Effect of Phosphorus and Gibberellic Acid on Growth and Yield of Tuberose (Polianthes tuberosa)

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Authors' contributions

This work was carried out in collaboration among all authors. Authors MHA and MNI planned the experiment and lead the research. Authors LM, MHA and MNI designed and carried out the research. Authors LM and MNI performed the statistical analysis. Authors LM and MHA carried out the research on the field. Author LM collected the data, wrote the manuscript and managed the literature searches. All authors provided critical feedback, helped shape the research, analysis, read and approved the final manuscript.

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ABSTRACT

The present study was carried out in the Horticulture farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during October 2017 to March 2018 to study the Effect of phosphorus (P) and gibberellic acid (GA₃) on growth and yield of tuberose (Polianthes tuberosa). Four phosphorus levels viz. P₀ = 0 kg P₂O₅ ha⁻¹, P₁ = 65 kg P₂O₅ ha⁻¹, P₂ = 85 kg P₂O₅ ha⁻¹ and P₃ = 110 kg P₂O₅ ha⁻¹ and three GA₃ levels viz. G₀ = 0 ppm GA₃, G₁ = 115 ppm GA₃ and G₂ = 145 ppm GA₃. The experiment was laid out in the two factors Randomized Complete Block Design (RCBD) with three replications. Regarding P application, P₃ gave the highest plant height (61.02 cm) and number of leaves plant⁻¹ (7.29.35) compared to control treatment but the highest yield parameters no. of spike ha⁻¹ (368.60 thousand), bulb yield (25.88 t ha⁻¹) and bulblet yield (14.21 t ha⁻¹) were found from the treatment P₂ whereas control treatment P₀ showed lowest results. In case of GA₃ application, G₂ showed highest growth and yield parameter and the highest no. of spike ha⁻¹ (362.30 thousand), bulb yield (25.38 t ha⁻¹) and bulblet yield (14.00 t ha⁻¹) were obtained from G₂ whereas the lowest results were found from the control treatment G₀. Treatment combine of P and GA₃, the highest no. of spike ha⁻¹ (405.60 thousand), bulb yield (31.45 t ha⁻¹), and bulblet yield (16.01 t ha⁻¹) were found

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1. INTRODUCTION

Tuberose (Polianthes tuberosa L.), the common name derives from the Latin tuberosa, meaning swollen or tuberous in reference to its root system, Polianthes means “many flowers” in Greek. It is an erect perennial plant with a 75-120 cm stem. It is a member of family Amaryllidaceae, originated in Mexico and is grown on large scale in Asia [1]. It blooms in summer when planted in spring and its clustered spikes are rich in fragrance. It is an important cut flower crop from aesthetic as well as commercial point of view. There are three types of tuberose; single with one row of corolla segments, double having more than three rows of corolla segments and semi-double bearing flowers with two or three rows of corolla segments [2]. Tuberose is a gross feeder plant receives a large quantity of NPK as organic and inorganic form which have great influence on growth, flower and bulb production [3,4,5]. In determining the yields of flower crops, phosphorus (P) is also one of the major and crucial limiting factors. Thus, it has been called as “the key to life” because it is directly involved in most life processes. Deficiency of phosphorus may adversely affect the plant in maintaining the full supply of N and K and excess application of P may result in various nutritional problems including Ca and Zn deficiency [6]. Also, the potential use of plant growth regulator like GA3 in flower production has created considerable scientific interest in recent years [7,8]. In Bangladesh, it is necessary to know the real impact of plant growth regulator like GA3 on tuberose. Keeping in view, the importance of tuberose and unavailability of limited local information regarding its optimum phosphorus requirements and application of GA3, the present research was undertaken to explore the optimum doses of phosphorus and growth regulator (GA3) which can produce healthy plants with good quality flowers and give maximum number of spike and spikelets, bulb and bulblets with the following objectives

- To find out the optimum level of phosphorus and GA3 on growth, flowering and bulb production of tuberose.
- To find out the suitable combination of phosphorus and GA3 on growth, flowering and bulb production of tuberose.

2. MATERIALS AND METHODS

2.1 Experimental Site and Experimental Framework

The present piece of research work was conducted in the Horticulture Farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during August 2017 to October 2018. The location of the site is 90°33’ E longitude and 23°77’ N latitude with an elevation of 8.2 m from sea level. The soil of the experimental area belongs to the Modhupur Tract [9] under AEZ No. 28 and was dark grey terrace soil. The selected plot was medium high land and the soil series was Tejgaon [10]. The two factors experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The layout of the experiment was prepared for distributing the different combination of phosphorus and GA3 levels. The different combination of phosphorus and GA3 are control (P0), 140 kg TSP ha⁻¹ (P₁), 190 kg TSP ha⁻¹ (P₂), 240 kg TSP ha⁻¹ (P₃) and Control (G0), 115 ppm GA3 (G₁), 145 ppm GA3 (G₂) respectively. The 12 treatment combinations of the experiment were assigned at random into 36 plots. The size of each unit plot 1.5 m × 1 m. The distance between blocks and plots were 1.0 m and 0.5 m respectively. The tuberose variety “Double” was used for the present study.

2.2 Fertilizers and Manure Application

The manure and fertilizer were applied according to BARI recommendation, 2018. N, P and K were applied through urea, TSP and MoP respectively. Cowdung also used as organic

Keywords: Tuberose; phosphorus; gibberellic acid (GA3); bulb production.
manure. P was applied through TSP as per treatment.

2.3 Application and Preparation of \( \text{GA}_3 \)

The stock solution of 1000 ppm of \( \text{GA}_3 \) was made by mixing of 1 g of \( \text{GA}_3 \) with small amount of ethanol to dilute and then mixed in 1 litre of water. Then as per requirement of 115 ppm and 145 ppm solution of \( \text{GA}_3 \), 115 ml and 145 25 ml of stock solution were mixed with 1 litre of water respectively. Application of \( \text{GA}_3 \) was done at 40 days and 60 days after planting of bulb.

2.4 Statistical Analysis

The data collected from the experimental plots were analyzed statistically with the help of computer software programme MSTAT-C. The mean differences were adjusted with LSD Test [11].

2.5 Economic Analysis

Economic analysis was done to find out the cost effectiveness of different treatments like different levels of phosphorus and \( \text{GA}_3 \) in cost and return were done in details according to the procedure of Alam et al. (1989).

