EFFECT OF BULB SIZE AND DEPTH OF PLANTING ON GROWTH, FLOWERING AND YIELD OF TUBEROSE

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This is to certify that the thesis entitled ***'EFFECT OF BULB SIZE AND DEPTH OF PLANTING ON GROWTH, FLOWERING AND YIELD OF TUBEROSE'*** *submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of* ***MASTER OF SCIENCE*** *in* ***HORTICULTURE****, embodies the result of a piece of bona fide research work carried out by* ***SHABIHA SULTANA****, Registration number:* ***08-03110*** *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 duly been acknowledged.

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EFFECT OF BULB SIZE AND DEPTH OF PLANTING ON GROWTH, FLOWERING AND YIELD OF TUBEROSE

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ABSTRACT

The study was conducted at the Horticultural Farm of Sher-e-Bangla Agricultural University, Dhaka during the period from April 2013 to February 2014.The experiment consisted of two factors. Factor A: Three levels of bulb size: B_1-Small size, B_2-Medium size, B_3-Large size and Factor B: Three levels of depth of planting: D_1-3cm, D_2-5cm and D_3-7cm respectively.The experiment was laid out in a Randomized Complete Block Design with three replications. Bulb size and depth of planting showed significant variations on most of the parameters. In case of bulb size highest yield of spike (3,38,650 /ha) and bulb (21.53 t/ha) was recorded from B_3 and the lowest spike (2,80,760 /ha) and bulb (14.02 t/ha) from B_1. In case of depth of planting, the highest yield of spike (3,39,690 /ha) and bulb (20.49 t/ha) was found from D_2 and lowest spike (2,84,040 /ha) and bulb (16.25 t/ha) from D_1. For combined effect highest yield of spike (3,61,280 /ha) and bulb (24.46 t/ha) was found from B_3D_2 and the lowest spike (2,50,890 /ha) and bulb (13.48 t/ha) from B_1D_1. The highest benefit cost ratio (2.63) was noted from B_3D_2 and lowest (1.84) was from B_1D_1. So large size bulb planting in 5cm depth was found best for growth, flowering and yield of tuberose.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF APPENDICES

LIST OF ABBREVIATED TERMS

ABBREVIATIONS	FULL WORD
%	Percent
@	At the rate
AEZ	Agro Ecological Zone
ANOVA	Analysis of variance
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
j.	Journal
LSD	Least significant difference
m^2	Square meter
Max.	Maximum
ml/L	Mililitre per litre
^{O}C	Degree Celsius
ppm	Parts Per Million
R.H	Relative Humidity
SAU	Sher-e-Bangla Agricultural University
TSP	Triple Super Phosphate
Viz.	Namely

CHAPTER I

INTRODUCTION

Tuberose (*Polianthes tuberosa* L.) belongs to the family Amaryllidaceae is one of the most popular cut flower in tropical and sub-tropical areas. It is an important flowering crop with sweet fragrance from aesthetic as well as commercial point of view. It is a half-hardy bulbous perennial plant perpetuating itself through the bulb and bulblets, the leaves are long, narrow, linear, grass like, green which arise in rosette and roots are mainly adventitious and shallow. Tuberose is planted in beds and borders and can also be grown as potted plants (Sathynarayana *et al.*,1994).It is native of Mexico, from there, it was spread out to the different parts of the world during the 16th century (Tiwari and Singh, 2002). Now a days, it is cultivated on large scale in many countries e.g. France, Italy, South Africa, USA, including India and Bangladesh.

Tuberose is one of the most important commercial cut flowers. Tuberose occupies a very selective and special position to flower loving people. In the orient, where 'white' goes for virtue and purity, tuberose is much adored for its color, elegance and fragrance (Aditya, 1992). It has a great economic potential for cut flower trade and essential oil industry. The flowers remain fresh for quite a long time & stand long distance for transportation & fill a useful place in flower market. (Patel *et al*. 2006). 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, 1978). Apart from ornamental value, tuberose is extensively utilized as medicines for headache, diarrhea, rheumatism and allied pains (Mukhopadhyay, 1998).The natural flower oil of tuberose is one of the most expensive raw materials for perfume (Bankar and Mukhopadhyay, 1990). It is also used for table decoration arranged in bowls and vases.

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).Although tuberose is now grown in the country, very little is known about production technology in native condition. 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 and depth 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 (2005) 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.

Depth of planting depends on varieties, bulb size, depth of ploughed layer, moisture content of the soil and climatic conditions. It also influence the emergence period (Farrag, 1994). Planting depth has also been found useful in improving the growth, flowering and quality of flowers (Hagiladi *et al*., 1992). It was reported that planting depth for bulbs distance from surface to top is 3-10 cm in tuberose while these depth will varying under different conditions of planting time, soil type and bulb size (De Hertogh and Le Nard, 1998). Mane *et al*. (2003) reported that 5 cm depth of planting produced significantly superior results in case of diameter of spike, number of florets per spike and length of rachis.

Researcher believed that interaction of bulb size and depth of planting, are very important factors in improving the growth, flowering and quality of florets. So there is a scope of increasing flower yield, quality of flower and bulb production of tuberose with using suitable size of bulb and depth of planting. Very few researches have been conducted in Bangladesh on the effect of depth of planting on tuberose. Considering the present situations and above facts the present investigation was undertaken with the following objectives-

- To determine the effect of bulb size on growth, flowering and yield of tuberose.
- To determine the effect of depth of planting on growth, flowering and yield of tuberose.
- To determine the suitable combination of bulb size and depth of planting for better growth, flowering and yield of tuberose.

CHAPTER II

REVIEW OF LITERATURE

Tuberose is one of the important cut flower in Bangladesh and as well as many countries of the world. A very few studies on the related to growth, flower, and bulb production due to standard level of bulb size and depth of planting have been carried out in our country as well as many other countries of the world. Nevertheless, some of the important and informative works and research findings related to the bulb size and depth of planting on growth, flower and bulb production of tuberose reviewed under the following headings-

2.1 Effect of bulb size

Generally bulb and bulblets 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.

Ali and Akbari (2012) conducted an experiment with planting depth and bulb size on yield and flowering quality in tuberose, effect of three bulb sizes, including 1.5, 2.5 and 3.5 cm in diameter and planting depths: 4, 6 and 10 cm, on vegetative and flowering characteristics evaluated under greenhouse condition. Bulb size has influenced time of emergence of flower spike, diameter and length of spike, as well as germination percentage of bulbs. Results revealed that smaller bulbs, Due to failure in physiological maturity, produced lower flowers. Larger bulbs had the better quality in flowering, as well as because of more active metabolically processes such as carbohydrates breakdown latter germinated but developed earlier. So for increasing of yield and producing of desirable flowers with more value economically, the best of bulb size is advised 3.5 cm in diameter.

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 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.

Mane *et al*. (2003) conducted an experiment was laid out with three spacing (15, 20, 25 cm), two bulb sizes (2.5, 3 cm diameter) and three depths of planting (3, 5, 7 cm) of tuberose (*Polianthes tuberosa* cv. Single).The large bulb size(3cm) recorded significant increase in number of spikes per plant, the length and girth of spike, keeping quality of the spike at room temperature.

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. 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.

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 (*Polyanthus 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.

Raja and Palanisamy (2000) conducted a field experiment in Coimbatore, Tamil Nadu, India. 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.

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.

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.

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.

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. 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.

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. Bulblets 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 than 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.

Bankar and Mukhopadhyay (1990) reported that 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 as well as bulb and bulblet.

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.

2.2 Effect of depth of planting

Hussain *et al.* (2014) studied the effect of planting depths, potassium levels and their interaction during. The bulbs of tuberose were planted at a depth of 5, 10, and 15 cm and were fertilized with four levels of potassium 0, 50, 100 and 150 Kg of K_2O per hectare. Result of the study revealed that planting depth of 15 cm significantly increased length of spike (56.9 cm), number of florets spike^{-1} (54.84), and plant height (103.13) cm. Planting depth of 5 cm cause decreased number of days to last floret opening (180.08). Planting depth of 15 cm and fertilizer application of 150 kg of K_2O ha^{-1} proved to be superior regarding length of spike opening (64.4 cm), number of florets spike^{-1} (62.2) and plant height (106.20 cm). Hence planting tuberose at a depth of 15 cm and fertilizer application of 150 kg of K_2O ha^{-1} is recommended for commercial cultivation of tuberose.

Suleyman *et al* (2014) conducted an experiment on *Allium tuncelianum,*a wild ancestor of garlic to investigate the effect of 7.5 and 15 cm planting depth on morphological features of the plant. The experimental results indicated significantly positive effects of shallow sowing (7.5 cm depth) on vegetative characteristics like plant height, stem diameter, leaf length, bulb circumference, bulb diameter, number of bulbils per plant and bulb weight compared to deep sown (15 cm) bulbs. Flower diameter values varied between 5.74 and 6.07 cm, bulb diameter 2.79 and 3.06 cm and bulb weight between 21.01 and 23.67 g, respectively. Deep sowing had positive effects on generative characteristics like leaf width, number of leaves per bulb, length of leafless stems and inflorescence diameter.

