EFFECT OF NITROGEN AND POTASSIUM ON GROWTH FLOWER AND BULB YIELD OF TUBEROSE

BY

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CERTIFICATE

This is to certify that the thesis entitled, **"EFFECT OF NITROGEN AND POTASSIUM ON GROWTH FLOWER AND BULB YEILD OF TUBEROSE"** submitted to the Department of Horticulture & Postharvest technology, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka. In partial fulfilment 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 **MAMUNUR RASHID**, Registration No. 07-02637 under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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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Dedicated to
My
Beloved Parents

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ABSTRACT

The present study was conducted at the Horticulture farm of Sher-e-Bangla Agricultural University, Dhaka, during the period from 20 April, 2008 to 16 May, 2009 to investigate the effect of nitrogen and potassium on the growth, flower and bulb yield of tuberose. The experiment consisted of two factors. Factor A: Four levels of nitrogen i.e. N_0: 0, N_1: 185, N_2: 195 and N_3: 205 kg N/ha and Factor B: Four levels of potassium i.e. K_0: 0, K_1: 180, K_2: 190 and K_3: 200 kg K_2O/ha respectively. The experiment was laid out with Randomized Complete Block Design with three replications. The highest flower (24.51 t/ha) and bulb (28.18 t/ha) yield was recorded from N_3 and the lowest was obtained from control condition (8.71 t/ha and 15.19 t/ha respectively). On the other hand, the highest flower (18.00 t/ha) and bulb (23.91 t/ha) yield was noted from K_3 and the lowest was from control treatment (13.72 t/ha and 19.42 t/ha respectively). The maximum flower yield (28.12 t/ha), bulb yield (32.21 t/ha) and benefit cost ratio (3.27) was found from the treatment combination of N_3K_3 and the minimum from control. So, the best results were obtained from 205 kg N/ha when combined with 200 kg K_2O/ha.

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ABBREVIATIONS AND ACRONYMS

%	=	Percent
AEZ	=	Agro-Ecological Zone
ANOVA	=	Analysis of Variance
cm	=	Centimeter
CV	=	Coefficient of Variance
DAP	=	Days After Planting
et al.	=	and others
g	=	Gram
ha	=	Hectare
K	=	Potassium
Kg	=	Kilogram
LSD	=	Least Significant Difference
m^2	=	Square Meter
Max.	=	Maximum
Min.	=	Minimum
MP	=	Muriate of Potash
N	=	Nitrogen
NFPS	=	Number of Florets Per Spike
NLPP	=	Number of Leaves Per Plant
No.	=	Number
P	=	Phosphorus
RCBD	=	Randomized Complete Block Design
SAU	=	Sher-e-Bangla Agricultural University
SRDI	=	Soil Resources Development Institute
t	=	Ton
TSP	=	Triple Super Phosphate
Viz.	=	Namely

CHAPTER 1
INTRODUCTION

CHAPTER 1

INTRODUCTION

Tuberose (*Polianthes tuberosa* L.) belonging to the family Amaryllidaceae, produces attractive, elegant and fragrant white flowers. The flowers having excellent keeping quality are used as cutflowers. The flowers remain fresh for quite a long time and stand long distance transportation and fill a useful place in the flower market (Desai, 1957). It is used for artistic garlands, floral ornamentals, bouquets and buttonholes and also for extraction of perfume (Sadhu and Bose, 1973).

The long flower spikes of tuberose are excellent as cutflowers for table decoration when arranged in bowls and vases. 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.

Tuberose is a native of Mexico from where it spreads to the different parts of the world during 16^{th} century. How and when the tuberose found its entrance to India, Ceylon and elsewhere in the orient is probably an unanswerable question (Yadav and Maity, 1989). Now a days, it is cultivated on large scale in France, Italy, South Africa, USA, and in many tropical and subtropical areas, including India and Bangladesh.

In Bangladesh, for the last few years, tuberose has become a popular cutflower for its attractive fragrance and beautiful display in the vase. Now, it is one of the most important commercial cutflowers. 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 the country, very little is known about production technology in Bangladesh condition.

Tuberose is a half-hardy bulbus perennial 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 colour 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.

There are many factors which affect plant growth and economic cultivation of tuberose. Tuberose is a gross feeder and requires a large quantity of NPK, both in the form of organic and inorganic fertilizers (Crrito, 1975; Singh *et al*, 1976). Fertilizers have great influence on growth, building and flower production in tuberose (Mitra *et al*, 1979; Yadav *et al*, 1985). Effect of NPK on tuberose production has been reported by several authors for different geographical region (Sadhu and Bose, 1973;Cirrito, 1975; Singh *et al*, 1976; Mitra *et al*, 1979; Nanjan *et al*, 1980; Mukhopadhyay and Banker, 1985; Yadav *et al*, 1985).

The growing period of tuberose in normally one year or more. Therefore, a high amount of inorganic fertilizers are needed to maintain sustainable growth and flowering over a long period.

Nitrogen has significant effect on bulb production of tuberose. It also increases plant height, number of leaves, spike per hill, earlier flowering and higher number of flowers per spike (Cirrito, 1975; Mitra *et al*, 1979; Mukhopahyay and Banker, 1985; Roy, 1992). Phosphorus has a significant effect on spike production and floret quality (Jana *et al*, 1974; Banker and Mukhopadhyay, 1985). Potash appears to help in increasing the number of spike, flower per spike and number of flowers per hill (Cirrito, 1975; Singh *et al*, 1976). Roy (1992) reported the effect of nitrogen and potash on growth and development of tuberose.

However, under Bangladesh condition a few reports are available regarding the fertilizers requirement of this economically important cutflowers. The present experiment was, therefore, undertaken to study the effect of different doses of nitrogen and potassium on growth, flower and bulb yield of tuberose.

Considering the above mentioned facts, the present investigations were undertaken with the following objectives:

I. To determine the effects of nitrogen and potassium on growth, bulb and flower production of tuberose and

II. To determine the suitable combination of nitrogen and potassium for ensuring the higher yield of bulb and flower production of tuberose.

CHAPTER 2
REVIEW OF LITERATURE

CHAPTER 2

REVIEW OF LITERATURE

Tuberose (*Polianthes tuberosa* L.) is an important cutflower in the world trade. It is a gross feeder and requires judicial application of manures and fertilizers. The requirements 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 of Bangladesh in respect of nitrogen and potassium requirement. A brief review of these pertinent to the present study has been given below:

2.1 Growth and flowering behavior of tuberose

Yadav, (2007) conducted an experiment in Bikaner, Rajasthan, India, to study the effect of N (0, 10 and 20 g/m^2) and P (0, 6 and 12 g/m^2) fertilizers on the growth and flowering of tuberose cv. Shringar. Plant height, number of leaves per plant, number of flowers 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 (35.50 cm), number of leaves (34.40) per plant, 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.

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 *Polianthes tuberosa*. Greenhouse production had positive 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 20 kg N/ha. There were significant positive correlations between the number of flowers and flowering period. Phosphorus content had a significant negative correlation with copper content

Rajwal and Singh (2006) were 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) 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).

Gupta *et al.* (2006) were 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 fertilizers (P) at 0, 150 and 300 g/m^2 in 4 tuberose (*Polianthes tuberosa*) 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. The Variegated cultivar showed positive response with 80 g N/m^2 and 150 and 300 g P/m^2 applications.

Sultana *et al.* (2006) conducted a field trial on tuberose at the Floriculture field of Horticultural 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 experiment was laid out in a randomized complete block design replicated 3 times. 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. Plant height was highest with 300 kg N, 45 kg P and 80 kg K/ha along with 10 t/ha cowdung.

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 spacings 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 non 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.

Singh *et al.* (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 spacings (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.

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 (*Polianthes tuberosa*) 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^2) each of N and P, and 2 levels (10 and 20 g/m^2) 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 the N 20 g/m^2, P_2O g/m^2 and K_2O g/m^2 treatment over the control.

Bawedja *et al.* (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^2). Nitrogen application increased both plant 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^2 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^2 is the best treatment for producing quality tuberose flowers.

N (0, 50, 100, 150, 200 and 250 ppm) and Zn (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 Zn 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 Zn application. Interaction effects of N and Zn 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 Zn was optimum treatment for better tuberose growth and flowering. (Kumar *et al.*, 2003).

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 *Polianthes tuberosa* were studied under greenhouse conditions. The leaf N content at harvest increased with increasing N rate. P increased the leaf N content, although no significant variation between rates was observed. The highest leaf N content (2.64%) was obtained with 240 ppm N + 40 ppm P. The leaf P content decreased when N was applied at 120 to 240 ppm. The leaf P content increased with increasing P level. The highest leaf P content was obtained with 0 ppm N (0.26%) and 80 ppm P (0.25%). The leaf K content decreased with N and P application. The leaf K content was reduced from 3.64% (control) to 3.42% with 240 ppm N, and from 3.62% (control) to 3.39% with 80 ppm P. The spike N content was significantly affected by N, P and their combination. (Mohanasundaram *et al.*, 2003).

Yadav *et al.* (2002) supplied N at 0, 50, 100, 150 and 200 kg/ha, and Zn at 0. 5, 10 and 20 kg/ha to tuberose (*Polianthes tuberosa*) cv. Double. N application at 150 and 200 kg/ha slightly increased flower characteristics (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.

Yadav *et al.* (2002) 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.

Mohanty *et al.* (2002) conducted an experiment with tuberose (*Polianthes tuberosa)* 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^2. N applied in 3 splits was the most effective among the split application treatments. Weeding at 30 days interval gave the greatest plant height (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^2. 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 (0.949 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.

Tuberose (*P. tuberosa*) cv. Single bulbs were supplied with 0, 10, 20, 30 or 40 g N/m2 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 clump, 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 and bulb size increased with increasing rates of N up to 30 g/m^2. 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^2. 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. (Kumar *et al.*, 2002)

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 (*P. tuberosa*) cv. Single were determined in a field experiment conducted in Maharashtra, India during 1998-2001. Plant height, number of leaves per plant, length of spike per plant, length of rachis, number of florets per spike and per plant, and number of spikes per pot and per hectare increased with increasing rates of N. The values of all the parameters measured also increased with increasing rates of P up to 300 kg/ha except for plant height and number of leaves per plant which increased with increasing rates of P up to 350 kg/ha. (Kawarkhe and Jane, 2002).

Mishra *et al.* (2002) conducted an experiment in Bhubaneswar, Orissa, India, from March to December 1997 with tuberose (*Polianthes tuberosa*) cv. Single involving 4 levels of N, i.e. 0 (N_0), 10 (N_1), 20 (N_2) and 30 (N_3) g/m^2; 3 levels of P, i.e. 0 (P_0), 20 (P_1) and 30 (P_2) g/m^2; and 2 levels of spacing maintained at 15cm x15cm (S_1) and 30cm x 20 cm (S_2). Plant height and number of plants per clump observed after 3 months of planting were higher (39.54 cm and 4.45 cm, respectively) with 30 g N/m^2 followed by 20 g N/m^2 compared with other treatments. 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 or 30 g/m^2, but yield of florets per spike (weight basis) was significantly increased at 30 g/m^2. However, flower yield per hectare was remarkably higher (18.26 t/ha) under closer spacing. Interaction of N x P x S indicated that significantly highest yield of flowers per hectare (23.68 t/ha) was produced due to treatment with 30 g each of N and P, following closer spacing ($N_3P_2S_1$). Treatment combinations $N_3P_1S_1$ and $N_3P_0S_1$ also showed similar results.

Dahiya *et al.* (2001) undertaken a pot 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 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 180 ppm N and 60 ppm P levels; however, further increments in N above 180 ppm and P above 60 ppm adversely affected growth and dry matter yield.

Patil *et al.* (1999) conducted tubers of *Polianthes tuberosa* cv. Double were grown in 5 levels of community planting viz. 1, 2, 3, 4, whole clump or 6 tuber(s) per hill and treated with 4 rates of fertilizers viz. 150:50:50, 150:100:100, 200:150:150 and 250:200:200 kg NPK/ha in Karnataka, India . *P. tuberosa* planted at 6 tubers per hill resulted in the highest number of shoots and leaves and leaf area per plant, while 3 tubers per hill resulted in the highest plant growth, flower yields and number of spikes. 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. Application of 250:200:200 kg NPK/ha on 3 tuberose tubers per hill resulted in the highest flower and spike yields (7.86 t/ha, 3.33 spikes/ha, respectively) and plant growth (43.72 cm).

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 application of nitrogen at the rate of 400 kg per hectare. 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 application of 200 kg nitrogen per hectare.

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 × 30cm. All the P_2O_5 and K_2O and half the N were applied as a basal dressing; the remaining N was applied as a for 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+125 g K_2O/ha.

Parthiban *et al.* (1991) reported the effect of N, P and K on yield component and yield in n tuberose cv. Single. N was applied at 50, 75, 100 or 125 kg; P at 258, 50 or 75 kg and K at 37.5, 62.5 or 87.5 kg/ha. All the P and K were applied with half the at planting. The remaining N was applied 45 days hater. 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 *et al.* (1990) evaluated the effect of NPK on growth and flowering of tuberose cv. double. N was applied at 0, 5, 10, 15, org/m^2 P_2O_5 at 0, 20 or 40 g/m^2 and K_2O at 0, 20 or 40 g/m^2 . One half of the N and all of the p and k were applied before planting, the remaining N was applied as a top dressing of flower emergence. Data are 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 is recommended.

