer layers of garlic cloves were separated from each mother bulb for planting in the field. One hundred Fifty cloves were planted in each unit plot maintaining spacing of 10 cm ×15 cm. The cloves were dibbled at 2.5 cm depth of soil. Cloves were also planted around the experimental area to check border effect. The experimental area was kept under careful observation. The unsprouted cloves were replaced by healthy seedling taken from border plants within two weeks after planting. The damaged plants were also replaced by healthy border plants planted at the same time. Weeding in the control plots was done regularly to keep them free from weeds. Royal at the rate of 25 gm in 10 liters of water was applied at an interval of 15 days after planting up to one month before harvesting to control purple leaf blotch disease of garlic. Harvesting was done depending on the maturity of the plant starting from April 1 to April 10.

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Collection of data

Ten plants were selected randomly from each unit plot for the collection of data during different growing stages of plants. Data were collected at 30, 60, 75, 105 and 135 days after planting (DAP) in respect of following characters. Plant height (cm) was measured from the ground level to the tip of the longest leaf of the sample plants at 30, 60, 75,105 and 135 DAP. Likewise, leaf length (cm) was measured from the ground level to the tip of the longest leaf of the sample plants. The number of leaves of sample plants was counted. After drying under lab temperature, leaf sample was dried in an oven at 70°C for 72 hrs. till constant weight and average weight (g) was calculated. The fresh root sample was dried at 70°C for 72 hours and dry weight was taken. Alter final harvest, the diameter at middle part of the bulb was taken and the number of cloves of ten bulbs was counted thoroughly. The mean number of cloves was calculated by dividing total number of cloves counted from ten bulbs by ten. After removing the root and top portion keeping only 2.5 cm with neck, the bulb weight of 10 selected plants was taken. Bulb yield (t ha^{-1}) per plot was recorded by harvesting all the bulbs in each plot and taking their weight after removing roots and pseudo stem keeping only 2.5 cm with the neck.

Statistical analysis

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The collected data from the experiment on yield and yield components were statistically analyses following factorial experiment in randomized complete block design. The means for all the treatments were calculated and the analyses of variances for most of the characters under consideration were performed by "F" variance test. The significance of difference between pair of means was expressed as least significant difference (LSD) test taking the probability level of 5% as the minimum level of significance.

Results and Discussion

Effect of planting time and variety on plant characters in garlic

Plant height

Effect of planting time

The effect of planting time on plant height at different days after planting was significant (Table 1). Result revealed that delayed planting decreased plant height at different growth stages. The tallest plant was recorded at 21 October planting in all growth stages (22.99, 32.06, 40.04, 50.89, 52.38cm for 30, 60, 75, 105 and 135 DAP respectively) followed by November planting (21.13, 30.73, 39.56, 51.15 and 51.76 cm for 30, 60, 75, 105 and 135 DAP, respectively). In contrast, the shortest plant was recorded in 06 December planting (12.97, 18.06, 24.74, 38.12 and 44.80 cm for 30, 60, 75, 105 and 135 DAP, respectively). Early planted crops availed favorable environment, longer cool period and shorter day-length, which enhanced meristematic elongation of garlic plant resulting maximum plant height. Similar results were reported by Shuvra *et al*., (2017), Rahim *et al.,* (1984) and Siddique and Rabbani (1985) in garlic.

Effect of variety

The effect of variety on plant height at 30, 60, 75, 105 and 135 days after planting (DAP) of garlic was significant except 75 DAP (Table 1). Results revealed that plant height increased with age. The variety BAU garlic-1 was taller than BAU garlic-2 at different growth stages. Genotypic variations in plant height were observed by Hossain (2003) in garlic who found that BAU garlic-1 was taller than BAU garlic-2.

