EFFECT OF BULB SIZE AND GROWTH REGULATORS ON GROWTH AND FLOWERING OF TUBEROSE CV. SINGLE

A THESIS
BY

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Registration No. 25229/00349
Semester: January – June 2006
Session: 2004-2005

MASTER OF SCIENCE (MS)
IN
HORTICULTURE

DEPARTMENT OF HORTICULTURE AND POSTHARVEST TECHNOLOGY,
SHER-E-BANGLA AGRICULTURAL UNIVERSITY,
SHER-E-BANGLA NAGAR, DHAKA-1207.

JUNE 2006

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A Thesis

Submitted to the Department of Horticulture & Posthervest Technology Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

IN

HORTICULTURE

SEMESTER: JANUARY – JUNE 2006

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CERTIFICATE

This is to certify that thesis entitled, **"Effect of Bulb Size and Growth Regulators on Growth and Flowering of Tuberose"** submitted to the Faculty of Horticulture & 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 *bonafide* research work carried out by **Muhammad Shafiqul Hoq Akand** Registration No. **25229/00349** 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.

Dated:
Dhaka, Bangladesh.

....
Prof. Md. Ruhul Amin
Department of Horticulture
and Postharvest Technology
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Dedicated to

My

Beloved Parents

ACKNOWLEDGEMENT

All praises are due to the Almighty "Allah" Who kindly enabled the author to complete the research work and the thesis leading to Master of Science.

The author feels proud to express his profound respect, deepest sense of gratitude, heartful appreciation to Prof. Md. Ruhul Amin, Department of Horticulture and Postharvest Technology, Sher-e-Bangla Agricultural University, Dhaka for his constant inspiration, scholastic guidance and invaluable suggestions during the conduct of the research and for his constructive criticism and whole hearted cooperation during preparation of this thesis.

The author express his heartfelt gratitude and indebtness to Associate Professor Dr. Md. Nazrul Islam, Chairman, Department of Horticulture and Postharvest Technology, Sher-e-Bangla Agricultural University, Dhaka for his assistance in planning and execution of the study and for his constructive instruction, critical reviews and heartiest cooperation during preparation of the manuscript.

Cordial thanks are also to Dr. A. F. M. Jamal Uddin, Assistant Prof. Department of Horticulture and Postharvest Technology, Sher-e-Bangla Agricultural University, Dhaka for his kind help during the research work.

The author also express his heartfelt thanks to all the teachers of the Dept. of Horticulture and Postharvest Technology, Sher-e-Bangla Agricultural University, Dhaka , for their help, valuable suggestions and encouragement during the period of study.

The author is grateful to all his friends, especially Mukhlesur Rahman, Zakir, Anwar and Khadijatul Kobra for their help, encouragement and moral support towards the completion of the degree.

Tthe author also express his deepest respect and love to his dearest wife Zuairia Sultana for her continuous help and encouragement all time.

Lastly, the author would like to acknowledge his heartiest gratitude to his parents, sister and brothers whose blessings, inspiration and encouragement opened the gate and paved the way to his higher studies.

The author

ABSTRACT

The present study was conducted at the Horticulture farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, during the period from 01 May 2005 to 30 April 2006. The experiment was conducted to investigate the effect of bulb sizes i. e. small, medium and large (1.5-2.0 , 2.1-2.5 and 2.6-3.0 cm in diameter respectively) and growth regulators i. e. Gibberellin (GA_3) and Ethylene (ethrel) on the growth and flowering of tuberose cv. Single. Bulb size had significant effect on plant height, height of the side shoot, number of leaves/plant (mother bulb), number of leaves/plant (side shoot), number of side shoots per plant, days to spike emergence, days to first flowering, duration of flowering. Bulb size had also significant effect on yield contributing characteristics. Large bulb was found to be superior to medium and small bulb. GA_3 and ethrel significantly improved the plant characteristics relating to the growth and flowering of tuberose cv. Single. In general, influence of GA_3 was more pronounced than ethrel in respect of all parameters except duration of flowering. Significant interaction was observed between bulb size and growth regulators treatments in respect of different parameters studied except number of side shoot/plant, duration of flowering and number of florets in 100 gm. The best results were obtained in the large bulb size when combined with GA_3 followed by ethrel.

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ABBREVIATIONS AND ACRONYMS

DAP	= Days After Planting
et al.	= and others
GA_3	= Gibberellic acid
RH	= Relative Humidity
SAU	= Sher-e-Bangla Agricultural University
Viz.	= Namely

CHAPTER I

Introduction

INTRODUCTION

Tuberose (*Polianthes tuberosa* L.) belonging to the family Amaryllidaceae, produces 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 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 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). Nowadays, it is cultivated on large scale in France, Italy, South Africa, USA and in many tropical and subtropical areas, including India and Bangladesh.

Tuberose is a half-hardy, bulbous 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 borne in a spike. There are three types of tuberose: Single with one row of corolla segments, semidouble bearing flowers with two to three rows of corolla segments and double having more than three rows of corolla segments.

In Bangladesh, its commercial cultivation was introduced during 1980 by some pioneer and innovative farmers at Panishara union of Jhikorgacha thana under Jessore district. Tuberose has a high demand in the market and its production is highly profitable (Aditya, 1992). Although tuberose is now grown in the country, very little is known about production technology in Bangladesh condition (Ahmed, 1985).

The size of bulb plays an important role on the growth and flowering of tuberose, it influences the sprouting of bulb at the time required is inversely proportional to size of bulb (Sadhu and Das, 1978; Pathak et al., 1980). Larger bulbs were found to take more time for sprouting (Yadav et al., 1984). Bulb size also influences flowering. Larger bulb causes early flowering and give higher yield of spikes and flower (Sadhu and Das, 1978; Pathak et al., 1980; Yadav et al., 1984). Plant height and number of leaves per bulb also showed gradual increase with the increase in bulb size up to a certain limit (Yadav et al., 1984; Dhua et al., 1987).

Normal plant growth and development are regulated by naturally produced chemicals or endogenous plant hormones. Their role can often be substituted by application of synthetic growth regulating chemicals. These are becoming extremely important and valuable in the commercial control of crop growth in both agriculture and horticulture (Nickell, 1982). Many studies have indicated that the application of growth regulators can affect the growth and development of flowers.

There are many factors which can affect plant growth and economic cultivation of tuberose. Growth and developmental behaviour of bulbous plant is also regulated either by a single or by an interaction of several endogenous growth hormones like Gebberellin, Ethylene, Auxin, Cytokinin and Abscisic acid (ABA) (Bose and Yadav, 1998.)

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 flower number per spike. Duration of flowering 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. Nagaraja *et al.* (1999), conducted an experiment in which highest plant height was obtained using GA_3 while ethrel resulted in earlier plant emergence, a higher percentage of sprouting and earlier flowering compared to the control.

In Bangladesh, no studies have been done regarding the bulb size and use of growth regulators for growth and flowering of tuberose. So, research work on widely cultivated type Single is still lacking in the country.

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

1. to study the effect of bulb size on growth and flowering of tuberose cv. Single and
2. to determine the effect of growth regulators on growth and flowering of tuberose cv. Single

CHAPTER II

Review of Literature

REVIEW OF LITERATURE

Tuberose is one of the most popular cut flower in the world. Many research works have been done on various aspects of this important cut flower in different countries of the world. However, a limited research 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 Influence of bulb size on growth and flowering:

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 (20x20, 25x25, 30x30 cm) and planting depth (3,6 or 9 cm) on the growth and development of tuberose (*Polianthes tuberose* cv. Single) in Unium, Meghalaya, India, during 1998 and 1999. Sprouting was delayed with the increase in bulb size and planting depth, and reduction in spacing. Large bulb resulted in the earliest spike emergence (93.89 days). Spike emergence was delayed with the increase of the planting depth. Spike lengths 88.78 and 89.37 cm and rachis lengths 19.76 and 20.06 cm were greatest with medium and large bulbs. The depth of planting was inversely related to flower quality in terms of spike and rachis length. Thus, the longest spike 89.52 cm and rachis 19.48 cm were obtained with a planting depth of 9 cm. The number of flower spike decreased with deep planting of small 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 for a spacing of 30.30 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 25x25 cm gave higher yield of flower and bulb.

Field experiments were conducted by Misra *et al.* (2000) to determine the effect of bulb size and spacing on growth and flowering of two tuberose (*P. tuberosa*) cultivars (single and double) in Faizabad, Uttar Pradesh, India during 1997-98. 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 x 30 cm spacing was the best for both the cultivars.

Raja and Palanisamy (2000) conducted a field experiment in Coimbatore, Tamil Nadu, India, during 1997-98. Mother bulbs and fingers of tuberose (*Polianthes tuberosa*) of varying sizes (extra large, large, medium and small) were planted. Observations on days to emergence, percent emerge, vegetative growth and flower stalk characteristics and bulb yield traits were recorded. Mother bulb more than 2.5 cm in diameter performed better than fingers. The small bulb in the fingers took fewer days to emergence than larger bulbs. Plant height and number of plantlets/plant and number of leaves/plant increased with increasing size of planting materials. Mother bulbs 2.5-3.0 cm took 97 days to initiate flower stalk emergence, the medium and small bulbs did not produc flowers. The number of flower stalk, flower weight /stalk, length of flower stalk and flower yield/clump were higher for large mother bulbs than for large finger.

Raja and Palanisamy (1999) conducted a field experiment in Tamil Nadu, India, on P. tuberosa cv. Single mother bulbs with a diameter $\geq$4.0 cm. It gave the highest percent emergence (89.0), greatest plant height (48.2 cm) at 200 days after planting, highest number of flower stems (3.1), longest fl ower stems (106.4 cm), and highest flower yield per clump (131.7 g), weight of fingers per clump (64.4 g) and bulb weight per clump (161.7 g). Small mother bulbs (2.5 to 3.0 cm diameter) had the earliest flower stem emergence (96.7 days). Large bulbs (3.5 to 4.0 cm diameter) gave the highest number (3.41) and the heaviest (120.8 g) bulbs per clump. Medium bulbs (3.0 to 3.5 cm diameter) gave the highest number of fingers per clump (10.58).

Patil *et al.* (1987), conducted an experiment. In their experiment they used rhizomes having 1.5-2.5, 2.6-3.0 cm diameter and 15x20, 20x20 or 25x20 cm spacings and the plants were grown for three years for cut flowers. The highest yield of top quality flowers were obtained from the large rhizome planted at 15x20 cm.

Yadav *et al.,* 1984; Dhua et al:,1987 concluded that plant height and number of leaves per bulb also showed gradual increase with the increase in bulb size up to a certain limit.

