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Effect of Nitrogen in Premature Sprouting of Garlic (*Allium sativum*)

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Authors' contributions

This work was carried out in collaboration among all authors. Author MRS designed the study, performing the experiment and writing of manuscript, Author MSUK supervision of experiments, analysis of data and review of manuscript. Author NM supervision of experiments and review of manuscript. Author AS analysis of data and review of manuscript. Authors AJMO and FAN review of manuscript. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was carried out at Regional Spices Research Centre, Bangladesh Agricultural Research Institute, Magura during 2021-22 and 2022-23 to find out the effect of nitrogen in premature sprouting of garlic. The two factor experiment was designed in Randomized Complete Block Design (RCB) with three replications. The treatments comprised of three varieties of garlic (BARI Rashun-1, BARI Rashun- 3 and Advance line AS Mag-001) and four dose of nitrogen. Significant differences regarding yield and yield attributes were observed among different treatments. The highest plant height (92.00 cm in 2021-22 and 94.08 in 2022-23), individual bulb weight (30.33 g in 2021-22 and 31.58 g in 2022-23) and yield per hectare (13.30 t/ha in 2021-22 and 13.48 in 2022-23) were obtained from the treatment T_4V_3 (AS Mag-001 line with nitrogen@ 235kg/ha). The lowest plant height (69.67 cm), number of leaves per plant (7.67), individual bulb weight (23.67 g) and yield per hectare (8.31 t/ha) from the treatment T_2V_1 (BARI Rashun-3 with nitrogen @ 185kg/ha). The highest number of sprouted plant (43) with maximum incidence (22.88%) were observed in T_4V_3 (AS Mag-001 line with nitrogen @ 235kg/ha)) where the lowest number of sprouted plant (7) and with minimum incidence (4.55%) were observed in T_1V_2 (BARI Rashun-3 with nitrogen @ 160kg/ha).

Keywords: Ture sprouting; garlic; nitrogen; yield; BARI rashun-1; advance line.

1. INTRODUCTION

Garlic (*Allium sativum*) is one of the most important Allium plants widely cultivated throughout the world including Bangladesh. It is an aromatic herbaceous plant belonging to the family Alliaceae [1]. It is one the most important bulb vegetable which is used as spice and flavouring agent for food and as medicinal plant [2]. It has high nutritional value, and is rich in vitamins A and C. Garlic also contains antibiotic substances which makes it valuable for medical benefits [3]. The substance exhibits antioxidant, antimicrobial, antifungal, anticancer, and antiasthmatic properties [4,5,6]. Additionally, it demonstrates antiviral effects against influenza B, HIV (type 1), herpes simplex, coxsackie, and other viruses [7]. The multiple uses of garlic today translate into its increasing demand for domestic consumption as well as production input for pharmaceutical and cosmetic industries. About 50.16 lakh Metric tons of garlic produce in 0.73 lakh hectares of land during 2021-22 year [8]. But this production is very low compared to annual demand. In Bangladesh, the uses and demand of garlic is rising every year due to rapid increase of population. It is not possible to increase the cultivation area of crop due to limitation of land. The only way to solve the problem is to increase per hectare yield. Several problems enhance to decrease the yield of garlic among them physiological disorder of garlic is a serious problems [9].

A physiological disorder is defined as one that is caused by a physiological or biochemical cause, rather than a fungal, bacteria, virus or insect [10]. Physiological disorders may occur before and after harvest, particularly during storage. Premature sprouting is a major physiological disorder mainly occurs under excess soil moisture condition at early stage especially when the bulbs are going to be matured. Pre-mature sprouting of garlic bulbs characterized by the production of leaves instead of bulbing following the initial development of cloves [11]. The sprouts emerging from the cloves will rapidly burst through the covering of the leaf sheath. Sprouting causes the cloves to divide, resulting in a decrease in the market value of the bulbs [12]. The maximum observed losses in the field due to this disorder is 0.5% [13]. It shortens the shelf life as well as reduces quality of bulbs. The causes of this disorder is complex and several factors such as temperature (low and high), mineral imbalance, relative humidity, chemicals such as ethylene, water stress and certain agricultural methods [14]. However, the incidence varies from variety to variety coupled with crop management practices as well. The scientific causes of this phenomena are still unknown but some possible reason was strongly suspected such as heavy manuring or extended periods of high soil N levels, excess irrigation and fluctuating weather condition during bulb development.

Therefore, developments of high yielding varieties, appropriate management practices, production of quality bulb are some important factors to minimize the existing wide gap between production and consumption. For these consequences, the experiment was undertaken to find out the effect of nitrogen in premature sprouting of garlic.

