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Effects of planting system on growth and yield of two lines of garlic under dry land condition at BAU, Mymensingh

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Abstract: An experiment was conducted at the Allium Field Laboratory, Horticulture Farm, Department of Horticulture, Bangladesh Agricultural University, Mymensingh and laboratory of Horticulture Division, Bangladesh Institute of Nuclear Agriculture (BINA) on effects of planting system on growth and yield of two lines of garlic under dry land condition at BAU, Mymensinngh during the period October, 2016 to April 2017. The 2-factor experiment had 2 levels of planting system (Factor A) and 2 garlic lines (Factor B) as follows : Factor A- Plating system: a) Flat and b) Ridge method; Factor B – Garlic lines: G_2 and $G_{19;}$ The experiment was conducted in randomized complete block design (RCBD) with 3 replications. Unit plot size: 1.5m - 1m; plant spacing: 20 cm - 10 cm; total number of treatments: 2-2 = 4; total number of unit plots: 4-4 =16; total number of plants per plot = 75; date of planting: 9 Nov. 2016; date of harvesting: 28 march, 2017. The results revealed that the plant height, number of leaves per plant, fresh and dry weight of bulb, length and diameter of bulb, total number of cloves, yield per plot and yield per hectare were significantly influenced by the treatment of the experiment under study. Results showed that Garlic line G_{19} produced the highest yield (17.76 t/ha) and the lowest (13.24 t/ha) was found in garlic line G_2 in all the studied parameters under dry land condition. The ridge system of planting gave significantly higher yield of bulb (16.42 t/ha) than the flat system (14.58 t/ha). The genotype G_{19} with the ridge system gave the highest yield of bulb (18.72 t/ha and the lowest (12.37 t/ha) was recorded from flat planting system with garlic line G2.
Key words: Garlic, growth, dry land, planting system and yield.

Introduction

Garlic (*Allium sativum* L) is an aromatic herbaceous plant and one of the important bulb crops belonging to the family Alliaceae. It is the second most widely used spice crop of the cultivated Allium crops, next to onion in the world (Purseglove, 1975). China leads in the world production of garlic (10080 thousand mt.) and also in area (632 thousand hectares), but the highest national yield is recorded from the Netherlands (48 t/ha) followed by Jordan (36 t/ha) and Lebanon (20 t/ha. Garlic is grown extensively as a spice crop in Bangladesh, but its average yield is only 2.86 t/ha, which is very low compared to the yield of many other countries. The world average yield of garlic is 11.99 t/ha (FAO, 2017). In Bangladesh, the requirement of garlic is about 219 thousand metric ton, and the deficit was around 42 thousand metric ton. In the year, 22 thousand metric ton of garlic was imported costing around 4.42 million US$.

Garlic grows in a wide range of climatic conditions but cannot withstand too hot or cold weather. Extremely hot and long days are not conducive for bulb formation. Garlic requires sandy or clay loam soil, good drainage and a pH in the range of 6.0–8.4. The crop raised in sandy soils cannot be kept for a long time and the bulbs are also lighter in weight. Garlic cultivation in Bangladesh is not only cultivated in dry land areas but also in low laying flood affected areas too. Flood is a natural calamity and an annual affair in Bangladesh. Bangladesh suffers from flood every year and is normally associated with the yearly monsoon rain that pours into the entire Ganges-Jamuna-Meghna basin.

Garlic is propagated from cloves of the bulb. Garlic is a shallow rooted plant, so it needs continuous moisture supply to the soil. Planting system is an important factor for garlic production. Earthing up helps in pulverizing the soil leading to proper aeration, suppresses the weed growth and coverage of the growing bulb, besides provide support to the growing plants. Seed clove storage temperature and pre-planting temperature treatment have remarkable influence on the initiation, development and yield of garlic (Siddique and Rabbani, 1985; Rahim and Fordham, 1988; Haque *et al*., 1990, 1993). Initiation and development are also influenced by the environmental factors prevailing during the subsequent period of growth (Rahim and Fordham, 1990). However, information on this aspect is scanty. The farmers of Bangladesh generally plant garlic in furrows, make the soil flat and finally make ridges around the plants. There is no report of the comparative study of the ridge and flat soil conditions. In general, ridges have more available sunlight and higher temperature than the flat soil. Therefore, it is expected that soil configuration might have considerable effect on garlic growth, development and yield. Thus, this research was initiated to find out the suitable planting system for two lines of garlic under dry land condition at BAU, Mymensingh**.**

