INFLUENCE OF PLANT SPACING AND PLANT GROWTH REGULATORS ON GROWTH AND YIELD PERFORMANCE OF TUBEROSE (*Polianthes tuberosa*)

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*This is to certify that the thesis entitled, "INFLUENCE OF PLANT SPACING AND PLANT GROWTH REGULATORS ON GROWTH AND YIELD PERFORMANCE OF TUBEROSE (Polianthes tuberosa L.) submitted to the Department of Horticulture and Postharvest Technology , Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE IN HORTICULTURE embodies the result of a piece of bona-fide research work carried out by **Md.Selimur Rahman, Registration No. 02633** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

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Dedicated to

My

Beloved Parents

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ABSTRACT

An experiment (RCBD) was conducted at the Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka during May 2007 to April 2008 to study the effect of spacing (S_1: 20 x 15 cm, S_2: 20 x 20 cm and S_3: 20 x 25) and GA_3 (G_0: 0 ppm, G_1: 220 ppm, G_2: 240 ppm and G_3: 260 ppm) on growth, bulb and flower yield of tuberose. The widest plant spacing result in the highest bulb yield (9.61 t/ha) and flower yield (10.19 t/ha) whereas the closest plant spacing produced the lowest. Plant growth regulator (GA_3) had also significant influence on the yield of tuberose. The higher level of GA_3 (260 ppm GA_3) performed the highest bulb (9.81 t/ha) and flower (11.60 t/ha) production. In respect of combined effect, the widest plant spacing (20 x 25 cm) with the highest level of GA_3 (260 ppm GA_3), produced the highest (9.71t/ha) yield of bulb and flower (10.89 t/ha).The lowest was recorded from the treatment combination of S_0G_0. Considering above findings the widest plant spacing (20 x 25 cm) with the highest level GA_3 (260 ppm GA_3) may be used for tuberose cultivation

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ABBREVIATIONS AND ACRONYMS

DAP	= Days After Planting
N	=Nitrogen
P	=Phosphorus
K	= Potassium
RH	=Relative Humidity
et al.	= and others
Viz.	= Namely

CHAPTER 1
INTRODUCTION

CHAPTER I

INTRODUCTION

Tuberose (*Polianthes tuberosa* L.) belonging to the family Amaryllidacaae, produce attractive, elegant and fragrant white flowers. It occupies a very selective and special position to flower loving people because of its prettiness, elegance and sweet pleasant fragrance. It has a great economic potential for cut flower trade and essential oil industry (Sadhu and Bose, 1973). The flowers remain fresh for quite a long time and stand distance transportation and fill a useful place in the flower market (Desai, 1957).

The long spikes of tuberose are used for vase decoration and bouquet preparation and the florets for making artistic garlands, ornaments and buttonhole use. The flowers emit a delightful fragrance and are the source of tuberose oil. The natural flower oil of tuberose is one of the most expensive perfumer's raw materials.

Tuberose is a native of Mexico from where it spread to the different parts of the world during 16th century. How and when the tuberose found its entrance to India, Cylon and elsewhere in the Orient is probably is probably an unanswerable question (Yadav and Maity, 1989). Now a day, it is cultivated on large scale in France, Italy, South Africa, USA and in many tropical and sub-tropical areas, including India even Bangladesh.

In Bangladesh, its commercial cultivation was introduced during 1980 by some pioneer and innovative farmers at Panishara union of Jhikorgacha thana under Jessore district. Due to multi use, it holds a high demand in the market and its production is appreciable (Aditya, 1992).

Although tuberose is now under cultivation in the country, very little knowledge of production technology is at hand to the growers (Ahmed, 1985).

There are many factors which can affect the plant growth and economic cultivation of tuberose. Spacing is of prime importance among the cultural factors which greatly influences the growth, bulbing and flower production. For economic production and good yield, proper spacing is to be determined. In case of low density, there is actually loss of land, labor and energy. When plants are grown at high density, competition occurs among plants for space, water, nutrient, light, carbondioxide and oxygen. Developmental process also depends on plant spacing. At closer spacing, flowering may occurs early before the completion of full vegetative growth, often senescence starts earlier and develops faster at wider plant spacing (Vandor Valk & Timmer, 1974). In case of tuberose, number of flower spikes per plant and bulb production increases with spacing (Mukhopdahyay *et al.*1986). However, there are reports that the maximum production of bulbs can be achieved from higher plant spacing (Cirrito and Zizzo, 1980).

Application of certain growth substances has been found to influence the growth and flowering of tuberose (Bose and Yadav, 1998). Mukhopdahyay and Banker (1983) sprayed the plants of cv. Single with GA_3 and observed that GA_3 increased spike length and number of flower per spike. Duration of flower in the field was improved with GA_3. According to Dhua *et al.* (1987), treatment with GA_3 caused earliest flowering and gave the maximum yield of spikes and flowers.

In Bangladesh, a little work has been done in respect of plant spacing and use of plant growth regulator for tuberose cultivation. So, research work is lack about the production technique of tuberose. Considering the facts, such research is very important for the greater interest of the scientist as well as the growers of our country.

The present study is, therefore, undertaken with the following objectives:

1. to find out the suitable plant spacing of tuberose in order to get a maximum growth, flower and bulb yield.
2. to determine the appropriate combination of plant spacing and growth regulator for ensuring the growth, flower and bulb production of tuberose.

CHAPTER 2
REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

Tuberose is one of the most important cut flower in the world. Many research works has been done on various aspects of this important cut flower in different countries of the world. However, a limited research works has been carried out on this flower under Bangladesh condition. A review of literature related to the present study has been presented in this chapter.

2.1 Effect of plant spacing on the growth, bulb and flower production in tuberose

Singh and Sangama (2000) noted the effect of seven plant spacing, viz. 30 X 30, 30 X 20, 30 X 10, 20 X 20, 20 X 12.5, 20 X 10 and 20 X 8.5 cm, on vegetative growth, flowering and postharvest quality of cut spikes in tuberose cv. Single was investigated at Bangalore, Karnataka, India, during 1997-98. Wider spacing resulted in longer rachis and heavier individual florets. Closer spacing produced higher yield of cut flower and loose flower per plot basis. Wider and closer spacing have vice versa effect on above floral parameters. Rest of the studied parameters namely, plant height number of leaves per clump, spike length, diameter of second floret, flowering duration under field condition and number of florets per spike and their corresponding weight and post harvest quality of cut flower were not influenced significantly by the plant densities.

Patel *et al,* (1997) conducted with three spacing (45 X45 cm, 45 X30 cm or 45 X15 cm) and 4 fertilizer rates (5 kg organic manure/m^2 or NPK at 100+50+0, 200+100+50 or 300+ 200+100 kg/ha) were compared in trials in Navsari, Gujarat, India, in 1992-95 with Polianthes tuberosa (cv.

Double) grown for cut flower. Neither plant height nor leaf width was affected by the different spacing or fertilizer treatments. Leaf number was highest with the widest spacing and highest NPK fertilizer rate. The field of flower spikes/plant was similar in all treatments but the yield/ha was highest at the closest spacing (1047530 spikes/ha). Flower spike length and the number of florets/spike were highest and the closest spacing with the highest NPK rate. The highest cost benefit ratios were obtained with the closest spacing (45 cm X15cm) and the highest NPK rate or organic manure.

A filed experiment was conducted by Balak *et al.*(1999) during 1994-96 at Bantha Research Station, Lucknow, India, to determine the N and plant spacing requirements of (*Polianthes tuberosa* L.), grown in sodic soil. Application of 180kg N/ha with a plant spacing of 45 X 30 cm significantly influenced growth (plant height, leaf area, number of spikes and spike length), and was the best treatment for promoting flower yield.

The N, P and K uptake by *Polianthes tuberosa* cv. Single was studied in an experiment conducted by Mohanty *et al.*, (1999) in Bapatla, Andhra Pradesh, India. Treatments consisted of 3 intrarow spacing 10 (S_1), 20 (S_2) and 30 (S_3) cm, keeping a constant interrow spacing of 30 cm; and /or 4 NPK application rates (100kg N +50kg P_20_5 +50 kg K_20/ha (F_1), 175 kg N+ 75kg P_20_5 + 75 g K_20/ha (F_2), 250 kg N + 100 kg P_20_5 + 100 kg K_20/ha (F_3), and 325 kg N +125 kg P_20_5 + 125 kg K_20/ha (F_4). F_4,S_3 and its combination resulted in the highest N,P and K uptake, both at 50% flowering stage and harvesting stage.

Sunil and Singh (1998) conducted, 2- year experiments at Kanpur, P tuberosa bulbs of diameter 11.5-2.0,2.1-2.5 or 2.6-3.0 cm were planted at spacing of 20 X20, 30 X 20 or 30 X30 cm given N at 0, 100, 200 or 300 kg /ha. Bulb yields increased with increasing N rate and initial bulb size and with wider spacing.

Singh and Sangama (2000) studied the N, B and K uptake by *Polianthes tuberosa* cv. Single conducted in Bapatla, Andhra Pardesh, India. Treatments consisted of 3 intrarow spacing (10(SI), 20 (S2) and 30 (S3) cm), Keeping a constant interrow spacing of 30 cm; and / or 4 NPK application rates (100 kg N+ 50 kg P205 + 50 kg K20/ha (F1). 175 kg N+ 75 kg P205 + 75 kg K20/ha (F2), 250kg N + 100 kg P205+ 100kg K20/ha (F3), and 325 kg N + 125kg P205 + 125 kg K20/ha (F4), F4,S3 and its combinations resulted in the highest N , P and K uptake , both at 50% flowering stage and harvesting stage.

Field experiments were conducted by Misra *et al.*(2000) to determine the effect of bulb size spacing on plant growth and flowering of two tuberose (*Polianthes tuberose* L.) cultivars (Single and Double) in Faizabad, Uttar Pradesh, India, during 1997 – 1998. Bulb size significantly influenced the initiation of spikes in both cultivars. The maximum days for spike initiation by smaller bulb size was 170.8 and 222.7 days for single and double cultivars, respectively. The larger bulb size produced the highest number of spikes/plant for both cultivars. With closer spacing, the plants took a longer time to produce spikes than wider spaced-plants. The number of spikes/plant was higher in wider spaced-plants. The spike length and number of florets decreased in closer spaced-plants. However, a bulb size of 2.60 – 3.00 cm at 30 x30 cm spacing was the best for both the cultivars.

Patil *et al.*(1987), conducted an experiment, they used rhizomes having 1.5 -2.5, 2.6 – 3.0 cm diameter15 x 20, 20 x 20 and 25 x 20 cm spacing and the plants are grown for three years for cut flowers. The highest yield of top quality flowers were obtained from the large rhizome planted at 15 x 20 cm.

Kumar *et al.*(2003) studied the effect of bulb size (<1.5, 1.5 – 2.5 or 2.5 – 3.5 cm in diameter), spacing (20 x20, 25 x 25, 30 x 30 cm) and planting depth (3, 6 or 9 cm) on growth and development of tuberose (*polianthes tuberosa* L. cv. Single) in Unium, Meghalaya, India, during 1998 and 1999. Sprouting was delayed with the increase in bulb size, planting depth and reduction in spacing. Large bulb resulted in the earliest spike emergence (93.89). Spike emergence was delayed with the increase of the planting depth. Spike length 88.78 and 89.37 cm and rachis lengths 19.76 and 20.06 cm were greatest with the medium and large size bulbs. The depth of planting was inversely related to flower quality in terms of spike and rachis length. Thus, the longest length of spike 89.52 cm and rachis length 19.48 cm were obtained with a planting depth with of 9 cm. The number of flower spike decreased with deep planting of small size of bulb at closer spacing. The number of floret/spike increased with the increase of spacing. Thus the highest number of florets/spike (33.70) was recorded from the spacing of 30 x 30 cm. This parameter, however, was independent of bulb size and planting depth. Increasing bulb size 2.5 cm and planting depth up to 9 cm increased bulb production.. Small bulb in combination with the widest spacing resulted in the earliest bulb sprouting 8.28 days, medium bulbs with moderate planting depth 6 cm and spacing 25 x 25 cm gave higher yield of flower and bulb.

Bulbs of tuberose cv. Single 1.5-2.0, 2.1-2.5 or 2.6-3.0 cm in diameter were planted as spacing of 20 X20, 30 X20 or 30 X30 cm by Sunil and Singh (1998) on 22 March 1991 or 15 march 1992 and given 0,100,200 or 300 kg N/ha as urea. The urea was applied half at planting and then as 2 top dressings 60 and 90 days later. Emergence was earliest from the smallest bulbs planted at the widest spacing and given the highest N rate. Cut flower field and quality and bulb production were greatest from the largest bulbs planted at the widest spacing and given the highest N rate.

2.1 Effect of growth regulator on the growth, bulb and flower production in tuberose

Singh *et al.* (2003) conducted an experiment in Meerut, Uttar Pradesh, India during 1997-98 on tuberose (*Palianthes tuberosa* L) cv. Double . The treatments comprised of water dipping (control); dipping in GA_3, IAA, and NAA at 50 and 100 ppm each; spraying GA_3 and 100 ppm each ; spraying GA_3, IAA., and NAA; and dipping + spraying GA_3, IAA, and NAA. The number of flowers, flower length, and longevity of the whole spike were highest for bulbs dipped in 100 ppm GA_3 for 24 hour before planting + spraying with 100 ppm GA_3 at 30 days after planting. Spike length and rachis length were also highest in bulbs dipped and sprayed with 100 ppm GA_3 at 100 ppm (dipping + spraying) increased the number (28.4), weight (90.52g), diameter (4.20cm), and yield (305.25 g/ha) of tuberose) .

