EFFECT OF NITROGEN AND PHOSPHORUS ON GROWTH AND YIELD OF TUBEROSE

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CERTIFICATE

This is to certify that thesis entitled, *"Effect of nitrogen and phosphorus on the growth and yield of tuberose"* submitted to the Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE IN HORTICULTURE,** embodies the result of a piece of *bona fide* research work carried out by **HEEYA BINTE HABIB**, **Registration No.08-03084** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma in any institute.

I further certify that such help or source of information, as has been availed of during the course of this investigation has duly been acknowledged.

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ABSTRACT

A field experiment was conducted at the horticulture farm of Sher-e-Bangla Agricultural University, Dhaka-1207, during April 2013 to March 2014 to study the effect of nitrogen and phosphorus on growth and yield of tuberose. The experiment consisted of four levels of nitrogen and three levels of phosphorus i.e. N_0: 0 kg, N_1: 180 kg, N_2: 200 kg and N_3: 220 kg N/ha and P_0: 0 kg, P_1: 170 kg and P_2: 190 kg P_2O_5/ha respectively and was laid out in a Randomized Complete Block Design with three replications. In case of nitrogen the highest number of spike (296100/ha) and bulb yield (24.37 t/ha) was recorded from N_2 and the lowest number of spike (183800/ha) and bulb yield (11.29 t/ha) was recorded from N_0. For phosphorus, the highest number of spike (256000/ha) and bulb yield (20.01 t/ha) was recorded from P_2 and the lowest number of spike (232800/ha) and bulb yield (18.15 t/ha) was recorded from P_0. For combined effect, the highest number of spike (302400/ha), bulb yield (25.76 t/ha) and benefit cost ratio (3.06) was recorded from N_2P_2 and the lowest from control. So, 200 kg N/ha with 190 kg P_2O_5/ha was found best for growth and flowering of tuberose.

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ABBREVIATIONS	ELABORATIONS
%	Percent
@	At the rate
AEZ	Agro-Ecological Zone
Agric.	Agriculture
Agril.	Agricultural
Agron.	Agronomy
ANOVA	Analysis of Variance
BARI	Bangladesh Agricultural Research Institute
BBS	Bangladesh Bureau of Statistics
BD	Bangladesh
BINA	Bangladesh Institute of Nuclear Agriculture
CEC	Cation Exchange Capacity
Cm	Centi-meter
CV%	Percentage of coefficient of variation
Df	Degrees of Freedom
DMRT	Duncan's Multiple Range Test
EC	Emulsifiable concentration
et al	and others
Etc	Etcetera
FAO	Food and Agriculture Organization of United Nations
G	Gram
hr.	Hours
j.	Journal
Kg/ha	Kilograms per hectare
Kg	Kilogram

M	Meter
m^2	square meter
MOA	Ministry of Agriculture
MSE	Mean Square of the Error
No.	Number
Ppm	parts per million
RCBD	Randomized Complete Block Design
Rep.	Replication
Res.	Research
SAU	Sher-e-Bangla Agricultural University
Sc.	Science
SE	Standard Error
Univ.	University
var.	variety

CHAPTER I

INTRODUCTION

Tuberose (*Polianthes tuberosa* L.) belonging to the family Amaryllidaceae, produce attractive, elegant and fragrant white flowers. It occupies a very selective and special position to flower loving people because of its prettiness, elegance and sweet pleasant fragrance. It has a great economic potential for cut flower trade and essential oil industry. The flowers remain fresh for quite a long time and stand distance transportation and occupy a useful place in the flower market (Patel *et al.*, 2006).

The long spikes of tuberose are used for vase decoration and bouquet preparation and the florets for making artistic garlands, ornaments and buttonhole use. The flowers emit a delightful fragrance and are the source of tuberose oil. The natural flower oil of tuberose remains today as one of the most expensive of the perfumes raw materials. It is used for artistic garlands, floral ornamentals, bouquets and buttonholes and also for extraction of perfume (Sadhu and Bose, 1973)

Tuberose is a native of Mexico from where it spreads to the different parts of the world during 16th century. How and when the tuberose found its entrance to India, Ceylon and elsewhere in the orient is probably an unanswerable question (Yadav *et al.*, 1985). Now a days, it is cultivated on large scale in France, Italy, South Africa, USA and in many tropical and sub tropical areas, including India and Bangladesh. In Bangladesh, for the last few years, tuberose has become a popular cut flower for its attractive fragrance and beautiful display qualities. Now, it is one of the most important commercial cut flowers. Tuberose has high demand in the market and its production is highly profitable.

In Bangladesh, its commercial cultivation was introduced during 1980 by some pioneer and innovative farmers at Panishara union of Jhikorgacha thana under Jessore district near the benapol border. Although tuberose is now grown in different parts of the country, very little is known about production technology in Bangladesh condition.

Tuberose is a half-hardy bulbus perennial herb multiplying itself through the bulblets. Roots are mainly adventitious and shallow, the leaves are long, narrow, linear grass like, green and arise in rosette, the flowers have a funnel shaped perianth, waxy white in color and born in a spike. There are three types of tuberose: single with one row of corolla segments, semi- double bearing flowers with two to three rows of corolla segments and double having more than three rows of corolla segments.

The important problems faced by commercial growers of it are low yield and inferior quality of cut flower. Productivity of cut flower is low as compared to other countries. There is a lack of technical information regarding nutritional aspect of this crop with respect to growth, flowering and vase life behaviors. Due to lack of sufficient knowledge and appropriate technology, farmers are not able to produce quality tuberose in our country.

The growing period of tuberose is normally one year or more. Therefore, a high amount of inorganic fertilizer are needed to maintain sustainable growth and flowering over a long period. Large amount of organic and inorganic fertilizers are needed to maintain sustainable growth and flowering of tuberose over a long period (Amarjeet and Godara, 1998).

Tuberose has varying response to different nitrogen doses with respect to the yield and quality of the produce. Nitrogen has a significant effect on bulb production of tuberose. It also increases plant height, number of leaves, spike per hill, earlier flowering and higher number of flower per spike (Cirrito,1975; Mitra *et al.,*1979; Banker and Mukhopadhyay, 1985; Roy (1992). Nitrogen has significant effect on spike production and floret quality (Singh *et al.,* 2004). Tuberose has varying response to different nitrogen doses with respect to the yield and quality of the produce. Phosphorus has a significant effect on spike production and floret quality (Jana *et al.,* 1974; Banker and Mukhopadhyay, 1985; Singh *et al.,* 2001).

However, under Bangladesh condition a few reports are available regarding the fertilizers requirement of this economically important cutflowers.
Considering the above mentioned facts, the present investigations were undertaken with the following objectives:

1. To determine the optimum dose of nitrogen on growth, flower and bulb production of tuberose.
2. To find out the optimum dose of phosphorus on growth and yield of flower and bulb production of tuberose.
3. To determine the suitable combination of nitrogen and phosphorus for ensuring the higher yield of flower and bulb production of tuberose.

CHAPTER II

REVIEW OF LITARATURE

Tuberose(*Polianthestuberosa* L.) is an important cut flower in the world trade.It is a gross feeder and judicial application of manures and fertilizers. Therequirements of manures and fertilizers for optimum growth and development of a crop depends upon the climatic and soil conditions.A few reports are available regarding the requirement of fertilizers for growth,flowering and bulb production of tuberose.The N, P and K levels on tuberose has been studied in various part of the world.But very limited studies have been done on this crop under the agro-ecological condition in respect of Nitrogen and Phosphorus requirement.A brief review of these pertinent to the present study has been given below:

2.1 Influence of Nitrogenand Phosphorus on growth and flowering behavior of tuberose

An experiment was conducted by Yadav (2007) in Bikaner,Rajasthan,India to study the effect of N (0,10 and 20g/m^2) and P(0, 6 and 12g/m^2) fertilizers on the growth and flowering of tuberose cv.Shringar.Plant height, number of leaves per plant, leaf length, number of flower per spike, length of spike,length of rachis, number of spike per plot and weight of flower per spike was remarkably increased with N and P application, alone and in combination.However, N and P fertilizers did not have any significant effect on the flower length.Plant height (35.50cm), number of leaves per plant (34.40), leaf length (38.37) number of flowers (37.50) per spike, length of spike (49.40 cm), length of rachis (20.80 cm),number of spike per plot (33.90) and weight of flower (109.50 g) per spike were higher with combination of 20 g N and 12 g P per plot.

Gupta *et al.* (2006) conducted field studies in Uttar Pradesh,India, during the 1998/99 and 1999/2000 cropping seasons,to determine the role of nitrogen (N) at 0, 40 and 80 g/m^2 and phosphorus fertilizer (P) at 0, 150 and 300 g/m^2 in 4 tuberose (*Polianthestuberosa*) cultivars, i.e. Single, Double, Semi-double and Variegated, for reproductive growth parameters such as spike emergence, growth period of bud, total number of flowers per spike and number of flowers appeared at a time per spike and reported that the Variegated cultivar showed positive response with 80 g N/m^2 and 150 and 300 g P)m^2 applications.

A field trial on tuberose was undertaken by Sultana *et al*.(2006) at the Floriculture field of Horticulture Research Centre, BARI, Joydebpur, Gazipur, Bangladesh during the summer seasons of 2003 and 2004 to observe the response of tuberose (cv. Single) to different nutrient elements. Nutrients were 4 levels of nitrogen (0, 100, 200 and 300 kg/ha), 3 levels of phosphorus (0, 45 and 90 kg P/ha) and 3 levels of potassium (0, 80 and 160 kg K/ha) along with a blanket dose of 10 t/ha cowdung. The application of NPK significantly influenced the growth, flowering and flower quality of tuberose. All the parameters except plant height were the highest with 200 kg N, 45 kg P and 80 kg K/ha along with 10 t/ha cowdung.

Rajwal and Singh (2006) studied the effects of various N rates (100, 125 and 150 kg/ha) on the performance of *P.tuberosa* (cv. Double) in Muzaffarnagar, Uttar Pradesh, India, during 2002-03. The application of 150 kg N/ha resulted in the lowest number of days to the sprouting of bulbs (9.04) and greatest number of sprouts per bulb after 120 days (5.52), number of leaves per bulb after 120 days (44.45), length of the longest leaf (56.27 cm), plant height after 120 days (53.07 cm), number of clumps per bulb (3.80), number of flowers per spike (29.87), spike length (80.47 cm), rachis length (21.50 cm), spike diameter (0.82), weight of the largest bulb per clump (25.19 g), bulb length (6.87 cm) and diameter of the largest bulb per clump (3.12 cm). The number of days to the opening of flowers was lowest (89.67) for 125 kg N/ha. The highest number of bulblets per clump was recorded for 100 kg N/ha (17.50).

Patel *et al*. (2006) conducted a multifactor experiment on tuberose cv. Single at Instructional Farm of ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari, India, during 2002-04. The treatments comprised four levels of nitrogen (100, 200, 300 and 400 kg N/ha), three levels of phosphorus (100, 150 and 200 kg P/ha) and three spacing i.e. 30x20, 30x30, and 30x45 cm, in a randomized block design with factorial concept replicated thrice. The results revealed that for higher yield of spikes and bulbs tuberose could be planted at a closer spacing of 30x20 cm and fertilized with 400 kg nitrogen and 200 kg phosphorus per hectare. Spikes/plant was found to be higher under wider spacing (30x45 cm). Application of nitrogen at 400 kg/ha recorded significantly the highest values of vegetative and floral characters. The effect of phosphorus was not significant on vegetative characters while floral characters viz., rachis length and number of florets/spike were found significant.

Bulb yield in terms of clump weight (t/ha) was also found significant and 200 kg P/ha recorded the higher values.

The effects of N (0, 60, 120, 180 or 240 ppm) as urea and P (0, 20, 40,60 or 80 ppm) as potassium dihydrogen phosphate on the nutrient content of *Polianthestuberosa* were studied under greenhouse conditions by Mohanasundaram*et al.*(2003).P increased the leaf N content, although no significant variation between rates was observed.The leaf P content increased with increasing P level.The highest leaf P content was obtained at ppm P (0.25%).

Alan *et al.* (2007) conducted a trial in 2003 and 2004, under Odemis (Turkey) ecological conditions, in the field and greenhouse to determine the effect of different nitrogen rates (0, 10, 20, 30 and 40 kg/da) on flower yield, some quality characteristics and leaf mineral content in *Polianthestuberosa.* Greenhouse production had position effects on spike length, number of spikes, number of flowers and flowering period. Different nitrogen applications affected the flower quality of tuberose in the field and greenhouse in Odemis.The best flower characteristics were obtained upon treatment with 20kg N/ha. There were significant period.Phosphorus content had a significant negative correlation with copper content.

Banker *et al.* (1985) investigated response of *Polianthestuberosa*cv. “Single” to high doses of NPK. N, P_2O_5 and/or K_2O were applied at plant and floral characteristics were assessed.N had significantly beneficial effects on all of the parameters studied where as P had a significant effect on floret quality only.K had no appreciable effect.Survival of spike in the field was longest (22.8 days) with the highest N rates.

Kumar *et al*. (2002) planted tuberose (*P. tuberosa*) cv. Single bulbs were supplied with 0, 10, 20, 30 or 40 g N/m^2 and 0, 12, 24 or 32 g P/ m^2 in a field experiment conducted in Meghalaya, India during 1998-99. Plant height, number of leaves per chimp, number of days before flowering, number of bulbs per clump, rachis length, number of florets per spike and durability of spike increased with increasing rates of N, whereas the number of spikes per clump, weight of bulb per clump, spike length, spike weight and bulb size increased with increasing rates of N up to 30 g/m Similarly, the number of leaves and spikes per clump, number of bulbs per clump and weight of bulb per clump increased with increasing rates of P up to 24 g/m P application had no significant effects on the rachis and spike length, number of florets per spike, durability of spike and bulb size of the crop.

The effects of N (150, 200 and 250 kg/ha) and P (250, 300 and 350 kg/ha) on the growth and yield of tuberose(*Polianthestuberosa*) cv. Single were determined in a field experiment conducted in Maharashtra,India during 1998-2001 by Kawarkhe and Jane(2002).The authors reported that plant height, number of leaves per plant, length of spike per plant, length of rachis, number of floret per spike and per plant and number of spike per plot and per hectare increased with increasing rates of P up to 300 kg/ha and N up to 200 kg/ha except for plant height and number of leaves per plant which increased with increasing rates of P up to 350kg/ha.

Mishra *et al.* (2002) conducted an experiment in Bhubaneswar, Orissa, India from March to December 1997 with tuberose(*Polianthestuberosa)* cv. Single involving 4 levels of N, i.e. 0, 10, 20 and 30 g/m^2;3 levels of P, i.e. 0, 20 and 30 g/m^2 and 2 levels of spacing maintained at 15cmx15cm and 30cmx30cm.The authors reported that P application showed no appreciable effect on different growth parameters studied, but flowering attributes such as spike length,rachis length and weight of florets per spike and weight of 100 florets improved due to P application at 20 g or 30 g/m^2.Yield of flowers/ha (weight basis) also improved due to P treatments at 20 g or 30 g/m^2, but yield of florets/spike(weight basis) was significantly increased at 30 g/m^2.

