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Effects of nitrogen and potassium on growth and yield of two lines of garlic under dry land condition

Md. Shamsul Alam[1]*, Md. Abdur Rahim[2], Sima Panahi Rad[3], Sadia Afrin[4]

[1]Horticulture Division, Bangladesh Institute of nuclear Agriculture (BINA), Mymensingh-2202, Bangladesh.
[2]Department of Horticulture, BAU, Mymensingh, Mymensingh- 2202, Bangladesh.
[3]Department of Horticulture, University of Tabriz, Tabriz, Iran.
[4]VDB Project, Horticulture Division, Bangladesh Institute of nuclear Agriculture (BINA), Mymensingh-2202, Bangladesh.

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***Corresponding Author**

MS Alam
mithuhort@yahoo.com

ABSTRACT

The study was undertaken by the problem of late planted garlic in Bangladesh and similar tropical regions where production is only possible during the short cool winter period after which rapid increase in temperature as well as humidity adversely affect the growth. A experiment were carried out to assess the effects of different levels of nitrogen and potassium on growth and yield of two lines of garlic under dry land condition at BAU, Mymensingh in order to develop suitable variety (ies) and optimum doses of N and K get high yield and to overcome the stated adverse situation. The present research was carried out at the Alliums field laboratory, Horticulture Farm and laboratory of the BAU-Germplasm Centre, Department of Horticulture, Bangladesh Agricultural University, Mymensingh, during the period from 2016-2017). The 3-factor experiment had 4 levels of nitrogen (Factor A), 4 levels of potassium (Factor B) and 2 garlic lines (Factor C) as follows –Factor A: 4 levels of nitrogen N_0 : 0 kg N/ha (urea : 0 kg/ha; 0 g/plot); N_1 : 75 kg N/ha (urea : 166.66 kg/ha; 24 g/plot); N_2 : 125 kg N/ha (urea : 277.77 kg/ha; 41.66 g/plot);N_3 : 175 kg N/ha (urea : 388.88 kg/ha; 58.33 g/plot); Factor B: 4 levels of Potassium (K_2O at 0, 50, 100, and 200 kg/ha) ;K_0 : 0 kg K_2O/ha (M.P : 0 kg/ha; 0 g/plot); K_1 : 50 kg K_2O/ha (MP : 83.33 kg/ha; 12.49 g/plot); K_2 : 100 kg K_2O/ha (MP : 166.66 kg/ha; 20 g/plot); K_3 : 200 kg K_2O/ha (MP : 333.33 kg/ha; 40 g/plot) and Factor C: 2 Garlic lines: G_2 and G_{19}. The experiment was conducted in randomized complete block design with three replications using 20cm×10cm plant spacing. The size of a unit plot was 1.5m×1m accommodating 96 plots. The total number of plants per plot was 75. Planting date of the lines was 9 Nov., 2016 and harvesting date was 28th March, 2017The three-factor 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: 4×4×2=32; Total number of unit plots: 32×3 = 96; Total number of plants per plot = 75, Date of planting: 9 Nov.2016 and 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 in all the studied parameters under dry land condition. The highest yield was recorded from the maximum dose of nitrogen (175 kg/ha). Potassium also showed good effect on yield, and the maximum yield was obtained from the maximum dose of potassium (200 kg/ha). There was significant interaction effect of garlic lines, different doses of nitrogen and potassium on bulb yield per plot as well as per hectare. The maximum yield per plot (2.74 kg/plot) and per hectare yield (18.25 t/ha) were recorded from garlic line G_{19} x 175 kg N/ha x 200 kg K_2O/ha and the minimum (1.70 kg/plot) and (11.31 t/ha) from garlic line G_2 x 0 kg N/ha x 0 kg K_2O/ha respectively.

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

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2.86 t/ha (FAO, 2017), 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$. Use of high yielding variety is the most important consideration for cultivation of any crop. But very little attention has so far been given to the improvement of garlic either through selection, mutation breeding technique, hybridization or introduction of suitable variety in this country. In Bangladesh, there are many cultivated types of garlic, which are known either by the name of the locality where grown or characteristics of the crop. Fertilizer has great effect on the growth and yield of garlic. Many research works have been carried out in relation to fertilizer application in different countries. But research on the effect of fertilizer, specially nitrogen and potassium on the growth and yield of garlic in Bangladesh is limited. Judicious application of fertilizers may enhance bulb yields significantly. Nitrogen imparts greenness to plants by enhancing chlorophyll synthesis, which induces more photosynthetic production per unit photosynthetic area (Delvin, 1996). Potassium exerts a balancing role in the effect of both nitrogen and phosphorus (Brady, 1995; Shamim and Rahim, 2018 and Ebrahimi et al.2014). Among the yield promotion factors, application of proper doses of nitrogen and potassium is of great importance (Sotomayor, 1975 and Magray et al. 2017). Fertilizer is indispensable for the crop production systems of modern agriculture. Among the factors that influence the crop production, fertilizer is the most important one that plays a crucial role in yield increase. In Bangladesh, the demand for garlic is increasing gradually with the increasing of population. It is difficult to increase the area of the crop due to land constraint. One of the ways to overcome the problem is to increase yield per unit area. Application of balanced fertilizer and HYV is an important aspect for increasing yield. To ensure better yield, proper doses of nitrogenous and potassic fertilizer and high yielding variety need to be assured. A number of research works on fertilizers application and germplasm have been conducted in different parts of the world. But information under Bangladesh condition is not conclusive. In the above context, the study entitled, effects of different levels of nitrogen and potassium on growth and yield of two lines of garlic under dry land condition at BAU, Mymensingh was undertaken with the following objectives: ii) to develop garlic varieties through selection and ii) to find out the optimum doses of N and K for the developed garlic varieties.