A nutritional study in tuberose cv. Double was conducted by Bankar (1988). In two years field trials, plants received N, at 0, 5, 10, 15 or 20 g/m^2 and P_2O_5 and K_2O each at 0, 20 and 40 g/m^2, giving 45 treatments altogether. Data are tabulated on plant height, number of leaves/plant, days to spike emergence, number of spike/plant, spike length, rachis length and number of florets/spike, duration of flowering and number and weight of bulbs/plant. N improved vegetative growth, flowering and bulb production in the first year. P and K increased spike number, rachis length and duration of flowering only in the second year (the ratoon crop). The optimum fertilizer application rate was determined as 15 gm N + 40 gm P_2O_5 40 gm K_2O/m^2.

Mukhopadhyay *et al.* (1986) studied nutritional requirement of tuberose cv. Single in a trial over two years. The plants growing on 2 m × 1 m plots received N: P_2O_5 : K_2O at O-20: O-40: g/m^2 giving 45 treatment combinations. Of the three nutrients only N, especially at the highest rate, improved plant growth, spike yield and flower quality.

Studies on nutritional requirement of tuberose were reported by Mukhopadhyay *et al.* (1986).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 *et 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 creating the plant growth and flowering.

Banker *et al.* (1985) investigated response of *Polianthes tuberosa* 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 a significantly beneficial effect 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 rate.

Namisan 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.

Nanjan *et al.* (1980) studied the effects of nitrogen, phosphorus and potash on the production on 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.

In a sand culture experiment, Bhattacharjee *et al.* (1979) demonstrated the characteristic symptoms of deficiency of N, P and K on tuberose plants. High dose of N and P caused marked improvement in growth, flowering and bulb formation and the effect was more pronounced with N. Deficiencies of N and P completely suppressed flowering in tuberose.

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 year. Full dose of P_2O_5 and K_2O and half dose of N is to be applied as basal dressing, white the remaining half dose of N is to be applied 20 days after planting (Bhattacharjee *et al.*, 1979).

Flower yield of tuberose depends upon the dose of nitrogen, phosphorus and potash. Singh *et al.* (1976) recommended a dose of 80 kg nitrogen, 60 kg phosphorus and 40 kg potash per hectare, respectively under Uttar Pradesh, India conditions to have a 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 also the weight of flowers per spike.

High dose of nitrogen and phosphorus was required to promote leaf formation and flowering in tuberose (Jana *et al.*, 1974) 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.

Mitra *et al.* (1974) 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.

2.2 Bulb production

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 and Zizzo, 1980). Tuberose is group under bulbs by Laurie and Ries (1950) and commonly referred to as bulbs (Patil *et al.*, 1999).

The nutrient status of *Polianthes tuberosa* 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) was determined. 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. (Singh *et al.*, 2001)

Roy (1992) carried out an investigation at the Horticultural Farm of Bangladesh Agricultural University, Mymensingh. She observed that nitrogen had a significant effect on bulb production of tuberose the obtained the highest bulb yield by number an weight with the application of 600 Kg nitrogen per hectare. However, statistically similar yield was obtained from 200 Kg and 400 Kg nitrogen per hectare. Potash had no significant effect on the yield of tuberose bulb.

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 bulb production in the first year (Banker, 1988).

A beneficial effect of nitrogen was observed on the yield of bulb lets (22 cm in diameter), but not on the number of flowering sized bulbs (Mukhopadhyay, 1987).

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 levels. These showed positive interaction and maximum bulb let production was recorded in the treatment comprising 20 g P_2O_5 and 40 g K_2O/m^2. In the case of bulb lets production, phosphors and potassium bulbs and bulb lets were also heavier than those under control. Apparently P and K fertilization gad no appreciable effect on bulb yield.

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 (Cirrito, 1975).

Beneficial effect of nitrogen on bulb yield in tuberose had been reported earlier by Jana *et al.* (1974).

Very few reports are available regarding the effects fertilizers on bulb production of tuberose. Jana *et al.* (1974) found a marked influence of 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)

From an experiment with tuberose cv. "single" Nambisan and Krishnan (1983) recorded 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.

CHAPTER 3
MATERIALS AND METHODS

CHAPTER 3

MATERIALS AND METHODS

This chapter deals with the materials and methods that were used in execution of the experiment.

3.1 Experimental site

The experiment was conducted at Horticulture farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh during the period from April, 2008 to March, 2009.The location of the site in 23.774^0 N latitude and 90.335^0 E longitudes with an elevation of 8.2 m from sea level.

3.2 Climate

The experimental site was situated in subtropical zone April to September (Kharif season) and scanty rainfall during the rest of the year (Rabi season). Information regarding average monthly the maximum and the minimum temperature, rainfall and relative humidity recorded by the weather yard, Bangladesh Metrological Department (climate division) Agargaon, during the period of study has been presented in Appendix-I

3.3 Soil

The soil of the experimental area belonged to the Modhupur Tract in Agro ecological zone (AEZ) 28. The analytical data of the soil sample collected from the experimental area were determined in the Soil Resources Development Institute. Soil Testing Laboratory, Khamarbari, Dhaka have been presented in Appendix-II.

The experimental site was a medium high land and pH of the soil was 5.6. The morphological characters of the soil of the experimental plots are given below:

AEZ No. – 28

Soil series – Tejgaon

General Soil – Non-calcarious dark grey.

3.4 Land preparation

The land was first open by ploughing in the month of May, 2008 with the help of power tiller and then it kept open to sun for seven days prior to further ploughing. Afterwards it was prepared by ploughing and cross ploughing followed by laddering. The 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 manures and fertilizers were mixed into the soil during final land preparation.

3.5 Treatment(s) of the experiment

The experiment was designed to study the effect of nitrogen and potassium on growth, flower and bulb yield of tuberose.

The experiment consisted of two factors, which are as follows:

Factor A: Nitrogen (N)

N_0 = No nitrogen

N_1 = 185 kg N/ha

N_2 = 195 kg N/ha

N_3 = 205 kg N/ha

Factor B: Potassium (K)

K_0 = No potassium

K_1 = 180 kg K_2O/ha

K_2 = 190 kg K_2O/ha

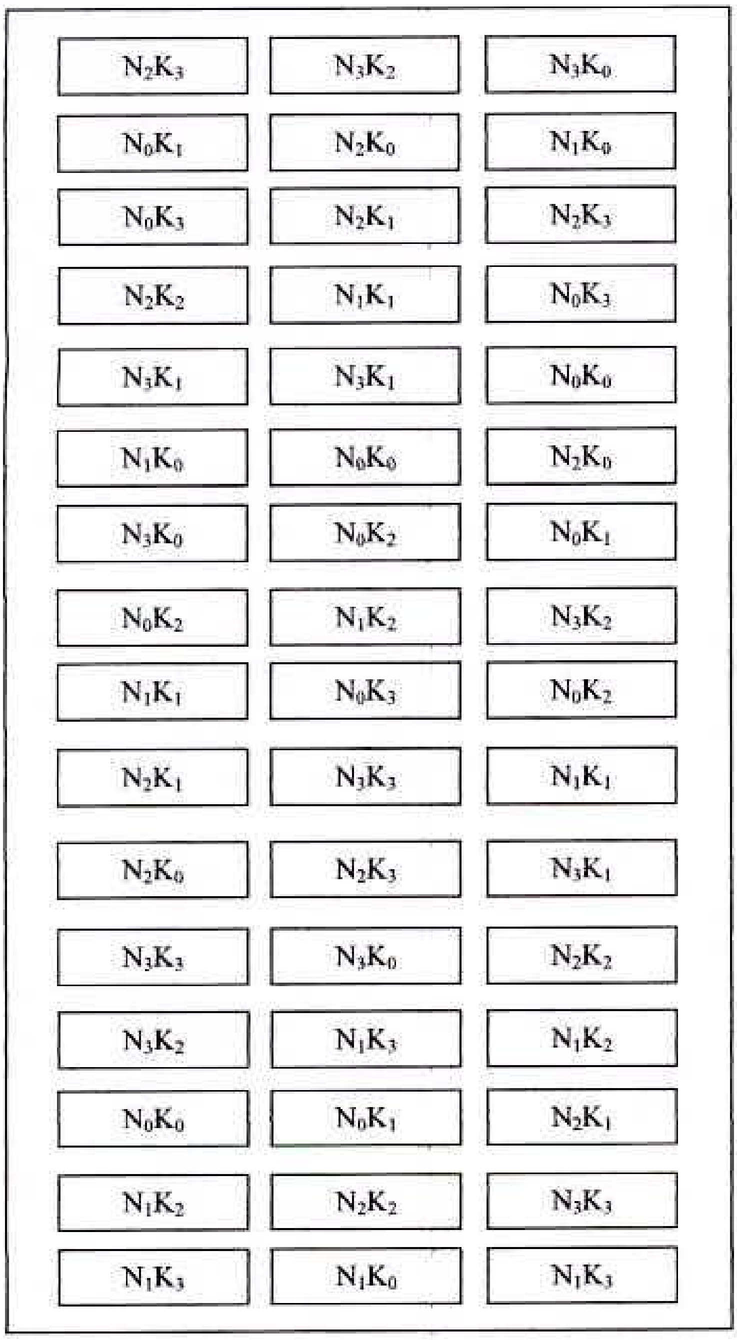
K_3 = 200 kg K_2O/ha

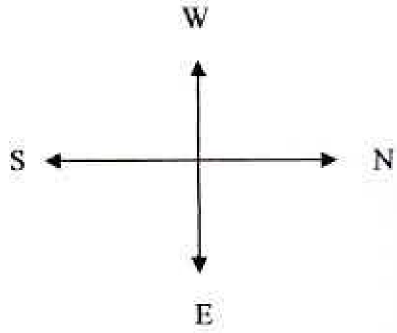
3.6 Planting materials

The bulbs of tuberose cv. Double were collected from Horticulture Farm of Sher-e-Bangla Agricultural University (SAU), Sher-e-Bangla Nagar, Dhaka-1207.

3.7 Design of layout of the experiment

The two factors experiment was laidout in Randomized Complete Black Design (RCBD) with 3 replications. Each block was divided into 16 plots, where treatments were allotted at random. Thus, there were 48 (16×3) unit plots altogether in the experiment. The size of each plot was 2 m x 1 m. The distance between blocks 1m and 0.5 m wide drains were made between the plots. Every unit plot had 5 rows with 10 plants each. Row to row and plant to plant distance was 20 cm both and 50 bulbs were planted in each plot. The complete layout of the experiment has been shown in figure 1.





Plot size: 2 m×1 m

Block spacing: 1 m

Plot spacing: 50 cm

Factor A: Nitrogen (N)

N_0= 0 Nitrogen

N_1= 185 kg N/ha

N_2= 195 kg N/ha

N_3= 205 kg N/ha

Factor B: Potassium (K)

K_0 = 0 Potassium

K_1 = 180 kg K_2O/ha

K_2 = 190 kg K_2O/ha

K_3 = 200 kg K_2O/ha

Figure. 1 Field layout of the two factors experiment in the Randomize Complete Block Design (RCBD)

3.8 Manures, fertilizers and their application methods

Urea, Triple Super Phosphate (TSP) and Muriate of Potash (MP) were used as source of nitrogen, phosphorus and potassium respectively. Full dose of cow dung (25 t/ha), and TSP (300 kg/ ha) were incorporated during final land preparation. The total dose of nitrogen and potash were applied in three equal installments. The first installment was applied at 30 days after planting. The second and third installments were applied at 65 and 100 days respectively after planting.

3.9 Planting of bulbs

Uniform bulbs (2.0 to 3.0 cm in diameter) of tuberose cv. Double were selected for planting separately. Uniform bulbs were planted in each unit plot at a depth of 6 cm on April 20, 2008. The planting distance was 20 cm × 20 cm between row to row and plant to plant. Just after planting a light irrigation was given with the hose pipe, so that irrigation water could not move from unit plot.

3.10 Weeding and mulching

The field was weeded as and when necessary. The soil was mulched frequently after irrigation by breaking the crust for easy aeration and to conserve soil moisture.

3.11 Irrigation

The experimental plots were irrigated as and when necessary during the crop period.

3.12 Staking

For staking bamboo stick was placed and spike was tied with the rope.

3.13 Selection and tagging of plants

Ten plants from each of the plots were selected randomly for recording data for different characters.

3.14 Insect management

For controlling aphid and borer Malathion @ 0.1% was sprayed at the interval of 15 days.

3.15 Disease management

Dithane M-45 @ 0.2% was sprayed to check the fungal infection.

3.16 Harvesting

The spikes of tuberose were harvested when the first floret in the rachis opened. Harvesting was done during 22 August to 14 December, 2008 and bulb and bulblet were harvested on 16 March, 2009.

3.17 Collection of data

3.17.1 Plant height

Plant height refers to the length of the plant from ground level upto shoot apex of the plant. It was measured at an interval of 25 days starting from 25 days after planting (DAP) till 125 days.

3.17.2 Number of leaves/plant (mother bulb)

The number of leaves produced by mother plant was referred to the number of leaves per mother bulb. All the leaves of ten randomly selected plants were counted and their mean was calculated at an interval of 25 days starting from 25 days after planting (DAP) till 125 DAP.

3.17.3 Maximum length of leaves

Maximum length of leaves was measured from the base to the tip of the longest leaf at an interval 25 days starting from 25 days after planting (DAP) till 125 days.

