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EFFECT OF NITROGEN, PHOSPHORUS AND POTASSIUM ON THE GROWTH AND YIELD PERFORMANCE OF GARLIC (*Allium sativum* L.) IN COASTAL ZONE OF BANGLADESH

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ABSTRACT

The experiment was carried out at Agricultural Research Field, Noakhali Science and Technology University, Noakhali, Bangladesh during the period from November 2021 to March 2022, to observe the effect of nitrogen (N), phosphorus (P) and potassium (k) fertilizer on growth and yield of garlic (*Allium sativum* L. V: BINA Roshun-1). The experiment was laid out in a Randomized Complete Block Design (RCBD) comprising four treatments with three replications. The treatments were T_0 (no NPK), T_1 (NPK 70-70-100 kg ha^{-1}), T_2 (NPK 100-100-140 kg ha^{-1}), T_3 (NPK 130-130-180 kg ha^{-1}), and here, N = Nitrogen, P=P_2O_5, K= K_2O respectively. Data were recorded from harvesting stages of plant growth on the plant height, number of leaves per plant, leaf length, number of roots per plant, bulb diameter, bulb length, number of cloves per plant, whole weight of plant, fresh weight of bulb and fresh bulb yield per hectare. All the recorded parameters were statistically significant ($p<0.01$). The highest plant height (69.57 cm) was recorded from T_3 (NPK 130-130-180 kg ha^{-1}) whereas the lowest plant height (51.40 cm) was obtained from the control T_0 (no NPK). The maximum number of leaves per plant (9.97), leaf length (38.10 cm), number of roots per plant (90.83), bulb length (3.30 cm), bulb diameter (3.80 cm), number of cloves per plant (28.97), whole weight of plant (65.07 g), fresh weight of bulb (42.50 g) and fresh bulb yield per hectare (2.83 t/ha) was found in treatment T_3 (NPK 130-130-180 kg ha^{-1}) whereas lowest data recorded from control T_0 (no NPK). Observing the results, it can be stated that application of NPK fertilizer @ N 130 kg ha^{-1}, P_2O_5 130 kg ha^{-1} and K_2O 180 kg ha^{-1} for garlic cultivation gave better growth and yield in coastal zone of Bangladesh.

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INTRODUCTION

Garlic (*Allium sativum* L.) is one of the most important bulb crops belongs to family Alliaceae (FAO, 2016; Kurian, 1995). Garlic is the second most significant cultivated Allium after onion in world (Bose and Som, 1990) as well as in Bangladesh. Garlic is well known as a spice crop in Bangladesh as well as in the world. During the rabi season, garlic is grown throughout Bangladesh and consumed by the majority of the people (Rashid, 1996). Garlic is cultivated all over Bangladesh mainly in Natore, Manikgonj, Faridpur, Jashore, Rajshahi, Dinajpur, Dhaka, Pabna and Rangpur (BBS, 2019). Garlic is widely used for a variety of purposes all over the world. It is widely used as popular spice to make various dishes. It is highly enriched in carbohydrate, protein and phosphorus (Augusti, 1977). It is cultivated as spice and also used as medicine. The Average yield of garlic in Bangladesh is only 5.21 ton per hectare (BBS, 2012) which is very low as compared to many countries of the world. In Bangladesh about 485448 metric tons of garlic was produced from approximately 73652 ha of land in 2019-20 (BBS, 2021). Use of appropriate nutrient management plays a specific role in the growth and yield of garlic. A balanced application of fertilizer can enhance bulb yield significantly. Nitrogen is required for cell division and vital for plant growth. It directly involved in photosynthesis. Most of the agricultural lands in Bangladesh are deficient in nitrogen due to low level of organic matter. Nitrogen application that is unbalanced and poorly regulated reduces yields and causes significant reactive nitrogen losses to the environment. (Cassman *et al.,* 2002). In early growth, nitrogen boosted the rates of leaf start and extension in garlic (Garcia, 1980; Koltunov, 1984). It enhanced bulb growth and development (Buwalda and Freeman, 1987, Fritsch et al., 1990; Hossain, 1997). Phosphorus promotes early root formation and growth. It also involved cell division, cell enlargement and increase water use efficiency (Diriba-Shiferaw *et al.,* 2015). Potassium (K) is an essential nutrient for improving garlic yields. Appropriate application rates and timing are essential for producing a yield or quality response. As crop productivity increases, so does the amount of K required, as well as all other nutrients (Mendez et *al.,* 2001). Garlic K requirement ranges from 125 to 180 kg K_2O ha^{-1}. (Bertoni 1988; Zink 1963). With increasing levels of K application, total bulb yield increased (Sing and Verma 2001; Sharma *et al.,* 2003; Bybordi and Malakouti 2003; Linx and Niwuzhang 1997 and Melzer *et al.,* 1999). Potassium helps in the root development and increase the efficiency of leaf in the manufacture of sugar and starch.