Dahiya*et al.* (2001) undertaken a plot culture experiment with sandy loam soil to evaluate the effect of N (0, 60, 120, 180 and 240 ppm as urea) and P (0, 20, 40, 60 and 80 ppm as KH) on the growth and dry matter yield of tuberose cv. Double.The authors observed that application of N and P greatly improved the growth (plant height and number of leaves) and dry matter yield (dry weight of leaves and spike), and total dry weight (leaves +spike). Growth and dry matter yield increased up to 180ppm N and 60 ppm P levels.However,further increments in N above 180 ppm and P above 60ppm adversely affected growth and dry matter yield.

An experiment was investigated by Patil*et al.* (1999) to know the effect of 4 rates of fertilizers viz. 150:50:50, 150:100:100, 200:150:150 and 250:200:200 kg NPK/ha in Karnakata,India.Among the fertilizer rates, 250:200:200 kg NPK/ha resulted in the highest number of shoots leaves and spikes, maximum plant height and flower yield.

Singh and Singh (2005) conducted a field experiment during the summer of 2002/03, at Muzaffarnagar, Uttar Pradesh, India, to evaluate the effects of different N levels(100, 150 and 200 kg/ha) and spacing (20x20, 25x25 and 30x30 cm) on tuberose. Data were recorded for various vegetative growth, flowering and bulb yield parameters. Application of N at 200 kg/ha and medium plant spacing (25x25 cm) recorded maximum growth, flower and bulb production in tuberose.

Naggar*et al.* (2002) conducted an experiment to identify the effects of GA_3 (0, 100, 200 and 300 ppm) and nitrogen fertilizer (0, 15, 30 and 50 kg/feddan as ammonium nitrate) on tuberose (*Polianthestuberosa*L.) cv. Double in Alexandria, Egypt, during the summer season of 2000 and 2001. The and 8.67 g) and total chlorophyll content (229.87 mg/100 g leaf fresh weight). The highest average floret dry weight (4.47 g) was obtained with 100 ppm GA_3 + 30 Kg N/feddan,whreas the highest N content (3.92%) was obtained with 300 ppm GA_3 + 30 Kg N/feddan. The contribution ratio of soil N decreased with increasing N fertilizer rate but increased with increasing GA_3 rate.

Dalal*et al.* (1999) conducted a field experiment to study the influence of N application rate (0, 50, 60 and 70 kg/ha) and GA_3 concentration (0, 10, 20 or 40 ppm) on flower quality of *Polianthestuberosa.* The optimum N application rate was 70 kg/ha; rachis length, flower stalk length, flower weight and vase life were 30.68 cm, 88.87 cm, 89.14 g/plant and 12.74 days. The optimum concentration of GA_3 was 40 ppm; rachis length, flower stalk length, flower weight and vase life were 30.93 cm, 91.06 cm, 106.14 g/plant and 12.94 days. The interaction between N and GA_3 was significant only inrespect of weight of flowers per plant.

Kumar *et al*. (2004) conducted a pot culture experiment in sandy loam soil to evaluate the effect of N (0, 50, 100, 150, 200 and 250 ppm) and Zn (0, 2.5, 5.0, 7.5 and 10.0 ppm) on spike length, bulb production and nutrient content of tuberose cv. Double. Spike length increased significantly with the application of N. The maximum spike length (56.7 cm) was recorded at 200 ppm N level which was at par with 150 ppm N. Zinc application also increased the spike length significantly and the maximum spike length (58.2 cm) was observed with 10 ppm Zn level. The application of N and Zn significantly increased the bulb production (number of bulbs, average weight of bulb and yield of bulbs per plant). Leaf N and Zn content increased with increasing rates of their application. Leaf P content decreased with N and Zn application but K remained unaffected. The application of 100-150 ppm N along with 7.5 ppm Zn was observed optimum for tuberose cultivation. Approximately 1.70% N and 45 ppm Zn content in leaf at spike emergence stage were associated with good spike length and better bulb production.

Singh *et al*. (2004) conducted a study with tuberose (*Polianthestuberosa*) cv. Double in Faizabad, Uttar Pradesh, India, during 1998-99. The treatments consisted of 18 combinations with 3 levels (10, 20 and 30 g/m each of N and P, and 2 levels (10 and 20 g/m of K, and a control. The various fertilizer levels had no significant effect on the vegetative as well as floral characters, except for length of spike and number of spikes per clump. The length of spike at opening of last floret and number of spikes per clump were highest (50.33 cm and 1.91, respectively) in treatment over the control.

Bawedja (2003) was studied the nitrogen requirement of tuberose (cultivars Single and Double) in Himachal Pradesh, India, during 1992-93. Treatments comprised:five nitrogen rates (0, 5, 10, 20 and 30 g/m Nitrogen application increased bothplant height (PH) and number of leaves per plant (NLPP). The cultivar x nitrogen interaction recorded the highest PH (53.88 cm) and NLPP (75.92) in Single at 30 g N/m^2 However, in Double, the highest PH and NLPP were observed upon treatment with 20 and 30 g N/m^2 respectively. All nitrogen rates accelerated flowering, but double flowered earlier than Single. Nitrogen rates up to 10 g/m advanced the flowering date in both cultivars. The number of florets per spike (NFPS) was highest in Double. All nitrogen rates increased the NFPS over the control. Nitrogen at 30 g/m is the best treatment for producing quality tuberose flowers.

Kumar *et al*. (2003) carried out an experiment with N (0, 50, 100, 150, 200 and 250 ppm) and P (0, 2.5, 5.0, 7.5 and 10.0 ppm) on the growth, flowering and chlorophyll content of tuberose cv. Double. Application of N and P significantly improved the growth (plant height, leaf number and leaf area) and floral characters (spike length and floret number per spike). Leaf chlorophyll content significantly increased with N and P application. Interaction effects of N and P were synergistic and significant in influencing the growth and flowering of tuberose. Based on these results, the application of 150-200 ppm N along with 7.5 ppm P was optimum treatment for better tuberose growth and flowering.

Mohanty*et al*. (2002) conducted an experiment with tuberose (*Polianthestuberosa)* in Bhubaneswar, Orissa, India, during 1997-98, involving 2 levels of N (30 and 40 g/m2), 3 split application of N and 2 weeding intervals (30 and 45 days). N was applied to each plot as basal dressing depending upon the level and number of split allotted to each plot. The rest of the N was applied as top dressing after 30 days, 30 and 60 as well as 30, 60 and 90 days after basal dressing in case of 2, 3 and 4 splits, respectively. The greatest plant height (44.76 cm) was obtained from 40 g N/m N. applied in 3 splits was the most effective among the split application treatments. Weeding at 30 days interval gave the greatest plantheight (43.72 cm). Application of 30 g N/m^2 resulted in the highest number of leaves (72.01) and number of plants per clump (13.06 cm). The widest (0.952 cm) leaf and the longest (21.92 cm) rachis were recorded with 40 g N/ m^2 while the longest (75.40 cm) spike and the highest number of florets per spike (28.00), spike yield per plot (20.44) and number of bulbs per clump (19.16) were recorded under 30 g N/m However, the greatest weight (103.55 g) of bulbs was obtained with 40 g N/m^2 Application of N in 4 splits resulted in the highest number of leaves per clump (73.82), while 3 splits resulted in the widest (0.94 cm) leaf, highest number of plants per clump (14.10), longest spike (78.52 cm) and rachis (22.75 cm), and highest number of florets per spike (29.60), spike yield per plot (31.33), number of bulbs per clump (20.15) and weight of bulbs per clump (109.49 g). Interaction effects of N, its split application and weeding intervals were not significant for most of the characters studied.

Yadav*et al*. (2002a) supplied N at 0, 50, 100, 150 and 200 kg/ha, and Zn at 0. 5, 10 and 20 kg/ha to tuberose (*Polianthestuberosa*) cv. Double. N application at 150 and 200 kg/ha slightly increased flower characteristics like spike length, rachis length and number and weight of florets. Floral characteristics were also improved by Zn, particularly at the highest level. Leaf N and Zn content increased with increasing N and Zn rates. Leaf P and K contents were not affected by the treatments. Bulb production increased up to the highest level of N, but was not affected by Zn.

Gowda*et al*. (1991) reported the effect of N, P and K on growth and flowering of tuberose cv. Double. Three rates of N application (100, 150 and 200 kg/ha), three of P_2O_5 (50, 75 and 100 kg/ha) and three of K_2O (100,125 and 150 kg/ha) were compared for a cutflower crop of tuberose grown at a spacing of 30cm x 30cm. All the P_2O_5 and K_2O and half of N were applied as a basal dressing; the remaining N was applied as dressing 30 days after planting. Increasing N significantly increased plant height. Both N and K_2O significantly influenced the number of days required for flower spike emergence. Increasing P and K_2O rates resulted in a greater number of flower spikes and number of florets/spike. The highest yield of florets (40.20/spike), the longest spike (81.28 cm) and the longest duration of flowering (29.75 days) were obtained with 200 kg N+75 kg P_2O_5 +125g K_2O/ha.

Parthiban*et al*. (1991) reported the effect of N, P and K on yield component and yield in tuberose cv. Single. N was applied @50, 75, 100 or 125 kg; P at 25, 50 or 75 kg and K at 37.5, 62.5 or 87.5 kg/ha. All P and K were applied with half at planting. The remaining N was applied 45 days later. Application of 100 g N+75 kg P+62.5 kg/ha resulted in the highest number of spikes/plant (1.72), number of florets/spike (39.67) and the highest flower yield (3578.6 kg/ha).

Bankar and Mukhopadhyay (1990) evaluated the effect of NPK on growth and flowering of tuberose cv. double. N was applied @ 0, 5, 10, 15, g/m^2 P_2O_5 @ 0, 20 or 40 g/ m^2 and K_2O @ 0, 20 or 40 g/ m^2 One half of N and all of P and were applied before planting, the remaining N was applied as a top dressing before flower emergence. Data were tabulated on plant growth and flowering parameters and NPK contents of the leaves, N application advanced flowering and improved growth. The highest number of flower spikes/ m^2 (20.0 g) was obtained with the highest N rate. Fertilization of tuberose with N:P_2O_5:K_2O at 20:20:20 g/ m^2 was recommended.

Mukhopadhyay and Bankar (1986) reported nutritional requirement of tuberose. Nitrogen was most effective in influencing growth, flowering and bulb production in tuberose. All the flower quality parameters viz, length of spike, length of rachis and weight of individual florets showed marked improvement as a result of added nitrogen phosphorus had marginal effect on improving plant height and leaf numbers, though spike yield was not improved, but phosphate fertilizer at the higher dose of 40 g/m^2 improved the length of spike and number of weight of florets.

Yadav*el al*. (1985) carried out a three year investigation on nutrient requirements of tuberose in West Bengal, India. In their experiments, 300 kg nitrogen in two splits and 20 kg phosphorus per hectare per year proved to be the most effective in improving the plant growth and flowering. He found that with best agronomic practices in “single” tuberose about 5 lakh flower spikes and/or 10.5 tons of loose flowers can be obtained per hectare under Nadia District of West Bengal.

Nambisan and Krishran (1983) reported that the requirement of manures and fertilizers for tuberose vary with climatic conditions and soil types. During the preparation of soil, a basal application of leaf mould, farmyard manure or cattle manure at the rate of 20 to 50 t/ha depending on climatic conditions and soil type should be done to ensure better growth and flowering of tuberose. He recorded from an experiment with tuberose cv. “single” a flower yield of 12000 kg/ha, by using FYM alone and application of nitrogen and phosphorus fertilizers increased yield to 20951 kg/ha under South Indian condition.

Nanjan*et al*. (1980) studied the effects of nitrogen, phosphorus and potash on the production of tuberose cv. Single in a neutral clay soil having high amount of potassium. They recommended a nutrient combination of 200 kg nitrogen, 60 kg phosphorus and 50 kg potash/ha is soils low in potassium.

Bhattacharjee*et al*. (1979) carried out an experiment in an alkaline and nitrogen deficient soil, application of 20 kg N, 40 kg P_2O_5 and 20 kg K_2O over a basal dose of 2.5 kg of FYM/m^2 was recommended per year. Full dose of P_2O_5 and K_2O and half dose of N were to be applied as basal dressing; while the remaining half dose of N was applied 20 days after planting.

Singh *et al*. (1976) recommended that flower yield of tuberose should receive a dose of 80 kg nitrogen, 60 kg phosphorus and 40 kg potash per hectare, respectively under Uttar Pradesh, India conditions to have optimum flower yield. According to them nitrogen and potash increased the yield of fresh flowers through increasing the number of spike, number and weight of flower per hill and also the weight of flower per hill and per spike.

Jana *et al*. (1974) conducted an experiment and found that high dose of nitrogen and phosphorus was required to promote leaf formation and flowering in tuberose. Flowering was improved through increased number of spike. They also reported that the effects of potash was less pronounced than nitrogen and phosphorus and plants with low doses of nitrogen and phosphorus showed growth inhibition and failed to flower.

The response of tuberose (*Polianthestuberosa)* cv. single to high doses of NPK, N, P_2O_5 and /or K_2O were applied at plant and floral characteristics. N had a significant beneficial effect on all of the parameters studied where as P had a significant effect on floret quality only K had no appreciable effect was investigated by Banker *et al*. (1985).

2. 2 Influence of Nitrogen and Phosphorus on bulb production of tuberose

Very few reports are available regarding the effects of fertilizer on bulb production of tuberose. A brief review of these pertinent to the present study has been given below:

Cirrito and Zizzo(1980) reported that fertilizers influence not only the production of flower but also the production of bulb. Production of bulb in tuberose is important from economic point of view.Bulbs are grown commercially for sale as propagating unit.Although tuberose bulbs are often termed as rhizome.

Cirrito(1975) reported from application of 200 kg nitrogen, 400 kg phosphorus and 600 kg potash per hectare increased the weights of both saleable and individual bulbs of tuberose. Jana *et al*. (1974) reported earlier the beneficial effect of nitrogen on bulb yield in tuberose. They found a marked influence of nitrogen and phosphorus on bulb formation. Very few reports are available regarding the effects fertilizers on bulb production of tuberose.

Mukhopadhyay (1987) observed a beneficial effect of nitrogen on the yield of bulblets (22 cm in diameter), but not on the number of flowering size bulbs.

Roy (1992) carried out an investigation at the Horticulture Farm of Bangladesh Agricultural University, Mymensingh. She applied 200 kg, 400 kg, 600 kg nitrogen per hectare and also 250, 500 kg potash per hectare. She observed that nitrogen at the rate of 200 kg/ha significantly increased the number of side shoot. Statistically similar result was produced by 400 kg and 600 kg nitrogen/ha. Maximum number of leagues per mother bulb (15.34) was obtained by the application of nitrogen at the rate of 400 kg per hectare and found that production of leaves per side shoot increased gradually by application of nitrogen up to 400 kg/ha. The fresh weight of top per hill increased significantly by the application of 200 kg nitrogen per hectare. She observed that nitrogen had a significant effect on bulb production of tuberose the obtained the highest bulb yield by number and weight with the application of 600 Kg nitrogen per hectare. However, statistically similar yield was obtained from 400 Kg nitrogen per hectare. Potash had no significant effect on the yield of tuberose bulb.