MATERIALS AND METHODS

The experiment was carried out from October, 2016 to April 2017 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).

The three-factor experiment was conducted in randomized complete block design (RCBD) with 3 replications. The 3-factor experiment had 4 levels of nitrogen (Factor A), 4 levels of potassium (Factor B) and 2 garlic lines (Factor C) as follows

Factor A: 4 levels of nitrogen N_0 : 0 kg N/ha (urea : 0 kg/ha; 0 g/plot); N_1 : 75 kg N/ha (urea : 166.66 kg/ha; 24 g/plot); N_2 : 125 kg N/ha (urea : 277.77 kg/ha; 41.66 g/plot);N_3 : 175 kg N/ha (urea : 388.88 kg/ha; 58.33 g/plot);

Factor B: 4 levels of Potassium (K_2O at 0, 50, 100, and 200 kg/ha) ;K_0 : 0 kg K_2O/ha (M.P : 0 kg/ha; 0 g/plot); K_1 : 50 kg K_2O/ha (MP : 83.33 kg/ha; 12.49 g/plot); K_2 : 100 kg K_2O/ha (MP : 166.66 kg/ha; 20 g/plot); K_3 : 200 kg K_2O/ha (MP : 333.33 kg/ha; 40 g/plot) and

Factor C: 2 Garlic lines: G_2 and G_{19}.

Plant spacing: 20 cm × 10 cm; unit plot size: 1.5m×1m; Total number of treatments: 4×4×2=32; Total number of unit plots: 32×3 = 96; Total number of plants per plot = 75, Date of planting: 9 Nov.2016 and Date of harvesting: 28 March, 2017.

Fertilizer dozes: The entire amount of cowdung and TSP at the rates of 5 tons and 267 kg/ha, respectively, were applied as basal doses during land preparation to all plots irrespective of nitrogen and potassium doses. Urea and muriate of

potash (MP) were used as the source of nitrogen and potassium, respectively. One-third of the doses of urea and MP as per treatment were added to the soil at the time of final land preparation 7 days before planting. Rest 2/3 urea and 2/3 MP, as per treatment, were top dressed in three equal installments at 25, 50 and 75 days after planting of cloves.The garlic lines were collected from the Alliums project of Bangladesh Agricultural University,Mymensingh. Intercultural operations were done as and when necessary. 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.

Statistical analysis

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 AND DISCUSSION

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 in this chapter.

Height of plant

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 of plant (73.66 cm) was obtained from germplasm G_{19} at 120 DAP and that the shortest (26.40 cm) was found from garlic line G_2 at 30 DAP (Table 1).

The influence of different nitrogen levels in respect of height of plant was found to be significant. The maximum height of plant (77.61 cm) at 120 days after planting was obtained in plants grown with 175 kg N/ha. The height of plant showed a general trend of gradual increase with the increasing level of nitrogen from up to 175 kg N/ha and the lowest (22.01 cm) was found from 0 kg N/ha at 30 DAP (Table 2).

Table 1
Main effect of garlic lines on height of plant, number of leaves per plant at different days after planting, growth and yield of garlic bulb at harvest under dry land condition.

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						
G19	27.53	46.01	65.32	73.66	56.00	4.37	5.30	6.62	7.69	6.66	32.26	3.52	3.46	24.96	2.42	16.15
G2	26.40	44.79	61.06	70.72	53.82	4.12	5.79	6.27	7.46	6.49	25.88	3.43	3.32	24.16	1.94	12.94
LSD 5%	-	-	-	-	-	-	-	-	-	0.14	-	-	0.09	0.62	-	-
1%	0.80	0.97	1.39	1.52	1.23	0.12	0.16	0.18	0.23	-	0.32	-	0.12	-	0.02	0.45
Level of Significance	**	**	**	**	**	**	**	**	**	*	**	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 level of nitrogen on height of plant, number of leaves per plant at different days after planting, growth and yield 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)	Bulb diameter (cm)	No. of cloves/ bulb	Yield/ plot (kg)[1]	Yield (t/ha)
	30	60	90	120	135	30	60	90	120	135						
N_0	22.01	39.58	58.11	66.50	46.76	3.97	4.61	5.48	7.02	6.11	27.30	3.23	3.14	21.80	2.05	13.65
N_1	25.52	44.22	62.25	70.51	53.85	4.22	5.19	6.10	7.28	6.37	28.75	3.41	3.33	23.97	2.16	14.37
N_2	27.66	46.65	65.02	74.15	57.21	4.33	5.87	6.72	7.77	6.76	29.35	3.58	3.39	25.50	2.20	14.67
N_3	32.66	51.15	67.39	77.61	61.82	4.46	6.50	7.49	8.24	7.07	30.87	3.71	3.68	26.98	2.32	15.49
LSD 5%	0.85	1.04	1.48	1.62	1.31	0.13	0.17	0.19	0.240	0.08	0.34	0.08	0.12	0.87	0.02	0.48
1%	1.14	1.38	1.97	2.15	1.74	0.18	0.23	0.25	0.32	0.26	0.45	0.11	0.16	1.16	0.03	0.64
Level of Significance	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**