Various biotic and abiotic stress factors have a significant impact on garlic production. Soil salinity is one of the reasons that affect garlic productivity. Soil Salinity has a negative impact on crop quality, yield, and growth (Razzouk and Whittington, 1991; Dong, 2008). The suitable crops growing conditions are decreasing due to the salinity in many coastal areas of Bangladesh (Ali *et al.,* 2022). In coastal region of Bangladesh, most of the farmers lacking knowledge about the appropriate levels of nitrogen, phosphorus and potassium fertilizer for garlic cultivation. Lower yield of garlic in coastal zones of Bangladesh is subjected to many factors; especially deficiency of nutrients is one of them. Keeping this in mind, the present research work has been undertaken to find out an optimum dose of nitrogen, Phosphorus and Potassium for yield maximization of garlic in coastal zone of Bangladesh. Hopefully this research work will be end up with a positive outcome and helps to contribute the production of garlic as well as agricultural sector.

MATERIALS AND METHODS

Description of the experimental site Location and soil

The research site belongs to Young Meghna Estuarine Flood Plain under the soil of Agro Ecological Zones (AEZ)-18. The site is used for cultivation of horticultural and cereal crops. The soil type is loamy with organic matter (0.68%), with total nitrogen of 0.04 g/kg, available P in the soil 27.79 µg/g, and available K in the soil 0.18 meq/100 g soil with soil is pH value 7.4 and the soil salinity 5.08 ds/m.

Experimental design and layout

Single factor experiment was laid out at Randomized Complete Block Design (RCBD) comprising four treatments with three replications. The experimental area was divided into three blocks each representing a replication. Each block was then divided into 4 plots. Therefore, the total number of plots was 16. The size of unit plot was 1m × 1m = $1m^2$ where block to block and plot to plot distance was 0.5m and 0.5m respectively. The spacing was 15cm × 10cm.

Experimental treatment detail

The experiment was designed to study the effect of nitrogen, phosphorus and potassium on the growth and yield of garlic. The experiment was laid out in a Randomized Complete Block Design (RCBD) comprising four treatments. The treatments were T_0 (no NPK), T_1 (NPK 70-70-100 kg ha^{-1}), T_2 (NPK 100-100-140 kg ha^{-1}), T_3 (NPK 130-130-180 kg ha^{-1}) and here, N = Nitrogen, P=P_2O_5, K= K_2O.

Planting materials:

Seeds or cloves of garlic variety, 'BINA Roshun-1' were used and planting on 10th November 2021.

Land preparation and Sowing

The experimental field was opened 1st November 2021 with the help of a power tiller and then it was kept open to sun for 7 days prior to further ploughing. Following that, it was ploughed and cross ploughed before being laddered. After each laddering, the weeds and stubbles were cleared. Cloves are planted on seed bed by hand and planting on 10th November 2021.

