INFLUENCE OF BULB SIZE AND BORON ON GROWTH AND YIELD OF TUBEROSE

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INFLUENCE OF BULB SIZE AND BORON ON GROWTH AND YIELD OF TUBEROSE

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CERTIFICATE

This is to certify that the thesis entitled **"**INFLUENCE OF BULB SIZE AND BORON ON GROWTH AND YIELD OF TUBEROSE**"** submitted to the Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE in HORTICULTURE**, embodies the result of a piece of *bona fide* research work carried out by UMME KULSUM SHAMPA, Registration No. **06-02013** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated: June, 2013
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DEDICATED

TO MY

BELOVED PARENTS

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ABSTRACT

A field experiment was conducted at the Floriculture Research Field, Bangladesh Agricultural Research Institute, Gazipur from February 2013 to November 2013. The experiment consisted of two factors such as Factor A: bulb size (3 levels): $S_{1:}$ small (1.0-1.5cm)$_{,}$ $S_{2:}$ medium (>1.5-2.0 cm) and $S_{3:}$ large (>2.0-2.5 cm) and Factor B: Four levels of boron, B_0: Control, B_1: 1kg/ha, B_2: 2 kg/ha and B_3: 3 kg/ha. The experiment was laid out in Randomized Complete Block Design with three replications. The results of the experiment showed that the bulb size significantly influenced the time taken for emergence, spike initiation, flowering, spike length, rachis length, flower durability, leaves/plant, florets/spike, spikes/ha and bulbs/ha.Large bulb produced flower earlier than small bulb and better quality spikes. The highest yield of spikes (3,40,000 no./ha) and bulb (9.0 t/ha) were also produced form $S_{3.}$ All doses of boron significantly improve on the yield contributing characters of tuberose over control, while the most effective dose was $B_{2.}$ However, the treatment combination of large size bulb with 2 kg/ha boron contributed the best performance in respect of vegetative growth, flower and bulb production in tuberose.

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The Author

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LIST OF ABBREVIATED TERMS

ABBREVIATIONS	**FULL WORD**
%	Percent
@	At the rate
Agric.	Agriculture
Agril.	Agricultural
ANOVA	Analysis of variance
B	Boron
BARI	Bangladesh Agricultural Research Institute
cm	Centi-meter
CV%	Percentage of Coefficient of Variation
cv.	Cultivar (s)
df	Degrees of Freedom
DMRT	Duncan’s Multiple Range Test
et al.	And others
etc.	Etcetera
HRC	Horticulture Research Centre
K	Potassium
Kg	Kilogram
m^2	Square meter
Max.	Maximum
mg/L	Miligram per Litre
N	Nitrogen
^{O} C	Degree Celsius
P	Phosphorus
ppm	Parts Per Million
RCBD	Randomized Complete Block Design
S	Sulphur
SAU	Sher-e-Bangla Agricultural University
TSP	Triple Super Phosphate
Viz.	Namely
Zn	Zinc

Chapter 1

Introduction

CHAPTER I
INTRODUCTION

Tuberose (*Polianthes tuberosa* L.), a member of Amaryllidaceae family was originated in Mexico and grown on large scale in Asia. It is an important cut flower crop from aesthetic as well as commercial point of view. From Mexico, it spreaded out to the different parts of the world during the 16^{th} century (Tiwari and Singh, 2002). In Bangladesh, its commercial cultivation was introduced during 1980 by some pioneer and innovative farmers at Panishara union of Jhikorgacha thana under Jessore district near the Benapol border (Hoque *et al*., 1992). In the orient, where 'white' goes for virtue and purity, tuberose is much adored for its colour, elegance and fragrance (Aditya, 1992). Tuberose occupies a very selective and special position to flower loving people. It has a great economic potential for cut flower trade and essential oil industry (Shanker *et al.*, 2010). Apart from ornamental value, tuberose is extensively utilized in medicines for headache, diarrhoea, rheumatism and allied pains (Mukhopadhyay, 1998).

The spikes are useful as cut flowers in vase decoration and bouquets while individual floret is used for making veni, garland, button-holes or crown (Bose *et al.*, 1999; Sadhu and Bose, 1973). Tuberose is planted in beds and borders and can also be grown as potted plants (Sathynarayana *et al*., 1994). It has a delightful fragrance and is the source of tuberose oil. The natural flower oil of tuberose is one of the most expensive raw materials for perfume (Bankar and Mukhopadhyay, 1980). In Bangladesh, for the last few years, tuberose has become a popular cut flower of its attractive fragrance and beautiful display in the vase. Now it has high demand in the market and its production is highly profitable (Ara *et al.*, 2009).

Due to its increasing demand, farmers have begun growing tuberose as a field crop under different management practices. Good variety, proper spacing, optimum size of bulbs, fertilizer requirement, irrigation schedule, use of growth regulators and chemicals, optimum time of planting etc. are some of the important factors that may help increase the yield and quality of tuberose (Anjum *et al.,* 2001; Dalal *et al.,* 1999; Bankar and Mukhopadhay, 1990). Ahmad *et al*., (2009), Mahanta *et al*., (1998) and Kumar and Singh (1998) noted that size and quality of tuberose flowers are directly related to the size of bulb used for planting. Sadhu and Das (1978) reported that tuberose plants raised from large bulbs had the greatest plant height, the maximum number of leaves, bulb and bulblet per clump, the longest spike and rachis, the maximum florets per spike and also showed earliest flowering.

It was also stated that hardness of stick, beautifulness and brightness of petals, floret numbers and even shelf life of flower can also be prolonged to some extent by applying micro-nutrients specially boron and zinc along with blanket dose of NPK (Halder *et al*., 2007). Boron can play a vital role in cut flower production. It is reported that boron is highly responsive to opening the flower buds of tuberose and can significantly increase the fragrance of flower (Bhattercharjee, 2010). Boron has a significant effect on spike production and floret quality. It also helps in increasing the number of leaves, bulbs, spikes and flowers (Kumar and Singh, 1998). Length of spike and rachis increased significantly (opening of first floret and last floret) with increasing doses of B fertilizer ranging 0.5 kg to 2 kg/ha (Khalifa *et al*., 2011). Tuberose is highly responsive to chemical fertilizers. It has been reported that nitrogen (N), phosphorus (P), potassium (K) with micro-nutrients especially B and Zn remarkably increased weight and number of bulbs and bulblets per hill (Bose *et al.*, 2003).

The growers do not have any recommended doses of chemical fertilizers especially micro-nutrients for quality bulb and bulblets production. Even the flower producers multiply their bulbs without applying any chemical fertilizers. Resulting, they are deprived of getting optimum sized bulbs and bulblets for flower cultivation. So, boron are treated to be the limiting elements for maximizing bulbs and bulblets in tuberose production.

In Bangladesh, very few studies have been done regarding the bulb size and application of boron for growth, flowering, bulb and bulblet production of tuberose. Considering the above mentioned facts the present investigations were undertaken with the following objectives:

1. To find out the appropriate bulb size on yield of tuberose.
2. To study the growth, flower and bulb production of tuberose under different doses of boron and
3. To find out the suitable combination of bulb size and dose of boron for ensuring the higher yield of tuberose.

Chapter 2

Review of literature

CHAPTER II

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 effects of bulb size, application of boron on growth, flower, bulb and bulblet production of tuberose is given below under the following headings.

Effect of bulb size

Generally bulb and bulblet are used as planting materials for propagation tuberose. Size of bulb used at planting has direct effects on bulb lets, bulbs and flowering of tuberose.

Kumar *et al*., 2003 studied the effect of bulb size (<1.5, 1.5-2.5 or 2.5-3.5 cm) and spacing (20 × 20, 25 × 25 and 30 × 30 cm) and planting depth (3, 6 or 9 cm) on growth and development of tuberose (*Polianthes tuberosa* cv. Single) in Unium, Meghalays, 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 days). Spike emergence 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.

The number of flower spike decreased with a deep planting of small bulb at closer spacing. The number of floret/spike 33.70 was recorded for a spacing of 30 × 30 cm.

However, increasing bulb size 2.5 cm and planting depth up to 9 cm increased bulb production. Small bulb in combination with widest spacing resulted in the earliest bulb sprouting 8.28 days, medium bulbs with moderate planting depth 6 cm and spacing 25 × 25 cm gave higher yield of flower and bulb (Bankar and Mukhopadhyay, 1983).

A field experiment was conducted to investigate the effect of corm size on the vegetative and floral attributes and corm and cormel production in gladiolus by Memon *et al.,* (2009) in Pakistan. For this purpose, corms of three commercially grown varieties viz. Traderhorn, White Friendship and Peter Pears of three different sizes- small, (dia. 2.2-2.4 cm), medium (dia. 2.7-3.0 cm) and large (dia. 3.2-3.5 cm) were planted in split plot design consecutively for two years, i.e., 2006 and 2007. Large sized corms significantly increased the leaf breadth, length of flowering spike, and number of florets spike^{-1} over those produced from small and medium ones, whereas plant height was greatly decreased in response to large sized corms. Regarding corm production, large sized corms produced significantly higher weight of corms plant^{-1}, cormels plant^{-1} and combined total weight of corms and cormels plant^{-1} in all the three varieties of gladiolus.

Misra *et al*., (2000) studied the effect of bulb size and spacing (10 × 30, 15 × 30, 20 × 30 and 30 × 30 cm) on growth and flowering of tuberose (*P. tuberosa*) cultivars (Single and double) in Faizabad, Uttar Pradesh. India, during 1997-98. Bulb size significantly influenced spikes initiation 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. However, a bulb size of 2.6-3.0 cm at 30 × 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 tuberose*) of varying sizes (extra large, large, medium and small) were planted. Observation on days to emergence, percent emergence, 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 bulb 2.5-3.0 cm took 97 days to initiate flower stalk emergence, the medium and small bulbs did not produce flowers. The number of flower stalk and flower yield/clump were higher for large mother bulbs than for large fingers. The number and weight of mother bulbs and fingers per clump were highest when large and extra large mother bulbs were used as planting material. Highest bulb weight per clump was recorded from bulbs with a diameter of 4 cm.

In 2-year experiments Mitra and Singh (1998) studied *P. tuberosa* bulbs of diameter 1.5-2.0, 2.1-2.5 or 2.6-3.0 cm were planted at spacing of 20 × 20, 30 × 30 or 30 × 30 cm and given N at 0, 100, 200 or 300 kg/ha. Bulb yield increased with N @ 200 kg/ha and 2.6-3.0 cm bulb size with wider spacing.

Dalal *et al.,* (1999) carried out an experiment to investigate the effect of different levels of phosphorus and size of bulb on growth and flower yield of tuberose cv. Single.

They planted the bulb of 1.0-1.5, 2.0-2.5 and >2.5 cm in diameter on 30 March. The best results were obtained with the largest bulbs (>2.5 cm in diameter) planted with 200 kg/ha phosphorus.

