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Effect of spacing and nitrogenous fertilizer on growth and yield parameters of garlic (*Allium sativum* L.)

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Abstract
The present investigation was conducted at Lovely Professional University, Phagwara (Punjab) during *rabi* season (October 2017-April 2018). The experiment consisted of six treatments of different combination of spacing and nitrogen doses using garlic variety cv. PG-18 laid out in Randomized Block Design (RBD) with three replications. Two spacing S_1 (15 cm × 10 cm), S_2 (15 cm × 10 cm) and three nitrogen doses N_1 (50 kg/ha), N_2 (100 kg/ha), N_3 (150 kg/ha) were used. Data on plant height, number of leaves per plant, maturity period, neck thickness of bulb, bulb diameter, fresh weight of bulb and bulb yield per hectare were recorded. Among all the treatments, the observed growth parameters *viz.,* plant height was maximum in treatment S_1 (34.27cm) and N_3 (35.92cm), no. of leaves per plant was maximum in treatment S_2 (6.08) and N_2 (6.03) and earliness was found in S_1 (138 DAS) and N_2 (140 DAS), while interaction between spacing and nitrogen level was best in treatment S_2N_3 observed in plant height (36.16 cm) and combination S_1N_2 lead to earliness (136 DAS). Yield parameters *viz.,* neck thickness of bulb was observed maximum in S_1 (0.94cm) and N_3 (0.91cm), bulb diameter was maximum in S_1 (2.63cm) and N_3 (2.55cm), fresh weight of bulb in treatment S_1 (28.28g) and N_2 (26.78g), bulb yield was recorded highest in S_1 (6.89t/ha) and N_2 (5.80t/ha), while interaction S1N3 was found best for yield parameters neck thickness (1.01cm), bulb diameter (2.82cm), fresh weight of bulb (29.86g) and bulb yield (7.05t/ha). On the basis of observation recorded for different parameters, it was concluded that S_1N_3 (15 cm x 10 cm with combination of 150kg nitrogen per hectare) treatment showed significant variation and found best with respect to quality and yield parameters.

Keywords: Bulb diameter, nitrogen, spacing, earliness

Introduction
Garlic (*Allium sativum L.*) is the second most widely used bulb crop after onion and belongs to the family *Alliaceae,* originated from southern Europe to western Asia (Etoh and Simon, 2002) [4]. It is a vertical biennial plant with 60 cm average plant height. Garlic bulbs have a flattened conical stem from which several cloves (10-16) or individual sections consisting of thickened storage leaves and a growing point arise. The leaves are flat, solid and whenever formed, the flowers are pink (Rice *et al*., 1990) [9]. Garlic contains about 40% dry matter, 6-7% proteins, 0.2% lipids, 23-28% carbohydrates, 0.7-0.9% fibre, 1.1-1.4% ash matter and vitamins, especially B1, B2, B6 and C (Losak and Wisniowska-Kielian, 2006) [6]. Garlic has good export potential as bulb as well as in the form of dehydrated products. It is highly placed for its flavor enhancing capacity (Roy & Chakraborty, 2002).

The growth and yield of the garlic crop is governed by several factors and among these plant spacing play an important role. Closer planting can lead to competition for fertilizer, water and sunlight etc. causing poor growth of plants; whereas, wider spacing results in wastage of valuable space. Therefore, it is essential to determine the optimum plant spacing and fertilizer doses for any crop/variety under a particular soil and agro-climatic conditions. Nitrogen and spacing are inter-related and its interaction can have significant effect on plant development and yield. Therefore, information on combination of proper level of nitrogen and spacing for obtaining maximum yield of good quality is required.

Limited availability of nutrition from soil is considered as one of the factors limiting the high productivity of different crops. Loss of soil nutrients is caused by removal of surface soil by erosion, nutrients removal by crops from the soil, complete removal/destruction of plant residue from farmland and lack of crop rotation (Onweme and Sinha, 1991) [8]. Plants require nutrient elements for growing and development. Nitrogen (N), Phosphorus (P) and Potassium

(K) are major nutrients which are required by plants in large quantities. The deficiency of these elements is demonstrated in the form of growth and development disorders in plants and reduction in the yield and quality of produce (Tisdale *et al*., 1995) [12]. Judicious use of manures and mineral fertilizers could increase the leaf area, photosynthetic efficiency and yield and quality of garlic (Borabash and Kochina, 1989) [2]. Keeping the above points in view the present investigation was carried out on garlic for determining the optimum planting density and nitrogen dosage.