Manisha *et al.* (2002) studied tuberose (*Polianthes tuberosa* L.) cv. Single in Varanasi, Uttar Pradesh,India, during 1999-2000. Treatments comprised of a control of foliar sprays of gibberelic acid (GA_3) at 100, 150 and 200 ppm at 40, 60 and 80 days after planting. Treatment with GA_3 at all concentrations promoted the height of the plants and increased the number of leaves per plant, being maximum (55.50 cm and 15.99, respectively) with 150 ppm application, Approximately 5 days early appearance of floral bud (96.82 days) over control (102.00 days) was also observed with this treatment. GA_3 at all concentrations significantly increased the number of spikes per plant, number of flowers per spike and per hectare yield. All these characters were maximum in plants applied with GA_3 at 150 ppm. Applications of GA_3 at all concentrations significantly increased the length of leaf, flower spike and rachis. Among the 3 concentrations of GA_3 used, 150 ppm was found the most superior.

Nagar *et al.*(2002) conducted an experiment of identify the effects of gibberellic acid (GA_3; 0,100,200, and 300 mg/litre) and nitrogen fertilizer (0,15,30, and 50 kg/feddan as ammonium nitrate), singly or in combination, on tuberose (*Polianthes tuberosa* cv. Double) in Alexandria, Egypt. during the summer seasons of 2000 and 2001. The roots were soaked in GA_3 for 24 month after planting and twice within the following 42 days. The application of 200 mg GA_3/litre+30 kg N/faddan resulted in the earliest flowering (109.30 days), and the greatest average plant height (99.34 cm), number of leaves per plant (51.85), leaf dry weight (14.88 g), number of spike per plant (4.94), number of florets per spike (29.91), flower duration (18.28 days), number of corms and cormels per clump (28.74), fresh and dry weights of corms and cormels per clump (121.72 and 8.67 g respectively), and total cholorophyll content (229.87 mg/100 g leaf fresh weight). The highest average floret dry weight (4.47 g) was obtained with 100 mg GA_3/ litre + 30 kg N/feddan, whereas the highest nitrogen content (3.92%) was obtained with 300 mg GA_3/ litre + 50 kg N/Feddan. The contribution ratio of N fertilizer on growth and yield increased with increasing N rate. The contribution ratio of soil N decreased with increasing N fertilizer rate but increased with increasing GA_3 rate.

Tiwari and Singh (2002), Conducted and experiment of identify the effects of bulb size, i.e. large (> 1.5 cm diameter), medium (1.0-1.5 cm), and small (<1.00 cm), and preplan ting soaking in gibberellic acid (GA_3) at 50, 100,150,200, and 250 ppm on the growth flowering, and yield of tuberose (Polianthes tuberosa) in Kanpur, Uttar Pradesh, India, during 1992-93. Plants raised from large bulbs had the greatest plant height, number of leaves per clump, leaf length, leaf width, foliage weight, clump weight, bulb and bulblets per clump, inflorescence length, spike length, flower length, spike diameter, flowers per spike, and spikes per plant, and showed easlist flowering. Similar results were recorded for plants from bulbs treated with 200 ppm GA_3, except for leaf width which was highest with 150 ppm GA_3. Large bulbs soaked in 200 ppm GA_3 showed significant increase in growth flowering and bulb production.

Wankhade *et al.* (2002) conducted and experiment during 2000-2001 to study the effect of gibberellic acid with bulb soaking treatment and foliar spray on growth, flowering and yield of tuberose (*Polianthes tuberosa L.*) Data indicated that higher concentration of GA_3 (150 ppm) for bulb soaking treatment and 200 ppm of GA_3 as a foliar spray showed significant increase in plant height, number of leaves, number of florets/spike and number of spikes/plant under study. Early sprouting, early emergence to flower stalk and early opening of the first pair of florets were recorded by bulb soaking in water and foliar spray of water and of these with control treatment combinations.

Wankhade *et al.* (2002) conducted a field experiment during 2000-2001 at the Collage of Agriculture, Nagpur, Maharashtra, India, to study the effect of GA_3(gibberellic acid) treatments (soaking of bulbs in 0,50,100, and 150 ppm as main treatments, and foliar spraying of 0,100,150, and 200 ppm as sub -treatments) on P, tuberose (P.tuberosa). Higher concentrations of bulb soaking treatment at 150 ppm, foliar spraying of GA_3 at 200 ppm, and the interaction of these two treatments showed significant increase in diameter and length of fully opened floret, length of rachis, diameter of spike, weight of floret per spike, number of spikes, and fresh weight of bulbs.

Yang *et al.*(2002) in a greenhouse experiment on *P.* tuberosa bulbs were treated with GA_3 (40 and 80 ml/litre at 4^0C for 30 days or at 30°C for 15 days before planting. Bulbs were planted in October, November and December. The tubers treated with low temperature and planted in October had high sprouting rates. The low temperature combined with gibberellic acid increased the flowering rate. The highest flowering rate was over 95%, with an average of 62%.

In a trial by Sanap *et al.* (2000) at Pune, tuberose plants were sprayed with 100,150 or 200 ppm GA_3 100,200 or 300 ppm CCC Chlormequat 40,5 and 70 days after planting. Flower yield was highest (27.5t/ha) when 150 ppmGA_3 at a concentration of 200 mg 1-1 stimulated shoot growth and consequently flowering in cooled derooted tulip bulbs.

Nagaraja *et al.* (1999) conducted an experiment to investigate the effect of growth regulators on the growth and flowering of tuberose (*Polianthes tuberosa*), cultivar Single. The tuberose bulbs were soaked for 24 hour in solutions of GA_3, Ethrel (ethephon) or BA each at 100,500, 1000 and 1500 ppm and then planted in a randomized block design. All treatments influenced growth and flowering characteristics. All treatments resulted in earlier plant emergence, a higher percentage of sprouting and eariler flowering compared-to the control with GA_3 at 500 and 1500 ppm being particularly) effective. Plant height was greatest with GA_3 at 100ppm while ethrel at all concentrations reduced plant height compared to the control. The number of spikes/plant and florest/spike were enhanced by GA_3 at 500 and 1500 ppm. All GA_3 treatments increased flower spike length and rachis length. Length of flowering was greatest with ethrel at 1000 ppm. All GA_3 treatments and etherl at 100ppm increased bulb number whereas all other etheral and all BA treatments reduced bulb number.

Deotale *et al.*(1995) observed that Chrysanthemum (cv.Raja) was sprayed with GA_3 at 0,50.100 or 150 ppm, as 2 applications 15 days after planting and again 1 month later. Planting on 24 June and spraying with 105 ppm GA_3 producted the heaviest (2.15g) and largest (6.42 cm diameter) flowers.

Leena *et al.*(1992) carried out an experiment at Kerala, India on Gladiolus (cv.Friendship during 1989-90 with TIBA (150 or 300 ppm) . NAA (100 and 200 ppm), CCC (Cholormequat (250 or 500 ppm) or GA_3 (50 or 100 ppm) applied a foliar spray at 4.6 and 8 weeks after planting. Control plants were sprayed with distilled water. The 100 ppm

GA_3 treatment resulted with the greatest plant growth and earliest flowering. The greatest flower spike length, rachis length and number of florest/spike were obtained with the 50 ppm GA_3 treatment. The greatest corm weight (70.20 g) and size (71.00cm2) were obtained with the 100ppm NAAA treatment. The greatest number and weight of cormels (93.33 and 17.57 g, respectively) were obtained with 500 ppm CCC treatment.

Dhua *et al*. (1987) and Pathak *et al*. (1980) found that soaking of bulb in GA_3, Ethrel, Kinetin and Thiourea solutions before planting improved the growth and flowering of tuberose among the different chemicals used. GA_3 and thiourea proved more effective than others. Thiourea promoted plant height and leaf number while GA_3 improved flowering. Treatment with GA_3 at 200 mg/litre caused earliest flowering and gave the maximum yield of spikes and flowers.

Dhua *et al*. (1978) reported that tuberose (P.tuberosa) is an important cut flower crop. Using rhizomes with a diameter between 1.50-2.0 cm. storage of rhizomes at 4-10°C for 10-30 days and soaking in GA_3 (200 mg/L) or thiorea (2000mg/L) solution for 6 hour improved plant growth and increased the yield of spikes and flower spikes and improved flower quality.

Gowda (1985) concluded that GA_3 spray on rose cv. Super star resulted in more number of flowers and longer stems which are the important characters of a good cut flower.

According to Biswas *et al*.(1983) the highest number of flower spikes 6/clump was obtained after foliar application of GA_3 at 1000 mg/litre, CCC at 0.2 ml/litre and the highest number of flower/ spike (46) was on plant sprayed with GA_3 at 100 mg/litre.

Mukhopadhyay and Banker (1983) sprayed the plants of cv. Single 40 days after planting and twice at fortnightly interval with GA_3 at 25-100 ppm or Ethephon at 500 to 2000 ppm observed that increasing concentration reduced the plant height. GA_3 increased the spike length and flower/spike. Duration of flowering in the field was improved with GA_3 at 100 mg/litre.

Jana and Biswas (1982) reported that the shortest time of flower opening 97 days occured in plants treated with 10 ppm GA_3 and the greatest of flower/spike 3.5-5 was on plants treated with 1000 ppm SADH.

Bose *et al.* (1980) conducted an experiment by soaking bulbs of *Hippeastrum hybridum(cyclamen)* in three concentrations of indolacetic acid, gibberellic acid, cycocel or ethrel and they showed various responses on growth and flowering as observed. GA_3 at 1000 ppm promoted the number of leaves. But other treatments did not exert any significant effect. Ethrel at 1000 ppm resulted in the maximum length of flower stalks, while higher concentrations of GA_3 increased the stalk length.

According to Rama Swami *et al.* (1979) application of certain growth substance has been found to influence the growth and flowering of tuberose. Soaking of sprouting bulbs for 1 hour in solution of 100 ppm GA_3 or 400 ppm CCC advanced the flowering by 17 and 15 days respectively.

El-shafie (1978) reported that spraying of GA_3 on rose four (4) times at monthly intervals at 250 ppm on cv. Montezuma increased the number of flower and the length , thickness and FW of flower stems compared to other concentration (50,100,150 and 200 ppm).

Rees (1975) noted that growth and development behaviour of bulbous plant is also regulated either by a single or by a interaction of several endogenous growth hormones like Gibberelins, Auxin, Cytokinin, Ethylene and Abscisic acid. They play a major role in directing the movements of organic metabolites in establishing. It is revealed from the above review of literatures that both yield and quality of tuberose are influenced by the bulb size and growth regulations used.

CHAPTER 3

MATERIALS AND METHODS

CHAPTER III

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 the Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from May 2007 to April 2008. The site is situated between $23^{0}74^{/}$ N latitude and $90^{0}35^{/}$E longitude with an elevation of 8.2 m from sea level.

3.2 Climate

The experimental area is situated in the subtropical zone, characterized by heavy rainfall during Kharif season (April to September), and scanty in Rabi season (October to March). Rabi season is characterized by plenty of sunshine. Information regarding average monthly maximum and minimum temperature, rainfall and relative humidity, soil temperature as recorded by the Dhaka meteorology centre, Agagoan, Dhaka, during the period of study have been presented in Appendix I.

3.3 Soil

The soil of the experimental area was n0n-calcarious dark grey and belongs to the Madhupur Tract (UNDP, 1988) under AEZ 28. The selected plot was medium high land and soil series was Tejgoan (FAO, 1988) with a pH of 5.6. The analytical data of the soil sample collected from the experimental area were analyzed in the SRDI, Soil Testing

Laboratory, Khamarbari, Dhaka and details of the soil characteristics are presented in Appendix II.

3.4 Treatments of the experiment

The experiment was designed to study the effect of different sizes of bulbs and different levels of potassium on growth, flower and bulb yield of tuberose. The experiment consisted of two factors which are as follows:

Design of the Experiment:

Randomized Complete Block Design:

Replications: 3 (Three)

Factor(s): 2

Factor (A): Plant spacing (3 levels):

S_1 : 20 x 15 cm
S_2 : 20 x 20 cm
S_3 : 20 x 25 cm

Factor (B):Plant growth regulator (4 levels)

G_0: 0 ppm GA3
G_1: 220 ppm GA3
G_2: 240 ppm GA3
G_3: 260 ppm GA3

There were altogether 12 treatment combinations such as: S_1G_0, S_1G_1, S_1G_2, S_1G_3, S_2G_0, S_2G_1, S_2G_2, S_2G_3, S_3G_0, S_3G_1, S_3G_2 and S_3G_3.

3.5 Experimental design and layout

The two-factor experiment was laid out following Randomized Complete Block Design (RCBD) with three replications. Total area (159.9 m^2) of the experimental land was divided into three equal blocks. Each block was divided in to 12 plots where 12 treatments were allotted at random.

Thus, there were 36 (12 ×3) unit plots altogether in the experiment. The size of each plot was 3.0 m ×1.8 m.

The distance between blocks and between plots was kept respectively 1 and 0.5 m. The layout of the experiment shown in figure in 1.