** = Significant at 1% level of probability
N_0 = 0 kg/ha N, N_1 = 75 kg/ha N, N_2 = 125 kg/ha N, N_3 = 175 kg/ha N; The size of a plot was 1.5m × 1m

Table 3
Main effect of level of potassium on height of plant, number of leaves per plant at different days after planting, growth and yield of garlic bulb at harvest under dry land condition (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						
K_0	25.31	40.71	59.24	67.12	49.96	4.12	5.03	5.76	6.85	5.92	27.89	3.31	3.20	22.87	2.10	13.99
K_1	26.87	46.16	63.79	72.66	55.35	4.24	5.45	6.26	7.61	6.60	29.00	3.39	3.35	24.22	2.18	14.50
K_2	27.42	47.02	64.52	73.75	56.64	4.29	5.69	6.65	7.93	6.90	29.49	3.55	3.46	25.30	2.21	14.74
K_3	28.25	47.71	65.24	75.24	57.70	4.34	5.99	7.12	7.92	6.88	29.90	3.65	3.57	25.86	2.25	14.95
LSD 5%	0.85	1.04	1.48	1.62	1.31	0.13	0.17	0.19	0.24	0.20	0.34	0.08	0.12	0.87	0.10	0.48
1%	1.14	1.38	1.97	2.15	1.74	0.18	0.23	0.25	0.32	0.26	0.45	0.11	0.16	1.16	0.13	0.64
Level of Significance	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**

** = Significant at 1% level of probability
K_0 = 0 kg/ha K_2O, K_1 = 50 kg/ha K_2O, K_2 = 100 kg/ha K_2O, K_3 = 200 kg/ha K_2O ; The size of a plot was 1.5m × 1m

Potassium had significant effect on height of plant at 30, 60, 90, 120 and 135 days after planting. Potassium @ of 200 kg K_2O/ha gave the maximum height of plant (75.24 cm) at 120 DAP; while the control treatment gave the lowest value (25.31 cm) at 30 DAP. Height of plant at different levels of potassium was increased up to certain period, and then decreased (Table 3).

Significant variations between the different garlic lines and levels of nitrogen was recorded in respect of height of plant at 30, 60, 90 120 and 135 DAP. Highest height of plant (79.52 cm) was obtained from the treatment combination of 175 kg N/ha and garlic line G_{19} at 120 DAP whereas the lowest height of plant (21.17 cm) was observed at 0 kg N/ha and garlic line G_2 at 30 DAP.

Combined effect of garlic lines and different levels of potassium on height of plant at different days after planting was found to be significant. The maximum height of plant (76.70 cm) was found from the treatment combination of garlic lines G_{19} x 200 kg K_20/ha at 120 DAP and the minimum value (24.92 cm) at 30 DAP was noticed from the treatment combination of garlic line G_2 x 0 K_2O/ha.

Height of plant was significantly influenced by the combined effect of different levels of nitrogen and potassium at 30, 60, 90, 120 and 135 DAP. The highest height of plant (82.40 cm) was found from the treatment combination of 175 kg N/ha x 200kg K_2O/ha at 120 DAP. The lowest height of plant (19.00 cm) was observed at 0 kg N/ha x 0 kg K/ha treatment combination at 30 DAP.

Combined effect of garlic lines, different doses of nitrogen and potassium on height of plant at different days after planting was found to be significant. In all the treatment combinations, it was observed that the height of plant increased with passing of time after planting up to 120 DAP. The maximum height of plant (84.70 cm) was found from the treatment combination of garlic lines G_{19} x 175kg N/ha x 200 kg K_2O/ha at 120DAP and the minimum value (18.60 cm) was noticed from the treatment combination of garlic lines G_2 x 0 kg N/ha x 0kg K_2/ha at 30 DAP (Table 4).

Number of leaves per plant

Number of leaves was counted at 30, 60, 90, 120 and 135 days after planting. There were significant variations in leaf number at DAP. Leaf number increased up to 120 days after planting then decreased due to senescence. The lowest (4.12) number of leaves per plant was obtained from garlic line G_2 at 30 DAP and the highest (7.69) was found in garlic line G_{19} at 120 DAP (Table 1).

It was observed that the effect of different levels of nitrogen treatments of the production of leaves were highly significant (Table 2). The highest average number of leaves per plant (8.24) was observed at the highest dose of nitrogen (175 kg N/ha) at 120 DAP and the lowest number of leaves per plant (3.97) was produced in the plants raised without nitrogen at 30 days after planting. After 120 days of planting leaf number reduced gradually (Table 2).

Effect of different doses of potassium on the number of leaves per plant at 30, 60, 90, 120 and 135 days after planting was found to be statistically significant (Table 3). The data in Table showed that the maximum leaf number (7.92) was produced by plants grown with 200 kg K_2O/ha at 120 days after planting, while the control treatment was produced 4.12 at 30 DAP. Number of leaf increased up to 120 days after planting, and then decreased due to senescence.

Combined effect of garlic lines and different levels of nitrogen at different days after planting was found to be significant. The maximum number of leaves per plant (8.25) was recorded from 175 kg N/ha and garlic line G_{19} at 120 days after planting and the minimum number of leaves (3.38) was observed from 0 kg N/ha and garlic line G_2 at 30 DAP.

The combined effect of garlic line and different leaves of potassium on the number of leaves per plant at different days after plating was found to be significant. The number of leaves varied from 3.99 to 8.11 at 120 DAPS. The maximum number of leaves per plant (8.11) was recorded from garlic line G_{19} x 200 kg K_2O/ha and the minimum number of leaves (3.99) was found from garlic line G_2 x 0 kg K_2 0/ha at 30 DAP.