Larger bulbs were found to take more time for sprouting (Yadav et al., 1984). This might be due to the presence of more layers of membranous scales, which interfered the exchange of gasses and inhibited metabolic process (Kamerbeek, 1962).

Yadav *et al.* (1984) studied the effect of four bulb sizes 1.5-2, 2.1-2.5, 2.6-3.0 and 3.1-3.5 cm in diameter) on growth and flower production in Tuberose cv. *Single* for a period of three years and recorded that plant crop with large sized bulbs (3.1-3.5 cm) significantly improved the spikes. Considering the total production of three years planting of bulbs having 2.6-3.0 cm recorded the highest yield of spikes (15.1 lakhs/ha) and flowers (30.1 tons/ha.) In general, bulb having diameters between 2 and 3 cm are suitable for planting.

Pathak *et al.*, 1980, noted that bulb size also influences flowering. Larger bulbs cause early flowering and gives higher yields of spikes and flowers.

According to Sadhu and Das (1978) the size of bulb plays an important role on growth and flowering of tuberose. It influences the sprouting of bulbs and time required is inversely proportional to size of the bulb.

Kale and Bhujbal, 1972; Ramaswamy and Chokalingam, 1977, concluded that the numbers of flowers/ spike, flower quality, daughter bulb production etc. were also found to be related to bulb size.

2. Influence of plant growth regulators on growth and flowering:

Singh et al. (2003) conducted an experiment in Meerut, Uttar Pradesh, India, during 1997-98 on tuberose (*Polianthes tuberose*) 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, 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. GA_3 at 100 ppm (dipping + spraying) increased the number (28.4), weight (90.52 g), diameter (4.20 cm), and yield (305. 25 g/ha) of tuberose.

Manisha *et al.* (2002) studied tuberose (*Polianthes tuberosa*) cv. Single in Varanasi,Uttar Pradesh, India, during 1999-2000. Treatments comprised of a control and foliar sprays of gibberellic 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 the flower spike and rachis. Among the 3 concentrations of GA_3 used, 150 ppm was found the most superior.

Naggar *et al.* (2002) conducted an experiment to 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 hour before planting. N fertilizer was applied as a side dressing once in one month after planting and twice within the following 42 days. The application of 200 mg GA_3/litre+30 kg N/feddan 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 spikes 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 chlorophyll 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 an experiment to 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 preplanting 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 bulblet per clump, inflorescence length, spike length, flower length, spike diameter, flowers per spike, and spikes per plant, and showed earliest 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 an 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 of 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 College 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 concentration 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°C 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 or 100, 200 or 300 ppm CCC Chlormequat 40, 55 and 70 days after planting. Flower yield was highest (27.5 t/ha) when 150 ppm GA_3 was used.

At Skierniewice, Polland Saniewski *et al.* (1999) noticed that gibberellic acid (GA_3) at a concentration of 200mg 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 earlier flowering compared-to the control with GA_3 at 500 and 1500 ppm being particularly effective. Plant height was greatest with GA_3 at 500 and 100 ppm while ethrel at all concentrations reduced plant height compared to the control. The number of spikes/plant and florets/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 ethrel at 100 ppm increased bulb number whereas all other ethrel 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 produced the heaviest (2. 15g) and largest (6.42cm 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 (chlormequat) (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 florets/spike were obtained with the 50 ppm GA_3 treatment. The greatest corm weight (70.20g) and size ($71.00 cm^2$) were obtained with the 100 ppm NAA treatment. The greatest number and weight of cormels (93.33 and I 7.57g, respectively) were obtained with 500 ppm CCC treatment.

Dhua *et al.* 1987; 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.* (1987) 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 (200mg/L) or thiourea (2000mg/L) solution for 6 hour improved plant growth and increased the yield of spikes and flowers. These treatments also caused early emergence of 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.

Mukhopadhay 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 and 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 occurred in plants treated with 10 ppm GA_3 and the greatest of flowers/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 substances 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 flowers 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 an interection of several endogenous growth hormones like Gibberellins, Auxin, Cytokinin, Ethylene and Abscisic acid. They play a major role in directing the movements of organic metabolites in establishing sinks.

It is revealed from the above review of literatures that both yield and quality of tuberose are influenced by the bulb size and growth regulators used.

CHAPTER III

Methods and Materials

METHODS AND MATERIALS

The present investigation was carried out at the Horticulture farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, during the period from 01 May 2005 to 30 April 2006.

3.1 Climate

The experimental area is under the subtropical climate which is characterized by heavy precipitation during the month of April to September and scanty precipitation during the period from October to March. The detailed meteorological data in respect of air temperature, relative humidity, rainfall and sunshine hour recorded by the Dhaka meteorology centre, Dhaka for the period of experimentation have been presented in Appendix I.

3.2 Soil

The soil of the experimental area belongs to the Modhupur tract. The analytical data of the soil sample collected from the experimental area determined in the Soil Resources Development Institute, Farmgate, 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.

3.3 Treatment of the experiment

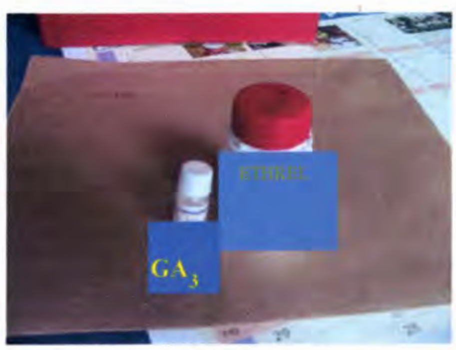
The experiment was set up to investigate the effect of bulb size and different growth regulators on the growth and flowering of tuberose var. single. The study consisted of two factors, which are given below.

Factor A: Bulb size

- i) B1 : Small bulb 1.5-2.0 cm in diameter
- ii) B2 : Medium bulb 2.1-2.5 cm in diameter
- iii) B3 : Large bulb 2.6-3.0 cm in diameter

Factor B: Foliar Application of growth regulators

- i) GA_3: Foliar application of Gibberellic Acid (GA_3) (200 ppm)
- ii) ET : Foliar Application of Ethylene (Ethrel) (200 ppm)
- iii) Co : Control



Growth regulators

3.4. Preparation of GA_3, Ethrel and control solutions

Gibberellic acid (GA_3)

A 1000 ppm stock solution of GA_3 was prepared by dissolving 1 gm in a small quantity of ethanol prior to dilution with distilled water in 1 litre of volumetric flask. The stock solution was used to prepare the 200 ppm concentration, 200 ml of this stock solution was diluted in 1 litre of distilled water to get 200 ppm GA_3 solution. A few drops of tween 80 was added to all solution including the control as an wetting agent. GA_3 was collected from LOBA CHEMIE PVT LTD. Mumbai, India.

Ethrel

Ethrel was collected from Wilson Laboratories, Mumbai, India in the form of concentrated solution (Laboratory Grade), which was used to prepare stock solution containing 1000 ppm. This was used to prepare fresh solution of 200 ppm ethrel for the experiment. 200 ml of this stock solution was diluted to 1 litre of distilled water to prepare 200 ppm solution. A few drops of tween 80 were added to all solution including the control as a wetting agent.

Control solution

A control solution also prepared only by adding a small quantity of ethanol with distilled water.

3.5 Planting material

The bulbs of tuberose cv. Single were collected from Ananda Nursery, Savar Bazar, Dhaka. It was chosen for its wide cultivation in Bangladesh.

3.6 Foliar application of growth regulators

Growth regulators and control solution were applied 30, 55 and 80 days after planting by using hand sprayer.

3.7 Land preparation

The land was first opened by ploughing in the month of April, 2005. Land was prepared by five ploughings followed by laddering. Raised beds were prepared for planting, keeping 0.5 m wide drain between two beds. The weeds and stubbles were removed from the plot and clods were pulverized before final land preparation. The basal doses of manures and fertilizers were applied as per recommendation during final land preparation.

3.8 Experimental design and layout

Two factor experiment was laid out in Randomized Complete Block Design (RCBD) with 3 replications. Each block was divided into 9 plots where 9 treatments were allotted at random. Thus, there were 27 (9x3) unit plots in the experiment. The size of unit plot was 1.6 m x 1.2 m. The distance between the blocks was 1 m and between the adjacent plots 0.5 m. Spacing of the bulbs were 20 X 30 cm and 32 bulbs were planted at each plot.

3.9 Manure and fertilizer

The crop was fertilized with the following doses of manure and fertilizers.

Manure/Fertilizers	Doses per plot	Doses per hectare
Cowdung	1.92 kg	10 ton
Urea	76.8 g	400 kg
TSP	57.6 g	300 kg
MP	57.6 g	300 kg

Entire amount of cow dung and TSP were applied during final land preparation. Urea and MP were applied in four splits, the first installment was applied after one month of planting. The remaining three installments were applied at two-months interval.

3.10 Planting of bulbs

The bulbs were planted in raised bed placing upright at a depth up to their neck. The planting was done in 01 May 2005.

3.11 Intercultural operations

The crop was kept free from weeds by regular weeding and irrigation was done as per necessity. Mulching and earthing up was done regularly. Dithane M-45 was applied to check fungal infestation.

3.12 Selections and tagging of plants and spikes

Ten plants from each of the plots were selected randomly for recording plant height, number of leaves per plant, number of side shoot per plant, and number of days to spike emergence. 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 throughout the season for recording length of spike, length of rachis, number of florets per spike and weight of spike and weight of florets.

3.13 Harvesting

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

3.14 Collection of data

3.14.1 Plant growth contributing characters

a) Plant height (cm)

Height of the plant refers to the length of the plant from ground level up to the tip of the longest leaf at 30, 56, 84, 112, 140, 168 and 200 days after planting.

b) Height of the side shoot (cm)

Height of the side shoot refers to the length of the plant from ground level up to the tip of the longest leaf of the side shoot.

c) Number of leaves/plant (mother bulb)

The number of leaves produced by mother plant was referred to the number of leaves of mother bulb.

d) Number of leaves/plant (side shoot)

For average number of leaves/side shoots, the total number of leaves produced by side shoot in each hill was counted and the mean was referred to average number of leaves per side shoot.

e) Number of side shoots per plant

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.

f) Days to spike emergence

Number of days from planting to spike initiation

g) Days to first flowering

Number of days from spike initiation to first floret opening.

h) Duration of flowering

Number of days from first floret opening to last floret opening in the field.