Materials and Methods

The experiment was conducted at the Allium Field Laboratory, Horticulture Farm, Department of Horticulture, Bangladesh Agricultural University, Mymensingh and laboratory of Horticulture Division, Bangladesh Institute of Nuclear Agriculture (BINA) on effects of planting system on growth and yield of two lines of garlic under dry land condition during October, 2016 to April 2017. The 2-factor experiment had 2 levels of planting system (Factor A) and 2 garlic lines (Factor B) as follows –Factor A- Plating system: a) Flat and b) Ridge method; Factor B – Garlic lines: G_2 and $G_{19;}$ The experiment was conducted in randomized complete block design (RCBD) with 3 replications. unit plot size: 1.5m - 1m; plant spacing: 20 cm - 10 cm; total number of treatments: 2-2 = 4; total number of unit plots: 4-4 =16; total number of plants per plot = 75; date of planting: 9 Nov. 2016; date of harvesting: 28 march, 2017. Two garlic lines (G_{19} and G_2) collected from the Allium Field Laboratory, Horticulture Farm, Department of Horticulture, Bangladesh Agricultural University, Mymensingh were used as the planting materials. The following data (height of plant, number of leaves per plant, fresh weight of leaves per plant, fresh weight of bulb,

fresh weight of roots per plant, dry weight of leaves per plant, dry weight of bulb, dry weight of roots per plant, diameter of bulb, length of bulb, no. of cloves per bulb, yield of bulb per plot, yield of bulb per hectare**)** on physio-morphological growth parameters at 30 days interval after planting as well as on yield were recorded and continued up to final harvest. Intercultural operations were done as and when necessary. The means for all treatments were calculated and the analyses of variances for all the characters under consideration were performed by 'F' variance test. The significance of difference between pair of means was performed by Least Significant Difference (LSD) test taking 5% probability level as the minimum unit of significance (Gomez and Gomez, 1984).

Results

The present investigation had marked influence on height of plant, number of leaves per plant, fresh weight of leaves, diameter of bulb, and number of cloves per bulb and yield of bulb per hectare during growth period as well as at final harvest. Results of the analyses of variance in respect of all parameters obtained from the present investigation have been presented and discussed.

Plant height: Height of plant was taken at 30, 60, 90, 120 and 140 days after planting. Height of plant from different garlic lines increased up to 120 days after planting and then decreased due to senescence. The influence of different garlic lines in respect of height of plant was found to be significant. The tallest (79.02 cm) plants were obtained from the plots in garlic line G_{19} at 120 DAP. Height of plant increased with the time of garlic from 30 to 120 days after planting and the lowest height of plant (15.25 cm) was found in garlic line G_2 at 30 DAP (Table 1). Height of plant was found to be significant in different planting system. Plant height of two planting system showed an increasing trend during the growing period up to 120 DAP and there after declined. The maximum plant height (77.66 cm) was recorded from the ridge planting system at 120 days after planting. The minimum height of plant was found in the flat planting system (15.80 cm) at 30 days after planting (Table 2). Combined effect of planting system and garlic lines was found to be significant in respect of height of plant (Table 3). The tallest plant (80.27 cm) was found in ridge system with garlic line G_{19} at 120 DAP and the lowest height of plant (14.10 cm) was obtained from flat system with garlic line G_2 at 30 DAP.

Number of leaves per plant: The number of leaves per plant had significant difference among different garlic. The highest number of leaves (9.65) per plant was found in garlic line G_{19} at 120 DAP while the lowest (3.35) number of leaves was observed from garlic line G_2 at 30 DAP (Table 1). The highest (9.85) number of leaves per plant was found ridge planting system at 120 DAP and the minimum number of leaves (3.47) was obtained from flat system at 30 DAP (Table 2). The combined effect planting system and garlic lines on the number of leaves per plant was significant. The maximum number of leaves was obtained from ridge planting (10.10) with garlic line G_{19} at 120 DAP and the minimum number (3.20) of leaves per plant was obtained from flat system with garlic line G_2 at 30 DAP (Table 3).