Table 4
Combined effect of garlic lines, level of nitrogen and potassium on height of plant, number of leaves per plant at different days after planting, growth and yield of garlic bulb at harvest under dry land condition (BAU, Mymensingh).

Treatment combination	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						
$V_1N_0K_0$	19.40	32.30	52.40	65.10	45.20	3.80	4.47	4.79	5.93	5.43	29.00	3.20	2.97	20.00	2.18	14.50
$V_1N_0K_1$	23.60	42.50	61.60	67.20	52.10	4.20	4.73	5.26	7.20	6.10	30.50	3.40	3.17	22.20	2.29	15.25
$V_1N_0K_2$	24.00	44.13	62.70	68.10	53.20	4.25	4.80	5.53	7.43	6.30	30.70	3.50	3.27	23.40	2.30	15.68
$V_1N_0K_3$	24.40	44.10	63.30	69.50	54.10	4.30	4.93	6.63	7.75	6.70	31.00	3.60	3.37	24.60	2.33	15.50
$V_1N_1K_0$	24.30	40.60	60.80	70.20	52.00	4.31	5.00	5.53	7.13	6.10	30.90	3.30	3.22	22.50	2.32	15.45
$V_1N_1K_1$	25.20	45.00	64.50	71.70	56.20	4.33	5.13	6.00	7.87	6.80	31.80	3.46	3.35	23.60	2.39	15.90
$V_1N_1K_2$	26.00	46.00	65.20	72.40	56.30	4.35	5.20	6.63	8.00	7.20	32.00	3.55	3.42	24.77	2.40	16.00
$V_1N_1K_3$	26.50	46.50	66.10	74.20	57.20	4.38	5.33	6.87	7.50	6.70	32.50	3.65	3.55	25.20	2.44	16.25
$V_1N_2K_0$	27.50	45.20	65.30	70.20	54.80	4.40	5.34	6.33	7.60	6.75	31.90	3.40	3.30	24.00	2.39	15.95
$V_1N_2K_1$	28.40	48.30	68.00	76.20	58.20	4.42	5.36	6.93	8.00	7.00	32.10	3.50	3.40	25.11	2.41	16.05
$V_1N_2K_2$	28.30	48.50	68.20	77.30	58.40	4.44	5.40	7.13	8.50	7.40	32.70	3.60	3.50	26.25	2.45	16.35
$V_1N_2K_3$	29.20	49.00	68.50	78.40	59.00	4.45	5.53	7.47	7.20	6.20	33.00	3.70	3.60	27.30	2.48	16.50
$V_1N_3K_0$	31.60	46.50	64.60	70.30	55.60	4.50	5.54	7.27	7.80	6.29	32.00	3.55	3.55	25.50	2.46	16.40
$V_1N_3K_1$	33.20	51.30	70.30	80.80	60.00	4.55	5.60	7.47	8.00	7.00	34.00	3.75	3.15	27.60	2.55	17.00
$V_1N_3K_2$	33.90	52.10	71.40	82.30	61.30	4.60	5.67	8.00	8.50	7.20	35.50	3.90	3.80	28.40	2.66	17.75
$V_1N_3K_3$	35.00	54.20	72.30	84.70	62.40	4.70	6.71	8.13	8.84	7.40	36.50	4.10	3.95	29.00	2.74	18.25
$V_2N_0K_0$	18.60	30.50	50.20	60.00	40.00	3.43	4.00	4.80	5.60	5.10	22.61	2.80	2.77	17.67	1.70	11.31
$V_2N_0K_1$	21.50	40.60	57.30	66.20	42.30	3.83	4.53	5.34	7.07	6.10	24.50	3.00	3.12	21.17	1.84	12.25
$V_2N_0K_2$	22.00	41.00	58.20	67.40	43.40	3.93	4.60	5.54	7.52	6.50	25.00	3.12	3.22	22.27	1.88	12.83
$V_2N_0K_3$	22.60	41.50	59.20	68.50	43.80	3.98	4.80	5.93	7.70	6.65	25.10	3.20	3.28	23.07	1.89	12.55
$V_2N_1K_0$	24.70	40.00	58.10	60.60	40.50	4.03	4.11	5.33	6.13	5.12	24.80	3.15	3.17	24.17	1.86	12.40
$V_2N_1K_1$	25.10	44.50	60.80	70.50	55.00	4.08	5.33	5.93	7.00	6.30	25.80	3.25	3.23	22.67	1.94	12.90
$V_2N_1B_2$	25.90	45.20	61.00	72.00	56.10	4.13	5.53	6.00	7.20	6.40	26.00	3.40	3.37	24.27	1.95	13.00
$V_2N_1K_3$	26.50	46.00	61.50	72.50	57.50	4.18	5.87	6.53	7.40	6.35	26.20	3.50	3.38	24.57	1.97	13.10
$V_2N_2K_0$	26.00	40.40	60.00	70.00	50.80	4.20	5.60	5.67	7.00	6.11	25.50	3.45	3.25	23.67	1.91	12.75
$V_2N_2K_1$	26.50	46.10	62.80	73.30	57.00	4.23	5.87	6.13	7.70	6.50	26.30	3.60	3.28	25.27	1.97	13.15
$V_2N_2K_2$	27.40	47.50	63.40	73.80	59.20	4.25	6.88	6.87	7.93	6.90	26.50	3.65	3.36	26.57	1.99	13.25
$V_2N_2K_3$	28.00	48.20	64.00	74.00	60.30	4.27	7.00	7.20	8.27	7.20	26.80	3.75	3.41	25.87	2.01	13.40
$V_2N_3K_0$	30.40	50.20	62.50	70.60	60.80	4.28	6.20	6.33	7.64	6.50	26.40	3.60	3.35	25.47	1.98	13.20
$V_2N_3K_1$	31.50	51.00	65.00	75.40	62.00	4.31	7.07	7.00	8.03	7.00	27.00	3.74	3.53	26.17	2.03	13.50
$V_2N_3K_2$	31.90	51.70	66.00	76.70	65.20	4.33	7.47	7.53	8.40	7.30	27.50	3.81	3.63	26.47	2.06	13.75
$V_2N_3K_3$	33.80	52.20	67.00	80.10	67.30	4.43	7.73	8.20	8.70	7.65	28.10	3.85	3.83	27.27	2.11	14.05
LSD 5%	2.42	2.93	4.19	4.57	3.71	0.38	0.48	0.53	0.68	0.56	0.67	0.56	0.35	2.46	0.07	1.36
1%	3.22	3.90	5.57	6.08	4.94	0.50	0.64	0.71	0.90	0.74	0.89	0.75	0.47	3.28	0.09	1.80
Level of Significance	**	**	**	**	**	**	**	**	**	**	**	*	**	**	**	**