Reddy *et al.*, (1998) noted that the number and length of tuberose cv. double leaves 180 days after planting were greatest from bulbs 2.1-2.5 cm in diameter.

Studies were conducted by Ahmad *et al.*, (2009) to observe the effect of different bulb size on growth, flowering and bulblet production of tuberose (*Polianthes tuberosa* L.) cv. Single under agro-ecological conditions of Faisalabad during 2005-06 so as to explore the best bulb size for the best quality flower spikes production as well as maximum bulb and bulblet production. It was observed that large bulb size resulted in vigorous growth, maximum yield and more number of bulblet as compared to small and medium sized bulbs.

Kumar and Singh (1998) reported that bulbs of *Polianthes tuberosa* cv. Single 1.5-2.0, 2.1-2.5 or 2.6-3.0 cm in diameter were planted at spacing 20 × 20, 30 × 30 or 30 × 30 cm on 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 largest bulbs planted at the widest spacing and given the highest N rate. Cut flower yield, quality and bulb production were greatest from the largest bulbs planted at the widest spacing and given the highest N rate.

Mahanta *et al.*, (1998) studied the effect of bulb size (diameter of 0.5-3.5 cm) on growth and flowering of *P. tuberosa* in India during 1993-95. It was found that shoot emergence was delayed with increasing bulb size. Other characters (height of plant, number of leaves and shoots per clump, days to flowering, length of spike and rachis and number of florets per spike) were enhanced increasing bulb size.

In an experiment at Hissar, India, Reddy and Singh (1997) reported that the number of bulbs and weight of bulbs per plant increased with increase in bulb size used for planting. Saleable bulbs per plant were greatest in the plants raised from bulbs measuring 2.1-3.0 cm in diameter. Bulb lets were smallest on plants from the smallest bulbs and largest on plants raised from large bulbs.

Mahanta and Paswan (1995) observed that bulbs of *Polianthes tuberosa* cv. Single, 2.25-3.00 cm (D_1), 1.50-2.25 cm (D_2) or 0.75-1.50 cm (D_3) in diameter, were planted at 20 × 20 (S_1), 20 × 15 (S_2) or 20 × 10 cm (S_3) for cut flower production. D_1 bulbs showed slower shoot emergence but flowered earlier, produced taller plants, longer spikes and rachis, more leaves/plant, florets/spike and bulbs/plants and heavier bulbs that D_2 and D_3. With regard to spacing, the number of leaves/plant decreased with plant density. The time to flowering was shortest with S_3 and longest with S_1. The highest number of spikes/m^2 (58.55) and spike yield (169.18 q/ha) were obtained with the combination of D_1 and S_3.

Sathyanarayana *et al.*, (1994) studied the effect of bulb size on the flowering of *Polianthes tuberosa*. Flower spikes from large bulbs emerged and produced flower earlier than those from small bulbs. The numbers of spike/plant and spike/ha increased with increasing bulb size. Flower spikes from large bulbs had more florets than those from small bulbs.

Rao *et al*., (1992) conducted a field experiment at Tirupati. India. Bulbs of *P. tuberosa* cv. Single of different sizes were planted at depths of 2, 4 or 6 cm. With large bulbs, the number of leaves, bulbs and side shoots produced per clump were higher, sprouting and flowering were earlier and flower yield per clump and per spike were higher.As planting depth increased, vegetative growth and flower yield decreased. There was no significant interaction between planting depth and bulbs size.

Patil *et al.,* (1987) used rhizomes having 0.5-1.5, 1.5-2.5 or 2.5-3.5 cm in diameter and 15 × 20, 20 × 20 or 25 × 20 cm spacing 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 20 × 15 cm.

Yadav *et al.,* (1984) studied the effect of four bulb sizes 1.5-2.0, 2.1-2.5, 2.6-3.0 and 3.1-3.5 cm in diameter on growth and flower production of tuberose (*Polianthes tuberosa* cv. Single) for a period of three years and recorded that plant crops with large bulb 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 t/ha). In general, bulb having diameters between 2 and 3 cm are suitable for planting. Pathak and Choudhuri (1980) noted that bulb size also influenced flowering. Larger bulb cause early flowering and gives higher yield 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 influenced sprouting of bulbs and time required is inversely proportional to size of the bulb.

Kale and Jhujbal (1972) concluded that the numbers/spike, flower quality, daughter bulb production etc. were also found to be related to bulb size.

Effect of boron on growth and yield of tuberose

Boron is one of the important micronutrient among essential elements for plant growth, and plays a significant role in the physiological and biochemical processes within plants. Several reports in the literature indicated that the supply of B in the substrate may affect the behavior of other micronutrients in plants, but the specific function of B on the behavior of other micronutrients is not well defined. Presumably, due to its complex chemistry in soil and little known physiological and biochemical functions in plants. Moreover, it is well understood that the B chemistry in soil and its role in plant is differs from other micronutrients, such as Zn, Cu Fe, Mn and Mo, but its deficiency or excess may affect the solubility of these micronutrients in soil and uptake by plants (Mishra *et al.*, 2002).

Boron is needed by the crop plants for cell division, nucleic acid synthesis, uptake of calcium and transport of carbohydrates. Boron also plays an important role in flowering and fruit formation. Boron deficiency affects the growing points of roots and youngest leaves. The leaves become wrinkled and curled with light green colour. Its deficiency affects translocation of sugar, starches, nitrogen and phosphorus, synthesis of amino acids and proteins. In boron deficient plants the youngest leaves become pale green, losing more colour at the base then at the tip. Boron deficiency symptoms will often appear in the form of thickened wilted, or curled leaves, a thickened, cracked, or water soaked condition of petioles and stems, and discoloration, cracking or rotting of fruit, tubers or roots (Singh *et al.*, 1998).

Boron’s widespread role within the plant includes cell wall synthesis, sugar transport, cell division, differentiation, membrane functioning, root elongation, and regulation of plant hormone levels (Marschner, 1995).

Boron is one of the most commonly deficient micronutrients in agriculture, with reports of deficiencies in 132 crops and in 80 countries (Shorrocks, 1997). These deficiencies typically result from boron leaching occurring in humid areas with coarse textured soils (Mortvedt and Woodruff, 1993).

No crop can reach its full potential without minute but adequate supply of boron. Several disorders in horticultural crops are found to be due to boron deficiency. Boron is essential for plant growth, new cell division in meristematic tissue, translocation of sugar, starch, nitrogen, phosphorus, certain hormones, synthesis of amino acids and protein, regulations of carbohydrate metabolism, development of phloem etc (Naza, 1985).

A study was conducted by Nath and Biswas (2002) on the effect of boron on vegetative and reproductive growth in tuberose (*Polianthes tuberosa* L.) cv. Single. It revealed that the foliar application of boron 100 ppm twice at monthly interval produced the maximum height of plant and increased the number of leaves per clump resulting in improved yield of spikes per plot.

A field study of Boron and Zinc on flower production of Tuberose was conducted by Halder *et al*., (2007) at Floriculture Research Farm of Horticulture Research Centre, BARI, Joydebpur, Gazipur during the months of March to July in the year of 2005-2007. The objectives were to evaluate the response of tuberose to B and Zn micronutrients and to find out the optimum dose of Boron and Zinc for maximizing flower yield and quality of tuberose. Sixteen treatments comprising four levels of B (1, 1.2 and 3 kg ha^{-1}) and four levels of Zn (0, 1.5, 3.5 and 4.5 kg ha^{-1}) along with blanket does of N_{300} P_{90} K_{170} S_{20} kg/ha and cow dung 5 t/ha were used in the trial. Tuberose (CV. Double) was taken as a test crop. It was revealed that B and Zn and their combination had a profound effect on flower characters and flower yield of Tuberose. It was also evident that Boron-Zinc integration was appeared to be more responsive than their single applications. All the studied parameters like plant height, effective leaves, length of rachis and spike, number of florets and flower size and weight of stick were greatly influenced with the added higher doses of boron-zinc combination but subsequent augmentation of B and Zn suppressed the flower production.

Mishra *et al.,* (2002) and Bhattacharjee (2010) reported that boron was needed for successful cultivation of flower. He again stated that application of B at a rate of 1kg/ha increased the number of leaves, leaf area, earlier time of flowering and harvest in lilium. It also improved the length and diameter of flower stalk, length of floret, number of flower buds, yield of flower and number and weight of bulb and bulblet.

Amarjeet *et al.,* (1996) studied a fertilizer trial with P and B in *P. tuberosa* cv. Single. Application of high rates of P and B delayed spike emergence and toxicity. Length of Spike and rachis increased significantly at both developmental stages (opening of first floret and last floret) with optimum doses of P and B fertilizer @ 100 kg/ha and 1 kg/ha respectively.

Parthiban *et al.,* (1992) studied that *P. tuberosa* cv. Single plants were supplied with 50 or 75 kg P/ha along with B 1 or 2 kg/ha resulted the greatest plant height (58.93 cm), highest mean number of leaves (41.34) and number of side suckers/clump and flower yield.

Chapter 3

Materials and Methods

CHAPTER III
MATERIALS AND METHODS

An experiment was conducted to study the "Influence of bulb size and boron on growth and yield of tuberose" during February 2013 to November 2013 at the Floriculture Research Field, Horticulture Research Centre of Bangladesh Agricultural Research Institute (BARI), Gazipur. The details of the experiment and techniques adopted during the course of investigation are presented in this chapter.

Experimental site

The location of the site was about 35 km North of Dhaka city with 24.09^0 N latitude and 90.26^0 E longitude and elevation of 8.40 m from the sea level.

Climate

The experimental site was situated in the subtropical climatic zone and characterized by heavy rainfall during the month of May to September while scanty rainfall during the rest of the year. The weather data of the growing period are presented in Appendix I.

Soil

The soil of the experimental field was silty clay loam in texture and acidic in nature. It belongs to the "Shallow red- brown Terrace" soil of Madhupur Tract (Haider *et al*., 1991). Soil sample of the experimental plot was collected from a depth of 0-30 cm before conducting the experiment and analyzed in the Soil Science Division, Bangladesh Agricultural Research Institute (BARI), Gazipur and have been presented in Appendix-II.

Treatment of the experiment

The experiment was designed to study the effect of bulb size and boron on growth, flowering, bulb and bulblet production production of tuberose. The experiment consisted of two factors, which are as follows:

Factor A = Bulb Size

S_1 : Small bulb (1.0-1.5 cm in diameter)

S_2 : Medium bulb (>1.5 to 2.0 cm in diameter)

S_3 : Large bulb (>2.0 to 2.5 cm in diameter)

Factor B = Boron Fertilizer

B_0 : Control

B_1 : 1kg/ha

B_2 : 2 kg/ha

B_3 : 3 kg/ha

Planting materials

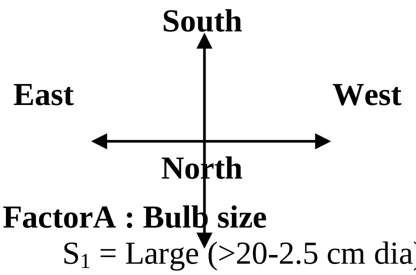
Different sizes of bulb in Tuberose single cultivar (PT-001) were selected as planting materials (Plate 1). The single ever blooming Mexican Tuberose is one of the most fragrant of cultivated plants. This wonderful cut flower bears clusters of waxy, white tube-shaped flowers from early to late summer.