2. MATERIALS AND METHODS

2.1 Experimental Site

Two field experiments were conducted at the research field in Regional Spices Research Centre, BARI, Magura, during the years 2020-2021 and 2021-2022 to find out the effect of nitrogen in premature sprouting of garlic. The experimental site belongs to Agro-Ecological Zone (AEZ) No. 11 (High Ganges River Floodplain), and the geographic coordinates are latitude: 23^{0}29'18.468546" N, longitude: 89^{0}24'8.06306" E. The soil was moderately deep with clay loam in texture and had a pH of 7.54. Table 1 shows the chemical properties of the soil from the experimental plot. Soil samples were randomly collected at 0-30 cm soil depth for physical and chemical analysis before the commencement of the experiment. The soil sample was air dried ground and sieved. Then the soil sample was ready for analysis. Soil properties were analyzed by using the following methods (Table 1). All soil chemical properties were analyzed in the Regional Laboratory, Soil Resource Development Institute (SRDI), Khulna.

2.2 Experimental Design and Treatments

The experiment was laid out in factorial randomized complete design with three replications. The treatments are Factor A (Nitrogen); T_1: Nitrogen @160kg/ha, T_2: Nitrogen @ 185kg/ha, T_3: Nitrogen @ 210kg/ha, T_4: Nitrogen @ 235 kg/ha and Factor B (Varieties); V_1: BARI Rashun-1, V_2: BARI Rashun- 3, V_3: AS Mag-001 line. The unit plot size was 3m x 1.2 m maintaining the spacing 15 cm x10 cm.

2.3 Fertilization and Intercultural Operation

Nitrogen fertilizer was applied according to the treatments. The other fertilizers were applied in the form of triple super phosphate, muriate of potash, gypsum at the rate of P_{54} K_{75} S_{20} kg/ha. Well-decomposed manure was incorporated before final land preparation. The entire quantity of P, K, S. Cultural operations like watering, fertilizer application, weeding and plant protection measures were performed as per the needs of the garlic crop during the season. Three-hand weedings at 30, 50 and 70 DAP. Three irrigations at 20, 50 and 80 DAP were provided. The fungicide Rovral (Iprodione) @ 3 g/L liter of water was sprayed at 30 days intervals commencing from one month after transplanting of seedlings.

2.4 Data Collection and Analysis

Weather data such as maximum temperature, minimum temperature, and rainfall which were recorded during two cropping seasons are presented in Table 2. The weather data were collected from the Weather Observatory Station, Regional Spices Research Sub-Centre, BARI, Magura, Bangladesh. Data on plant height (cm), number of leaves/plant, bulb diameter (cm), individual bulb weight, bulb yield were recorded. The incidence of secondary sprouting of garlic was calculated by the following formula:

$$\text{Incidence of secondary sprouting (\%)} = \frac{Number\ of\ infected\ plants}{\text{Total number of plants}} x100$$

Table 1. Chemical properties of initial soil (before sowing) of the experimental site

Soil properties		Methods of analyses	Reference
Soil pH	7.8	Glass electrode method	Carter [15].
OM (%)	1.55	Wet oxidation method	Piper [16]
K (meq/100g soil)	0.34	Bray and Kurtz method	Bray and Kurtz [17]
Total N (%)	0.09	Atomic absorption spectrophotometer	Cristian and Feldmen, [18]
P (µg/g soil)	52.71	Atomic absorption spectrophotometer	Thomas, [19]
S (µg/g soil)	11.47	Turbidity method	Chesnin and Yein, [20]
Z (µg.g^1 soil)	0.98	0.1N HCl (hydrochloric acid) extraction' method	Huq and Alam, [21]
B (µg.g^{-1}soil)	0.42	Hot water text method	Berger and Truog, [22]
Soil texture	Clay loam	Hydrometer method	USDA Soil Survey Staff [23]

Source: Soil Resource Development Institute (SRDI), Khulna

The recorded data were analyzed statistically to find out the level of significance caused by experimental treatments. Data on various parameters were statistically analyzed using Statitix10 software.

3. RESULTS AND DISCUSSION

3.1 Response of Variety

Yield and yield contributing characters of different garlic varieties are presented in Table 2. Plant height, individual bulb weight and yield of garlic were significantly influenced by different varieties. The highest plant height (87.75 cm in 2021-22 and 89.73 cm in 2022-23), individual bulb weight (28.57 g in 2021-22 and 29.81 g in 2022-23) and yield per hectare (12.07 t/ha in 2021-22 and 12.69 t/ha in 2022-23) were obtained from AS Mag-001. The lowest plant height (72.67cm in 2021-22 and 74.74 cm in 2022-23), individual bulb weight (19.15 g in 2021-22 and 25.92 g in 2022-23) and yield per hectare (9.16 t/ha in 2021-22 and 9.33t/ha in 2022-23).