** = Significant at 1% level of probability; * = Significant at 5% level of probability; V_1 = Garlic line G_{19} V_2 = Garlic line G_2
N_0 = 0 kg/ha N N_1 = 75 kg/ha N N_2 = 125 kg/ha N N_3 = 175 kg/ha N
K_0 = 0 kg/ha K_2O K_1 = 50 kg/ha K_2O K_2 = 100 kg/ha K_2O K_3 = 200 kg/ha K_2O
The size of a plot was 1.5m × 1m

There was significant variation in number of leaves per plant due to the combined effect among different levels of nitrogen and potassium at different days after planting. The maximum number of leaves per plant (8.77) was produced from the 175 kg N/ha x 200 kg K_2O/ha treatment combination at 120 DAP and the minimum number of leaves per plant (3.62) was obtained from 0kg N/ha x 0 kg K_2O/ha at 30 DAP.

Combined effect of garlic lines at different doses of nitrogen and potassium on the number of leaves per plant at different days after planting was found to be insignificant. The maximum number of leaves per plant (8.84) was recorded from garlic line G_{19} x 175 kg N/ha x 200 kg K_2O/ha at 120 DAP and the minimum number of leaves (3.43) was found from garlic line G_2 x 0 kg N/ha 0 kg K_2O/ha at 30 DAP (Table 4).

Fresh weight of bulb at harvest

The fresh weight of bulb at different garlic lines exhibited significant variations. Garlic line G_{19} produced comparatively higher fresh bulb weight. Higher fresh weight of bulb (32.26 g) was found in garlic line G_{19} and the lowest (25.88 g) was found from garlic line G_2 (Table 1).

The fresh weight of bulb at different levels of nitrogen exhibited significant variation at 30, 60, 90, 120 and 135 days after planting (Table 2). The maximum bulb weight (30.87 g) was produced from the treatment of 175 kg N/ha at 120 days after planting. The control treatment produced the minimum bulb weight (27.30 g) at 120 days after planting.

Different potassium levels exerted significant influence on the fresh weight of bulb at different dates after planting. Bulb weight increased gradually with the increase of potassium up to the rate of 200 kg K_2O/ha. The maximum weight of bulb (29.90 g) was obtained from the maximum level of K (200 kg/ha) at 120 days after planting while the control treatment produced the lowest weight of bulb (27.89 g) (Table 3).

Significant interaction between garlic line and different levels of nitrogen was found significant. Highest fresh weight of bulb (34.50 g) was obtained from the treatment combination of 175 kg N/ha x garlic line G_{19} whereas the lowest fresh weight of bulb (24.30 g) was observed at 0 kg N/ha x garlic line.

Significant interaction between garlic line and different levels of potassium was found significant. Highest fresh weight of bulb (33.25 g) was obtained from the treatment combination of 175 kg N/ha x garlic line G_{19} whereas the lowest fresh weight of bulb (24.83 g) was observed at 0 kg N/ha x garlic line G_2 at 120 DAP.

The combined effect of nitrogen and potassium on fresh weight of bulb was significant. It appeared that the treatment combination of 175 kg N/ha x 200 kg K_2O/ha produced the highest fresh weight of bulb (32.30 g) and 0 kg N/ha x 0 kg K_2O/ha treatment combination produced the lowest weight of bulb (25.80 g).

Combined effect of garlic line, different doses of nitrogen and potassium on fresh weight of bulb was found to be significant. The maximum fresh weight of bulb (36.50 g) was found from garlic line G_{19} x 175 kg N/ha x 200 kg K_2O/ha whereas the minimum (22.61 g) was found from garlic line G_2 x 0 kg N/ha x 0 kg K_2O/ha (Table 4).

Length of bulb at harvest

Non significant effect was observed on the length of bulb at harvest on garlic lines. The highest length (3.52 cm) of bulb at harvest was found in garlic line G_{19} and the lowest (3.43 cm) was found in garlic line G_2 (Table 1).