2.6 Benefit Cost Ratio (\( \text{Bcr} \))

The economic indicator \( \text{BCR} \) was calculated by the following formula for each treatment combination.

\[
\text{Benefit cost ratio (Bcr)} = \frac{\text{Gross income per hectare}}{\text{Total cost of production per hectare}}
\]

3. RESULTS AND DISCUSSION

3.1 Growth Parameters

3.1.1 Plant height

Significant influence was observed in plant height of tuberose at different growth stages (Fig. 1). Results indicated that the highest plant heights (22.54, 45.37, 52.30 and 61.02 cm at 30, 55, 80 and 105 DAP, respectively) were found from the treatment \( \text{G}_2 \) whereas the lowest plant height (18.90, 40.03, 46.51 and 54.33 cm at 30, 55, 80 and 105 DAP, respectively) was found from the control treatment \( \text{G}_0 \). This result indicated that the plant height increased linearly with the increasing level of \( \text{GA}_3 \). The observed results were in agreement with the findings of Nagaraja et al. [12] and Wankhade et al. [13] and they found that plant height was increased with the increasing level of \( \text{GA}_3 \) to a certain level.

Significant variation was recorded due to combined effect of P and \( \text{GA}_3 \) in terms of plant height of tuberose at 30, 55, 60, 80 and 105 days after planting (DAP) (Table 1). Results showed that the highest plant height (21.67, 4.91, 51.05 and 59.46 cm at 30, 55, 80 and 105 DAP, respectively) was found from the treatment \( \text{G}_2 \) whereas the lowest plant height (18.90, 40.03, 46.51 and 54.33 cm at 30, 55, 80 and 105 DAP, respectively) was found from the control treatment \( \text{G}_0 \). This result indicated that the plant height increased linearly with the increasing level of \( \text{GA}_3 \). The observed results were in agreement with the findings of Nagaraja et al. [12] and Wankhade et al. [13] and they found that plant height was increased with the increasing level of \( \text{GA}_3 \) to a certain level.

Significant differences were recorded on number of leaves plant\(^{-1}\) at different growth stages except at 30 DAP by applying different levels of P plant\(^{-1}\) (Fig. 3). The highest number of leaves plant\(^{-1}\) (7.02, 13.92, 24.14 and 29.35 at 30, 55, 80 and 105 DAP, respectively) was found from the treatment \( \text{P}_3 \) whereas the lowest number of leaves plant\(^{-1}\) (6.00, 9.53, 15.89 and 19.34 at 30, 55, 80 and 105 DAP, respectively) was found from the control treatment \( \text{P}_0 \).

Significant variation was found in case of number of leaves plant\(^{-1}\) due to application of different
levels of GA$_3$ at different days after planting except 30 DAP. (Fig. 4). The highest number of leaves plant$^{-1}$ (6.80, 13.24, 22.73 and 27.17 at 30, 55, 80 and 105 DAP, respectively) was found from the treatment G$_2$ whereas the lowest number of leaves plant$^{-1}$ (6.24, 10.83, 18.13 and 22.10 at 30, 55, 80 and 105 DAP, respectively) was found from the control treatment G$_0$. The number of leaves increased with the advancement of time with increasing of GA$_3$. The higher number of leaves per plant achieved on account of higher level of plant growth regulators. The present findings also support to the results of Wankhede et al. [13].
Significant variation was recorded on number of leaves plant\(^{-1}\) of tuberose due to combined effect of P and GA\(_3\) in terms of except 30 DAP (Table 2). It was observed that the highest number of leaves plant\(^{-1}\) (7.33, 15.11, 26.13 and 31.98 at 30, 55, 80 and 105 DAP, respectively) was found from the treatment combination of P\(_2\)G\(_2\). At 105 DAP, the highest number of leaves plant\(^{-1}\) (29.35) was statistically similar with the treatment combination of P\(_3\)G\(_1\). The lowest number of leaves plant\(^{-1}\) (5.91, 8.16, 14.97 and 18.39 at 30, 55, 80 and 105 DAP, respectively) was found from the control treatment combination of P\(_0\)G\(_0\). At 105 DAP, the lowest number of leaves plant\(^{-1}\) (18.39) was statistically similar with the treatment combination of P\(_3\)G\(_1\) and P\(_0\)G\(_2\).

### 3.1.3 Number of side shoots plant\(^{-1}\)

Significant variation was observed in terms of number of side shoot plant\(^{-1}\) affected by different levels of P at different growth stages (Table 3). The maximum number of side shoot plant\(^{-1}\) (2.04, 4.47 and 6.69 at 30, 55 and 80 DAP, respectively) was found from the treatment P\(_2\) which was statistically identical with P\(_3\) at all growth stages whereas the minimum number of side shoot plant\(^{-1}\) (0.92, 2.17 and 4.07 at 30, 55 and 80 DAP, respectively) was found from the control treatment P\(_0\). Different levels of P showed a gradual increasing trend in terms of number of side shoot per plant of tuberose with the increasing of P application to a certain level.

Different concentrations of GA\(_3\) showed significant difference on number of side shoot plant\(^{-1}\) at different growth stages (Table 3). The highest number of side shoot plant\(^{-1}\) (2.00, 4.43 and 6.64 at 30, 55 and 80 DAP, respectively) was found from the treatment G\(_2\) whereas the lowest number of side shoot plant\(^{-1}\) (1.13, 2.59 and 4.57 at 30, 55 and 80 DAP, respectively) was found from the control treatment G\(_0\). Pathak et al. [14] found similar trend of results in their trial which is support to the present finding by using GA\(_3\) they found that side shoot was increased with increasing GA\(_3\) rate and it was highest with 200 ppm.

Combined effect of P and GA\(_3\) showed the significant variation in terms of number of side shoot per plant of tuberose at different growth stages (Table 3). The highest number of side shoot plant\(^{-1}\) (2.66, 5.49 and 7.79 at 30, 55 and 80 DAP, respectively) was recorded from the treatment combination of P\(_2\)G\(_2\) whereas the lowest number of side shoot plant\(^{-1}\) (0.3, 1.70 and 3.17 at 30, 55 and 80 DAP, respectively) was found from the control treatment combination of P\(_0\)G\(_0\).