3.17.4 Breadth of leaves (cm)

The breadth of leaves was taken from one leaf margin (side) to another. Data were recorded as the average of 10 leaves selected at10 random plants at 25 days interval starting from 25 days after planting till 125 days.

3.17.5 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 25 days starting from 25 days after planting (DAP) till 125 days.

3.17.6 Length of spike (cm)

Length of the spike was measured from the base to the tip of the spike.

3.17.7 Length of rachis (cm)

Length of rachis refers to the length from the axil of first floret upto the tip of the inflorescence.

3.17.8 Diameter of a single spike (cm)

Ten spikes were cut from randomly selected plants from each unit plot and the diameter of spikes was taken at 30 cm from the soil surface and their mean was calculated.

3.17.9 Number of florets per spike

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

3.17.10 Weight of a single spike (g)

Ten spikes were cut from randomly selected plants from each unit plot and the weights of spikes were recorded to calculate their mean.

3.17.11 Number of spikes per hectare ('000)

Number of spikes per hectare was computed from number of spikes per plot and converted.

3.17.12 Flower yield per plot (kg)

Flower yield per plot was computed from weight of spike per plot.

3.17.13 Flower yield (t/ha)

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

3.17.14 Number of bulblets per plant

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

3.17.15 Length of bulb (cm)

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

3.17.16 Diameter of bulb (cm)

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

3.17.17 Fresh weight of bulb per hill (g)

It was determined by weighting the bulbs ten randomly selected plants just after harvest and mean weight was calculated.

3.17.18 Dry weight of bulb (g)

100 g bulb was taken and was dried under direct sunshine for 72 hours and then was dried in an over at 70^0c for 3 days before taking dry weight till it was constant. The dry weight was recorded with the help of an electric balance.

3.17.19 Number of bulbs per hectare ('000)

It was calculated by converting the number of bulb per plot to per hectare.

3.17.20 Yield of bulb (t/ha)

It was calculated by converting the yield of bulb per plot to per hectare.

3.18 Statistical analysis

The recorded data on 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 for the treatments was calculated and analysis of variance for each of the characters 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.

CHAPTER 4
RESULTS AND DISCUSSION

CHAPTER 4

RESULTS AND DISCUSSION

The present experiment was undertaken to determine the effect of nitrogen and potassium fertilizers at different levels on growth, flower and bulb yield of tuberose (*Polianthes tuberose* L.) cv. Double. The analyses of variance (ANOVA) of the data on different characters are given in appendix III-VI. The results of the study have been presented and discussed and possible interpretations have been given under the following headings.

4.1 Plant height (cm)

Plant height was significantly influenced by nitrogen (Figure 2 & Appendix III). Although the different levels of nitrogen showed a gradual increasing trend in plant height of tuberose start from N_0 to N_3 at 25, 50, 75, 100 and 125 DAP (Figure 2). The tallest plant height (47.92 cm) was obtained from N_3 which was followed by N_2, N_1 and N_0 and the shortest plant height (25.47 cm) was recorded from N_0 at 125 DAP. It is evident from Figure 2 that high dose of nitrogen significantly increased the height of plants. Similar findings have also been obtained by Bankar *et al.* (1985) and Bhattacharjee *et al.* (1979).

In considering the plant height at 25, 50, 75,100 and 125 DAP different levels of potassium showed a statistically significant variation (Figure 3 & Appendix III).The plant was also increased with the increasing level of potassium. The tallest tuberose plant (40.17 cm) was recorded from K_3 and the shortest (34.18 cm) was found from the K_0 at 125 DAP.

Combined effect of higher levels of nitrogen and potassium showed significant variation was recorded on plant height of tuberose in all observations (Table 1 & Appendix III). However, at 125 DAP the tallest (50.43 cm) plant height of tuberose was found from N_3K_3 and the shortest (20.50 cm) was recorded in control condition i.e. without nitrogen and potassium application.

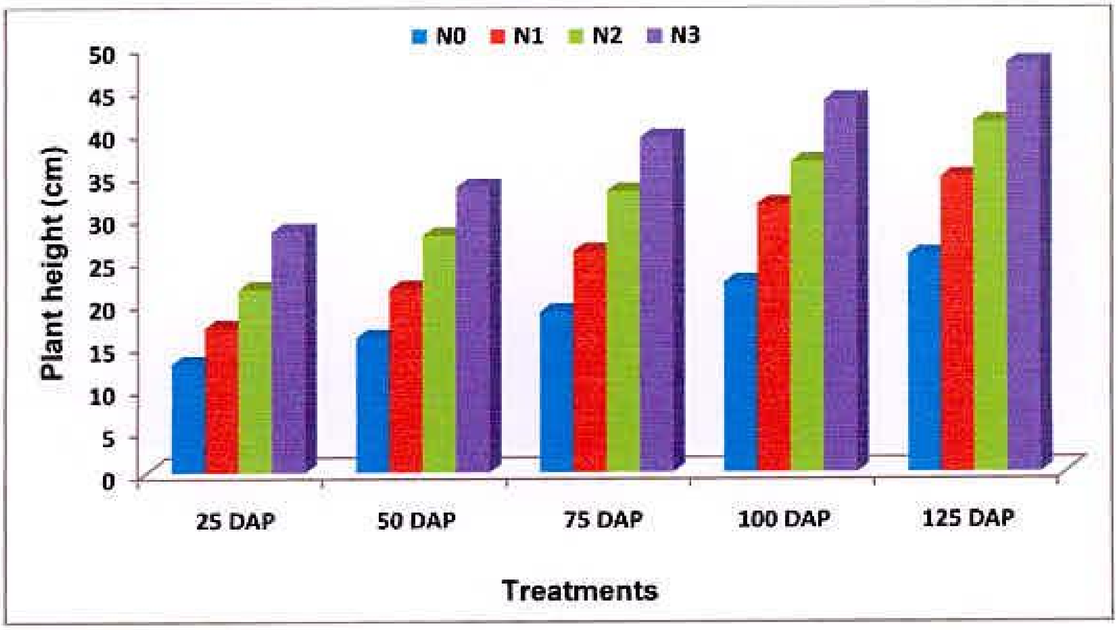


Figure 2. Effect of nitrogen on plant height of tuberose at different days after planting (DAP)

N_0 = 0 kg N ha^{-1}
N_1= 185 kg N ha^{-1}
N_2= 195 kg N ha^{-1}
N_3= 205 kg N ha^{-1}

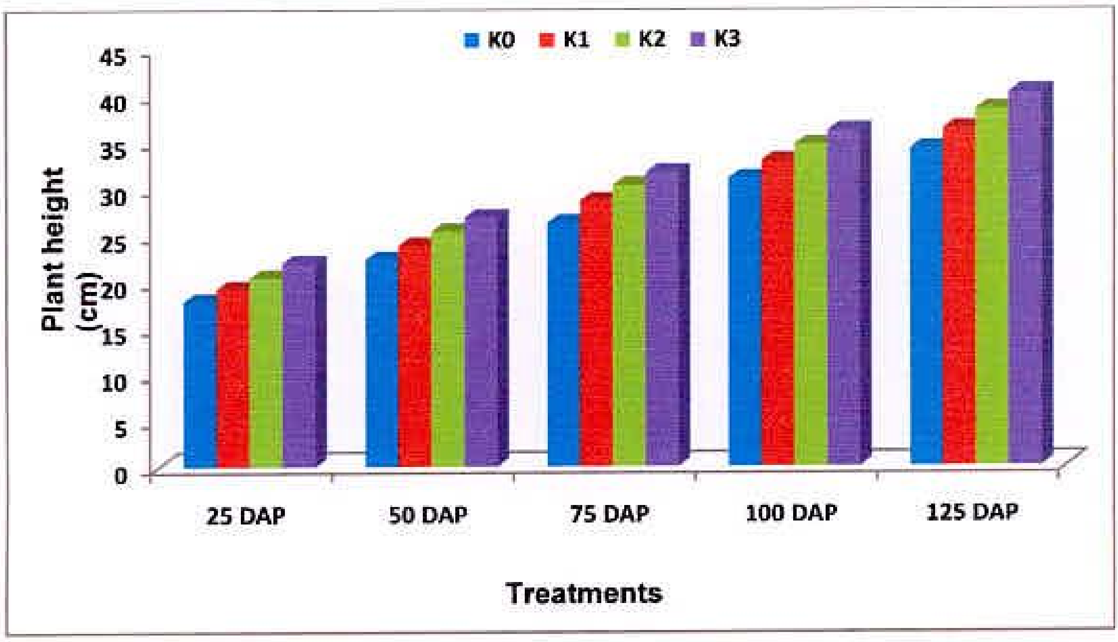


Figure 3. Effect of Potassium on plant height of tuberose at different days after planting (DAP)

K_0= 0 kg K_2O ha^{-1}
K_1= 180 kg K_2O ha^{-1}
K_2= 190 kg K_2O ha^{-1}
K_3= 200 kg K_2O ha^{-1}

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

Treatment(s)	Plant height (cm)				
	25 DAP	50 DAP	75 DAP	100 DAP	125 DAP
N_0K_0	10.77p	13.13p	14.00p	18.50p	20.50p
N_0K_1	12.40o	15.50o	18.50o	21.50o	24.43o
N_0K_2	13.40n	16.63n	20.73n	23.50n	27.47n
N_0K_3	14.50m	18.00m	22.13m	25.57m	29.47m
N_1K_0	15.63l	19.27l	23.77l	29.03l	32.40l
N_1K_1	16.43k	20.60k	25.40k	30.47k	33.77k
N_1K_2	17.43j	22.47j	26.57j	32.43j	35.47j
N_1K_3	18.50i	23.83i	28.07i	33.70i	36.77i
N_2K_0	19.47h	25.53h	29.90h	35.07h	38.13h
N_2K_1	20.47g	27.03g	32.13g	36.80g	39.80g
N_2K_2	22.00f	28.50f	34.03f	38.13f	42.10f
N_2K_3	24.00e	30.00e	35.77e	39.63e	44.03e
N_3K_0	25.53d	31.53d	36.50d	41.43d	45.70d
N_3K_1	27.60c	32.50c	38.60c	42.83c	47.17c
N_3K_2	28.87b	34.00b	40.00b	44.50b	48.40b
N_3K_3	31.00a	35.77a	40.80a	45.80a	50.43a
$LSD_{0.05}$	0.42	0.35	0.63	0.38	0.40
CV (%)	1.34	0.87	1.30	0.68	0.67

N_0 = 0 kg N ha^{-1}
N_1 = 185 kg N ha^{-1}
N_2 = 195 kg N ha^{-1}
N_3 = 205 kg N ha^{-1}

K_0 = 0 kg K_2O ha^{-1}
K_1 = 180 kg K_2O ha^{-1}
K_2 = 190 kg K_2O ha^{-1}
K_3 = 200 kg K_2O ha^{-1}

4.2 Number of leaves per plant (Mother bulb)

Due to application of different levels of nitrogen showed significant variation in all observations (Figure 4 & Appendix III). The number of leaves per plant showed gradually increased with increasing level of nitrogen. The maximum (14.85) number of leaves/plant was recorded from N_3 and the minimum (6.28) was obtained from control (N_0) at 125 DAP. The results of the experiment support the findings of Banker (1988). Rajwal and Sing (2006) were studied the effects of various N rates (100,125 and 150 Kg/ha) on the performance of tuberose cv. Double. He found 44.45 leaves per mother bulb at 120 days after planting.

Different levels of potassium showed a significant effect on number of leaves/plant at 25, 50, 75, 100 and 125 DAP under the present trial (Figure 5 & Appendix III). With the increasing levels of potassium, the number of leaves/plant performed increasing trend. At 125 DAP the maximum (11.78) number of leaves/plant was recorded from K_3 and the minimum (9.68) was found from control condition (K_0) where the plots did not receive potassium.

Combined effect of nitrogen and potassium showed significant difference in all the observations (Table 2 & Appendix III). The maximum (15.77) number of leaves/plant was obtained from the treatment combination N_3K_3 whereas, the minimum (4.90) was from N_0K_0 at125 DAP.