There was significant variation in length of bulb at harvest due to application of different levels of nitrogen. Results revealed that Nitrogen 175 kg/ha gave the highest length of bulb at harvest (3.71 cm) and the control treatment produced the lowest length of bulb at harvest (3.23 cm) (Table 2).

The length of bulb at harvest was found to be significantly influenced by different levels of

potassium. Results presented in table 3 revealed that of 200kg K_2O/ha gave the highest length of bulb at harvest (3.65 cm), while control treatment produced the lowest length of bulb at harvest (3.31 cm) (Table 3).

Significant interaction effect was recorded between garlic line and different levels of nitrogen in respect of length of bulb at harvest. The highest length of bulb at harvest (3.82 cm) was recorded from the combination of 175 kg N/ha x garlic line G_{19} and the lowest (3.10 cm) from combination of 0 kg N/ha x garlic line G_2.

It was observed that interaction effect of garlic line and different doses of potassium was found to be significant. The maximum length of bulb at harvest (3.72 cm) was obtained from garlic line G_{19} x 200 kg K_2O/ha and the minimum (3.25 cm) from garlic line G_2 x 0 kg K_2O/ha.

Difference in length of bulb at harvest caused by the combined effect of different levels of nitrogen and potassium was significant. The treatment combination of 175 kg N/ha x 200 kg K_2O/ha produced the maximum length of bulb at harvest (3.97 cm), and the minimum length of bulb at harvest (3.00 cm) was recorded at 0 kg N/ha 0 kg K_2O/ha treatment combination.

It was observed that combined effect of garlic lines, different doses of nitrogen and potassium of length of bulb at harvest of garlic per plant was found to be significant. The maximum length of bulb at harvest (4.10 cm) was obtained from garlic line G_{19} x 175 kg N/ha x 200 kg K_2O/ha and the minimum (2.80 cm) was obtained from garlic line G_2 x 0 kg N/ha x 0 kg K_2O/ha (Table 4).

Diameter of bulb at harvest

Highly significant variation was observed on diameter of bulb at harvest of garlic lines. The highest diameter of bulb (3.46 cm) was recorded from garlic line G_{19} and the lowest (3.32 cm) was found in garlic line G_2 (Table 1).

There was significant variation in diameter of bulb at harvest due to application of different levels of nitrogen. Results revealed that @ Nitrogen 175 kg/ha gave the highest diameter of bulb at harvest (3.68 cm) and the control treatment produced the lowest diameter of bulb at harvest (3.14 cm) (Table 2).

The diameter of bulb at harvest was found to be significantly influenced by different levels of potassium. Results presented in Table 3 revealed that of 200 kg K_2O/ha gave the highest diameter of bulb at harvest (3.57 cm), while control treatment produced the lowest diameter of bulb at harvest (3.20 cm).

Significant combined effect was recorded between garlic line and different levels of nitrogen in respect of diameter of bulb. The highest diameter of bulb at harvest (3.61 cm) was recorded from the combination of 175 kg N/ha x garlic line G_{19} and the lowest (3.03 cm) from combination of 0 kg N/ha x garlic line G_2.

It was observed that combined effect of garlic line and different doses of potassium on diameter of bulb at harvest of garlic was found to be significant. The maximum diameter of bulb at harvest (3.65 cm) was obtained from garlic line G_{19} x 200 kg K_2O/ha and the minimum (3.13 cm) was found in the combination of garlic line G_2 x 0 kg K_2O/ha.

Difference in diameter of bulb at harvest caused by the combined effect of different levels of nitrogen and potassium was significant. The treatment combination of 175 kg N/ha x 200 kg K_2O/ha produced the maximum diameter of bulb at harvest (3.90 cm) and the minimum diameter of bulb at harvest (2.87 cm) was recorded at 0 kg N/ha 0 kg K_2O/ha treatment combination.

It was observed that combined effect of garlic lines, different doses of nitrogen and potassium of diameter of bulb at harvest per plant was found to be significant. The maximum diameter of bulb at harvest (3.95 cm) was obtained from garlic line G_{19} x 175 kg N/ha x 200 kg K_2O/ha and the minimum (2.80 cm) was obtained from garlic line G_2 x 0 kg N/ha x 0 kg K_2O/ha (Table 4).

Number of cloves per bulb

The effects of different garlic lines on the number of cloves per bulb were found to be significant. Garlic line G_{19} gave the higher number of cloves

(24.96) and garlic line G_2 produced the lower number of cloves per bulbs (24.16) (Table 1).

There was significant variation in number of cloves per bulbs due to the effect of different nitrogen levels. At final harvest, the highest average number of cloves (26.98) obtained in plants grown with 175 kg N/ha and the lowest (21.80) with control treatment (Table 2).

There was significant variation in number of cloves per bulb due to the effect of different potassium levels. The highest average number of cloves (25.86) was obtained in plants grown with 200 kg K_2O/ha and the lowest number of cloves (22.87) produced with control treatment (Table 3).

Significant combined effect was observed between garlic lines and different levels of nitrogen in respect of number of cloves per bulb at final harvest. The treatment combination of garlic line G_{19} x 175 kg N/ha produced the maximum number of cloves per bulb (26.34) and the minimum number of cloves (21.04) was observed with garlic line G_2 x 0 kg N/ha treatment combination.

There was significant variation due to garlic lines and different levels of potassium in respect of number of cloves per bulb at final harvest. The treatment combination of garlic line G_9 x 200 kg K_2 0/ha produced the highest number of cloves per bulb (26.52) and the lowest number of cloves (22.74) was observed in the treatment combination of garlic line G_2 and 0 kg K_2O/ha.