3.14.2 Flower yield and yield contributing character

a) Length of spike (mother bulb) (cm)

The length of spike at harvesting stage when first florets open

b) Length of spike (side shoot) (cm)

The length of spike at harvesting stage when first florets open

c) Diameter of the spike (cm)

Mean diameter of spikes at top and bottom positions

d) Weight of the single spike (g)

Average weight of a single spike

e) Length of the rachis (mother bulb) (cm)

The length from basal floret to the tip of last floret

f) Length of the rachis (side shoot) (cm)

The length of the rachis was taken from basal floret to the tip of last floret

g) Number of floret/spike (mother bulb)

Total number of floret at each spike

h) Number of floret/spike (side shoot)

Total number of floret/spike produced from the side shoot

i) Number of floret in 100 g

Total number of floret in 100 g

j) Number of spikes/ha (thousands)

Number of total harvested spikes

k) Flower yield/ha (tons)

Calculated from weight of total harvested spikes.

3.15 Statistical analysis

The recorded data on different parameters were statistically analyzed using MSTAT software 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 1% or 5% probability.

CHAPTER IV

Results and Discussion

RESULTS AND DISCUSSION

The present study was undertaken to investigate the role of bulb size (small, medium and large bulb) and growth regulators viz. GA_3 and Ethrel on growth and flowering of tuberose. The response of tuberose to treatments was reflected in different qualitative and quantitative characters. The analyses of variances (ANOVA) for different characters have been presented in Appendix III. The results of the study have been presented and discussed in this chapter under the following headings.

Plant growth contributing characters

4.1 Plant height

The results on main effect of bulb size on plant height of tuberose at 30, 56, 84, 112, 140, 168 and 200 days after planting have been presented in Fig. 1. There was no significant difference among different bulb sizes for plant height until 56 days after planting. But significant difference was found from 84 days to 200 days after planting. The highest plant height (64.22 cm) was recorded from the large bulb at 200 days after planting. On the other hand, the lowest plant height (52.3 cm) at 200 DAP was obtained from small bulb size. This might be due to the fact that higher reserve food resulted in better growth and ultimately gave maximum plant height in comparison to small bulb. Raja and Palanisamy. (1999) while working with different sizes of bulbs on growth and flowering of tuberose found similar result.

The variation in plant height due to the effect of growth regulators was also significant. The highest plant height (60.2 cm) at 200 DAP was obtained from the plant treated with GA_3 followed by control (58.15 cm) (Fig. 2). Ethrel treatment (55.78 cm) was found to be inferior to all other treatments in respect of plant height. The observed results are in agreement with the findings of Nagaraja *et al.* (1999) and Wankhade *et al.* (2002).

The interaction between bulb size and growth regulator on plant height was also found to be significant from 84 DAP. Plants from large bulb treated with GA_3 produced maximum plant height of 66.62 cm, (Table 1) while it was least in the combination of small bulb and ethrel (50.39 cm) at 200 DAP.

4. 2 Number of leaves/plant (mother bulb)

In the present study, number of leaves per plant was significantly influenced by different bulb size used and the results have been presented in Fig. 3. The maximum number of leaves per plant (22.07) was obtained from large bulb and the minimum (15.13) from small bulb. Yadav *et al.*, 1984; Dhua *et al.*, (1987) obtained similar results and reported that larger bulbs produced more leaves compared to smaller bulbs.

The growth regulators had significant effect on the number of leaves per plant. The maximum number of leaves (20.01) was obtained from the plant treated with GA_3 followed by ethrel (18.28) (Fig. 4). All the treatments showed better performance over control (17.2). Wankhade *et al.* (2002) found similar result.

The interaction between bulb size and growth regulators in respect of number of leaves per plant was found to be significant. The combined effect revealed that plants produced from large bulbs and receiving GA_3 had the maximum number of leaves per plant (23.71) and treatment combination of small bulb and control produced the lowest number of leaves (Table 3).

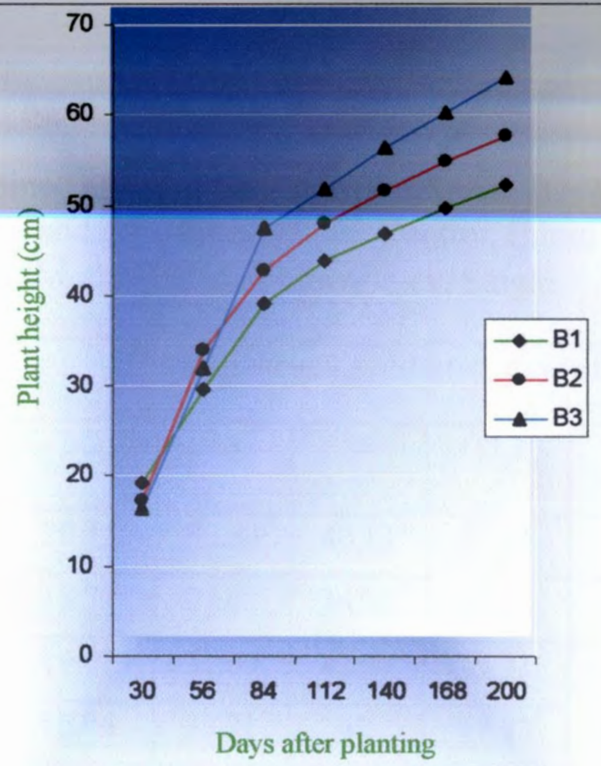


Fig. 1. Effect of bulb size on plant height of tuberose at different days

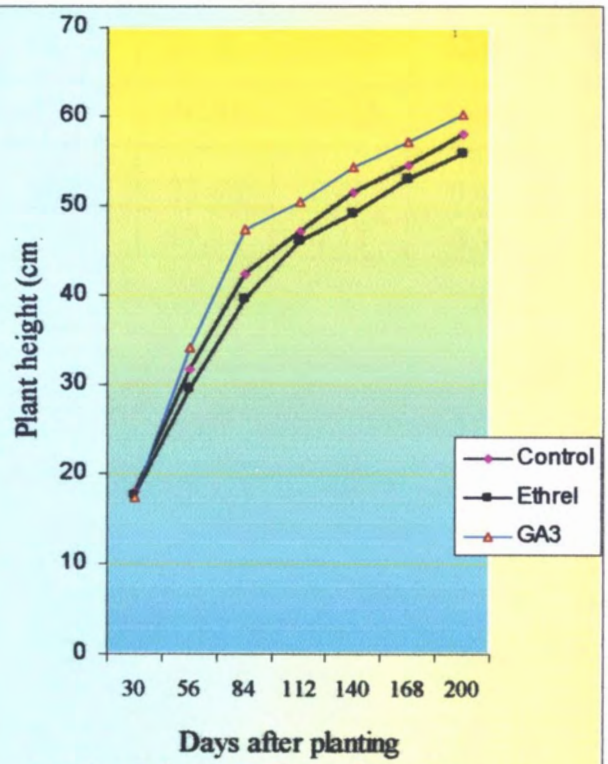


Fig. 2. Main effect of growth regulators on plant height of tuberose at different days after planting

Table 1. Combined effect of bulb size (B1: Small, B2: Medium and B3: Large) and growth regulators (Control, Ethrel and GA_3) on plant height (Mother bulb) of tuberose cv. Single

Treatment		Plant height at different days after planting (cm)						
		30	56	84	112	140	168	200
B1	Co	20.15	30.84	40.13	43.11	46.84	49.82	52.38
	ET	18.77	27.07	34.51	42.82	45.29	47.43	50.39
	GA_3	19.07	31.09	42.97	45.71	48.75	51.84	54.14
B2	Co	16.94	33.71	42	47.83	51.85	54.03	57.96
	ET	17.94	32.75	40.1	46.92	49.97	53.87	55.02
	GA_3	17.16	35.07	45.99	49.22	53.06	56.91	59.85
B3	Co	17.11	30.65	45.34	50.61	56.01	59.53	64.11
	ET	16.43	29.03	43.86	48.44	52.37	57.99	61.93
	GA_3	15.9	36.51	53.23	56.65	60.9	63.03	66.62
LSD 1%		15.92	23.85	0.45	0.47	0.48	0.45	0.48
LSD 5%		11.55	17.31	0.33	0.34	0.35	0.33	0.35

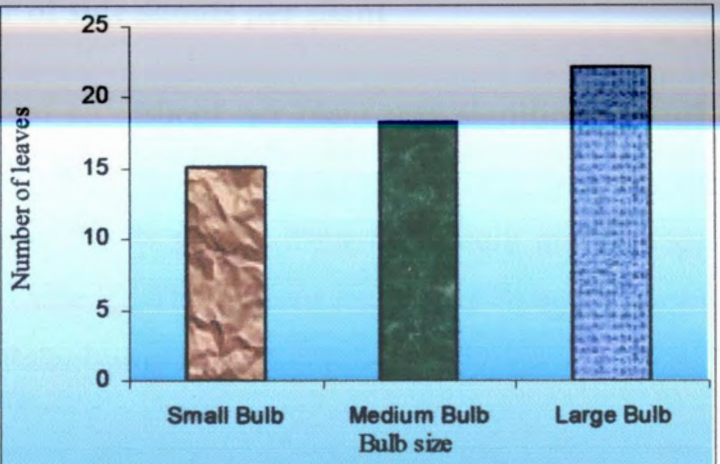


Fig 3. Effect of bulb size on number of leaves/plant of tuberose

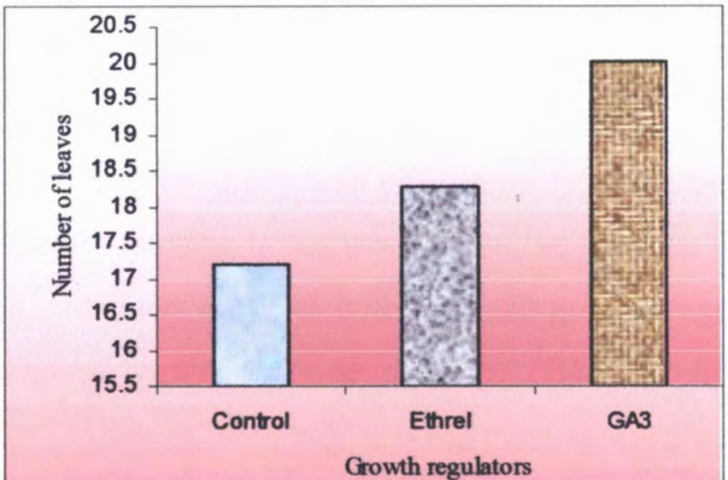


Fig. 4. Effect of growth regulators on number of leaves/plant of tuberose

4. 3 Number of side shoots per plant

The number of side shoot per plant was significantly different due to the different bulb size used. The highest number of side shoot (19.58) was obtained in the plants grown from large bulb and the lowest (9.01) from small bulb (Table 2). The present results are in agreement with the findings of Raja and Palanisamy (1999).