Plate 1. Different size of bulbs in Tuberose cv. Single

Design and Layout

The experiment was laid out in a Randomized Complete Block (RCB) Design with three replications. The unit plot size was 1.8 m × 1.5 m accommodating 45 plants per plot. Two adjacent unit plots were separated by 60 cm space and there was 80 cm space between the blocks.

R_1	R_2	R_3
S_3B_3	S_1B_2	S_2B_1
S_3B_2	S_1B_1	S_2B_0
S_3B_1	S_1B_0	S_2B_3
S_3B_0	S_3B_3	S_1B_3
S_2B_3	S_3B_1	S_1B_2
S_2B_2	S_3B_2	S_1B_1
S_2B_1	S_3B_0	S_1B_0
S_2B_0	S_2B_2	S_3B_3
S_1B_3	S_2B_3	S_3B_0
S_1B_2	S_2B_0	S_3B_2
S_1B_1	S_2B_1	S_3B_1
S_1B_0	S_1B_3	S_2B_2



FactorA : Bulb size

S_1 = Large (>20-2.5 cm dia)
S_2= Medium (>1.5-2.0 cm dia)
S_3= Small (>1-1.5 cm dia)

Factor B: Boron fertilizer

B_0= Control
B_1= 1.0 kg/ha
B_2= 2.0 kg/ha
B_3= 3.0 kg/ha

Plot size = 1.8 m × 1.5 m
Plot to plot distance = 60 cm
Block to block distance = 80 cm
Plant spacing = 30 cm × 20 cm

Figure 1. Layout of the experiment

Land preparation

The experimental plot was first opened on last week of January 2013 with a power tiller for sun curing for 7 days before next ploughing. The land was then ploughed and cross ploughed several times using power tiller to obtain a good tilth. Ploughing was followed by laddering for breaking large soil clods and for leveling the land surface. The weeds and stubbles were removed from the land just after laddering with special care to remove the rhizomes of mutha grass.

Recommended Manure and fertilizer doses

Manure and Fertilizers	Dose/ha
Cowdung	**10t/ha**
N	**150 kg**
P	**30 kg**
K	**100 kg**
S	20 kg
Zn	2 kg

Source: Halder *et al*., (2007)

Application of manure and recommended fertilizer doses

The entire amount of cowdung, P, K, S and Zn were applied during final plot preparation. B was also applied as per of the treatment during final plot preparation. N was applied in three installments at 35, 55 and 75 days after planting of bulbs.

Planting of bulbs

Bulbs were thoroughly treated with fungicide Provex for 5 minutes and planted at a depth of 7 cm in furrows on February, 2013. Spacing was maintained at 30 cm from row to row and 20 cm from plant to plant.

Intercultural Operation

Weeding

Weeding was done periodically whenever necessary.

Irrigation

The experimental plot was irrigated as and when necessary during the whole period of plant growth following flood method.

Mulching

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

Earthing up

Earthing up were done three times at 40, 60 and 80 days after planting throughout the growing period.

Selection and tagging of plants

Ten plants from each plot were selected randomly and marked by tagging for recording data.

Harvesting

The spikes of tuberose were harvested from April to July, 2013 at the tight bud stage and when three basal flower buds showed colour so that these may easily open indoors one by one (Misra *et al*., 2001). Bulbs and bulblets were harvested on November, 2013 when the leaves also started yellowing (Ramesh *et al*., 2002).

Plant protection measure

Leaf blight disease is a serious problem for tuberose cultivation. But the severity of this disease was not so prominent during the study period. Tilt @ 1.5 ml/L was applied once in a fortnight interval. Compared to disease, the insects of tuberose are not so serious. Marshal and Malathion @ 1 ml/L were applied to protect mealybugs and aphids.

Data collection

Observation were recorded from randomly chosen 10 plants form each plot on following parameters.

Plant height

Plant height refers to the total length of the 10 randomly selected plants from ground level to tip of erect leaf measured by a meter scale at flower harvest and the mean was calculated and expressed in centimeter.

Leaves/plant

Number of leaves produced per plant was recorded from the selected plants by counting the number of leaves at flower harvest and average number of leaves produced per plant was worked out.

Plant/hill

Number of plant per hill was recorded by counting all the plant per hill from 10 randomly plants of each unit plot and the mean was calculated.

Plant spread

The plant spread was measured at two positions (NS and EW) at right angles to each other and average was worked out at flower harvest. The readings were taken from the selected plants and expressed in square centimeter.

Days required to 80% visible spike

It was recorded by counting the days from bulb planting to 80% visible spike initiation from randomly selected 10 plants in each plot, then averaged and expressed in days.

Spike length (cm)

It was measured from the end where from it was cut off at the base to the tip of the spike by measuring scale from 10 randomly selected spikes and then mean was calculated and expressed in centimeter.

Rachis length (cm)

Length of rachis refers to the length from the axils of first floret up to the tip of inflorescence from 10 randomly selected plants.

Floret number

It was recorded by counting the number of florets from 10 randomly selected spikes and then mean was calculated.

Spike weight

Ten spikes were cut from 10 randomly selected plants from each unit plot and the weights of spikes were recorded to calculate their mean and expressed in grams.

Flower durability

Flower durability was recorded from the time of first floret opening to the maximum freshness from 10 randomly selected spikes in field condition and expressed in days.

Flower yield/ha

Flower yield per hectare was computed from counting the number of spikes per plot and converted to hectare.

Bulb number

It was calculated from the number of bulb obtained from 10 randomly selected plants and mean was calculated.

Bulblet number

It was calculated from the number of bulblets obtained from 10 randomly selected plants and mean was calculated.

Bulb diameter (cm)

Diameter of harvested bulb was measured by using slide calipers from 10 randomly selected plants, averaged and expressed in centimeter.

10 bulblet weight (g)

Weight of 10 bulblet/plant was recorded from the mean weight of 10 randomly selected sample plants and expressed in grams.

Bulb yield t/ha

Bulb yield ton per hectare was computed from weighting the bulbs per plot and converted to hectare.

Bulblet yield t/ha

Bulblet yield ton per hectare was computed from weighting the bulblets per plot and converted to hectare.

Statistical Analysis

The recorded data on different parameters were statistically analyzed using 'MSTAT-C' 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 Duncan's Multiple Range Test (DMRT) according to Steel *et al*., (1997) at 5% level of probability. The analysis of variance (ANOVA) of data on different characters of tuberose is given in Appendix III-V.

Chapter 4

Results and Discussion

CHAPTER IV
RESULTS AND DISCUSSION

The present experiment was undertaken to determine the effect of bulb size and different levels of boron fertilizer on growth, flowering and bulb production of tuberose. The analysis of variance (ANOVA) of the data on different characters is given in Appendix III-V. The results of the study have been presented and discussed and possible interpretations have been given under the following headings:

Plant height (cm)

Plant height (cm) was significantly influenced by bulb size. Although the different bulb size showed a gradual increasing trend in plant height of tuberose start from small to large size bulb at different days of bulb planting (Figure 2). However, at harvest (80 days after bulb planting), the tallest plant (55.0 cm) was recorded in large size bulb which was followed by medium size bulb (50.0 cm). The shortest plant (45.0 cm) at harvest was recorded for small size bulb. This might be due to the fact that higher reserve food in large bulb resulted in optimum growth and ultimately gave tallest plant in comparison to small bulb. Raja and Palanismay (2000) while working with different sizes of bulbs found similar results on growth and flowering of tuberose.

In considering the plant height, boron fertilizer also showed variation at different days after bulb planting in tuberose. However, the tallest plant (56.0 cm) was recorded due to application of 2.0 kg boron per hectare in tuberose (Figure 3). On the other hand the shortest tuberose plant (48.0 cm) was recorded in the plot with control condition i.e. no boron fertilizer application. The observed results are in agreement with the findings of Halder *et al.,* (2007).