Singh *et al*. (2001) evaluate the nutrient status of *Polianthestuberosa* plants treated with different N, P and K levels (0, 10, 20, 30 and 40 kg N/ha; 0, 10 and 20 kg P/ha; and 0, 10 and 20 kg K/ha). The N, P and K contents of leaves significantly increased with the increase in rate of N, P and K fertilizers, respectively. Leaf P and K concentrations decreased with increasing N fertilizer rate. N, P and K contents in leaves were higher than those in bulbs (rhizomes). Bulb N increased with increasing rates of all fertilizers. Bulb P content was affected by N and P fertilizers, but not by K fertilizer. Bulb K content also increased with increasing rates of all fertilizers.

Yadav*et al*. (2002b) carried out field experiments in Hisar, Haryana, India during 1998-99 to study the removal of macro and micronutrients by tuberose (*P. tuberosa*) cultivars Single and Double from sandy loam soil which was low in N, and high in P and K. The fresh and dry weights of leaves were higher in cv. Single, whereas the fresh and dry weights of bulbs were higher in Double. The total fresh weight was higher in cv. Single, whereas the total dry weight was higher in cv. Double. Nitrogen and phosphorus content were highest in the spike and lowest in the bulb of both cultivars, whereas the potassium, calcium and magnesium content were highest in the leaves. Cultivar Double contained higher N content compared to Single.

Banker (1988) reported that, Bulb yield in term of number and weight of bulbs produced per plant were significantly increased of higher doses of N but P and K were ineffective in tuberose cv. “Double” N improved bulbs production in the first year.

Mukhopadhyay and Banker (1986) conducted a fertilizer experiment for two years with tuberose cv. Single and reported that the yield of bulbs and bulb lets as influenced by the different fertilizer levels ,it was found that only the number of bulb lets got increased by added nitrogen,while the number of flowering size bulbs was not affected by N level.These showed positive interaction and maximum bulb let production was recorded in the treatment comprising 20g P_2O_5 and 40g K_2O/m^2.In the case of bulb let production, with phosphorus and potassium bulbs and bulb lets were also heavier than those under control. Apparently P and K fertilizer had no appreciable effect on bulb yield.

Jana *et al*. (1974) conducted an experiment and found that, nitrogen and phosphorus on bulb formation.

In Jessore region, Baksh*et al.* (1993) investigated that July to August was peck period for tuberose yield and January to March as lean period. But during first year, tuberose yielded highest in January-February.Considering total yield, double stick was major about 69% in first year followed by 59% and 58% during second and third year respectively.

With best agronomic practices in “single” tuberose about 5 lakh flower spikes and/or 10.5 tons of loose flowers can be obtained per hectare under Nadia District of west Bengal(Yadav*et al.*,1984)

Mitra*et al.* (1979) reported the effects of nitrogen and bulb size on production of tuberose. They found that 75 kg/ha nitrogen and large bulbs produced highest percentage of flowering plants with earliest flowering and the highest number of flowers per spike.

CHAPTER III

MATERIALS AND METHODS

The field experiment was conducted during the period from April, 2013 to March, 2014 to find out the influences of nutrient sources and mulch on growth and yield of tuberose. The materials and methods that were used for conducting the experiment are presented in this chapter under the following headings:

3.1 Experimental site

The experiment was conducted at the Horticulture Farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka (Appendix I). The location of the study site is situated in 23°74$^{/}$N latitude and 90°35$^{/}$E longitude with an elevation of 8.2 m from sea level (Anon., 1989). The morphological characteristics of the land are presented in (Appendix II.) and the physical and chemical characteristics of the soil are presented in (Appendix II.)

3.2 Characteristics of soil

The experimental soil of experimental area was non-calcarious dark grey and belongs to the Modhupur Tract under AEZ No. 28 (UNDP, 1988). The selected experimental plot was medium high land and the soil series was Tejgaon (FAO, 1988) with a pH of 5.6. The components of the soil were analyzed in the SRDI, Soil testing Laboratory, Farmgate, Dhaka and detail of the soil characteristics are presented in Appendix II.

3.3 Weather condition of the experimental site

The climate of experimental site was under the subtropical, characterized by three distinct seasons, the monsoon or the winter season from November to February and the pre-monsoon period or hot season from March to April and the monsoon period from May to October (Edris *et al.*, 1979). Meteorological data related to the temperature, relative humidity, rainfalls and sunshine during the period of the experiment was collected from the Bangladesh Meteorological Department, Sher-e-Bangla Nagar, Dhaka and presented in Appendix III.

3.4 Planting materials

Bulbs of tuberose were used as planting materials and those were collected from the Horticultural Farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka- 1207.

3.5 Treatment of the experiment

The experiment had two factors.

Factor A: Nitrogen (N) : 4 levels

i. N_0 = Control – 0 kg N/ha

ii. N_1 = 180 kg N/ha

iii. N_2 = 200 kg N/ha

iv. N_3 =220 kg N/ha

Factor B : Phosphorus (P) : 3 levels

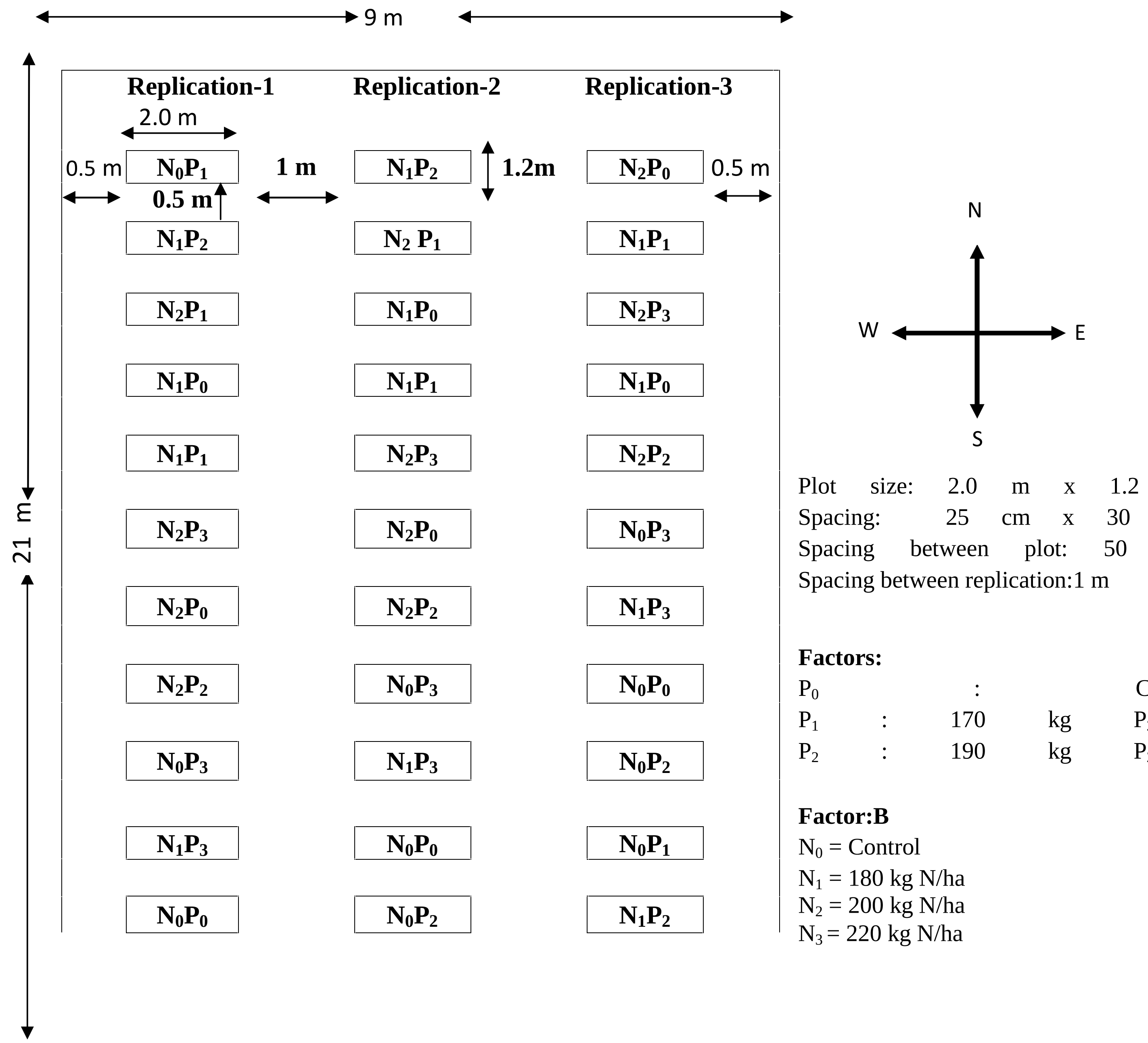
i. P_0 = Control – 0 kg P_2O_5/ha

ii. P_1 = 170 kg P_2O_5/ha

iii. P_2 = 190 kg P_2O_5/ha

There were 12 (4 x 3) treatment combinations such as N_0P_0, N_0P_1, N_0P_2, N_1P_0, N_1P_1, N_1P_2, N_2P_0, N_2P_1, N_2P_2, N_3P_0, N_3P_1 and N_3P_2 .

3.6 Experimental design and layout



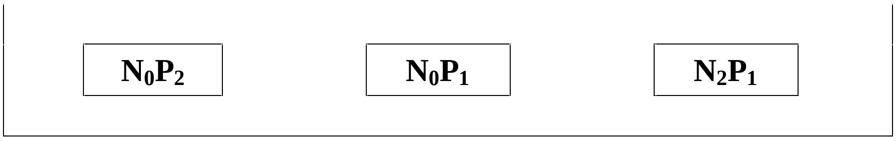


Figure 1: Field layout of the two factors experiment

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. An area of 21 m x 9 m was divided into three equal blocks and each block was divided into 12 plots for distribution 12 treatment randomly. There were 36 unit plots the size of each was 2.0 m x 1.2 m with a plant spacing 25 x 30 cm. The layout of the experiment is shown in Figure-1.

3.7 Land preparation

The experimental plot was opened in the first week of April 2013, by ploughing with a power tiller and left exposed to the sun for a week prior to further ploughing. After one week the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain good tilth. Weeds and stubbles were removed after each laddering. Simultaneously the clods were broken and the soil was made into good tilth. The basal dose of manure and fertilizer were mixed into the soil during final land preparation.

3.8 Manure and fertilizers

Urea, TSP and MP were applied as sources of nitrogen, phosphorus and potassium respectively. Full dose of cow dung (30 t/ha), TSP (as per treatment) and MoP (200 kg/ha) were used in the three equal splits at 30, 65 and 100 DAP in each plot.

The amount of fertilizers was used in the experimental plot as treatment basis is shown as tabular form:

Fertilizer / Manure	Treatments	Amount of total fertilizer (g)	Dose /Plot (g)	During land preparation	Amount of fertilizer (g)		
					30 DAP	65 DAP	100 DAP
Urea	N_0	-	-	-	-	-	-
	N_1	845	94	-	282	282	282
	N_2	940	104	-	313	313	313
	N_3	1033	115	-	344	344	344
TSP	P_0	-	-	-	-	-	-
	P_1	355	38	All	-	-	-
	P_2	397	44	All	-	-	-

3.9 Planting of bulblet

The experimental plot was partitioned into unit plots in accordance with the experimental design mentioned in Figure 1. The bulbs were planted on 20 April, 2013 with a distance on 30 cm x 25 cm and the number of bulb/plot was 32. Just after planting a light irrigation was given with the hose pipe, so that irrigation water could not move from unit plot.

3.10 Intercultural operation

When the seedlings started to emerge in the beds it was always kept under careful observation. After emergence of seedlings, various intercultural operations, weeding, top dressing was accomplished for better growth and development of tuberose seedlings.

3.10.1 Irrigation and drainage

Over-head irrigation was provided with a watering can to the plots once immediately after germination in every alternate day in the evening. Further irrigation was done when needed. Stagnant/Excess water was effectively drained out at the time of heavy rains.

3.10.2 Weeding

Weeding was done to keep the plots free from weeds, easy aeration of soil, which ultimately ensured better growth and development. The newly emerged weeds were uprooted carefully after complete emergence of seedlings whenever it is necessary. Breaking the crust of the soil was done when needed and it was done for 3 times at 15, 30 and 50 days after planting.

3.10.3. Mulching

The soil was mulched frequently after irrigation by breaking the crust for easy aeration and to conserve soil moisture.

3. 10.4 Earthing-up

Earthing-up was done during the growing period when necessary.

3.10.5 Staking

The plants were staked with bamboo sticks and the spikes were tide with the rope.

3.10.6 Selection and tagging of plants

Five plants from each unit plot were selected randomly for recording data for different characters.

3.10.7 Plant Protection

For controlling aphid and borer Malathion @ 0.1% was sprayed 2 times at an interval of 15 days starting soon after the appearance of infestation. No remarkable attack of disease was found.

3.10.8 Harvesting

The spikes of tuberose were harvested when the first floret in the rachis opened from the lower portion of the spike. Harvesting was done during 25 August to 24 December, 2013 and bulb and bulblet were harvested on 5 march, 2014.

3.11 Top Dressing

After basal dose, the remaining doses of urea were top-dressed in 3 equal installments. The fertilizers were applied on both sides of plant rows and mixed well with the soil by hand. Earthing-up was done with the help of nirani immediately after top-dressing of nitrogen fertilizer.

3.12 Data collection

Data were recorded on the following parameters from the sample plants during the course of experiment. Five plants were randomly selected from each unit plot for collection of data.

3.12.1 Plant height

The height of plant was recorded in centimeter (cm) at 30, 60, 75, 90 and 120 days after planting (DAP) in the experimental plots. The height was measured from the ground level up to the tip of the growing point of the plant.

3.12.2 Number of leaves per plant

All the leaves of five plants were counted at an interval of 15 days at 30, 60, 90 and 120 days after planting (DAP) in the experimental plots.

3.12.3 Maximum length of leaves

maximum length of leaves was measured from the base to the tip of the longest leaf at an interval of 30 days starting from 30 days after planting (DAP) till 90 days.

3.12.4 Number of side shoot

All the green shoots above the soil surface which developed from mother bulb and adjoined to it were counted as side shoot. It was measured at an interval of 15 days at 30, 45, 60, 75 and 90 days after planting (DAP) in the experimental plots.

3.12.5 Length of spike

Length of flower stalk was measured from the base to the tip of the spike and expressed in centimeter.

3.12.6 Length of rachis

Length of rachis refers to the length from the axel of first floret up to the tip of the inflorescence in centimeter.

3.12.7 Diameter of the spike

Five spikes were cut from randomly selected plants from each unit plot and diameter of the spike was taken at 25 cm from the soil surface and their mean was calculated.

3.12.8 Number of florets per spike

All the florets of the spike were counted from five randomly selected plants and their mean was calculated.

3.12.9 Weight of the single spike

It was determined by weighing the spike from the five randomly selected plants and mean weight was calculated and expressed in gram

3.12.10 Number of spikes per hectare

Number of spikes per hectare was calculated from numbers of spikes per plot and converted to hectare.