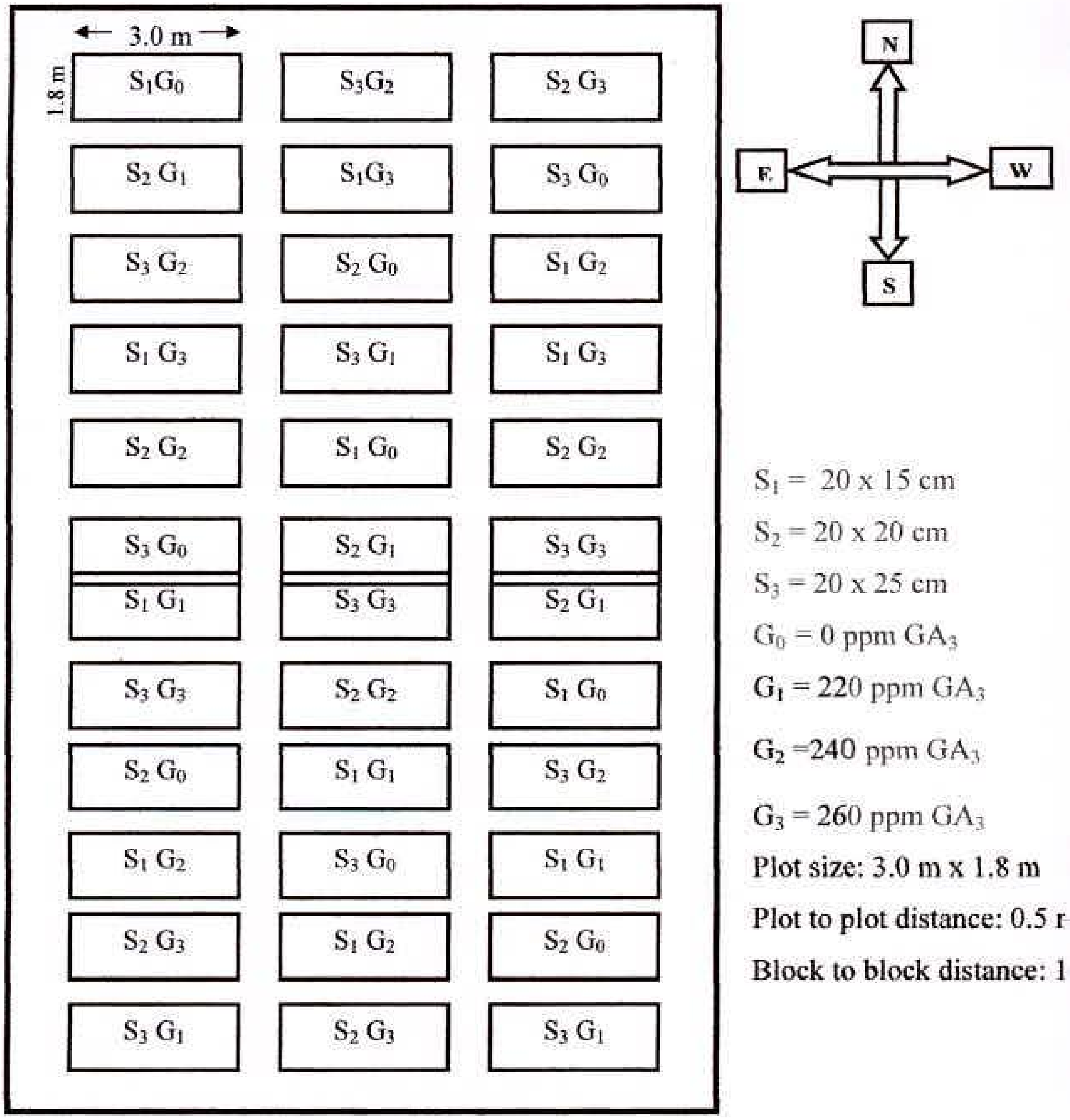

Figure 1. Field layout of the two factors experiment in the Randomized Complete Block Design (RCBD)

3.6 Land preparation

The land which was selected to conduct the experiment was opened on 15 April, 2007 with the help of a power tiller and then it was kept open to sun for 7 days prior to further ploughing. Afterwards it was prepared by ploughing and cross ploughing followed by laddering. Deep ploughing was done to have a good tilth, which was necessary for getting better yield of this crop. The weeds and stubbles were removed after each laddering. Simultaneously the clods were broken and the soil was made until good tilth.

3.7 Application of manures and fertilizer

The following doses of manures and fertilizers were used for tuberose production.

Manures/fertilizer	Doses per hectare
Cowdung	15 ton
Urea	260 kg
Triple Super Phosphate(TSP)	200 kg
Muriate of Potash (MP) as K_2O	250 kg

The entire amount of cowdung, TSP and half of urea were applied during final land preparation. The applied manures were mixed properly with the soil in the plot using a spade. The rest urea and MP were used as equal four top dressing. First top dressing was done 30 days after emergence of bulbs. Second and third were done after 30 days of first and second top dressing respectively. The last top dressing was done during first blooming of the 25% plants in each plot.

3. 8 Collection and planting of bulbs

The bulbs of tuberose were used in the experiment. The bulbs were collected from Barisal Nursery, Saver,Dhaka.

The bulbs were planted in the field on 5 May 2007. The bulbs were planted in raised bed placing upright and hole was made for each bulb upto the neck of bulbs at a distance of 20 cm, along the row spaced at a distance of 25 cm. Only one bulb was placed in each hole and covered with loose soil.

3.9 Intercultural operations

3.9.1 Weeding

The plots were kept from weeds by regular weeding. The weeds were eradicated very carefully with roots were done as per necessity.

3.9.2 Irrigation and drainage

Irrigation and drainage were done as necessity.

3.9.3. Pest management

Mole cricket, field cricket and cutworm attacks were a problem during seedling stage for tuberose cultivation. As a preventive measure against the insect pest, Dursban 20 EC was applied @ 0.2% at 15 days interval for three times starting from 20 days after emergence of bulb.

3.9.4 Diseases management

The crop was healthy and disease free and no fungicide were used.

3.10 Selection and tagging of plants and spikes

Ten plants from each plot were selected randomly for recording plant height, number of leaves per plant, number of side shoot per plant, number to days to first flowering, weight of bulb. Ten spikes from each plot were labeled with details of date of first flowering and after opening of basal floret to each spike. Spikes were labeled again with date for recording duration of flowering on plant. Ten spikes of each plot were selected randomly for three times for throughout the season for recording the length of spike, length of rachis, number of florets per spike and weight of spike.

3.10 Harvesting

The spikes were harvested when the basal floret opened and data were recorded for number spike per hectare and yield per hectare.

3.11 Data collection

Data on the following parameters were recorded from the sample plants during the course of experiment. Ten plants were sampled randomly from each unit plot for the collection of per plant data. The whole plot was harvested to record per plot data.

Data were collected on different growth and yield component and yield. The plants in the outer rows and at the extreme end of the middle rows were excluded from the random selection to avoid the border effect. The following observations were made regarding plant growth, yield and yield attributes as affected by different sizes bulbs and levels of potassium.

The following parameters were recorded.

3.11.1 Plant height

Plant height was measured in centimeter (cm) by a meter scale at 30, 55, 80, 105 and 130 DAP from the point of attachment of the leaves to the bulb (ground level) up to the tip of the longest leaf.

3.11.2 Number of leaves per plant (mother plant)

Number of leaves per plant of ten random selected plants were counted at 30,55, 80, 105 and 130 DAP. All the leaves of each plant were counted separately. Only the smallest young leaves at the growing point of the plant were excluded from the counting and the average number was recorded.

3.11.3 Length of leaf (cm)

Leaves were made detached by a sharp knife of ten random selected plants were measured at 30,55, 80, 105 and 130 DAP with a meter scale top to beneath of the leaf and average was taken in centimeter.

3.11.4 Number of side shoots per plant

Number of side shoot per plant was taken from ten random sample plants at 25, 50, 75, 100 and 125 DAP and average was recorded. Side shoot refers to those plants, which developed from the mother bulb, all the green shoot above the soil surface and adjoined to the mother plant were counted as side shoot.

4.11.5 Days to spike emergence

Days to spike emergence was recorded from planting to spike emergence.

3.11.6 Length of spike (mother bulb) (cm)

The average length of spike was measured from ten random selected plants in centimeter with the help of a meter scale from the basal (cutting) end of the spike to the last point of the tippest floret of the spike in each treatment.

3.11.7 Length of spike (side shoot) (cm)

The average length of spike which produced from side shoot was measured from ten random selected plants in centimeter with the help of a meter scale from the basal (cutting) end of the spike to the last point of the tippest floret of the spike in each treatment.

3.11.8 Diameter of spike (cm)

Diameter of spike from ten selected plants were measured with the help of a slide calipers after harvest and expressed in centimeter. Mean diameter was taken from top, middle and bottom portion of the harvested spikes.

3.11.9 Length of rachis (mother bulb) (cm)

Immediately after harvest, the length of rachis which raised from mother bulbs was measured with the help of a meter scale from ten random selected plants and mean was expressed in centimeter. Length of rachis refers to the length from the basal floret to the tip of the last floret.

3.11.10 Length of rachis (side shoot) (cm)

After harvest, the length of rachis which produced from side shoots were measured with the help of a meter scale from ten random selected plants and mean was expressed in centimeter. Which raised from mother bulb

3.11.11 Number of florets per spike (mother bulb)

At harvest, the number of florets per spike was counted and average was recorded which only produced from mother bulbs.

3.11.12 Number of spikes per hectare ('000)

Total number of spikes was counted from ten selected plants at each unit ($1.4m^2$) area of plot and was converted the total number of spikes per hectare

3.11.13 Weight of single spike (g)

After harvested spikes from ten selected plants were weighed and average was considered as weight of single spike which expressed in gram (g).

3.11.14 Weight of individual bulb

After colleted bulbs from ten selected plants were weighed and average was considered as weight of individual bulb which expressed in gram (g).

3.11.15 Yield of bulbs per hectare

The yield of bulbs per hectare was calculated in ton by converting the total yield of bulbs per plot.

3.11.16 Yield of flowers per hectare

The yield of flowers per hectare was calculated in ton by converting the total yield of flowers per plot.

3.12 Statistical analysis

The data collected from the experimental plots were statistically analyzed. The mean value for all the treatments was calculated and the analysis of variance for most of the characters was accomplished by F variance test. The significance of difference between pair of means was tested by the Duncan's Multiple Range Test (DMRT) test at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER 4

RESULTS AND DISCUSSION

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted to investigate the effect of different plant spacing and different levels of growth regulator on the growth, flower and bulb production of tuberose. The analysis of variances for different characters have been presented in Appendices IV and V. Data on different parameters were analyzed statistically and the results have been presented in Tables 1 to 9, plates 1 to 6 and figures 1 to 11. The results of the present study have been presented and discussed in this chapter under the following headings.

4.1 Effect of plant spacing and growth regulators on growth, flower and bulb production of tuberose.

4.1.1 Plant height

The plant height was recorded at different stages of growth i.e. 30, 55, 80, 105 and 130 days after planting (DAP). The plant height varied significantly due to sowing of different size of bulbs (Fig.2). During the period of plant growth stage, the longest plant was observed in S_3 (highest spacing; 20 x 25 cm). It was found that, the plant height gradually increased at all observations. However, at 130 DAP, the longest plant (67.77 cm) was obtained from S_3 and the shortest plant (58.15 cm) was obtained from the closest spacing at 20 x15 cm (S_1). Balak *et al.*(1999) reported that, wider spacing gave the longest plant height. The present investigation their statement.

The plant height varied also significantly due to application of different levels of potassium. The plant height of tuberose increased linearly with the increasing level of GA_3 (Fig 3). At 130 DAP, the longest plant (69.81 cm) was obtained from the highest level of GA_3 (G_3; 260 ppm of GA_3) and the shortest plant (56.33 cm) was obtained from the control level of GA_3 (G_0; 0 ppm of GA_3). The findings of the study also supported the results of Mukhopadyay and Banker (1983); Gowda *et al.* (1985).

The plant height was significantly influenced by the combined effect of different levels of spacing and plant growth regulator. The tallest plant (68.79 cm) was obtained from the treatment combination of S_3G_3 (highest spacing with and 260 ppm GA_3) while the shortest (57.24 cm) was found from S_1G_0 at 130 DAP (Table 1 and Appendix III).

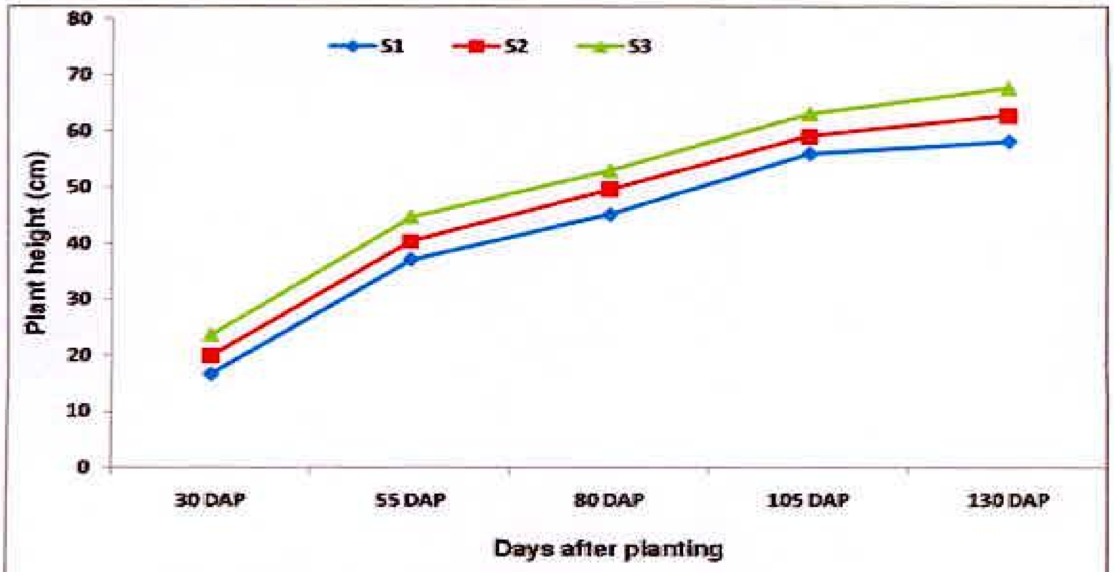

Figure 2: Effect of spacing on plant height of tuberose at different days after planting