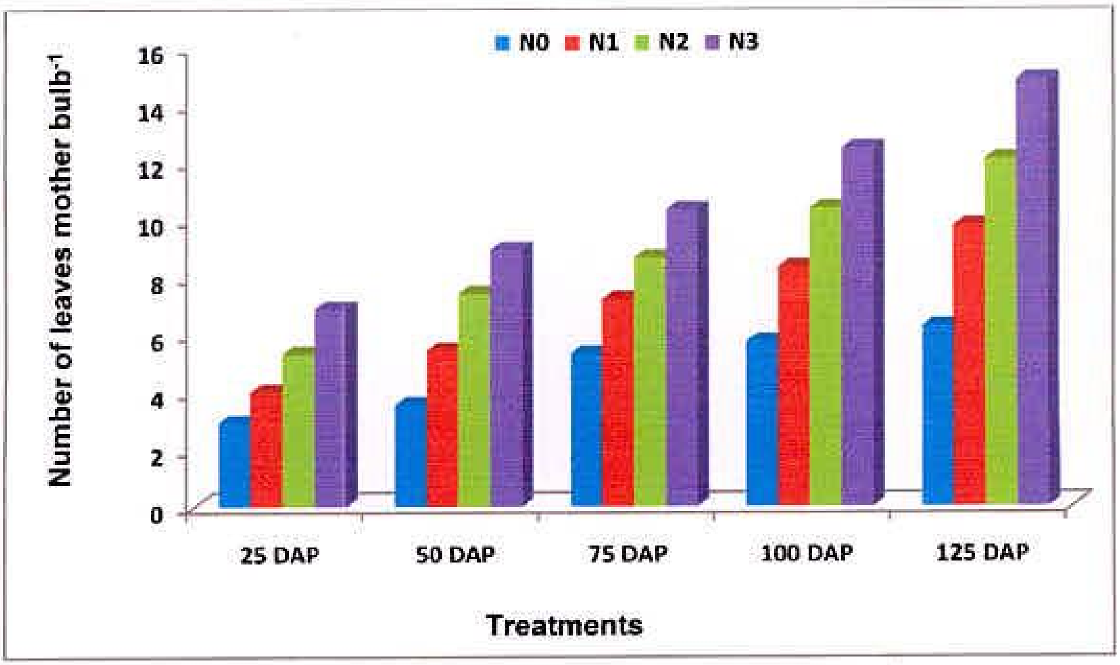


Figure 4. Effect of nitrogen on number of leaves mother bulb^{-1} of tuberose at different days after planting (DAP)

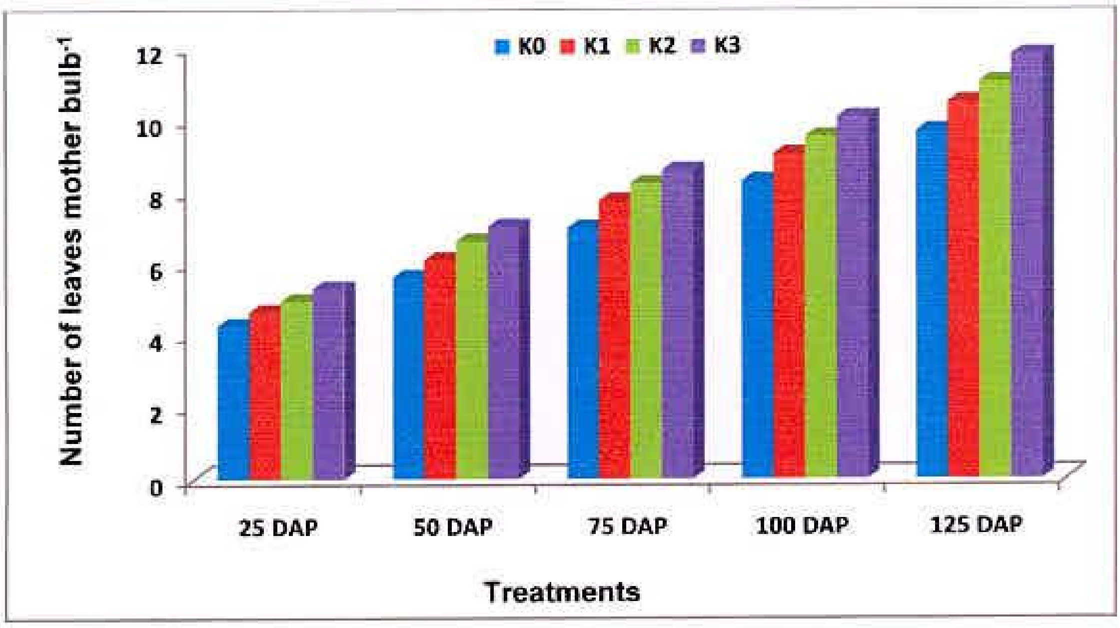


Figure 5. Effect of Potassium on number of leaves mother bulb^{-1} of tuberose at different days after planting (DAP)

Table 2. Combined effect of nitrogen and potassium on number of leaves mother bulb^{-1}of tuberose at different DAP

Treatment(s)	Number of leaves mother bulb^{-1}				
	25 DAP	**50 DAP**	**75 DAP**	**100 DAP**	**125 DAP**
N_0K_0	2.20o	2.50p	3.40p	4.10p	4.90p
N_0K_1	2.90n	3.30o	5.40o	5.70o	6.17o
N_0K_2	3.20m	4.00n	6.10n	6.23n	6.57n
N_0K_3	3.43l	4.40m	6.43m	6.97m	7.47m
N_1K_0	3068k	4.80l	6.77l	7.60l	8.73l
N_1K_1	3.88k	5.20k	7.10k	8.13k	5.90k
N_1K_2	4.10j	5.67j	7.40j	8.63j	10.13j
N_1K_3	4.40i	6.13i	7.67i	9.03i	10.70i
N_2K_0	4.77h	6.63h	8.10h	9.57h	11.23h
N_2K_1	5.10g	7.13g	8.50g	10.07g	11.63g
N_2K_2	5.50f	7.73f	8.90f	10.63f	12.27f
N_2K_3	5.97e	8.20e	9.17e	11.23e	13.20e
N_3K_0	6.40d	8.50d	9.70d	11.90d	13.83d
N_3K_1	6.73c	8.80c	10.00c	12.30c	14.63c
N_3K_2	7.00b	9.10b	10.50b	12.60b	15.17b
N_3K_3	7.40a	9.40a	11.13a	13.03a	15.77a
$LSD_{0.05}$	0.20	0.27	0.17	0.24	0.28
CV (%	2.89	2.55	1.33	1.60	1.58

4.3 Number of side shoots per plant

With the application of different levels of nitrogen performed the significant on the number of side shoot per plant (Figure 6 & Appendix IV). At different days after planting the maximum (11.54) number of side shoot/plant was recorded from N_3 and the minimum (5.54) was obtained from control treatment (N_0). Roy (1992) carried out an investigation at the Horticulture Farm of Bangladesh Agricultural University, Mymensing. She applied 200,400,600 Kg N/ha and observed that nitrogen at the rate of 200 Kg/ha significantly increased the number of side shoot per plant.

Different levels of potassium showed significant effect on number of side shoot/plant at 25, 50, 75, 100 and 125 DAP (Figure 7 & Appendix IV). With the increasing level of potassium, the number of side shoot/plant represents an increasing trend. The maximum (9.78) number of side shoot/plant was recorded from K_3 and the minimum (8.08) was observed in the plot with control condition (N_0).

Combined effect of nitrogen and potassium showed significant variation in all the observations (Table 3 & Appendix IV). The maximum (12.23) number of side shoots /plant was observed in N_3K_3 and the minimum (4.01) was recorded from control condition (N_0K_0) at 125 DAP.

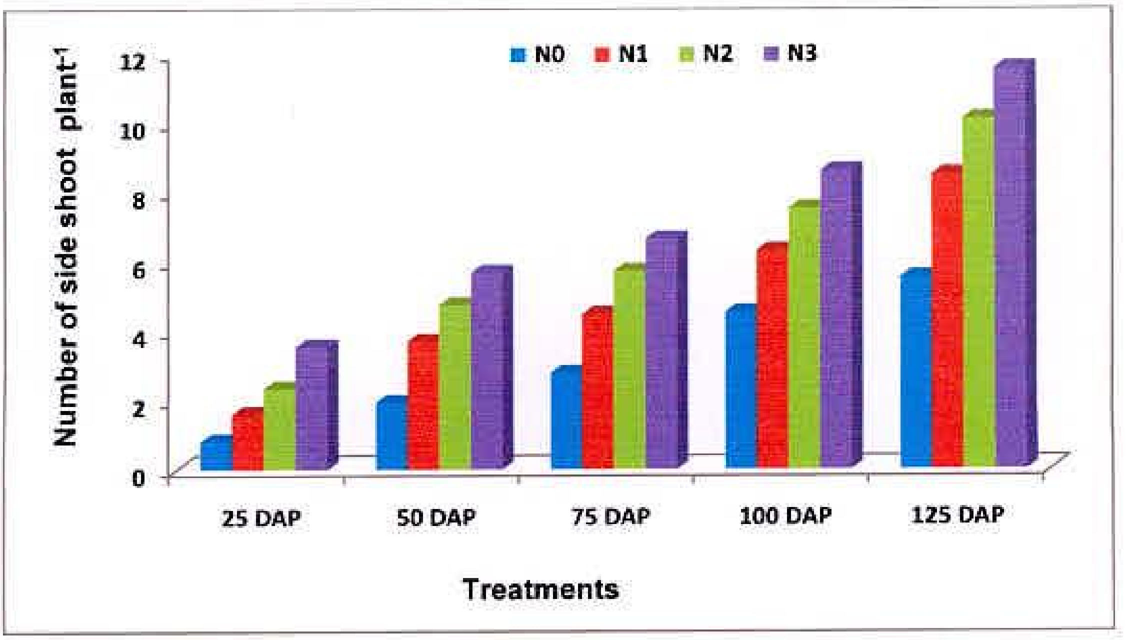


Figure 6. Effect of nitrogen on number of side shoot plant^{-1} of tuberose at different days after planting (DAP)

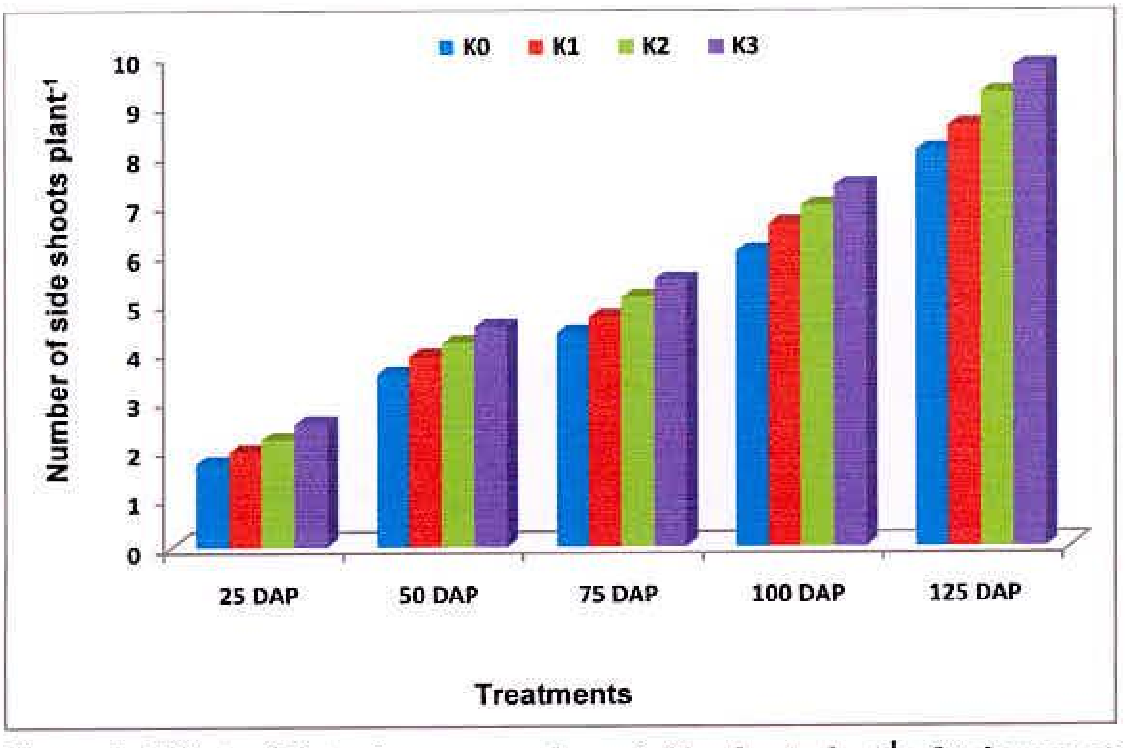


Figure 7. Effect of Potassium on number of side shoot plant^{-1} of tuberose at different days after planting (DAP)

Table 3. Combined effect of nitrogen and potassium on number of side shoots $hill^{-1}$ of tuberose at different DAP

Treatment(s)	Number of side shoots $hill^{-1}$				
	25 DAP	50 DAP	75 DAP	100 DAP	125 DAP
N_0K_0	0.50o	1.30m	1.90p	3.04p	4.01p
N_0K_1	0.70n	1.80l	2.40o	4.50o	4.73o
N_0K_2	0.95m	2.13k	3.20n	5.00n	6.30n
N_0K_3	1.10l	2.50j	3.63m	5.60m	7.10m
N_1K_0	1.35k	3.00i	4.00l	5.88l	7.80l
N_1K_1	1.55j	3.60h	4.30k	6.10k	8.30k
N_1K_2	1.65j	4.00g	4.60j	6.50j	8.73j
N_1K_3	1.85i	4.22g	5.00i	6.80i	9.17i
N_2K_0	2.02h	4.45f	5.30h	7.13h	9.50h
N_2K_1	2.25g	4.68e	5.60g	7.42g	9.97g
N_2K_2	2.45f	4.85de	5.88f	7.65f	10.30f
N_2K_3	2.65e	5.02d	6.08e	7.88e	10.60e
N_3K_0	2.90d	5.28c	6.27d	8.10d	11.00d
N_3K_1	3.20c	5.48bc	6.48c	8.40c	11.30c
N_3K_2	3.67b	5.70b	6.73b	8.70b	11.63b
N_3K_3	4.40a	6.27a	7.10a	9.20a	12.23a
$LSD_{0.05}$	0.13	0.21	0.15	0.16	0.23
CV (%)	3.98	3.20	1.90	1.45	1.57

4.4 Breadth of leaf (cm)

Nitrogen significantly influenced on breadth of leaf (Figure 8 & Appendix IV). Different levels of nitrogen showed a gradual increasing trend in terms of breadth of leaf of tuberose under the study at different days after planting. The maximum (2.98 cm) breadth of leaf was recorded from N_3 and the minimum (2.14 cm) was obtained from control treatment (N_0) at 125 DAP. Mohanty *et al.* (2002) conducted an experiment with tuberose involving 2 levels of N (30 and 40 g/m^2). He found 0.95 cm breadth of leaf with 40 g N/m^2.