Materials and methods

The present investigation was carried out at vegetable research farm, Lovely Professional University, Phagwara, Punjab, India during *rabi* season 2017-18. The experiment comprised of two spacings (S_1 - 15 x 10 cm and S_2 - 20 x 10 cm) and three levels of nitrogenous fertilization (N_1 - 50 kg/ha, N_2 - 100 kg/ha and N_3 - 150 kg/ha) laid out in Randomized Block Design (RBD) with three replications using garlic var. PG-18. Standard agronomic practices were adopted for cultivation garlic. To enrich the soil, well-rotten farm yard manure @ 25 t/ha was applied before harrowing and well-mixed with the soil by hand cultivator. Manure was incorporated into the experimental plots one month before planting the cloves. The manure was applied at about 15 cm depth in trenches. Cloves were planted on October, 2017 at the depth of 3-4 cm by sticking the cloves into the bed and covering them lightly with the soil. Supplemental irrigation was provided as required and uniformly to all beds. The weeds were completely removed at the time of field preparation. Ten plants were tagged to take observations in each treatment. The observation on growth parameters *viz.* plant height, no. of leaves/plant and maturity were recorded. Harvesting of crop was done when 70% of the leaves senesced or fell over gently pulling up individual plants by hand. After harvesting yield parameters *viz.* neck thickness of bulb, bulb diameter, fresh weight of bulb and bulb yield were recorded. The recorded data was subjected to OPSTAT online software for statistical analysis.

Results and discussion

Growth parameters

Plant height, no. of leaves per plant and days to maturity is most important growth parameter in garlic as it exhibits the vigour of the plant. Data (Table: 1) indicated that the spacing's (S_1 and S_2) were significant for plant height, no. of leaves per plant and days to maturity. The interaction (Table: 1) between spacing and nitrogen dose were found to be significant for plant height and weight of fresh leaves. Among the treatment combinations the treatment S_2N_3 shows the maximum plant height (36.16 cm), S_2N_3 shows maximum no. of leaves per plant (6.20) and S_1N_2 shows minimum maturity period (136.00).while, the treatment S_1N_1 shows minimum value for plant height (32.05 cm) and no. of leaves per plant (5.70), S_2N_1 shows minimum value for weight of fresh leaves (1.26 g), maximum maturity period (149.00) was obtained in S_2N_3. Results are accordance with the findings of Dhakulkar *et al*. (2009) [3], Abuga (2014) [1] and Naruka *et al*. (2001) [7].
The maximum growth of the garlic plant was obtained with medium spacing, due to the fact that the grater plant spacing helped the plant to uptake more nutrition, soil water, air and light resulted in better growth.

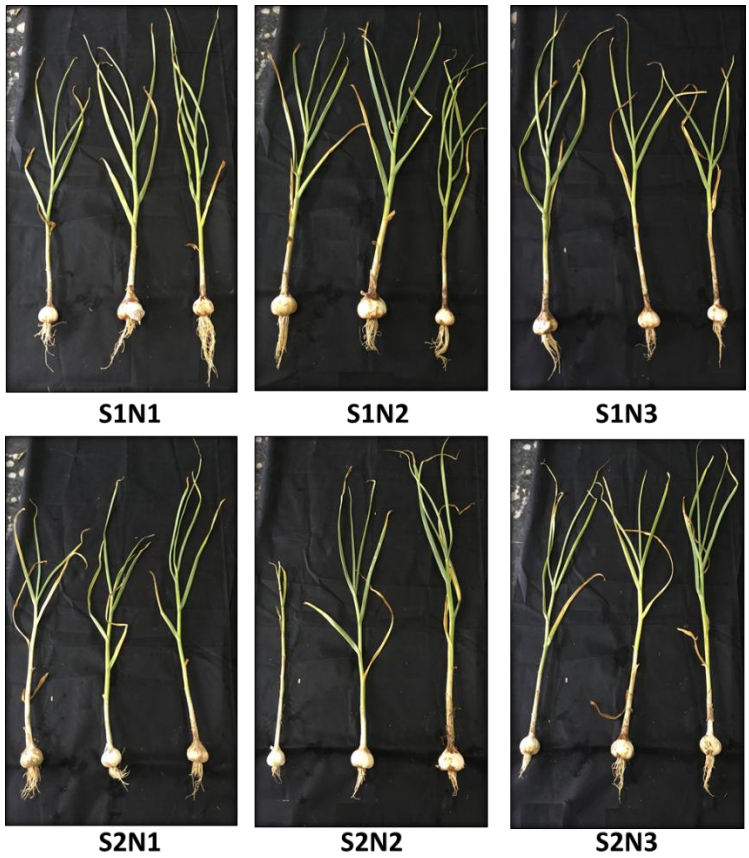

Fig 1: Garlic plants at the time of harvesting during full maturity stage. Phenotype of plants and bulbs are shown for each spacing and nitrogen fertilizer combination. S= spacing, N= Nitrogen dose levels.