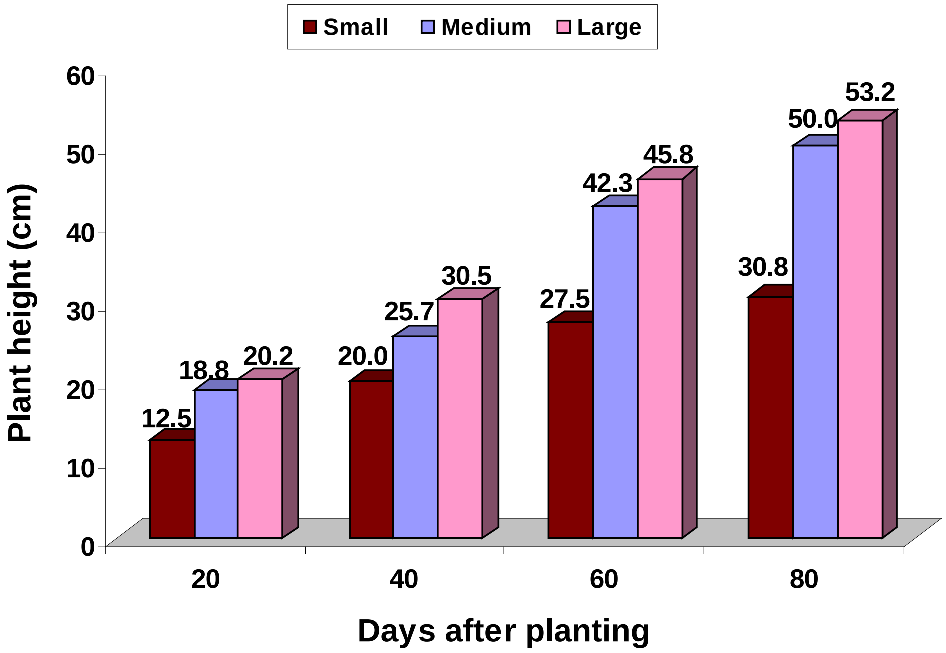


Figure 2. Effect of bulb size on plant height of tuberose

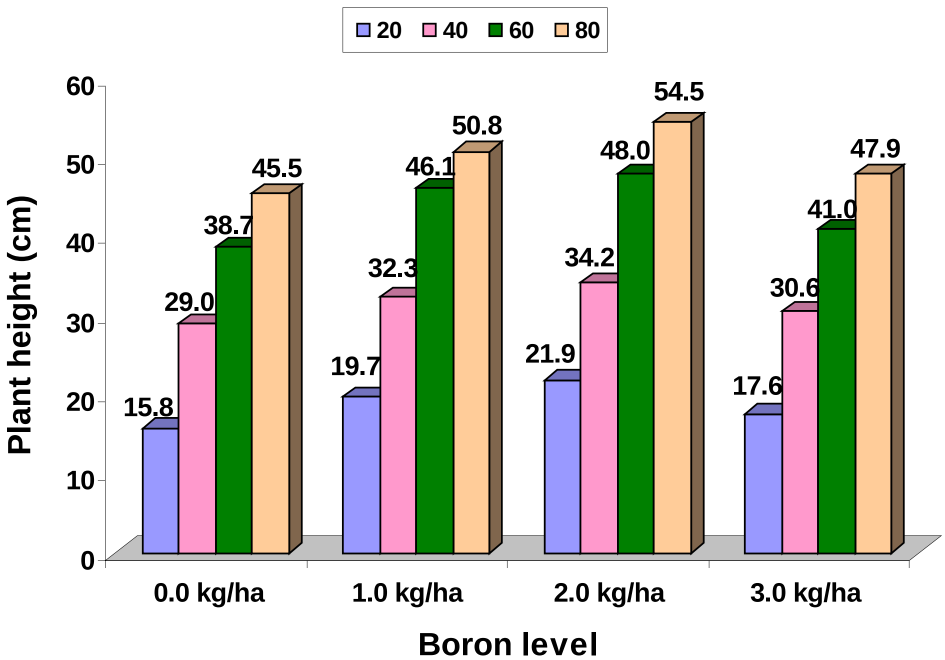


Figure 3. Effect of Boron level on plant height of tuberose

Interaction effect between bulb size and different level of boron fertilizer showed significant variation in plant height of tuberose. But tallest plant of tuberose (58.0 cm) at flower harvest was recorded in large size bulb with 2.0 kg/ha boron level and the shortest plant (35.9 cm) were recorded in small size bulb with no boron fertilizer application (Figure 4). These results are supported by Halder *et al.,* (2007) in tuberose.

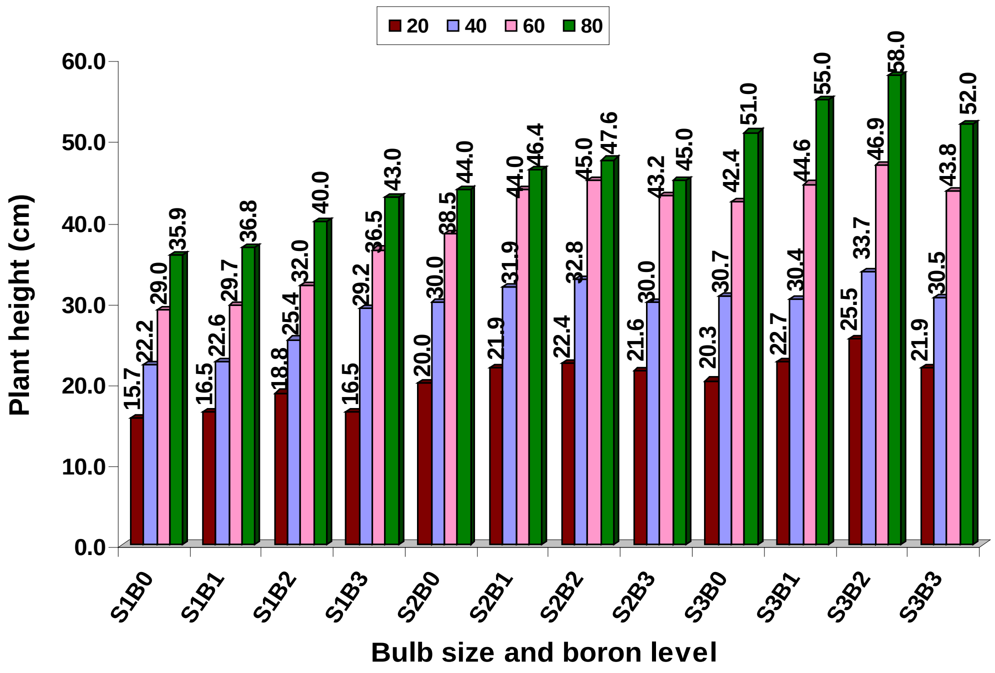


Figure 4. Interaction effect of bulb size and Boron level on plant height of tuberose

Number of leaves/plant

Bulb size significantly influenced the number of leaves/plant (Appendix III). Different bulb size showed a gradual increasing trend in terms of number of leaves/plant of tuberose under the study considering the small to large size bulb (Table 1). The maximum number (20.0) of leaves/plant was recorded in large size bulb closely followed by medium size bulb (17.0) and the minimum (15.0) was recorded for small size bulb. Mohanta and Paswan (1995) obtained similar results and reported that larger bulbs produced more leaves compared to smaller bulbs.

Table 1. Main effect of bulb size and boron level on vegetative growth of tuberose

Treatments (corm size)	Leaves/ plant	Plant/ hill	Plant spread (cm^2)
Effect of bulb size			
Small (S_1)	15.0 b	4.0 b	15.0 b
Medium (S_2)	17.0 ab	6.0 ab	17.0 ab
Large (S_3)	20.0 a	7.0 a	19.0 a
Level of significance	*	*	*
Effect of boron fertilizer			
Control (B_0) 0 kg/ha	15.0 b	4.0 b	12.0 b
(B_1) 1.0 kg/ha	20.0 ab	7.0 ab	16.0 ab
(B_2) 2.0 kg/ha	23.0 a	9.0 a	18.0 a
(B_3) 3.0 kg/ha	19.0 ab	6.0 ab	15.0 ab
Level of significance	*	*	*
CV (%)	7.0	8.4	5.3

Means with the same letter (s) are not significantly different at 5% level by DMRT
* Significant at 5% level
S_1 = Small (>1-1.5 cm dia), S_2= Medium (>1.5-2.0 cm dia) and S_3= Large (>20-2.5 cm dia)
B_0= Control, B_1= 1.0 kg/ha, B_2= 2.0 kg/ha and B_3= 3.0 kg/ha

Different levels of boron fertilizer showed a statistically significant variation for number of leaves/plant at harvest under the present trial (Appendix III). With the increases level of boron fertilizer upto 2 kg/ha number of leaves/plant represents an increasing trend (Table 1). The maximum (23.0) number of leaves/plant at harvest was recorded from 2.0 kg/ha boron. On the other hand the minimum number (15.0) of leaves/plant was recorded in control condition. The observation is similar to the findings of Halder *et al*., (2007) in tuberose. These variations in number of leaves per plant might be due to the fact that boron improves the physiological efficiency of the plant such as improvement of rate of photosynthesis, control of transpiration and photorespiration, efficient water and nutrient uptake, control of leaf senescence thus inducing resistant to environmental stress and ultimately increasing the harvest index.

Interaction effect was recorded between bulb size and different levels of boron fertilizer in terms of leaves/plant of tuberose (Appendix III). But maximum number (24.0) of leaves/plant at harvest was recorded from large size bulb with level of boron at 2.0 kg/ha and the minimum (15.0) was found from small size bulb (Table 2).

Table 2. Combined effect of bulb size and boron level on vegetative growth of tuberose

Treatments	Leaves/ plant	Plant/hill	Plant spread (cm^2)
S_1B_0	15.0 c	4.0 b	13.0 c
S_1B_1	16.0 bc	5.0 ab	14.0 bc
S_1B_2	17.0 bc	6.0 ab	14.5 bc
S_1B_3	16.0 bc	5.0 ab	14.0 bc
S_2B_0	19.0 bc	7.0 ab	14.0 bc
S_2B_1	21.0 bc	8.0 ab	15.0 b
S_2B_2	22.0 bc	8.0 ab	16.0 ab
S_2B_3	20.0 b	5.0 ab	15.8 ab
S_3B_0	20.0 b	5.0 ab	15.0 b
S_3B_1	22.0 ab	9.0 a	17.5 ab
S_3B_2	24.0 a	10.0 a	21.0 a
S_3B_3	21.0 ab	6.0 ab	16.2 ab
Level of significance	*	*	*
CV (%)	7.0	8.4	5.3

Means with the same letter (s) are not significantly different at 5% level by DMRT
* Significant at 5% level

S_1 = Small (>1-1.5 cm dia), S_2= Medium (>1.5-2.0 cm dia) and S_3= Large (>20-2.5 cm dia)
B_0= Control, B_1= 1.0 kg/ha, B_2= 2.0 kg/ha and B_3= 3.0 kg/ha

Number of plant per hill

Statistically on significant variation was recorded in terms of number of plants/hill (Appendix III). Different bulb size showed a gradual increasing trend in terms of number of plants/hill of tuberose under the study for small to large size bulb at flower harvest (Table 1).

The maximum (7.0) number of plants/hill at harvest was recorded in large size bulb and the minimum (4.0) was recorded for small size bulb. Khaled (2008) obtained similar results in tuberose.

Different level of boron fertilizer showed a statistically significant difference for number of plants/hill at flower harvest under the present study (Appendix III). The maximum (9.0) number of plants/hill was recorded at 2.0 kg/ha boron fertilizer closely followed by boron @ 1.0 kg/ha (7.0) of boron fertilizer. On the other hand the minimum (4.0) number of plants/hill was recorded in the plot with control condition i.e. no boron fertilizer. The observed results are in agreement with the findings of Halder *et al.,* (2007) in tuberose. They reported that application of boron might have resulted in cell division resulting in enhanced plants per hill.

Interaction effect between bulb size and different level of boron fertilizer showed significant variation in terms of number of plants/hill of tuberose (Appendix III). The maximum number (10) was recorded in large size bulb at 2.0 kg/ha boron fertilizer level and the minimum (4.0) was recorded in small size bulb was no boron fertilizer application (Table 2).

Plant spread

The plant spread of tuberose plant is an important morphological character that influences the yield, because it is correlated with photosynthesis by the higher leaf area. There were significant differences among bulb size in respect of plant spread (Table 1). The maximum plant spread was recorded in large bulb (19.0 cm) which was statistically different from other bulb size. The second highest plant spread (17.0 cm) was recorded in medium size bulb. The minimum plant spread (15.0 cm) was observed in small size bulb. Memon *et al.,* (2009) has also reported similar results.

Plant spread was influenced by the application of different boron level and the effect was statistically significant. Boron at 2.0 kg/ha showed the maximum plants spread (18.0 cm) while control treatment produced (12.0 cm) the minimum plant spread. Application of boron might have resulted in different cell wall synthesis, sugar transport, cell division and regulation of plant hormone levels resulting in enhanced plant spread (Marschner, 1995).

Interaction effect between bulb size and different level of boron fertilizer showed significant variation in plant spread of tuberose (Appendix III). But maximum plant spread of tuberose (21.0 cm) was recorded in large size bulb with 2.0 kg/ha boron level and the minimum plant spread (13.0 cm) were recorded in small size bulb with no boron fertilizer application (Table 2).