The combined effect of nitrogen and potassium was fond to be significant in respect of number of cloves per bulb at harvest. The treatment combination of 175 kg N/ha and 200 kg K_2O/ha produced maximum number of cloves (28.13) and the minimum number of cloves (18.83) was observed with 0 kg N/ha x 0 kg K_2O/ha treatment combination.

The combined effect of garlic lines, different doses of nitrogen and potassium on number of cloves per bulb was found to be significant. The treatment combination of garlic line G_{19} x 175 kg N/ha x 200 kg K_2O/ha gave maximum number of cloves per bulb (29.00) and the minimum number of cloves per bulb (17.67) was obtained from garlic line G_2 x 0 kg N/ha x 0 kg K_2O/ha at final harvest (Table 4).

Yield of bulb

Different garlic lines showed significant variation on yield of bulb per plot and per hectare. The higher yield was obtained from garlic line G_{19} (2.42 kg/plot) and yield per hectare (16.15 t/ha) and the lower yield (1.94 kg/ plot) and per hectare (12.94 t/ha) yield were found in garlic line G_2 (Table 1).

Different levels of nitrogen showed significant variation in yield of bulb per plot and per hectare (Figure 1). The 175 kg N/ha treatment gave the highest yield per plot (2.32 kg and yield per hectare (15.49 t/ha) while the lowest (2.05 kg/plot) and (13.65 t/ha) with control treatment (Table 2). The results showed that the yield of garlic per hectare increased with the increase in nitrogen level up to 175 kg/ha.

Different doses of potassium showed significant effect on the yield of bulb per plot and per hectare (Figure 2). The treatment of 200 kg K_2O/ha gave the highest yield per plot (2.25 kg and yield per hectate (14.95 t) and the control treatment gave the lowest yield per hectare (13.99 t). It was observed that the yield per hectare and yield per plot showed a general trend of gradual increase with the increasing rate of potassium

It was revealed that the combined effect of garlic lines and different doses of nitrogen on bulb yield per plot (Table 1) and per hectare was significant. The highest (2.60 kg) yield per plot and per hectare (17.35 t) were found in 200kg K_2O/ha x garlic line G_{19} and the lowest (1.83 kg) and yield per hectare (12.15 t) were found in 0 kg K_2O/ha x garlic line G_2 treatment combinations respectively.

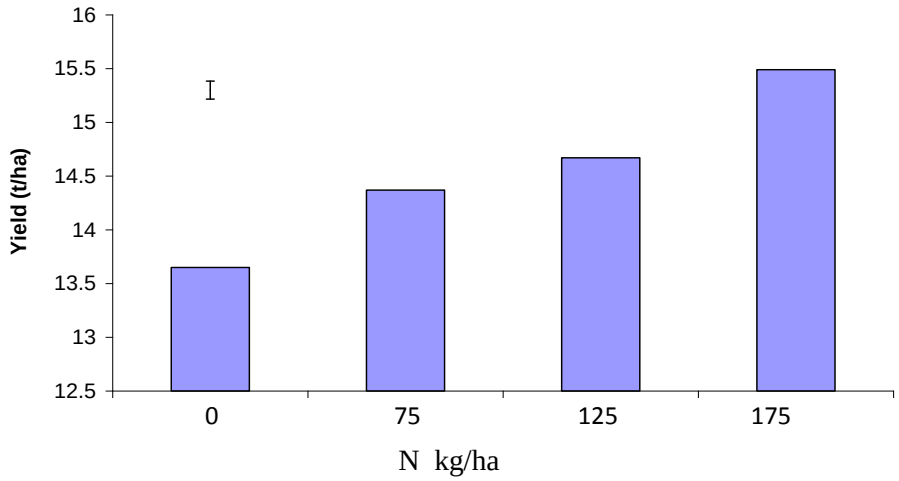

Figure.1
Effect of nitrogen on yield of garlic under dry land condition at BAU, Mymensingh.

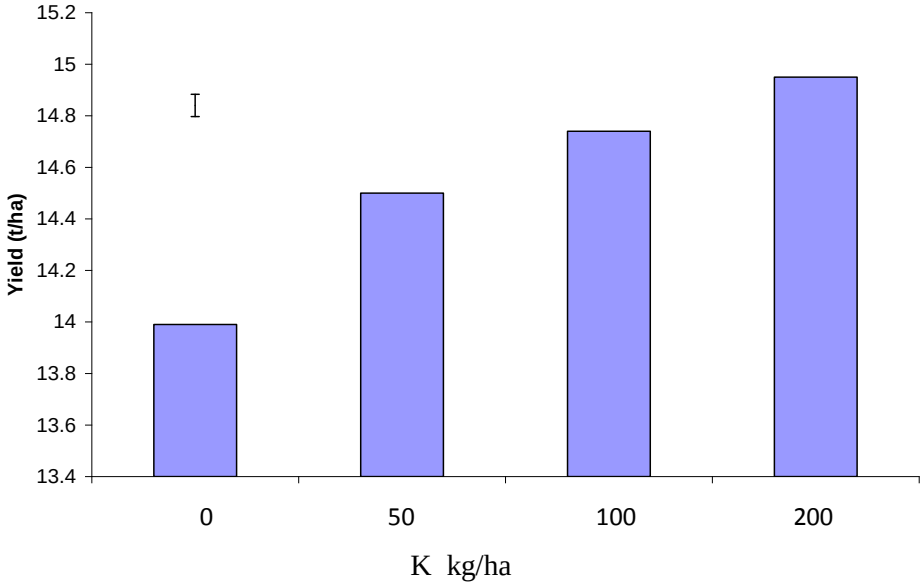

Figure 2
Effect of potassium on yield of garlic under dry land condition at BAU, Mymensingh.