There was significant variation among the different growth regulators in respect of number of side shoot per plant. The maximum number of side shoot per plant (16.61) was obtained from plants treated with GA3 followed by Ethrel (14.20). The minimum number of side shoot per plant (12.19) was found in the control (Table 2).

There was no significant interaction (Appendix III) between bulb size and growth regulator treatment in respect of number of side shoot per plant. However, the combined effect of bulb size and growth regulators revealed that the maximum number of side shoot (23.33) was obtained from the treatment combination of large bulb and the plant sprayed with GA_3. On the other hand, the treatment combination of small bulb and control produced the minimum number of side shoot per plant (6.87) (Table 3).

4. 4 Height of the side shoot

There was significant difference among different bulb sizes for height of the side shoot. The highest plant height (57.58 cm) was recorded from the large bulb. On the other hand, the lowest plant height (44.39 cm) was obtained from small bulb size (Fig. 5).

The effect of growth regulators on the height of the side shoot was also found to be significant. The highest height of the side shoot (53.86 cm) was obtained from the plant treated with GA_3 followed by Control (49.26 cm) (Fig. 6). Ethrel treatment (49.00 cm) was found to be inferior to all other treatments. The observed results are in agreement with the findings of Nagaraja *et al.* (1999).

The interaction between bulb size and growth regulators on height of the side shoot was found to be significant. However, large bulb treated with GA_3 produced maximum plant height of 60.38 cm (Table 3) while the minimum (42.98 cm) was obtained from the combination of small bulb and ethrel.

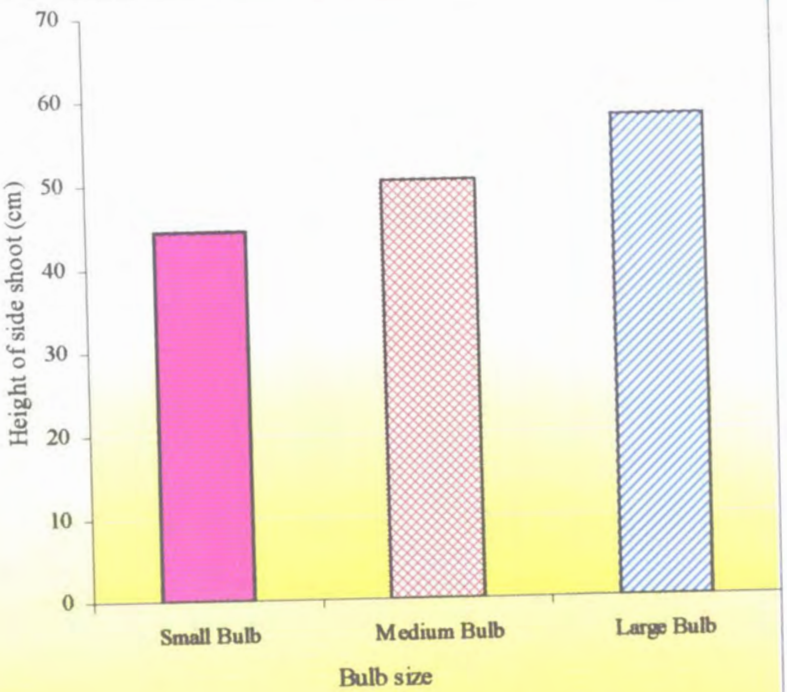


Fig. 5. Effect of bulb size on height of side shoot of tuberose

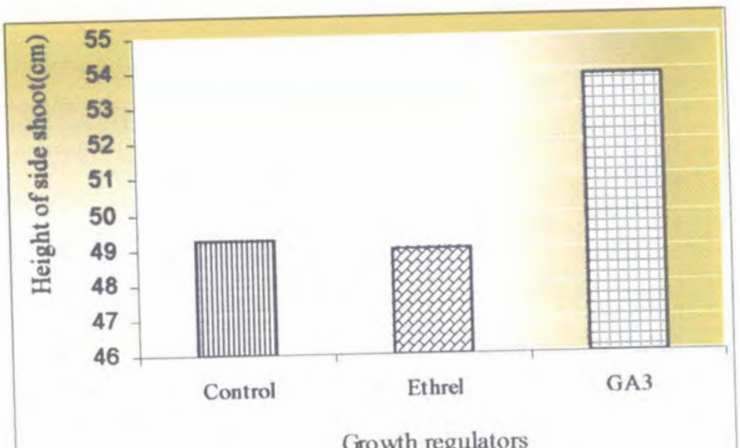


Fig. 6. Effect of growth regulators on height of side shoot

4.5 Number of leaves/side shoot

Different bulb sizes significantly influenced the number of leaves per side shoot and the results have been presented in Table 2. The maximum number of leaves per side shoot (17.31) was obtained from the large bulb and the minimum (9.91) from small bulb.

The average number of leaves produced by the side shoot was also significantly influenced by the growth regulators. The maximum number of leaves (14.96) was obtained from the plant treated with GA_3 followed by ethrel (13.31) which has been shown in Table 2. All the treatments showed better performance over control (12.15).

The interaction between bulb size and growth regulators in respect of number of leaves per side shoot was found to be significant (Appendix III). The combined effect revealed that plant produced from large bulbs and receiving GA_3 had the maximum number of leaves per plant (18.85) and treatment combination of small bulb and control produced the lowest number of leaves (8.09) (Table 3).

4.6 Days to spike emergence

The number of days required to spike emergence of the crop was significantly influenced by bulb size. The average days required to spike emergence ranged from 73.56 to 85.45 days. Small sized bulb took the longest time (85.45 days) to spike emergence while large bulb took the shortest time (73.56 days). Time required to spike emergence was found to be delayed gradually with the decrease in bulb size (Table 2). Similar results were reported by Pathak *et al.,* (1980).

The time required to spike emergence was also influenced by the plant growth regulators and the effect was statistically significant. The plants sprayed with GA_3 initiated spike earlier (77.5 days) followed by ethrel (79.59 days) whereas it was 82.56 days in control (Table 2). Tiwari and Singh (2002) found similar results.

The interaction between bulb size and growth regulators was found to be significant. Large bulb with GA_3 treatment took the shortest period to spike initiation (71.13 days), followed by large bulb with the plant sprayed with ethrel (73.30 days). Small bulb with control treatment took the longest time of 88.05 days (Table 3).

Table 2. Main effect of bulb size (B1: Small, B2: Medium and B3: Large) and growth regulators (Control, Ethrel and GA_3)on Number of side shoot/plant, Number of leaves/side shoot, Days to spike emergence and Days to first flowering of tuberose cv. Single

Treatment	Number of side shoot/ plant	Number of leaves/ side shoot (cm)	Days to Spike emergence	Days to first flowering
Bulb size				
B1	9.01	9.91	85.45	20.10
B2	14.4	13.21	80.64	17.03
B3	19.58	17.31	73.56	13.88
LSD 1%	4.66	0.25	0.26	0.39
LSD 5%	3.38	0.18	0.19	0.28
Growth regulators				
Control	12.19	12.15	82.56	18.2
Ethrel	14.2	13.31	79.59	16.91
GA_3	16.61	14.96	77.5	15.91
LSD 1%	4.66	0.25	0.26	0.39
LSD 5%	3.38	0.18	0.19	0.28

Table 3. Combined effect of bulb size (B1: Small, B2: Medium and B3: Large) and growth regulators (Control, Ethrel and GA_3) on Number of leaves/plant, Number of side shoot/plant, Height of side shoot, Number of leaves/side shoot, Days to spike emergence and Days to first flowering and duration of flowering of tuberose cv. Single

Treatment		Number of leaves/plant (mother plant)	Number of side shoot/plant	Height of side shoot (cm)	Number of leaves/side shoot (cm)	Days to Spike emergence	Days to first flowering	Duration of flowering
B1	Co	14.04	6.87	43.15	8.09	88.05	21.8	12.04
	ET	15.03	9.57	42.98	9.89	85.43	19.55	15.09
	GA3	16.33	10.58	47.03	11.75	82.87	18.95	14.79
B2	Co	16.85	12.47	48.20	12.32	83.38	18.02	16.00
	ET	18.01	14.83	48.10	13.01	80.04	17.07	18.91
	GA3	19.98	15.9	54.16	14.29	78.51	16.01	17.75
B3	Co	20.70	17.22	56.44	16.05	76.24	14.78	18.6
	ET	21.81	18.19	55.93	17.04	73.3	14.1	20.38
	GA3	23.71	23.33	60.38	18.85	71.13	12.77	19.97
LSD 1%		0.48	8.07	0.45	0.44	0.45	0.68	4.06
LSD 5%		0.35	5.86	0.33	0.32	0.33	0.49	2.95

4.7 Days to first flowering

There was a significant influence of bulb size on number of days required to first flowering after spike initiation. Spike from the small sized bulb took the longest time (20.10 days) to first flowering while spike from the large bulb took the shortest time (13.88 days). Time required to first flowering was found to be delayed gradually with the decrease in bulb size (Table 2). Pathak *et al.,* (1980) found similar result.

The time required to first flowering was also influenced by the plant growth regulators and the effect was statistically significant. The plants sprayed with GA_3 flowered earlier (15.91days) followed by ethrel (16.91 days) whereas it was 18.20 days in control (Table 2). This has similarities with the finding of Rama Swami *et al.*, (1979).

The interaction between bulb size and growth regulators was found to be significant (Appendix III). The result is presented in Table 3. Large bulb with GA_3 treatment took the shortest period to first flowering (12.77 days), followed by large bulb with the plant sprayed with ethrel (14.1 days), whereas, small bulb with control treatment needed the longest time (21.80 days).

4.8 Duration of flowering

Duration of flowering was significantly influenced by different bulb sizes. The highest duration of flower (19.65 days) was obtained from the large bulb followed by medium bulb (17.55 days). The shortest duration of flowering (13.97 days) was obtained from the small bulb (Fig. 7).

There was significant variation among the different growth regulators in respect of duration of flowering. The maximum duration of flowering (18.13 days) was obtained from plants treated with ethrel followed by GA_3 (17.50 days). The minimum duration of flowering (15.55 days) was found in the control (Fig. 8). Nagaraja et al. (1999) found similar result.

There was no significant interaction between bulb size and growth regulators in respect of duration of flowering. However, large bulb with Ethrel treatment had the highest duration of flowering and the lowest duration was in small bulb with control treatment (Table 3).