Different levels of potassium showed significant effect on breadth of leaf at 25, 50, 75, 100 and 125 DAP under the present study (Figure 9 & Appendix IV). With the increasing level of potassium, the breadth of leaf represents an increasing trend. The maximum (2.82 cm) breadth of leaf was found from K_3 and the minimum (2.37 cm) was observed in control condition at 125 DAP.

Combined effect of nitrogen and potassium showed significant variation in all the observations (Table 4 & Appendix IV). The maximum (3.15 cm) breadth of leaf was obtained from the treatment combination of N_3K_3 and the minimum (1.50 cm) was recorded from control condition (N_0K_0) at 125 DAP.

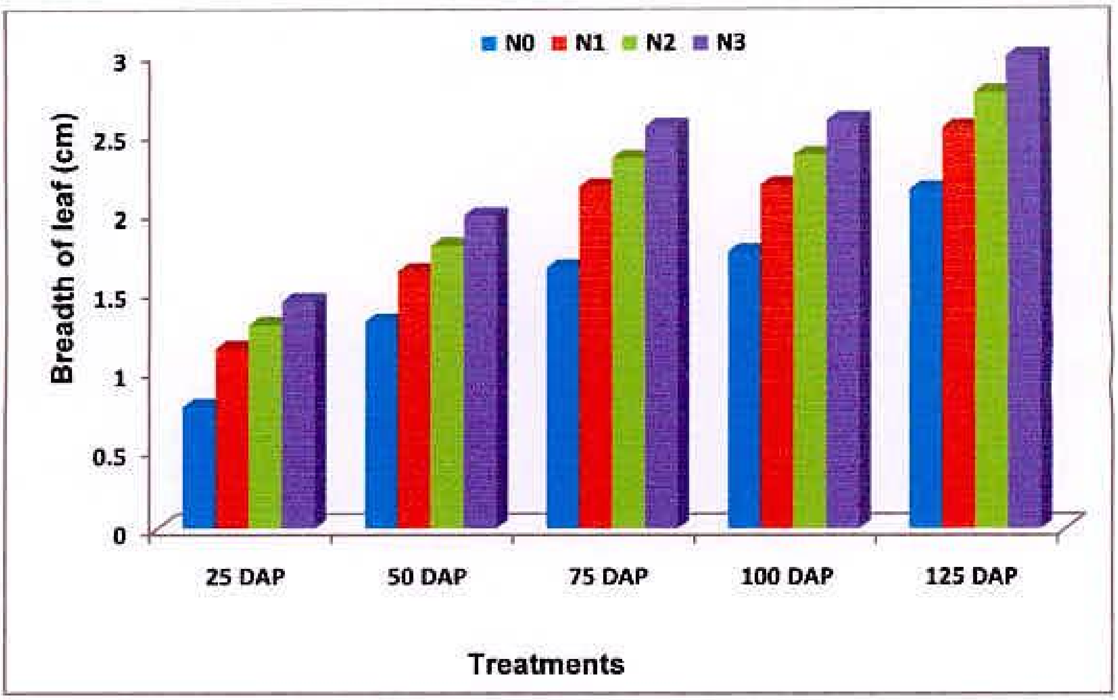


Figure 8. Effect of nitrogen on breadth of leaf of tuberose at different days after planting (DAP)

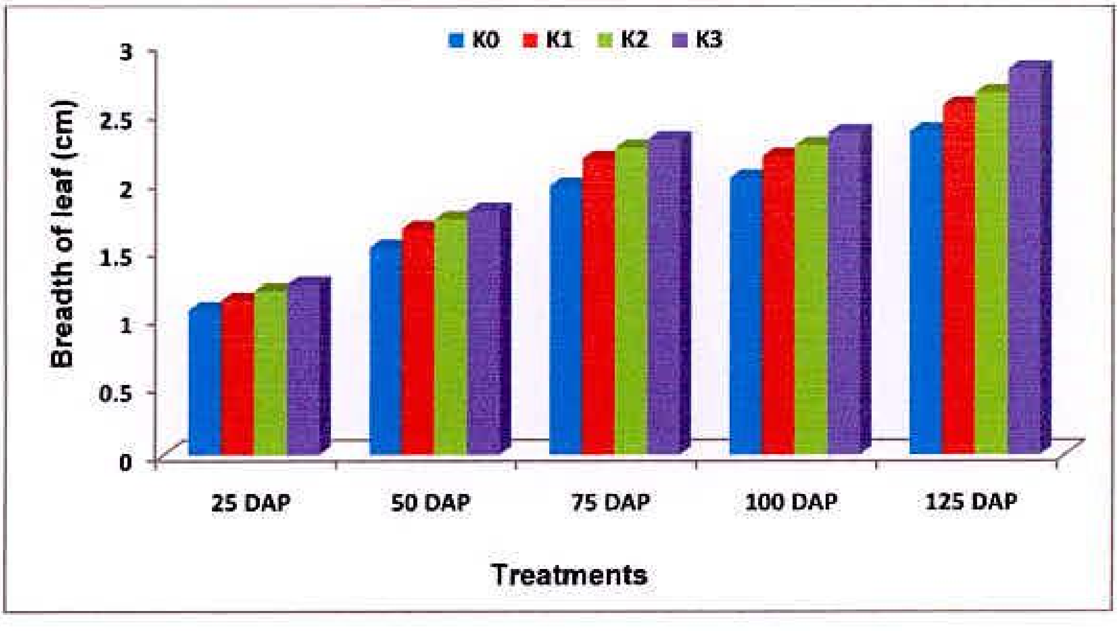


Figure 9. Effect of potassium on breadth of leaf of tuberose at different days after planting (DAP)

Table 4: Combined effect of nitrogen and potassium on breadth of leaf (cm) of tuberose at different DAP

Treatment(s)	Breadth of leaf (cm)				
	25 DAP	50 DAP	75 DAP	100 DAP	125 DAP
N_0K_0	0.50n	0.90l	1.09n	1.25m	1.50n
N_0K_1	0.70m	1.35k	1.70m	1.78l	2.10m
N_0K_2	0.88l	1.47j	1.85l	1.92k	2.28l
N_0K_3	0.98k	1.53ij	1.95k	2.04j	2.69gh
N_1K_0	1.10j	1.56i	2.08j	2.11i	2.42k
N_1K_1	1.12j	1.60hi	2.14i	2.14hi	2.50j
N_1K_2	1.15ij	1.65gh	2.19hi	2.19gh	2.56ij
N_1K_3	1.18hi	1.69fg	2.23gh	2.24g	2.62hi
N_2K_0	1.23gh	1.73ef	2.28g	2.30f	2.66gh
N_2K_1	1.26fg	1.76ef	2.33f	2.34ef	2.73fg
N_2K_2	1.31ef	1.80de	2.37ef	2.38de	2.77ef
N_2K_3	1.35de	1.85cd	2.40de	2.41d	2.82de
N_3K_0	1.39cd	1.90bc	2.44d	2.46c	2.88cd
N_3K_1	1.42bc	1.94b	2.49c	2.51c	2.92bc
N_3K_2	1.46ab	1.97b	2.57b	2.59b	2.96b
N_3K_3	1.50a	2.10a	2.67a	2.75a	3.15a
$LSD_{0.05}$	0.05	0.07	0.05	0.05	0.07
CV (%)	3.24	2.43	0.90	6.69	1.54

4.5 Length of spike (cm)

Due to application of different levels of nitrogen showed significant variation on length of spike of tuberose (Table 5 & Appendix V). However, the longest (57.47 cm) length of spike was recorded from N_3 and the shortest (34.20 cm) was obtained in the control treatment (N_0). Gowda *et al.* (1991) reported the effect of N, P and K on growth and flowering of tuberose cv. Double. He found spike length (81.28cm) with 200 Kg N/ha.

Different levels of potassium showed a statistically variation on length of spike under the present investigation (Table 5 & Appendix V). The longest (48.29 cm) length of spike was recorded from K_3 and the shortest (42.02 cm) was observed in the plot with control condition (K_0). Gowda *et al.* (1991) reported the effect of N, P and K on growth and flowering of tuberose cv. Double. He found spike length (81.28cm) with 125 Kg N/ha.

Combined effect of nitrogen and potassium showed significant difference on length of spike of tuberose (Table 6 & Appendix V). The longest (61.33 cm) length of spike was found from N_3K_3 and the shortest (31.00 cm) was recorded from control condition (N_0K_0).

4.6 Diameter of spike (cm)

Due to application of different levels of nitrogen showed significant variation on diameter of spike of tuberose (Table 5 & Appendix V). However, the maximum (1.09 cm) diameter of spike was recorded from N_3 and the minimum (0.63 cm) was obtained in the control treatment (N_0).

Different levels of potassium showed a statistically variation on diameter of spike under the present investigation (Table 5 & Appendix V). The maximum (0.95 cm) diameter of spike was recorded from K_3 and the minimum (0.81 cm) was observed in the plot with control condition (K_0).

Combined effect of nitrogen and potassium showed significant difference on diameter of spike of tuberose (Table 6 & Appendix V). The maximum (1.21 cm) diameter of spike was found from N_3K_3 and the minimum (0.53 cm) was recorded from control condition (N_0K_0).

4.7 Length of rachis (cm)

Due to application of different levels of nitrogen showed significant variation on length of rachis of tuberose (Table 5 & Appendix V). The longest (18.03 cm) length of rachis was recorded from N_3 and the shortest (12.77 cm) was obtained in the control treatment (N_0). Yadav *et al.* (2002) supplied N at 0, 50, 100, 150 and 200 Kg/ha and Zn at 0, 5, 10 and 20 Kg/ha to tuberose cv. Double. Nitrogen application at 150 and 200 Kg/ha increase rachis length.

Different levels of potassium showed a statistically variation on length of rachis under the present investigation (Table 5 & Appendix V). The longest (16.30 cm) length of rachis was recorded from K_3 and the shortest (14.46 cm) was observed in the plot with control condition (K_0).

Combined effect of nitrogen and potassium showed significant difference on length of rachis of tuberose (Table 6 & Appendix V). The longest (19.50 cm) length of rachis was found from N_3K_3 and the shortest (11.00 cm) was recorded from control condition (N_0K_0).

4.8 Number of floret per spike

Due to application of different levels of nitrogen showed significant variation on number of floret per spike of tuberose (Table 5 & Appendix V).However, the maximum (31.29) number of floret per spike was recorded from N_3 and the minimum (24.68) was obtained in the control treatment (N_0). Gowda *et al.* (1991) reported the effect of N, P and K on growth and flowering of tuberose cv. Double. He found 40.20 florets per spike with 200 Kg N/ha, 75 Kg P/ha and 125 Kg K/ha.

Different levels of potassium showed a statistically variation on number of floret per spike under the present investigation (Table 5 & Appendix V). The maximum (29.29) number of floret per spike was recorded from K_3 and the minimum (26.89) was observed in the plot with control condition (K_0).

Combined effect of nitrogen and potassium showed significant difference on number of floret per spike of tuberose (Table 6 & Appendix V). The maximum (33.10) number of floret per spike was found from N_3K_3 and the minimum (22.00) was recorded from control condition (N_0K_0)

4.11 Flower yield (t/ha)

Due to application of different levels of nitrogen showed significant variation on flower yield of tuberose (Table 5 & Appendix V). However, the highest (24.51 t/ha) flower yield was recorded from N_3 and the lowest (8.71 t/ha) was obtained in the control treatment (N_0). Patil *et al.* (1999) conducted tubers of *Polianthes tuberosa* cv. Double were grown in 5 levels of community planting viz. 1, 2, 3, 4, whole clump or 6 tuber(s) per hill and treated with 4 rates of fertilizers viz. 150:50:50, 150:100:100, 200:150:150 and 250:200:200 kg NPK/ha. Application of 250:200:200 kg NPK/ha on 3 tuberose tubers per hill resulted in the highest flower yields (7.86 t/ha).

Different levels of potassium showed a statistically variation on flower yield under the present investigation (Table 5 & Appendix V). The highest (18.00 t/ha) flower yield was recorded from K_3 and the lowest (13.72 t/ha) flower yield (t/ha) was observed in the plot with control condition (K_0).

Combined effect of nitrogen and potassium showed significant difference on flower yield of tuberose (Table 6 & Appendix V). The highest (28.12 t/ha) flower yield was found from N_3K_3 and the lowest (7.68 t/ha) was recorded from control condition (N_0K_0).

4.9 Weight of single spike (g)

Due to application of different levels of nitrogen showed significant variation on weight of single spike of tuberose (Table 5 & Appendix V). However, the highest (71.25 g) weight of single spike was recorded from N_3 and the lowest (45.07 g) was obtained in the control treatment (N_0).

Different levels of potassium showed a statistically variation on weight of single spike under the present investigation (Table 5 & Appendix V). The highest (60.86 g) weight of single spike was recorded from K_3 and the minimum (54.15 g) was observed in the plot with control condition (K_0).

Combined effect of nitrogen and potassium showed significant difference on weight of single spike of tuberose (Table 6 & Appendix V). The highest (75.33 g) weight of single spike was found from N_3K_3 and the lowest (42.00 g) was recorded from control condition (N_0K_0).