S_1 = 20 x 15 cm
S_2 = 20 x 20 cm
S_3 = 20 x 25 cm

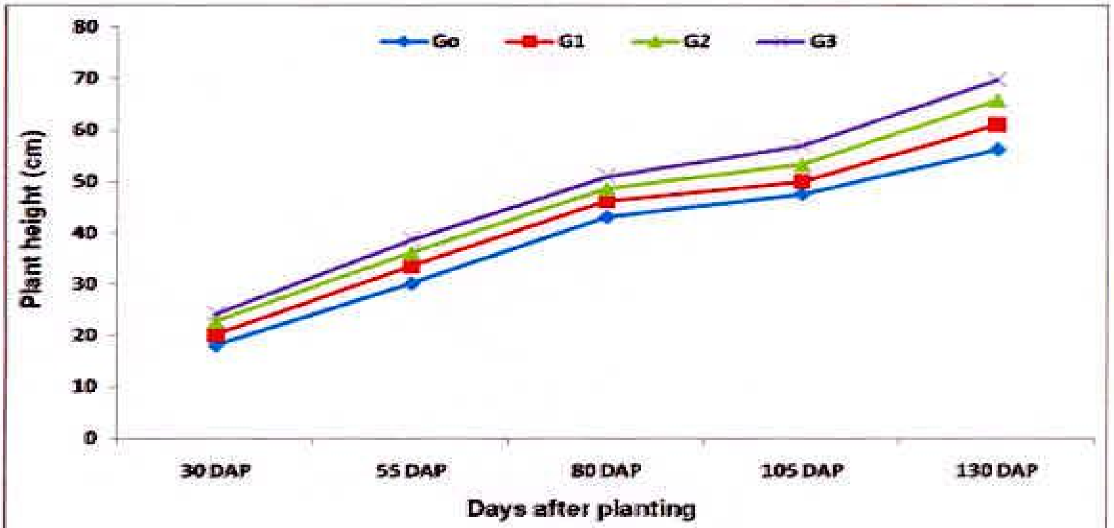

Figure 3: Effect of GA_3 on plant height of tuberose at different days after planting

G_0 = 0 ppm GA_3
G_1 = 220 ppm GA_3
G_2 = 240 ppm GA_3
G_3 = 260 ppm GA_3

Table 1. Combined effect of plant spacing and GA_3 on plant height of tuberose at different after planting

Treatments	30 DAP	55 DAP	80 DAP	105 DAP	130 DAP
S_1G_0	17.35f	33.61f	44.13h	51.85d	57.24f
S_1G_1	18.39e	35.32e	45.73g	53.06cd	59.66e
S_1G_2	19.75de	36.64cde	46.97f	54.72bc	62.04d
S_1G_3	20.44cd	36.92cd	48.13d	56.55b	63.98d
S_2G_0	19.10d	35.27e	46.41e	53.43cd	59.61e
S_2G_1	20.03cd	36.99cd	48.01d	54.64bc	62.03d
S_2G_3	21.38bc	38.31bc	49.26c	56.30b	64.41c
S_2G_4	22.07b	39.59ab	50.44b	58.13ab	66.35b
S_3G_0	20.89c	36.44b	48.09d	55.45bc	62.05d
S_3G_1	21.91b	39.15ab	49.69c	56.66b	64.47c
S_3G_2	23.26a	44.47ab	50.94b	58.32ab	66.85b
S_3G_3	23.95a	41.75a	52.09a	60.15a	68.79a
CV (%)	7.27	8.13	4.24	3.39	6.67
$LSD_{(0.05)}$	1.03	2.10	0.53	2.13	2.01
Level of significance	**	**	**	*	**

4.1.2 Number of leaves per plant (mother bulb)

Planting of different plant spacing significantly influenced on number of leaves per plant at different days after planting except 30 DAP (Fig. 4). At 30 DAP, the maximum number of leaves (7.02) per plant was produced by S_3 and the minimum number of leaves (4.93) was obtained from the small sized bulb. However, at 55 DAP, the highest number of leaves (11.41) per plant was found from highest plant spacing and the lowest number of leaves (6.91) per plant was obtained from the closest spacing of bulb plantation which was statistically similar to S_2 (8.22). However, at 130 DAT, the maximum number of leaves (27.82) was produced by S_3 and minimum number of leaves (23.33) per plant was recorded from S_1.

Significant variation was found in case of number of leaves per plant due to application of different levels of GA_3 at different days after planting except 30 DAP (Fig. 5). The number of leaves increased with the advancement of time. The maximum number of leaves (10.40) per plant was recorded from G_3 and the minimum (6.05) was from control condition at 55 DAP. At 80 DAP, G_3 the produced the maximum number of leaves (11.93) while the minimum number of leaves (7.94) per plant was counted from control treatment which were identical to G_2 (10.17) and G_1 (8.99). The maximum number of leaves (20.66) per plant was recorded from G_3 and the minimum (9.99) was from control condition at 105 DAP. At 130 DAP, G_3 (260ppm GA_3) produced the maximum number of leaves (24.99) while the minimum number of leaves (13.07) per plant was counted from G_0 (where the plots did not receive plant growth regulator). Such response may be accounted for the physiochemical and biological improvement occurred in the soil including favorable temperature and moisture regimes, nutrient availability. The higher number of leaves per plant achieved on account of higher level of plant growth regulator. The present findings also support the results of Wankhade *et al.* (2002).

The number of leaves per plant was significantly influenced by the combined effect of different levels of spacing and plant growth regulator only at 130 DAP. (Table 2 and Appendix IV). However, at 130 DAP, the highest number of leaves (26.40) per plant was recorded from the treatment combination S_3G_3. The lowest number of leaves (18.20) per plant was observed from S_1G_0 whereas, closest spacing of bulb planting and lower level of GA_3 were used.

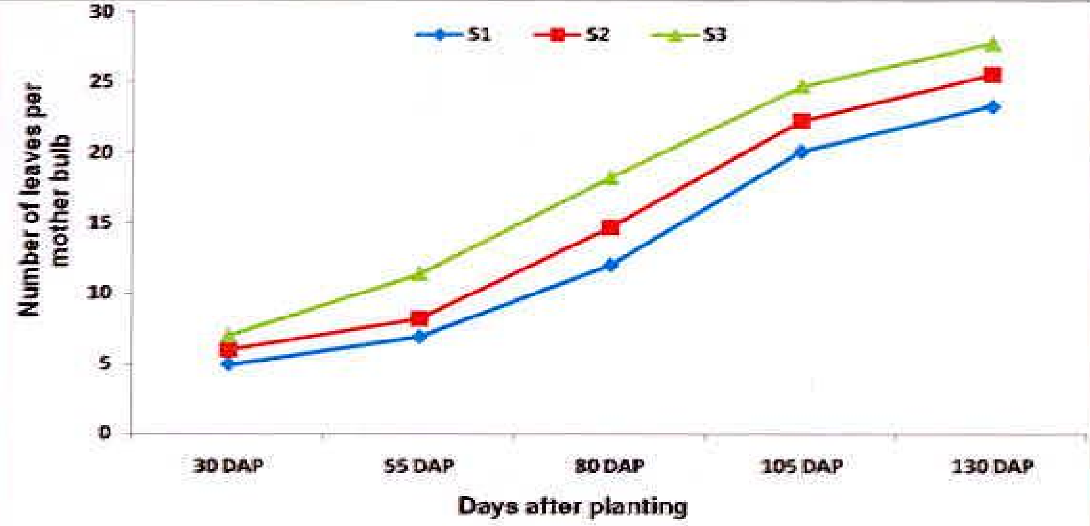

Figure 4: Effect of spacing on number of leaves per mother bulb of tuberose at different days after planting

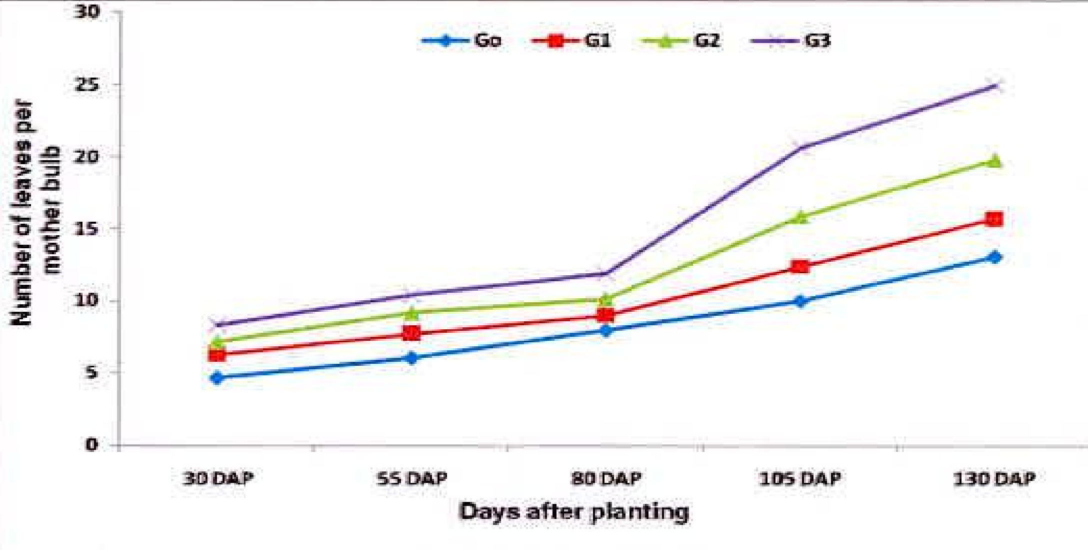

Figure 5: Effect of GA_3 on number of leaves per mother bulb of tuberose at different days after planting

Table 2. Combined effect of plant spacing and GA_3 on number of leaves of tuberose at different after planting

Treatments	30 DAP	55 DAP	80 DAP	105 DAP	130 DAP
S_1G_0	4.80	6.48	9.98	15.05	18.20
S_1G_1	5.60	7.31	10.51	16.27	19.55
S_1G_2	6.03	8.04	11.10	18.03	21.60
S_1G_3	6.61	8.65	11.98	20.39	24.16
S_2G_0	5.33	7.13	11.34	16.11	19.32
S_2G_1	6.13	7.96	11.85	17.33	20.67
S_2G_3	6.56	8.70	12.44	19.04	22.72
S_2G_4	7.41	9.31	13.32	21.46	25.28
S_3G_0	5.84	8.73	13.09	17.37	20.44
S_3G_1	6.64	9.56	13.62	18.59	21.79
S_3G_2	7.08	10.29	14.21	20.35	23.85
S_3G_3	7.65	10.90	15.09	22.71	26.40
CV (%)	6.96	7.29	8.92	6.67	9.90
$LSD_{(0.05)}$	3.75	4.99	6.99	7.91	2.11
Level of significance	NS	NS	NS	NS	*

4.1.3 Length of leaf

A significant variation was found due to use of different size of bulbs at 30, 55, 80, 105 and 130 days after planting (Fig 6). The longest leaf (21.12) was obtained S_3 while the lowest (12.16 cm) was found from S_1 at 25 DAP. At 55 DAP, the wider spacing (20 x25 cm) gave the longest (42.44 cm) length of leaf while the closest spacing (20 x15 cm) produced the shortest (32.81) length of leaf. At 80 DAP, the longest leaf length (51.96 cm) was produced by S_3 and the shortest (44.09 cm) was found from S_1. However, at 130 DAP, treatment S_3 performed the longest leaf length (60.99) and the shortest (52.14) was noted from S_1.

Due to application of different levels of GA_3 showed significant variation on length of leaf at 30, 55, 80, 105 and 130 DAP (Fig.7). However, at 130 DAP, the higher level of GA_3 (260 ppm) produced the longest leaf (62.92

cm) and the treatment G_0 gave the shortest leaf (55.63 cm). Monisha *et al.*(2002) showed the maximum length of leaf in all concentration of GA_3 compare to control treatment which agreed to the present study.

Due to the combined effect of different levels of plant spacing and plant growth regulator showed significant variation on length of leaf (Table 3 and Appendix V). At 130 DAP, the longest length of leaf (65.45 cm) was recorded from S_3G_3 (wider spacing and 260 ppm GA_3) whereas, the shortest (53.88 cm) was obtained from treatment combination of S_1G_0.

4.1.4 Number side shoots per plant

The number of side shoot varied significantly due to use of different levels of spacing at different days after planting (Fig 8). At 30 DAP; the highest number of side shoot (7.63) was recorded from the S_3 which was similar (5.88) to (S_2) while the lowest number of side shoots (3.78) per plant was found from S_1. Treatment S_3 gave the maximum (7.96) number of side shoots per plant and the minimum (4.40) was noted from the closest spacing (S_1) at 55 DAP. At 80 DAP, the maximum number of side shoots (9.01) was performed by S_3 whereas, the minimum (4.80) was found from S_1. The maximum number of side shoots per plant (12.01) was recorded from the widest plant spacing (20 x25 cm) and the lowest number of side shoots (8.52) was obtained from the closest plant spacing (S_1).

Application of different levels of GA_3 showed significant variation on number of side shoots per plant at days after planting (Fig 9). However, at 130 DAP, the higher level of GA_3 (260 ppm) produced the maximum number of shoots (11.82) and the lowest number of shoots (9.40) was counted from control treatment where the plot did not receive GA_3. Sanap (2000); Tiwari and Singh (2002) recorded, the number of side shoot varied due to the application of GA_3. The present investigation as in support to their statement.

The number of side shoot per plant was also varied due to the combined effect of different levels of plant spacing and plant growth regulator (Table 4 and Appendix VI). The maximum number of side shoots (11.91) was recorded from S_3G_3 whereas, the minimum (8.96) was obtained from treatment combination of S_1G_0, at 130 DAP.