Asad *et al*. (2014) conducted a research to find out the effect of planting depths, potassium levels and their interaction on growth and flowering of tuberose in Peshawar, Pakistan. The bulbs of tuberose were planted at a depth of 3, 5, and 7 cm and were fertilized with four levels of potassium 0, 50, 100 and 150 Kg of K2O per hectare. Result of the study revealed that planting

depth of 5 cm significantly increased length of spike (56.9 cm), number of florets spike (54.84), and plant height (103.13) cm. Planting depth of 3cm cause decreased number of days to last floret opening (180.08).

Ali and Akbari (2012) conducted an experiment with planting depth and bulb size on yield and flowering quality in tuberose, effect of three bulb sizes, including 1.5, 2.5 and 3.5 cm in diameter and planting depths: 4, 6 and 10 cm, on vegetative and flowering characteristics evaluated under greenhouse condition. In study of interaction of planting depth and bulb size, difference between treatments was not significant in parameters of days to emergence of spike, length of flower spike; total number of nodes per spike but differences in other characteristics was significant. For increasing of yield and producing of desirable flowers with more value economically, the best planting depth of 6 cm for cultivation of tuberose flowers.

Sikder *et al*. (2002) conducted a field experiment at the Horticulture farm of Bangladesh Agricultural University, Mymensingh to study the effects of spacing, and depth of planting on the growth and yield of two varieties of onion. There were three levels of plant spacing (viz., 20cm × 20cm, 20cm × 15cm and 20cm × 10cm) and two levels of depth of planting (viz., 2cm and 4cm).Wider spacing produced the maximum number of leaves per plant, longest plant height, maximum diameter and fresh weight of bulb while the closer spacing produced maximum yield of bulb. Bulb yield was significantly higher at lesser depth of planting. The combined effect of spacing and depth of planting was found to be significant on most of the growth and yield parameters. The combination of 20cm × 10cm spacing with 2cm depth of planting gave significant higher yield compared with other treatment combinations. So shallow planting showed better performance over deep planting.

Arya *et al*(2006) conducted a field trial consisting of three different planting depth (4.0, 5.5 and 7.0 cm) and two spacing (10x20cm and 20x20cm) at C.C.S.

University, Merrut (U.P.) to asses the comparative performance of these planting depths and spacing for improving the yield of tuberose. Maximum number of sprouts (3.94 and 5.06), number of leaves (23.52 and 38.57), length of longest leaf at 65 and 85 days after planting were found where the bulbs were planted at the depth of 4.0 cm. Wider spacing (20x20 cm) produced maximum number of sprouts and highest number of leaves per plant. Spacing had no significant effect on length of longest leaf and height of the plant. Therefore 4.0 cm depth of planting may be recommended for better vegetative growth of tuberose.

Sadhu and Das (2005) conducted a research on the effects of bulb size, planting density and depth of planting on tuberose (*Polianthes tuberosa* Linn. cv. single). Deep planting (6 cm) resulted in delay of sprouting as compared to shallow planting (4 cm). The number of flower sticks produced was found to be directly related to the depth of planting. Bulb yield increased with the increasing size of bulbs and depth of planting, but decreased with planting density.

Mane *et al*. (2003) conducted an experiment was laid out with three spacing (15, 20, 25 cm), two bulb sizes (2.5, 3 cm diameter) and three depths of planting (3, 5, 7 cm). Planting the bulbs at shallow depth (3 cm) resulted in the earliest spike emergence, but had no identical difference with medium depth (5 cm) of planting. The length of spike, number of spikes per plant and longevity of spike in field increased significantly at 7 cm depth, while the treatment (5 cm) recorded significantly superior results in case of diameter of spike, number of florets per spike and length of rachis. 5 cm depth of planting was found best to get maximum commercial advantage for achieving higher flower yield and quality of tuberose.

Kumar *et al*. (2003) the effects of bulb size (<1.5, 1.5-2.5 or 2.5-3.5 cm), spacing (20x20, 25x25 or 30x30 cm) and planting depth (3, 6 or 9 cm) on the growth and development of tuberose (Polianthes tuberosa cv. Single) were

studied in Umium, Meghalaya, India, during 1998 and 1999. Sprouting was delayed with the increase in bulb size and planting depth, and reduction in spacing. Spike emergence was delayed with the increase in the planting depth. . The depth of planting was inversely related to flower quality in terms of spike and rachis length. The longest spike (89.52 cm) and rachis (19.48 cm) were obtained with a planting depth of 9 cm. The number of flower spikes decreased with the deep planting of small bulbs at closer spacing. Planting depth up to 9 cm increased bulb production. Medium bulbs with moderate planting depth (6 cm) and spacing (25x25 cm) gave higher yields of flowers and bulbs.

Mahros (1999) conducted an experiment at the Experimental Farm of Assiut University during 1997 and 1998 to evaluate the effects of growing media, planting depth and the size of tuberose bulbs on growth, flowering, bulb production and contents of N, P and K as well as total sugars in both leaves and bulbs. The two planting depths were 3 and 6 cm, and the bulbs planted were single bulbs 2.0 cm in diameter, 2.5 cm bulbs with 3 bulblets and 3.0-cm bulbs with 6 bulblets. Bulbs grown at 3 cm sprouted earlier than those planted deeper. While the time to flowering was not affected, lengths of stems and spike, number of leaves per stem and bulb production were higher at a planting depth of 3 cm.

Singh (1999) conducted an experiment at Meerut, Uttar Pradesh, India, during 1989-91, tuberose *[Polianthes tuberosa*] was planted on 3 dates (2nd week of October, March or June) at 3 spacing (15 x 20, 20 x 20 or 25 x 20 cm) and at 2 planting depths (5 or 8 cm). The longest flower spikes and the highest numbers of spikes/clump resulted from June planting and the lowest plant density. Planting at 5cm gave more spikes/clump than 8cm. deep planting gave more bulbs/plant than shallow planting.

Incalcaterra (1992) investigated the effect of planting depth and plant density for corm production of gladiolus. Cormels were planted at depth of 2, 4, 8, 16

and 20 cm, it was observed that higher yield and better quality was planting at a depth of 8 cm.

Vinceljak (1990) carried out an experiment to investigate the effects of planting depth and planting density on gladiolus crom production. Cormels were planted at a depth of 2, 4, 8, 16 and 20 cm. It was found that planting depth of 16 and 20 cm gave markedly lower yields than shallower planting depth. The best treatment combination for higher yield and better quality was planting at a depth of 8 cm.

Syamal *et al*. (1987) studied the effect of corm size, planting distance and depth of planting on growth and flowering of gladiolus cv. Happy End in India. They found that large corms (4-5 and 5-6 cm in diameter) gave earlier sprouting and increased inflorescence and stem length. On the other hand, planting depth had no effect on total number and size of individual flowers.

Mattos *et al*. (1984) reported that the propagation of gladiolus was influenced by the depth of planting. Planting depth of 7.3 cm was best for parent corms for the production of corms over the range ‘Jumbo’ down to type 5. They also reported that a depth of 5.6 cm was better for producing large quantities of cormels.

Mottos *et al*. (1983) planted gladiolus corms of cultivars at 5 and 15 cm depth in dark red latosol of high fertility. They observed that planting at 5 cm depth produced the highest percentage of large corms.

CHAPTER III

MATERIALS AND METHODS

The field experiment was conducted during the period from April 2013 to February 2014 to find out the effect of bulb size and depth of planting on growth, flowering and yield of tuberose. The materials and methods that were used for conducting the experiment have been presented in this chapter under the following headings:

3.1 Experimental site

The experiment was conducted at the Horticultural Farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar; Dhaka (Plate 1).The location of the study site is situated in $23^0 74^/$N latitude and $90^0 35^/$E longitude. (Anon., 1989)

3.2 Characteristics of soil

The experimental soil belongs to the Modhupur Tract under AEZ No. 28 (Appendix IX).The selected experimental plot was medium high land and the soil series was Tejgaon (FAO, 1988). The characteristics of the soil were analyzed in the SRDI, Soil testing Laboratory, Farmgate, Dhaka and presented in Appendix I.

3.3 Weather condition of the experimental site

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

Plate 1: Experimental plot

3.4 Planting materials

Bulbs of tuberose (cv. single) were used as planting materials (Plate 2) and collected from Bangladesh Agricultural Research Institute (BARI), Gazipur.

3.5 Treatment of the experiment

The experiment consisted with two factors.