4.10 Number of spike per hectare ('000)

Due to application of different levels of nitrogen showed significant variation on number of spike of tuberose (Table 5 & Appendix V). The maximum (343.70) number of spike was recorded from N_3 and the minimum (193.30) was obtained in the control treatment (N_0). Parthiban *et al.* (1991) reported the effect of N, P, and K on yield component of tuberose. Application of 100 Kg N, 75 Kg P 62.5 Kg K_2O/ha was found highest number (1.72) of spikes/plant.

Different levels of potassium showed a statistically variation on number of spike under the present investigation (Table 5 & Appendix V). The maximum (285.30) number of spike was recorded from K_3 and the minimum (244.40) was observed in the plot with control condition (K_0).

Combined effect of nitrogen and potassium showed significant difference on number of spike of tuberose (Table 6 & Appendix V). The maximum (375.00) number of spike was found from N_3K_3 and the minimum (183.30) was recorded from control condition (N_0K_0).

Table 5: Main effect of nitrogen and potassium on flower yield (t/ha) of tuberose

Treatment(s)	Length of spike (cm)	Diameter of spike (cm)	Length of rachis (cm)	Number of florets $spike^{-1}$	Weight of single spike (g)	Number of spikes ha^{-1} ('000)	Flower yield ($t\ ha^{-1}$)
N_0	34.20d	0.63d	12.77d	24.68d	45.07d	193.30d	8.71d
N_1	40.75c	0.82c	14.61c	27.43c	52.18c	233.60c	12.23c
N_2	48.66b	0.95b	16.21b	29.17b	61.58b	287.60b	17.74b
N_3	57.47a	1.09a	18.03a	31.29a	71.25a	343.70a	24.51a
$LSD_{0.05}$	0.43	0.03	0.27	0.29	0.50	2.16	0.19
CV (%)	1.16	4.73	2.14	1.25	1.05	0.98	1.48
K_0	42.02d	0.81d	14.46d	26.89d	54.15d	244.40d	13.72d
K_1	44.29c	0.85c	15.18c	27.86c	56.58c	259.20c	15.17c
K_2	46.45b	0.87b	15.68b	28.53b	58.49b	269.30b	16.31b
K_3	48.29a	0.95a	16.30a	29.29a	60.86a	285.30a	18.00a
$LSD_{0.05}$	0.43	0.03	0.27	0.29	0.50	2.16	0.19
CV (%)	1.16	4.73	2.14	1.25	1.05	0.98	1.48

Table 6: Combined effect of nitrogen and potassium on flower yield (t/ha) of tuberose

Treatment(s)	Spike length (cm)	Spike diameter (cm)	Rachis length (cm)	Florets number spike^{-1}	Single spike weight (g)	Spikes number ha^{-1} ('000)	Flower yield (t ha^{-1})
N_0K_0	31.00p	0.53n	11.00o	22.00o	42.00	183.30p	7.68p
N_0K_1	33.83o	0.62m	12.80n	24.63n	45.00	191.70o	8.61o
N_0K_2	35.47n	0.67lm	13.47m	25.80m	46.17	196.70n	9.07n
N_0K_3	36.50m	0.72kl	13.80lm	26.30lm	47.10	201.30m	9.48m
N_1K_0	38.00l	0.77jk	14.10kl	26.87kl	48.67	209.70l	10.20l
N_1K_1	39.83k	0.81ij	14.40jk	27.27jk	51.00	230.00k	11.73k
N_1K_2	41.67j	0.84h-j	14.73ij	27.57ij	53.07	240.00j	12.73j
N_1K_3	43.50i	0.87g-i	15.20hi	28.03hi	56.00	254.70i	14.26i
N_2K_0	45.50h	0.90f-h	15.63gh	28.60gh	58.43	270.00h	15.76h
N_2K_1	47.50g	0.93e-g	16.10fg	29.00fg	60.50	280.00g	16.94g
N_2K_2	49.80f	0.96d-f	16.40ef	29.33ef	62.40	290.30f	18.11f
N_2K_3	51.83e	0.99c-e	16.70de	29.73de	65.00	310.00e	20.15e
N_3K_0	53.70d	1.03b-d	17.10cd	30.10cd	67.50	314.70d	21.23d
N_3K_1	56.00c	1.05bc	17.43c	30.53c	69.83	335.00c	23.39c
N_3K_2	58.87b	1.08b	18.10b	31.43b	72.33	350.00b	25.31b
N_3K_3	61.33a	1.21a	19.50a	33.10a	75.33	375.00a	28.12a
$LSD_{0.05}$	0.87	0.07457	0.5480	0.5872	1.01	4.333	0.3911
CV (%)	1.16	4.73	2.14	1.25	1.05	0.98	1.48

4.12 Number of bulblets per plant

Different levels of nitrogen performed significant variation on number of bulblets per plant of tuberose (Table 7 & Appendix VI). The maximum (14.45) number of bulblets per plant was recorded from N_3 and the minimum (7.38) was obtained in the control treatment (N_0). Roy (1992) carried out an investigation at the Horticultural Farm of Bangladesh Agricultural University, Mymensingh. 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 200 Kg and 400 Kg nitrogen per hectare.

Different levels of potassium showed a statistically variation on number of bulblets per plant under the present investigation (Table 8 & Appendix VI). The maximum (11.95) number of bulblets per plant was recorded from K_3 and the minimum (9.52) was observed in the plot with control condition (K_0).

Combined effect of nitrogen and potassium showed significant difference on number of bulblets per plant of tuberose (Table 9 & Appendix VI). The maximum (15.75) number of bulblets per plant was found from N_3K_3 and the minimum (4.93) was recorded from control condition (N_0K_0).

4.13 Length of large bulb (cm)

Different levels of nitrogen performed significant variation on length of large bulb of tuberose (Table 7 & Appendix VI). However, the maximum (6.05 cm) length of large bulb was recorded from N_3 and the minimum (4.41 cm) was obtained in the control treatment (N_0).

Different levels of potassium showed a statistically variation on length of large bulb under the present investigation (Table 8 & Appendix VI). The maximum (5.54 cm) length of large bulb was recorded from K_3 and the minimum (4.99 cm) was observed in the plot with control condition (K_0).

Combined effect of nitrogen and potassium showed significant difference on length of large bulb of tuberose (Table 9 & Appendix VI). The maximum (6.28 cm) length of large bulb was found from N_3K_3 and the minimum (3.73 cm) was recorded from control condition (N_0K_0)

4.14 Length of medium bulb (cm)

Different levels of nitrogen performed significant variation on length of medium bulb of tuberose (Table 7 & Appendix VI). The maximum (4.48 cm) length of medium bulb was recorded from N_3 and the minimum (3.03 cm) was obtained in the control treatment (N_0).

Different levels of potassium showed a statistically variation on length of medium bulb under the present investigation (Table 8 & Appendix VI). The maximum (4.10cm) length of medium bulb was recorded from K_3 and the minimum (3.54 cm) was observed in the plot with control condition (K_0).

Combined effect of nitrogen and potassium showed significant difference on length of medium bulb of tuberose (Table 9 & Appendix VI). The maximum (4.70 cm) length of medium bulb was found from N_3K_3 and the minimum (2.23 cm) was recorded from control condition (N_0K_0).

4.15 Length of small bulb (cm)

Different levels of nitrogen performed significant variation on length of small bulb of tuberose (Table 7 & Appendix VI). However, the maximum (3.62 cm) length of small bulb was recorded from N_3 and the minimum (2.53 cm) was obtained in the control treatment (N_0).

Different levels of potassium showed a statistically variation on length of small bulb under the present investigation (Table 8 & Appendix VI). The maximum (3.35 cm) length of small bulb was recorded from K_3 and the minimum (2.84 cm) was observed in the plot with control condition (K_0).

Combined effect of nitrogen and potassium showed significant difference on length of small bulb of tuberose (Table 9 & Appendix VI). The maximum (3.76 cm) length of small bulb was found from N_3K_3 and the minimum (1.55 cm) was recorded from control condition (N_0K_0).

4.16 Diameter of large bulb (cm)

Different levels of nitrogen performed significant variation on diameter of small bulb of tuberose (Table 7 & Appendix VI). However, the maximum (3.58 cm) diameter of large bulb was recorded from N_3 and the minimum (2.62 cm) was obtained in the control treatment (N_0).

Different levels of potassium showed a statistically variation on diameter of large bulb under the present investigation (Table 8 & Appendix VI). The maximum (3.37 cm) diameter of large bulb was recorded from K_3 and the minimum (2.97 cm) was observed in the plot with control condition (K_0).

Combined effect of nitrogen and potassium showed significant difference on diameter of small bulb of tuberose (Table 9 & Appendix VI). The maximum (3.68 cm) diameter of large bulb was found from N_3K_3 and the minimum (1.90 cm) was recorded from control condition (N_0K_0).

4.17 Diameter of medium bulb (cm)

Different levels of nitrogen performed significant variation on diameter of medium bulb of tuberose (Table 7 & Appendix VI). The maximum (2.22 cm) diameter of medium bulb was recorded from N_3 and the minimum (1.44 cm) was obtained in the control treatment (N_0).

Different levels of potassium showed a statistically variation on diameter of medium bulb under the present investigation (Table 8 & Appendix VI). The maximum (2.03 cm) diameter of medium bulb was recorded from K_3 and the minimum (1.76 cm) was observed in the plot with control condition (K_0).

Combined effect of nitrogen and potassium showed significant difference on diameter of medium bulb of tuberose (Table 9 & Appendix VI). The maximum (2.43 cm) diameter of medium bulb was found from N_3K_3 and the minimum (1.20 cm) was recorded from control condition (N_0K_0).

4.18 Diameter of small bulb (cm)

Different levels of nitrogen performed significant variation on diameter of small bulb of tuberose (Table 7 & Appendix VI). The maximum (1.76 cm) diameter of small bulb was recorded from N_3 and the minimum (1.13 cm) was obtained in the control treatment (N_0).

Different levels of potassium showed a statistically variation on diameter of small bulb under the present investigation (Table 8 & Appendix VI). The maximum (1.58 cm) diameter of small bulb was recorded from K_3 and the minimum (1.36 cm) was observed in the plot with control condition (K_0).

Combined effect of nitrogen and potassium showed significant difference on diameter of small bulb of tuberose (Table 9 & Appendix VI). The maximum (1.86 cm) diameter of small bulb was found from N_3K_3 and the minimum (0.90 cm) was recorded from control condition (N_0K_0).

4.19 Fresh weight of bulb per hill (g)

Different levels of nitrogen performed significant variation on fresh weight of bulb of tuberose (Table 7 & Appendix VI). However, the maximum (112.7 g) fresh weight of bulb was recorded from N_3 and the minimum (60.75 g) was obtained in the control treatment (N_0).

Different levels of potassium showed a statistically variation on fresh weight of bulb under the present investigation (Table 8 & Appendix VI). The maximum (95.63 g) fresh weight of bulb was recorded from K_3 and the minimum (77.69 g) was observed in the plot with control condition (K_0).

Combined effect of nitrogen and potassium showed significant difference on fresh weight bulb of tuberose (Table 9 & Appendix VI). The maximum (128.80 g) fresh weight of bulb per hill was found from N_3K_3 and the minimum (45.00 g) was recorded from control condition (N_0K_0).

4.20 Dry weight of bulb per 100 g

Different levels of nitrogen performed significant variation on dry weight of bulb of tuberose (Table 7 & Appendix VI). The maximum (76.49 g) dry weight of bulb was recorded from N_3 and the minimum (49.88 g) was obtained in the control treatment (N_0).

Different levels of potassium showed a statistically variation on dry weight of bulb under the present investigation (Table 8 & Appendix VI). The maximum (68.72 g) dry weight of bulb was recorded from K_3 and the minimum (58.99 g) was observed in the plot with control condition (K_0).

Combined effect of nitrogen and potassium showed significant difference on dry weight bulb of tuberose (Table 9 & Appendix VI). The maximum (84.00 g) dry weight of bulb was found from N_3K_3 and the minimum (39.50 g) was recorded from control condition (N_0K_0).

4.21 Number of bulbs per hectare ('000)

Different levels of nitrogen performed significant variation on number of bulbs of tuberose (Table 7 & Appendix VI). The maximum (3861) number of bulbs was recorded from N_3 and the minimum (2096) was obtained in the control treatment (N_0). Roy (1992) carried out an investigation at the Horticultural Farm of Bangladesh Agricultural University, Mymensingh. She observed that nitrogen had a significant effect on bulb production of tuberose the obtained the highest bulb yield by number an weight with the application of 600 Kg nitrogen per hectare. However, statistically similar yield was obtained from 200 Kg and 400 Kg nitrogen per hectare.

Different levels of potassium showed a statistically variation on number of bulbs under the present investigation (Table 8 & Appendix VI). The maximum (3238) number of bulbs per hectare was recorded from K_3 and the minimum (2629) was observed in the plot with control condition (K_0).

Combined effect of nitrogen and potassium showed significant difference on number of bulbs of tuberose (Table 9 & Appendix VI). The maximum (4188) number of bulbs per hectare was found from N_3K_3 and the minimum (1483) was recorded from control condition (N_0K_0).

4.22 Yield of bulb (t/ha)

Different levels of nitrogen performed significant variation on yield of bulb of tuberose (Table 7 & Appendix VI). The maximum (28.18 t/ha) yield of bulb was recorded from N_3 and the minimum (15.19 t/ha) was obtained in the control treatment (N_0). 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 (Cirrito, 1975).