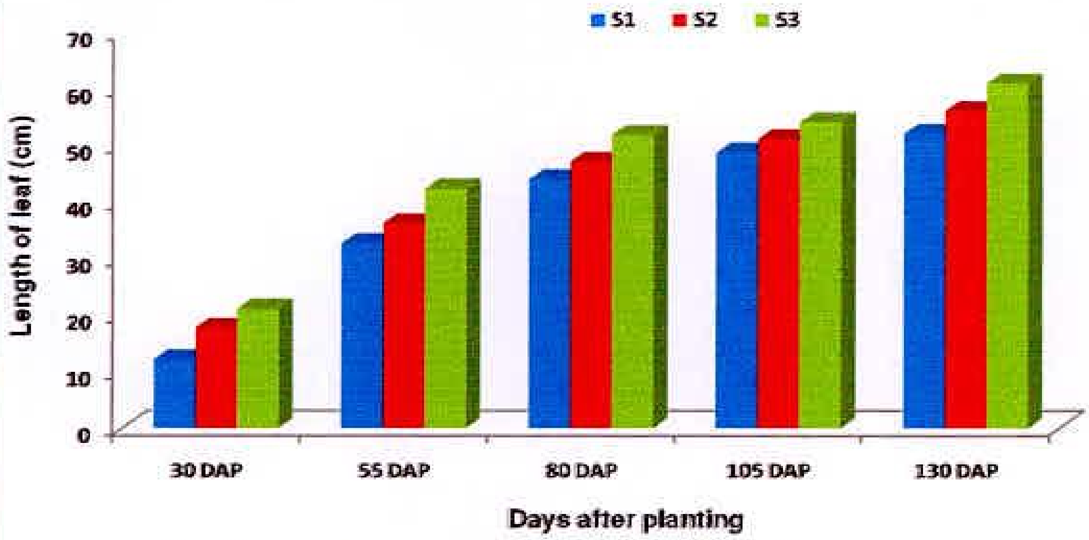

Figure 6: Effect of spacing on length of leaf (cm) of tuberose at different days after planting

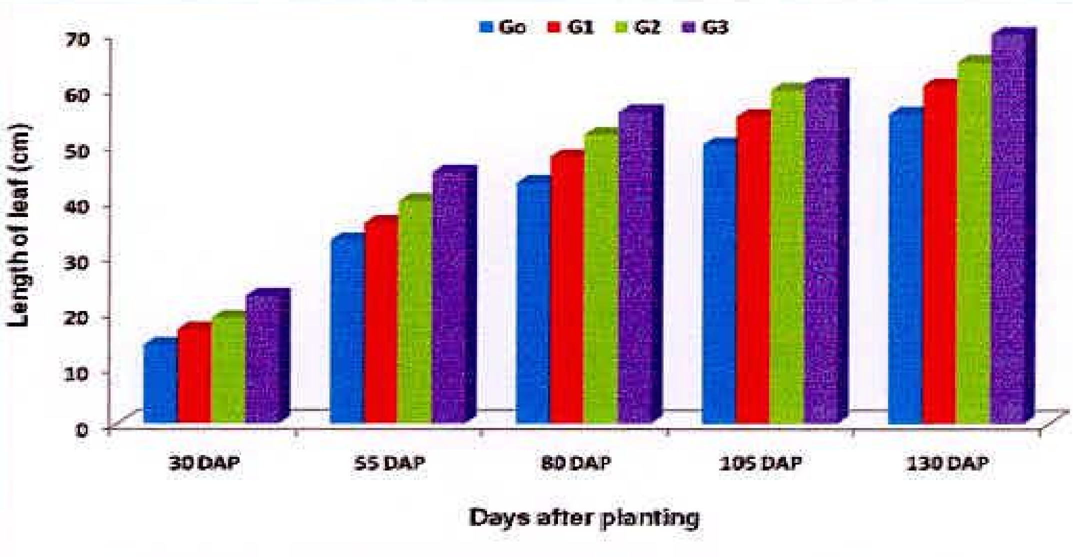

Figure 7: Effect of GA_3 on length of leaf (cm) of tuberose at different days after planting

Table 3. Combined effect of plant spacing and GA_3 on length of leaf of tuberose at different after planting

Treatments	30 DAP	55 DAP	80 DAP	105 DAP	130 DAP
S_1G_0	13.14h	32.92g	43.71f	49.48	53.88e
S_1G_1	14.53g	34.48f	46.04e	52.00	56.55ef
S_1G_2	15.57fg	36.43e	48.05c	54.35	58.30c
S_1G_3	17.58de	38.98c	50.04cde	54.87	61.03bc
S_2G_0	15.95a	34.67f	45.28e	55.70	55.91d
S_2G_1	17.35e	36.22e	47.61e	53.22	58.47c
S_2G_3	18.39cd	38.18cd	49.62bc	55.57	60.54bcd
S_2G_4	20.40b	40.73b	51.61bcd	56.09	63.05abc
S_3G_0	17.62de	37.74d	47.65e	52.17	58.31c
S_3G_1	19.01c	39.29c	49.98bc	54.70	60.87bc
S_3G_2	20.05b	41.25ab	51.98ab	57.04	62.94a
S_3G_3	22.06a	43.80a	53.97a	57.56	65.45a
CV (%)	8.12	3.78	6.64	9.45	8.85
$LSD_{(0.05)}$	1.02	1.28	2.03	8.95	2.78
Level of significance	**	**	**	NS	**

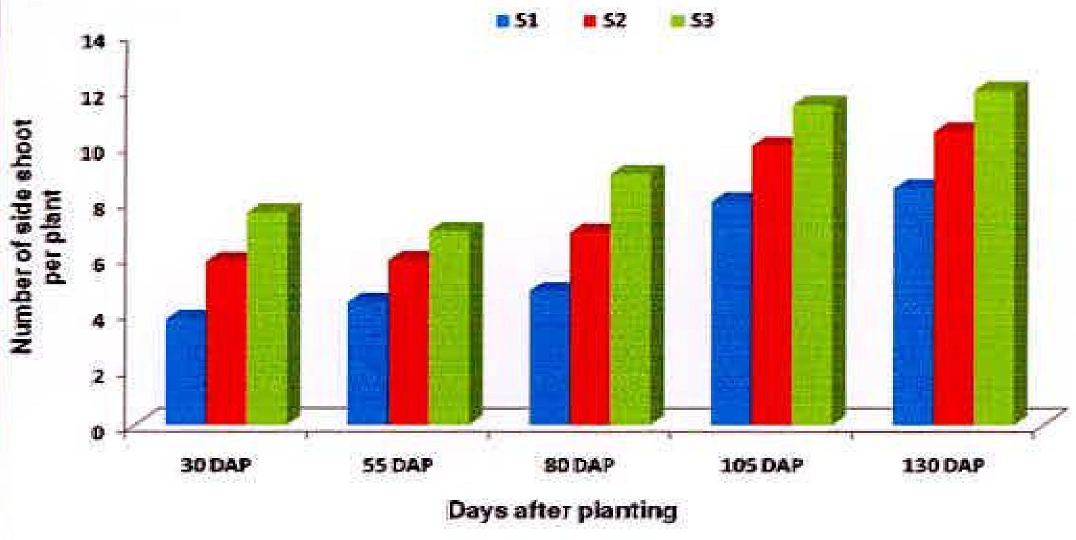

Figure 8: Effect of spacing on number of side shoot per plant of tuberose at different days after planting

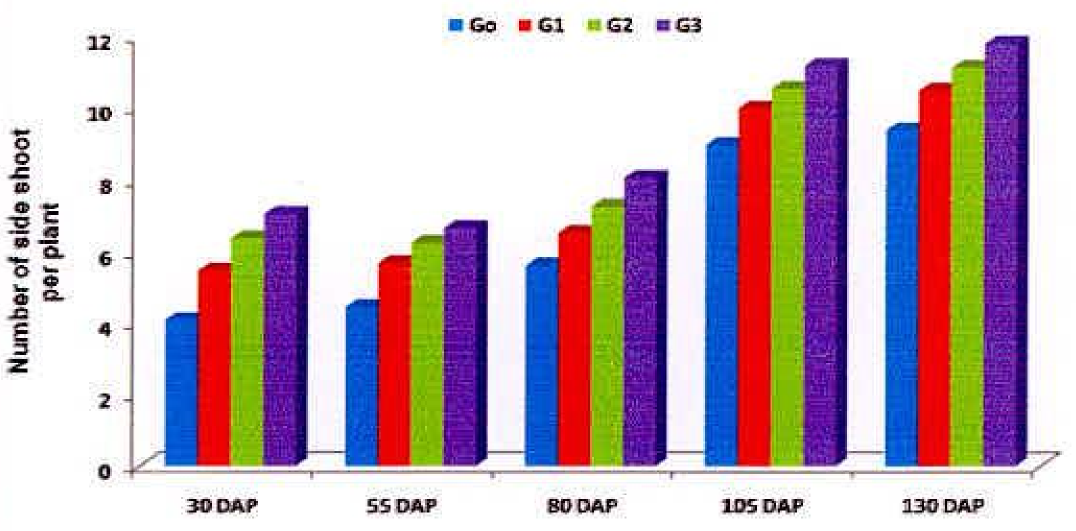

Figure 9: Effect of GA_3 on number of side shoot per plant of tuberose at different days after planting

Table 4. Combined effect of plant spacing and GA_3 on number of side shoot per plant of tuberose at different after planting

Treatments	30 DAP	55 DAP	80 DAP	105 DAP	130 DAP
S_1G_0	3.94i	4.43g	5.22j	8.51g	8.96h
S_1G_1	4.64h	5.07f	5.67i	9.01f	9.51g
S_1G_2	5.09gh	5.33ef	6.04h	9.29f	9.83fg
S_1G_3	5.42efg	5.54de	6.44g	9.61e	10.17ef
S_2G_0	4.99gh	5.19e	6.27gh	9.51ef	9.96f
S_2G_1	5.69de	5.81d	6.73f	10.02d	10.52e
S_2G_3	6.04cd	6.09cd	7.09e	10.29d	10.84cde
S_2G_4	6.07cd	6.30bc	7.49d	10.61c	11.15cd
S_3G_0	5.66c	5.71d	7.32de	10.25d	10.70e
S_3G_1	6.26bc	6.33bc	7.78c	10.75bc	11.26bc
S_3G_2	6.36ab	6.61ab	8.14b	11.03ab	11.58ab
S_3G_3	6.75a	6.82a	8.54a	11.35a	11.91a
CV (%)	9.65	7.76	6.39	4.56	5.87
$LSD_{(0.05)}$	0.46	0.41	0.26	0.31	0.37
Level of significance	**	**	**	**	**

4.1.5 Days to spike emergence

Days to spike emergence showed significant differences due to different plant spacing (table 5).The longest days (84.56 days) was required to spike emergence from S_3 while the shortest days (77.77days) were required for S_1.

Different levels of GA_3 also showed significant variation on days to spike emergence (Table 5). The highest period (85.05 days) was required for S_1 and the shortest period (75.01 days) was for S_3. Rama Swami (1997); Jana and Biswas (1992); Mohanthy *et al.* (1999) and Monisha *et al.* (2000) stated from their findings that, the plants required minimum days to spike emergence due to application of GA_3. The present investigation supported their results.

The combined effect of plant spacing and GA_3 did not show significant differences on days to spike emergence (Appendix VII). However, the maximum days (84.80 days) were counted for spike emergence from the treatment combination of S_1G_0 and the minimum (76.39 days) from S_3G_3 (Table 6)

4.1.6 Length of spike (mother bulb)

The length of spike showed significant differences due to different plant spacing (table 5 and plate 1). The longest length of spike (80.16 cm) was obtained from the widest spacing (S_3) while the shortest (70.72 cm) was recorded from closest spacing (20 x 15 cm).

Application of different levels of GA_3 showed significant variation on length of spike (Table 5 and plate 2). However, the higher level of GA_3 (260 ppm) produced the longest length of spike (85.30 cm) and the shortest length of spike (71.81 cm) was recorded from control treatment. The results of Balak *et al* (1999); El-shafie (1978) and Bose *et al.*(1980) also found similar trends of findings.

Due to the combined effect of spacing and GA_3 did not show significant variation on length of spike of mother bulb (Appendix VII). However, the longest length of spike (82.73 cm) was recorded from S_3G_3 (widest plant spacing and 260 ppm GA_3) whereas, the treatment combination of S_1G_0 produced the minimum (71.26 cm) length of spike.

Plate 1. Effect of plant spacing on length of spike in tuberose, produced from mother bulb

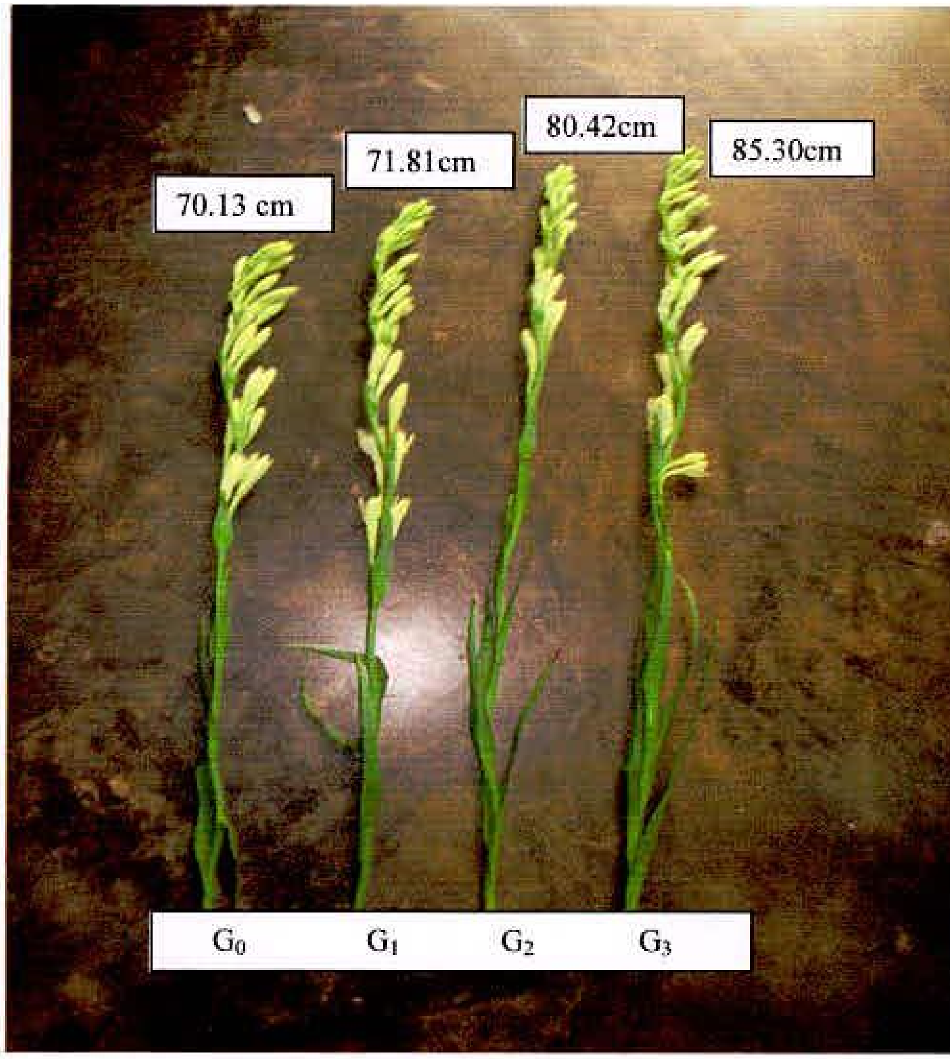

Plate 2. Effect of GA_3 on length of spike in tuberose produced from mother bulb

4.1.7 Length of spike (side shoot)

The length of spike of side shoot varied significantly due to planting of different size of bulbs at different days after sowing (Table 5 and plate 3). Treatment S_3 produced he longest length of spike (65.39 cm) while S_1 (closest spacing) showed the shortest (57.04 cm) length of spike. Kumer *et al.* (2003) also found similar trends of result.