Factor A: Bulb size: 3 levels

i. B_1 - Small size (1.0-1.5 cm in diameter)

ii. B_2 - Medium size (>1.5 to 2.0 cm in diameter)

iii. B_3 - Large size(>2.0 to 2.5 cm in diameter)

Factor B: Depth of planting: 3 levels

i. D_1 - 3 cm depth of planting

ii. D_2 - 5 cm depth of planting

iii. D_3 - 7 cm depth of planting

There were 9 (3 × 3) treatment combinations such as B_1D_1, B_1D_2, B_1D_3, B_2D_1, B_2D_2, B_2D_3, B_3D_1, B_3D_2 and B_3D_3.

3.6 Experimental design and layout

The experiment was laid out following Randomized Complete Block Design (RCBD) with three replications. An area of 14.6 m × 8.0 m was divided into three equal blocks and each block was divided into 9 plots for distribution 9 treatment randomly. There were 9 unit plots with the size of the each unit plot was 2.0 m × 0.90 m. The layout of the experiment is shown in Figure 1.

3.7 Land preparation

The experimental plot was opened in the first week of April 2013, with a power tiller and left exposed to the sun for a week. After one week the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain until good tilth. Weeds and stubbles were removed and finally obtained a desirable tilth of soil.

Small

Medium

Large

Plate 2: Different size of bulbs in Tuberose cv. Single

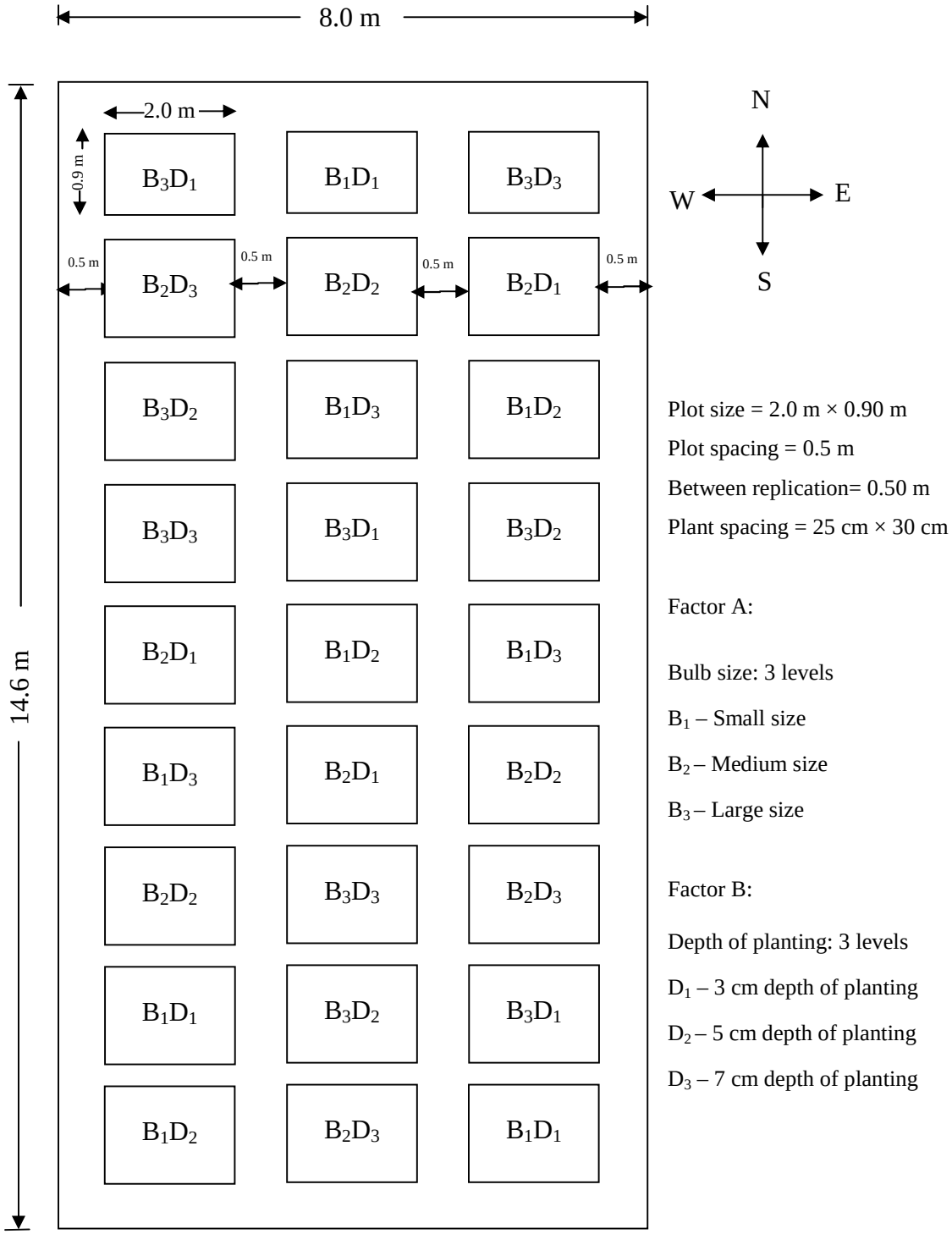


Figure 1. Layout of the experimental plot

3.8 Application of manure and fertilizers

The sources of N, P_2O_5, K_2O as urea, TSP and MP were applied, respectively as per recommended dose (Halder *et al*., 2007). The entire amounts of TSP and MP were applied during the final land preparation. Urea was applied in three equal installments at 30, 55 and 85 days after planting bulb of tuberose. Well-rotten cowdung also applied during final land preparation. The following amount of manures and fertilizers were used which shown as tabular form:

Table 1. Dose and method of application of fertilizers in tuberose field

Fertilizers	Dose/ha	Application (%)			
		Basal	30 DAP	55 DAP	85 DAP
Cowdung	10 ton	100	--	--	--
Nitrogen (as urea)	260 kg	25	25	25	25
P_2O_5 (as TSP)	200 kg	100	--	--	--
K_2O (as MP)	200 kg	100	--	--	--

3.9 Planting of bulblet

The experimental plot was partitioned into unit plots in accordance with the experimental design mentioned in Figure 1. The bulbs were planted on 15 April, 2013 with maintaining distance 25 cm × 30 cm and the number of bulbs/plot was 24.

3.10 Intercultural operation

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

3.10.1 Irrigation and drainage

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

3.10.2 Weeding

Weeding was done to keep the plots free from weeds, easy aeration of soil, which ultimately ensured better growth and development. The newly emerged weeds were uprooted carefully after complete emergence of seedlings whenever it is necessary. Breaking the crust of the soil was done when needed and it was done for 4 times at 15, 30, 45 and 60 DAP.

3.10.3 Top Dressing

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

3.11 Plant Protection

For controlling leaf caterpillars Nogos @ 1 ml/L water were applied 2 times at an interval of 10 days starting soon after the appearance of infestation. There was no remarkable attack of disease was found.

3.12 Data collection

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

3.12.1 Plant height

The height of plant was recorded in centimeter (cm) at 30, 45, 60, 75, 90 and 105 days after planting (DAP) in the experimental plots. The height was measured from the attachment of the ground level up to the tip of the growing point.

3.12.2 Number of leaves per plant

All the leaves of ten plants were counted at an interval of 15 days at 30, 45, 60, 75, 90 and 105 (DAP) in the experimental plots.

3.12.3 Days required from planting to emergence of spike

It was achieved by recording the days taken for emergence of tuberose spike from each unit plot.

3.12.4 Days required from planting to flowering

It was achieved by recording the days taken for emergence of tuberose flower from each unit plot.

3.12.5 Flowering plant

It was calculated by counting the numbers of plants that bearing flowers in each unit plot and divided by the number of plants emerged and converted to percentage.

3.12.6 Length of flower stalk at harvest

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

3.12.7 Length of rachis at harvest

Length of rachis refers to the length from the axils of first floret upto the tip of the inflorescence and expressed in centimeter.

3.12.8 Number of florets per spike

All the florets of the spike were counted from 10 randomly selected plants and their mean was calculated.

3.12.9 Number of spike per plot

Number of spikes per plot was counted from each plot and express in numbers of spikes per plot and converted to hectare.

3.12.10 Number of spike per hectare (‘000)

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

3.12.11 Weight of individual bulb

It was determined by weighting the bulb from the ten randomly selected plants and mean weight was calculated and expressed in gram.

3.12.12 Thickness of individual bulb

Bulbs were separated from the plant and the thickness of bulb was taken by a slide calipers and expressed in centimeter.

3.12.13 Diameter of individual bulb

A slide calipers was used to measure the diameter of the bulb and expressed in centimeter and mean of 10 bulbs was recorded.

3.12.14 Number of bulblet per plant

It was calculated from the number of bulblet obtained from ten randomly selected plants and mean was recorded.

3.12.15 Weight of bulblet

Individual weight of bulblet was recorded from the mean weight of ten randomly selected sample bulblets and expressed in gram.