Fertilizer application

Cowdung @ 5 tha^{-1} was applied during final land preparation. Nitrogen was applied in the form of urea. Phosphorus and potassium were applied in the form of triple super phosphate and muriate of potash. Full dose of TSP was applied as dose at time of planting. Half amount of Urea and MoP was applied at the time of final land preparation and the rest amount of Urea and MoP was applied as top dress after 60 and 90 days after planting.

Intercultural operation

Weeding was done three times in plots to keep plots free from weeds. First weeding was done one month after planting, second one month after first weeding and third at later stage of crop. Irrigations were given by hand sprayer when needed. Imidacloprid and mancozeb was applied at 2 times for the control of insect and fungi.

Data Collection

Data on plant height, number of leaves, leaf length, number of roots, bulb length, bulb diameter, Number of cloves per bulb**,** Whole plant weight, fresh weight of bulb and fresh bulb yield per hectare of garlic were recorded from nine plants being randomly selected from each plot.

Statistical Analysis

The mean values for all the parameters were calculated and the analysis of variances for the characters was accomplished by F variance test. The significance of difference between pair of means was tested by the least significant difference (LSD) test at 1% levels of probability (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Plant height

Plant heights of garlic were significantly influenced by nitrogen, phosphorus and potassium fertilization (Table 1). The maximum plant height (69.57 cm) was recorded in treatment T_3 (NPK 130-130-180 kg ha^{-1}) which was followed by treatment T_2 (66.40 cm) and the minimum plant height (51.40 cm) was recorded in the control plot receiving no NPK fertilizer. This result showed that the application of nitrogen, phosphorus and potassium fertilizer increased plant height of garlic in coastal region but application of NPK fertilizer @ N 130 kg ha^{-1}, P_2O_5 130 kg ha^{-1} and K_2O 180 kg ha^{-1} for garlic cultivation gave better growth in coastal zone. Hewitt and Smith (1974) suggested the increased growth and number of leaves in response to nitrogen application may be attributed to the role nitrogen plays in cell division, elongation and leaf growth. Consistent with the findings of this study, Kakar *et al.* (2002) and Kilgori *et al*. (2007) reported an increased garlic height up to 100 kg N ha^{-1}. However, Grad *et al*. (1993) and Singh and Singh (1999) founded the tallest garlic plants at the rates of 90 and 80 kg P ha^{-1} respectively. Jiku *et al*. (2020) obtained the tallest garlic plants at the rates of 200 kg potassium ha^{-1}.

Number of leaves

Application of nitrogen, phosphorus and potassium fertilizer showed statistically significant ($p<0.01$) variation on the number of leaves per plant (Table 1). The maximum number of leaves per plant (9.97) was recorded in treatment T_3 (NPK 130-130-180 kg ha^{-1}) followed by treatment T_2 (9.40), T_1 (9.10) and T_0 (6.70), respectively. This result showed that the application of nitrogen, phosphorus and potassium fertilizer increased the number of leaves per plant of garlic coastal region but application of NPK fertilizer @ N 130 kg ha^{-1}, P_2O_5 130 kg ha^{-1} and K_2O 180 kg ha^{-1} for garlic cultivation gave better growth in coastal zone. Hewitt and Smith (1974) suggested the increased growth and number of leaves in response to nitrogen application may be attributed to the role nitrogen plays in cell division, elongation and leaf growth. Kakar *et al.* (2002) and Kilgori *et al.* (2007) reported an increased leaf number of garlic up to 100 kg N ha-^{1}. Jiku *et al*. (2020) obtained the maximum number of leaves at the rates of 200 kg potassium ha-^{1}.