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Table 1. Effect of variety, planting time on plant height at different days after planting in garlic

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Treatment	Plant height (cm) at				
	30 DAP	60 DAP	75 DAP	105 DAP	135 DAP
Variety					
BAU garlic-1	19.40	27.77	34.98	48.52	51.71
BAU garlic-2	18.37	26.02	34.78	44.50	47.83
Level of significance	**	**	NS	**	**
LSD (0.05)	0.41	0.83	1.03	1.00	0.96
LSD (0.01)	0.55	1.10	1.37	1.33	1.27
Planting time					
21 October	22.99	32.06	40.04	50.89	52.38
06 November	21.13	30.73	39.56	51.15	51.76
21 November	18.46	26.74	34.36	45.88	50.13
06 December	12.97	18.06	24.74	38.12	44.80
Level of significance	**	**	**	**	**
LSD (0.05)	0.54	0.92	1.11	1.16	1.01
LSD (0.01)	0.72	1.22	1.48	1.54	1.35
CV (%)	4.94	5.92	5.55	4.31	3.52

** indicate significant at 1% level of probability

Combined effect of variety and planting time on plant height

The combined effect of variety and planting time on plant height at all growth stage was significant (Table 2). The longest plant was recorded in the treatment combination of BAU garlic-1 with 21 October planting at the growth stages (24.62, 35.22, 41.47, 54.87 and 54.65 cm for 30, 60, 75, 105 and 135 DAP, respectively) followed by BAU garlic- with 06 November planting. On the other hand, the shortest plant was observed in BAU garlic-2 with 06 December planting at different growth stages (11.17, 17.42, 25.02, 35.60 and 43.90 cm for 30, 60, 75, 105 and 135 DAP, respectively).

Table 2. Combined effect of variety and planting time on plant height at different days after transplanting in garlic

Combined	Plant height (cm) at				
(Variety × planting time)	30 DAP	60 DAP	75 DAP	105 DAP	135 DAP

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BAU garlic-1 × Oct. 21	24.62	35.22	41.47	54.87	54.65
BAU garlic-1 × Nov. 06	20.44	31.12	38.95	53.47	54.47
BAU garlic-1 × Nov. 21	17.77	26.05	33.42	45.10	52.02
BAU garlic-1 × Dec. 06	14.77	18.70	24.45	40.65	45.70
BAU garlic-2 × Oct. 21	21.35	28.90	38.60	46.90	50.12
BAU garlic-2 × Nov. 06	21.82	30.35	40.17	48.82	49.05
BAU garlic-2 × Nov. 21	19.15	27.42	35.30	46.67	48.25
BAU garlic-2 × Dec. 06	11.17	17.42	25.02	35.60	43.90
Level of significance	**	**	**	**	**
LSD (0.05)	0.72	1.30	1.57	1.64	1.43
LSD (0.01)	1.01	1.73	2.09	2.18	1.90
CV (%)	4.94	5.92	5.55	4.31	3.52

** indicate significant at 1% level of probability

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Leaf length

Effect of planting time

The effect of planting time on leaf length at different days after planting was significant (Table 6). Results revealed that leaf length became shorter with delay planting at different growth stages. Results further revealed that leaf length rapidly increased till 105 DAP and thereafter increased slowly. The highest leaf length was recorded in 21 October planting at different growth stages (21.66, 25.35, 28.92, 37.36 and 37.66 cm for 30, 60, 75, 105 and 135 DAP respectively) followed by 06 November planting (21.23, 24.28, 29.92, 32.13 and 34.85 cm for 30, 60, 75, 105 and 135 DAP, respectively). In contrast, the lowest leaf length was recorded in 06 December planting (11.71, 14.01, 19.58, 27.53 and 30.00 cm for 30, 60, 75, 105 and 135 DAP, respectively). The Early planted crops availed favorable environment, longer cool period and shorter day-length were available for early planted crop, which enhanced plant growth and development resulting longer leaf was attained. Similar results were reported by Shin *et al*. (1988) in garlic.

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Effect of variety

Leaf length varied significantly due to variety at 30, 60, 75, 105 and 135 DAP (Table 3). The variety BAU garlic-1 showed longer leaves than BAU garlic-2 at all growth stages. This variation might be due to the fact of genetically character of the varieties.