3.12.16 Diameter of bulblets

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

3.12.17 Bulb yield per plot and hectare

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

3.12.18 Bulblet yield per plot and hectare

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

3.13 Statistical analysis

The experimental data obtained for different parameters were statistically analyzed. The mean values of all the recorded characters were calculated and analysis of variance was performing by the 'F' (variance ratio) test. The significance of the difference among the individual and treatment combinations means was estimated by the Duncan's Multiple Range Test (DMRT) at 5% level of probability Steel *et al*., (1997).

3.14 Economic analysis

The cost of production was analyzed in order to find out the most economic treatment of bulb size and planting depth. All input cost were considered in computing the cost of production. The market price flower, bulb and bulblets were considered for estimating the return. The benefit cost ratio (BCR) was calculated as follows:

$$\text{Benefit cost ratio} = \frac{\text{Gross return per hectare (Tk.)}}{\text{Total cost of production per hectare (Tk.)}}$$

CHAPTER IV

RESULTS AND DISCUSSION

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

4.1 Plant height

Plant height of tuberose showed statistically significant variation due to different bulb size at 30, 45, 60, 75, 90 and 105 days after planting (DAP) (figure 2). At harvest 105 DAP, the tallest plant (51.42 cm) was recorded from B_3 (large size bulb) which was followed by B_2 (medium size bulb) (49.07 cm) while the shortest plant (46.54 cm) was found from B_1 (small size bulb), respectively (Appendix III). The plant height was higher in larger bulb size because of larger bulb had huge stored food material that support to increase vegetative growth of the plants. Ahmad *et al.* (2009) observed that large bulb size resulted in vigorous growth as compared to small and medium sized bulbs.

Different depth of planting showed statistically significant variation in terms of plant height of tuberose at different days after planting (Figure 3). At 105 DAP, the tallest plant (52.13 cm) was found from D_2 (5 cm depth of planting), whereas, the shortest plant (49.25cm) was observed from D_1 (3 cm depth of planting), which was statistically similar (49.72 cm) to D_3 (7 cm depth of planting) for the same DAP, respectively (Appendix III). Suleyman *et al* (2014) reported that shallow sowing of bulb gave better performance over deep sowing.

Combined effect of different bulb size and depth of planting showed statistically significant variation in terms of plant height of tuberose at different days after planting (Table 2).The tallest plant (54.13 cm) was observed from B_3D_2 at 105 DAP, whereas the shortest plant (47.39 cm) was recorded from B_1D_3 at same DAP, respectively(Appendix III).

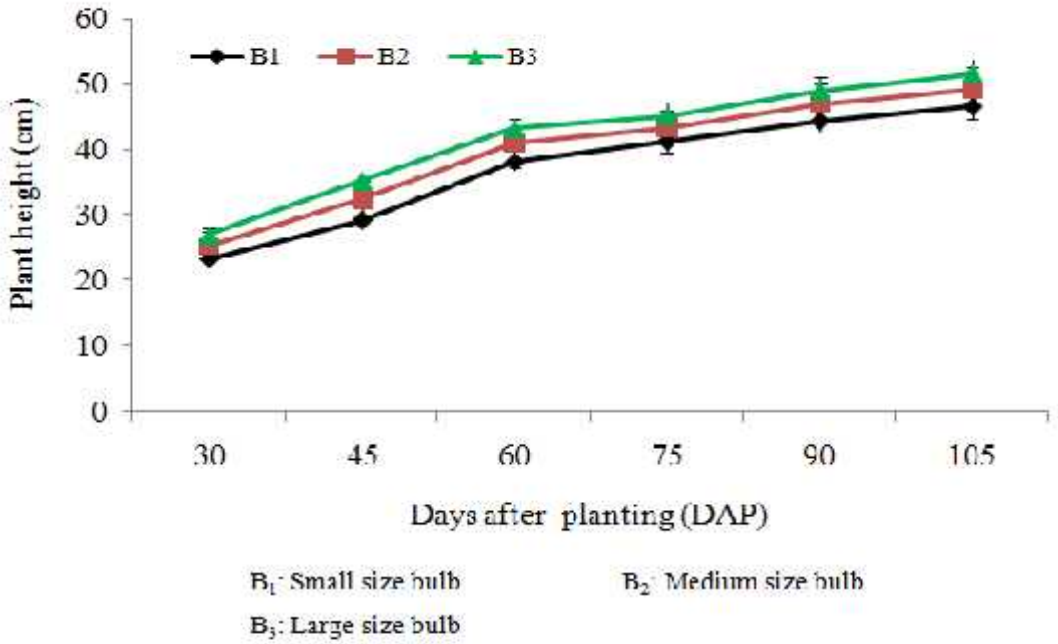


Figure 2. Effect of bulb size on plant height of tuberose. Vertical bars represent LSD value at 5% level of significance.

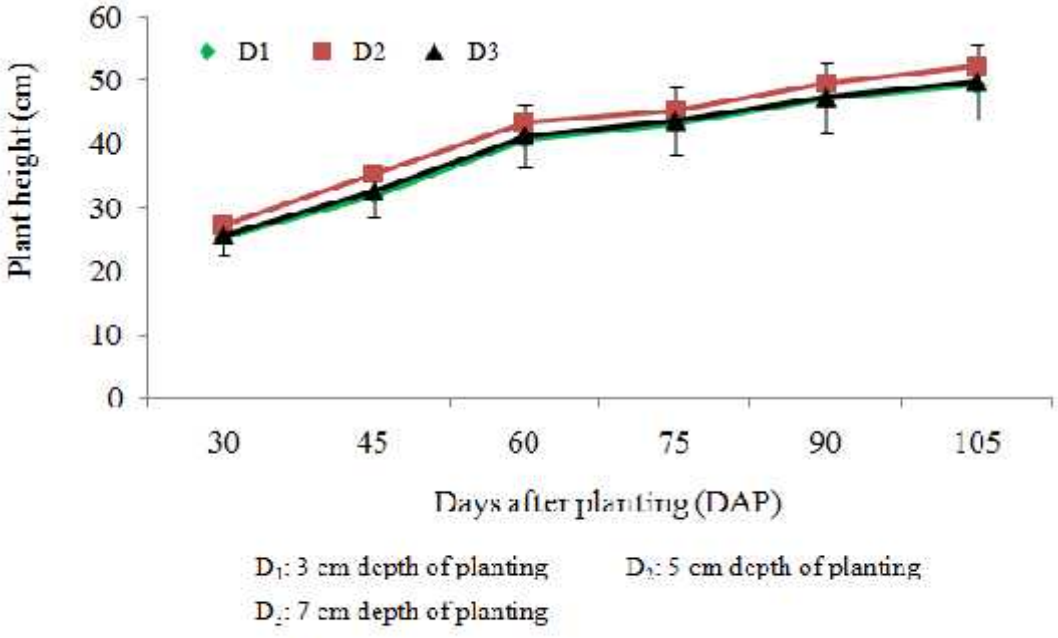


Figure 3. Effect of depth of planting on plant height of tuberose. Vertical bars represents LSD value at 5% level of significance.

Table 2. Combined effect of bulb size and depth of planting on plant height at different days after planting (DAP) of tuberose

Treatment	Plant height (cm) at					
	30 DAP	45 DAP	60 DAP	75 DAP	90 DAP	105 DAP
B_1D_1	25.25 bcd	29.90 bc	39.32 b	42.75 bc	47.16 bc	49.10 bc
B_1D_2	26.28 abcd	34.76 ab	42.30 ab	43.73 abc	46.92 bc	50.42 abc
B_1D_3	23.60 d	29.35 c	38.96 b	42.46 c	45.49 c	47.39 c
B_2D_1	24.06 cd	29.55 c	39.20 b	42.51 bc	45.67 c	48.76 bc
B_2D_2	27.19 ab	33.75 abc	42.34 ab	45.24 abc	49.71 ab	51.85 ab
B_2D_3	28.00 ab	33.92 abc	42.45 ab	44.13 abc	48.00 bc	51.53 abc
B_3D_1	26.67 abc	31.99 bc	39.35 b	44.19 abc	48.71 abc	49.90 abc
B_3D_2	28.34 a	37.20 a	45.51 a	46.63 a	51.81 a	54.13 a
B_3D_3	26.96 abc	32.33 bc	39.39 b	45.59 ab	48.28 abc	52.81 ab
$LSD_{(0.05)}$	2.649	4.715	3.650	2.754	3.461	3.889
Level of significance	0.05	0.05	0.05	0.05	0.05	0.05
CV(%)	5.83	8.17	5.03	3.60	4.17	4.44

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

Here,

B_1: Small size bulb
B_2: Medium size bulb
B_3: Large size bulb

D_1: 3 cm depth of planting
D_2: 5 cm depth of planting
D_3: 7 cm depth of planting