3.12.11 Flower yield

Yield of flower per hectare was calculated from weight of spike per plot and converted to hectare.

3.12.12 Length of mother bulb

A slide calipers was used to measure the length of the bulb.

3.12.13 Diameter of mother bulb

A slide calipers was used to measure the diameter of the bulb and expressed in centimeter

3.12.14 Number of bulblet per plant

It was calculated by total number of plantable sized bulblets excluding main bulb per plant.

3.12.15 Bulb yield

Total bulb yield per plot was recorded by adding the total harvested bulb in a plot and expressed in kilogram and converting the yield of tuberose bulb per plot to per hectare and expressed in ton per hectare.

3.12.16 Fresh weight of bulb

Fresh weight of bulb was determined by weighing the five bulbs randomly selected plants just after harvest and mean weight was calculated.

3.12.17 Dry weight of bulb per 100 gm

100 g bulb was taken and was dried under direct sunshine for 72 hours and then it was dried in an oven at 70^{o}c for 3 days before taking dry weight till it was constant. The dry weight was recorded with the help of an electric balance.

3.13 Statistical Analysis

The experimental data obtained for different parameters were statistically analyzed using MSTAT-C computer package program developed by Russel (1986) to find out the significance of variation resulting from the experimental treatments. The mean values of all the recorded characters were calculated and analysis of variance was performed by ‘F’ (variance ratio) test. The differences between the treatment means were evaluated by LSD test at 5% probability. The analysis of variance (ANOVA) of the data on different characters of tuberose is given in Appendix-III to VI

The significance of the difference among the individual and treatment combinations means was estimated by the Duncan’s Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

3.14 Benefit Cost Ratio

Benefit Cost Ratio was calculated by calculating the total cost of production and net return using MS Excel.

CHAPTER IV

RESULTS AND DISCUSSION

This chapter comprises the presentation and discussion of the results obtained from the effect of nitrogen and phosphorous on the growth, flower and bulb size of tuberose**.** The results of each parameter studied in the experiment have been presented and discussed under the following headings.

4.1 Effect of Nitrogen and Phosphorous and their combined effect on growth characters in tuberose

4.1.1 Plant height

Plant height of tuberose varied significantly (Appendix IV and Fig. 2) due to the application of different levels of nitrogen at 30, 60, 90 and 120 DAP. At 30 DAP the longest plant (25.53cm) was recorded from N_2, while the shortest plant (13.19cm) was recorded from N_0 (control). The longest plant (32.82cm) was recorded from N_3 and the shortest plant (19.61) was recorded from N_0 at 60 DAP. At 90 DAP the longest plant (42.75cm) was recorded from N_3, while the shortest plant (24.39cm) was recorded from N_0. The longest plant (50.05cm) was recorded from N_2, while the shortest (29.66cm) from N_0 at 120 DAP (fig.2). Similar trend of findings was found by Kumar *et al*. (2002).

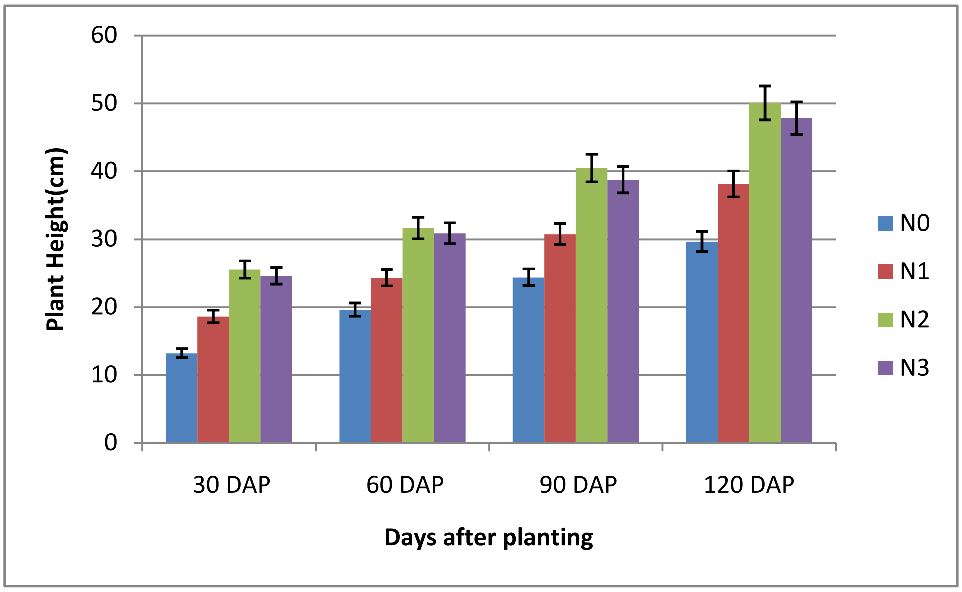


Fig. 2: Effect of nitrogen on the plant height of tuberose

Plant height of tuberose varied significantly (Appendix IV) due to the application of different levels of phosphorous at 30, 60, 90 and 120 DAP. At 30 DAP the longest plant (23.41cm) was recorded from P_2 while the shortest plant (17.71cm) was recorded from P_0 (control). The longest plant (29.40cm) was recorded from P_1 and the shortest plant (23.42cm) was recorded from P_0 at 60 DAP. At 90 DAP, the longest plant (35.92cm) was recorded from P_1 while the shortest plant (32.69cm) was recorded from P_0. The longest plant (43.56cm) was recorded from P_2 whereas the shortest (39.69 cm) was from P_0 at 120 DAP (Fig.3). The results also agreed to the findings of Sultana *et al*.(2006).

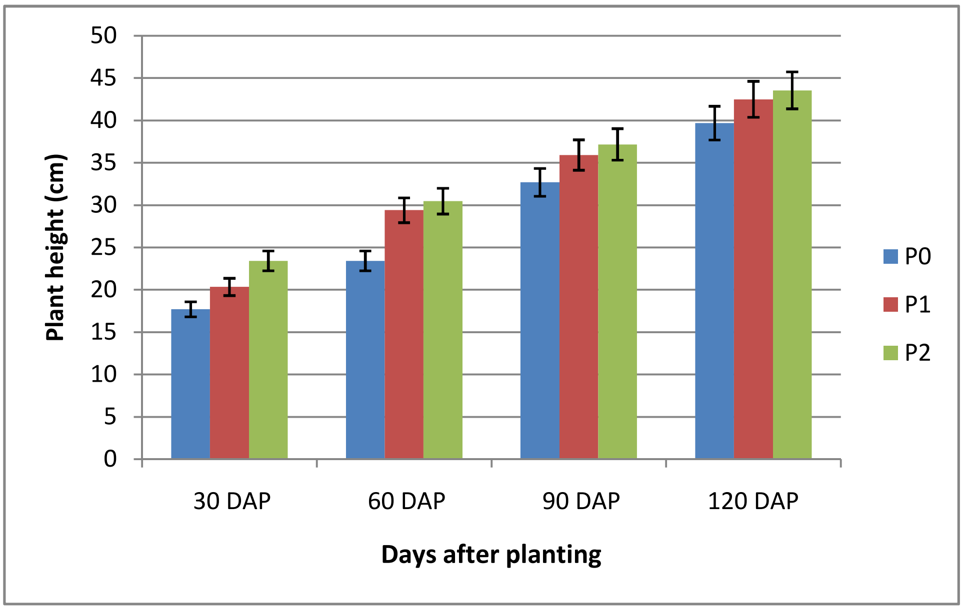


Fig. 3: Effect of phosphorous on the plant height of tuberose

Due to combined effect of different levels of nitrogen and phosphorous showed significant differences on plant height of tuberose at 30, 60, 90, and 120 DAT (Appendix IV). The longest plant height (29.66 cm) was recorded at the 30 DAP from N_2P_2 which was similar (29.58 cm) to treatment combination of N_3P_2 and the shortest plant (12.24 cm) was recorded at 30 DAP from N_0P_0 (control). At the 60 DAP the highest plant (36.38 cm) was recorded from N_2P_2 which was statistically similar (36.24 cm) to N_2P_1 longest while and the shortest plant (17.58 cm) was recorded at the 60 DAP from N_0P_0 (control). At the 90 DAP the longest plant (45.45 cm) was recorded from N_2P_2 which was statistically similar to N_2P_1 (44.97 cm), N_3P_1 (44.14 cm) and N_3P_2 (42.80 cm) and the lowest plant height (23.25 cm) was recorded at the 90 DAP from N_0P_0 (control). The highest plant height (52.45 cm) was recorded at the 120 DAP from

N_2P_2 which was statistically similar to N_2P_1 (51.63 cm), N_3P_1 (51.60 cm) and N_3P_2 (52.25 cm) and the lowest plant height (28.66 cm) was recorded at the 120 DAP from N_0P_0 (control) (Table 1). Result revealed that influence of nitrogen on plant height was greater than phosphorous at all growth stages. This result is supported by Sultana *et al.*(2006) in tuberose who reported that nitrogen had much more influence on plant growth and development in tuberose that phosphorous. Dahiya *et al.*(2001), stated that increasing of nitrogen and phosphorous after a certain level adversely affected growth which agreed to the present study.

Table 1. Combined effect of nitrogen and phosphorous on plant height of tuberose at different DAP

Treatment (s)	Plant height			
	30 DAP	**60 DAP**	**90 DAP**	**120 DAP**
N_0P_0	12.24 i	17.58 h	23.25 f	28.66 g
N_0P_1	14.25 h	20.53 g	26.38 e	30.24 f
N_0P_2	15.24 g	23.73 f	26.72 e	33.25 e
N_1P_0	16.45 g	20.44 g	28.12 e	36.41 d
N_1P_1	22.35 e	27.74 d	32.41 d	40.72 c
N_1P_2	23.66 e	27.86 d	41.44 bc	48.69 b
N_2P_0	22.24 f	25.24 e	39.14 c	40.62 c
N_2P_1	26.44 b	36.24 a	44.97 a	51.63 a
N_2P_2	29.66 a	36.38 a	45.45 a	52.45 a
N_3P_0	22.71 de	33.81 bc	34.71 d	40.40 c
N_3P_1	24.68 c	34.43 b	44.14 a	51.60 a
N_3P_2	29.58 a	33.40 c	42.80 ab	52.25 a
LSD (0.05)	1.276	0.728	2.643	1.042
CV (%)	9.41	8.07	9.66	7.65

N_0 = 0 kg N/ha P_0 = 0 kg P_2O_5/ha

N_1 = 180 kg N/ha P_1 = 170 kg P_2O_5/ha

N_2 = 200 kg N/ha P_2 = 190 kg P_2O_5/ha

N_3 = 220 kg N/ha

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability.

4.1.2 Number of leaves per plant

Application of different levels of nitrogen had significant variation on leaf production at 30, 60, 90 and 120 DAP (Appendix IV). The maximum number of leaves per plant

(7.21) was recorded from N_3 at 30 DAP and the minimum (4.52) was obtained from N_0 (control). At 60 DAP, the maximum number of leaves per plant (8.50) was recorded from N_3, while the minimum (5.92) was obtained from N_0 (control). The maximum number of leaves per plant (9.05) was recorded from N_2 and minimum (6.65) was obtained from N_0 (control) at 90 DAP. The maximum number of leaves per plant (13.12) was recorded from N_3, while the minimum (7.53) from N_0 at 120 DAP(Fig.4). Present study was supported by Gupta *et al.* (2006).

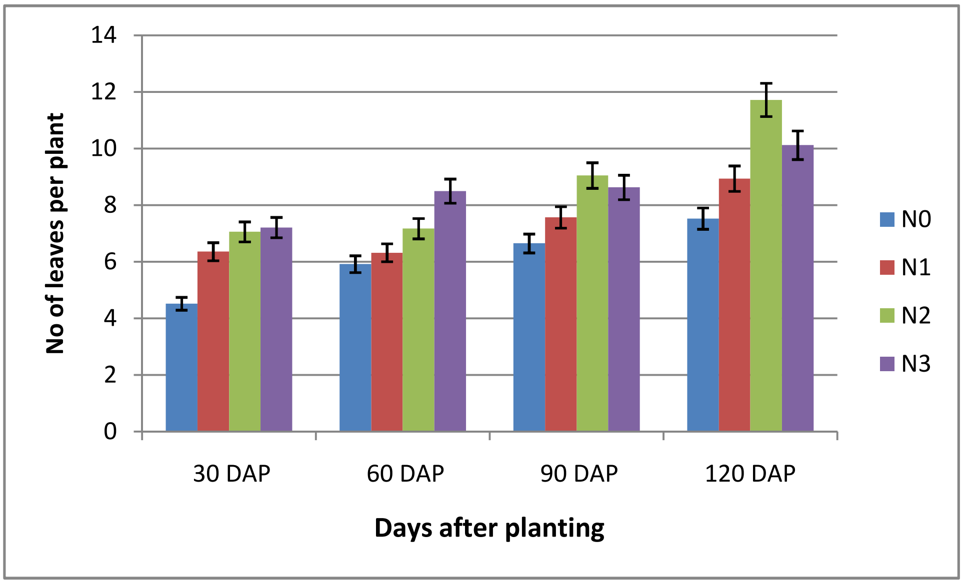


Fig. 4. Effect of nitrogen on number of leaves per plant of tuberose

Different levels of phosphorous application showed significant variation on leaf production (Appendix IV) at 30, 60, 90 and 120 DAP. The maximum number of leaves per plant (6.74) was obtained from P_1 at 30 DAP and the minimum (5.62) was found from N_0 (control). At 60 DAP the maximum number of leaves per plant (7.14) was recorded from P_1, while the minimum (6.78) was obtained from P_0 (control). The maximum number of leaves per plant (8.39) was recorded from P_1 and the minimum (7.62) was obtained from P_0 (control) at 90 DAP. The maximum number of leaves per plant (10.20) was recorded from P_1, while the minimum (9.43) from P_0 at 120 DAP (Fig.5). The similar trends of results were recorded by Dahiya *et al.* (2001).