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Table 3. Effect of variety, planting time, irrigation and mulch on leaf length at different days after planting in garlic

Treatment	Leaf length (cm) at				
	30 DAP	60 DAP	75 DAP	105 DAP	135 DAP
Variety					
BAU garlic-1	18.98	22.39	27.00	33.32	36.42
BAU garlic-2	17.93	20.43	25.53	30.80	31.89
Level of significance	**	**	**	**	**
LSD (0.05)	0.52	0.59	0.65	0.78	0.79
LSD (0.01)	0.69	0.79	0.96	1.04	1.05
Planting time					
21 October	21.66	25.35	28.92	37.36	37.66
06 November	21.23	24.28	29.92	32.13	34.85
21 November	19.23	22.01	26.63	31.21	34.10
06 December	11.71	14.01	19.58	27.53	30.00
Level of significance	**	**	**	**	**
LSD (0.05)	0.68	0.78	0.83	0.91	0.94
LSD (0.01)	0.90	1.08	1.10	1.21	1.25
CV (%)	6.38	6.34	5.47	4.93	4.76

** indicate significant at 1% level of probability

Combined effect of variety and planting time on leaf length

The leaf length at all growth stages was significantly influenced by the combined effect of variety and planting time in garlic (Table 4). The tallest leaf was recorded in the treatment combination of BAU garlic-1 with 21 October planting at all growth stages (23.07, 27.52, 30.35, 37.27 and 40.45 cm for 30, 60, 75, 105 and 135 DAP, respectively) followed by BAU garlic- with 06 November planting. On the other hand, the shortest leaf was observed in BAU garlic-2 with 06 December planting at all growth stages (11.80, 13.60, 19.50, 26.22 and 28.07 cm for 30, 60, 75, 105 and 135 DAP, respectively).

Table 4. Combined effect of variety and planting time on leaf length at different days after transplanting in garlic

Combined	Leaf length (cm) at

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(Variety × planting time)	30 DAP	60 DAP	75 DAP	105 DAP	135 DAP
BAU garlic-1 × Oct. 21	23.07	27.52	30.35	37.27	40.45
BAU garlic-1 × Nov. 06	21.95	24.95	30.55	33.77	36.95
BAU garlic-1 × Nov. 21	19.30	22.67	27.45	33.40	36.35
BAU garlic-1 × Dec. 06	11.62	14.42	19.67	28.85	31.92
BAU garlic-2 × Oct. 21	20.25	23.17	27.50	37.45	34.87
BAU garlic-2 × Nov. 06	20.52	23.62	29.30	30.50	32.75
BAU garlic-2 × Nov. 21	19.17	21.35	25.82	29.02	31.85
BAU garlic-2 × Dec. 06	11.80	13.60	19.50	26.22	28.07
Level of significance	**	**	**	**	**
LSD (0.05)	0.96	1.11	1.17	1.29	1.33
LSD (0.01)	1.28	1.47	2.56	1.72	1.77
CV (%)	6.38	6.34	5.47	4.93	4.76

** indicate significant at 1% level of probability

Number of leaves per plant

Effect of variety

The influence of two garlic varieties was found to be significant in respect of leaf number per plant at 30, 60, 75, 105 and 135 DAP except 60 DAP (Table 5). Results showed that leaf number increased with age. It also found that at early growth stages (30 and 60 DAP), the leaf number was greater in BAU garlic-1 than BAU garlic-2 but at later growth stages (75-135 DAP); the leaf number was higher in BAU garlic-2 than in BAU garlic-1. The difference in number of leaves among the cultivars might be due to varying varietals characters. Genotypic variation in leaves per plant was also observed by Sultana *et al.*, (1995) which supported the present experimental results.