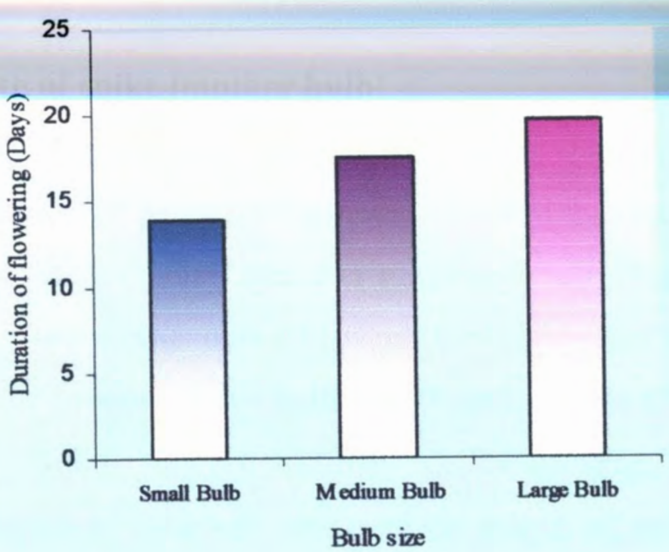


Fig. 7. Effect of bulb size on duration of flowering

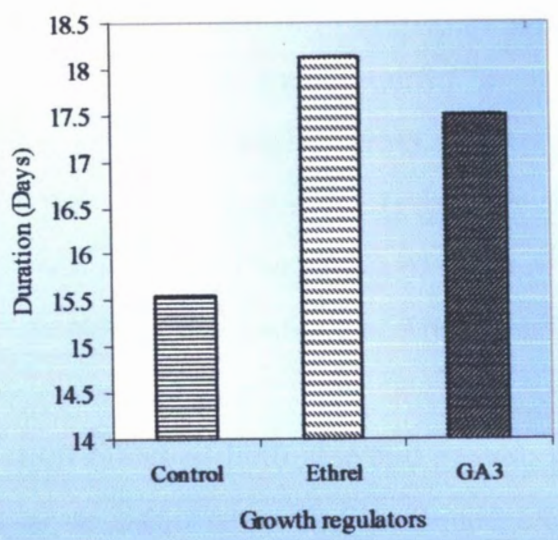


Fig. 8 . Effect of growth regulator on duration of flowering

Flower yield and yield contributing character

4.9 Length of spike (mother bulb)

The results of the present experiment revealed that variation in spike length due to the effect of bulb size was statistically significant. The highest spike length (77.43cm) was obtained when the large sized bulb was used. It was followed by medium sized bulb (71.88 cm). On the other hand, the shortest spike (67.38 cm) was produced by small bulb (Fig. 9). Plate 1 shows the distinct effect of different bulb size on length of spike of tuberose. The increased spike length from large bulb was probably due to the better vegetative growth of the plant. Similar results were reported by Kumar et al., 2003.

Growth regulators had significant effects on the length of spike. The highest spike length (74.39 cm) was obtained in the plants treated with GA_3 followed by ethrel (71.74 cm) whereas the minimum length (70.55 cm) was found from the control treatment (Fig. 10). Plate 2 shows the effect of different growth regulators on length of spike of tuberose The present results are in agreement with the findings of Mukhopadhay and Banker (1983).

The interaction effect of bulb size and growth regulator on the spike length was found to be significant. The combined effect of bulb size and growth regulator revealed that the maximum length of spike (80.26 cm) was produced from large bulb treated with GA_3 followed by large bulb treated with ethrel (76.71 cm), which was minimum in small bulb with control treatment (66.05) (Table 5).

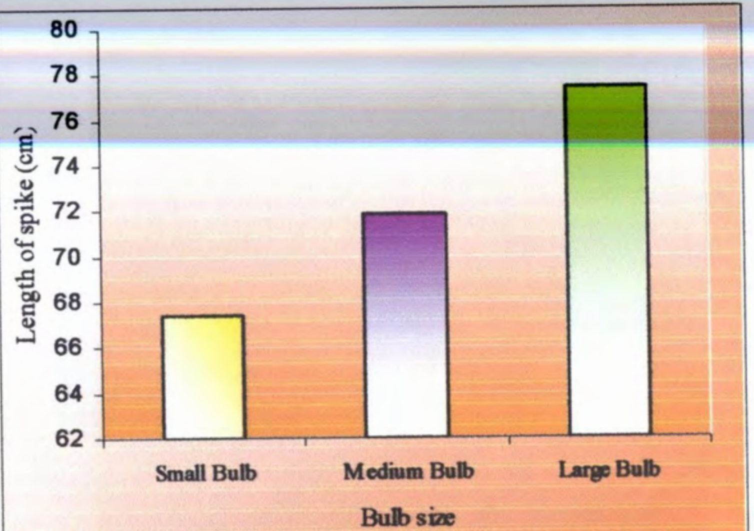


Fig. 9. Effect of bulb size on the length of spike

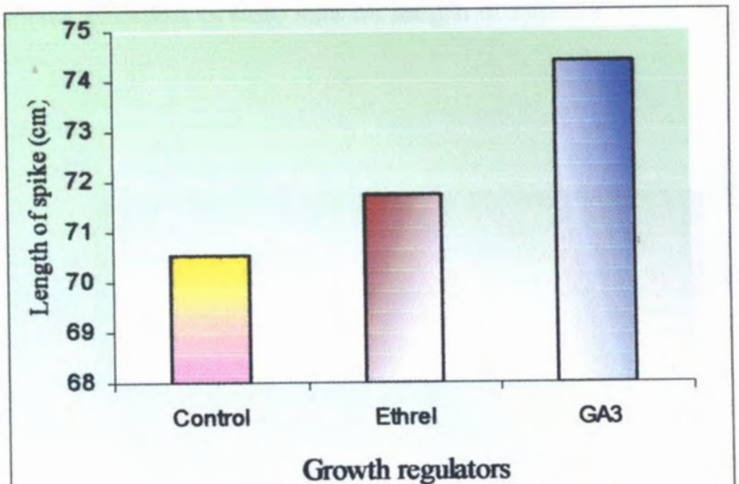


Fig. 10. Effect of Growth regulators on the length of spike

Plate 1. Effect of bulb size on length of spike of tuberose

Plate 2. Effect of growth regulators on length of spike of tuberose

4.10 Length of spike (side shoot)

The effect of bulb size was statistically significant in respect of length of spike of side shoot. The longest spike (75.03cm) was obtained when the side shoot was produced from the large sized bulb. It was followed by medium sized bulb (68.83 cm). On the other hand, the shortest spike length (63.92) was obtained from the side shoot produced by small bulb (Table 4).

Growth regulators had significant effects on the length of spike. The highest spike length (71.29 cm) was obtained from the plants treated with GA_3 followed by ethrel (68.68 cm) whereas the length was minimum (67.81 cm) in control (Table 4).

The interaction effect of bulb size and growth regulator on the spike length was found to be significant (Appendix III). The combined effect of bulb size and growth regulator revealed that the maximum length of spike (77.50 cm) was produced from large bulb treated with GA_3 followed by large bulb treated with ethrel (74.17 cm), which was minimum in small bulb with control treatment (62.21) (Table 5).

4.11 Diameter of the spike (mother bulb)

Bulb size significantly influenced the diameter of the spike. Spike produced from the large bulb had the maximum diameter (1.13 cm) while it was minimum (0.77 cm) in the spike produced from the small bulb (Table 4).

There was also significant variation among the growth regulators. GA_3 gave the highest spike diameter (0.99 cm) followed by ethrel (0.96 cm). Minimum spike diameter (0.86 cm) was obtained from the control (Table 4). Wankhede *et al.* (2002) found that GA_3 increases the diameter of the spike.

Interaction between bulb size and plant growth regulators was found to be significant (Appendix III). The highest spike diameter (1.23 cm) was obtained from the treatment combination of large bulb with GA_3, while the minimum (0.73 cm) was found from the small bulb with control (Table 5).

4.12 Weight of the single spike (mother bulb)

The average weight of spike varied significantly due to the effects of different bulb sizes. The plants from large bulb gave the maximum average weight of spike (41.76 gm) whereas the minimum average weight of spike (33.25 gm) was obtained in plant that was produced from small bulb (Table 4).

There was also significant difference among the different growth regulators in respect of average weight of spike. GA_3 gave the maximum weight of single spike (39.00 g) followed by ethrel (37.80 g). Control treatment (35.66 g) was found to be inferior to all other treatments (Table 4).

The treatment combination of large bulb and GA_3 gave the best result (43.21 gm) regarding this character which has been shown in Table 5. Interaction between bulb size and growth regulators regarding the weight of single spike was statistically significant.

4.13 Length of the rachis (mother bulb)

There was significant difference in rachis length due to different sizes of bulb used. The rachis length was increased with the increase in bulb size (Table 4). Plants from large bulb produced the longest rachis (18.72 cm). On the other hand, plant grown from small bulbs produced the shortest rachis (15.27 cm). Better performance of the plants from larger bulbs might be due to the better growth of the plants from large bulb. Mukhopadhyay and Yadav (1984) reported similar results.

The different growth regulator treatments had significant effect on the length of rachis. The highest rachis length (18.16 cm) was obtained from plants treated with GA_3 followed by ethrel (16.85 cm) as shown in Table 4. Manisha *et al.* (2002) found similar results.

The length of rachis was also significantly influenced by the treatment combination of bulb size and growth regulator. Plants from the large bulb treated with GA_3 produced the maximum rachis length (20.00 cm) in tuberose, while it was minimum (14.35 cm) in treatment combination of small bulb with control (Table 5).