4.2 Number of leaves per plant

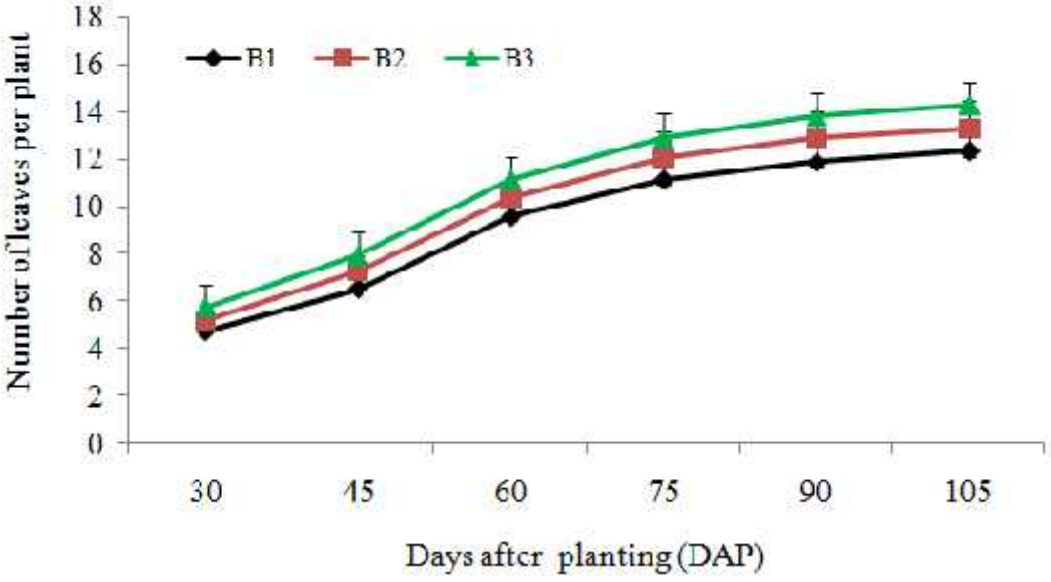
Number of leaves per plant of tuberose showed statistically significant variation due to different bulb size at 30, 45, 60, 75, 90 and 105 DAP (Figure 4). The maximum number of leaves per plant (14.24) was observed from B_3 at 105 DAP, which was followed (13.26) by B_2, while the minimum number (12.34) was recorded from B_1 at the same DAP (Appendix IV). Mohanta and Paswan (1995) obtained similar results and reported that larger bulbs produced more leaves compared to smaller bulbs.

Different depth of planting showed statistically significant variation in terms of number of leaves per plant of tuberose at 30, 45, 60, 75, 90 and 105 DAP (Figure 5). At 105 DAP, the maximum number of leaves per plant (14.60) was recorded from D_2, whereas, the minimum number (13.04) was found from D_1, which was statistically similar (13.87) to D_3 for the same DAP, respectively (Appendix IV). Arya *et al* (2006) reported that maximum number of leaves per plant was found where the bulbs were planted at the depth of 4.0 cm.

Combined effect of different bulb size and depth of planting showed statistically significant variation in terms of number of leaves per plant of tuberose at 30, 45, 60, 75, 90 and 105 DAP (Table 3).The maximum number of leaves per plant (15.80) was obtained from B_3D_2 at 105 DAP, whereas the minimum number (12.53) was found from B_1D_3 at same DAP, respectively (Appendix IV).

4.3 Days required from planting to emergence of spike

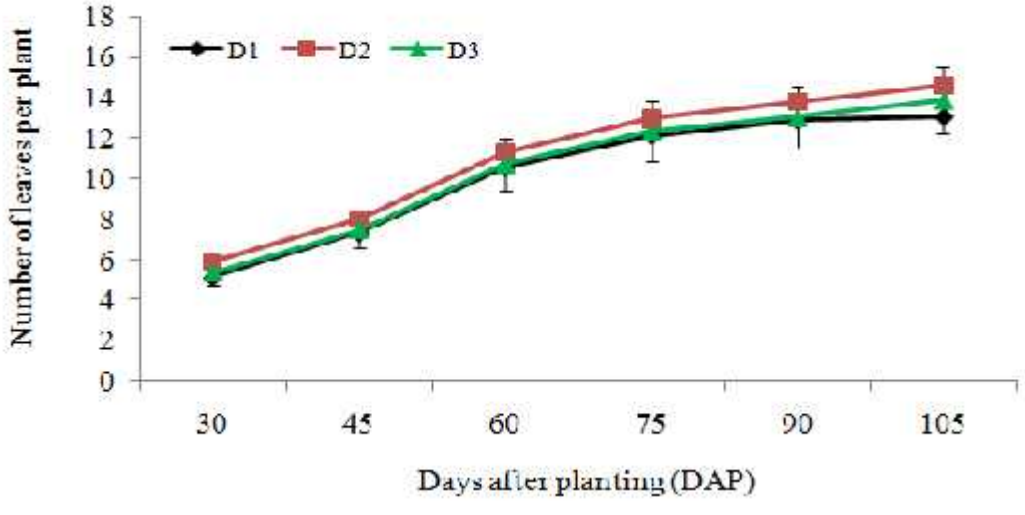
Days required from planting to emergence of spike of tuberose showed statistically significant variation due to different bulb size (Table 4). The maximum days (67.00) required from planting to emergence of spike was recorded from B_2 which was statistically similar (66.22) to B_1, while the minimum days (63.11) was found from B_3 (Appendix V). Kumar *et al*. (2003), Sathyanarayana *et al.*, (1994) reported that large bulb resulted in the earliest spike emergence.



B_1: Small size bulb B_2: Medium size bulb

B_3: Large size bulb

Figure 4. Effect of bulb size on number of leaves per plant of tuberose. Vertical bars represent LSD value at 5% level of significance.



D_1. 3 cm depth of planting D_2. 5 cm depth of planting

D_3 7 cm depth of planting

Figure 5. Effect of depth of planting on number of leaves per plant of tuberose. Vertical bars represents LSD value at 5% level of significance.

Table 3. Combined effect of bulb size and depth of planting on number of leaves per plant at different days after planting (DAP) of tuberose

Treatment	Number of leaves per plant at					
	30 DAP	45 DAP	60 DAP	75 DAP	90 DAP	105 DAP
B_1D_1	5.13 bc	7.53 bc	10.73 bc	11.87 b	12.67 bc	13.00 bc
B_1D_2	5.67 ab	7.20 c	10.53 c	12.47 ab	13.13 bc	13.93 b
B_1D_3	4.67 c	6.93 c	10.13 c	11.73 b	11.80 c	12.53 c
B_2D_1	5.13 bc	7.27 c	10.27 c	12.07 b	12.73 bc	12.93 bc
B_2D_2	5.87 ab	8.27 ab	11.60 ab	12.87 ab	13.67 ab	14.07 b
B_2D_3	5.33 bc	7.47 bc	11.07 abc	12.33 b	13.07 bc	13.73 bc
B_3D_1	5.20 bc	7.13 c	10.60 bc	12.33 b	13.13 bc	13.20 bc
B_3D_2	6.13 a	8.53 a	11.80 a	13.53 a	14.60 a	15.80 a
B_3D_3	5.89 ab	8.33 ab	11.13 abc	12.33 b	13.67 ab	14.07 b
$LSD_{(0.05)}$	0.668	0.860	0.951	1.031	1.313	1.210
Level of significance	0.05	0.05	0.05	0.05	0.05	0.01
CV(%)	7.07	6.51	5.05	4.76	5.72	5.05

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

Here,

B_1: Small size bulb
B_2: Medium size bulb
B_3: Large size bulb

D_1: 3 cm depth of planting
D_2: 5 cm depth of planting
D_3: 7 cm depth of planting

Statistically significant variation was recorded in terms of days required from planting to emergence of spike of tuberose (Table 4).The maximum days (66.67) required from planting to emergence of spike was recorded from D_1 which was statistically similar (66.33) to D_3 whereas, the minimum days (63.33) was found from D_2 (Appendix V). Kumar *et al*. (2003) obtained similar result and reported that spike emergence was delayed with the increase of the planting depth. Mahros (1999) reported that bulbs grown at 3 cm sprouted earlier than those planted deeper.

Combined effect of different bulb size and depth of planting showed statistically significant variation in terms of days required from planting to emergence of spike (Table 5).The maximum days (74.00) required from planting to emergence of spike was observed from B_2D_3 and the minimum days (58.67) was recorded from B_3D_2 (Appendix V).

4.4 Days required from planting to flowering

Statistically significant variation was recorded in terms of days required from planting to flowering of spike of tuberose due to different bulb size (Table 4). The maximum days (82.11) required from planting to flowering of spike was recorded from B_2 which was statistically similar (81.11) to B_1, while the minimum days (78.56) was found from B_3 (Appendix V). Rao *et al*. (1992) reported that plants grown from larger bulbs need less time to flowering than smaller one.

In terms of days required from planting to flowering of spike of tuberose depth of planting showed statistically significant variation (Table 4). The maximum days (81.78) required from planting to flowering of spike was observed from D_1 which was statistically similar (81.56) to D_3 whereas, the minimum days (78.44) was found from D_2 (Appendix V). These results are in accordance with the results of Asad *et al*. (2014).