Different levels of potassium showed a statistically variation on yield of bulb under the present investigation (Table 8 & Appendix VI). The maximum (23.91 t/ha) yield of bulb was recorded from K_3 and the minimum (19.42 t/ha) was observed in the plot with control condition (K_0).

Combined effect of nitrogen and potassium showed significant difference yield of bulb of tuberose (Table 9 & Appendix VI). The maximum (32.21 t/ha) yield of bulb per hectare was found from N_3K_3 and the minimum (11.25 t/ha) was recorded from control condition (N_0K_0).

Table 7: Main effect of different levels of nitrogen on bulb production of tuberose

Treatment(s) Nitrogen (N)	Number of bulblets mother bulb^{-1}	Length of large bulb (cm)	Length of medium bulb (cm)	Length of small bulb (cm)	Diameter of large bulb (cm)	Diameter of medium bulb (cm)	Diameter of small bulb (cm)	Fresh weight of bulb hill^{-1}	Dry weight of bulb per 100 g	Number of bulbs ha^{-1} ('000)	Yield of bulb (t ha^{-1})
N_0	7.38d	4.41d	3.03d	2.53d	2.62d	1.44d	1.13d	60.75d	49.88d	2096d	15.19d
N_1	9.76c	5.13c	3.79c	3.14c	3.19c	1.86c	1.40c	81.50c	62.60c	2690c	20.38c
N_2	11.86b	5.54b	4.16b	3.36b	3.43b	2.00b	1.60b	93.54b	67.72b	3215b	23.38b
N_3	14.45a	6.05a	4.48a	3.62a	3.58a	2.22a	1.76a	112.7a	76.49a	3861a	28.18a
$LSD_{0.05}$	0.19	0.07	0.05	0.02	0.04	0.06	0.02	0.54	0.61	47.64	0.13
CV (%)	2.10	1.78	1.59	1.22	1.62	4.34	2.21	0.76	1.15	1.93	0.76

Table 8: Main effect of different levels of potassium on bulb production of tuberose

Treatment(s) Potassium (K_2O)	Number of bulblets mother $bulb^{-1}$	Length of large bulb (cm)	Length of medium bulb (cm)	Length of small bulb (cm)	Diameter of large bulb (cm)	Diameter of medium bulb (cm)	Diameter of small bulb (cm)	Fresh weight of bulb $hill^{-1}$	Dry weight of bulb per 100 g	Number of bulbs ha^{-1} ('000)	Yield of bulb (t ha^{-1})
K_0	9.52d	4.99d	3.54d	2.84d	2.97d	1.76d	1.36d	77.69d	58.99d	2629d	19.42d
K_1	10.70c	5.19c	3.83c	3.18c	3.19c	1.83c	1.44c	84.25c	63.25c	2936c	21.06c
K_2	11.27b	5.40b	3.99b	3.28b	3.29b	1.90b	1.51b	90.97b	65.74b	3069b	22.74b
K_3	11.95a	5.54a	4.10a	3.35a	3.37a	2.03a	1.58a	95.63a	68.72a	3238a	23.91a
$LSD_{0.05}$	0.19	0.07	0.05	0.02	0.04	0.06	0.02	0.54	0.61	47.64	0.13
CV (%)	2.10	1.78	1.59	1.22	1.62	4.34	2.21	0.76	1.15	1.93	0.76

Table 9: Combined effect of different levels of nitrogen and potassium on bulb production of tuberose

Treatment(s) Nitrogen (N x K)	Number of bulblets mother bulb^{-1}	Length of large bulb (cm)	Length of medium bulb (cm)	Length of small bulb (cm)	Diameter of large bulb (cm)	Diameter of medium bulb (cm)	Diameter of small bulb (cm)	Fresh weight of bulb hill^{-1}	Dry weight of bulb per 100 g	Number of bulbs ha^{-1} ('000)	Yield of bulb (t ha^{-1})
N_0K_0	4.93m	3.73n	2.23n	1.55m	1.90m	1.20k	0.90m	45.00p	39.50n	1483m	11.25p
N_0K_1	7.77l	4.30m	3.15m	2.70l	2.63l	1.35j	1.10l	61.00o	50.00m	2192l	15.25o
N_0K_2	8.23k	4.70l	3.30l	2.88k	2.90k	1.5i	1.23k	66.00n	53.00l	2308k	16.50n
N_0K_3	8.60jk	4.88k	3.44k	2.97j	3.05j	1.70h	1.30j	71.00m	57.00k	2400jk	17.75m
N_1K_0	8.90j	4.97jk	3.55j	3.04i	3.12ij	1.80gh	1.33ij	76.00l	60.00j	2475j	19.00l
N_1K_1	9.33i	5.08ij	3.70i	3.12h	3.17hi	1.85fg	1.36i	81.00k	62.50i	2583i	20.25k
N_1K_2	9.80h	5.17hi	3.90h	3.17h	3.22gh	1.88e-g	1.42h	83.00j	63.47hi	2700h	20.75j
N_1K_3	11.00g	5.30gh	4.01g	3.22g	3.27fg	1.91e-g	1.48g	86.00i	64.45gh	3000g	21.50i
N_2K_0	11.43f	5.40fg	4.08fg	3.28f	3.34ef	1.94d-f	1.52fg	90.00h	65.50g	3108f	22.50h
N_2K_1	11.65ef	5.48ef	4.12ef	3.33f	3.42de	1.97d-f	1.57f	92.50g	67.48f	3163ef	23.12g
N_2K_2	11.90e	5.57de	4.19de	3.40e	3.46cd	2.01c-e	1.62e	95.00f	68.48ef	3225e	23.75f
N_2K_3	12.45d	5.70cd	4.26cd	3.44de	3.48cd	2.06b-d	1.66de	96.67e	69.43e	3363d	24.16e
N_3K_0	12.80d	5.84bc	4.30c	3.48d	3.51bc	2.11bc	1.68cd	99.77d	70.97d	3450d	24.94d
N_3K_1	14.07c	5.90b	4.36c	3.57c	3.55bc	2.14bc	1.72c	102.50c	73.00c	3767c	25.62c
N_3K_2	15.17b	6.16a	4.56b	3.67b	3.59ab	2.18b	1.78b	119.90b	78.00b	4042b	29.96b
N_3K_3	15.75a	6.28a	4.70a	3.76a	3.68a	2.43a	1.86a	128.80a	84.00a	4188a	32.21a
$LSD_{0.05}$	0.38	0.15	0.10	0.05	0.09	0.13	0.05	1.09	1.23	95.28	0.27
CV (%)	2.10	1.78	1.59	1.22	1.38	4.34	2.21	0.76	1.15	1.93	0.76

4.23 Economic analysis

Input costs for land preparation, bulb, fertilizer, pesticide, irrigation and manpower required for all the operations including harvesting of flowers, bulb and bulblet, were recorded for unit plot and converted into cost per hectare. Prices of the spikes, bulb and bulblet were considered in the market rate basis. 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

4.23.1 Gross return

In the combination of different levels of nitrogen and potassium showed different gross return. The highest gross return (Tk. 1019200.00) was obtained from the treatment combination of 205 kg N/ha and 200 kg K_2O/ ha (N_3K_3) and the second highest gross return (TK. 949200.00) was obtained from the treatment combination of 205 kg N/ha and 190 kg K_2O/ ha (N_3K_2). The lowest gross return (Tk. 408300.00) was obtained from the control condition (N_0K_0).

4.23.2 Net return

In case net return different treatment combination showed various net return. The highest net return (Tk. 780760.00) was obtained from the treatment combination of 205 kg N/ha and 200 kg K_2O/ ha (N_3K_3) and the second highest net return (TK. 712163.00) was obtained from the treatment combination of 205 kg N/ha and 190 kg K_2 O/ ha (N_3K_2). The lowest net return (Tk. 204588.00) was obtained from the control condition (N_0K_0).

Table 10. Cost and return of tuberose cultivation as influenced by different levels of nitrogen and potassium

Treatment(s) Nitrogen × Potassium		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	Net return	Benefit cost ratio
0 kg N/ha	0 kg K_20/ha	203712	183300	183300	11.25	225000	408300	204588	1.00
	180 kg K_20/ha	229318	191700	191700	15.25	305000	496700	267382	1.67
	190 kg K_20/ha	230721	196700	196700	16.50	330000	526700	295979	1.28
	200 kg K_20/ha	232126	201300	201300	17.75	355000	556300	324174	1.40
185 kg N/ha	0 kg K_20/ha	209404	209700	209700	19.00	380000	589700	380296	1.82
	180 kg K_20/ha	235010	230000	230000	20.25	405000	635000	399990	1.70
	190 kg K_20/ha	236413	240000	240000	20.75	415000	655000	418587	1.77
	200 kg K_20/ha	237818	254700	254700	21.50	430000	684700	446882	1.88
195 kg N/ha	0 kg K_20/ha	209716	270000	270000	22.50	450000	720000	510284	2.43
	180 kg K_20/ha	235321	280000	280000	23.12	462400	742400	507079	2.15
	190 kg K_20/ha	236726	290300	290300	23.75	475000	765300	528574	2.23
	200 kg K_20/ha	238124	310000	310000	24.16	483200	793200	555071	2.33
205 kg N/ha	0 kg K_20/ha	221826	314700	314700	24.94	498800	813500	591674	2.67
	180 kg K_20/ha	235632	335000	335000	25.62	512400	847400	611768	2.60
	190 kg K_20/ha	237037	350000	350000	29.96	599200	949200	712163	3.00
	200 kg K_20/ha	238440	375000	375000	32.21	644200	101920	780760	3.27

Market price of bulb @ Tk. 20,000/t
Market price of spike @ Tk. 1/spike.

4.23.3 Benefit cost ratio

In the combination of different levels of nitrogen and potassium showed different benefit cost ratio. The highest benefit cost ratio (3.27) was obtained from the treatment combination of 205 kg N/ha and 200 kg K_2O/ ha (N_3K_3). The lowest benefit cost ratio (1.00) was obtained from the control condition (N_0K_0). From economic point of view, it is apparent from the above results that 205 kg N/ha and 200 kg K_2O/ ha (N_3K_3) was more profitable than the rest of the treatments.

CHAPTER 5
SUMMARY AND CONCLUSION

CHAPTER 5

SUMMARY AND CONCLUSION

A field experiment was conducted in the Horticulture farm of Sher-e-Bangla Agricultural University. Dhaka, Bangladesh from April, 2008 to March, 2009 to study the effect of nitrogen and potassium on growth, flower and bulb yield of tuberose (*Polianthes tuberose* L.) cv. Double. The experiment comprised of two factors, such as Factor A: Nitrogen (4 levels) i.e. 0, 185, 195 and 205 kg N/ha; Factor B: Potassium (4 levels) i. e. 0, 180, 190 and 200 kg K_20/ha. There were 16 (4×4) treatment combinations. The experiment was laidout in Randomized Complete Block Design. Data on growth, flowering and bulb production of tuberose were recorded. Economic analysis was done to find the profitability of the treatments.

The tallest (47.92 cm) plant was recorded from N_3 and the shortest (25.47cm) at 125 DAP in case of control condition (N_0). The tallest (40.17 cm) plant was obtained from K_3 and the shortest (34.81 cm) was noticed in control condition i.e. no potassium application.

The maximum (11.54) number of side shoot / plant was recorded from N_3 and the minimum (5.54) at 125 DAP was recorded from control condition. The maximum (9.78) number of side shoot/plant was obtained from K_3 and the minimum (8.08) was noticed in control condition (N_0).

The maximum (14.85) number of leaves/plant was recorded from N_3 and the minimum (6.28) at 125 DAP was recorded from control condition. The maximum (11.78) number of leaves plant was obtained from K_3 and the minimum (9.68) was noticed in control condition i. e. no potassium application.

The maximum (2.98 cm) breadth of leaf of plant was recorded from N_3 and the minimum (2.14 cm) at 125 DAP was recorded from control condition. The maximum (2.82 cm) breadth of leaf of plant was obtained from K_3 and the minimum (2.37 cm) at 125 DAP was noticed in control condition i. e. no potassium application.

The longest (57.47 cm) length of spike was recorded from N_3 and the shortest (34.20 cm) length of spike was recorded from control condition. The longest (48.29 cm) length of spike was obtained from K_3 and the shortest (42.02 cm) length of spike was noticed in control condition (K_0).

The longest (18.03 cm) length of rachis was recorded from N_3 and the shortest (12.77 cm) was obtained in the plot from control condition. The longest (16.30 cm) length of rachis was recorded from K_3 and the shortest (14.46 cm) length of rachis was observed in the plot with control condition (K_0).

The maximum (31.29) number of floret per spike was recorded from N_3 and the minimum (24.68) was obtained in the plot from control condition (N_0). The maximum (29.29) number of floret per spike was recorded from K_3 and the minimum (26.89) was observed in the plot with control condition (K_0).

The highest (343.70) thousand number of spike per hectare was recorded from N_3 and the lowest (193.30) thousand was obtained in the plot from control condition (N_0). The highest (285.30) thousand number of spike per hectare was recorded from K_3 and the lowest (244.40) was observed in the plot with control condition (K_0).

The highest (24.51 t/ha) flower yield was recorded from N_3 and the lowest (8.71 t/ha) was obtained in the plot from control condition (N_0). The highest (18.00 t/ha) flower yield was recorded from K_3 and the lowest (13.72 t/ha) was observed in the plot with control condition.