### 3.2 Yield Contributing Parameters and Yield

#### 3.2.1 Spike length (cm)

Different levels of phosphorus significantly influenced the spike length (Table 4). The

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**Table 1. Plant height of tuberose at different days after planting as influenced by phosphorus and GA\(_3\)**

| Treatments | 30 DAP | 55 DAP | 80 DAP | 105 DAP |
|------------|--------|--------|--------|---------|
| P\(_0\)G\(_0\) | 16.85 i | 36.35 i | 44.24 i | 50.82 h |
| P\(_0\)G\(_1\) | 17.55 h | 37.50 hi | 44.83 hi | 52.74 g |
| P\(_0\)G\(_2\) | 18.19 g | 38.20 gh | 45.53 gh | 53.68 fg |
| P\(_1\)G\(_0\) | 18.78 fg | 39.38 g | 46.51 fg | 54.33 f |
| P\(_1\)G\(_1\) | 19.84 e | 41.04 f | 47.43 ef | 56.47 de |
| P\(_1\)G\(_2\) | 22.03 c | 44.12 cd | 51.30 c | 59.69 c |
| P\(_2\)G\(_0\) | 19.28 ef | 42.49 ef | 47.25 ef | 55.00 ef |
| P\(_2\)G\(_1\) | 21.27 d | 42.77 de | 49.91 d | 58.81 c |
| P\(_2\)G\(_2\) | 22.54 bc | 45.49 bc | 52.17 c | 60.31 bc |
| P\(_3\)G\(_0\) | 20.68 d | 41.92 ef | 48.07 e | 57.16 d |
| P\(_3\)G\(_1\) | 23.00 b | 46.37 ab | 53.63 b | 61.75 b |
| P\(_3\)G\(_2\) | 23.92 a | 47.83 a | 55.20 a | 64.15 a |
| LSD\(_{0.05}\) | 0.6245 | 1.557 | 1.078 | 1.559 |
| CV(%) | 6.56 | 8.36 | 10.30 | 9.61 |

In a column, figure(s) bearing same letter do not differ significantly at \(P \leq 0.05\) by LSD. \(P\(_0\) = \) Control (0 kg P\(_2\)O\(_5\) ha\(^{-1}\)), \(P\(_1\) = 140\) kg TSP ha\(^{-1}\), \(P\(_2\) = 190\) kg TSP ha\(^{-1}\), \(P\(_3\) = 240\) kg TSP ha\(^{-1}\) = 110 kg P\(_2\)O\(_5\) ha\(^{-1}\), \(G\(_0\) = \) Control, \(G\(_1\) = 115 ppm GA\(_3\), \(G\(_2\) = 145 ppm GA\(_3\).
The highest spike length (79.13 cm) was found from the treatment P₂ which was statistically identical with P₃ whereas the lowest spike length (64.06 cm) was found from the control treatment P₀. This result is in agreement with the findings of Dahiya et al. [15] who reported that the number of side shoots plant⁻¹ increased with increasing phosphorus levels from 30 to 150 kg P₂O₅ ha⁻¹ in tuberose.

Application of different concentration of GA₃ showed significant variation on length of spike (Table 4). The highest spike length (78.66 cm) was found from G₂ and the lowest spike length (67.24 cm) was found from the control treatment G₀. Results also showed that spike length was increased with increasing rate of GA₃. The results also agreed with the findings of Singh [16] in tuberose plant who reported that the higher spike length was due to 150 ppm compared to 50 and 100 ppm GA₃.

Application of different combination of P and GA₃ showed significant variation on spike length (Table 4). The highest spike length (85.96 cm) was found from the treatment combination of P₂G₂ which was significantly 40 different from all other treatment combinations. The lowest spike length (60.64 cm) was found from the control treatment combination of P₀G₀.

**Fig. 3.** Number of leaves plant of tuberose at different days after planting as influenced by phosphorus

P₀ = Control (0 kg P₂O₅ ha⁻¹), P₁ = 140 kg TSP ha⁻¹ = 65 kg P₂O₅ ha⁻¹, P₂ = 190 kg TSP ha⁻¹ = 85 kg P₂O₅ ha⁻¹, P₃ = 240 kg TSP ha⁻¹ = 110 kg P₂O₅ ha⁻¹

**Fig. 4.** Number of leaves plant of tuberose at different days after planting as influenced by GA₃

G₀ = Control, G₁ = 115 ppm GA₃, G₂ = 145 ppm GA₃
Different levels of phosphorus significantly influenced the rachis length (Table 4). The highest rachis length (31.21 cm) was found from the treatment P₂ which was statistically identical with P₃ whereas the lowest rachis length (24.91 cm) was found from the control treatment P₀.

3.2.3 Rachis length (cm)

Different levels of phosphorus significantly influenced the rachis length (Table 4). The highest rachis length (31.21 cm) was found from the treatment P₂ which was statistically identical with P₃ whereas the lowest rachis length (24.91 cm) was found from the control treatment P₀.

Application of different concentration of GA₃ showed significant variation on rachis length (Table 4). The highest rachis length (31.01 cm) was found from the treatment G₂ which was significantly different from all other treatments. The lowest rachis length (26.33 cm) was found from the control treatment G₀.

Combined effect of P and GA₃ showed significant variation in terms of rachis length of tuberose (Table 4). The highest rachis length (34.20 cm) was found from the treatment combination of P₂G₂ which was significantly different from all other treatment combinations followed by P₂G₀. The lowest rachis length (23.07 cm) was found from the control treatment combination of P₀G₀.

3.2.4 Number of florets spike⁻¹

Different levels of phosphorus showed significant influence on number of florates spike⁻¹ (Table 4). Results indicated that the highest no. of florates spike⁻¹ (21.95) was found from the treatment P₂ which was statistically identical with P₃. The lowest no. of florates spike⁻¹ (14.96) was found from the control treatment P₀.

Different concentrations of GA₃ showed significant difference on no. of florates spike⁻¹ (Table 4). It was observed that the highest no. of florates spike⁻¹ (21.75) was found from the treatment G₂ whereas the lowest no. of florates spike⁻¹ (16.72) was found from the control treatment G₀.

### Table 2. Number of leaves plant of tuberose at different days after planting as influenced by phosphorus and GA₃

| Treatments | 30 DAP | 55 DAP | 80 DAP | 105 DAP |
|------------|--------|--------|--------|---------|
| P₀G₀       | 5.96   | 6.39   | 6.03   | 8.31    |
| P₀G₁       | 6.01   | 7.95   | 16.03  | 19.07   |
| P₀G₂       | 6.08   | 10.69  | 16.67  | 20.57   |
| P₀G₃       | 6.10   | 11.19  | 17.72  | 21.57   |
| P₀G₄       | 6.44   | 11.77  | 19.20  | 24.14   |
| P₁G₀       | 6.85   | 13.17  | 23.42  | 27.71   |
| P₁G₁       | 6.28   | 11.67  | 18.60  | 22.64   |
| P₁G₂       | 6.75   | 12.90  | 22.40  | 27.16   |
| P₁G₃       | 6.95   | 14.01  | 24.72  | 28.46   |
| P₁G₄       | 6.67   | 12.29  | 21.23  | 25.78   |
| P₂G₀       | 7.05   | 14.35  | 25.07  | 30.30   |
| P₂G₁       | 7.33   | 15.11  | 26.13  | 31.95   |
| P₂G₂       | 5.96   | 6.39   | 6.03   | 8.31    |
| P₂G₃       | 6.01   | 7.95   | 16.03  | 19.07   |
| P₂G₄       | 6.08   | 10.69  | 16.67  | 20.57   |
| P₃G₀       | 6.10   | 11.19  | 17.72  | 21.57   |
| P₃G₁       | 6.44   | 11.77  | 19.20  | 24.14   |
| P₃G₂       | 6.85   | 13.17  | 23.42  | 27.71   |
| P₃G₃       | 6.28   | 11.67  | 18.60  | 22.64   |
| P₃G₄       | 6.75   | 12.90  | 22.40  | 27.16   |
| P₄G₀       | 6.95   | 14.01  | 24.72  | 28.46   |
| P₄G₁       | 6.67   | 12.29  | 21.23  | 25.78   |
| P₄G₂       | 7.05   | 14.35  | 25.07  | 30.30   |
| P₄G₃       | 7.33   | 15.11  | 26.13  | 31.95   |
| LSDₙ₀.₀₅   | NS     | 0.8992 | 1.777  | 2.233   |