Yield parameters:

Among the treatment combinations the treatment S_1N_3 shows maximum neck thickness of bulb (1.01 cm), bulb diameter (6.20), maximum fresh weight of bulb (29.86 g) and shows maximum bulb yield (7.05 t/ha). while, the minimum value pertaining to neck thickness of bulb (0.75 cm) was observed in S_2N_1, is minimum value for bulb diameter (2.11cm) in S_2N_1, S_2N_3 shows minimum value for fresh weight of bulb (21.58 g) and minimum bulb yield (4.19 t/ha) [Figure 1 and Table 1]. Similar results were reported by Hernia (2003) [5], Viloria *et al*. (2003) [13], Stoffella (1996) and Naruka *et al.* (2001) [7].

Table 1: Growth and yield parameters of garlic and interaction.

Treatments	Plant height (90 DAS) (cm)	No of leaves per plant (90 DAS)	Maturity period (DAS)	Neck thickness of bulb (cm)	Bulb diameter (cm)	Fresh weight of bulb (gm)	Bulb yield (t/ha)
Spacing (cm)							
S_1 (15 × 10) cm	34.27	5.79	138.22	0.94	2.63	28.28	6.89
S_2 (20 × 10) cm	33.77	6.08	145.56	0.81	2.27	23.40	4.56
SE (mean)	0.15	0.02	1.30	0.01	0.04	0.79	0.03
F value	0.04497*	0.00000***	0.00259**	0.00012***	0.00012***	0.00139**	0.00000***
CD at 5 %	0.49	0.07	4.16	0.05	0.13	2.52	0.10
Nitrogen dose (kg/ha)							
N_1 (50 kg)	32.43	5.88	142.33	0.84	2.34	25.02	5.75
N_2 (100 kg)	33.69	5.88	140.50	0.87	2.44	26.78	5.80
N_3 (150kg)	35.92	6.03	142.83	0.91	2.55	25.72	5.62
SE (mean)	0.19	0.03	1.59	0.02	0.05	0.97	0.04
F value	0.00000***	0.00525*	0.57069	0.04992*	0.05118	0.46150	0.01625*
CD at 5 %	0.60	0.09	-	0.06	-	-	0.12
Interaction							
S_1N_1	32.05	5.70	142.00	0.92	2.58	25.33	6.65
S_1N_2	35.05	5.80	136.00	0.89	2.49	29.65	6.96
S_1N_3	35.69	5.86	136.67	1.01	2.82	29.86	7.05
S_2N_1	32.82	6.07	142.67	0.75	2.11	24.72	4.86
S_2N_2	32.33	5.97	145.00	0.86	2.40	23.91	4.64
S_2N_3	36.16	6.20	149.00	0.82	2.29	21.58	4.19
SE (mean)	0.27	0.04	2.25	0.03	0.07	1.37	0.05
F value	0.00010***	0.05836	0.06837	0.02812*	0.02706*	0.05036	0.00000***
CD at 5 %	0.85	-	-	0.08	0.23	-	0.17

Application of S_1N_3 (15 x 10 cm + 150 kg N/ha) was found significantly superior over other treatments and gave maximum neck thickness (1.01cm). The highest diameter of bulb was annexed with 150 kg N/ha + 15 x 10 cm spacing which was more than rest of the treatments. The maximum bulb weight (29.86 gm) was observed in S_1N_3 (15 x 10 cm +150 kg N/ha). The treatment was superior over remaining treatments in respect of bulb weight. This might be due to increased length and diameter of bulb and consequently increased bulb weight. Similar findings were also reported by Viloria *et al*. (2003) [13].

Conclusion

Garlic (*Allium sativum* L.) is a high value vegetable crop. The enhancement of garlic production and productivity can be related with different growth factors. The use of appropriate agronomic management can undoubtedly contribute in higher crop yields. Intra-row spacing and nitrogen fertilizer levels are among the key agronomic practices which affect total yield and quality of garlic bulbs. From present investigation it can be deduced that among various growth parameters, the combined application of wider spacing and high nitrogen dose can lead to higher total yield. Highest mean weight of fresh leaves was recorded in the when 15cm × 10cm spacing and 50 kg N/ha were used. Highest maturity period was recorded at the combined application of 20cm × 10cm spacing and 150 kg N ha-1. Among the yield characters maximum mean neck thickness of bulb, bulb diameter, fresh weight of bulb and bulb yield were recorded at the combined application of 15cm × 10cm spacing and 150 kg N ha-1. Therefore, it can be concluded that, closer spacing and higher dosage of nitrogen fertilization can significantly improve the total yield and quality of the garlic crop.

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