3.2 Response of Nitrogen

Mean performance of garlic varieties at different nitrogen levels was presented in Table 3. Yield and yield components of garlic were significantly influenced by different levels of nitrogen. The highest plant height (84.89 cm in 2021-22 and 87.00 cm in 2022-23), individual bulb weight (28.33g in 2021-22 and 29.92 g in 2022-23) and yield per hectare (11.70 t/ha in 2021-22 and 11.42 in 2022-23) were obtained from T4 (Nitrogen @ 235 kg/ha). The lowest plant height (77.78 cm in 2021-22 and 79.59 cm in 2022-23), individual bulb weight (25.56 g in 2021-22 and 27.28 g in 2022-23) and yield per hectare (9.82 t/ha in 2021-22 and 10.60 t/ha in 2022-23) were obtained from T_1 (Nitrogen @ 160 kg/ha).

3.3 Interaction Effect of Variety and Nitrogen on Yield and Yield Components of Garlic

The impact of different types and nitrogen levels on the yield and yield-contributing characteristics of garlic varieties is shown in Table 4. The yield and components of garlic were considerably affected by varying nitrogen doses and different kinds. The treatment T4V3 (AS Mag-001 with nitrogen @ 235 kg/ha) resulted in the highest plant height of 92 cm in 2021-22 and 94.08 cm in 2022-23, individual bulb weight of 30.33 g in 2021-22 and 31.58 g in 2022-23, and yield per hectare of 13.30 t/ha in 2021-22 and 11.76 t/ha in 2022-23. The treatment T2V1 (BARI Rashun-3 with nitrogen @ 185 kg/ha) exhibited the lowest plant height, with measurements of 69.67 cm in 2021-22 and 72.01 cm in 2022-23. Additionally, this treatment had the lowest individual bulb weight, with values of 23.67 g in 2021-22 and 25.34 g in 2022-23. Furthermore, the yield

Table 2. Mean performance of different garlic varieties in respects of yield and yield components

Garlic varieties and advance line	Plant height(cm)		Individual bulb weight (g)		Yield (t/ha)	
	2021-22	2022-23	2021-22	2022-23	2021-22	2022-23
V_1 : BARI Rashun-1	83.33 b	85.14 b	24.24 b	28.68 b	10.85 b	10.54 b
V_2 : BARI Rashun-3	72.67 c	74.74 c	19.15 c	25.92 c	9.16 c	9.33 c
V_3 : AS Mag-001	87.75 a	89.73 a	28.57 a	29.81 a	12.07 a	12.69 a
CV (%)	0.25	0.59	9.55	6.54	1.2	2.1

Note: Mean followed by the same letter did not differ significantly. CV= Coefficient of variation

Table 3. Effect of different nitrogen on yield and yield contributing characters of garlic varieties

Treatments	Plant height (cm)		Individual bulb weight (g)		Yield (t/ha)	
	2021-22	2022-23	2021-22	2022-23	2021-22	2022-23
T_1: Nitrogen @ 160 kg/ha	77.78 d	79.59	25.56 d	27.28	9.82 d	10.60
T_2: Nitrogen @ 185 kg/ha	80.00 c	81.73	26.00 a	27.28	10.44 c	10.66
T_3: Nitrogen @ 210 kg/ha	82.33 b	84.52	23.67 a	28.08	10.82 b	10.76
T_4: Nitrogen @ 235 kg/ha	84.89 a	87.00	28.33 a	29.92	11.70 a	11.42
CV (%)	0.31	0.98	10.49	8.75	1.17	4.36

Note: Mean followed by the same letter did not differ significantly. CV= Coefficient of variation

Table 4. Interaction performance of variety and nitrogen on yield and yield contributing characters of garlic varieties