Application of different levels of GA_3 showed significant variation on length of spike (Table 5 and plate 4). However, the higher level of GA_3 (260 ppm) produced the longest length of spike (70.65 cm) and the shortest length of spike (56.11 cm) was recorded from control treatment where the plot did not receive potassium fertilizer. The present investigation agreed to the findings of Misra *et al.* (2000); Mukhapadayay and Banker (1983).

There were no significant variations among different levels of plant spacing and GA_3 on length of spike of side shoot due to combined effect (Appendix vii). However, the longest length of spike (68.02cm) was obtained from S_3G_3 (20 x 25 cm spacing and 260 ppm GA_3) while the treatment combination of S_1G_0 gave the shortest length of spike (56.57 cm) of side shoot (Table 6).

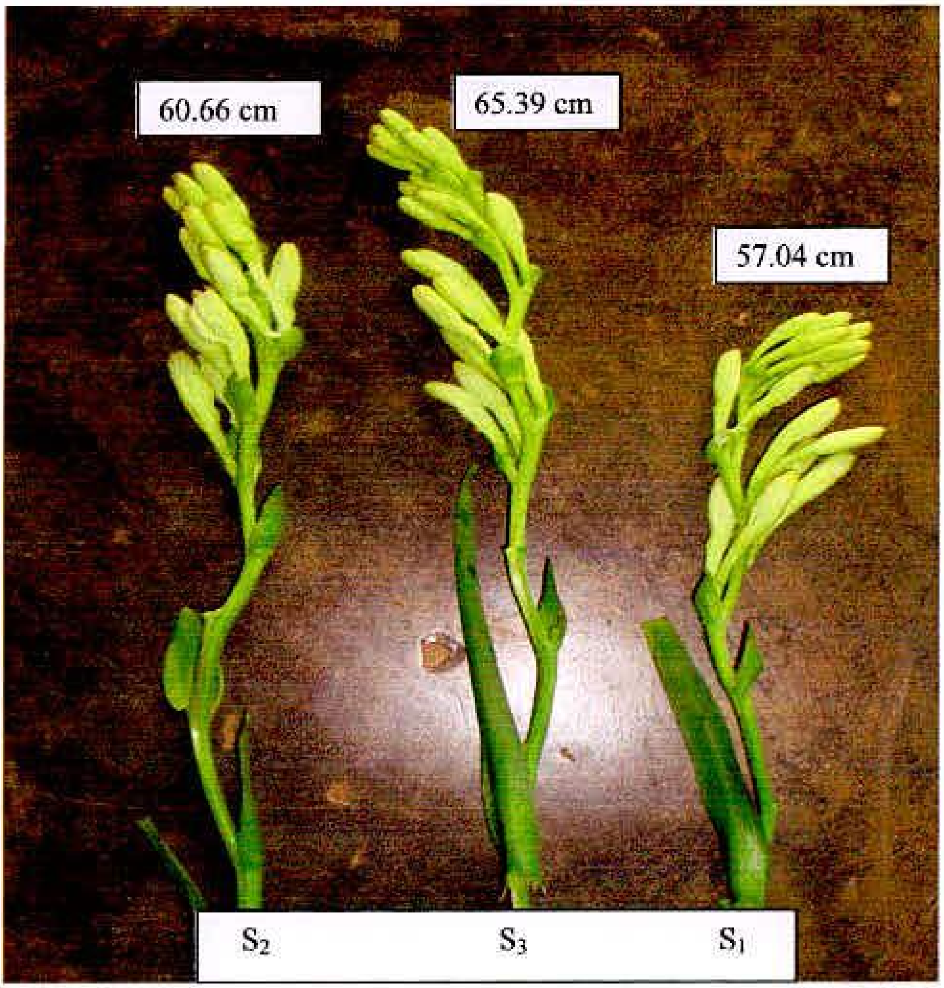

Plate 3. Effect of plant spacing on length of spike in tuberose, produced side shoot

Plate 4. Effect of GA_3 on length of spike in tuberose, produced from side shoot

4.1.8 Diameter of spike

Diameter of spike did not show the significant differences due to use of different size of bulbs (Table 5). The highest diameter spike (0.85 cm) was obtained from S3 while the lowest (0.74 cm) was recorded from S_1.

There was a significant variation on diameter of spike due to application of different levels of GA_3 (Table 5). However, the higher level of GA_3 (260 ppm) produced the highest diameter of spike (0.81 cm) and the shortest length of spike (0.71 cm) was recorded from control treatment. Tiwari and Singh (2002); Singh *et al.* (2003); Wankhade *et al.*(2002) found similar trends of results.

Combined effect of different levels of plant spacing and plant growth regulator did not perform the significant variation on diameter of spike (Appendix vii). The maximum diameter of spike (0.83 cm) was recorded from S_3G_3 (widest plant spacing and 260 ppm GA_3) whereas, the minimum (0.72 cm) was recorded from the treatment combination of S_1G_0 (Table 6).

4.1.9 Length of rachis (mother bulb)

A significant variation was found on length of rachis of mother bulb due to use of different size of bulbs (Table 5 and plate 5). The widest plant spacing (S_3; 20 x 25 cm) produced the longest length of rachis (25.99 cm) from mother bulb and the shortest (20.84 cm) was recorded from the closest

Plate 5. Effect of plant spacing on length of rachis in tuberose produced from mother bulb

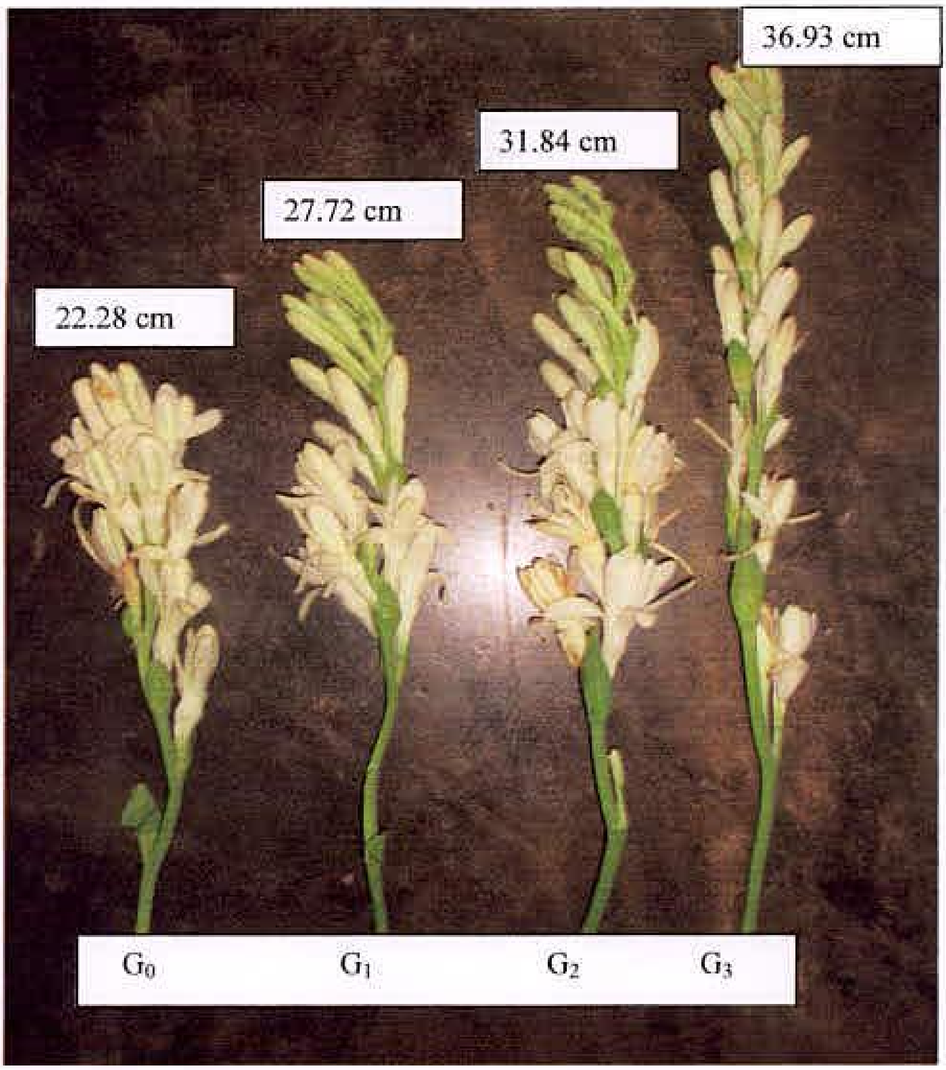

Plate 6. Effect of GA_3 on length of rachis in tuberose produced from mother bulb

spacing (S_1; 20 x 15 cm). The present study supported the findings of Singh and Sangama (2000).

Different levels of GA_3 showed significant variation on length of rachis (Table 5 and plate 6). The higher level of GA_3 (260 ppm) produced the highest length of rachis (36.93 cm) and the shortest length of rachis (22.28 cm) was recorded from control treatment.

There was no significant variation on length of rachis of mother bulb due to combined effect of different levels plant spacing and GA_3 (Appendix vi). The longest length of rachis (31.46 cm) was recorded from the treatment combination of S_3G_3 whereas, the minimum (21.56 cm) was recorded from the treatment combination of S_1G_0 (Table 6).

4.1.10 Length of rachis (side shoot)

Length of rachis showed significant differences due to use of different plant spacing in the present study (Table 5). The highest length of rachis (18.55 cm) was obtained from S_3 while the shortest (13.35 cm) was recorded from S_1.Kumer *et al.* (2003) noted that wider plant spacing produced the maximum length of rachis.

Application of different levels of GA_3 showed significant variation on length of rachis (Table 5). However, the higher level GA_3 (260 ppm GA_3) produced the longest rachis (28.03 cm) and the shortest length of spike (15.90 cm) was recorded from control treatment where the plots did not receive GA_3.

Combined effect of plant spacing and plant growth regulator did not show the significant variation on length of rachis produced from side shoot

(Appendix v). The maximum length of rachis from side shoot (23.29 cm) was recorded from S_3G_3 (widest spacing and 260 ppm GA_3) whereas, the minimum (14.82 cm) was recorded from the treatment combination of S_1G_0 (Table 6).

Table 5. Main effect of plant spacing and GA_3 on yield contributing characters of tuberose

Treatments	Days to spike emergence	Length of spike (Mother bulb) (cm)	Length of spike (Side shoot) (cm)	Diameter of spike (Mother bulb) (cm)	Length of rachis (Mother bulb) (cm)	Length of rachis (Side shoot) (cm)
S_1	84.56a	70.72c	57.04c	0.74c	20.84c	13.35c
S_2	82.19b	75.58b	60.66b	0.78b	23.94b	16.40b
S_3	77.77c	80.16a	65.39a	0.85a	25.99a	18.55a
CV (%)	4.84	3.69	6.78	5.95	6.52	7.77
$LSD_{(0.05)}$	1.19	4.01	3.33	0.022	2.03	2.10
Level of significance	**	**	**	**	**	**
Levels of GA_3						
G_0	85.05a	71.81d	56.11d	0.71d	22.28d	15.90d
G_1	81.00b	76.13c	61.77c	0.74c	27.72c	21.99c
G_2	79.32c	80.42b	65.34b	0.77b	31.84b	24.01b
G_3	75.08d	85.30a	70.65a	0.81a	36.93a	28.03a
CV (%)	4.81	3.69	6.78	5.95	6.52	7.77
$LSD_{(0.05)}$	1.37	3.84	3.10	0.021	4.04	1.23
Level of significance	**	**	**	**	**	**

Table 6. Combined effect of plant spacing and GA_3 on yield contributing characters of tuberose

Treatments	Days to spike emergence	Length of spike (Mother bulb) (cm)	Length of spike (Side shoot) (cm)	Diameter of spike (Mother bulb) (cm)	Length of rachis (Mother bulb) (cm)	Length of rachis (Side shoot) (cm)
S_1G_0	84.80	71.26	56.57	0.72	21.56	14.62
S_1G_1	82.79	73.42	59.41	0.74	24.28	17.67
S_1G_2	81.94	75.57	61.19	0.73	26.34	18.83
S_1G_3	79.78	78.01	63.84	0.77	28.88	20.69
S_2G_0	83.62	73.69	58.38	0.74	23.11	16.15
S_2G_1	81.59	75.85	61.18	0.76	25.83	19.19
S_2G_3	80.75	78.00	63.00	0.77	27.89	20.20
S_2G_4	78.60	80.44	65.65	0.79	30.43	22.21
S_3G_0	81.41	75.98	60.75	0.78	24.13	17.22
S_3G_1	79.38	78.14	59.40	0.79	26.85	20.27
S_3G_2	78.54	80.29	65.36	0.81	28.91	21.28
S_3G_3	76.39	82.73	68.02	0.83	31.46	23.29
CV (%)	4.84	3.69	6.78	5.95	6.52	7.77
$LSD_{(0.05)}$	9.60	12.72	13.05	1.28	10.82	9.07
Level of significance	NS	NS	NS	NS	NS	NS

4.1.11 Number of florets per spike (mother bulb)

A significant variation was found on number of florets per spike (mother bulb) due to use of different plant spacing (Table 7). The widest spacing (S_3; 20 x 25 cm) produced the highest number of florets per spike (30.99) and the shortest (23.03) was recorded from S_1.