Effect of planting time: Number of leaves per plant was significantly influenced by different days after planting (Table 5). Results revealed that leaf number decreased with delayed planting. There was a gradual increase leaves with progress of time in all planting dates. The highest number of leaves per plant was observed in 21 October planting at all growth stages (4.03, 4.72, 5.85, 6.52 and 7.15 per plant for 30, 60, 75, 105 and 135 DAP, respectively) followed by 6 November planting. On the other hand, the lowest number of leaves per plant was recorded in 6 December planting at all growth stages (3.01, 3.43, 4.21, 5.50 and 6.02 per plant for 30, 60, 75, 105 and 135 DAP, respectively). This is possibly due to the fact that early planting attained longer

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period for vegetative growth and development that increased leaves compared to delay planting. These findings agree with the results of Anwar *et al.*, (1996), Azad (2002) and Hossain (2003), swati *et al*., (2013) and Rahman *et al*., (2007) in garlic.

Table 5. Effect of variety and planting time on number of leaves per plant at different days after planting in garlic

Treatment	Number of leaves per plant at				
	30 DAP	60 DAP	75 DAP	105 DAP	135 DAP
Variety					
BAU garlic-1	3.59	4.13	5.07	5.42	6.07
BAU garlic-2	3.37	4.03	5.51	6.82	7.35
Level of significance	**	NS	**	**	**
LSD (0.05)	0.09	0.13	0.13	0.11	0.13
LSD (0.01)	0.12	0.17	0.17	0.15	0.18
Planting time					
21 October	4.03	4.72	5.85	6.52	7.15
06 November	3.75	4.42	5.76	6.46	6.96
21 November	3.13	3.74	5.35	6.01	6.70
06 December	3.01	3.43	4.21	5.50	6.02
Level of significance	**	**	**	**	**
LSD (0.05)	0.11	0.15	0.15	0.14	0.15
LSD (0.01)	0.15	0.19	0.19	0.19	0.20
CV (%)	5.41	6.12	4.78	3.93	3.89

** indicate significant at 1% level of probability; NS = Not significant

Combined effect of variety and planting time on leaf number

The combined effect of variety and planting time on number of leaves per plant at all growth stages was significant (Table 6). Results revealed that leaf production decreased with delay planting in both the varieties. The highest number of leaves per plant was recorded in the treatment combination of BAU garlic-1 with 21 October planting at all growth stages followed by BAU garlic-1 and 6 November planting. On the other hands the lowest number of leaves per plant was observed in BAU garlic-1 with 06 December planting at most of the growth stages. The highest number of

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leaves per plant was observed in the treatment combination of BAU garlic-2 with 21 October planting.

Table 6. Combined effect of variety and planting time on number of leaves per plant at different days after transplanting in garlic

Combined (Variety × planting time)	Number of leaves per plant at				
	30 DAP	60 DAP	75 DAP	105 DAP	135 DAP
BAU garlic-1 × Oct. 21	4.19	4.73	5.47	5.60	6.63
BAU garlic-1 × Nov. 06	4.05	4.52	5.45	5.37	6.07
BAU garlic-1 × Nov. 21	3.15	3.73	5.11	5.42	5.92
BAU garlic-1 × Dec. 06	2.97	3.54	4.25	5.30	5.65
BAU garlic-2 × Oct. 21	3.87	4.72	6.22	7.45	7.67
BAU garlic-2 × Nov. 06	3.45	4.32	6.07	7.55	7.85
BAU garlic-2 × Nov. 21	3.12	3.75	5.60	6.60	7.47
BAU garlic-2 × Dec. 06	3.05	3.32	4.17	5.70	6.40
Level of significance	**	*	**	**	**
LSD (0.05)	0.15	0.21	0.21	0.20	0.21
LSD (0.01)	0.21	0.37	0.28	0.27	0.28
CV (%)	5.41	6.12	4.78	3.93	3.89

** indicate significant at 1% level of probability

Leaf dry weight per plant

Effect of variety

The effect of variety on leaf dry weight per plant was significant (Table 7). The higher leaf dry weight was observed in BAU garlic-1 (1.51 g per plant) compared to BAU garlic-2 (1.42 g per plant). The leaf dry weight was higher in BAU garlic-1 might be due to increased leaf size in BAU garlic-1 than BAU garlic-2. Genotypic variation in leaf dry weight was observed by Hossain (2003) in garlic that supported the present experimental results.