Combined effect of different bulb size and depth of planting showed statistically significant variation in terms of days required from planting to

Table 4. Effect of bulb size and depth of planting on different growth characters of tuberose

Treatment	Days required from planting to emergence of spike	Days required from planting to flowering	Flowering plant (%)	Length of flower stalk at harvest (cm)	Length of rachis at harvest (cm)	Number of florets per spike
Bulb size						
B_1	66.22 a	81.11 ab	80.27 c	75.32 b	27.13 c	11.32 c
B_2	67.00 a	82.11 a	85.28 b	80.65 b	29.02 b	12.51 b
B_3	63.11 b	78.56 b	90.26 a	85.82 a	30.96 a	13.55 a
$LSD_{(0.05)}$	2.809	2.617	4.678	4.992	1.773	0.728
Level of significance	0.05	0.05	0.05	0.05	0.05	0.05
Depth of planting						
D_1	66.67 a	81.78 a	84.28 b	79.99 b	29.32 b	12.67 b
D_2	63.33 b	78.44 b	91.00 a	86.56 a	31.58 a	13.71 a
D_3	66.33 a	81.56 a	88.63 ab	83.66 ab	29.82 ab	12.98 b
$LSD_{(0.05)}$	2.809	2.617	4.678	4.992	1.773	0.728
Level of significance	0.05	0.05	0.05	0.05	0.05	0.05
CV (%)	4.30	3.25	5.32	5.99	6.87	5.55

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

B_1: Small size bulb
B_2: Medium size bulb
B_3: Large size bulb

D_1: 3 cm depth of planting
D_2: 5 cm depth of planting
D_3: 7 cm depth of planting

Table 5. Combined effect of bulb size and depth of planting on different growth characters of tuberose

Treatment	Days required from planting to emergence of spike	Days required from planting to flowering	Flowering plant (%)	Length of flower stalk at harvest (cm)	Length of rachis at harvest (cm)	Number of florets per spike
B_1D_1	70.00 ab	78.67 bc	85.53 bc	82.14 bcd	31.68 ab	12.94 bcd
B_1D_2	69.33 ab	80.33 abc	84.23 bc	78.97 cd	29.33 bc	12.68 cd
B_1D_3	65.67 bc	84.33 a	83.93 bc	77.13 d	25.47 d	12.15 d
B_2D_1	65.00 bc	84.67 a	84.40 bc	79.40 cd	28.09 cd	12.52 d
B_2D_2	62.00 cd	79.00 bc	92.57 ab	88.35 abc	31.41 abc	14.10 ab
B_2D_3	74.00 a	82.67 ab	86.67 bc	83.15 abcd	30.71 abc	12.77 bcd
B_3D_1	65.00 bc	82.00 ab	82.90 c	78.43 d	28.18 cd	12.54 d
B_3D_2	58.67 d	76.00 c	96.20 a	92.36 a	34.01 a	14.35 a
B_3D_3	65.67 bc	77.67 bc	92.57 ab	90.69 ab	31.69 ab	14.01 abc
$LSD_{(0.05)}$	4.866	4.532	8.102	8.646	3.072	1.260
Level of significance	0.01	0.05	0.05	0.05	0.01	0.05
CV(%)	4.30	3.25	5.32	5.99	6.87	5.55

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

Here,

B_1: Small size bulb
B_2: Medium size bulb
B_3: Large size bulb

D_1: 3 cm depth of planting
D_2: 5 cm depth of planting
D_3: 7 cm depth of planting

flowering of spike (Table 5).The maximum days (84.67) required from planting to flowering of spike was observed from B_2D_1 and the minimum days (76.00) was recorded from B_3D_2 (Appendix V).

4.5 Flowering plant

Different bulb size showed statistically significant variation in terms of flowering plant of tuberose (Table 4).The highest flowering plant (90.26%) was recorded from B_3 which was followed (85.28%) by B_2, while the lowest (80.27%) was found from B_1 (Appendix V). Ali and Akbari (2012) reported that increasing desirable flowers with more value economically; the best bulb size is advised 3.5 cm in diameter.

Flowering plant of tuberose showed statistically significant variation due to different depth of planting (Table 4).The highest flowering plant (91.00%) was found from D_2 which was statistically similar (88.63%) to D_3 whereas, the lowest (84.28%) was observed from D_1 (Appendix V). The result agrees with the findings of Asad *et al*. (2014) who reported that planting depth of 5 cm significantly increased number of flowering plant.

Combined effect of different bulb size and depth of planting showed statistically significant variation in terms of flowering plant (Table 5). The highest flowering plant (96.20%) was observed from B_3D_2 and the lowest (82.90%) was recorded from B_3D_1 (Appendix V).

4.6 Length of flower stalk at harvest

Length of flower stalk at harvest of tuberose showed statistically significant variation due to different bulb size (Table 4).The highest length of flower stalk at harvest (85.82 cm) was recorded from B_3, while the lowest (75.32 cm) was found from B_1 which was statistically similar (80.65 cm) to B_2 (Appendix V). Mahanta *et al.* (1998) reported that length of flower stalk was enhanced by increasing bulb size.

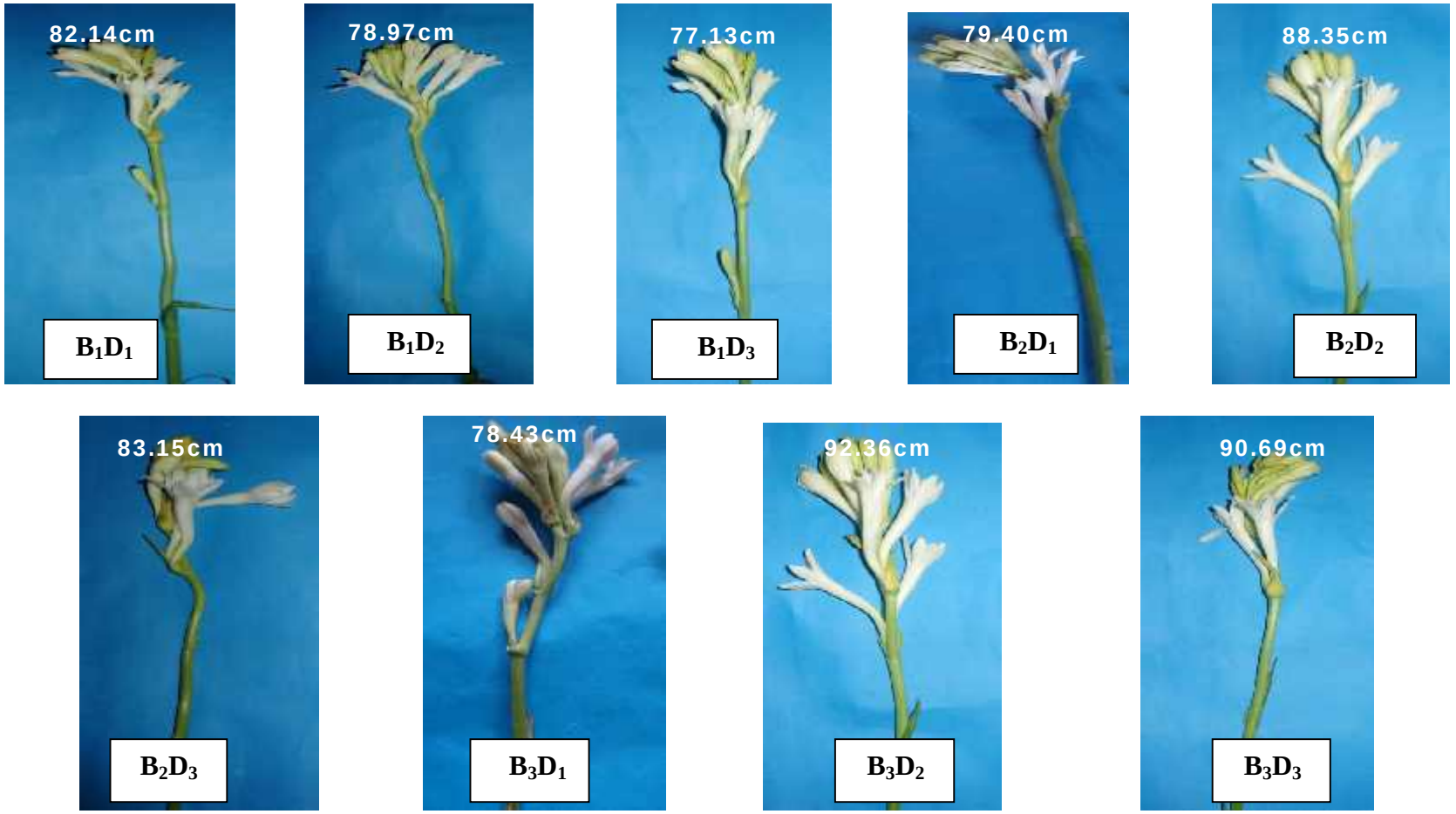


Plate 3: Influence of bulb size and depth of planting on length of flower stalk of tuberose

Statistically significant variation was recorded in terms of length of flower stalk at harvest of tuberose at different depth of planting (Table 4). The highest length of flower stalk at harvest (86.56 cm) was found from D_2 which was statistically similar (83.66 cm) to D_3 whereas, the lowest (79.99 cm) was observed from D_1 (Appendix V).These results agreed with the results of Sadhu *et al*. (2005).