Table 1. Main effect of garlic lines on height of plant, number of leaves per plant at different days after planting, fresh weight of bulb, length and diameter of bulb, no. of cloves per bulb, yield per plot and yield per hectare of garlic bulb at harvest under dry land condition at BAU, Mymensingh

Treatments	Height of plant in cm at DAP					No. of leaves/plant at DAP					Fresh wt. of bulb (g)	Length of bulb (cm)	Diameter of bulb (cm)	No. of cloves/ bulb	Yield/ plot (kg)[1]	Yield (t/ha)
	30	60	90	120	135	30	60	90	120	135						
G_{19}	18.55	28.14	51.26	79.02	71.20	3.91	5.52	6.82	9.65	9.72	37.50	4.46	4.39	31.50	2.66	17.76
G_2	15.25	24.57	47.41	73.05	62.35	3.35	4.82	5.98	9.30	9.18	27.95	4.09	3.99	27.45	1.99	13.24
LSD 5%	-	-	-	-	-	-	-	-	0.35	0.48	-	-	-	-	-	-
LSD 1%	1.53	3.06	3.83	4.60	3.98	0.41	0.38	0.46	-	-	2.29	-	-	2.65	0.41	1.27
Level of Sign.	**	**	**	**	**	**	**	**	*	*	**	NS	NS	**	**	**

** = Significant at 1% level of probability, * = Significant at 5% level of probability, NS = Non significant, The size of a plot was 1.5m × 1m

Table 2. Main effect of different sources of nitrogen on growth and yield of garlic bulb under wetland condition at BAU, Mymensingh

Treatments	Height of plant in cm at DAP					No. of leaves/plant at DAP					Fresh wt. of bulb (g)	Length of bulb (cm)	Diameter of bulb (cm)	No. of cloves/ bulb	Yield/ plot (kg)[1]	Yield (t/ha)
	30	60	90	120	135	30	60	90	120	135						
Flat system	15.80	25.28	47.51	74.41	65.15	3.47	4.92	6.01	9.10	9.07	31.25	4.19	4.09	27.85	2.19	14.58
Ridge system	18.00	27.43	51.16	77.66	68.40	3.79	5.42	6.79	9.85	9.83	34.20	4.36	4.29	31.10	2.46	16.42
LSD 5%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LSD 1%	1.53	3.06	3.83	4.60	3.98	0.41	0.38	0.46	0.50	0.69	2.29	-	-	2.65	0.41	1.27
Level of Sign.	**	**	**	**	**	**	**	**	**	**	**	NS	NS	**	**	**

** = Significant at 1% level of probability, NS = Non significant, 1 The size of a plot was 37m × 1m

Fresh weight of bulb at harvest: There was a significant difference in the fresh weight of bulb at harvest due to different garlic lines. The highest fresh weight of bulb (37.50 g) was obtained from garlic line G_{19} and the lowest (27.95 g) was in garlic line G_2 (Table 1). Different planting system showed highly significant variation in respect of fresh weight of bulb. The result indicates that the ridge system gave the highest (34.20 g) fresh weight of bulb and the lowest fresh weight of bulb was found (31.25 g) in flat system (Table 2). Significant variation was found due to the combined effect of planting system and garlic lines in respect of fresh weight of bulb. The maximum fresh weight of bulb (39.00 g) was obtained from ridge planting with garlic line G_{19} and the minimum fresh weight of bulb was obtained from (26.50 g) flat planting with garlic line G_2 (Table 3).

Length of bulb: Non significant effect was observed on length of bulb due to main and combined effect (Tables 1,

2, 3). The highest length of bulb (4.46 cm) was found with the plants having garlic line G_{19} and the lowest (4.09 cm) was obtained from garlic line G_2 (Table 1). The larger bulb having length of 4.36 cm was obtained from ridge system and the lowest (4.19 cm) length of bulb was recorded from flat system (Table 2). The highest value (4.52 cm) was found from garlic line G_{19} with ridge system and the lowest (3.98 cm) was obtained from garlic line G_2 with flat system (Table 3).

Table 3. Combined effect of garlic lines and planting system on height of plant, number of leaves per plant at different days after planting, fresh weight of bulb, length and diameter of bulb, no. of cloves per bulb, yield per plot and yield per hectare of garlic bulb at harvest under dry land condition at BAU, Mymensingh

Treatments	Height of plant in cm at DAP					No. of leaves/plant at DAP					Fresh wt. of bulb (g)	Length of bulb (cm)	Diameter of bulb (cm)	No. of cloves/ bulb	Yield/ plot (kg)[1]	Yield (t/ha)
	30	60	90	120	135	30	60	90	120	135						
V_1S_1	17.50	26.78	49.27	77.77	70.30	3.75	5.30	6.32	9.20	9.15	36.00	4.40	4.27	29.36	2.52	14.60
V_1S_2	19.60	29.50	53.25	80.27	72.10	4.08	5.75	7.32	10.10	10.30	39.00	4.52	4.50	33.65	2.81	13.72
V_2S_1	14.10	23.78	45.75	71.05	60.00	3.20	4.55	5.70	9.00	9.00	26.50	3.98	3.91	26.35	1.85	13.14
V_2S_2	16.40	25.37	49.08	75.05	64.70	3.50	5.10	6.27	9.60	9.37	29.40	4.20	4.07	28.55	2.12	12.75
LSD 5%	1.51	3.02	3.77	4.52	3.92	0.30	0.38	0.45	0.49	0.68	0.56	-	-	2.61	0.40	10.88
LSD 1%	2.17	4.33	5.42	6.50	5.63	0.44	0.54	0.65	0.70	0.97	0.81	-	-	3.75	0.58	10.49
Level of Sign.	**	**	**	**	**	**	**	**	**	**	**	NS	NS	**	**	10.14