Effect of planting time

There was significant variation on leaf dry weight due to planting time (Table 7). Results revealed that leaf dry weight decreased with delay planting due to decreased number of leaf production. The highest dry weight of leaves (1.75 g) was found on 21 October planting and the lowest was recorded in 6 December planting (1.07 gm). Leaf

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dry weight decreased with delay planting as reported by many workers (Anwar *et al*., 1996; Ara *et al.*, 1993; Azad, 2002).

Table 7. Effect of variety and planting time on growth, yield attributes and yield in garlic

Treatment	Leaf dry weight per plant (g)	Root dry weight per plant (g)	Bulb diameter (cm)	Cloves per plant (no.)	Bulb weight per plant (g)
Variety					
BAU garlic-1	1.51	0.55	3.25	18.70	12.66
BAU garlic-2	1.42	0.63	3.62	19.73	13.14
Level of significance	**	**	**	**	**
LSD (0.05)	0.04	0.02	0.05	0.47	0.28
LSD (0.01)	0.05	0.03	0.067	0.62	0.37
Planting time					
21 October	1.75	0.63	3.89	22.31	16.42
06 November	1.61	0.73	3.43	21.50	15.78
21 November	1.43	0.56	3.30	17.71	10.93
06 December	1.07	0.43	3.10	15.34	8.47
Level of significance	**	**	**	**	**
LSD (0.05)	0.06	0.02	0.10	0.57	0.36
LSD (0.01)	0.08	0.03	0.13	0.62	0.48
CV (%)	6.91	4.51	3.67	5.81	4.88

** indicate significant at 1% level of probability

Combined effect of variety and planting time on leaf dry weight

The combined effect of variety and planting time on leaf dry weight was significant (Table 8). Results revealed that leaf dry weight decreased with delay planting in both the varieties. The highest leaf dry weight per plant was recorded in the treatment combination of BAU garlic-2 with 21 October planting (1.89 g per plant) followed by BAU garlic-1 and 6 November planting (1.79 g per plant). On the other hand, the lowest leaf dry weight per plant was observed in BAU garlic-2 with 06 December planting (0.99 g per plant).

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Table 8. Combined effect of variety and planting time on growth, yield attributes and yield in garlic

Combiend (Variety × planting time)	Leaf dry weight per plant (g)	Root dry weight per plant (g)	Bulb diameter (cm)	Cloves per plant (no.)	Bulb weight per plant (g)
BAU garlic-1 × Oct. 21	1.61	0.62	3.44	21.10	16.45
BAU garlic-1 × Nov. 06	1.79	0.72	3.32	21.35	15.10
BAU garlic-1 × Nov. 21	1.48	0.56	3.21	17.39	10.85
BAU garlic-1 × Dec. 06	1.15	0.28	3.03	14.95	8.27
BAU garlic-2 × Oct. 21	1.89	0.65	4.35	23.52	16.40
BAU garlic-2 × Nov. 06	1.43	0.73	3.54	21.64	16.47
BAU garlic-2 × Nov. 21	1.38	0.55	3.39	18.02	11.02
BAU garlic-2 × Dec. 06	0.99	0.58	3.17	15.72	8.67
Level of significance	**	*	**	**	**
LSD (0.05)	0.08	0.06	0.12	0.81	0.51
LSD (0.01)	0.11	0.034	0.16	1.08	0.68
CV (%)	6.91	4.51	3.67	5.81	4.88

*and ** indicate significant at 5% and 1% level of probability, respectively

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Root dry weight per plant

Effect of variety

In varieties, root dry weight per plant varied significantly. The higher root dry weight per plant was recorded in BAU garlic-2 (0.63 g) compared to BAU garlic-1. The variation in root dry weight might be due to differences in root number of garlic. Genotypic variation in root dry weight was also observed by Hossain (2003) in garlic that supported the present experimental result.