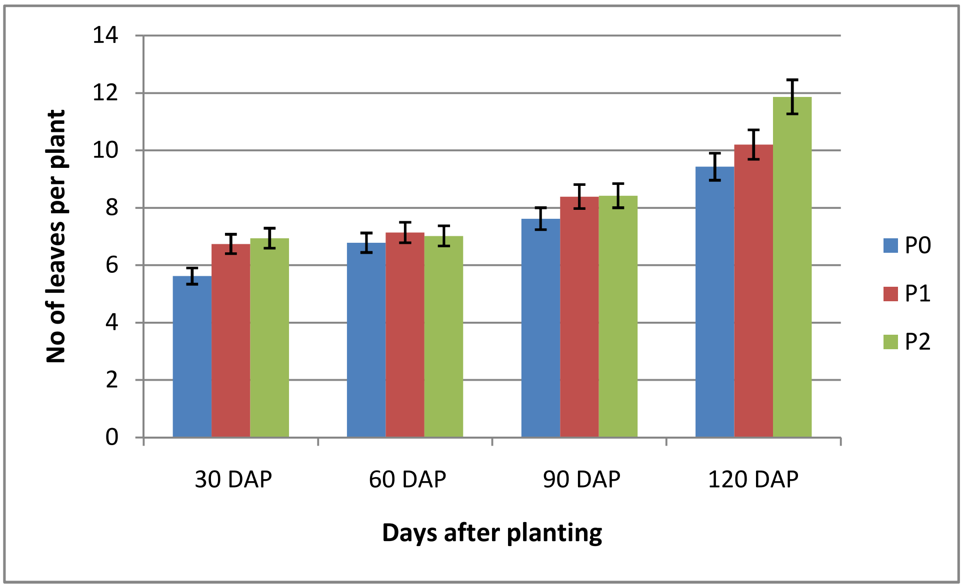


Fig. 5. Effect of phosphorous on number of leaves per plant of tuberose

Table 2. Combined effect of nitrogen and phosphorous on number of leaves per plant of tuberose at different days after planting

Treatment (s)	Number of leaves/plant			
	30 DAP	**60 DAP**	**90 DAP**	**120 DAP**
N_0P_0	3.02 h	3.12 g	4.78 g	6.05 e
N_0P_1	5.41 g	6.01 f	7.05 f	8.57 d
N_0P_2	5.43 g	7.19 ef	7.89 f	8.86 d
N_1P_0	5.93 f	7.27 ef	8.07 ef	9.12 d
N_1P_1	7.12 cd	7.16 ef	9.57 cd	10.70 bc
N_1P_2	6.30 ef	7.58 e	8.45 e	10.13 c
N_2P_0	6.47 e	7.49 ef	9.82 bc	10.50 bc
N_2P_1	7.11 cd	8.29 d	10.01 b	13.48 a
N_2P_2	7.89 a	9.92 a	10.46 a	14.48 a
N_3P_0	7.44 bc	7.18 ef	9.30 d	10.59 bc
N_3P_1	6.97 d	9.72 ab	9.97 b	11.17 b
N_3P_2	7.50 ab	9.12 bc	9.47 cd	14.08 a
LSD (0.05)	0.383	0.517	0.389	0.763
CV (%)	7.97	8.71	8.57	7.95

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability.

Due to combined effect of different levels of nitrogen and phosphorous showed significant differences on tuberose of leaves at 30, 60 and 90 but except at 120 DAT (Appendix IV). However the maximum number of leaves per plant (7.89) was recorded at the 30 DAP from N_2P_2 which was statistically similar to N_3P_2 (7.50) and the minimum (3.02) was recorded from N_0P_0 . At the 60 DAP, the maximum number of leaves per plant (9.92) was recorded from N_2P_2 which was statistically similar to N_3P_1 (9.72) and the minimum (3.12) was recorded from N_0P_0. At the 90 DAP the maximum number of leaves per plant (10.46) was recorded from N_2P_2 and the minimum (4.78) was recorded at 90 DAP from N_0P_0. The highest number of leaves per plant (14.48) was recorded at 120 DAP from N_2P_2 which was statistically similar to N_2P_1 (13.48) and N_3P_2 (14.08) and the lowest (6.05) was recorded at 120 DAP from N_0P_0 (Table 2). The similar trends of results were recorded by Kumar *et al.* (2003).

4.1.3 Leaf length

The effect of different levels of nitrogen on leaf length showed significant variation (Appendix V) at 30, 60, 90 and 120 DAP. The maximum leaf length (26.19 cm) was recorded from N_3 at 30 DAP and the minimum (16.28 cm) was obtained from N_0 (control). At 60 DAP the maximum leaf length (39.55 cm) was recorded from N_3, while the minimum (30.81 cm) was obtained from N_0. Maximum leaf length (44.41 cm) was recorded from N_3 and minimum (34.34 cm) was obtained from N_0 at 90 DAP. The present results revealed that the length of leaf was increased with the increasing levels of nitrogen (Fig.6). This result was very much similar to the findings of Rajwal and Singh (2006).

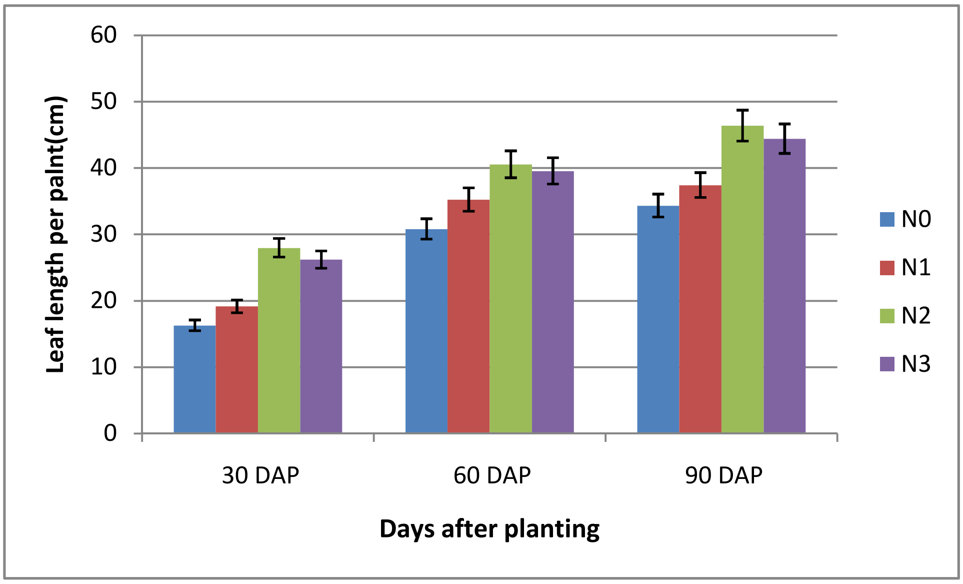


Fig. 6. Effect of nitrogen on the leaf length of tuberose

Due to application of different levels of phosphorous had significant variation on leaf length at 30, 60, 90 and 120 DAP(Appendix V). The maximum leaf length (21.66 cm) was recorded from P_2 and the minimum (20.31 cm) was obtained from P_0 (control) at 30 DAP. At 60 DAP, the maximum leaf length (36.31 cm) was recorded from P_2, while the minimum (34.90 cm) was obtained from N_0. The maximum leaf length (41.59 cm) was recorded from P_2 and the minimum (37.41 cm) was obtained from P_0 at 90 DAP (Fig.7). The similar trends of results was found by Yadav (2006).

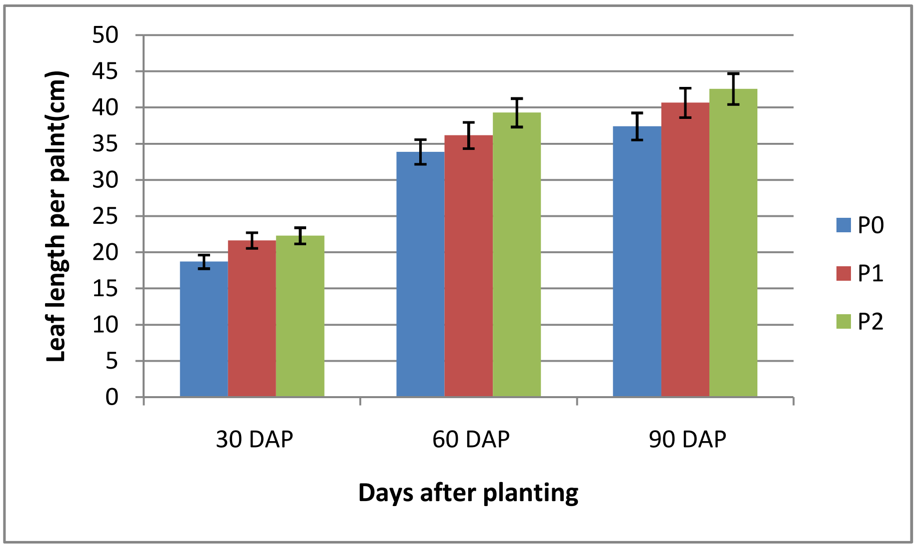


Fig. 7. Effect of phosphorous on the leaf length of tuberose

Table 3. Combined effect of nitrogen and phosphorous on leaf length of tuberose at different DAP

Treatment (s)	**Leaf length (cm)**		
	30 DAP	**60 DAP**	**90 DAP**
N_0P_0	17.16 h	30.96 f	33.29 h
N_0P_1	17.19 h	30.98 f	35.59 g
N_0P_2	15.54 h	33.55 e	37.20 f
N_1P_0	19.57 g	34.08 e	35.70 g
N_1P_1	20.63 ef	37.95 c	39.06 e
N_1P_2	23.49 d	36.85 d	40.59 d
N_2P_0	20.32 f	38.09 c	40.14 d
N_2P_1	26.73 b	39.15 b	46.42 ab
N_2P_2	28.18 a	40.70 a	46.65 a
N_3P_0	21.09 e	38.47 bc	44.60 c
N_3P_1	26.70 b	40.55 a	45.68 b
N_3P_2	24.33 c	40.47 a	46.03 ab
LSD (0.05)	0.537	1.078	0.833
CV (%)	11.09	8.39	7.93

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability.

Significant variation was found due to the combined effect of different levels of nitrogen and phosphorous on leaf length at different days after planting (Appendix V). The maximum leaf length (28.18 cm, 40.70 cm and 46.65 cm) was recorded at the 30, 60 and 90 DAP respectively from N_2P_2 and the minimum leaf length (17.16 cm, 30.96 cm and 33.29 cm) was recorded from N_0P_0 at same date of observations (Table 3). Kawarkhe and Jane (2002) was found the similar trend of results which was support to the present study.

4.1.4 Number of side shoots per plant

A significant differences was recorded on side shoot production due to the effect of different levels of nitrogen in tuberose at 30, 60 and 90 DAP (Appendix V). However, at 30 DAP, the maximum number of side shoot (20.9) produced by N_3 whereas the minimum (0.63) was found from control condition. The miximum number of side shoots (4.29) was obtained from N_3 and the control treatment (N_0) gave the minimum (1.74) number of side shoots at 60 DAP. At 90 DAP, the highest number of side shoots (6.57) was recorded from N_3 and the lowest number of side shoots (3.13) was observed in N_3 (Fig.8). The present results also agreed to the findings of patil *et.al.* (1999) and Roy (1992).

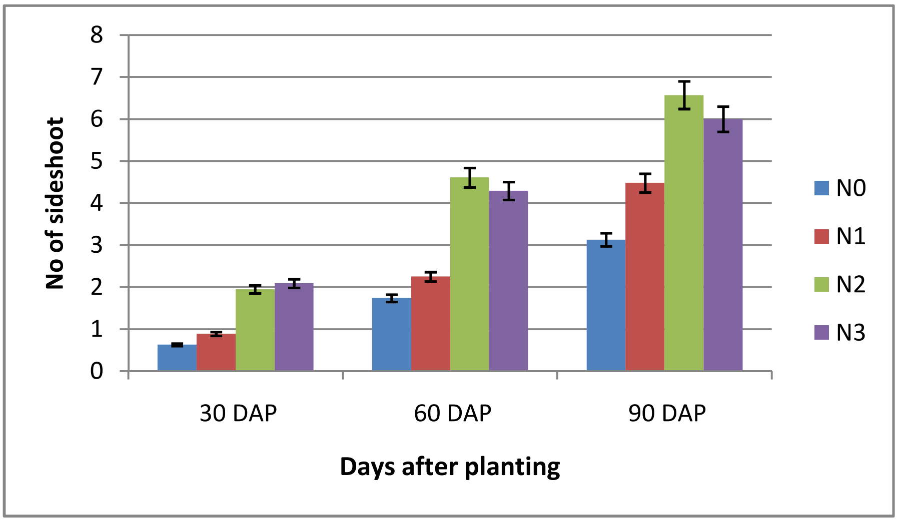


Fig. 8. Effect of nitrogen on the number of side shoots production in tuberose

Different levels of phosphorous application in tuberose had significant variation on side shoots production at 30, 60 and 90 DAP (Appendix V). The maximum number of side shoots (1.24) was recorded from P_2 at 30 DAP and the minimum (1.10) was obtained from P_0 (control). At 60 DAP the maximum number of side shoots (3.04) was recorded from P_1, while the minimum (2.57) was obtained from N_0. The maximum number of side shoots (5.50) was recorded from P_2 and minimum (4.60) was obtained from P_0 at 90 DAP (Fig.9). This result also agreed to the findings of Patil *et al.* (1999).

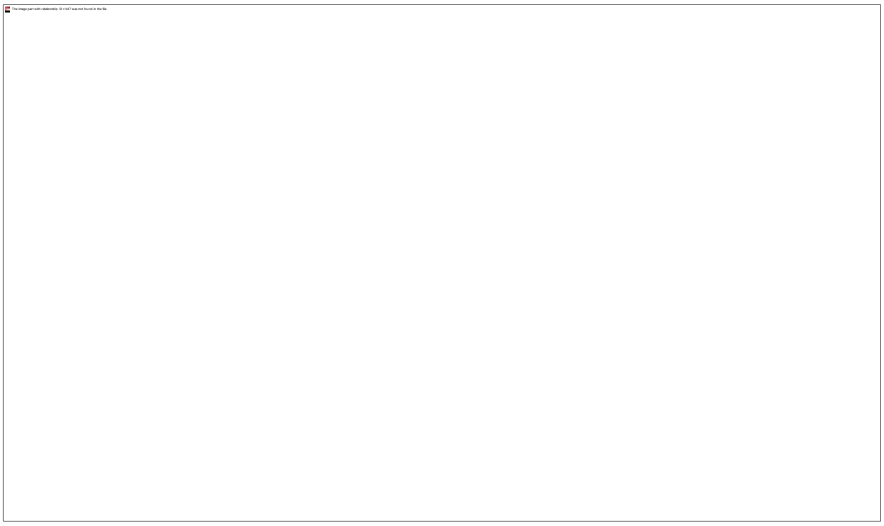


Fig. 9. Effect of phosphorous on the number of side shoots production in tuberose

Table 4. Combined effect of nitrogen and phosphorous on number on side shoot of tuberose at different DAP

Treatment (s)	**Number of side shoot/plant**		
	30 DAP	**60 DAP**	**90 DAP**
N_0P_0	0.59 f	1.33 i	2.89 e
N_0P_1	0.62 f	1.96 h	3.21 de
N_0P_2	0.84 e	2.06 h	4.14 c
N_1P_0	0.89 e	2.23 g	3.57 cd
N_1P_1	0.93 e	2.40 f	3.73 cd
N_1P_2	0.96 e	2.93 e	5.96 b
N_2P_0	1.01 de	2.29 fg	5.78 b
N_2P_1	2.03 b	3.97 b	6.96 a
N_2P_2	2.27 a	4.55 a	7.20 a
N_3P_0	1.24 c	3.7 d	5.73 b
N_3P_1	1.20 cd	3.37 c	6.81 a
N_3P_2	2.07 ab	4.50 a	6.15 b
LSD (0.05)	0.193	0.136	0.629
CV (%)	9.57	8.91	9.18

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability.