** = Significant at 1% level of probability, V_1 = Garlic line G_{19}, V_2 = Garlic line G_2, S_1 = Flat system, S_2 = Ridge system, NS = Non significant, 1 The size of a plot was 1.5m × 1m

Diameter of bulb: Non significant effect was observed on diameter of bulb due to main and combined effect (Tables 1, 2, 3). The highest diameter of bulb (4.39 cm) was obtained with the plants having garlic line G_{19} and the lowest (3.99 cm) was obtained from garlic line G_2 (Table 1). The results indicate that the larger bulb having diameter of 4.29 cm was produced from ridge system and the lowest (4.09 cm) diameter of bulb was found from flat system (Table 2). The highest value (4.50 cm) was found from garlic line G_{19} with ridge system and the lowest (3.91 cm) was achieved from garlic line G_2 with flat system (Table 3).

Number of cloves per bulb: Statistically significant variations were found in number of cloves per bulb due to garlic lines. The highest number of cloves per bulb was recorded from (31.50) garlic line G_{19} and the lowest (27.45) was found in garlic line G_2 (Table 1). There was a significant variation in the number of cloves per bulb as affected by the planting system. Ridge system produced the highest (31.10) number of cloves per bulb and the lowest (27.85) was recorded from flat system (Table 2). A significant combined effect of planting system and different garlic lines was observed. Ridge system with garlic line G_{19} gave the highest (33.65) number of cloves per bulb and the lowest (26.35) was found in case of flat system with garlic line G_2 (Table 3).

Yield per plot: Highly significant variation in respect of yield per plot was observed among the different garlic lines. The highest (2.66 kg) yield was obtained from garlic line G_{19} and the lowest (1.99 kg) was found in case of garlic line G_2 (Table 1). There were statistically significant differences in yield per plot due to the effect of different planting system. Ridge system gave the highest (2.46 kg) yield per plot. The lowest (2.19 kg) was observed from flat system (Table 2). The combined effect of planting system and different garlic line on yield per plot was found to be statistically significant. Ridge system with garlic line G_{19} gave the highest (2.52 kg) yield per plot. The lowest (1.85 kg) was recorded from garlic line G_2 with flat system (Table 3).

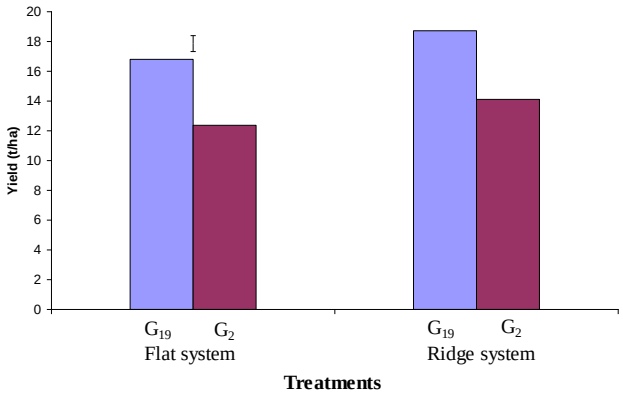

Fig. 1. Combined effect of garlic lines and planting system on the yield of garlic bulb under dry land condition at BAU, Mymensingh during 2016-17. Vertical bar represents LSD at 5% level

Yield per hectare: Yield (t/ha) was found to be statistically significant due to the effect of garlic lines (Table 1). The highest (17.76 t/ha) yield was observed from garlic line G_{19} and the lowest (13.24 t/ha) was found in garlic line G_2 (Table 1). There was also a significant difference in respect of yield (t/ha) due to the different planting system. Yield was maximum (16.42 t/ha) in ridge system and the minimum (14.58 t/ha) was found in flat system (Table 2). Significant variations in yield (t/ha) was observed due to combined effect of planting system and different garlic lines. Ridge system with garlic line G_{19} gave the highest (18.72 t/ha) yield (t/ha) and the lowest (12.37 t/ha) was recorded from flat planting system with garlic line G_2 (Fig. 1).