A significant variation was found on number of florets per spike due to application of different levels of GA_3 (Table 7). The higher level of GA_3 (260 ppm GA_3) produced the highest number of florets per spike (39.86) and the lowest number of florets per spike (24.62) was recorded from control condition. Nagar *et al.*(2002) found the maximum number of florets per spike from higher level of GA_3 which supported to the present trial.

Significant variation was observed on number of florets per spike produced from mother bulb due to combined effect of different levels of plant spacing and plant growth regulator (Appendix VIII). The highest number of florets per spike (35.42) was counted from the treatment combination of S_3G_3 which was similar to (32.57) S_3G_2 while the minimum (23.82) was recorded from S_1G_0.

4.1.12 Number of spikes per hectare (000')

Number of number of spikes per hectare ('000') showed significant differences due to use of different plant spacing (Table 7).The highest number of spikes (237.10) per hectare in thousand was recorded from S_3 while the lowest (233.33) was counted from the closest spacing. Balak *et al* (1999) found the maximum number of spikes from the wider spacing. Application of different levels of GA_3 showed significant variation on number of spikes per hectare (Table 7). However, the higher level of GA_3 (260 ppm GA_3) produced the maximum number of spikes per hectare (248.20) and the minimum number of florets per spike (234.01) was counted from control treatment. Similar trends of result were obtained by Dhua *et al.*(1987).

Combined effect of different levels plant spacing and plant growth regulator showed significant variation on number of spikes per hectare in thousand (Appendix VIII). The maximum number of spikes (242.65) per hectare was recorded from S_3G_3 (20 x 25 cm and 260 ppm GA_3) whereas, the minimum (228.67) was counted from the treatment combination of S_1G_0.

4.1.13 Weight of single spike

A significant variation was found on weight of single spike due to use of different plant spacing (Table 7). The large sized bulb produced the highest weight of single spike (48.05 g) and the lowest (33.33 g) was weighed from the closest plant spacing.

A significant variation was found on weight of single spike due to application of different levels of GA_3 (Table 7). The higher level of GA_3 (260 ppm GA_3) produced the highest weight of single spike (46.74 g) and the lowest weight of single spike (35.55 g) was recorded from control condition. Singh *et al.*(2003); Deotale *et al.*(1995) stated that higher level of GA_3 produced the highest weight of single spike. The present study agreed to their findings.

Significant variation was observed on weight of single spike due to combined effect of plant spacing and plant growth regulator (Appendix VIII). The highest weight of single spike (44.87 g) was noted from the treatment combination of S_3G_3 while the minimum (34.44 g) was recorded from S_1G_0.

4.1.14 Weight of individual bulb

Weight of individual bulb showed significant differences due to the effect of different plant spacing (Table 7). The maximum weight of bulb (43.00 g) was obtained from S_3 while the closest spacing (S_1) produced the minimum (23.00 g) individual weight of bulb.

Application of different levels of potassium showed significant variation on of weight of bulb (Table 7). However, the higher level of GA_3 (260 ppm GA_3) produced the maximum weight of bulb (43.25 g) and the minimum weight of bulb (37.32 g) was recorded from control treatment. Nagaraja *et al.* (1999); Leena *et al.* (1992); found similar trends of results from their study.

Combined effect of different plant spacing and plant growth regulator showed significant variation on weight of individual bulb (Appendix VIII). The maximum weight of bulbs (45.65 g) was recorded from S_3G_3 which was similar to S_3G_2 (45.02 g) whereas, the minimum (30.16 g) was recorded from the treatment combination of S_1G_0.

4.1.15 Yield of bulb per hectare

A significant variation was found on yield of bulb per hectare due to the effect of different plant spacing (Fig. 10). The widest plant spacing (S_3; 20 x 25 cm) produced the highest yield of bulb (9.61 t/ha) and the lowest (7.66 t/ha) was recorded from the closest spacing (S_1; 20 x 15 cm). Sunil and

A significant variation was found on yield of bulb per plant due to application of different levels of GA_3 (Fig. 12). The highest yield of bulb (9.81 t/ha) was obtained from the higher level of GA_3 (260 ppm GA_3) and the control treatment performed the lowest (7.79 ton) yield of bulb per hectare.

A significant variation was observed on yield of bulb per hectare due to combined effect of different levels plant spacing and plant growth regulator (Table 8 and Appendix VIII). The highest yield (9.71 t/ha) was noted from the treatment combination of S_3G_3 (widest plant spacing and 260 ppm GA_3) which was statistically similar to S_3G_2 (9.50 t/ha) and S_2 G_3 (9.42 t/ha). The minimum (7.72 t/ha) was recorded from S_1G_0 which was similar to (8.32 t/ha) S_1G_1. Singh (1998) recorded the highest yield of bulb from the treatment combination of 30 x 30 cm spacing with 2.6 – 3.0 cm diameter in bulb size.

4.1.16 Yield of flower per hectare

Yield of flower per hectare showed significant differences due to plant spacing (Fig, 11).The highest yield of flower (10.19 t/ha) was obtained from the widest spacing (S_3) while the lowest (7.77 t/ha) was noted from the closest spacing (S_1). This statement also support to the finding of Patil *et al.*(1987).

Due to application of different levels of GA_3 showed significant differences on flower yield (Fig. 13). However, the highest yield (11.60 t/ha) was obtained from GA_3 (260 ppm GA_3) whereas, the lowest (8.32 t/ha) was noted from the control treatment. Misra *et al.* (2000); Kumer *et al.* (2003); Yang (2002); reported similar trends of results which supported to the present investigation.

Due to combined effect of different levels of plant spacing and plant growth of regulator performed the significant variation on flower yield

(Appendix VIII). However, the highest yield 0f flower (10.89 t/ha) was noted from S_3G_3 and the lowest (8.04 t/ha) was from S_1G_0. Rees (1975) recorded the maximum the yield of flower of tuberose (*Polianthes tuberosa* L.) from the treatment combination of higher level of GA_3 with larger size of bulbs.

Table 7. Main effect of plant spacing and GA_3 on flowering and bulb yield of tuberose

Treatments	Number of florets per spike (Mother bulb)	Number of spikes / ha ('000)	Weight of single spike (Mother bulb) (g)	Weight of individual bulb (g)
S_1	23.03c	233.33c	33.33c	23.00c
S_2	26.22b	235.00b	40.83b	36.13b
S_3	30.99a	237.10a	48.05a	43.00a
CV (%)	8.82	4.49	7.33	8.76
LSD $_{(0.05)}$	3.82	1.11	2.07	5.55
Level of significance	**	**	**	**
Levels of GA_3				
G_o	24.62d	234.01d	35.55d	36.32d
G_1	29.92c	239.27c	40.00c	39.81c
G_2	34.16b	243.40b	41.30b	42.00b
G_3	39.86a	248.20a	46.74a	43.25a
CV (%)	8.82	4.49	7.33	8.76
LSD $_{(0.05)}$	4.22	3.16	1.10	1.97
Level of significance	**	**	**	**

Table 8. Combined effect of plant spacing and GA_3 on flowering and bulb yield of tuberose

Treatments	Number of florets per spike (Mother bulb)	Number of spikes / ha ('000)	Weight of single spike (Mother bulb) (g)	Weight of individual bulb (g)	Yield of bulb (t/ha)	Yield of flower (t/ha)
S_1G_0	23.82e	228.67g	34.44g	30.16i	7.72g	8.04e
S_1G_1	26.47de	236.30ef	36.66fg	31.40h	8.32fg	8.67e
S_1G_2	28.59cd	238.36cd	36.31ef	32.50gh	8.52ef	8.91e
S_1G_3	31.44bc	240.76bc	44.03cd	33.12g	8.73de	7.68d
S_2G_0	25.82e	234.50f	38.19def	36.72f	8.41e	8.95e
S_2G_1	28.07c	236.13de	40.41cd	36.97e	9.08cd	9.58c
S_2G_3	30.19bc	239.20cd	41.06c	39.06de	9.21bc	9.82bc
S_2G_4	33.04ab	241.60ab	43.78ab	39.69d	9.42ab	10.32b
S_3G_0	27.80c	235.55e	39.27def	42.68c	8.70de	9.24c
S_3G_1	30.45b	238.18cd	41.50bc	43.93b	9.30b	9.88bc
S_3G_2	32.57ab	240.25bc	42.15bc	45.02ab	9.50ab	10.12b
S_3G_3	35.42a	242.65a	44.87a	45.65a	9.71a	10.89a
CV (%)	8.82	4.49	7.33	8.76	4.25	4.85
$LSD_{(0.05)}$	3.06	2.02	2.65	1.12	0.29	0.62
Level of significance	**	**	**	**	**	**