Table 1. Effect of nitrogen, phosphorus and potassium fertilizer on vegetative growth of garlic

Treatment	Plant height (cm)	Number of leaves	Leaf length (cm)	Root number
T_0	51.40^{c}	6.70^{b}	26.63^{c}	57.67^{d}
T_1	63.03^{b}	9.10^{a}	34.53^{b}	72.87^{c}
T_2	66.40^{ab}	9.40^{a}	37.10^{ab}	83.90^{b}
T3	69.57^{a}	9.97^{a}	38.10^{a}	90.83^{a}
CV (%)	2.47	7.83	2.75	1.12
LSD	4.68	2.08	2.84	2.58
Level of Significance	**	**	**	**

T_0 = (no fertilizer), T_1 = (N 70 kg ha^{-1}, P_2O_5 70 kg ha^{-1} and K_2O 100 kg ha^{-1}), T_2 = (N 100 kg ha^{-1}, P_2O_5 100 kg ha^{-1} and K_2O 140 kg ha^{-1}), T_3 = (N 130 kg ha-1, P_2O_5 130 kg ha^{-1} and K_2O 180 kg ha^{-1}).
CV = Co-efficient of variation; LSD = Least Significant Difference; ** = Significant at 1% level of probability

Table 2. Effect of nitrogen, phosphorus and potassium fertilizer on yield parameters of garlic

Treatment	Bulb length (cm)	Bulb diameter (cm)	Number of cloves	Whole plant weight (g)	Fresh weight of bulb (g)	Fresh bulb yield (t/ha)
T_0	2.47^{d}	2.53^{d}	20.43^{d}	22.60^{d}	11.77^{d}	5.77^{d}
T_1	2.80^{c}	2.90^{c}	23.93^{c}	39.60^{c}	20.93^{c}	10.26^{c}
T_2	3.07^{b}	3.20^{b}	26.17^{b}	51.77^{b}	33.30^{b}	16.32^{b}
T_3	3.30^{a}	3.80^{a}	28.97^{a}	65.07^{a}	42.50^{a}	20.83^{a}
CV (%)	2.07	2.46	2.60	1.57	2.76	2.76
LSD	0.18	0.23	1.96	2.13	2.27	1.11
Level of Significance	**	**	**	**	**	**

T_0 = (no fertilizer), T_1 = (N 70 kg ha^{-1}, P_2O_5 70 kg ha^{-1} and K_2O 100 kg ha^{-1}), T_2 = (N 100 kg ha^{-1}, P_2O_5 100 kg ha^{-1} and K_2O 140 kg ha^{-1}), T_3 = (N 130 kg ha-1, P_2O_5 130 kg ha^{-1} and K_2O 180 kg ha^{-1}).
CV = Co-efficient of variation; LSD = Least Significant Difference; ** = Significant at 1% level of probability

Leaf length

The effect of nitrogen, phosphorus and potassium on leaf length was shown in Table 1. Considering the treatments, significant ($p<0.01$) variation was recorded in leaf length of garlic. The longest leaf (38.10 cm) of garlic was measured in T_3 (NPK 130-130-180 kg ha^{-1}), and the shortest (26.63 cm) was recorded in the treatment T_0 (no NPK) followed by the treatment T_1 (34.53 cm), and T_2 (37.10 cm), respectively. This result showed that the application of nitrogen, phosphorus and potassium fertilizer increased leaf length of garlic in coastal region soil. Hewitt and Smith (1974) suggested the increased growth and number of leaves in response to nitrogen application may be attributed to the role nitrogen plays in cell division, elongation and leaf growth.

Root number

Application of NPK fertilizer showed statistically significant ($p<0.01$) variation on the number of roots per of garlic plant (Table 1). The maximum number of roots per plant (90.83) was recorded in T_3 (NPK 130-130-180 kg ha^{-1}) followed by T_2 (NPK 100-100-140 kg ha^{-1}) which was (83.90). While the minimum number of roots per plant was recorded in T_0 (no NPK), which was (57.67). This result showed that the application of nitrogen, phosphorus and potassium fertilizer increased the number of roots per plant of garlic coastal region soil but application of NPK fertilizer @ N 130 kg ha^{-1}, P_2O_5 130 kg ha^{-1} and K_2O 180 kg ha^{-1} for garlic cultivation gave better growth. Application of phosphorus and potassium fertilizer mainly increased number of roots per of garlic plant.