*In a column, figure(s) bearing same letter do not differ significantly at P ≤ 0.05 by LSD, P₀ = Control (0 kg P₂O₅ ha⁻¹), P₁ = 140 kg TSP ha⁻¹, P₂ = 190 kg TSP ha⁻¹, P₃ = 240 kg TSP ha⁻¹ = 110 kg P₂O₅ ha⁻¹, G₀ = Control, G₁ = 115 ppm GA₃, G₂ = 145 ppm GA₃*
Table 3. Number of side shoot plant\(^1\) of tuberose at different days after planting as influenced by phosphorus and GA\(_3\)

| Treatments | Number of side shoot plant\(^1\) |
|------------|---------------------------------|
|            | 30 DAP | 55 DAP | 80 DAP |
| Effect of phosphorus (P) | | | |
| P\(_0\)   | 0.92 c | 2.17 c | 4.07 c |
| P\(_1\)   | 1.52 b | 3.36 b | 5.57 b |
| P\(_2\)   | 2.04 a | 4.47 a | 6.69 a |
| P\(_3\)   | 1.94 a | 4.35 a | 6.55 a |
| LSD\(_{0.05}\) | 0.201 | 0.205 | 0.221 |
| CV (%)    | 4.22   | 7.64   | 9.74   |
| Effect of GA\(_3\) | | | |
| G\(_0\)   | 1.13 c | 2.59 c | 4.57 c |
| G\(_1\)   | 1.69 b | 3.75 b | 5.96 b |
| G\(_2\)   | 2.00 a | 4.43 a | 6.64 a |
| LSD\(_{0.05}\) | 0.142 | 0.17  | 0.187  |
| CV (%)    | 4.22   | 7.64   | 9.74   |
| Combined effect of P and GA\(_3\) | | | |
| P\(_0\)G\(_0\) | 0.73 i | 1.70 h | 3.17 i |
| P\(_1\)G\(_0\) | 0.87 hi| 1.95 gh| 4.10 h |
| P\(_2\)G\(_0\) | 1.17 gh| 2.85 f | 4.95 g |
| P\(_3\)G\(_0\) | 1.02 ghi| 2.16 g | 4.44 h |
| P\(_2\)G\(_1\) | 1.66 de| 3.77 d | 5.86 e |
| P\(_2\)G\(_2\) | 1.87 cd| 4.16 c | 6.42 d |
| P\(_3\)G\(_0\) | 1.29 fg | 3.09 ef | 5.20 fg |
| P\(_2\)G\(_1\) | 2.18 b | 4.85 b | 7.07 bc |
| P\(_3\)G\(_2\) | 2.66 a | 5.49 a | 7.79 a |
| P\(_3\)G\(_0\) | 1.48 ef | 3.42 e | 5.47 f |
| P\(_3\)G\(_1\) | 2.03 bc | 4.43 c | 6.78 cd |
| P\(_3\)G\(_2\) | 2.32 b | 5.21 a | 7.40 b |
| LSD\(_{0.05}\) | 0.301 | 0.343 | 0.386 |
| CV (%)    | 4.22   | 7.64   | 9.74   |

In a column, figure(s) bearing same letter do not differ significantly at P ≤ 0.05 by LSD, P\(_0\) = Control (0 kg P\(_2O_5\) ha\(^{-1}\)), P\(_1\) = 140 kg TSP ha\(^{-1}\) = 65 kg P\(_2O_5\) ha\(^{-1}\), P\(_2\) = 190 kg TSP ha\(^{-1}\) = 85 kg P\(_2O_5\) ha\(^{-1}\), P\(_3\) = 240 kg TSP ha\(^{-1}\) = 110 kg P\(_2O_5\) ha\(^{-1}\), G\(_0\) = Control, G\(_1\) = 115 ppm GA\(_3\), G\(_2\) = 145 ppm GA\(_3\).

Combined effect of P and GA\(_3\) demonstrated the significant variation regarding no. of florates spike\(^1\) of tuberose (Table 4). It was noted that the highest no. of florates spike\(^1\) (24.57) was found from the treatment combination of P\(_2\)G\(_2\) which was statistically similar with P\(_3\) whereas the lowest no. of florates spike\(^1\) (12.37) was found from the control treatment combination of P\(_0\)G\(_0\).

3.2.5 Single spike weight (g)

Different levels of phosphorus significantly influenced the single spike weight (Table 4). The highest single spike weight (69.22 g) was found from the treatment P\(_2\) which was statistically identical with P\(_3\) whereas the lowest single spike weight (58.67 g) was found from the control treatment P\(_0\).

Application of different concentration of GA\(_3\) showed significant variation on single spike weight (Table 4). The highest single spike weight (68.71 g) was found from the treatment G\(_2\) which was significantly different from all other treatments. The lowest single spike weight (60.85 g) was found from the control treatment G\(_0\).

Different concentrations of P and GA\(_3\) combinations showed statistically significant variation on single spike weight (Table 4). The highest single spike weight (74.50 g) was found from the treatment combination of P\(_2\)G\(_2\) which was significantly different from all other treatment combinations followed by P\(_3\)G\(_2\). The lowest single spike weight (56.13 g) was found from the control treatment combination of P\(_0\)G\(_0\) which was also significantly different from all other treatment combinations.
Table 4. Yield contributing parameters and yield of tuberose spike as influenced by phosphorus and GA3