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Effect of planting time

The effect of planting time on root dry weight was significant. Results revealed that root dry weight decreased after 6 November planting due to might be decreased number of root production (Sultana, 1995). The highest root dry weight (0.73 g per plant) was found on 6 November planting and the lowest was recorded in 6 December

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planting (0.43 g per plant). Root dry weight decreased with delay planting as reported by many workers (Lipinski, 1993; Mishra *et al.*, 1997; Islam *et al.*, 1998).

Combined effect of variety and planting time on root dry weight

The combined effect of variety and planting time on root dry weight was significant (Table 8). Results revealed that root dry weight decreased with delay planting in both the varieties. The highest root dry weight per plant was recorded in the treatment combination of BAU garlic-2 with 6 November planting (0.73 g per plant) followed by BAU garlic-1 and 6 November planting (0.72 g per plant) with same statistical rank. On the other hand, the lowest root dry weight per plant was observed in BAU garlic-1 with 06 December planting (0.0.28 g per plant).

Effect of variety and planting time on yield attributes and yields in garlic

Bulb diameter

Effect of planting time

The effect of planting time on bulb diameter was significant Result revealed that delayed planting decreased bulb diameter because of delay planting crop get less time for growth and development of bulb compared to early planting crop. The highest bulb diameter was recorded in 21 October planting (3.89 cm) followed by 06 November planting (3.43 cm). In contrast, the lowest bulb diameter was recorded in 06 December planting (3.10 cm). Early planted crops availed longer cool period and shorter day-length, which enhanced growth and development of bulb in garlic and as a result maximum bulb diameter was obtained in early planting. Early planted crops produced larger bulb than delayed planting in garlic as reported by Rahim *et al*., (1984) and Siddique and Rabbani (1985) in garlic.

Effect of variety

The effect of variety on bulb diameter was significant (Table 7). The bulb diameter was higher in BAU garlic-2 (3.62 cm) compared to BAU garlic-1 (3.25 cm). Genotypic variations in bulb diameter were also observed by Hossain (2003) in garlic who reported that bulb diameter was higher in BAU garlic-2 than BAU garlic-1 which supported the present experimental result.

Combined effect of variety and planting time on bulb diameter: The combined effect of variety and planting time on bulb diameter was significant (Table 8). The

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highest bulb diameter was recorded in the treatment combination of BAU garlic-2 with 21 October planting (4.35 cm). On the other hand, the lowest bulb diameter was observed in BAU garlic-1 with 06 December planting (3.03 cm).

Number of cloves per bulb

Effect of planting time

Number of cloves bulb was significantly influenced by different days after planting (Table 7). Results revealed that clove number decreased with delayed planting. The highest number of cloves per bulb was observed in 21 October planting (22.31 per plant) followed by 6 November planting (21.50 per plant). On the other hand, the lowest number of cloves per bulb was recorded in 6 December planting (15.34 per bulb). This is possibly due to the fact that early planting attained longer period for vegetative growth and development that enhance increased cloves compared to delay planting. These findings agree with the results of Azad (2002) in garlic.

Effect of variety

The effect of variety on number of cloves per bulb was significant (Table 7). The clove number per bulb was greater in BAU garlic-2 (19.73) than BAU garlic-1 (18.70). Genotypic variation in clove number per bulb was also observed by Faruq (2000) in garlic which supported the present experimental result.

Combined effect of variety and planting time on number of cloves per bulb

The combined effect of variety and planting time number of clove per bulb was significant (Table 8). Results revealed that clove production decreased with delay planting in both the varieties. The highest number of cloves per bulb was recorded in the treatment combination of BAU garlic-2 with 21 October planting (23.52) followed by BAU garlic-2 and 6 November planting (21.64). On the other hand, the lowest number of cloves per bulb was observed in BAU garlic-1 with 06 December planting (14.95).