Bulb length

Statistically significant ($p<0.01$) variation was recorded on bulb length of garlic for different levels of NPK fertilizer management practices (Table 2). The maximum length of bulb (3.3 cm) of garlic was measured in T_3 (NPK 130-130-180 kg ha^{-1}), and the minimum length of bulb (2.5 cm) was recorded in the treatment T_0 (no fertilizer) followed by the treatment T_1 (2.8 cm), and T_2 (3.1 cm), respectively. This result showed that the application of different levels of nitrogen, phosphorus and potassium fertilizer increased bulb length of garlic but application of NPK fertilizer @ N 130 kg ha^{-1}, P_2O_5 130 kg ha^{-1} and K_2O 180 kg ha^{-1} for garlic cultivation gave better bulb length in coastal zone.

Bulb diameter

Bulb diameter of garlic was significantly ($p<0.01$) influenced by the application of different levels of NPK fertilizer (Table 2). The highest bulb diameter of garlic (3.8 cm) was recorded in treatment T_3 (NPK 130-130-180 kg ha^{-1}) followed by treatment T_2 (3.2 cm), T_1 (2.9 cm) and where the lowest bulb diameter of garlic (2.5 cm) was recorded in treatment T_0 (no fertilizer), respectively. This result showed that the application of different levels of nitrogen, phosphorus and potassium fertilizer increased bulb diameter of garlic in coastal region but application of NPK fertilizer @ N 130 kg ha^{-1}, P_2O_5 130 kg ha^{-1} and K_2O 180 kg ha^{-1} treatment possibly favored plant growth and development, thus producing wider bulb. Setty and Sulikeri (1989), Hossain (1997), Talukder (1998), El-Bassiony (2006) and Jiku *et al*. (2020) also found larger bulb from increased K level up to 200 kg k/ha.

Number of cloves per bulb

Different levels of NPK fertilizer showed significant variation for number of cloves per bulb of garlic (Table 2). Observed result showed that the maximum number of cloves per bulb of garlic (29.0) was recorded from treatment T_3 (NPK 130-130-180 kg ha^{-1}) where the minimum number of cloves per bulb of garlic (20.4) was recorded from treatment T_0 (no NPK). This result showed that the application of different levels of nitrogen, phosphorus and potassium fertilizer increased number of cloves per bulb of garlic but application of NPK fertilizer @ N 130 kg ha^{-1}, P_2O_5 130 kg ha^{-1} and K_2O 180 kg ha^{-1} treatment possibly favored plant growth and development, thus producing maximum number of cloves per bulb of garlic in coastal zone. Setty and Sulikeri (1989), Hossain (1997), Talukder (1998), El-Bassiony (2006) and Jiku *et al*. (2020) also found maximum bulb yield from increased K level up to 200 kg k/ha.