Due to the combined effect of different levels of nitrogen and phosphorus showed significant differences on number of side shoots at 30, 60, and 90 DAP (Appendix V). The maximum number of side shoots (2.27) was found from the treatment combination of N_2P_2 was statistically similar (2.07) to N_3P_2 and the control treatment (N_0P_0) gave the minimum number of side shoots (0.54) at 30 DAP. At 60 DAP, the maximum number of side shoots (4.55) was recorded from N_2P_2 was statistically similar (4.50) to N_3P_2 and the minimum number of side shoots (1.33) was obtained from $N_0P_{0.}$ The maximum number of side shoots (7.20) was found from the treatment combination of N_2P_2 which was statistically similar (6.81) to N_3P_1 . The minimum number of side shoots (2.89) was recorded from control treatment combination (Table 4).

4.2 Effect of Nitrogen and Phosphorous and their combined effect on reproductive characters in tuberose

4.2.1 Spike length

Significant variation was found on spike length due to application of different levels of nitrogen (Appendix VI). Result showed that spike length increased with the increasing nitrogen level. The longest spike length (40.22 cm) was recorded from N_2 and the shortest (29.95 cm) was obtained from N_0 (Table 5). This result was agreed to the findings of Alan *et al*. (2007).

Different levels of phosphorous application on tuberose had significant variation on spike length (Appendix VI). The longest spike length (33.41 cm) was recorded from P_2 and the shortest (30.37) was obtained from P_0 (Table 5). The similar trend of results was recorded by Mishra *et al.* (2002).

Due to combined effect of different levels of nitrogen and phosphorous showed significant difference on spike length (Appendix VI). The longest spike length (42.75 cm) was recorded from N_2P_2 and shortest (29.03 cm) was recorded from N_0P_0 (Table 5). Mukhopadhyay and Banker (1986) found similar trend of results in their study.

4.2.2 Spike diameter

Significant difference was found on the spike diameter of tuberose due to the application of different levels of nitrogen (Appendix VI). Result showed that spike diameter increased with the increasing nitrogen level. The maximum spike diameter (1.03 cm) was recorded from N_2 and the minimum (0.69 cm) was obtained from N_0 (Table 5). This result was also similar to the findings of Alan *et al*. (2007).

Different levels of phosphorous application on tuberose had significant variation on spike diameter (Appendix VI). The maximum spike diameter (0.91 cm) was recorded from P_1 and the minimum (0.79 cm) was obtained from P_0 (Table 5). The similar trend of results was recorded by Mishra *et al.* (2002).

Significant difference was recorded on spike diameter due to combined effect of different levels of nitrogen and phosphorous (Appendix VI). The maximum spike diameter (1.03 cm) was recorded from N_2P_2 which was statistically similar to N_2P_1 (1.00 cm), N_3P_2 (1.01 cm) and N_3P_1 (0.97 cm). The minimum diameter of spike(0.65 cm) was recorded from N_0P_0 which was statistically similar to N_0P_1 (0.66 cm) (Table 5). Kumar *et al.* (2002) agreed to the findings of the present trial.

4.2.3 Rachis Length

There was a significant difference in the rachis length of tuberose due to different levels of nitrogen application (Appendix VI). The maximum rachis length (15.96 cm) was recorded from N_2 and the minimum (11.33 cm) was obtained from N_0 (Table 5). Singh *et al.* (2002) found similar trend of results which was supported to the present study.

Different levels of phosphorous exhibited significant variation on length of rachis (Appendix VI). The maximum rachis length (13.26 cm) was recorded from P_2 which was statistically similar to P_1 (13.16 cm) and the minimum (12.49 cm) was obtained from P_0 (Table 5). Mukhopadhyay and Banker (1986) showed that the similar findings with this present study.

Combined effect of different levels of nitrogen and phosphorous showed significant variation on length of rachis in tuberose (Appendix VI). The maximum rachis length (16.70 cm) was recorded from N_2P_2 which was statistically similar to N_3P_2 (16.50 cm) and minimum (11.17 cm) was recorded from N_0P_0 which was statistically similar to N_0P_1 (11.35 cm) and N_0P_2 (11.45 cm) (Table 5). Kawarkhe and Jane (2002) found the similar trend of results which was found in present study.

4.2.4 Number of florets per spike

Significant variations were recorded on florets per spike of tuberose due to application of different levels of nitrogen (Appendix VI). The maximum number of florets per spike (33.20) was recorded from N_2 which was statistically similar (33.09) to N_3 and the minimum (16.90) was obtained from N_0 (Table 5). The result was supported by Parthiban *et al.* (1991).

Applications of different levels of phosphorous showed significant variation on number of florets per spike in tuberose (Appendix VI). The maximum florets per spike (27.72) was recorded from P_2 and the minimum (24.90) was obtained from P_0(Table 5). The similar trend of results was recorded by Banker *et al.* (1985).

Significant difference was found on number of florets per spike due to combined effect of different levels of nitrogen and phosphorous (Appendix VI). The maximum number of florets per spike (34.49) was recorded from N_2P_2 which was statistically similar to N_3P_2 (34.41) and the minimum (15.30) was recorded from N_0P_0 (Table 5).

4.2.5 Weight of single spike

Significant difference was found on single spike weight in tuberose due to the application of different levels of nitrogen (Appendix VI). The maximum weight of single spike (58.71 g) was recorded from N_2 and the minimum (43.35 g) was obtained from N_0 (Table 5). This result was supported by Alan *et al.* (2007).

Due to application of different levels of phosphorous had significant variation on single spike weight (Appendix VI). The maximum weight of single spike (52.66 g) was recorded from P_2 which was statistically similar (52.56 g) to P_1 and the minimum (48.54 g) was obtained from P_0 (Table 5). Mishra *et al.* (2002) stated that higher doses of phosphorous contributed the maximum weight which agreed to the present study.

4.2.6 Number of Spike per hectare

Due to the application of different level of nitrogen showed significant difference on spike number per hectare in tuberose (Appendix VI). The maximum number of spike per hectare (296.10/ha) was recorded from N_2 which was statistically similar to N_3 (276.80/ha) and the minimum (183.80/ha) was obtained from N_0 (Table 5). The similar trend of results was recorded by Parthiban *et al*. (1991).

Different levels of phosphorous application on tuberose had significant variation on spike number per hectare (Appendix VI). The maximum number of spikes (256.00/ha) per hectare was recorded from P_2 and the minimum (232.80/ha) was obtained from P_0 (Table 5). This result was supported by Gowda *et al.* (1991).

Significant difference was found on number of spike per hectare due to combined effect of different levels of nitrogen and phosphorous (Appendix VI). The maximum number of spikes per hectare (302.40/ha) was recorded from N_2P_2 which was statistically similar to N_3P_1 (301.10/ha) and N_3P_2 (302.20/ha) and the minimum (173.80/ha) was recorded from N_0P_0 (Table 5). This finding was similar to Parthiban *et al*. (1991) and Sultana *et al*. (2006).

Table 5. Effect of nitrogen, phosphorous and their combination effect on spike length, spike diameter, rachis length, number of florets per spike, spike number per hectares, single spike weight(g) and flower yield (t/ha) of tuberose

Treatments	Spike length (cm)	Spike diameter (cm)	Rachis length (cm)	Number of florets/ spike	Weight of single spike(g)	Number of spikes/ ha ('000)
Effect of Nitrogen						
N_0	29.95 d	0.69 d	11.33 d	16.90 c	43.35 d	183.80 d
N_1	34.87 c	0.81 c	11.73 c	22.56 b	45.09 c	226.30 c
N_2	40.22 a	1.03 a	15.96 a	33.20 a	58.71 a	296.10 a
N_3	36.90 b	0.96 b	12.96 b	33.09 a	57.85 b	276.80 a
LSD (0.05)	2.013	0.0531	0.366	0.272	0.813	10.661
Effect of phosphorous						
P_0	30.37 c	0.79 c	12.49 b	24.90 c	48.54 b	232.80 c
P_1	32.70 b	0.84 b	13.16 a	26.18 b	52.56 a	248.40 b
P_2	33.41 a	0.91 a	13.26 a	27.72 a	52.66 a	256.00 a
LSD (0.05)	1.27	0.0621	0.25	0.964	2.360	5.552
Combined effect of nitrogen and phosphorous						
N_0P_0	29.03 g	0.65 e	11.17 g	15.30 g	43.17 e	173.80 h
N_0P_1	30.03 f	0.66 e	11.35 g	16.62 f	43.49 e	189.30 g
N_0P_2	30.53 f	0.73 d	11.45 g	18.51 e	43.39 e	188.30 g
N_1P_0	33.57 e	0.74 d	11.72 ef	19.75 d	44.89 d	214.50 f
N_1P_1	34.01 e	0.84 c	11.78 e	23.79 c	45.04 d	233.40 e
N_1P_2	37.08 d	0.84 c	12.52 d	23.52 b	45.34 d	231.00 e
N_2P_0	36.88 d	0.76 d	11.70 ef	23.80 c	51.49 c	258.20 d
N_2P_1	40.83 b	1.00 ab	13.12 c	32.31 b	60.91 a	269.90 c
N_2P_2	42.75 a	1.03 a	16.70 a	34.49 a	61.17 a	302.40 a
N_3P_0	37.20 d	0.93 b	12.94 c	32.25 b	54.60 b	285.00 b
N_3P_1	39.01 c	0.97 ab	14.55 b	32.35 b	60.80 a	301.10 a
N_3P_2	40.70 b	1.01 ab	16.50 a	34.41 a	60.74 a	302.20 a
LSD (0.05)	0.865	0.0546	0.328	0.813	0.677	6.502
CV (%)	8.33	7.39	9.12	7.22	6.65	8.99

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability.

Combined effect of different levels of nitrogen and phosphorus showed significant difference on weight of single spike (Appendix VI). The maximum weight of single spike (61.17 g) was recorded from N_2P_2 which was statistically similar to N_2P_1 (60.91 g), N_3P_1 (60.80 g) and N_3P_2 (60.74 g). The minimum (43.17 g) was recorded from N_0P_0 which was statistically similar to N_0P_1 (43.49 g) and N_0P_2 (43.39 g) (Table 5). The results also agreed to the findings of Mukhopadhyay and Banker (1986).

4.3 Effect of Nitrogen and Phosphorous and their combined effect on bulb characters in tuberose

4.3.1 Bulb length

There was a significant difference on bulb length of tuberose due to the application of different levels of nitrogen application (Appendix VII). The maximum bulb length (6.88 cm) was recorded from N_2 and the minimum (5.60 cm) was obtained from N_0 (Table 6). The results also agreed to the findings of Rajwal and Singh (2006).

Application of different levels of phosphorous showed significant variation on bulb length (Appendix VII). The maximum (5.54 cm) bulb length was recorded from P_2 and the minimum (4.97 cm) was obtained from P_0 (Table 6). Gowda *et al.* (1991) observed that application of phosphorous fertilizer increased bulb length of tuberose that supported the present experimental result.

Due to combined effect of different levels of nitrogen and phosphorous had significant variation on bulb length in tuberose (Appendix VII). The maximum bulb length (8.36 cm) was recorded from the treatment combination of N_2P_2 which was statistically similar(8.11 cm) to N_3P_2 and the minimum bulb length (6.67 cm) was recorded from N_0P_0 (Table 6). This result was similar to Dahiya (2001).

4.3.2 Bulb diameter

Application of different levels of nitrogen showed significant difference in the bulb diameter of tuberose (Appendix VII). Result showed that bulb diameter increased with the increasing nitrogen level. The maximum bulb diameter (3.38 cm) was recorded from N_3 and the minimum (2.66 cm) was obtained from N_0 (Table 6). Singh and Singh (2005) stated that higher doses of nitrogen gave similar trends of results which agreed to the present study.

Different levels of phosphorous application on tuberose had significant variation on bulb diameter (Appendix VII). The maximum bulb diameter (3.28 cm) was recorded from P_2 and the minimum (2.79 cm) was obtained from P_0 (Table 6). This result was supported with the results of Banker (1988).

Combined effect of different levels of nitrogen and phosphorous exhibited significant variation on bulb diameter (Appendix VII). The maximum bulb diameter (4.02 cm) was recorded from N_2P_2 and minimum (2.62 cm) was recorded from N_0P_0 (Table 6). The similar trend of results was recorded by Cirrito and Zizzo (1980).

4.3.3 Fresh weight of Bulb per plant

Significant difference was found on bulb weight per plant in tuberose due to application of different levels of nitrogen application (Appendix VII).The maximum bulb weight per plant (155.40 g) was recorded from N_2 and the minimum (95.31 g) was obtained from N_0 (Table 6). Jana *et al*. (1974) reported the beneficial effect of nitrogen on bulb yield in tuberose which was similar to this finding.

Application of different levels of phosphorous had significant variation on fresh weight of bulb per plant (Appendix VII). The maximum fresh weight per plant (132.80 g) was recorded from P_2 which was statistically similar (113.00gm) to $P_1$and the minimum (116.80 g) was obtained from P_0 (Table 6). The results also agreed to the findings of Cirrito (1975).

Due to combined effect of different levels of nitrogen and phosphorus showed significant difference on fresh weight of bulb per plant in tuberose (Appendix VII). The maximum fresh weight of bulb per plant (162.40 g) was recorded from N_2P_2 and minimum (85. 83 g) was recorded from N_0P_0 (Table 6). The results also agreed to the findings of Singh *et al*. (2001).

4.3.4 Number of bulblet per plant

Significant differences were found on number of side shoot per plant of tuberose due to application of different levels of nitrogen (Appendix VII). The maximum bulblet per plant (15.63) was recorded from N_2 and the minimum (8.76) was obtained from N_0 (Table 6). This finding was similar with Roy (1992).

Application of different levels of phosphorous had significant variation on bulblet per plant (Appendix VII). The maximum side bulb per plant (13.55) was recorded from P_2 and the minimum (12.35) was obtained from P_0 (Table 6). The results also agreed to the findings of Jana *et al*. (1974).

There was a significant difference recorded on number of bulblet per plant due to combined effect of different levels of nitrogen and phosphorous (Appendix VII). The maximum bulblet per plant (16.37) was recorded from N_2P_2 which was statistically similar (16.27) to N_3P_2 and the minimum bulblet per plant (7.42) was recorded from N_0P_0(Table 6).