Bulb weight per plant

Effect of planting time

There was a significant variation on bulb weight due to planting time (Table 8). Results revealed that bulb weight decreased with delay planting due to decreased number of cloves production. The highest bulb weight (16.42 g per bulb) was found on 21 October planting and the lowest was recorded in 6 December planting (8.47 g). Bulb decreased with delay planting as reported by many workers (Anwar *et al*., 1996; Ara *et al.*, 1998; Azad, 2002).

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Effect of variety

The effect of variety on bulb weight was significant. The higher bulb weight was observed in BAU garlic-2 (13.14 g per bulb) compared to BAU garlic-1 (12.66 g per bulb). The bulb weight was higher in BAU garlic-2 might be due to increased cloves number than BAU garlic-1. Genotypic variation in bulb weight was also observed by Hossain (2003) in garlic that supported the present experimental results.

Combined effect of variety and planting time on bulb weight

The combined effect of variety and planting time on bulb weight was significant (Table 8). Results revealed that bulb weight decreased with delay planting in BAU garlic-1 while in BAU garlic-2, bulb weight did not decreased till 6 November planting. The highest bulb weight per plant was recorded in the treatment combination of BAU garlic-2 with 6 Novenber planting (16.47 g per bulb) followed by BAU garlic-1 and 21 October planting (16.45 g per bulb). On the other hand, the lowest bulb weight per bulb was observed in BAU garlic-1 with 06 December planting (8.27 g per bulb).

Bulb yield

Effect of variety

The effect of variety on bulb yield ha was significant (Fig. 1). The higher bulb yield was observed in BAU Garlic-2 (6.71 t ha^{-1}) compared to BAU garlic-1 (5.92 t ha^{-1}). The bulb yield was higher in BAU garlic-2 might be due to increased individual bulb weight than BAU garlic-1 (Table 7). Genotypic variation in bulb yield was also observed by Hossain (2003) in garlic that supported the present experimental results.

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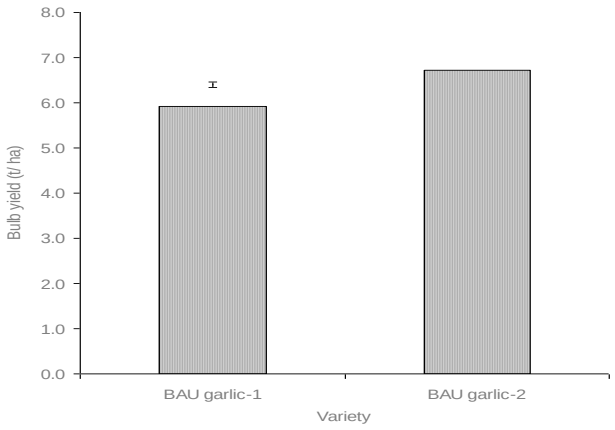

Fig.1. Bulb yield in two garlic varieties. Vertical bar represents LSD (0.05)

Effect of planting time

Bulb yield was significantly influenced by planting time (Fig. 2). Results revealed that bulb yield decreased with delay planting due to decreased number of cloves per plant and smaller size bulb production (Table 5 and 7). The highest bulb yield (8.13 t ha^{-1}) was found on 21 October planting and the lowest was recorded in 6 December planting (4.18 t ha^{-1}). Bulb decreased with delay planting as reported by many researchers (Anwar *et al*., 1996; Ara *et al.*, 1998; Azad, 2002).