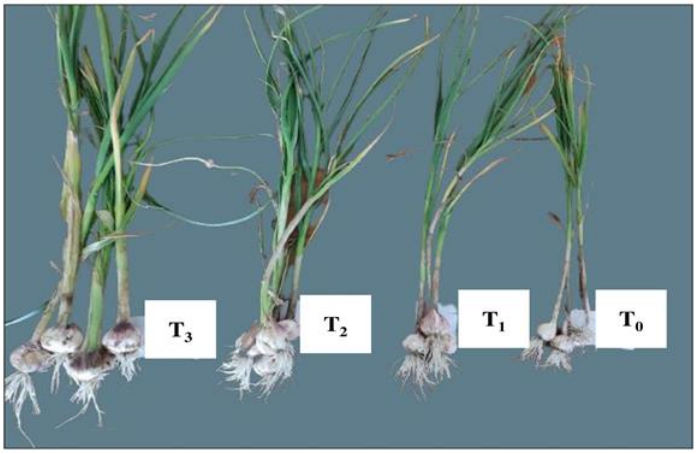

Figure 1. Effects of NPK fertilizer on yield of garlic

Whole plant weight

Whole plant weight of garlic was significantly ($p<0.01$) influenced by the application of different levels of NPK fertilizer (Table 2). The highest whole plant weight of garlic (65.1 g) was recorded in treatment T_3 (NPK 130-130-180 kg ha^{-1}) followed by treatment T_2 (51.8 g), T_1 (39.6 g) and where the lowest whole plant weight of garlic (22.6 g) was recorded in treatment T_0 (no fertilizer), respectively. This result showed that the application of NPK fertilizer @ N 130 kg ha^{-1}, P_2O_5 130 kg ha^{-1} and K_2O 180 kg ha^{-1} for garlic cultivation gave highest whole plant weight in coastal zone. Jiku *et al*. (2020) found maximum from highest whole plant weight of garlic increased K level up to 200 kg k/ha.

Fresh weight of bulb

Application of NPK fertilizer showed statistically significant ($p<0.01$) variation on fresh weight of bulb (Table 2) (Figure 1). Observed result showed that the maximum fresh weight of bulb of garlic (42.5 g) was recorded from treatment T_3 (NPK 130-130-180 kg ha^{-1}) where the minimum fresh weight of bulb of garlic (11.8 g) was recorded from treatment T_0 (no NPK). This result showed that the application of NPK fertilizer @ N 130 kg ha^{-1}, P_2O_5 130 kg ha^{-1} and K_2O 180 kg ha^{-1} for garlic cultivation gave maximum fresh weight of bulb in coastal zone. Setty and Sulikeri (1989), Hossain (1997), Talukder (1998), and El-Bassiony (2006) and Jiku *et al*. (2020) also found larger bulb from increased K level up to 200 kg k/ha.

Fresh bulb yield

Application of nitrogen, phosphorus and potassium fertilizer showed statistically significant ($p<0.01$) variation on fresh bulb yield of garlic (Table 2) (Figure 1). The maximum fresh bulb yield of garlic (20.83 t/ha) was recorded from treatment T_3 (NPK 130-130-180 kg ha^{-1}) where the minimum fresh bulb yield of garlic (5.77 t/ha) was recorded from treatment T_0 (no NPK). . This result showed that the application of different levels of nitrogen, phosphorus and potassium fertilizer increased fresh bulb yield of garlic but application of NPK fertilizer @ N 130 kg ha^{-1}, P_2O_5 130 kg ha^{-1} and K_2O 180 kg ha^{-1} for garlic cultivation gave better fresh bulb yield in coastal zone of Bangladesh. Setty and Sulikeri (1989), Hossain (1997), Talukder (1998), El-Bassiony (2006) and Jiku *et al*. (2020) also found maximum bulb yield from increased K level up to 200 kg k/ha.

CONCLUSION

The results indicated that nitrogen, phosphorus and potassium fertilizer doses had a positive impact on the growth and yield parameters of garlic like plant height, number of leaves, leaf length number of roots, bulb length, bulb diameter, number of cloves per bulb**,** whole plant weight, fresh weight of bulb and fresh bulb yield per hectare. Comparative results of various parameters studied in the present investigation suggested that T_3 was the best treatment because fresh weight of bulb was highest (42.50 g) in treatment T_3 and also the highest fresh bulb yield (20.83 t/ha) was found in treatment T_3 (NPK 130-130-180 kg ha^{-1}). Therefore, recommendation of NPK fertilizer @ N 130 kg ha^{-1}, P_2O_5 130 kg ha^{-1} and K_2O 180 kg ha^{-1} as fertilizer dose necessitates both regional and multi-location trials.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interests regarding the publication of this paper.

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