Table 6. Effect of nitrogen, phosphorous and their combined effect on bulb length, bulb diameter, fresh weight of bulb per plant, number of side shoot per plant, bulb yield and dry weight of bulb of tuberose

Treatments	Bulb length (cm)	Bulb diameter (cm)	Fresh weight of bulb/plant(g)	Number of bulblets/ plant	Bulb yield (t/ha)	Dry weight of bulb(g)
Effect of nitrogen						
N_0	5.60 c	2.66 d	95.31 d	8.76 d	11.29 c	18.93 c
N_1	6.01 b	2.73 c	114.20 c	12.04 c	17.58 b	19.73 b
N_2	6.88 a	3.19 b	155.40 a	15.63 a	24.37 a	22.73 a
N_3	6.07 b	3.38 a	142.60 b	15.23 b	23.97 a	21.54 a
LSD (0.05)	0.720	0.063	6.605	0.145	0.592	1.31
Effect of phosphorous						
P_0	4.97 c	2.79 c	116.80 b	12.35 c	18.15 c	21.08 c
P_1	5.16 b	2.91 b	131.00 a	12.83 b	19.74 b	25.14 b
P_2	5.54 a	3.28 a	132.80 a	13.55 a	20.01 a	28.02 a
LSD (0.05)	0.119	0.061	4.821	0.122	0.256	0.661
Combined effect of nitrogen and phosphorous						
N_0P_0	6.67 h	2.62 g	85.83 i	7.42 i	10.70 h	15.93 f
N_0P_1	6.71 h	2.65 g	91.95 h	9.52 h	11.56 g	16.31 e
N_0P_2	6.80 gh	2.72 fg	108.10 g	9.34 h	11.61 g	18.56 c
N_1P_0	6.78 gh	2.69 fg	107.70 g	10.42 g	14.87 f	19.73 d
N_1P_1	6.81 gh	2.73 fg	112.70 f	13.46 e	16.05 e	20.89 d
N_1P_2	7.84 c	2.77 ef	122.20 e	12.23 f	21.80 d	24.57 c
N_2P_0	7.01 fg	2.68 fg	125.80 e	15.86 b	18.56 b	29.37 b
N_2P_1	7.11 ef	2.89 e	139.60 d	14.65 c	23.43 bc	32.29 a
N_2P_2	8.36 a	4.02 a	162.40 a	16.37 a	25.76 a	33.16 a
N_3P_0	7.25 c	3.18 d	147.80 c	15.71 b	19.10 c	30.31 b
N_3P_1	8.55 d	3.38 c	157.10 b	13.71 d	23.20 c	31.09 a
N_3P_2	8.11 a	3.59 b	161.30 a	16.27 a	25.60 a	32.58 a
LSD (0.05)	0.249	0.122	3.583	0.244	0.513	1.324
CV (%)	8.80	9.10	8.83	6.30	7.24	5.59

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability.

Significant difference was found on bulb yield due to combined effect of different levels of nitrogen and phosphorous (Appendix VII). The maximum bulb yield (25.76 t/ha) was recorded from N_2P_2 which was statistically similar to N_3P_2 (25.60 t/ha) and minimum (10.70 t/ha) was recorded from N_0P_0 (Table 6). Mukhopadhyay and Banker (1986) showed the similar results of their study.

4.3.5 Bulb yield

Due to the application of different levels of nitrogen showed significant difference on bulb yield (Appendix VII). The maximum bulb yield (24.37 t/ha) was recorded from N_2 which was statistically similar to N_3 (23.97 t/ha) and the minimum (11.29 t/ha) was obtained from N_0 (Table 6). The results also agreed to the findings of Roy (1992).

Application of different levels of phosphorous had significant variation on bulb yield (Appendix VII). The maximum bulb yield (20.01 t/ha) was recorded from P_2 and the minimum (18.15 t/ha) was obtained from P_0 (Table 6). The similar trend of results was recorded by Cirrito and Zizzo (1980).

4.3.6 Dry weight of bulb

There was a significant difference on dry weight of bulb due to the application different levels of nitrogen (Appendix VII). The maximum dry weight of bulb (22.73 g) was recorded from N_2 which was statistically similar (21.54 g) to N_3 and the minimum (18.93 g) was obtained from N_0 (Table 6). This result also agreed to the findings of Yadav *et al*. (2002b).

Different levels of phosphorus application on tuberose had significant variation on dry weight of bulb (Appendix VII). The maximum dry weight of bulb (28.02 g) was recorded from P_2 and the minimum (21.08 g) was obtained from P_0 (Table 6). This result also agreed to the findings of Yadav *et al*. (2002a).

Combined effect of different levels of nitrogen and phosphorus had significant difference on dry weight of bulb (Appendix VII). The maximum dry weight of bulb (33.16 g) was recorded from the treatment combination of N_2P_2 which was statistically similar to N_2P_1 (32.29 g), N_3P_1 (31.09 g) and N_3P_2 (32.58 g) and the minimum dry weight of bulb (15.93 g) was recorded from N_0P_0 (Table 6). This result also agreed to the findings of Yadav *et al*. (2002b).

4.4. Economic analysis

Input cost of land preparation, bulb, fertilizer, pesticide, irrigation and manpower required for all the operations including harvesting of flowers, bulb and bulb let were recorded from unit plot and converted into cost per hectare. Prices of the spikes, bulb and bulb let were considered in the flower market rate at Agargaon, Dhaka-1207. The economic analysis was done to find out the gross and the net return and the benefit cost ratio in the present experiment and the presented under the following headings.

4.4.1 Gross return

In the combination of different level of nitrogen and phosphorous showed different gross return. The highest gross return (Tk. 560000/ha) was obtained from the treatment combination 200 kg N/ha and 190 kg P_2O_5/ha (N_2P_2) and the second highest gross return (Tk. 558200/ha) was obtained from the treatment combination 220 kg N/ha and 190 kg P_2O_5/ha (N_3P_2). The lowest gross return (Tk. 280800/ha) was obtained from the controlled condition (Table 7).

4.4.2 Net return

In case of net return different treatment combination showed different net return. The highest net return (Tk. 422374/ha) was obtained from the treatment combination 220 kg N/ha and 190 kg P_2O_5/ha (N_2P_2) and the second highest net return (Tk. 419583/ha) was obtained from the treatment combination 220 kg N/ha and 170 kg P_2O_5/ha (N_3P_2). The lowest net return (Tk. 168417/ha) was obtained from the controlled condition. (Table 7)

4.4.3 Benefit cost ratio

In the combination of different levels of nitrogen and phosphorous showed different benefit cost ratio. The highest benefit cost ratio (3.06) was obtained from the treatment combination 200 kg N/ha and 190 kg P_2O_5/ha (N_2P_2). The lowest benefit cost ratio (1.39) was obtained from N_0P_2. From the economic point of view, it is apparent from the above results that 200 kg N/ha and 190 kg P_2O_5/ha (N_2P_2) was more profitable than the rest of treatment.

Table 7. Cost and return of tuberose cultivation as influenced by different levels of nitrogen and phosphorous

Interaction N x P		Cost of Production (Tk/ha)	No. of spike/ha	Price of spike (Tk/ha)	yield of bulb (t/ha)	Price of bulb (tk/ha)	Gross return (Tk/ha)	Net return (Tk/ha)	Benefit cost ratio
0 kg N/ha	0 kg P_2O_5/ha	112383.4	173800	173800	10.7	107000	280800	168416	1.49
	170 kg P_2O_5/ha	124079.6	189300	189300	11.56	115600	304900	180820	1.45
	190 kg P_2O_5/ha	127336.4	188300	188300	11.61	116100	304400	177063	1.39
180 kg N/ha	0 kg P_2O_5/ha	121634.6	214500	214500	14.87	148700	363200	241565	1.98
	170 kg P_2O_5/ha	133330.8	233400	233400	16.05	160500	393900	260569	1.95
	190 kg P_2O_5/ha	136587.6	231000	231000	21.8	218000	449000	312412	2.28
200 kg N/ha	0 kg P_2O_5/ha	122673	258200	258200	18.56	185600	443800	321127	2.61
	170 kg P_2O_5/ha	134369.2	269900	269900	23.43	234300	504200	369830	2.75
	190 kg P_2O_5/ha	137626	302400	302400	25.76	257600	560000	422374	3.06
220 kg N/ha	0 kg P_2O_5/ha	123664.2	285000	285000	19.1	191000	476000	352335	2.84
	170 kg P_2O_5/ha	135360.4	301100	301100	23.2	232000	533100	397739	2.93
	190 kg P_2O_5/ha	138617.2	302200	302200	25.6	256000	558200	419582	3.02

CHAPTER V

SUMMARY AND CONCLUSION

This experiment was conducted in the Horticulture farm ofSher-e-Bangla Agricultural University Dhaka 1207, (Tejgaon series under AEZ No.28) from April 2013 to March 2014, to study the Effect of different levels of nitrogen and different concentrations of phosphorus on the growth and yield of tuberose. The soil was silty clay loam in texture having pH 6.1 and organic carbon content of 0.45%. Four levels of nitrogen (0 kg urea, 180 kg urea, 200 kg urea and 220 kg urea) and three levels of phosphorus (0, 170kg P_2O_5/ha and 190kg P_2O_5/ha) were used in the study. Levels of these two nutrient elements make 12 treatment combinations. The experiment was carried out in Randomized Complete Block Design (RCBD) with three replications. The unit plot size was 2 m x 1.2m which accommodated 36 plants.

Data on growth and yield contributing parameters were recorded, and the collected data were statistically analyzed to evaluate the treatment effects. The summary of the results has been presented in this chapter.

At 120 days after transplantation nitrogen had a significant effect on plant height. The tallest plant (50.05 cm) wasrecordedfrom N_2 andthe shortest (29.66 cm) plant was observed from N_0 (control). The tallest plant (43.56 cm) was recorded from P_2 andthe shortest (39.69 cm) plant was observed from P_0 (control).The treatment combinations demonstrated significant variation in plant height at 30, 60, 90 and 120 DAP. At 120 DAP the tallest plant (52.45 cm) was recordedfrom N_2P_2 while the shortest (28.66 cm) was shown from N_0P_0 (control).

The maximum number of leaves (13.12) were recorded from N_3 andthe minimum (7.53) on number of leaves were recorded from N_0 (control) at 120 DAP. The maximum on number of leaves (10.20) were recorded from P_1 andthe minimum (9.43) on number of leaves were recorded from P_0 (control) at 120 DAP. The treatment combinations demonstrated significant variation in number of leaves at 30, 60, 90 and 120 DAP. At 120 DAP the maximum on number of leaves (14.48) were recorded from N_2P_2andthe minimum (6.05) number of leaves were recorded from N_0P_0 (control).

The maximum leaf length (44.14 cm) was recorded from N_3 andthe minimum (34.34 cm) leaf length was recorded from N_0 (control) at 90 DAP. The maximum leaf length (41.59 cm) was recorded from P_2 andthe minimum (37.41 cm) leaf length was recorded from P_0 (control) at 90 DAP. The treatment combinations demonstrated significant variation in leaf length at 30, 60 and 90 DAP. At 90 DAP the maximum leaf length (46.65 cm) was recorded from N_2P_2 andthe minimum (33.29 cm) leaf length was recorded from N_0P_0 (control).

The maximum number of side shoots (6.57) were recorded from N_2 andthe minimum (3.13) on number of side shoots were recorded from N_0 (control) at 90 DAP. The maximum number of side shoots (5.50) were recorded from P_2 andthe minimum (4.60) number of side shoots were recorded from P_0 (control) at 90 DAP. The treatment combinations demonstrated significant variation in number of side shoots at 30, 60 and 90 DAP. At 90 DAP the maximum on number of side shoots (7.20) were recorded from N_2P_2andthe minimum (2.89) number of leaves were recorded from N_0P_0 (control).

The longest length of spike (40.22 cm) was recorded from N_2andthe minimum (29.95 cm) length of spike was recorded from N_0 (control). The longest length of spike (33.41 cm) was recorded from P_2 andthe minimum (30.37 cm) length of spike was recorded from P_0 (control). The treatment combinations demonstrated significant variation in length of spike. The longest length of spike (42.75 cm) was recorded from N_2P_2 andthe minimum (29.03 cm) length of spike was recorded from N_0P_0 (control).

The maximum spike diameter (1.03 cm) was recorded from N_2andthe minimum spike diameter (0.69 cm) was recorded from N_0 (control). The maximum spike diameter (0.91 cm) was recorded from P_2andthe minimum (0.79 cm) spike diameter was recorded from P_0 (control). The treatment combinations demonstrated significant variation in spike diameter. The maximumspike diameter (1.03 cm) was recorded from N_2P_2andthe minimum (0.65cm) spike diameter was recorded from N_0P_0 (control).

The longest length of rachis (15.96 cm) was recorded from N_2andthe shortest (11.33 cm) length of rachis was recorded from N_0 (control). The longest length of rachis (13.26 cm) was recorded from P_2andthe shortest (12.40 cm) length of rachis was recorded from P_0 (control). The treatment combinations demonstrated significant variation in length of rachis. The longest length of rachis (16.70 cm) was recorded from N_2P_2 andthe shortest (9.15 cm) length of rachis was recorded from N_0P_0 (control).

The maximum florets per spike (33.20) was recorded from N_2 andthe minimum florets per spike (16.90) was recorded from N_0 (control). The maximum florets per spike (27.72) was recorded from P_2 andthe minimum (24.90) florets per spike was recorded from P_0 (control). The treatment combinations demonstrated significant variation in florets per spike. The maximum florets per spike (34.49) was recorded from N_2P_2 andthe minimum (15.30) number of spike per hectares was recorded from N_0P_0 (control).

The maximum number of spike per hectares (296.10) was recorded from N_2andthe minimum number of spike per hectares (183.80) was recorded from N_0 (control). The maximum number of spike per hectares (256.00) was recorded from P_2 andthe minimum (232.80) number of spike per hectares was recorded from P_0 (control). The treatment combinations demonstrated significant variation in number of spike per hectares. The maximum number of spike per hectares (302.40) was recorded from N_2P_2 andthe minimum (173.80) number of spike per hectares was recorded from N_0P_0 (control).

The maximum single spike weight (58.71 g) was recorded from N_2andthe minimum single spike weight (43.35 g) was recorded from N_0 (control). The maximum single spike weight (52.66 g) was recorded from P_2 andthe minimum (48.54 g) single spike weight was recorded from P_0 (control). The treatment combinations demonstrated significant variation in single spike weight. The maximum single spike weight (61.17 g) was recorded from N_2P_2 andthe minimum (43.17) single spike weight was recorded from N_0P_0 (control).

The maximum bulb length (6.88 cm) was recorded from N_2andthe minimum bulb length (5.60 cm) was recorded from N_0 (control). The maximum bulb length (5.54 cm) was recorded from P_2 andthe minimum (4.97 cm) bulb length was recorded from P_0 (control). The treatment combinations demonstrated significant variation in bulb length. The maximum bulb length (8.55 cm) was recorded from N_3P_1andthe minimum (6.67 cm) bulb length was recorded from N_0P_0 (control).

The maximum bulb diameter (3.38 cm) was recorded from N_3 andthe minimum bulb diameter (2.66 cm) was recorded from N_0 (control). The maximum bulb diameter (3.28 cm) was recorded from P_2 andthe minimum (2.79 cm) bulb diameter was recorded from P_0 (control). The treatment combinations demonstrated significant variation in bulb diameter. The maximum bulb diameter (4.02 cm) was recorded from N_2P_2 andthe minimum (2.62 cm) bulb diameter was recorded from N_0P_0 (control).

The maximum bulb weight per plant (155.40 g) was recorded from N_2andthe minimum bulb weight per plant (95.31 g) was recorded from N_0 (control). The maximum bulb weight per plant (132.80 g) was recorded from P_2 andthe minimum (116.80 g) bulb weight per plant was recorded from P_0 (control). The treatment combinations demonstrated significant variation in bulb weight per plant. The maximum bulb weight per plant (162.40 g) was recorded from N_2P_2andthe minimum (85.83 g) bulb weight per plant was recorded from N_0P_0 (control).