Combined effect of different bulb size and depth of planting showed statistically significant variation in terms of length of flower stalk at harvest (Table 5 and Plate 3).The highest length of flower stalk at harvest (92.36 cm) was observed from B_3D_2 and the lowest (77.13 cm) was recorded from B_1D_3 (Appendix V).

4.7 Length of rachis at harvest

Statistically significant variation was recorded in terms of length of rachis at harvest of tuberose due to different bulb size (Table 4).The highest length of rachis at harvest (30.96 cm) was recorded from B_3 which was followed (29.02 cm) by B_2, while the lowest (27.13 cm) was found from B_1 (Appendix V). Kumar *et al*. (2003), Mahanta and Paswan (1995) reported that larger bulb produces longer rachis than smaller one.

Length of rachis at harvest of tuberose showed statistically significant variation due to different depth of planting (Table 4). The highest length of rachis at harvest (31.58 cm) was found from D_2 which was statistically similar (29.82 cm) to D_3 whereas, the lowest (29.32 cm) was observed from D_1 (Appendix V). Mane *et al*. (2003) reported that length of rachis was higher in case of 5 cm depth of planting than 3 or 7 cm.

Combined effect of different bulb size and depth of planting showed statistically significant variation in terms of length of rachis at harvest (Table 5 and Plate 4). The highest length of rachis at harvest (34.01 cm) was observed from B_3D_2 and the lowest (25.47 cm) was recorded from B_1D_3 (Appendix V).

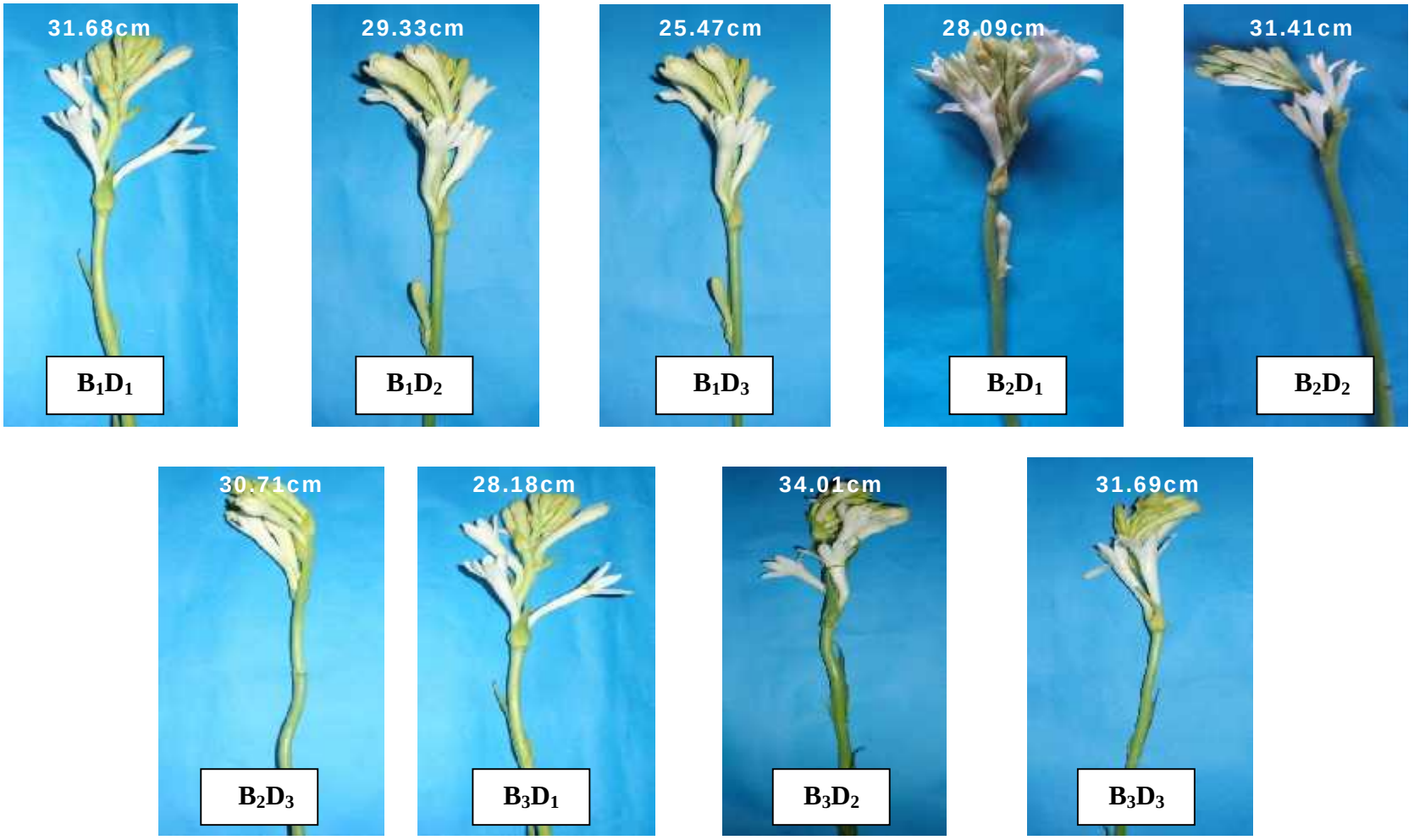


Plate 4: Influence of bulb size and depth of planting on length of rachis of tuberose

4.8 Number of florets per spike

Number of florets per spike of tuberose showed statistically significant variation due to different bulb size (Table 4).The highest number of florets per spike (13.55) was recorded from B_3 which was followed (12.51) by B_2, while the lowest number of florets per spike (11.32) was found from B_1 (Appendix V). These results agreed with the results of Sathyararyana *et al.,* (1994) who also observed that larger bulb produced more florets per spike compared to smaller size of bulb in tuberose.

Different depth of planting showed statistically significant variation in terms of number of florets per spike of tuberose (Table 4).The highest number of florets per spike (13.71) was found from D_2 whereas, the lowest number of florets per spike (12.67) was observed from D_1 which was statistically similar (12.98) to D_3 (Appendix V). Asad *et al*. (2014) reported that planting depth of 5 cm increased the number of florets per spike.

Combined effect of different bulb size and depth of planting showed statistically significant variation in terms of number of florets per spike (Table 5 and Plate 5).The highest number of florets per spike (14.35) was observed from B_3D_2 and the lowest number of florets per spike (12.15) was recorded from B_1D_3 (Appendix V).

4.9 Number of spikes per plot

Statistically significant variation was recorded in terms of number of spikes per plot of tuberose due to different bulb size (Table 6).The highest number of spikes per plot (60.91) was recorded from B_3 which was followed (57.90) by B_2, while the lowest number of spikes per plot (50.50) was found from B_1 (Appendix VI).

Number of spikes per plot of tuberose showed statistically significant variation due to different depth of planting (Table 6). The highest number of spikes per