Days required to complete 80% visible spike

The days required to complete 80% visible spike initiation in tuberose were significantly influenced by bulb size and delayed gradually with the decrease in bulb size. The average days required to 80% visible spike ranged from 70 to 80 days. Small bulb took 80 days to complete 80% visible spike. On the other hand the large bulb took the shortest period (70 days) to do the same. Similar result was reported by Pathak *et al.,* (1980).

Application of different levels of boron fertilizer showed statistically significant difference for days required for planting to 80% visible spike under the present trial (Appendix IV). With the increasing level of boron fertilizer days required to visible spike showed different results (Table 3). The minimum 72 days required to visible spike was recorded due to application of at 2.0 kg boron /ha and the highest days (75) required to visible spike was recorded in the control plot. Singh *et al.,* (2005) obtained similar trend of results.

Table 3. Main effect of bulb size and boron level on flowering of tuberose

Treatments	Days required to 80% visible spike	Spike length (cm)	Rachis length (cm)	Floret number /spike	Spike weight (g)	Flower durability (days)
Effect of bulb size						
Small (S_1)	80.0 a	63.0 c	20.0 c	32.0 b	45.0 c	8.0 b
Medium (S_2)	75.0 b	70.0 b	24.0 b	38.0 ab	50.0 b	10.0 ab
Large (S_3)	70.0 c	78.0 a	28.0 a	41.0 a	55.0 a	12.0 a
Level of significance	*	*	*	*	*	*
Effect of boron level						
Control (B_0) 0 kg/ha	75.0 a	68.0 c	21.0 c	35.0 c	50.0	8.0 b
(B_1) 1.0 kg/ha	73.0 a	77.0 ab	26.0 ab	40.0 ab	57.0	12.0 ab
(B_2) 2.0 kg/ha	72.0 a	80.0 a	30.0 a	43.0 a	60.0a	13.0 a
(B_3) 3.0 kg/ha	74.0 a	75.0 b	25.0 b	38.0 b	55.0	10.0 ab
Level of significance	*	*	*	*	*	*
CV (%)	**8.6**	**9.5**	**8.8**	**6.2**	**10.5**	**7.2**

Means with the same letter (s) are not significantly different at 5% level by DMRT
* Significant at 5% level

S_1 = Small (>1-1.5 cm dia), S_2= Medium (>1.5-2.0 cm dia) and S_3= Large (>20-2.5 cm dia)
B_0= Control, B_1= 1.0 kg/ha, B_2= 2.0 kg/ha and B_3= 3.0 kg/ha

There was significant interaction effect was found between bulb sizes and boron level regarding the period required to 80% spike initiation (Appendix IV). The large size bulb combined with 2.0 kg boron /ha took the shortest time (75 days) for 80% visible spike while, 88 days was required by the treatment combination of small bulb and control (Table 4). This might be due to the combined effect of large bulb having short dormancy period along with boron that has a role in flower initiation resulting on quicker visible spike.

Table 4. Combined effect of bulb size and boron level on flowering of tuberose

Treatments	Days required to 80% visible spike	Spike length (cm)	Rachis length (cm)	Floret number /spike	Spike weight (g)	Flower durability (days)
S_1B_0	88.0 a	70.0 c	20.0 d	31.0 d	44.0 de	9.0 b
S_1B_1	84.0 b	75.0 bc	21.0 cd	33.0 cd	45.0 e	10.0 ab
S_1B_2	85.0 ab	74.0 bc	22.0 cd	35.0 c	48.0 de	11.0 ab
S_1B_3	86.0 ab	72.0 bc	24.0 cd	34.0 cd	50.0 d	10.0 ab
S_2B_0	84.0 b	73.0 bc	24.0 cd	35.0 c	51.0 cd	10.0 ab
S_2B_1	81.0 bc	75.0 bc	27.0 bc	38.0 bc	54.0 cd	12.0 ab
S_2B_2	82.0 bc	76.0 b	29.0 bc	41.0 ab	56.0 bc	12.0 ab
S_2B_3	83.0 b	73.0 bc	26.0 bc	38.0 bc	55.0 c	10.0 ab
S_3B_0	80.0 c	75.0 bc	25.0 c	37.0 bc	55.0 c	10.0 ab
S_3B_1	76.0 cd	80.0 ab	31.0 ab	43.0 ab	62.0 ab	12.0 ab
S_3B_2	75.0 d	82.0 a	33.0 a	45.0 a	65.0 a	14.0 a
S_3B_3	78.0 cd	76.0 b	30.0 b	40.0 b	60.0 b	11.0 ab
Level of significance	*	*	*	*	*	*
CV (%)	**8.6**	**9.5**	**8.8**	**6.2**	**10.5**	**7.2**

Means with the same letter (s) are not significantly different at 5% level by DMRT
* Significant at 5% level
S_1 = Small (>1-1.5 cm dia), S_2= Medium (>1.5-2.0 cm dia) and S_3= Large (>20-2.5 cm dia)
B_0= Control, B_1= 1.0 kg/ha, B_2= 2.0 kg/ha and B_3= 3.0 kg/ha

Spike length

The length of spike varied significantly due to the effect of different bulb sizes. The highest spike length (78.0 cm) was obtained from the large sized bulb. It was followed by medium sized bulb (70.0 cm). On the other hand, the shortest spike (63.0 cm) was produced by small bulb (Table 3). The increased spiked length of large bulb was probably due to the better vegetative and reproductive growth of the plant. The results also agreed with the findings of Ahmad *et al.*, (2009) who concluded that the increased spike length was due to the use of large bulb.

Different levels of boron fertilizer showed a statistically variation on spike length under the present trial (Appendix IV). With the increasing level of boron fertilizer spike length performed an increasing trend (Table 3). The longest spike (80.0 cm) was recorded in the level of boron fertilizer at 2.0 kg/ha. On the other hand the shortest 68.0) length of spike was recorded in the plot with control condition i.e. no boron fertilizer. Bhattacharjee (2010) reported similar results in crops.

Interaction effect of bulb size and different boron fertilizer level showed significant difference on spike length of flower stalk of tuberose (Appendix IV). The longest (82.0 cm) spike was recorded from large size bulb with the level of boron fertilizer at 2.0 kg/ha and the shortest (70.0 cm) was obtained from small size bulb with no boron fertilizer (Table 4).

Rachis length

The results of the present experiment revealed that variation in rachis length due to the effect of bulb size was statistically significant. The rachis length was increased with the increase in bulb size (Table 3). Plants from large bulb produced the longest rachis (28.0 cm). On the other hand, plant grown from small bulb produced the shortest rachis (20.0 cm) (Table 3). Better performance of the plants from larger bulbs might be due to the better growth of the plants from bulb. This observation is similar to the findings of Memon *et al.,* (2009) and Bankar and Mukhopadhyay (1980) in gladiolus and tuberose.

Different level of boron fertilizer showed a statistically variation for length of rachis (cm) under the present trial (Appendix IV). With the increase level of boron fertilizer length of rachis showed an increasing trend (Table 3). The longest (30.0 cm) length of rachis was recorded in the level of boron fertilizer at 2.0 kg/ha. On the other hand the shortest (20.0 cm) length of rachis was recorded in the plot with control condition. Similar results were reported by Ramesh *et al.,* (2002) in tuberose.

Interaction effect of between bulb size and different levels of boron fertilizer showed significant difference in length of rachis (Appendix IV). But longest (33.0 cm) length of rachis was recorded from large size bulb with the level of boron fertilizer at 2.0 kg/ha and the shortest (20.0 cm) was recorded in small size bulb with no boron fertilizer application (Table 4).

Number of florets per spike

The floret number is in important parameter of tuberose. There was significant variation on the number of florets per spike was observed due to use of different sizes of corm. The number of florets per spike was increased with the increasing in bulb size (Table 3). Plants from large bulb size produced the highest number of florets (41.0). On the other hand, plant grown from small bulb produced the lowest number of florets (32.0). It was concluded that the large sized bulb performed better and produced the maximum number of florets/spike which might be due to availability of more photosynthates. These results agreed with the results of Sathyararyana *et al.,* (1994) who also observed that larger bulb produced more florets compare to smaller size of bulb in tuberose.

Statistically significant variation was found on for number of floret/spike due to application of different levels of boron fertilizer under the present trial (Appendix IV). The maximum (43.0) number of floret/spike was recorded in the level of boron fertilizer at 2.0 kg/ha. On the other hand the minimum (35.0) number of floret/spike was recorded where the plot did not receive boron fertilizer. Gowda *et al.,* (1991) reported similar results in tuberose.

The maximum (45.0) number of floret/spike was recorded in large size bulb with the level of boron fertilizer at 2.0 kg/ha and the minimum (31.0) was recorded in small size bulb with no boron fertilizer application (Plate 2).

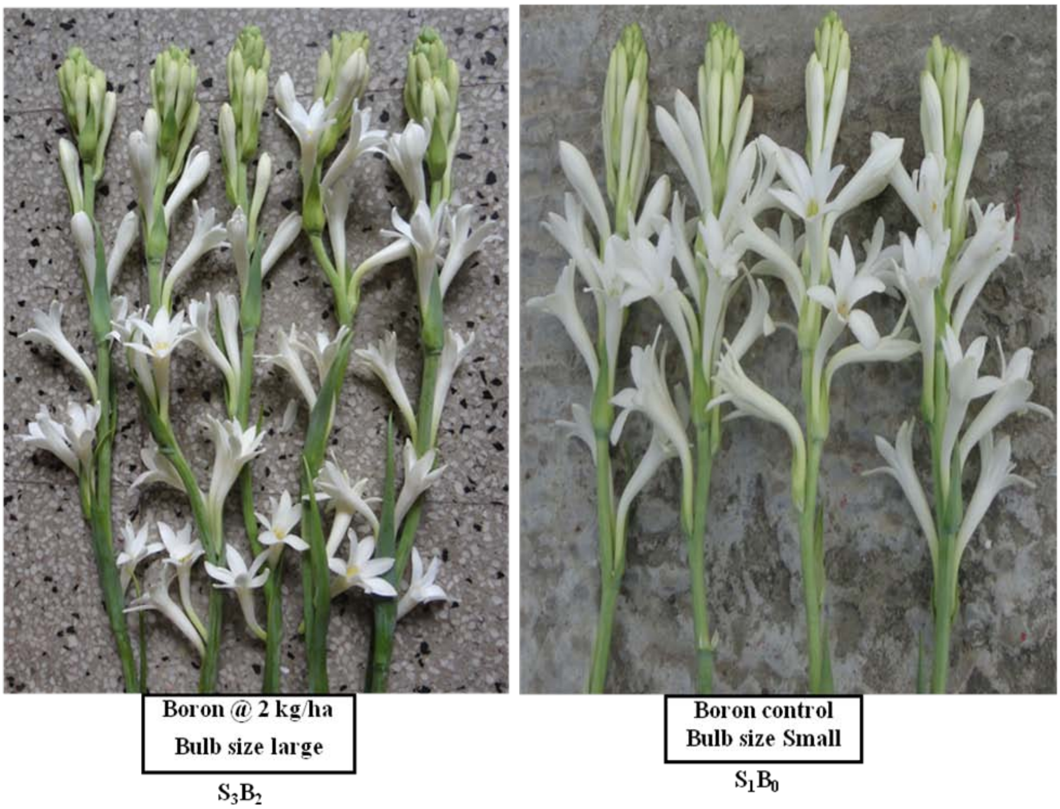


Plate 2. Floret number influenced by bulb size and boron level

S_1 = Small (>1-1.5 cm dia), S_2= Medium (>1.5-2.0 cm dia) and S_3= Large (>20-2.5 cm dia)
B_0= Control, B_1= 1.0 kg/ha, B_2= 2.0 kg/ha and B_3= 3.0 kg/ha

Spike weight

Spike weight was significantly influenced by bulb sizes. Large bulb showed maximum spike weight (55.0g) of spike while small sized bulb gave the minimum weight (45.0g) of spike (Table 3). Similar trend of results were reported by Satyavir and Singh (1998) in tuberose.