It was revealed that the combined effect of garlic line and different doses of potassium on bulb yield per plot and per hectare was significant. The highest (2.50 kg) yield per plot and yield per hectare (16.62 t/ha) were found in 200kg K_2O/ha x garlic line G_{19} and the lowest was found in (1.86 kg/ha) and yield per hectare (12.41 t/ha) were recorded on 0 kg K_2O/ha x garlic line G_2 treatment combinations respectively.

It was revealed that the combined effect of nitrogen and potassium on bulb yield per plot and per hectare was statistically significant. The treatment combination of 175 kg N/ha 200 kg K_2O/ha produced the maximum yield per plot (2.42 kg/plot) and per hectare (16.15 t/ha), and the treatment combination of 0 kg N/ha x 0 kg K_2O/ha produced the minimum yield per plot (1.94 kg/plot) and per hectare yield (12.90 t/ha) respectively.

There was significant interaction effect of garlic lines, different doses of nitrogen and potassium on bulb yield per plot (Table 4) as well as per hectare. The maximum yield per plot (2.74

t/plot) and per hectare yield (18.25 t/ha) were recorded from garlic line G_{19} x 175 kg N/ha x 200 kg K_2O/ha and the minimum (1.70 kg/plot) and per hectare yield (11.31 t/ha) from garlic line G_2 x 0 kg N/ha x 0 kg K_2O/ha.

Germplasm showed significant effect on physical parameters. The garlic line G_{19} showed better performance than garlic line G_2. Germplasm G_{19} was better in respect of plant height, number of leaves per plant, fresh weight of bulb, length and breadth of bulb, number of cloves per bulb and yield on bulb than other germplasm (Halim, 2015). This may be due to its genetical behavior. Leaf production is related to plant height. Therefore, it might be possible that due to higher plant height observed in germplasm G_{19} influenced the production of higher number of leaves which helped in maximum photosynthesis and accumulation of photosynthates in the bulb. Garlic line G_{19} had more stored food materials and also more extensive and strong root system which after planting could establish readily in soil. After establishment the cloves could start all physiological activities quickly leading to completion of full vegetative growth and ultimate higher yield.

The application of nitrogen increased vegetative growth as well as yield. The magnitude of enhancement was lengthened as the doses of N_2 were increased. Nitrogen encouraged cell division, cell enlargement and consequently more LAI leading to more photosynthetic activities for higher yield (Baten et al., 1989; Zaman et al.2011; Kakar et al.2002 and Ebrahimi et al. 2014). In a normal situation, the dry matter of garlic leaf should contain about 6% N_2 that can ensure maximum yield (Brewster, 1994). The present finding of achieving higher yield with increased dose of N_2 is supported by the results of Setty et al. (1989). The approximation confirmed that high photosynthetic accumulation occurs in the leaves of garlic fertilized with high N, which is later translocated to the cloves formed in axils resulting in large clove size. Potassium helps in the root development and increases the efficiency of leaf in the manufacture of sugar and starch. It is essential for the translocation of sugars. Potassium exerts a balancing role in the effect of both nitrogen and phosphorus. Consequently, it is especially important in a multinutrient fertilizer application (Brady, 1995). So, nitrogen at the rate of 175kg/ha gave higher yield.

Potash at the rate of 200kg/ha gave higher yield. The presence of potash in leaves encourages more photosynthetic activities and afterwards translocation of starch. The intensity was reported to the higher in leaves containing more than 4% K_2O (dry weight basis) than having less than 4% (Tsuno and Fujise, 1965). Again high ratio of critical K_2O/N_2 in soil not only increases photosynthetic activities but also bulb growth leading to accelerated translocation of photosynthates from leaves to bulb (Fujise and Tsuno, 1967). In the present experiment application of potash at higher dose, possibly, therefore, gave increased yield. Our present finding is in conformity with the results of Magray et al. (2017) and Asandhi (1989).

However, this result was closely supported by the reports of Hossain (1997), Anwar et al. (1995), Talukder et al. (2010) and Shamim (2014). They stated that the yield and yield contributing characters was found to increase gradually with the increasing levels of nitrogen and potassium and the highest yield recorded at the highest levels of nitrogen (175 kg N/ha) and potassium (200 kg K_2O/ha).

SUMMARY

The effects of different doses of nitrogen and potassium on the growth and yield of two garlic germplasm (G_{19} and G_2) were studied under dry land condition at BAU, Mymensingh during the growing season 2015-16. The genotype G_{19} with the highest doses of N and K_2O (175kg N and 200kg K_2O/ha) gave the highest yield of bulb (18.25 t/ha). The genotype G_2 with the highest doses of N and K_2O (175kg N and 200kg K_2O/ha) yielded 14.05 t/ha.

CONCLUSION

Considering the findings of the experiments under study, the following practices may be recommended for the production of line G_{19}

and garlic line G_2 in Bangladesh: The optimum doses of nitrogen and potassium for garlic production are 175 kg N/ha and 200 kg K_2O/ha, respectively; however, further investigation is necessary to same experiments.

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