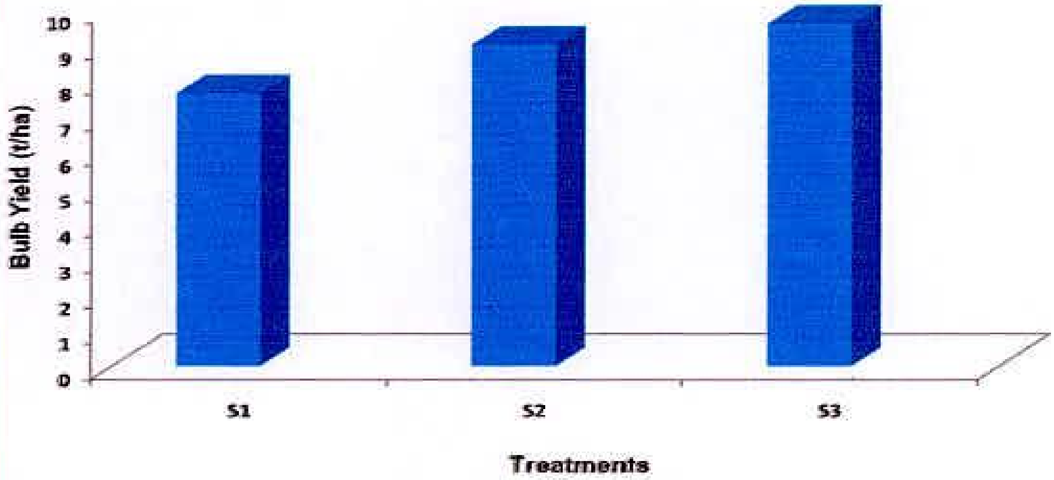

Figure 10: Effect of spacing on yield of bulb (t/ha) of tuberose

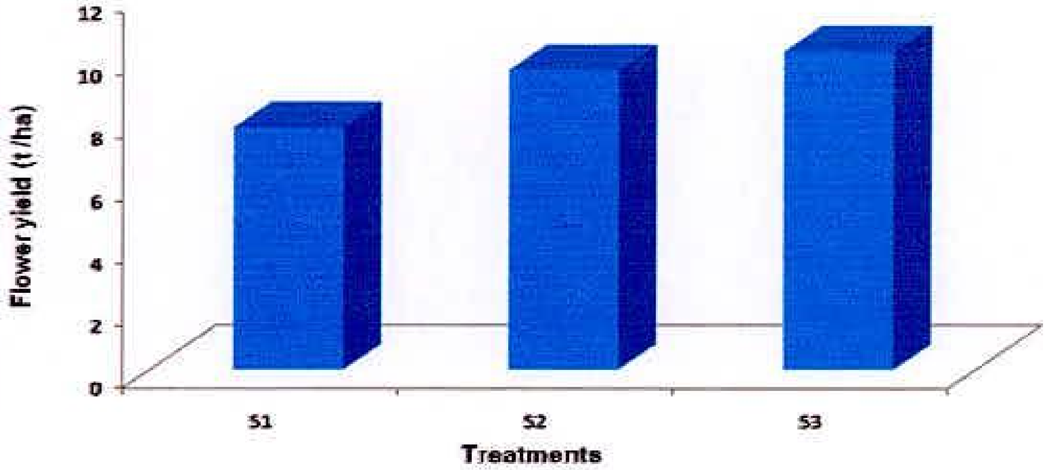

Figure 11: Effect of spacing on yield of flower (t/ha) of tuberose

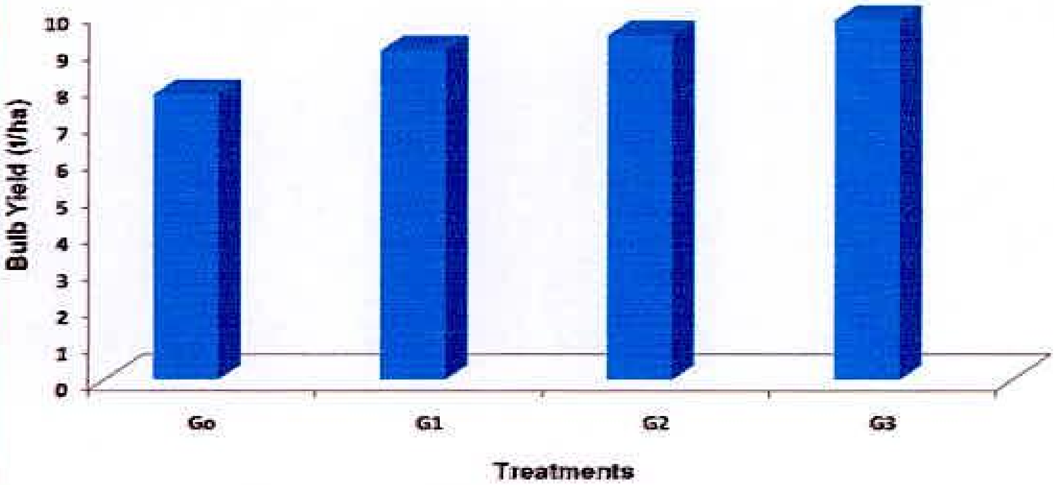

Figure 12: Effect of GA_3 on yield of bulb (t/ha) of tuberose

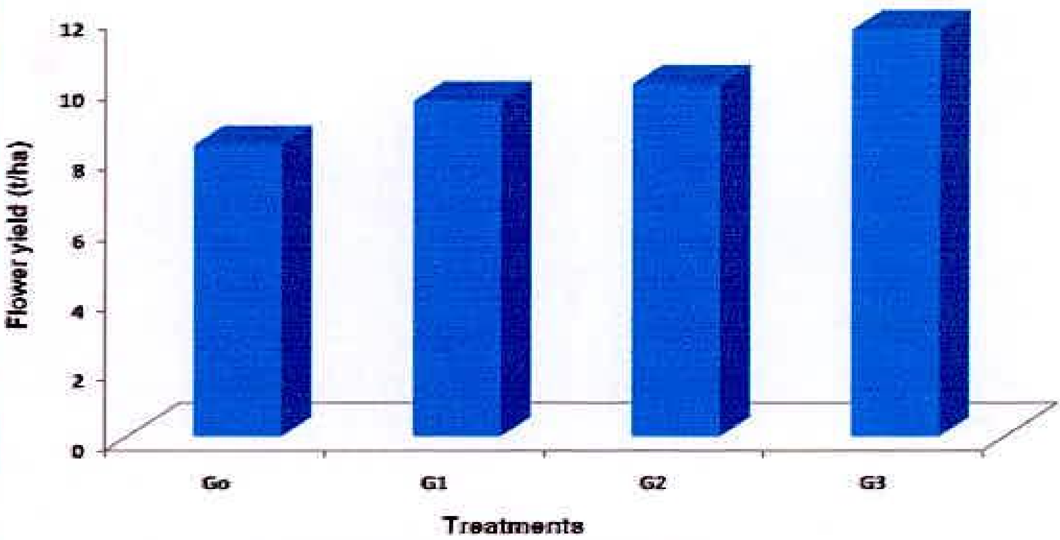

Figure 13: Effect of GA_3 on flower yield (t/ha) of tuberose

Due to combined effect of different levels of plant spacing and plant growth regulator perform the significant variation on flower yield (Appendix VIII). However, the yield of flower (10.89t/ha) was noted from S_3G_3 and the lowest (8.04 t/ha) was from S_1G_0. Rees (1975) recorded the maximum yield of flower of tuberose from the treatment combination of higher level of GA with large size of bulb.

CHAPTER 5
SUMMARY AND CONCLUSION

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted at the Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka Bangladesh, to evaluate the effect of bulb size of tuberose and different levels of potassium on the growth, bulb and flower yield of tuberose during the period from May 2007 to April 2008. The experiment consisted of three plant spacing viz.,S_1 (20 x 15 cm) ,S_2 (20 x20 cm), S_3 (20 x25 cm) and different levels of GA_3 viz., G_0 (no GA_3;control), G_1 (220 ppm GA_3), G_2 (240 ppm GA_3) and G_3 (260 ppm GA_3).

The two-factor experiment was laid out in Randomized Complete Block Design with three replications. There were altogether 12 treatment combinations in this experiment. A unit plot size was 3.0 m× 1.8 m keeping 1.0 m and 0.5 m gap between the blocks and plots, respectively. The experimental plots were fertilized at the rate of 15 ton/ha, 260 kg/ha of urea, 200 kg/ha of TSP and 260 kg/ha of MP were used as per treatment. Entire cowdung, TSP and half of the urea were used as basal doses during the final land preparation. The rest of half urea and entire MP were applied as top dressing. The bulbs of tuberose were collected from Barishal nursery, Saver, Dhaka and were sown on 7 May, 2007. All the intercultural operations were done as and when needed. Data on growth and yield parameters were collected from 10 randomly selected plants of each plot and analyzed statistically. The mean differences were adjudged by Duncan's Multiple Range Test (DMRT).

Plant spacing significantly influenced all the parameters except number of leaves per plant at 30 DAP. The widest spacing(S_3; 20 x 25 cm) gave the maximum plant height (66.77 cm), number of leaves (27.82/plant), length of leaf (60.99 cm) at 130 DAP. The maximum number of side shoot per plant (12.01), length of spike which produced from mother bulb (80.16 cm), number of spikes (237.10)per hectare ('000), weight of single spike (48.05 g), weight of individual bulb (43.00 g), yield of bulb (9.61 t/ha) and yield of flowers (10.19 t/ha) was recorded from the widest plant spacing (S_3; 20 x25 cm) treatment which was significantly superior to all other treatments and the minimum result was performed by the closest plant spacing in all above parameters but the maximum time was required for days to spike emergence (84.56 days) due to effect of control treatment (G_0).

Application of different levels of GA_3 treatments showed significant influenced on all parameters except number of leaves at 30 DAP. The higher level of GA_3 performed the highest results in all cases of observations but the minimum results were require to spike emergence.

The maximum vegetative growth was recorded at 130 DAP. The maximum plant height (69.81 cm), number of leaves (24.99/plant), length of leaf (69.92 cm) and the maximum number of side shoot per plant (11.82) at 130 DAP. Weight of single spike (46.74 g), number of spikes (248.20)per hectare ('000), weight of individual bulb (43.25 g), yield of bulb (9.81 t/ha) and yield of flowers (11.60 t/ha) was recorded from 260 ppm GA_3 and the minimum result was performed by control treatment in all above parameters. Incase of days to spike emergence, the highest level of GA_3 (260 ppm GA_3) took the minimum days (75.01 days).

Combined effects different levels of plant spacing and plant growth regulator had significant influenced on plant growth, bulbing and flower yield contributing characters of tuberose. However, the widest spacing with higher level of GA_3 (treatment combination of S_3G_3) performed the longest plant (68.79 cm) while the lowest shortest plant (57.24 cm) was observed from the treatment combination of S_1G_0 (closest spacing and no GA_3) at 130 DAP. At 130 DAP, the highest number of side shoot per plant (11.91) was recorded from the treatment combination of widest plant spacing with higher level of GA_3 (S_3G_3) and the lowest (8.96) was from S_1G_0. Treatment combination of S_3G_3 took the minimum (76.39 days) days to spike emergence whereas, the maximum (84.80 days) was required for S_1G_0. The longest length of spike which produced from mother bulb (82.73 cm) was recorded from S_3G_3 and the shortest (71.26 cm) was found from S_1G_0.The longest length of rachis which produced from mother bulb (31.46 cm) was obtained from the treatment combination of widest plant spacing (20 x 25 cm) with higher level of GA_3 (260 ppm GA_3) while S_1G_0 treatment gave the shortest (21.56 cm) The longest length of rachis which produced from side shoot (23.29 cm) was obtained from the treatment combination of S_3G_3 while the S_1G_0 treatment gave the shortest (14.62 cm). The maximum number of spikes (242.45) per hectare ('000) was counted from S_3G_3 while the treatment combination of S_1G_0 gave the lowest number of spikes (228.67/ha) in thousand. The highest yield of bulb (9.71 t/ha) was obtained from the treatment combination of S_3G_3 and the lowest bulb yield (7.72t/ha) was found from S_1G_0. Treatment combination of S_3G_3 gave the highest yield of flowers (10.89t/ha) while S_1G_0 showed the lowest yield (8.04t/ha).

Conclusion and suggestions

It may be concluded that the results obtained from present investigation, the widest plant spacing; 20 x 25 cm with 260 ppm GA_3 is the suitable combination for maximum growth of plant, bulb and flower production in tuberose.

However, such type of study further may be conducted with different plant spacing and different levels of GA_3 in various soils and climatic situation for more confirmation of results before final recommendation to the tuberose growers.

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APPENDICES

APPENDICES

Appendix I. Soil analysis data of the experimental plot

Mechanical analysis

Constituents	Percentage (%)
Sand	28.0
Silt	42.5
Clay	29.5
Textural classification	Silty - clay

Chemical analysis

Soil properties/constituents	Values
P^H	6.5
Organic carbon	0.84%
Total nitrogen	0.08%
Available P	18 ppm
Available K	45 ppm
Available S	8 ppm

Source: SRDI, Khamarbari, Farmgate, Dhaka, Bangladesh

Appendix II. Monthly records of air temperature, relative humidity, rainfall and sunshine during the period from May 2007 to April 2008

Year	Month	** Air temperature (^{0}C)			** Soil temp. at different depth			**Relative humidity (%)	*Rainfall (mm)	**Sunshine (Hours)
		Max.	Min.	Mean	5 cm	10 cm	20 cm			
2007	May	33.7	25.0	29.35	25.4	25.0	24.9	74.1	288	240.0
	June	33.2	26.5	29.85	20.6	19.8	19.0	80.2	358	98.02
	July	31.4	25.4	28.4	20.4	21.2	21.4	81.3	542	134.8
	August	32.4	26.8	29.6	22.2	22.4	22.0	82.4	402	110.8
	September	32.2	32.8	32.5	23.4	23.8	23.2	81.7	381	148.4
	October	30.2	30.4	30.3	22.8	23.6	23.0	77.80	401	142.2
	November	28.78	18.54	23.76	25.4	25.9	26.2	71.53	83.1	235.0
	December	25.32	14.40	19.86	21.4	22.0	22.5	67.06	0.00	219.4
2008	January	21.77	10.17	15.97	17.5	16.9	18.3	83.65	Trace	165.6
	February	26.77	15.49	21.13	21.1	21.6	21.4	75.21	27.10	229.2
	March	27.95	18.11	23.03	24.1	24.5	24.3	75.39	114.00	199.3
	April	33.74	23.57	28.65	24.5	24.0	23.6	76.04	81.00	242.4

*Monthly total, ** Monthly average; Source: Dhaka meteorology centre, Agargoan, Dhaka.

Appendix III. Analysis of variance of different characters of tuberose

Sources of variation	Degree of freedom	Mean of sum of square				
		Plant height (cm)				
		30 DAP	55 DAP	80 DAP	105 DAP	130 DAP
Block	2	8.978	7.343	6.047	20.0567	54.876
Factor-A (plant spacing)	2	385.475**	222.264**	499.694*	767.783**	656.743**
Factor-B (GA_3)	3	142.231**	167.123**	444.632**	503.327**	485.568**
Interaction (A × B)	6	8.438**	5.582*	25.648**	21.087**	16.763**
Error	22	0.547	2.498	5.432	4.002	5.005

** = Significant at 1% level

* = Significant at 5% level

Appendix IV. Analysis of variance of different characters of tuberose

Sources of variation	Degree of freedom	Mean of sum of square				
		Number of leaves (cm)				
		30 DAP	55 DAP	80 DAP	105 DAP	130 DAP
Block	2	6.324	0.443	2.762	0.674	3.054
Factor-A (plant spacing)	2	10.076^{NS}	11.321**	13.496**	15.879**	17.856**
Factor-B (GA_3)	3	8.112^{NS}	7.125**	8.886**	9.853**	9.681**
Interaction (A × B)	6	0.661^{NS}	0.436^{NS}	0.746^{NS}	0.432^{NS}	0.537^{NS}

** = Significant at 1% level

* = Significant at 5 % level

NS = Non-significant

Appendix V. Analysis of variance of different characters of tuberose

Sources of variation	Degree of freedom	Mean of sum of square				
		Length of leaf (cm)				
		30DAP	55 DAP	80 DAP	105 DAP	130 DAP
Block	2	8.098	1.908	2.091	0.380	2.023
Factor-A(plant spacing)	2	12.123**	15.843*	13.099*	17.246**	12.096**
Factor-B (GA_3)	3	8.896**	6.654*	10.012*	9.765**	91.009*
Interaction (A × B)	6	0.564**	0.672*	0.874**	0.678*	0.619**
Error	22	0.352	0.089	0.672	0.061	0.342

** = Significant at 1% level

* = Significant at 5% level

Appendix.V1. Analysis of variance of different characters of tuberose

Sources of variation	Degree of freedom	Mean of sum of square				
		Number of side shoots per plant (cm)				
		30DAP	55DAP	80 DAP	105 DAP	130 DAP
Block	2	7.987	1.604	15.045	0.879	6.005
Factor-A (plant spacing)	2	10.895**	12.927**	14.435**	18.395**	12.126**
Factor-B (GA_3)	3	6.754**	7.324*	6.097**	6.265**	7.234**
Interaction (A × B)	6	0.546**	0.293**	0.576*	0.497**	0.895*
Error	22	0.440	0.829	0.674	0.344	0.561

** = Significant at 1% level

* = Significant at 5% level

Appendix VII. Analysis of variance of different characters of tuberose

Sources of variation	Degree of freedom	Means square					
		Days to spike emergence (days)	Length of spike (mother bulb)(cm)	Length of spike (side shoot) (cm)	Diameter of spike(mother bulb) (cm)	Length of rachis (mother bulb)(cm)	Length of rachis (side shoot)(cm)
Block	2	1.098	0.654	0.073	0.017	0.725	0.047
Factor-A (bulb size)	2	708.098**	25.006**	9.946**	5.453**	1053.123*	7.023**
Factor-B (potassium)	3	908.375**	7.326*	7.092*	4.675**	659.625**	383.623**
Interaction (A × B)	6	185.783**	0.994**	0.873**	0.543*	50.078**	0.632*
Error	22	4.822	7.325	0.028	0.482	0.769	0.574

** = Significant at 1% level

* = Significant at 5% level

Appendix VIII. Analysis of variance of different characters of tuberose

Sources of variation	Degree of freedom	Means square					
		Number of florets/spike (mother bulb)	Number of spikes/ha ('000')	Weight of single spike (g)	Weight of individual bulb (g)	Yield of bulb (t/ha)	Yield of flower (t/ha)
Block	2	0.047	0.097	0.169	0.432	0.0765	0.784
Factor-A (bulb size)	3	4.521*	8.498**	4.147**	67.334**	77.986**	74.907**
Factor-B (potassium)	3	7.025**	2.186**	1.580**	54.094**	34.978**	43.010**
Interaction (A × B)	9	0.147**	0.492**	0.157*	6.665**	3.456*	30.026*
Error	30	0.739	0.542	1.881	0.756	0.384	0.620

** = Significant at 1% level

* = Significant at 5% level