The maximum (14.45) number of bulblets per mother bulb was recorded from N_3 and the minimum (7.38) was obtained in the plot from control condition (N_0). The maximum (11.95) number of bulblets per mother bulb was recorded from K_3 and the minimum (9.52) was observed in the plot with control condition (K_0).

The maximum (112.7 g) fresh weight of bulb per hill was recorded from N_3 and the minimum (60.75 g) was obtained in the plot from control condition (N_0). The maximum (95.63 g) fresh weight of bulb per hill was recorded from K_3 and the minimum (77.69 g) was observed in the plot with control condition.

The maximum (76.49 g) dry weight of bulb was recorded from N_3 and the minimum (49.88 g) was obtained in the plot from control condition. The maximum (68.72 g) dry weight of bulb was recorded from K_3 and the minimum (58.99 g) was observed in the plot with control condition (K_0).

The maximum (3861) thousand number of bulbs per hectare was recorded from N_3 and the minimum (2096) thousand was obtained in the plot from control condition (N_0). The maximum (3238) thousand number of bulbs per hectare was recorded from K_3 and the minimum (2629) was observed in the plot with control condition (K_0).

The maximum (28.18 t) yield of bulb per hectare was recorded from N_3 and the minimum (15.19 t) was obtained in the plot from control condition. The maximum (23.91 t) yield of bulb per hectare was recorded from K_3 and the minimum (19.42 t) was observed in the plot with control condition.

There were interaction effects between different levels of nitrogen and potassium. The highest gross return (Tk.1019200.00) was obtained from the treatment combination of 205 kg N/ha and 200 g $K_2 0$ /ha (N_3K_3) and the lowest gross return (Tk. 408300.00) was found from control condition (N_0K_0). The highest net return (Tk. 780760.00) was obtained from the treatment combination of 205 kg N/ha and 200 kg K_2O/ ha (N_3K_3) and the lowest net return (Tk. 204588.00) was obtained from the control condition (N_0K_0). The highest benefit cost ratio (3.27) was obtained from the treatment combination of 205 kg N/ha and 200 kg K_2O/ ha (N_3K_3) and the lowest benefit cost ratio (1.00) was obtained from the control condition (N_0K_0).

Conclusion

Finally, the treatment combination 205 kg N/ha and 200 Kg K_20/ha (N_3K_3) exhibited the highest result. The highest benefit cost ratio was obtained from the treatment combination of 205 kg N/ha and 200 kg K_20/ha (N_3K_3). So, it may be concluded that 205 kg N/ha and 200 kg K_20/ha (N_3K_3) application is the best considering the growth, flowering and bulb yield of tuberose.

Considering the situation of the present experiment further studies in the following areas may be suggested:

1. Such study is needed in different agro ecological zones (AEZ) of Bangladesh for regional adaptability and other performances.
2. Higher levels of nitrogen i.e.> 205 kg N/ha may be used in the treatments for further study for identify better performance.
3. Higher levels of potassium i.e. >200 kg $K_2 0$ /ha may be used for further study to get better result.

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APPENDICES

APPENDICES

Appendix I: Monthly recorded of year temperature, rainfall, relative humidity and sunshine hours during the period from March, 2008 to February, 2009

Year	Month	Average air temperature (^{0}C)			Total rainfall (mm)	Average relative humidity (%)	Total sunshine hours
		Maximum	Minimum	Mean			
2008	March	34.6	16.5	26.6	45	67	5.9
	April	36.9	19.6	29.2	91	64	8.5
	May	36.7	20.3	29.3	205	70	7.7
	June	35.4	22.5	28.7	577	80	4.2
	July	36.0	24.6	28.5	563	83	3.1
	August	36.0	23.6	28.8	319	81	4.0
	September	34.8	24.4	28.9	279	81	4.4
	October	34.8	18.0	27.1	227	77	5.8
	November	32.3	16.3	23.7	0	69	7.9
	December	29.0	13.0	20.4	0	79	3.9
2009	January	28.1	11.1	19.7	1	72	5.7
	February	33.9	12.2	23.3	1	55	8.7

Source: Bangladesh Meteorological Department (Climate Division) Agargaon, Dhaka- 1207.

Appendix II: Soil characteristics of Horticulture farm of SAU analyzed by Soil Resources Development Institute (SRDI), Khamar Bari, Farmgate, Dhaka

A. Morphological characteristics of the experimental field

Morphological features	**Characteristics**
Location	Horticulture Farm, SAU, Dhaka
AEZ	Modhupur Tract (28)
General Soil Type	Non-calcarious
Land type	High
Soil Series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained
Cropping pattern	Fallow- Tuberose

B. Physical and chemical properties of the initial soil

Characteristics	Value
Particle size analysis	
% Sand	27
% Silt	43
% Clay	30
Textural class	Silt-clay loam
p^H	5. 6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total- N (%)	0.30
Available P (ppm)	20.00
Exchangeable K (meg/100g soil)	0.10
Available S (ppm)	45

Source: SRDI, 2008

Appendix III: Analysis of variance of the data on plant height and number of leaves per plant (Mother bulb) as influenced by different levels of nitrogen and potassium of tuberose

Source of variation	Degree of freedom	Mean Square									
		Plant height					Number of leaves per plant (Mother bulb)				
		25 DAP	50 DAP	75 DAP	100 DAP	125 DAP	25 DAP	50 DAP	75 DAP	100 DAP	125 DAP
Replication	2	2.15	3.38	2.40	2.22	2.21	0.00	0.16	0.03	0.16	0.46
Nitrogen (N)	3	525.36**	699.37**	929.90**	994.24**	1100.29**	35.10**	66.79**	54.12**	98.47**	157.70**
Potassium (K)	3	37.54**	45.55**	64.95**	59.58**	81.50**	2.20**	4.66**	5.82**	6.80**	9.58**
Interaction (N x K)	9	0.80**	0.22**	2.83**	0.90**	3.03**	0.07**	0.11**	0.68**	0.35**	0.10**
Error	30	0.07	0.05	0.15	0.05	0.06	0.02	0.03	0.01	0.02	0.03

** Significant at 1% level of probability

Appendix IV: Analyses of variance of the data on number of side shoot per plant and breadth of leaf as influenced by different levels of nitrogen and potassium of tuberose

Source of variation	Degree of freedom	Mean Square									
		Number of side shoots per plant					Breadth of leaf (cm)				
		25 DAP	50 DAP	75 DAP	100 DAP	125 DAP	25 DAP	50 DAP	75 DAP	100 DAP	125 DAP
Replication	2	0.04	0.03	0.07	0.10	0.28	0.00	0.00	0.00	0.03	0.01
Nitrogen (N)	3	16.17**	31.01**	33.50**	36.61**	79.57**	1.01**	0.95**	1.17**	1.60**	1.82**
Potassium (K)	3	1.44**	2.13**	2.70**	3.89**	6.67**	0.09**	0.16**	0.18**	0.25**	0.30**
Interaction (N x K)	9	0.13**	0.08**	0.14**	0.43**	0.63**	0.02**	0.04**	0.08**	0.09**	0.08**
Error	30	0.01	0.02	0.01	0.01	0.02	0.00	0.00	0.00	0.02	0.00

** Significant at 1% level of probability

Appendix V: Analysis of variance of the data on flowering as influenced by different levels of nitrogen and potassium of tuberose

Source of variation	Degree of freedom	Mean Square						
		Length of spike (cm)	Diameter of spike (cm)	Length of rachis (cm)	No. of florets per spike	Weight of single spike (g)	No. of spikes/ ha ('000)	Flower yield (t/ha)
Replication	2	3.86	0.01	0.03	0.21	4.83	0.40	0.54
Nitrogen (N)	3	1213.67**	0.45**	60.60**	93.74**	1554.36**	51330.41**	570.80**
Potassium (K)	3	87.39**	0.04**	7.28**	12.48**	97.29**	3539.63**	39.36**
Interaction (N x K)	9	0.88**	0.00**	0.69**	1.77**	1.31**	174.50**	2.45**
Error	30	0.28	0.00	0.11	0.12	0.37	6.75	0.06

** Significant at 1% level of probability

Appendix VI: Analysis of variance of the data on bulb production as influenced by different levels of nitrogen and potassium of tuberose

Source of variation	Degree of freedom	Mean Square										
		No. of bulblets/ mother bulb	Length of large bulb (cm)	Length of medium bulb (cm)	Length of small bulb (cm)	Diameter of large bulb (cm)	Diameter of medium bulb (cm)	Diameter of small bulb (cm)	Fresh weight of bulb/hill (g)	Dry weight of bulb/100 g	No. of bulbs /ha ('000)	Yield of bulb (t/ha)
Replication	2	0.28	0.01	0.01	0.00	0.00	0.02	0.00	9.18	1.56	17639.97	0.57
Nitrogen (N)	3	108.62**	5.77**	4.68**	2.62**	2.13**	1.27**	0.88**	5698.84**	1485.04**	6788935.55**	355.96**
Potassium (K)	3	12.76**	0.71**	0.71**	0.62**	0.36**	0.15**	0.11**	737.07**	203.35**	797286.24**	46.05**
Interaction (N x K)	9	1.24**	0.10**	0.14**	0.26**	0.15**	0.02**	0.01**	101.73**	28.55**	77193.65**	6.36**
Error	30	0.05	0.01	0.00	0.00	0.00	0.01	0.00	0.43	0.55	3264.97	0.03

** Significant at 1% level of probability

AppendixVII: Production cost of tuberose per hectare

A. Input cost

Interaction (Nitrogen × Potassium)		Labour cost	Ploughing cost	Bulb cost	Irrigation cost	Insecticide cost	Manures and Fertilizer cost				Miscell aneous cost	Sub Total (A)
							Cowdung	Urea	MP	TSP		
0 kg N/ha	0 kg K_20/ha	38500	1235.00	4800	3000	3000	25000	0	0	21000	10000	106535
	180 kg K_20/ha	38500	1235.00	4800	3000	3000	25000	0	21700	21000	10000	128235
	190 kg K_20/ha	38500	1235.00	4800	3000	3000	25000	0	22890	21000	10000	129425
	200 kg K_20/ha	38500	1235.00	4800	3000	3000	25000	0	24080	21000	10000	130615
185 kg N/ha	0 kg K_20/ha	38500	1235.00	4800	3000	3000	25000	4824	0	21000	10000	111395
	180 kg K_20/ha	38500	1235.00	4800	3000	3000	25000	4824	21700	21000	10000	133059
	190 kg K_20/ha	38500	1235.00	4800	3000	3000	25000	4824	22890	21000	10000	134249
	200 kg K_20/ha	38500	1235.00	4800	3000	3000	25000	4824	24080	21000	10000	133439
195 kg N/ha	0 kg K_20/ha	38500	1235.00	4800	3000	3000	25000	5088	0	21000	10000	111623
	180 kg K_20/ha	38500	1235.00	4800	3000	3000	25000	5088	21700	21000	10000	133323
	190 kg K_20/ha	38500	1235.00	4800	3000	3000	25000	5088	22890	21000	10000	134513
	200 kg K_20/ha	38500	1235.00	4800	3000	3000	25000	5088	24080	21000	10000	135703
205 kg N/ha	0 kg K_20/ha	38500	1235.00	4800	3000	3000	25000	5352	0	21000	10000	121887
	180 kg K_20/ha	38500	1235.00	4800	3000	3000	25000	5352	21700	21000	10000	133587
	190 kg K_20/ha	38500	1235.00	4800	3000	3000	25000	5352	22890	21000	10000	134777
	200 kg K_20/ha	38500	1235.00	4800	3000	3000	25000	5352	24080	21000	10000	135967

Labour 350 @ 110/Capita/day
Bulb : Tk. 2.0/Piece (Average)

Cowdung : @ Tk. 1000/t
Urea :@ Tk. 12/kg
Mp : @ Tk. 70/kg
TSP : @ Tk. 70/kg

Appendix: Production cost of tuberose per hectare

B. Overhead cost

Nitrogen × Potassium		Cost of lease of land for 1 year (13% of value of land Tk. 600000)	Miscellaneous Cost (Tk. 5% of the input cost)	Interest on running capital for 1 year (Tk. 13% of total input cost)	Subtotal Tk. (B)	Total cost of production (Tk./ha) [Input cost (A) + Overhead cost (B)]
0 kg N/ha	0 kg K_20/ha	7800.00	5327	13850	97177	203712
	180 kg K_20/ha	7800.00	6412	16671	101083	229318
	190 kg K_20/ha	7800.00	6471	16825	101296	230721
	200 kg K_20/ha	7800.00	6531	16980	101511	232126
185 kg N/ha	0 kg K_20/ha	7800.00	5568	14477	98045	209404
	180 kg K_20/ha	7800.00	6653	17298	101951	235010
	190 kg K_20/ha	7800.00	6712	17452	102164	236413
	200 kg K_20/ha	7800.00	6772	17607	102379	237818
195 kg N/ha	0 kg K_20/ha	7800.00	5581	14512	98093	209716
	180 kg K_20/ha	7800.00	6666	17332	101998	235321
	190 kg K_20/ha	7800.00	6726	17487	102213	236726
	200 kg K_20/ha	7800.00	6785	17641	102426	238129
205 kg N/ha	0 kg K_20/ha	7800.00	6094	15845	99939	221826
	180 kg K_20/ha	7800.00	6679	17366	102045	235632
	190 kg K_20/ha	7800.00	6739	17521	102260	237037
	200 kg K_20/ha	7800.00	6798	17675	102473	238440