| Treatments | Yield contributing parameters and yield of tuberose spike
|------------|--------------------------------------------------------|
|            | Spike length (cm) | Spike diameter (cm) | Rachis length (cm) | No. of florates Spike\(^1\) | Single spike weight (g) | Spike yield (No. of spike ha\(^{-1}\)) (‘000’)
|------------|-------------------|---------------------|-------------------|-----------------------------|-------------------------|---------------------|
| **Effect of phosphorus (P)** | | | | | | |
| P\(_0\) | 64.06 c | 1.65 | 24.91 c | 14.96 c | 58.67 c | 241.30 c |
| P\(_1\) | 72.93 b | 1.70 | 28.47 b | 19.14 b | 64.45 b | 323.60 b |
| P\(_2\) | 79.13 a | 1.93 | 31.21 a | 21.95 a | 69.22 a | 368.60 a |
| P\(_3\) | 78.23 a | 1.80 | 31.04 a | 21.79 a | 68.07 a | 365.30 a |
| LSD\(_{0.05}\) | 2.142 | 0.412 NS | 0.9956 | 0.9708 | 1.294 | 9.082 |
| CV(%) | 8.98 | 8.55 | 6.76 | 5.10 | 7.33 | 8.12 |
| **Effect of GA3** | | | | | | |
| G\(_0\) | 67.24 c | 1.78 | 26.33 c | 16.72 c | 60.85 c | 277.80 c |
| G\(_1\) | 74.85 b | 1.86 | 29.39 b | 19.92 b | 65.75 b | 334.00 b |
| G\(_2\) | 78.66 a | 1.95 | 31.01 a | 21.75 a | 68.71 a | 362.30 a |
| LSD\(_{0.05}\) | 1.796 | 0.491 NS | 1.375 | 1.193 | 1.404 | 8.001 |
| CV(%) | 8.98 | 8.55 | 6.76 | 5.10 | 7.33 | 8.12 |
| **Combined effect of P and GA3** | | | | | | |
| P\(_1\)G\(_0\) | 60.64 i | 1.62 | 23.07 i | 12.37 h | 56.13 i | 189.60 j |
| P\(_1\)G\(_1\) | 63.53 h | 1.63 | 24.98 h | 14.69 g | 58.43 h | 241.80 i |
| P\(_1\)G\(_2\) | 68.01 fg | 1.71 | 26.69 fg | 17.83 f | 61.45 g | 292.40 g |
| P\(_2\)G\(_0\) | 65.99 g | 1.69 | 25.80 g | 16.10 g | 60.19 g | 267.50 h |
| P\(_2\)G\(_1\) | 75.58 d | 1.92 | 29.46 de | 20.20 de | 65.54 e | 345.80 de |
| P\(_2\)G\(_2\) | 77.23 cd | 1.97 | 30.15 d | 21.11 cd | 67.61 d | 357.70 cd |
| P\(_3\)G\(_0\) | 70.07 ef | 1.84 | 27.64 f | 18.60 ef | 63.03 f | 321.50 f |
| P\(_3\)G\(_1\) | 81.36 bc | 2.03 | 31.78 c | 22.67 bc | 70.14 bc | 378.70 b |
| P\(_3\)G\(_2\) | 85.96 a | 2.22 | 34.20 a | 24.57 a | 74.50 a | 405.60 a |
| P\(_3\)G\(_3\) | 72.29 e | 1.89 | 28.79 e | 19.79 de | 64.06 f | 332.50 ef |
| P\(_0\)G\(_1\) | 78.95 c | 2.00 | 31.32 c | 22.11 bc | 68.87 cd | 369.80 bc |
| P\(_0\)G\(_2\) | 83.46 b | 2.09 | 33.01 b | 23.49 ab | 71.28 b | 393.60 a |
| LSD\(_{0.05}\) | NS | 0.675 | 1.119 | 1.681 | 1.467 | 14.10 |
| CV(%) | 8.98 | 8.55 | 6.76 | 5.10 | 7.33 | 8.12 |

In a column, figure (s) bearing same letter do not differ significantly at P ≤ 0.05 by LSD. P\(_0\) = Control (0 kg P\(_2\)O\(_5\) ha\(^{-1}\)), P\(_1\) = 140 kg TSP ha\(^{-1}\) = 65 kg P\(_2\)O\(_5\) ha\(^{-1}\), P\(_2\) = 190 kg TSP ha\(^{-1}\) = 85 kg P\(_2\)O\(_5\) ha\(^{-1}\), P\(_3\) = 240 kg TSP ha\(^{-1}\) = 110 kg P\(_2\)O\(_5\) ha\(^{-1}\), G\(_0\) = Control, G\(_1\) = 115 ppm GA3, G\(_2\) = 145 ppm GA3.

3.2.6 Number of spike ha\(^{-1}\) (‘000’)

Different levels of phosphorus significantly influence the no. of spike ha\(^{-1}\) (Table 4). The highest no. of spike ha\(^{-1}\) (368.60 thousand) was found from the treatment P\(_1\) which was statistically identical with P\(_3\). The lowest no. of spike ha\(^{-1}\) (241.30 thousand) was found from the control treatment P\(_0\).

Application of different concentration of GA3 showed significant variation on no. of spike ha\(^{-1}\) (Table 4). The highest no. of spike ha\(^{-1}\) (362.30 thousand) was found from the treatment G\(_2\) which was significantly different from G\(_1\) and control treatment. The lowest no. of spike ha\(^{-1}\) (277.80 thousand) was found from the control treatment G\(_0\). The result obtained from the present study was similar with the findings of Bharti and Ranjon [17] [2] who concluded that GA3 (150 ppm) was observed best in inducing early spike emergence and maximum spike yield per sq. meter.

Different concentrations of P and GA3 combinations showed significant variation on number of spike ha\(^{-1}\) (Table 4). The highest no. of spike ha\(^{-1}\) (405.60 thousand) was found from the treatment combination of P\(_2\)G\(_3\) which was statistically identical with the treatment combination of P\(_1\)G\(_1\) followed by P\(_2\)G\(_1\). The lowest no. of spike ha\(^{-1}\) (189.60 thousand) was found from the control treatment combination of P\(_1\)G\(_0\).

3.2.7 Bulb length (cm)

Different levels of phosphorus significantly influenced the bulb length (Table 5). However,
the highest bulb length (7.69 cm) was found from the treatment $P_2$ whereas the lowest bulb length (6.71 cm) was found from the control treatment $P_0$.

Application of different concentration of $GA_3$ showed significant variation on bulb length (Table 5). The highest bulb length (7.68 cm) was found from the treatment $G_2$ whereas the lowest bulb length (6.89 cm) was found from the control treatment $G_0$.

Different concentrations of $P$ and $GA_3$ combinations showed statistically significant variation on bulb length (Table 5). The highest bulb length (8.19 cm) was found from the treatment combination of $P_2 G_2$ which was statistically similar with $P_3$ whereas the lowest bulb length (6.51 cm) was found from the control treatment combination of $P_0 G_0$.

### 3.2.8 Bulb diameter (cm)

Different levels of phosphorus significantly influenced the bulb diameter (Table 5). The highest bulb diameter (4.11 cm) was found from the treatment $P_2$ which was statistically identical with $P_3$ whereas the lowest bulb diameter (3.17 cm) was found from the control treatment $P_0$.