Levels of boron significantly influenced of spike weight. Boron at 2.0 kg/ha gave the maximum weight (60.0 g) of spike while control treatment showed the minimum weight (50.0 g) of spike (Table 3).

There was significant interaction effect between bulb size and boron regarding the weight of spike. When the combined effect was considered, the maximum weight of spike (65.0 g) was found in treatment combination of large bulb size treated with 2.0 kg/ha boron while small bulb size treated with control fertilizer showed the minimum (44.0 g) performance (Table 4).

Flower durability

Flower durability was significantly different due to the different bulb sizes used. Spikes produced from large bulb showed the maximum shelf life (12 days) whereas spikes obtained from small bulb showed the minimum shelf life (8 days) (Table 3). These results are in line with the results of Kale and Jhujbal (1972) who attributed that duration of flowering was shortest for plants produced from small bulb in tuberose.

Statistically significant variation was recorded on durability of flower due to use of different levels of boron fertilizer under the trial (Appendix IV). Increase the level of boron fertilizer upto 2.0 kg/ha, performed the maximum durability of flower (13 days) (Table 4). On the other hand the lowest (8 days) shelf life was recorded in the plot without use of boron fertilizer. Pal and Biswas (2005) reported similar results in tuberose.

Interaction effect of bulb size and different boron fertilizer level showed significant differences in terms on flower durability (Appendix IV). The highest (14 days) shelf life was recorded in large size bulb with the level of boron fertilizer at 2.0 kg/ha and the lowest (9 days) was recorded in small size bulb with no boron fertilizer application (Table 4).

Flower yield

Bulb size showed significant effect on the flower yield per hectare. The maximum 340000 spikes per hectare were obtained from the plant grown from large bulb. On the other hand, the minimum yield (310000 spikes) was observed when small bulb was used as planting material (Table 3).

Boron significantly influenced yield of spike. The results showed that total spike was increased with the increasing in concentration of boron upto 2.0 kg/ha. Boron at 2.0 kg/ha gave the highest (350000 spikes/ha) yield while control treatment showed the lowest yield (325000 spikes/ha) of tuberose (Table 3).

There was significant interaction effect was observed on yield due to application of different sizes of bulb and boron (Appendix IV). The combined effect of large size bulb and 2.0 kg boron /ha showed the maximum yield (400000 spikes/ha) and the minimum yield (315000 spikes/ha) was obtained from the treatment combination of small bulb size and no boron fertilizer was used (Table 4). These results are in accordance with findings of Khalifa *et al.*, (2011) in tuberose.

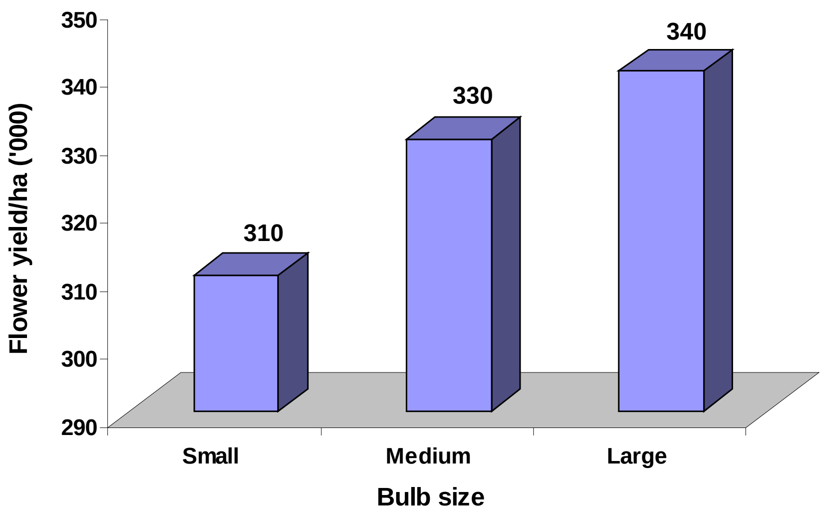


Figure 5. Effect of bulb size on flower yield of tuberose

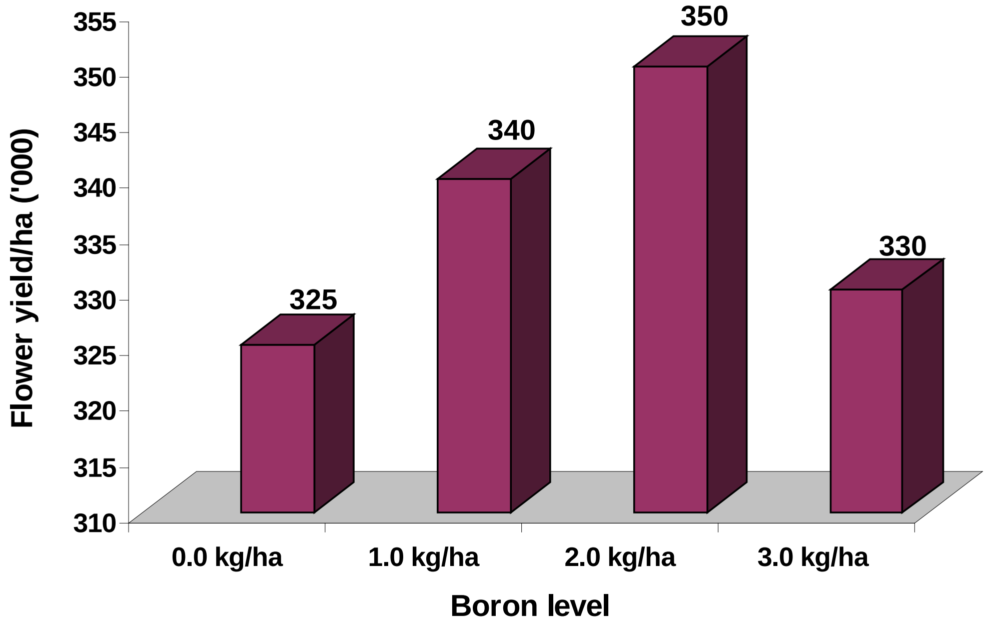


Figure 6. Effect of Boron level on flower yield of tuberose

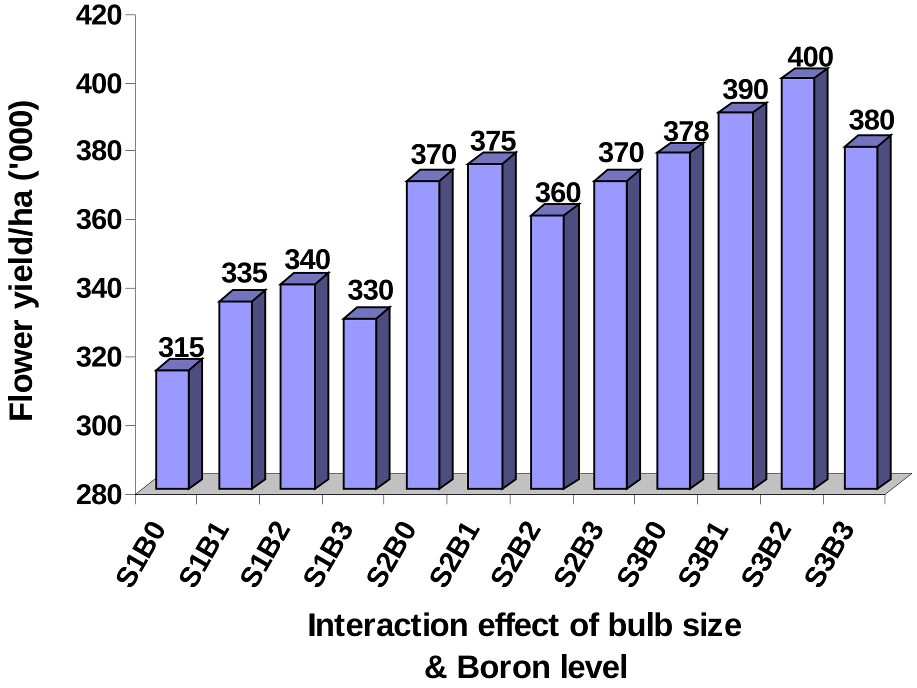


Figure 7. Interaction effect of bulb size and Boron level on flower yield of tuberose

Number of bulb per plant

The bulb size had significant effect on the number of bulb per plant. The large size bulb produced the maximum number (5.0) of bulb per plant while the small bulb produced minimum number (2.0) of bulb per plant (Table 5). These results are in accordance with the results of Kumar *et al*., (2003) in tuberose. They reported more bulb and bulblet from large size bulb than other bulb size.

Table 5. Main effect of bulb size and boron level on bulb and bulblet production of tuberose

Treatments	Bulb number/ plant	Bulblet number/ plant	Bulb diameter (cm)	10 bulblet weight (g)	Yield of bulb (t/ha)	Yield of bulblet (t/ha)
Effect of bulb size						
Small (S_1)	2 b	5 c	1.3 b	40 c	5.3 b	7.3 b
Medium (S_2)	3 ab	9 b	2.5 ab	46 b	8.2 ab	9.4 ab
Large (S_3)	5 a	13 a	3.0 a	50 a	9.0 a	11.5 a
Level of significance	*	*	*	*	*	*
Effect of boron level						
Control (B_0) 0 kg/ha	3 b	8 c	1.8 b	46.0 c	5.3 b	8 b
(B_1) 1.0 kg/ha	5 ab	11 b	3.3 a	53.0 ab	8.5 ab	11 ab
(B_2) 2.0 kg/ha	6 a	15 a	3.5 a	56.0 a	9.3 a	12.0 a
(B_3) 3.0 kg/ha	4 ab	10 bc	2.9 ab	50.0 b	7.5 ab	10.5 ab
Level of significance	*	*	*	*	*	*
CV (%)	**6.6**	**7.5**	**8.0**	**9.3**	**10.5**	**9.2**

Means with the same letter (s) are not significantly different at 5% level by DMRT
* Significant at 5% level

S_1 = Small (>1-1.5 cm dia), S_2= Medium (>1.5-2.0 cm dia) and S_3= Large (>20-2.5 cm dia)
B_0= Control, B_1= 1.0 kg/ha, B_2= 2.0 kg/ha and B_3= 3.0 kg/ha

The number of bulb per plant was influenced by the application of different boron level and the effect was statistically significant. Boron at 2.0 kg/ha showed the highest number of bulb per plant (6.0) while the lowest number of bulb (3.0) was obtained from control (Table 5).