Table 4. Main effect of bulb size (B1: Small, B2: Medium and B3: Large) and growth regulators (Control, Ethrel and GA_3)on flowering of tuberose cv. Single

Treatment	Length of spike (Side shoot) cm	Diameter of the spike (mother bulb) cm	Weight of the single spike (mother bulb) gm	Length of the rachis (mother bulb) cm	Length of the rachis (Side shoot) cm	Number of floret/spike (mother bulb)	Number of floret/spike (Side shoot)	Number of floret in 100 gm	Number of spikes/ha (thousand
Bulb size									
B1	63.92	0.77	33.25	15.27	11.24	34.38	31.46	143.04	287.24
B2	68.83	0.9	37.45	16.92	14.75	40.55	36.49	132.53	362.27
B3	75.03	1.13	41.76	18.72	17.29	47.56	43.26	123.15	424.08
LSD 1%	0.27	0.04	0.27	0.26	0.26	0.25	0.27	14.27	0.27
LSD 5%	0.19	0.03	0.19	0.19	0.19	0.18	0.20	10.35	0.20
Growth regulators									
Control	67.81	0.86	35.66	15.89	13.28	38.91	34.89	137.5	339.05
Ethrel	68.68	0.96	37.8	16.85	14.07	40.27	36.51	132.87	353.96
GA3	71.29	0.99	39	18.16	15.94	43.32	39.81	128.35	380.59
LSD 1%	0.27	0.04	0.27	0.26	0.26	0.25	0.27	14.27	0.27
LSD 5%	0.19	0.03	0.19	0.19	0.19	0.18	0.20	10.35	0.20

Table 5. Combined effect of bulb size (B1: Small, B2: Medium and B3: Large) and growth regulators (Control, Ethrel and GA_3)on flowering of tuberose cv. Single

Treatment		Length of spike (mother bulb) cm	Length of spike (Side shoot) cm	Diameter of the spike (cm)	Weight of the single spike (gm)	Length of the rachis (Mother bulb) cm	Length of the rachis (Side shoot) cm	Number of floret/spike (mother bulb)	Number of floret/spike (Side shoot)	Number of floret in 100 gm	Number of spikes/ha (thousand	Flower yield /ha (tons)
B1	Co	66.05	62.21	0.73	30.84	14.35	9.83	32.64	29.58	148.23	260.04	8.05
	ET	66.98	63.52	0.78	33.63	14.98	11.2	34.02	31.63	141.1	280.79	9.44
	GA3	69.1	66.03	0.80	35.29	16.49	12.7	36.47	33.17	139.79	320.88	11.32
B2	Co	70.29	67.81	0.88	36	15.98	14.05	38.93	34.19	135.42	345.99	12.45
	ET	71.53	68.35	0.90	37.85	16.78	14.23	40.1	36.01	132.01	360.75	13.65
	GA3	73.81	70.33	0.93	38.51	17.99	15.98	42.63	39.26	130.17	380.08	14.64
B3	Co	75.32	73.42	0.97	40.13	17.35	15.95	45.15	40.91	128.85	411.11	16.7
	ET	76.71	74.17	1.19	41.93	18.8	16.79	46.69	41.88	125.51	420.33	17.62
	GA3	80.26	77.5	1.23	43.21	20.00	19.13	50.85	46.99	115.1	440.8	19.05
LSD 1%		0.46	0.46	0.08	0.46	0.45	0.45	0.44	0.47	24.71	0.47	0.48
LSD 5%		0.34	0.34	0.05	0.34	0.32	0.33	0.32	0.34	17.93	0.34	0.35

4.14 Length of the rachis (side shoot)

Different sizes of bulb significantly influenced the rachis length of side shoot. Plants from large bulb produced the longest rachis (17.29 cm). On the other hand, plant grown from small bulbs produced the shortest rachis (11.24 cm) (Table 4).

The different growth regulators had significant effect on the rachis length of the side shoot. The highest rachis length (15.94 cm) was obtained from plants treated with GA_3 followed by ethrel (14.07 cm) as shown in Table 4. It was found minimum (13.28 cm) in control.

The length of rachis was also significantly influenced by the treatment combination of bulb size and growth regulator. Large bulb treated with GA_3 produced the maximum rachis length (19.13 cm) in tuberose, while it was minimum (9.83cm) in treatment combination of small bulb with control (Table 5).

4.15 Number of floret/spike (mother bulb)

The number of floret per spike was significantly different due to the different bulb size used. The highest number of floret (47.50) was obtained in the plants grown from large bulb and the lowest (34.38) from small bulb (Table 4). This might be due to higher food reserve in the large bulb.

There was significant variation among the different growth regulator treatments in respect of number of florets per spike. The maximum number of florets per spike (43.32) was obtained from plant treated with GA_3 followed by ethrel (40.27). The minimum number of floret per spike (38.91) was found in the control (Table 4). Mukhopadhyay and Banker (1983) found similar result.

There was significant interaction between bulb size and growth regulator in respect of number of floret per spike. The combined effect of bulb size and growth regulator revealed that the maximum number of floret (50.85) was obtained from the treatment combination of large bulb treated with GA_3. On the other hand, the treatment combination of small bulb and control produced the minimum number of floret per spike (32.64) (Table 5).

4.16 Number of floret/spike (side shoot)

There was significant difference in number of floret/spike in side shoot due to the different bulb sizes. The highest number of floret (43.26) was obtained in the plants grown from large bulb and the lowest (31.46) from small bulb (Table 4).

There was also significant variation among the different growth regulator in respect of number of florets per spike. The maximum number of florets per spike (39.81) was obtained from plant treated with GA_3 followed by Ethrel (36.51). The minimum number of floret per spike (34.89) was found in the control (Table 4).

Bulb size and growth regulator had significant interaction in respect of number of floret per spike. The combined effect of bulb size and growth regulator treatment revealed that the maximum number of floret (46.99) was obtained from the treatment combination of large bulb treated with GA_3. On the other hand, the treatment combination of small bulb and control produced the minimum number of floret per spike (29.58) (Table 5).

4.17 Number of floret in 100 g

Bulb size had significant effect on the number of floret in 100 gm. The maximum number (143.04) of floret in 100 gm was obtained from the small bulb whereas it was the minimum in case of florets produced from the large bulb (123.15) (Table 4).

The effect of growth regulators in respect of number of floret in 100 gm was found to be insignificant. However, the lowest number (128.35) of floret in 100 gm was obtained from the GA3 treatment, which was highest (137.50) in case of control (Table 4).

Bulb size and growth regulator had no significant interaction in respect of number of floret in 100gm (Appendix III). However, the combined effect of bulb size and growth regulator revealed that the maximum number of floret in 100gm (148.23) was obtained from the treatment combination of small bulb and control. On the other hand, the treatment combination of large bulb and GA_3 needed minimum number of floret in 100 gm (115.10) (Table 5).

4.18 Number of spikes/ha (thousands)

In the present study, bulb size had significant effect on the number of spikes/ha. The maximum number spike (424.08 thousand) was obtained from plants that were produced from large bulbs. On the other hand, plants from small bulb produced minimum number of (287.24 thousands) spike/ha. (Table 4). Pathak *et al.* (1980) found similar result.

Growth regulator significantly influenced the production of spikes/ha. Plant treated with GA_3 produced the highest number (380.59 thousands) of spike/ha followed by ethrel (353.96 thousands). The minimum number of spikes/ha (339.05 thousands) was obtained from the control treatment (Table 4). The result had similarities with the findings of Manisha *et al.* (2002).

There was also significant interaction between the bulb size and growth regulators in respect of number of spike/ha in tuberose. Large size bulb treated with GA_3 produced the maximum number of spikes/ha (440.80 thousands) and small sized bulb with control treatment produced the minimum number of spikes/ha (260.04 thousands) (Table 5).

4.19 Flower yield/ha (tons)

Bulb size had significant effect on the yield of spike per hectare. The highest yields of spike (17.79 ton/ha) were obtained from large size bulb in the present experiment. The yield of spike gradually increased as the size of bulb increased and was the lowest (9.60 ton/ha) in small bulb as shown in Fig. 11. The increased yield of spike was due to the increased weight and diameter of mother bulb, formation of maximum proportion of large bulblets and positive enhancement of other parameters like plant height and number of leaves per plant with the use of large bulb. The results of the present experiment are in agreement with the findings of Yadav et al., 1984.

The yield of spike per hectare was significantly different among the different growth regulator treatments used. The yield of spike per hectare increased with the application of GA_3 but decreased in the control treatment as shown in Fig. 12. Thus, in case of spike per hectare, the highest yield (15.00 t/ha) was obtained from the treatment of GA_3 followed by ethrel (13.57 ton/ha) and the control plants produced the lowest yield of spike per hectare (12.40 ton/ha). Manisha *et al.* (2002) also found similar results.

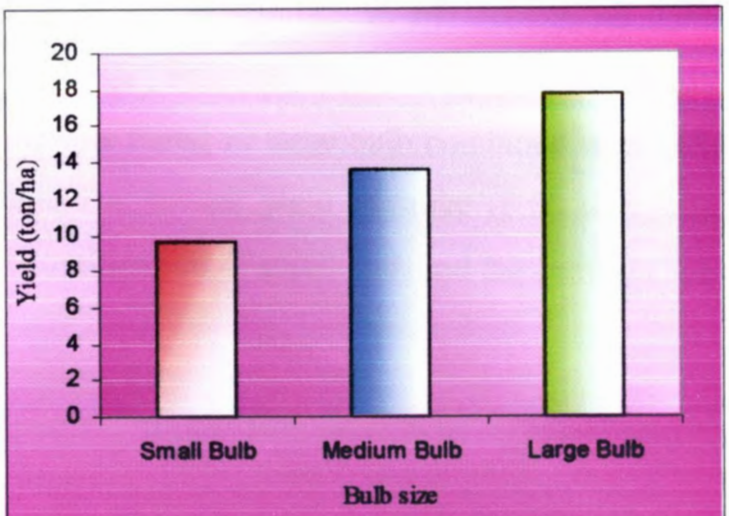


Fig. 11. Effect of bulb size on the flower yield of tuberose

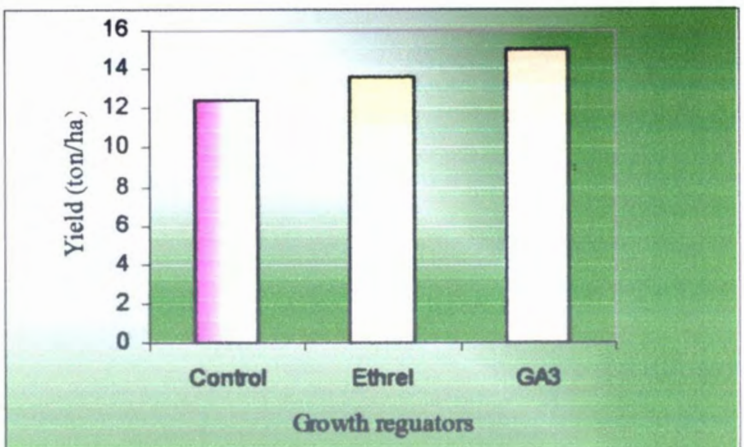


Fig. 12. Effect of growth regulators on the flower yield of tuberose

The interaction between bulb size and growth regulator was significant in respect of yield of spike per hectare. The highest yield of spike per hectare (19.05 ton) was found in large bulb combined with GA_3 followed by ethrel (17.62 ton). The lowest yield of spike (8.05 ton) was obtained from the treatment combination of small bulb and the control (Table 5).