Due to application of different concentrations of $GA_3$ showed significant variation on bulb diameter (Table 5). The highest bulb diameter (4.09 cm) was found from the treatment $G_2$ which was significantly different from all other treatments. The lowest bulb diameter (3.42 cm) was found from the control treatment $G_0$.

Different concentrations of $P$ and $GA_3$ combinations showed significant variation on bulb diameter (Table 5). The highest bulb diameter (4.52 cm) was found from the treatment combination of $P_2 G_2$ which was statistically similar with $P_3 G_2$ followed by $P_2 G_1$. The lowest bulb diameter (2.90 cm) was found from the control treatment combination of $P_0 G_0$.

### 3.2.9 Number of bulb plant$^1$

Different levels of phosphorus significantly influenced the number of bulb plant$^1$ (Table 5). The highest no. of bulb plant$^1$ (5.02) was found from the treatment $P_2$ which was statistically identical with $P_3$ whereas the lowest no. of bulb plant$^1$ (3.32) was found from the control treatment $P_0$.

Application of different concentration of $GA_3$ showed significant variation on no. of bulb plant (Table 5). The highest no. of bulb plant$^1$ (4.95) was found from the treatment $G_2$ whereas the lowest no. of bulb plant$^1$ (3.67) was found from the control treatment $G_0$.

Different concentrations of $P$ and $GA_3$ combinations showed significant variation on no. of bulb plant$^1$ (Table 5). The highest no. of bulb plant$^1$ (5.77) was found from the treatment combination of $P_2 G_2$ which was statistically identical with $P_1 G_2$ followed by $P_2 G_1$. The lowest no. of bulb plant$^1$ (2.81) was found from the control treatment combination of $P_0 G_0$.

### 3.2.10 Fresh weight of bulb plant$^1$ (g)

Different levels of phosphorus significantly influenced the fresh weight of bulb plant$^1$ (Table 5). The highest fresh weight of bulb plant$^1$ (129.4 g) was found from the treatment $P_2$ which was significantly different from all other treatments. The lowest fresh weight of bulb plant$^1$ (82.87 g) was found from the control treatment $P_0$.

Application of different concentration of $GA_3$ showed significant variation on fresh weight of bulb plant$^1$ (Table 5). The highest fresh weight of bulb plant$^1$ (126.9 g) was found from the treatment $G_2$ whereas the lowest fresh weight of bulb plant$^1$ (90.99 g) was found from the control treatment $G_0$.

Different concentrations of $P$ and $GA_3$ combinations showed significant variation on fresh weight of bulb plant$^1$ (Table 5). The highest fresh weight of bulb plant$^1$ (157.3 g) was found from the treatment combination of $P_2 G_2$ which was significantly different from all other treatment combinations followed by $P_2 G_1$. The lowest fresh weight of bulb plant$^1$ (72.85 g) was found from the control treatment combination of $P_0 G_0$.

### 3.2.11 Bulb yield (t ha$^{-1}$)

Different levels of phosphorus significantly influenced the bulb yield (Table 5). The highest bulb yield (25.88 t ha$^{-1}$) was found from the treatment $P_2$ which was significantly different from all others. The lowest bulb yield (16.57 t ha$^{-1}$) was found from the control treatment $P_0$. Similar result was also observed by Sharma et al. [18] and they found that 70 kg $P_2 O_5$ per
hectare treatment improved the bulb production.

Application of different concentration of GA3 showed significant variation on bulb yield (Table 5). The highest bulb yield (25.38 t ha\(^{-1}\)) was found from the treatment G\(_2\) but the lowest bulb yield (18.20 t ha\(^{-1}\)) was found from the control treatment G\(_0\). Tiwari and Singh [19] also found similar result on bulb production and concluded that 200 ppm GA\(_3\) showed significant increase in bulb production.

Different concentrations of P and GA\(_3\) combinations showed significant variation on bulb yield (Table 5). The highest bulb yield (31.45 t ha\(^{-1}\)) was found from the treatment combination of P\(_0\)G\(_2\) which was significantly different from all other treatment combinations followed by P\(_3\)G\(_2\). The lowest bulb yield (14.57 t ha\(^{-1}\)) was found from the control treatment combination of P\(_0\)G\(_0\).

### 3.2.12 Number of bulblets plant\(^{-1}\)

Different levels of phosphorus significantly influenced the single spike weight (Table 6). The highest no. of bulblets plant\(^{-1}\) (12.75) was found from the treatment P\(_2\) which was statistically identical with P\(_3\) whereas the lowest no. of bulblets plant\(^{-1}\) (8.86) was found from the control treatment P\(_0\).

Application of different concentration of GA\(_3\) showed significant variation on number of bulblets plant\(^{-1}\) (Table 6). The highest no. of bulblets plant\(^{-1}\) (12.66) was found from the treatment G\(_2\) which was significantly different from others whereas the lowest number of bulblets plant\(^{-1}\) (9.60) was found from the control treatment G\(_0\).

| Treatments | Yield contributing parameters and yield of tuberose bulb |
|------------|----------------------------------------------------------|
|            | Bulb length (cm)  | Bulb diameter (cm)  | No. of bulb plant\(^{-1}\)  | Fresh weight of bulb plant\(^{-1}\) (g)  | Bulb yield (t ha\(^{-1}\))  |
| Effect of phosphorus (P) |  |  |  |  |  |
| P\(_0\) | 6.71  | 3.17 c | 3.32 c | 82.87 d | 16.57 d |
| P\(_1\) | 7.28  | 3.74 b | 4.23 b | 102.8 c | 20.56 c |
| P\(_2\) | 7.69  | 4.11 a | 5.02 a | 129.4 a | 25.88 a |
| P\(_3\) | 7.67  | 4.08 a | 4.91 a | 123.1 b | 24.63 b |
| LSD\(_{0.05}\) | 0.996\(^{NS}\) | 0.320 | 0.1749 | 4.198 | 1.027 |
| CV(\%) | 5.68  | 5.96  | 5.72  | 10.37  | 7.37   |
| Effect of GA\(_3\) |  |  |  |  |  |
| G\(_0\) | 6.89  | 3.42 c | 3.67 c | 90.99 c | 18.20 c |
| G\(_1\) | 7.45  | 3.82 b | 4.48 b | 110.8 b | 22.15 b |
| G\(_2\) | 7.68  | 4.09 a | 4.95 a | 126.9 a | 25.38 a |
| LSD\(_{0.05}\) | 0.863\(^{NS}\) | 1.340 | 0.126 | 3.809 | 0.8968 |
| CV(\%) | 5.68  | 5.96  | 5.72  | 10.37  | 7.37   |
| Combined effect of P and GA\(_3\) |  |  |  |  |  |
| P\(_0\)G\(_0\) | 6.51 i | 2.90 j | 2.81 i | 72.85 j | 14.57 j |
| P\(_1\)G\(_0\) | 6.71 hi | 3.15 i | 3.30 h | 82.23 i | 16.44 i |
| P\(_2\)G\(_0\) | 6.91 gh | 3.59 gh | 3.85 g | 93.53 gh | 18.70 gh |
| P\(_3\)G\(_0\) | 6.82 gh | 3.40 h | 3.53 h | 87.68 hi | 17.54 hi |
| P\(_0\)G\(_1\) | 7.44 e | 3.92 def | 4.48 de | 109.5 e | 21.89 e |
| P\(_1\)G\(_1\) | 7.57 de | 4.01 cde | 4.67 cd | 113.7 e | 22.25 e |
| P\(_2\)G\(_1\) | 7.01 fg | 3.70 fg | 4.05 fg | 99.13 fg | 19.82 fg |
| P\(_3\)G\(_1\) | 7.87 c | 4.22 bc | 5.23 b | 131.9 c | 26.38 c |
| P\(_0\)G\(_2\) | 8.19 a | 4.52 a | 5.77 a | 157.3 a | 31.45 a |
| P\(_1\)G\(_2\) | 7.20 f | 3.83 ef | 4.30 ef | 104.3 ef | 20.86 ef |
| P\(_2\)G\(_2\) | 7.77 cd | 4.14 cd | 4.92 c | 119.5 d | 23.90 d |
| P\(_3\)G\(_2\) | 8.05 ab | 4.39ab | 5.51 a | 145.6 b | 29.11 b |
| LSD\(_{0.05}\) | 0.233 | 0.226 | 0.273 | 8.110 | 1.622 |
| CV(\%) | 5.68  | 5.96  | 5.72  | 10.37  | 7.37   |