Combined effect of large size bulb planting with 2.0 kg/ha boron produced the highest number of bulb per plant (6.0) while small bulb and control treatment produced the lowest number of bulb (2.5) per plant (Table 5 and Appendix v).

Number of bulblet per plant

There was significant difference on the number of bulblet per plant was observed due to different sizes of bulb used. The number of bulblet per plant was increased with the increase in bulb size (Appendix v). Plants from large bulb produced the highest number of bulblet (13.0). On the other hand, plant grown from small bulb produced the lowest number of bulblet (5.0) (Table 5). This might be due to higher food reserve in the large bulb. The present results are in accordance with the findings of Pathak *et al.,* (1980) and Ahmad *et al.,* (2009) who obtained the higher number of bulblet in plants grown from large bulb.

The different levels of boron treatments had significant effect on the number of bulblet per plant. The maximum number of bulblet (15.0) per plant was obtained from bulb planting 2.0 kg/ha boron followed by 1.0 kg/ha boron. The minimum number of bulblet per plant (8.0) was produced by bulb with no boron application (Table 5). The result agrees with the findings of Mohanta *et al.,* (1998) who concluded that boron increased the number of bulblet per plant in tuberose.

The interaction effect of bulb size and boron on the number of bulblet per spike was found significant (Appendix V). However, the combined effect of bulb size and boron application revealed that the maximum number of bulblet (15.0) was obtained from the treatment combination of large bulb with 2.0 kg/ha boron. On the other hand, the treatment combination of small boron and control produced the minimum number of bulblet (6.0) per plant (Table 6 and Plate 5).

Table 6. Combined effect of bulb size and boron level on bulb and bulblet production of tuberose

Treatments	Bulb number/ plant	Bulblet number/ plant	Bulb diameter (cm)	10 bulblet weight (g)	Yield of bulb (t/ha)	Yield of bulblet (t/ha)
S_1B_0	2.5 b	6.0 c	1.8 b	40.0 d	5.5 b	7.5 b
S_1B_1	2.8 ab	9.0 bc	2.7 ab	42.0 cd	7.0 ab	8.0 ab
S_1B_2	3.0 ab	10.0 b	2.8 ab	44.0 cd	7.5 ab	8.3 ab
S_1B_3	2.6 ab	8.0 bc	2.5 ab	41.0 cd	7.0 ab	7.5 ab
S_2B_0	3.2 ab	10.0 b	2.8 ab	42.0 cd	9.0 ab	9.0 ab
S_2B_1	5.0 ab	11.0 ab	3.1 ab	47.0 bc	9.5 ab	9.3 ab
S_2B_2	4.0 ab	12.0 ab	3.2 ab	48.0 bc	9.6 ab	9.5 ab
S_2B_3	4.8 ab	10.0 b	3.0 ab	45.0 c	8.5 ab	9.8 ab
S_3B_0	3.5 ab	10.0 b	3.0 ab	47.0 bc	9.0 ab	10.0 ab
S_3B_1	5.0 ab	13.0 ab	3.3 ab	52.0 ab	9.7 ab	11.0 ab
S_3B_2	6.0 a	15.0 a	3.5 a	55.0 a	10.0 a	12.0 a
S_3B_3	4.0 ab	11.0 ab	3.1 ab	50.0 b	9.5 ab	10.8 ab
Level of significance	*	*	*	*	*	*
CV (%)	**6.6**	**7.5**	**8.0**	**9.3**	**10.5**	**9.2**

Means with the same letter (s) are not significantly different at 5% level by DMRT
* Significant at 5% level

S_1 = Small (>1-1.5 cm dia), S_2= Medium (>1.5-2.0 cm dia) and S_3= Large (>20-2.5 cm dia)
B_0= Control, B_1= 1.0 kg/ha, B_2= 2.0 kg/ha and B_3= 3.0 kg/ha

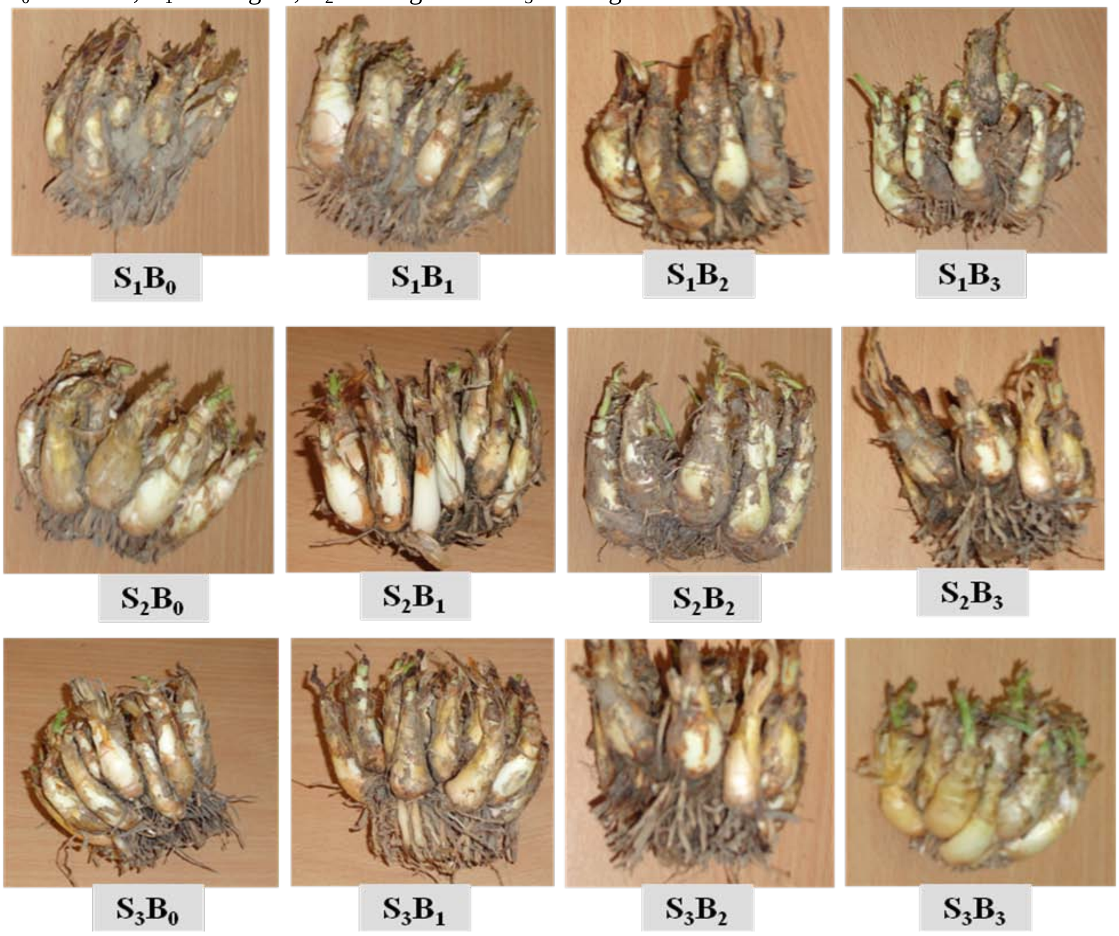


Plate 3. Bulblet number influenced by bulb size and boron level

S_1 = Small (>1-1.5 cm dia), S_2= Medium (>1.5-2.0 cm dia) and S_3= Large (>20-2.5 cm dia)
B_0= Control, B_1= 1.0 kg/ha, B_2= 2.0 kg/ha and B_3= 3.0 kg/ha

Bulb diameter

Bulb diameter significantly varied due to the effect of bulb size (Appendix v). The plants grown from larger bulb size produced the maximum diameter (3.0 cm). Whereas the small bulbs produced the minimum diameter (1.3 cm) of bulb (Table 5). Better performance of the plants from larger bulbs might be due to the better growth of the plants from in tuberose bulbs. The observation is similar to the findings of Mahanta *et al.*, (1998) in tuberose.

Plate 4. Bulb diameter influenced by bulb size and boron level

S_1 = Small (>1-1.5 cm dia), S_2= Medium (>1.5-2.0 cm dia) and S_3= Large (>20-2.5 cm dia)
B_0= Control, B_1= 1.0 kg/ha, B_2= 2.0 kg/ha and B_3= 3.0 kg/ha

Due to application of different levels of boron fertilizer showed statistically significant variation on diameter of bulb (Appendix V). The maximum (3.5) diameter of bulb was recorded in the level of boron fertilizer upto 2.0 kg/ha which was statistically superior to other boron fertilizer level. On the other hand, the minimum (1.8 cm) diameter of bulb was recorded in the plot with control condition. The observed results are in agreement with the findings of Singh and Godara (1998) in tuberose.

Interaction effect of bulb size and different levels of boron fertilizer showed significant differences on diameter of bulb under the present trial (Appendix V). The maximum (3.5 cm) diameter of bulb was recorded from large size bulb with boron at 2.0 kg/ha and the minimum (1.8 cm) was found from small size bulb with no boron fertilizer application (Table 6 and Plate 4).

Bulblet weight

Bulb size had significant influence on 10 bulblets weight (Appendix v). The highest weight (50.0 g) was obtained from the plants those grown from large bulbs whereas the lowest (40.0 g) was recorded when small bulbs were used as planting material (Table 5). This is in line with the findings of Ahmad *et al.,* (2009) in tuberose.

Different levels of boron fertilizer application showed a statistically significant variation in terms of weight of 10 bulblets (Appendix V). The highest (56.0g) weight of 10 bulblet was recorded in level of boron fertilizer at 2.0 kg/ha and the lowest (46.0g) was recorded in small size bulb with no boron fertilizer level application (Table 5).

Significant variation was observed due to the interaction effect of bulb size and boron level on the 10 bulblet weight (Appendix V). The minimum (40.0 g) was found in the treatment combination of small bulb and control while the maximum (55.0 g) was obtained from the treatment combination of large bulb and boron at 2.0 kg/ha (Table 6). These results are in accordance with the results of Bhattacharjee (2010) in tuberose.