Discussion

Earthing up and irrigation have significant effect on yield and yield contributing characters. Minimum days were required for clove emergence with earthing up because the cloves got sufficient moisture in ridge method. Garlic is a shallow rooted plant so it needs continuations moisture supply to the soil. Polishchuk *et al*. (1993) also reported that maximum height of plant was found from earthing up and irrigation started at planting time and when required and the lowest was found from the control treatment. The increasing trend in height of plant may be attributed to the

availability of uninterrupted moisture supply to the soil through earthing up and irrigation. Minimum time was required from earthing up and irrigation started at planting time and when necessary in relation to bulb formation. In no earthing up plots, there was a gradual removal of water from the soil due to evaporation, which hampered and showed a downward growth. According to Geremew *et al*., (2010), planting techniques play important role in productivity of garlic. By altering spacing and method of planting the quality of bulbs, size and shape can be improved.

Vegetative growth of garlic plant was significantly affected by earthing up and irrigation application. Well established plant carried out a better physiological and metabolic activity all through their life cycle. Consequently, more dry matter accumulation might have taken place during vegetative growth and bulb formation compared to non-irrigated plants. This might have attributed to higher yield. Mondal *et al.* (1988) reported to have obtained similar results from their experiment regarding this character.

Earthing up treated plant also exhibited similar vegetative growth in garlic plant as stated earlier, hence it might have helped produce heavier bulb. Heavier and larger sized cloves were obtained from the plants that were under earthing up. Initial food reserve of clove promotes rapid and maximum germination. Irrigation application resulting in producing heavier and larger sized bulb might have had such initial food reserve and ultimately helped better germination.

However, the effect of bed configuration on the plant height was more pronounced within the cultivar themselves. Temperature has a positive impact on the growth of crop plant. In general, high temperature**,** within some limit, favours crop growth. Soil temperature was observed higher in ridges than the other methods of planting (Radke, 1982). Thus, increased plant height in the ridge planting method could be ascribed for the high temperature in it. Identical findings were reported for onion (Singh and Singh, 1995). The higher plant height in cv. Faridpur seemed to be due to its higher mother clove size during planting. Large sized cloves and bulbs enhanced the plant height in garlic and onion (Grad *et al*., 1993; Singh and Sachan, 1998; Castellanos *et al*., 2004 Castillo *et al*., 1996; Haque *et al*., 2016).

Highest number of leaves was found from garlic line G_{19}. Mother clove size has a regulatory effect on the number of leaves (Couto, 1961; Burba *et al*., 1982) and large sized cloves and bulbs produced greater number of leaves per plant both in garlic and onion (Grad *et al*., 1993; Singh and Sachan, 1998). The highest number of leaves per plant in cv. Faridpur might be due to the highest clove size in this cultivar.

The higher individual bulb weight of garlic line G_{19} was related to the higher weight of the mother clove at the time of planting triggered by the favourable environmental condition created by the ridges. Increased weight of bulb was resulted by higher seed clove weight (Couto, 1961; Baten *et al*., 1994).

Yield was significantly influenced by the interaction between garlic lines and methods and maximum yield ((18.72 t/ha)) was obtained from the interaction between Ridge method x garlic line G_{19}). The lowest yield (12.37 t/ha) was recorded in Flat method x Garlic line G_2 (Fig. 1). Maximum yield was recorded by Ridge method in the present study. A significant increase in grain yield was reported by ridge seedbeds over their flat counterparts for different tillage systems has been reported in sorghum (Kanton *et al*., 2000).

Garlic yield has been gradually decreasing in Bangladesh. Due to the continuing population growth, the demand of garlic is increasing every year. The area under garlic cultivation can, under no circumstances, be increased here. To increase total production, the only way is the improvement of the yield.

The effects of planting system on the growth and yield of garlic germplasm G_{19} and G_2 under dry land condition were investigated in Expt. 5 during the growing season 2005-06. The ridge system of planting gave significantly higher yield of bulb than the flat system. The genotype G_{19} with the ridge system gave the highest yield of bulb (18.72 t/ha). The genotype G_2 under the ridge system yielded 12.37 t/ha.

Conclusion: The results presented here indicate that garlic yield can be increased by adopting ridge planting method instead of flat method under dry land condition. However, further studies are required to investigate the microclimatic conditions that favour garlic growth and yield under ridge planting method.

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