*In a column, figure(s) bearing same letter do not differ significantly at P ≤ 0.05 by LSD, P\(_0\) = Control (0 kg P\(_2\)O\(_5\) ha\(^{-1}\)), P\(_1\) = 140 kg TSP ha\(^{-1}\) = 65 kg P\(_2\)O\(_5\) ha\(^{-1}\), P\(_2\) = 190 kg TSP ha\(^{-1}\) = 85 kg P\(_2\)O\(_5\) ha\(^{-1}\), P\(_3\) = 240 kg TSP ha\(^{-1}\) = 110 kg P\(_2\)O\(_5\) ha\(^{-1}\), G\(_0\) = Control, G\(_1\) = 115 ppm GA\(_3\), G\(_2\) = 145 ppm GA\(_3\)
Table 6. Yield contributing parameters and yield of tuberose bulblets as influenced by phosphorus and \( \text{GA}_3 \)

| Treatments | Yield contributing parameters of tuberose | Bulblet yield (t ha\(^{-1}\)) |
|------------|------------------------------------------|-----------------------------|
|            | Number of bulblets plant\(^{-1}\) | Fresh weight of bulblet plant\(^{-1}\) (g) |                          |
| \( P_0 \)  | 8.86 c                                  | 50.10 c                      | 10.02 c                   |
| \( P_1 \)  | 11.12 b                                 | 61.55 b                      | 12.31 b                   |
| \( P_2 \)  | 12.75 a                                 | 71.03 a                      | 14.21 a                   |
| \( P_3 \)  | 12.47 a                                 | 69.55 a                      | 13.91 a                   |
| LSD\(_{0.05}\) | 1.147                                   | 2.333                        | 0.466                     |
| CV(\%)     | 6.93                                    | 8.78                         | 7.48                      |

### Effect of phosphorus (\( P \))

| \( G_0 \) | 9.60 c                                  | 54.07 c                      | 10.81 c                   |
| \( G_1 \) | 11.64 b                                 | 65.10 b                      | 13.02 b                   |
| \( G_2 \) | 12.66 a                                 | 70.01 a                      | 14.00 a                   |
| LSD\(_{0.05}\) | 0.662                                   | 1.911                        | 0.492                     |
| CV(\%)     | 6.93                                    | 8.78                         | 7.48                      |

### Combined effect of \( P \) and \( \text{GA}_3 \)

| \( P_0 \text{G}_0 \) | 7.66 i                                  | 45.25 i                      | 9.05 i                    |
| \( P_0 \text{G}_1 \) | 8.77 h                                  | 50.33 h                      | 10.07 h                   |
| \( P_0 \text{G}_2 \) | 10.14 g                                 | 54.71 g                      | 10.94 g                   |
| \( P_0 \text{G}_3 \) | 9.18 h                                  | 52.72 gh                     | 10.54 gh                  |
| \( P_1 \text{G}_1 \) | 11.88 e                                 | 64.09 e                      | 12.82 e                   |
| \( P_1 \text{G}_2 \) | 12.29 de                                | 67.85 d                      | 13.57 d                   |
| \( P_1 \text{G}_3 \) | 10.60 fg                                | 58.24 f                      | 11.65 f                   |
| \( P_2 \text{G}_1 \) | 13.25 bc                                | 74.82 b                      | 14.97 b                   |
| \( P_2 \text{G}_2 \) | 14.41 a                                 | 80.04 a                      | 16.01 a                   |
| \( P_2 \text{G}_3 \) | 10.97 f                                 | 60.07 f                      | 12.01 f                   |
| \( P_3 \text{G}_1 \) | 12.66 cd                                | 71.16 c                      | 14.23 c                   |
| \( P_3 \text{G}_2 \) | 13.78 ab                                | 77.42 ab                     | 15.48 ab                  |
| LSD\(_{0.05}\) | 0.783                                   | 2.780                        | 0.603                     |
| CV(\%)     | 6.93                                    | 8.78                         | 7.48                      |

In a column, figure(s) bearing same letter do not differ significantly at \( P \leq 0.05 \) by LSD. \( P_0 \) = Control (0 kg \( P_2\text{O}_5 \) ha\(^{-1}\)), \( P_1 \) = 140 kg TSP ha\(^{-1}\), \( P_2 \) = 190 kg TSP ha\(^{-1}\), \( P_3 \) = 240 kg TSP ha\(^{-1}\), \( G_0 \) = Control, \( G_1 \) = 115 ppm \( \text{GA}_3 \), \( G_2 \) = 145 ppm \( \text{GA}_3 \).

Different concentrations of \( P \) and \( \text{GA}_3 \) combinations showed statistically significant variation on bulblet yield (Table 6). The highest bulblet yield (16.01 t ha\(^{-1}\)) was found from the treatment combination of \( P_2 \text{G}_2 \) which was statistically identical with the treatment combination of \( P_3 \text{G}_2 \). The lowest bulblet yield (9.05 t ha\(^{-1}\)) was found from the control treatment combination of \( P_0 \text{G}_0 \).