CHAPTER V

Summary and Conclusion

SUMMARY AND CONCLUSION

The present experiment was conducted at the Horticulture farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, to study the effect of bulb size and growth regulators on the growth and flowering of tuberose during the period from 01 May 2005 to 30 April 2006. Three levels of bulb size (1.5-2.0, 2.1-2.5 and 2.6-3.0 cm in diameter) and three different treatment of growth regulators (GA_3, Ethrel and control) as foliar application were used for this purpose. The two factor experiment was laid out in Randomized Complete Block Design with three replications. There were altogether 9 treatment combinations in this experiment.

Bulbs of tuberose cv. Single were planted at the spacing of 30X20 cm. Data were collected on plant height, height of the side shoot, number of leaves/plant (mother bulb), number of leaves/plant (side shoot), number of side shoots per plant, days to spike emergence, days to first flowering, duration of flowering, length of spike (mother bulb), length of spike (side shoot), diameter of the spike, weight of the single spike, length of the rachis (mother bulb), length of the rachis (side shoot), number of floret/spike (mother bulb), number of floret/spike (side shoot), number of floret in 100 gm, number of spikes/ha and flower yield/ha

The result of the experiment revealed that bulb size had significant influence on all parameters studied. Foliar application of growth regulators had also significant effect on the parameters studied except number of floret in 100 gm. Significant interaction was observed between bulb size and growth regulator treatments in respect of different parameters studied except number of side shoot/plant, duration of flowering and number of floret in 100 gm.

Plant height and number of leaves per plant at different stages of growth i.e. 84, 112, 140 ,168 and 200 days after planting were increased significantly with the increase of bulb size of tuberose. GA_3 also showed better performance in respect of plant height but ethrel slightly reduced plant height compared to the control. But GA3 and ethrel showed better performance in case of number of leaves per plant over control. The combined effect of bulb size and growth regulator also influenced significantly on the growth of tuberose.

The number of side shoot per plant was increased with the increase of bulb size. On an average 19.58 side shoot was obtained from large bulb and the lowest 9.01 was from small bulb. Growth regulators also influenced number of side shoot/plant. Maximum number of side shoot per plant (16.61)was obtained from GA_3, while the least number of side shoot per plant (12.19) was found in control .

The highest height of side shoot (57.58 cm) was recorded from the large bulb while the lowest plant height (44.39 cm) was obtained from small bulb size. In case of growth regulators the highest height of the side shoot was found (53.86 cm) from GA_3 while lowest height of side shoot (49.00 cm) was found from ethrel tretment. Large bulb treated with GA_3 produced maximum plant height of 60.38 cm while it was least in the combination of small bulb and ethrel (42.98 cm).

Number of leaves per side shoot increased with the increase of bulb size. The maximum number of leaves per side shoot 17.31 was obtained from the side shoot produced from the large bulb and the minimum 9.91 from small bulb. The maximum number of leaves (14.96) was obtained from the plant treated with GA_3 which is the least in control (12.15). The combined effect revealed that plant produced from large bulbs and receiving GA_3 had the maximum number of leaves per plant (18.85) and treatment combination of small bulb and control produced the lowest number of leaves (8.09).

Bulb size, growth regulators and also their combination had great influence on days to spike emergence. Small sized bulb took the longest time (85.45 days) while large bulb took the shortest time (73.56 days). The plants sprayed with GA_3 initiated spike earlier (77.5 days) but it was 82.56 days in control. Large bulb with GA_3 treatment took the shortest period for spike initiation (71.13 days) while small bulb with control treatment took the longest time for spike initiation (88.05 days).

Large bulb and GA_3 caused earlier flowering 13.88 days and 15.91days respectively, which was the longest in small bulb and control. In case of their combination plant from the large bulb with GA_3 also caused early flowering (12.77 days) but small bulb with control treatment needed the longest time (21.80 days).

The highest duration of flowering was obtained from the large bulb (19.65 days) and the shortest duration of flowering was obtained from the small bulb (13.97 days). The maximum duration of flowering (18.13 days) was obtained from plants treated with ethrel while minimum duration of flowering (15.55 days) was found in the control.

Length of the spike both for mother plant and for side shoot, including length of rachis increased with the increase of the bulb size and application of GA_3.

Spike produced from the large bulb had the maximum diameter (1.13 cm) while it was minimum (0.77 cm) in the spike produced from the small bulb. GA_3 gave the highest spike diameter (0.99 cm) while minimum spike diameter (0.86) was obtained from the control. In combined treatment the highest spike diameter (1.23 cm) was obtained from the treatment combination of large bulb with GA_3, and the minimum (0.73) from small bulb with control.

The maximum average weight of spike (41.76 gm) was obtained from large bulb which was minimum (33.25 gm) in small bulb. GA_3 gave the maximum weight of single spike (39.00 gm) but control treatment (35.66 gm) was found to be inferior to the all other treatments. The combination of large bulb and GA_3 gave the best result (43.21 gm).

The highest number of floret (47.50) was obtained in the plants grown from large bulb and the lowest (34.38) from small bulb. GA_3 produced the maximum number of florets per spike (43.32) while the minimum number of floret per spike (38.91) was found from control. The maximum number of floret (50.85) was obtained from the treatment combination of large bulb treated with GA_3 but control produced the minimum number of floret per spike (32.64). Similar results were found in case of side shoot.

The maximum number (143.04) of floret in 100 gm was obtained from the small bulb whereas it was minimum in case of florets produced from the large bulb (123.15).

In case of number of spikes/hectare, the maximum number spike (424.08 thousand) was obtained from plants of large bulbs. On the other hand, plants from small bulb produced minimum number (287.24 thousands). GA_3 also produced the highest number (380.59 thousands) of spike/ha while minimum number of spikes/ha (339.05 thousands) was in control treatment . Large size bulb treated with GA_3 produced the maximum number of spikes/ha (440.80 thousands) and small sized bulb with control treatment produced the minimum number (260.04) of spikes/ha.

The yield of spike gradually increased as the size of bulb increased. The highest yields (17.79 ton/ha) were obtained from large size bulb while the lowest (9.60 ton/ha) was in small bulb .The highest yield (15.00 t/ha) was obtained from the treatment GA_3 but the control plants produced the lowest yield of spike per hectare (12.40 ton/ha). In combination of bulb size and growth regulators, the highest yield of spike per hectare (19.05 ton/ha) was found in large bulb combined with GA_3 while the lowest yield (8.05 ton/ha) was noted from the combination of small bulb and control.

The results obtained from the present investigation suggested that large size bulb in combination of GA_3 showed increased vegetative growth and flowering. However, further trials should be done on similar soil and climatic condition before recommending it to the growers.

References

REFERENCES

Aditya, D. K. 1992. Floriculture in National Economy in Sharfuddin, A. F. M., M. G. Rabbani and D. K. Aditya (eds) Horticulture in National Development. Proc. Sixth Nat. Hort. Con. Symp. Bangladesh Soc. Hort. Sci., Bangladesh 184 p.

Ahmed, F. 1985. Effect of Spacing on Growth, bulb and flower production of Tuberose (*Polianthes tuberosa* L.). M. Sc. (Ag.) thesis, Dept. of Hort., BAU, Mymensingh. 3 p.

Biswas, J.; T.K. Bose and R.G. Maiti. 1983. Effect of growth substances on growth and flowering of tuberose (*Polianthes tuberosa* L.). South Indian Hort., 31(2-3):129-132.

Biswas, J.; T.K. Bose and R.G. Maiti. 1983. Tuberose, T.K. Bose and L.P. Yadav. Commercial Flowers. Naya prokash, Calcutta, Inida. p. 528.

Bose, T. K. and L. P.Yadav. 1998. Commercial Flowers. Naya Prakash, Calcutta, India. 528 p.

Bose, T.K.; B.K. Jana and T.P. Mukhopadhya. 1980. Effect of growth regulators on growth and flowering in *Hippeastrum hybridum.* Scientia Hort., 12:195-200.

Deotale, A. B.; P.V. Belorkar; M. H. Dahale; S. R. Patil and V. N. Zade. 1995. Effect of date of planting and foliar application of GA_3 on growth of Chrysanthemum. J. Soils Crops, 5(1): 83-86 [Cited from Plant growth regulator Abstr., 22(2):129, 1996.

Dhua, R.S.; S. K. Ghosh; S.K. Mitra; L.P. Yadav and T.K. Bose. 1987. Effect of bulb size, temperature treatment of bulbs and chemicals on growth and flower production in tuberose (*Polianthes tuberosa* L.). Acta Hort., 205: 121-128.

El-Shafie. 1978. Effect of spraying of GA_3 on the flowering of different varieties of rose. Arch Gartenb., 26:287-96 (Cited from Commercial Flowers 86, 1985).

Gowda, J.V.N. 1985. Effect of foliar application of GA_3 on rose cv. Super Star. The Indian Rose Ann. 3:54-55 (Cited from Commercial Flowers 86, 1985).

Jana, B. K. and S. Biswas. 1982. South Indian Hort., 30: 62-65.

Kale, P. N. and B. G. Bhujbal. 1972. Indian J. Orn. Hort., 3: 102-3.

Kamerbeek, G. A. 1962. Acta. Bot. Neerl., 11: 331-410.

Kumar, R.; S. Gobind; D.S. Yadav. 2003. Growth,flowering and bulb production of tuberose as influenced by different bulb size, spacing and depth of planting. Hariana J.Hort. Sci. 2003: 32 (1/2): 66-69

Leena, R.; P. K. Rajeevan; P. K. Valsalakumari and L. Ravidas. 1992. Effect of foliar application of growth regulators on the growth, flowering and corm yield of gladiolus cv. Friendship. South Indian.Hort., 40(6) : 335.

Manisha, N.; M. M. Syamal; M. Narayan; R. L. Misra-RL (ed.) and M. Sanyat. 2002. Effect of gibberellic acid on tuberose. Floriculture research trend in India. Proceedings of the national symposium on Indian floriculture in the new millennium, Lal-Bagh, Bangalore, 25-27 February, 2002. 2002, 350; 1.

Misra, H; A. K. Singh and O. P. Singh. 2000. Effect of bulb size and spacing on growth and flowering behaviour of tuberose (Polianthes tuberosa Linn.). Advances in Plant Sciences. 2000, 13: 2, 563-566; 4 .

Mukhopadhyay, A. and G. J. Banker. 1983. Scintia Hort., 19: 149-52.