Yield of bulb

A statistically significant variation was recorded due to different bulb size in terms of yield of bulb per hectare (Appendix V). The highest (9.0 t/ha) yield of bulb was recorded in large size bulb which was closely followed (8.2 t/ha) by medium bulb size and the lowest (5.3 t/ha) yield of bulb was recorded for small size bulb. The result of the present experiment is in agreement with the findings of Mukhopadhyay and Banker (1983) reported that highest yield was attained from large size of bulb of tuberose.

Application of different levels of boron fertilizer application showed a statistically significant difference in terms of yield of bulb (Appendix V). Increase the level of boron fertilizer, yield of bulb showed an increasing trend under the trial upto 2.0 kg/ha (Table 5). The highest (9.3 t/ha) yield of bulb was recorded in the level of boron fertilizer at 2.0 kg/ha. On the other hand the lowest (5.3 t/ha) yield of bulb was recorded in the plot with control condition. Similar results were reported by Singh *et al.*, (1996) in tuberose.

Interaction effect of bulb sizes and different boron fertilizer level showed significant variation in terms of yield of bulb (Appendix V). The highest (10.0 t/ha) yield of bulb was recorded from large size bulb with boron fertilizer level at 2.0 kg/ha and the lowest (5.5 t/ha) was recorded in small size bulb with no boron fertilizer application (Table 6).

Yield of bulblet

A statistical significant variation was recorded on different bulb size in terms of yield of bulblet per hectare (Appendix V). The highest (11.5 t/ha) yield of bulb was recorded in large size bulb which was closely followed (9.4 t/ha) by medium bulb size and the lowest (7.3 t/ha) yield of bulb was recorded from small size bulb. The present results are in agreement with the findings of Mukhopadhyay and Banker (1983) reported that the highest yield of bulblet was attained from large size of bulb of tuberose.

Due to application of different levels of boron fertilizer showed a statistically significant variation in terms of yield of bulblet (Appendix V). Increasing the level of boron fertilizer, yield of bulblet showed an increasing trend under the trial upto 2.0 kg/ha (Table 5). The highest (12.0 t/ha) yield of bulblet was recorded in the level of boron fertilizer at 2.0 kg/ha. On the other hand the lowest (8.0 t/ha) yield of bulb was recorded in the plot with control condition. Similar trend of results were reported by Singh *et al.,* (1996) in tuberose.

Interaction effect of bulb sizes and different levels of boron fertilizer showed significant variation in terms of yield of bulblet (Appendix V). The highest (12.0 t/ha) yield of bulblet was recorded from large size bulb with boron fertilizer level at 2.0 kg/ha and the lowest (7.5 t/ha) was recorded in small size bulb with no boron fertilizer application (Table 6).

Chapter 5

Summary and conclusion

CHAPTER V

SUMMARY AND CONCLUSION

Summary

The experiment was conducted at the Floriculture Research Field, Horticulture Research Centre, Bangladesh Agricultural Research Institute (BARI), Gazipur with the objective to study the effects of bulb size and boron on the growth, flower and bulb production of gladiolus during the period from February 2013 to November 2013. Three levels of bulb size: small - S_1 (1.0-1.5 cm dia.), medium- S_2 (>1.5 to 2.0 cm dia.) and large- S_3 (>2.0 to 2.5 cm dia.) and four different level of boron (B_0: control, B_1: 1.0 kg/ha, B_2: 2.0 kg/ha and B_3: 3.0 kg/ha) were used for this purpose. The two-factor experiment was laid out in randomized complete block design with three replications. There were all together 12 treatment combinations in this experiment.

Bulb of tuberose (*Polianthes tuberosa*) was planted on February 2013 with spacing of 30 x 20 cm. The spikes of tuberose were harvested from April to July, 2013 at the tight bud stage and when two-three basal flower buds showed colour so that these may easily open indoors one by one. Bulb and bulblet were harvested on May, 2013 when leaves turned brown. Data were collected on plant height, number of leaves, number of plants per plant, plant spread, days required to 80% visible spike, spike length, rachis length, number of florets per spike, spike weight, flower durability, flower yield, bulb number, bulblet number , bulb diameter, 10 bulblets weight, bulb and bulblet yield.

The results of the experiment revealed that bulb size and boron had significant effect on all parameters studied. Plant height, number of leaves, plant spread and number of plants per hill were significantly increased with the increase of bulb size. Boron at 2.0 kg/ha showed better performance in respect of plant growth over control. Large bulb with boron at 2.0 kg/ha produced the maximum plant height (58.0 cm), highest number of plants/hill (10.0), maximum plant spread (21.0 cm^2) and highest number of leaves (24.0).

Days taken to 80% visible spike was observed earlier in plant produced from large bulb (70 days) than in plant produced from medium and small bulb (75 and 80 days respectively). Boron at 2.0 kg/ha completed initiation of 80% visible spike earlier (72 days) than control (75 days).

The plant from large bulb produced the highest spike length (78.0 cm) and the shortest spike length was produced in plant grown from small bulb (63.0 cm). The length of spike was highest (80.0 cm) with the treatment of 2.0 kg/ha boron over control (68.0 cm). However, the combined effect of bulb size and boron level treatment revealed that the maximum spike length (82.0) was obtained from the treatment combination of large bulb with 2.0 kg/ha boron.

The plant from large bulb produced the highest rachis length (28.0 cm) whereas it was least (20.0 cm) with the use of small bulb. Boron had also significant effect on rachis length. The length of rachis was maximum (33.0 cm) with the treatment of 2.0 kg/ha boron in combination with large bulb over control (20.0 cm).

Number of florets per spike was maximum in large bulb (41.0) and was minimum in small bulb (32.0). Boron at 2.0 kg/ha produced the maximum number of florets per spike (43.0) followed by boron @ 1.0 kg/ha (40.0) and the control treatment produced the minimum number of florets (35.0).

However, the combined effect of bulb size and boron level treatment revealed that the maximum number of florets (45.0) was obtained from the treatment combination of large bulb with 2.0 kg/ha boron.

It was revealed that different bulb size and boron level had significant effect on weight of spike. Boron at 2.0 kg/ha with large bulb attained the maximum weight of spike (65.0 g).

The maximum flower durability (14 days) was found from the spike produced by the large bulb treated with boron 2.0 kg/ha while untreated bulb (without boron) showed the lowest performance (9 days). The highest flower yield per hectare (400000 spikes) was recorded from the treatment combination of large bulb size with boron @ 2.0 kg/ha.

Bulb and bulblet production also significantly influenced by different sizes of bulb and boron levels. The maximum number of bulb and bulblet (6.0 and 15.0) were produced by large bulb size with boron @ 2.0 kg/ha. The same level of boron with large bulb also showed better performance in bulb diameter (3.5 cm), bulb yield (10.0 t/ha) and bulblet yield (12.0 t/ha).

Conclusion

- Tuberose cv. single planted at large size (>2.0 to 2.5 cm dia.) produced the tallest plant, maximum number of leaves, tallest spike of maximum weight, superior rachis quality of maximum length and the maximum weight of individual bulb and bulblet per plant.

- All doses of boron significantly improved the all characteristics of tuberose cv. Single over control, while the most effective dose of boron was 2.0 kg/ha.

- ❖ Considering interaction effect between bulb size and different boron levels that the large size bulb in combination with 2.0 kg boron/ha increased vegetative growth, flower and bulb production of tuberose under agro-ecological conditions of Joydebpur.

Recommendation

- ❖ The study was conducted only one growing season. So, such types of experiment may be conducted in different agro-ecological zones (AEZ) of Bangladesh for regional adaptability and other performance.

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Appendices

APPENDICES

Appendix I. Mean monthly weather data during February 2013 to November 2013

Year	Month	Air temperature (°C)		Relative Humidity (%)	Rainfall (mm)
		Max.	Min.		
2013	February	22.25	17.74	85.60	07.10
2013	March	31.42	25.98	69.15	06.40
2013	April	32.10	29.00	75.00	57.50
2013	May	31.33	27.42	76.15	250.10
2013	June	32.00	29.15	64.10	377.50
2013	July	31.20	25.95	85.00	361.50
2013	August	30.86	25.75	86.40	590.00
2013	September	31.50	27.00	86.50	208.45
2013	October	29.75	26.80	85.28	183.40
2013	November	26.22	22.75	80.17	07.50

Source: Bangladesh Agricultural Research Institute, (BARI), Gazipur.

Appendix II. Analytical data of soil sample at Floriculture field of HRC, BARI

Year	p^H	Total N	OM	Ca	Mg	K
		%		Meq/100g		
2013	6.1	0.077	1.46	4.76	1.97	0.15
Critical level				2.0	0.8	0.2

Appendix II. Cont'd.

Year	p^H	P	S	B	Cu	Fe	Mn	Zn
		µg/g						
2013	6.1	15	38	0.32	6.0	232	10	3.30
Critical level		14	14	0.2	1.0	10.0	5.0	2.0

Source: Soil Science Division, Bangladesh Agricultural Research Institute, (BARI), Gazipur.

Appendix III. Analysis of variance of the data on different flower characters of tuberose as influenced by bulb size and boron

Source of variation	Degrees of freedom	Days to sprouting	Leaf number	Plant spread
Replication	2	3.05	1.09	3.14
Bulb size (A)	2	14.50*	15.12*	12.63*
Boron level (B)	3	0.65*	0.41*	0.58*
Interaction (A) x (B)	6	0.70*	1.20*	1.17*
Error	22	0.06	0.24	1.09

* = Significant at 5% level of probability

Appendix IV. Analysis of variance of the data on different plant characters of tuberose as influenced by bulb size and boron

Source of Variation	Degrees of freedom	Spike length	Rachis length	Number of floret/ spike	Spike weight	Flower durability
Replication	2	17.50	9.74	1.53	3.73	5.74
Bulb size (A)	2	66.52*	712.40*	114.10*	3549.16*	58.12*
Boron level (B)	3	80.74*	77.05*	11.05*	173.72*	151.33*
Interaction (A) x (B)	6	10.50*	11.86*	0.46*	6.89*	18.62*
Error	22	5.38	3.29	3.11	3.50	4.67

* = Significant at 5% level of probability

Appendix V. Analysis of variance of the data on different bulb characters of tuberose as influenced by bulb size and boron

Source of Variation	Degrees of freedom	Number of bulb/plant	Bulb diameter	Bulb weight	Number of bulblet/ plant	10 bulblets weight	Bulb yield t/ha	Bulblet yield t/ha
Replication	2	4.13	0.15	1.14	4.20	0.07	0.07	0.07
Bulb size (A)	2	31.40*	36.52*	32.40*	29.16*	18.12*	18.12*	18.12*
Boron level (B)	3	379.21*	0.74*	17.05*	0.47*	0.33*	0.33*	0.33*
Interaction (A) x (B)	6	11.20*	0.15*	58.50*	1.89*	0.16*	0.16*	0.16*
Error	22	3.81	0.04	3.29	1.23	0.03	0.03	0.03

* = Significant at 5% level of probability