The maximum number of side bulb per plant (15.63) was recorded from N_2 andthe minimum number of side bulb per plant (8.76) was recorded from N_0 (control). The maximum number of side bulb per plant (13.55) was recorded from P_2 andthe minimum (12.35) number of side bulb per plant was recorded from P_0 (control). The treatment combinations demonstrated significant variation in number of side bulb per plant. The maximum number of side bulb per plant (16.37) was recorded from N_2P_2andthe minimum (7.42) number of side bulb per plant was recorded from N_0P_0 (control).

The maximum bulb yield (24.37 t/ha) was recorded from N_2 andthe minimum bulb yield (11.29 t/ha) was recorded from N_0 (control). The maximum bulb yield (20.01 t/ha) was recorded from P_2 andthe minimum (18.15 t/ha) bulb yield was recorded from P_0 (control). The treatment combinations demonstrated significant variation in bulb yield. The maximum bulb yield (25.76 t/ha) was recorded from N_2P_2 andthe minimum (10.70 t/ha) bulb yield was recorded from N_0P_0 (control).

The maximum dry weight of bulb (52.66 g) was recorded from N_2 andthe minimum dry weight of bulb (35.93 g) was recorded from N_0 (control). The maximum dry weight of bulb (48.22 g) was recorded from P_2 andthe minimum (42.08 g) bulb yield was recorded from P_0 (control). The treatment combinations demonstrated significant variation in dry weight of bulb. The maximum dry weight of bulb (54.16 g) was recorded from N_2P_2 andthe minimum (30.93 g) dry weight of bulb was recorded from N_0P_0 (control).

Conclusion:

The treatment combination 200 kg N/ha and 190 kg P_2O_5/ha exhibited the highest result. The highest benefit cost ratio was obtained from the treatment combination 200 kg N/ha and 190 kg P_2O_5/ha. So, it may be concluded that combination of 200 kg N/ha and 190 kg P_2O_5/ha application is the best considering the growth, flowering and bulb yield of tuberose. Further studies are needed to confirm the result as well as for recommendation.

CHAPTER VI

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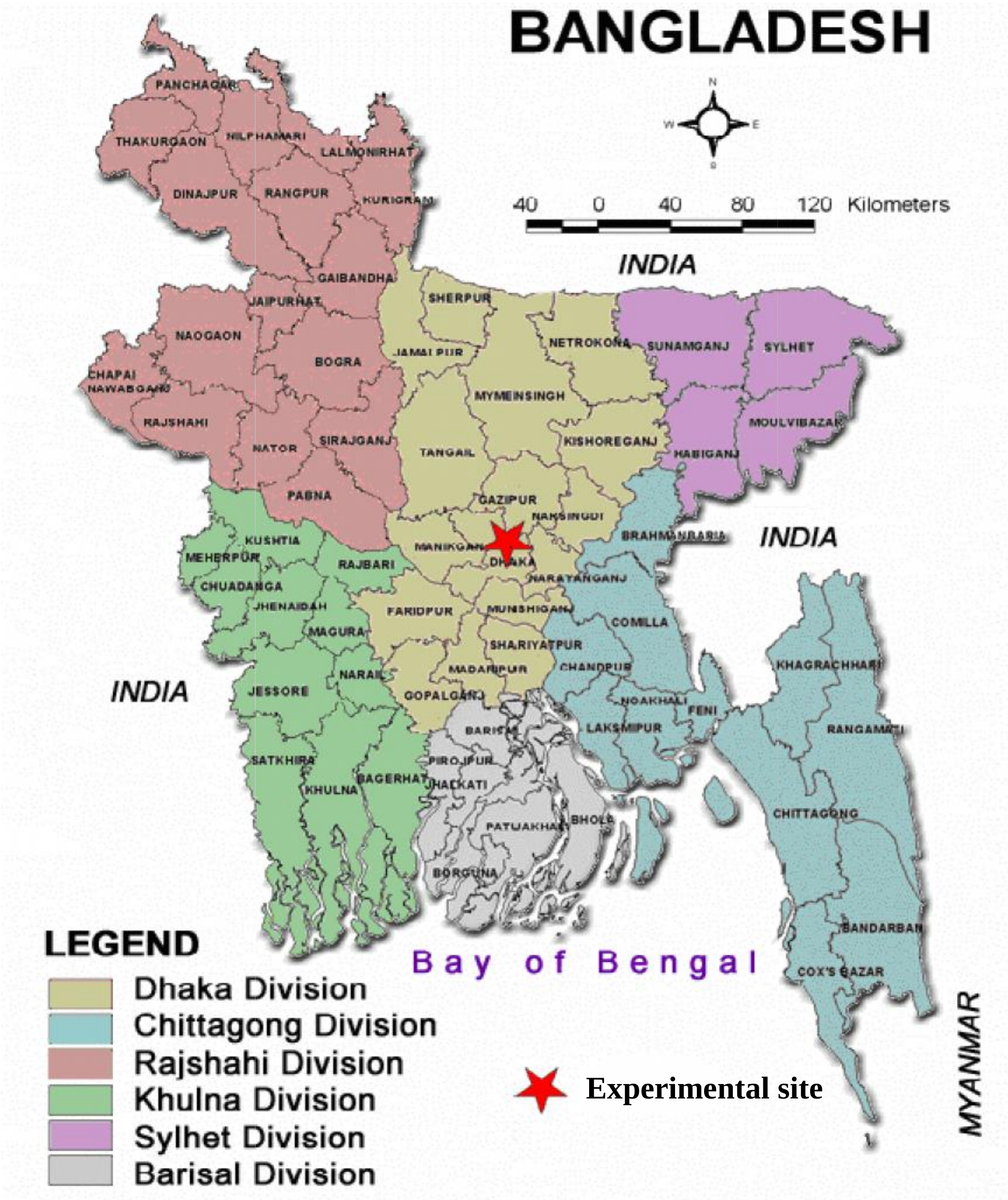
APPENDICES

Appendix I: **Experimental site at Sher-e-Bangla Agricultural University, Dhaka-1207**



The map of Bangladesh showing experimental site

Appendix II. Characteristics of Horticulture Farm soil is analyzed by Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka

A. Morphological characteristics of soil of the experimental plot

Morphological features	Characteristics
Location	Horticulture Garden, SAU, Dhaka
AEZ	Modhupur Tract (28)
General Soil Type	Shallow Red Brown Terrace Soil
Land Type	Medium high land
Soil Series	Tejgaon fairly leveled
Topography	Fairly level
Flood Level	Above flood level
Drainage	Well drained
Cropping Pattern	Fallow- Tuberose

B. Physical and chemical properties of the initial soil

Characteristics	Value
%Sand	27
%Silt	43
%clay	30
Textural class	Silty-clay
pH	6.1
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.077

Available P (ppm)	20.00
Exchangeable K (mel 100 g soil)	0.10
Available S (ppm)	45

Source : SRDI, 2013

Appendix III. Monthly record of air temperature, rainfall, relative humidity, soil temperature and Sunshine of the experimental site during the period from April 2013 to January 2014

Year	Month	Average air temperature (°C)			Average relative Humidity (%)	Total rainfall (mm)	Total Sunshine per day (hrs)
		Maximum	Minimum	Mean			
2013	April,	33.7	23.8	28.81	69	185	7.8
	May	36.7	20.3	28.5	70	205	7.7
	June	35.4	22.5	28.95	80	577	4.2
	July	36.0	24.6	30.3	83	563	3.1
	August	36.0	23.6	29.8	81	319	4.0
	September	34.8	24.4	29.6	81	279	4.4
	October	34.8	18.0	26.4	77	227	5.8
	November	29.7	20.1	24.9	65	5	6.4
	December	26.9	15.8	21.35	68	0	7.0
2014	January	24.6	12.5	18.7	66	0	5.5

Source: Bangladesh Meteorological Department (Climate & weather division), Agargoan. Dhaka –1212

Appendix-IV: Analysis of variance of the data on plant height and number of leaves per plant as influenced by different levels of nitrogen and phosphorous on tuberose

Source of variation	Degree of freedom	Mean Square							
		Plant height				Number of leaves per plant			
		30 DAP	60 DAP	90 DAP	120 DAP	30 DAP	60 DAP	90 DAP	120 DAP
Replication	2	0.221	0.08	12.53	1.73	0.26	0.24	1.88	1.79
Nitrogen (N)	3	297.41**	351.62**	660.00**	879.70**	13.75**	11.73**	10.56**	50.72**
Phosphorous (P)	2	97.62**	124.18**	34.29**	47.82**	4.15**	0.40*	1.83**	1.79**
Interaction(NxP)	6	2.01*	26.58**	14.17**	1.82**	1.48**	0.57**	0.16*	0.38 **NS**
Error	16	0.54	0.18	2.34	0.365	0.04	0.08	0.05	0.20

** Significant at 1 %Level of probability, * Significant at 5 %Level of probability, NS=Non Significant

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Appendix-V: Analysis of variance of the data on Leaf length and number of side shoots per plant as influenced by different levels of nitrogen and phosphorous on tuberose

Source of variation	Degree of freedom	Mean Square					
		Leaf Length			Number of side shoot per plant		
		30 DAP	60 DAP	90 DAP	30 DAP	60 DAP	90 DAP
Replication	2	0.06	0.15	0.17	0.03	0.28	0.48
Nitrogen (N)	3	160.83**	127.20**	208.50**	3.69**	11.22**	22.84**
Phosphorous	2	5.73**	7.25**	57.77**	0.07*	0.74**	2.54**

(P)							
Interaction(Nx P)	6	2.03**	4.10**	5.02**	0.03*	0.07**	1.26**
Error	16	0.10	0.39	0.23	0.01	0.005	0.12

** Significant at 1 %Level of probability, * Significant at 5 %Level of probability

Appendix-VI: **Analysis of variance of the data on flowering as influenced by different levels of nitrogen and phosphorous on tuberose**

Source of variation	Degree of freedom	Mean Square						
		Spike length (cm)	Spike diameter(cm)	Rachis length (cm)	Floret/spike	Spike number/ha	Single spike weight(g)	Flower yield(t)/ha
Replication	2	0.67	0.006	0.03	1.11	108.66	1.92	0.20
Nitrogen (N)	3	195.71**	0.20**	39.63**	587.75**	23151.90**	599.08**	381.10**
Phosphorous (P)	2	30.34**	0.03**	2.12**	23.96**	1668.76**	66.38**	39.86**
Interaction(N x P)	6	5.97**	0.004**	0.91**	3.16**	243.80**	21.04**	4.38**
Error	16	0.25	0.00	0.04	0.22	14.11	0.153	0.04

** Significant at 1 %Level of probability

Appendix-VII: Analysis of variance of the data on bulb length, bulb diameter, bulb weight, side bulbs, bulb yield and dry weight of bulb as influenced by different levels of nitrogen and phosphorous on tuberose

Source of	Degree	Mean Square

variation	of freedom	Bulb length	Bulb diameter	Bulb weight/plant	Side bulbs/plant	Bulb yield t/ha	Dry weight of bulb
Replication	2	0.58	0.08	158.47	0.44	0.22	2.68
Nitrogen (N)	3	2.65**	1.12**	6652.35**	92.22**	343.85**	664.56**
Phosphorous (P)	2	0.98**	0.76**	926.55**	4.37**	12.15**	112.82**
Interaction (N x P)	6	0.23**	0.31**	267.77**	4.82**	13.46**	15.29**
Error	16	0.02	0.005	4.28	0.02	0.09	0.58

** Significant at 1 %Level of probability

Appendix-VIII: Production cost of tuberose per hectare

A. Input cost

Interaction N x P		Labor	Ploughing cost	Bulb cost	Insecticide cost	Irrigation cost	Manure and Fertilizer cost				Miscellaneous	Sub Total (A)
							Cow dung	Urea	TSP	MP		
0 kg N/ha	0 kg P_2O_5/ha	38500	1230	24000	2500	3000	25000	0	0	11000	5000	88630
	170 kg P_2O_5/ha	38500	1230	24000	2500	3000	25000	0	9912	11000	5000	98542
	190 kg P_2O_5/ha	38500	1230	24000	2500	3000	25000	0	12672	11000	5000	101302
180 kg N	0 kg P_2O_5/ha	38500	1230	24000	2500	3000	25000	7840	0	11000	5000	96470
	170 kg P_2O_5/ha	3850	1230	24	2500	3000	2500	78	9912	1100	5000	106382

/h		0		0			0	4		0		
a	190 kg P_2O_5/ha	38500	1230	02400	2500	3000	25000	07840	12672	11000	5000	109142
200 kg N/ha	0 kg P_2O_5/ha	38500	1230	2400	2500	3000	25000	8720	0	11000	5000	97350
	170 kg P_2O_5/ha	38500	1230	2400	2500	3000	25000	8720	9912	11000	5000	107262
	190 kg P_2O_5/ha	38500	1230	2400	2500	3000	25000	8720	12672	11000	5000	110022
220 kg N/ha	0 kg P_2O_5/ha	38500	1230	2400	2500	3000	25000	9560	0	11000	5000	98190
	170 kg P_2O_5/ha	38500	1230	2400	2500	3000	25000	9560	9912	11000	5000	108102
	190 kg P_2O_5/ha	38500	1230	2400	2500	3000	25000	9560	12672	11000	5000	110862

Required total number labor 110

Tk 350/- day/capita

Bulb: TK 2.0/Piece(Average)

Cowdung @ Tk. 1000/t

Urea @Tk. 20/kg

TSP @ Tk. 28/kg

MP @Tk. 32/kg

B. Overhead cost

Interaction N x P		Cost of Lease of land for 1 year(13 % of value of land TK. 600000)	Miscellaneous cost (Tk. 5% of input cost)	Interest on running capital for 1 year (Tk 13% of total input cost)	Sub-total Tk(B)	Total cost of production (Tk/ha) [Input cost (A) +Overhead cost(B)]
0 kg N/ha	0 kg P_2O_5/ha	7800	4431.5	11521.90	23753.40	112383.40
	170 kg P_2O_5/ha	7800	4927.1	12810.46	25537.56	124079.56
	190 kg P_2O_5/ha	7800	5065.1	13169.26	26034.36	127336.36
180 kg N/ha	0 kg P_2O_5/ha	7800	4823.5	12541.10	25164.60	121634.60
	170 kg P_2O_5/ha	7800	5319.1	13829.66	26948.76	133330.76
	190 kg P_2O_5/ha	7800	5457.1	14188.46	27445.56	136587.56
200 kg N/ha	0 kg P_2O_5/ha	7800	4867.5	12655.50	25323.00	122673.00
	170 kg P_2O_5/ha	7800	5363.1	13944.06	27107.16	134369.16
	190 kg P_2O_5/ha	7800	5501.1	14302.86	27603.96	137625.96
220 kg N/ha	0 kg P_2O_5/ha	7800	4909.5	12764.70	25474.20	123664.20
	170 kg P_2O_5/ha	7800	5405.1	14053.26	27258.36	135360.36
	190 kg P_2O_5/ha	7800	5543.1	14412.06	27755.16	138617.16