### 3.2.13 Fresh weight of bulblet plant\(^{-1}\) (g)

Due to application of different levels of phosphorus significantly influenced on the fresh weight of bulblet plant\(^{-1}\) (Table 6). The highest fresh weight of bulblet plant\(^{-1}\) of tuberose (71.03 g) was found from the treatment \( P_2 \) which was statistically identical with \( P_3 \) whereas the lowest fresh weight of bulblet plant\(^{-1}\) (50.10 g) was found from the control treatment \( P_0 \).

Application of different concentration of \( \text{GA}_3 \) showed significant variation on fresh weight of bulblet plant\(^{-1}\) (Table 6). The highest fresh weight of bulblet plant\(^{-1}\) (70.01 g) was found from the treatment \( G_2 \) which was significantly different from others whereas the lowest fresh weight of bulblet plant\(^{-1}\) (54.07 g) was found from the control treatment \( G_0 \).

Different concentrations of \( P \) and \( \text{GA}_3 \) combinations showed significant variation on fresh weight of bulblet plant\(^{-1}\) (Table 6). The highest fresh weight of bulblet plant\(^{-1}\) (80.04 g) was found from the treatment combination of \( P_0 \text{G}_3 \) which was statistically identical with the treatment combination of \( P_3 \text{G}_2 \). The lowest fresh
weight of bulblet plant\(^{-1}\) (45.25 g) was found from the control treatment combination of P\(_0\)G\(_0\).

### 3.2.14 Bulblet yield (t ha\(^{-1}\))

Different levels of phosphorus significantly influenced the bulblet yield (Table 6). The highest bulblet yield (14.21 t ha\(^{-1}\)) was found from the treatment P\(_2\) which was statistically identical with P\(_3\) whereas the lowest bulblet yield (10.02 t ha\(^{-1}\)) was found from the control treatment P\(_0\).

Application of different concentration of GA\(_3\) showed significant variation on bulblet yield (Table 6). The highest bulblet yield (14.00 t ha\(^{-1}\)) was found from the treatment G\(_2\) which was significantly different from others whereas the lowest bulblet yield (10.81 t ha\(^{-1}\)) was found from the control treatment G\(_0\).

Different concentrations of P and GA\(_3\) combinations showed statistically significant variation on bulblet yield (Table 6). The highest bulblet yield (16.01 t ha\(^{-1}\)) was found from the treatment combination of P\(_2\)G\(_2\) which was statistically identical with the treatment combination of P\(_3\)G\(_2\). The lowest bulblet yield (9.05 t ha\(^{-1}\)) was found from the control treatment combination of P\(_0\)G\(_0\).

### 3.3 Economic Analysis

The economic analysis is presented under the following headlines:

#### 3.3.1 Gross income

The highest gross return (Tk. 471550) obtained from P\(_2\)G\(_2\) treatment combination and lowest gross return (Tk. 227470) obtained from the treatment combination of P\(_0\)G\(_0\).

#### 3.3.2 Net return

The highest net return (Tk. 289337) obtained from the treatment combination of P\(_2\)G\(_2\) and lowest net return (Tk. 57703) obtained from the treatment combination of P\(_0\)G\(_0\).

#### 3.3.3 Benefit cost ratio (BCR)

The highest BCR (2.59) was obtained from the treatment combination of P\(_2\)G\(_2\) and lowest BCR (1.34) was obtained from P\(_0\)G\(_0\) treatment combination. From economic point of view, it was noticeable from the above results, the treatment combination of P\(_2\)G\(_2\) was more profitable than rest of the treatment combinations.

### 4. CONCLUSION

In terms of growth parameters, results showed that the highest plant height (64.15 cm) and number of leaves plant\(^{-1}\) (31.95) were found from the treatment combination of P\(_2\)G\(_2\) but the 57 highest number of side shoot plant\(^{-1}\) (7.79) was found from the treatment combination of P\(_1\)G\(_2\) whereas the lowest plant height (50.82 cm), number of leaves plant\(^{-1}\) (18.39 a) and number of side shoot plant\(^{-1}\) (3.17) were found from the control treatment combination of P\(_0\)G\(_0\). In case of yield and yield contributing parameters of tuberose, the highest spike length (85.96 cm), spike diameter (2.22 cm), rachis length (34.20 cm), no. of florates spike\(^{-1}\) (24.57), single spike weight (74.50 g) no. of spike ha\(^{-1}\) (405.60 thousand), bulb length (8.19 cm), bulb diameter (4.52 cm), no. of bulblets plant\(^{-1}\) (157.3 g), bulb yield (31.45 t ha\(^{-1}\)), no. of bulblets plant\(^{-1}\) (14.41), fresh weight of bulblet plant-1 (80.04 g) and bulblet yield (16.01 t ha\(^{-1}\)) were found from the treatment combination of P\(_2\)G\(_2\) whereas the lowest spike length (60.64 cm), spike diameter (1.62 cm), rachis length (23.07 cm), no. of florates spike-1 (12.37), single spike weight (56.13 g), no. of spike ha\(^{-1}\) (189.60 thousand), bulb length (6.51 cm), bulb diameter (2.90 cm), no. of bulb plant\(^{-1}\) (2.81), fresh weight of bulblet plant\(^{-1}\) (72.85 g), bulb yield (14.57 t ha\(^{-1}\)), no. of bulblets plant\(^{-1}\) (7.66), fresh weight of bulblet plant\(^{-1}\) (45.25 g) and bulblet yield (9.05 t ha\(^{-1}\)) was found from the control treatment combination of P\(_0\)G\(_0\). In terms of economic analysis, the highest gross return (Tk. 471550/ha), net return (Tk. 289337/ha) and BCR (2.59) were obtained from the treatment combination of P\(_2\)G\(_2\) (85 kg P\(_2\)O\(_5\) ha\(^{-1}\) with 145 ppm GA\(_3\)) whereas the lowest gross return (Tk. 227470/ha), net return (Tk. 57703/ha) and BCR (1.34) was obtained from P\(_0\)G\(_0\) (no P and GA\(_3\)). From the above results, it can be concluded that the treatment combination of P\(_2\)G\(_2\) (85 kg P\(_2\)O\(_5\) ha\(^{-1}\) with 145 ppm GA\(_3\)) showed highest yield advantage regarding economic return. Therefore, the results suggest that the combination of P and GA\(_3\) i.e. P\(_2\)G\(_2\) (85 kg P\(_2\)O\(_5\) ha\(^{-1}\) with 145 ppm GA\(_3\)) is suitable for the higher spike, bulb and bulblet yield production of tuberose. So, this treatment combination can recommend as the best treatment combination considering yield and economic return.
COMPETING INTERESTS

Authors have declared that no competing interests exist.

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