Mukhopadhyay, A. and G. J. Banker. 1983. Tuberose, In: T.K. Bose and L. P. Yadav. Commercial Flowers. Naya prokash, Calcutta, Inida. p. 529.

Nagaraja, G. S.; J. V. N. Gowda and A. A. Farooqui. 1999. Effect of growth regulators on growth and flowering of tuberose (*Polianthes tuberosa* L.) cv. Single. Karnataka J. Agril. Sci. 1999, 12: 1-4, 236-238; 3.

Naggar, A. H. and A. L. Sharaf. 2002. Growth analysis of tuberose plants as affected by gibberellic acid (GAB) treatments and nitrogen fertilization. Alexandria J. Agril. Res. 2002, 47: 3, 93-107; 33.

Nagaraja, G.S.; J.V.N. Gowda and A. A. Farooqui. 1999. Effect of growth regulators on growth and flowering of tuberose (Polianthes tuberosa L.) cv. Single. Karnataka. J. Agril. Sci., 12 (1-2): 3236-238.

Nickell, L. G. 1982. Plant Growth Regulators, Agricultural Uses. Springer-verlag Berlin and Neidelberg. P. 173.

Pathak, S.; M. A. Choudhuri. and S. K. Chatterjee. 1980. Indian J. Pl. Physiol., 23: 47-54.

Patil, J. D.; B. A. Patil.; B. B. Chougule and N. R. Bhat. 1987. Effect of bulb size and Spacing on stalk and flower yield in tuberose (Polianthes tuberose L.) cv. Single. Current Res. Rep. mahatama phul Agril. Univ. 1987, 3: 2, 81-82

Raja, K. and V. Palanisamy. 1999. Effect of bulb size on growth, flowering and bulb yield in tuberose (*Polianthes tuberosa* L.) cv. "Single". South Indian Hort. 1999, 47: 1-6, 322-324; 5

Raja, K. and V. Palanisamy. 2000. Orissa J. Hort. 2000, 28: 2, 93-97; 6.

Rama Swamy, N. and P. Chockalingam. 1977. Progressive Hort., 8: 39-41.

Ramaswamy, N.; Palraj and P. Chockalingam. 1979. Annamalia Univ. Agric. Res. Annual., 7/8: 29-33.

Rees, A. R. 1975. The growth of bulbs. Vol. 1., Avademic press, London and Newyork.

Sadhu, M. K. and P. K. Das. 1978. Indain J. Hort., 35: 147-50.

Sadhu, M. K. and T. K. Bose. 1973. Tuberose for most artistic garland. Indian Hort., 18;17-21.

Sanap, P. B.; B. A. Patil, and B.V. Gondhali. 2000. Effect of growth regulators on quality and yield of flowers in tuberose *Polianthes tuberose* L.) cv. Single. Orissa J. Hort. 2000, 28: 1, 68—72; 6.

Saniewski, M., L.; Kawa-Miszczik; E. L. Wegezynowicz, and H. Okubo. 1999. Absicsic acid inhibited shoot growth induced by gibberellic acid in cooled derooted bulbs of tulip (Tulipa gesneriana L.). J. Fruit Ornamental Plant Res., 7(3): 97-104.

Singh, P. V.; S. Panwar and J. Kumar. 2003. Response of tuberose to plant growth regulators. J. Ornamental Hort. New Series. 2003, 6: 1, 80-81; 4.

Tiwari, J. K. and R. P. Singh. 2002. Effect of preplanting GA3 treatment on tuberose. J. Ornamental Hort. New Series. 2002, 5: 2, 44—45; 1.

Wankhade, S. G.; P. V. Belorkar; A. D. Mohariya; N. W. Allurwar; P. E.Band; K. Rosh. 2002. Effect of bulb soaking and foliar spray of GA3 on growth, flowering and yield of tuberose (Polianthes tuberosa L.). J. Soils and Crops. 2002, 12: 1, 105—107; 3.

Wankhede, S. G.; P. V. Belorkar; A. D. Mohariya; M. W. Alurwar; K. G. Rathod and P. P. Gawande.2002. Influence of bulb soaking and foliar spray of GA3 on flower quality and yield of tuberose (Polianthes tuberose L.). J. Soils and Crops. 2002, 12: 2, 293-295; 4.

Yadav, L. P. and R.G. Maity. 1989. Tuberose. (In. commercial flowersed. Bose, T. K. and Yadav, L. P. Naya Prakash, Bidhan Sarani, Calcutta, India). pp. 518-544.

Yadav, L. P.; T. K. Bose and R. G. Meity. 1984. Progressive Hort., 16: 209-13.

Yadav, L.P.; Bose, T. K. and R. G. Maiti. 1985. Progressive Hort. 17: 83-66.

Yang, J. H.; G. F. Zhao; J. K. Li; Y. Liu; J. H. Yang; G. F. Zhao; J. K. Li and Y. J. Liu.2002. Regulation of flowering in tuberose (Polianthes tuberosa L.) by temperature and gibberellin. J. Southwest Agril. Univ. 2002, 24: 4, 345; 6.

Appendices

Appendix I: Monthly record of air temperature, rainfall, relative humidity and sunshine hours during the period from May 2005 to April 2006

year	Month	Average air temperature (°C)			Total rainfall (mm)	Average relative humidity(%)	Total sunshine hours
		Maximum	Minimum	Mean			
2005	May	33.2	24.2	28.7	291	73	241.8
	June	33.4	26.8	30.1	259	79	96.0
	July	31.4	25.8	28.6	542	81	127.1
	August	32.0	26.6	29.3	361	82	108.5
	September	32.7	26.0	29.35	514	81	144.0
	October	30.5	24.3	27.4	417	80	142.6
	November	29.0	19.8	24.4	3	72	198.0
	December	27.0	15.6	21.3	0	66	217.0
2006	January	24.41	13.41	18.91	0	65.47	165.1
	February	30.68	18.77	24.73	0	65.95	171.01
	March	32.95	22.43	27.69	0	52.15	225.83
	April	33.74	23.87	28.81	185	69.41	234.6

Source: Dhaka meteorology center

Appendix II: Characteristics of horticulture farm soil is analyzed by Soil Resources Development Institute (SRDI), Farmgate, Dhaka.

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Horticulture garden, SAU, Dhaka
AEZ	Modhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained
Cropping pattern	Not Applicable

Source: SRDI

B. Physical and chemical properties of the initial soil

Characteristics	Value
Partical size analysis	
% Sand	27
%Silt	43
% Clay	30
Textural class	Silty-clay
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20.00
Exchangeable K (me/100 g soil)	0.10
Available S (ppm)	45

Source: SRDI

Appendix III. Analysis of variance of the data of experiment on the effect of bulb size and growth regulators on tuberose cv. Single

Sources of variation (sv)	Degrees of freedom (df)	Mean of sum squares						
		Plant height at						
		30 DAP	56 DAP	84 DAP	112 DAP	140 DAP	168 DAP	200 DAP
Replication	2	41.979	103.609	0.045	0.050	0.035	0.046	0.055
Treatment	8	5.68 NS	26.32 NS	78.53 **	52.66 **	68.23 **	72.72 **	91.39 **
Bulb Size (B)	2	19.198 NS	39.559 NS	155.289 **	144.750 **	201.701 **	247.485 **	320.728 **
Growth regulators (G)	2	1.057 NS	47.853 NS	143.393 **	48.572 **	56.942 **	40.543 **	44.097 **
B X G	4	1.222 NS	8.937 NS	7.720 **	8.664 **	7.159 **	1.431 **	0.380 **
Error	16	44.547	99.964	0.036	0.039	0.040	0.036	0.040

* Significant at 5% level of probability
* * Significant at 1% level of probability
NS Not-significant

Appendix III. Contd. Analysis of variance of the data of experiment on the effect of bulb size and growth regulators on tuberose cv. Single

Source of variation (sv)	Degrees of freedom (df)	Mean of sum squares								
		Number of leaves/plant (mother plant)	Number of side shoot/plant	Height of side shoot (cm)	Number of leaves/side shoot (cm)	Days to Spike emergence	Days to first flowering	Duration of flowering (Days)	Length of spike (mother bulb) cm	Length of spike (Side shoot) cm
Replication	2	0.048	9.952	0.042	0.048	0.054	0.036	2.194	0.045	0.049
Treatment	8	31.78 **	76.08 **	115.91 **	35.75 **	95.19 **	24.97 **	22.92 **	66.17**	77.408**
Bulb Size (B)	2	108.682 **	251.626 **	393.980 **	123.887 **	322.220 **	86.961 **	74.155 **	228.287**	278.917 **
Growth regulators (G)	2	18.07 **	44.076 *	67.096 **	17.946 **	58.064 **	11.842 **	16.130 *	34.743**	29.400 **
B X G	4	0.175 *	4.331 NS	1.290 **	0.576 **	0.213 **	0.539 **	0.606 NS	0.817**	0.658 **
Error	16	0.04	11.466	0.036	0.034	0.036	0.081	2.897	0.038	0.038

* Significant at 5% level of probability
* * Significant at 1% level of probability
NS Not-significant

ppendix III. Contd. Analysis of variance of the data of experiment on the effect of bulb size and growth regulators on tuberose cv. Single

ources of variation (sv)	Mean of sum squares									
	Degrees of freedom (df)	Diameter of the spike (cm)	Weight of the single spike (gm)	Length of the rachis (Mother bulb) cm	Length of the rachis (Side shoot) cm	Number of floret/spike (mother bulb)	Number of floret/spike (Side shoot)	Number of floret in 100 gm	Number of spikes/ha (thousands)	Flower yield /ha (tons)
plication	2	0.001	0.033	0.053	0.029	0.042	0.054	66.489	0.046	0.047
reatment	8	0.900 **	47.54 **	9.68 **	25.18 **	109.43 **	94.28 **	207.09 **	10778.68 **	41.69 **
Bulb Size (B)	2	0.295 **	162.741 **	26.730 **	83.001 **	391.836 **	315.640 **	890.879 **	42265.645**	150.880**
Growth egulators (G)	2	0.039 **	25.854 **	11.65 **	16.765 **	45.864 **	56.429 **	188.293 NS	3985.366 **	15.314 **
B X G	4	0.013 **	0.781 **	0.164 *	0.482 **	1.107 **	2.539 **	24.605 NS	226.861 **	0.298 **
Error	16	0.001	0.038	0.035	0.036	0.034	0.039	107.054	0.039	0.040

* Significant at 5% level of probability
** Significant at 1% level of probability
NS Not-significant