Treatments	Plant height (cm)		Individual bulb weight (g)		Yield (t/ha)	
	2021-22	2022-23	2021-22	2022-23	2021-22	2022-23
T_1V_1	80.33 g	82.07 g	25.67 ab	27.80 de	10.16 de	10.35 d
T_1V_2	69.67 k	72.01 j	23.67 ab	25.34 g	8.31g	9.68 ef
T_1V_3	83.33 e	84.67 ef	27.33 ab	28.69 cde	10.99 c	11.76 c
T_2V_1	82.00 f	83.33 fg	26.00 ab	27.21 ef	10.44 d	10.31 de
T_2V_2	72.33 j	74.01 i	24.00 ab	25.84 fg	9.06 f	9.06 f
T_2V_3	85.67 d	87.84 d	28.00 ab	28.76 cde	11.83 b	12.61 b
T_3V_1	83.33 e	85.19 e	27.00 ab	29.15 bcd	10.85 c	11.48c
T_3V_2	73.67 i	76.02 h	24.00 ab	24.90 g	9.42 f	9.33 f
T_3V_3	90.00 b	92.34 b	20.00 b	30.20 abc	12.19 b	12.93 ab
T_4V_1	87.67 c	89.96 c	28.67 a	30.58 ab	11.96 b	10.01de
T_4V_2	75.00 h	76.94 h	26.00 ab	27.60 de	9.84 e	9.28 f
T_4V_3	92.00 a	94.08 a	30.33 a	31.58a	13.30 a	13.48a
CV (%)	0.57	0.98	8.35	3.38	2.80	4.36

per hectare was also the lowest for this treatment, with 8.31 t/ha in 2021-22 and 9.68 t/ha in 2022-23. Nitrogen fertilisers stimulate vegetative growth, increase the number of cloves, elevate leaf count per plant, enhance plant height, and promote garlic bulb output [24].

3.4 Incidence of Premature Sprouting

Table 5 displayed the impacts of several treatments on the premature sprouting of garlic. In the 2021-22 and 2022-23 seasons, the highest number of premature sprouted plants per plot (38.76 and 34.67) was observed in T4V3 (AS Mag-001 with nitrogen at a rate of 235 kg/ha). On the other hand, the lowest number of premature sprouted plants per plot (9.49 in 2021-22 and 1.02 in 2022-23) was observed in T1V2 (BARI Rashun-3 with nitrogen at a rate of 160 kg/ha). The highest percentage of premature sprouting (22.88% in 2021-22 and 18.23% in 2022-23) was observed in T4V3 (AS Mag-001 with nitrogen at a rate of 235 kg/ha). Conversely, the lowest percentage of premature sprouting, (4.55% in 2021-22 and 0.46% in 2022-23), was observed in T1V2 (BARI Rashun-3 with nitrogen at a rate of 160 kg/ha).

By increasing the nitrogen levels, the bulbs undergo accelerated sprouting, resulting in bulb splitting and rubbering. Elevated nitrogen levels, along with heightened splitting, resulted in a decline in the quality of garlic bulbs [25].

Table 5. Effect of different treatment on premature sprouting of garlic

Treatment	Number of normal plants/plot (nos.)		Number of premature sprouted plants/plot (nos.)		Percent of premature sprouting (%)	
	2021-22	2022-23	2021-22	2022-23	2021-22	2022-23
T_1V_1	198.00 d	211.00 bc	19.77 f	14.00 cd	10.00 e	6.63 cd
T_1V_2	210.00 a	219.67 a	9.54 j	1.02 e	4.55 h	0.46 e
T_1V_3	190.00 e	209.33 c	25.86 d	15.67 c	13.64 d	7.49 c
T_2V_1	197.67 d	211 bc	20.02 f	14.00 cd	10.15 e	6.63 cd
T_2V_2	207.33 b	219.33 a	11.92 i	2.33 e	5.76 g	1.12 e
T_2V_3	180.33 f	203.33 d	32.38 c	21.67 b	18.03 c	10.68 b
T_3V_1	192.33 e	213.67 b	24.13 e	11.33 d	12.58 d	5.31 d
T_3V_2	205.00 b	219.33 a	13.95 h	2.00 e	6.82 g	0.91 e
T_3V_3	176.33 g	201.33 d	34.92 b	23.67 b	19.85 b	11.78 b
T_4V_1	178.00fg	211.33 bc	33.89 b	13.67 cd	19.09 bc	6.48 cd
T_4V_2	202.00 c	219.67 a	16.50 g	1.00 e	8.18 f	4.29 d
T_4V_3	169.67 h	190.33 e	38.76 a	34.67 a	22.88 a	18.23 a
CV (%)	0.77	2.32	3.34	7.27	5.34	7.53

4. CONCLUSION

From the above discussion, it was concluded that maximum premature sprouting was observed from those plots where application of nitrogen was higher (nitrogen @ 235 kg/ha) and it was highest in high yielding advance line AS Mag-001. Further physiological and biochemical elucidation is required for an in-depth study.

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DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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