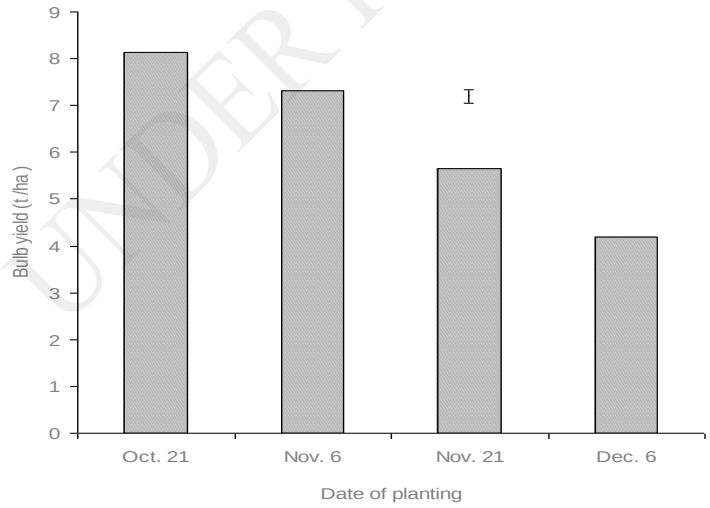

Fig.2. Bulb yield of garlic as influence by date of planting. Vertical bar represent LSD (0.05).

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Combined effect of variety and planting time

The combined effect of variety and planting time on bulb yield was significant (Fig. 3). The highest bulb yield was recorded in the treatment combination of BAU garlic-2 with 21 October planting (8.78 *t ha-1*) followed by BAU garlic-2 and 6 November planting (7.66 t ha^{-1}). On the other hand, the lowest bulb yield was observed in BAU garlic-1 with 06 December planting (4.07 t ha^{-1}).

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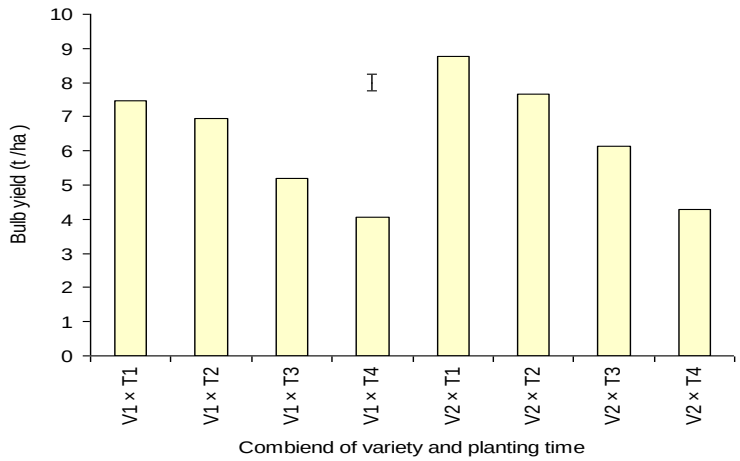

Fig.3. Combined effect of variety and planting time on bulb yield in garlic.

Vertical bar represents LSD (0.05)

V_1=BAU garlic-1, V_2= BAU garlic-2, T_1= Planting on 21 October, T_2 = 06 November, T_3 = 21 November, T_4 = 06 December

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Conclusions

The effect of planting time on morphological characters such as plant height, leaf length, leaf number per plant, leaf dry weight, root dry weight, yield attributes such as bulb diameter and number of cloves per bulb and bulb yield was significant. Results revealed that plant height, leaf length, leaf number, leaf and root dry weight, bulb diameter, clove number per plant and bulb yield decreased with delay planting. The highest plant height (52.38 cm), leaf length (37.66 cm, number of leaves per plant (7.15), leaf dry weight plant (1.75 g), bulb diameter (3.89 cm) and number of cloves per bulb (22.31) was recorded in 21 October planting resulting the highest bulb yield both per plant (16.42 g) and hectare (8.13 t ha^{-1}). In contrast, the above studied parameters were the lowest in 6 December planting resulting poor bulb yield. The combined effect of variety and planting time on all the plant parameters was significant. The highest plant height and leaf length was recorded in the treatment combination of BAU garlic-1 with 21 October planting while the highest number of leaves per plant, leaf and root dry weight, yield attributes such as bulb diameter and number of cloves per bulb and bulb yield was recorded in the treatment combination of BAU garlic-2 with 21 October planting. From our results it is revelaed that growth, yield attributes and yield of garlic decreased gradually with delayed planting.

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COMPETING INTERESTS DISCLAIMER:

Authors have declared that no competing interests exist. The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

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