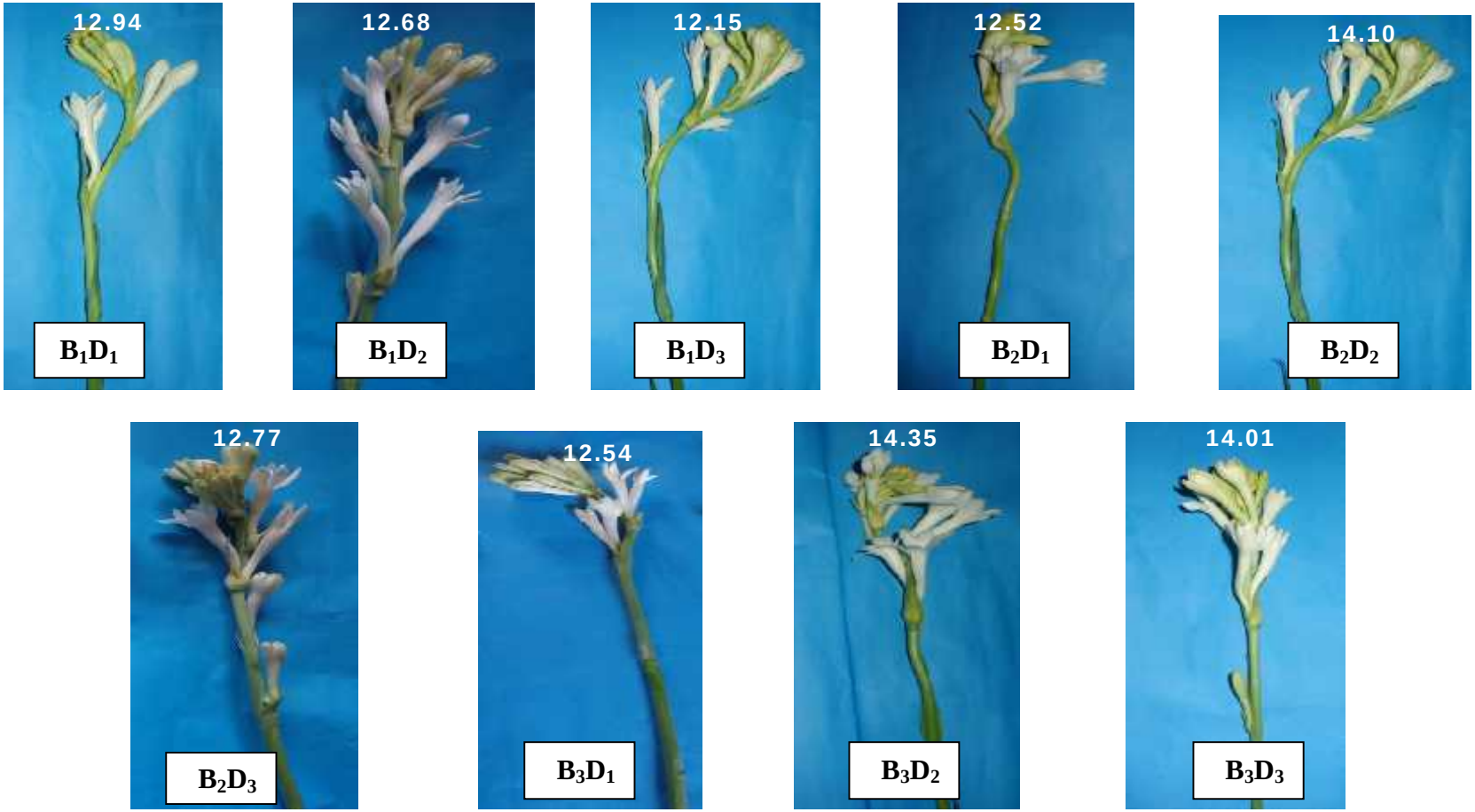


Plate 5: Influence of bulb size and depth of planting on number of floret per spike of tuberose

plot (61.09) was found from D_2 which was followed (57.13) by D_3 whereas, the lowest number of spikes per plot (51.09) was observed from D_1 (Appendix VI).

Combined effect of different bulb size and depth of planting showed statistically significant variation in terms of number of spikes per plot (Table 7).The highest number of spikes per plot (64.98) was observed from B_3D_2 and the lowest number of spikes per plot (45.12) was recorded from B_1D_1 (Appendix VI).

4.10 Number of spike per hectare (`000)

Different bulb size showed statistically significant variations in terms of number of spike per hectare of tuberose (Table 6).The highest number of spike per hectare (338.65 thousand) was recorded from B_3 which was followed (321.95 thousand) by B_2, while the lowest (280.76 thousand) was found from B_1 (Appendix VI). The observed results are in agreement with the findings of Yadav *et al.* (1984) who found that number of spike per hectare was higher in case of larger bulb.

Statistically significant variations were recorded in terms of number of spike per hectare of tuberose due to different depth of planting (Table 6).The highest number of spike per hectare (339.69 thousand) was found from D_2 which was followed (317.63 thousand) by D_3 whereas, the lowest (284.04 thousand) was observed from D_1 (Appendix VI). Ali and Akbari (2012) reported that increasing producing of desirable flowers with more value economically, the best planting depth of 6 cm for cultivation of tuberose flowers.

Combined effect of different bulb size and depth of planting showed statistically significant variation in terms of number of spike per hectare (Table 7).The highest number of spike per hectare (361.28 thousand) was observed from B_3D_2 and the lowest (250.89 thousand) was recorded from B_1D_1 (Appendix VI).

Table 6. Effect of bulb size and depth of planting on number of spike and bulb characters of tuberose

Treatment	Number of spike per plot	Number of spike per hectare (‘000)	Weight of individual bulb (g)	Thickness of individual bulb (cm)	Diameter of individual bulb (cm)
Bulb size					
B_1	50.50 c	280.76 c	224.23 c	4.17c	1.56 c
B_2	57.90 b	321.95 b	243.24 b	5.03 b	1.74 b
B_3	60.91 a	338.65 a	262.35 a	5.92 a	1.86 a
$LSD_{(0.05)}$	2.341	8.563	17.84	0.760	0.099
Level of significance	0.05	0.05	0.01	0.01	0.01
Depth of planting					
D_1	51.09 c	284.04 c	239.39 b	4.80 b	1.67 b
D_2	61.09 a	339.69 a	263.67 a	4.99 a	1.88 a
D_3	57.13 b	317.63 b	253.15 ab	4.22 b	1.77 b
$LSD_{(0.05)}$	2.341	8.563	17.84	0.760	0.099
Level of significance	0.05	0.05	0.05	0.01	0.01
CV(%)	6.02	6.02	7.08	11.99	5.52

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

Here,

B_1: Small size bulb
B_2: Medium size bulb
B_3: Large size bulb

D_1: 3 cm depth of planting
D_2: 5 cm depth of planting
D_3: 7 cm depth of planting

Table 7. Combined effect of bulb size and depth of planting on number of spike and bulb characters of tuberose

Treatment	Number of spike per plot	Number of spike per hectare (`000)	Weight of individual bulb (g)	Thickness of individual bulb (cm)	Diameter of individual bulb (cm)
B_1D_1	45.12 e	250.89 e	266.07 a	4.52 bc	1.66 c
B_1D_2	54.88 c	305.11 c	222.55 c	5.42 abc	1.72 bc
B_1D_3	51.49 d	286.28 d	216.72 c	4.05 c	1.60 c
B_2D_1	51.18 d	284.56 d	229.63 bc	4.16 c	1.65 c
B_2D_2	63.43 a	352.67 a	279.99 a	5.98 a	1.94 a
B_2D_3	59.10 b	328.61 b	258.13 ab	5.61 ab	1.89 ab
B_3D_1	56.96 c	316.67 c	222.47 c	5.73 ab	1.69 c
B_3D_2	64.98 a	361.28 a	288.47 a	6.58 a	1.96 a
B_3D_3	60.79 b	338.00 b	284.60 a	6.06 a	1.94 a
$LSD_{(0.05)}$	4.12	23.67	30.90	1.317	0.173
Level of significance	0.05	0.05	0.01	0.05	0.05
CV(%)	6.02	6.02	7.08	11.99	5.52

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

Here,

B_1: Small size bulb
B_2: Medium size bulb
B_3: Large size bulb

D_1: 3 cm depth of planting
D_2: 5 cm depth of planting
D_3: 7 cm depth of planting

4.11 Weight of individual bulb

Weight of individual bulb of tuberose showed statistically significant variation due to different bulb size (Table 6).The highest weight of individual bulb (262.35 g) was recorded from B_3 which was followed (243.24 g) by B_2, while the lowest (224.23 g) was found from B_1 (Appendix VI). Reddy and Singh (1997) reported that weight of individual bulb per plant increased with increase of bulb size used for planting.

Statistically significant variation was recorded in terms Weight of individual bulb of tuberose due to different depth of planting (Table 6).The highest weight of individual bulb (263.67 g) was found from D_2 which was statistically similar (253.15 g) to D_3 whereas, the lowest (239.39 g) was observed from D_1 (Appendix VI). Mahros (1999) also has reported similar results.

Combined effect of different bulb size and depth of planting showed statistically significant variation in terms of weight of individual bulb (Table 7). The highest weight of individual bulb (288.47 g) was observed from B_3D_2 and the lowest weight of individual bulb (216.72 g) was recorded from B_1D_3 (Appendix VI).

4.12 Thickness of individual bulb

Different bulb size showed statistically significant variation in terms of thickness of individual bulb of tuberose (Table 6).The highest thickness of individual bulb (5.92 cm) was recorded from B_3 which was followed (5.03 cm) by B_2, while the lowest (4.17 cm) was found from B_1 (Appendix VI). Reddy and Singh (1997) reported similar results in tuberose.

Thickness of individual bulb of tuberose showed statistically significant variations due to different (Table 6). Depth of planting The highest thickness of individual bulb (4.99 cm) was found from D_2 whereas, the lowest (4.22 cm) was observed from D_3 which was statistically similar (4.80 cm) to D_1

(Appendix VI). These results are in line with the results of Suleyman *et al* (2014).

Combined effect of different bulb size and depth of planting showed statistically significant variation in terms of thickness of individual bulb(Table 7) The highest thickness of individual bulb (6.58 cm) was observed from B_3D_2 and the lowest (4.05 cm) was recorded from B_1D_3 (Appendix VI).

4.13 Diameter of individual bulb

Statistically significant variations were recorded in terms diameter of individual bulb of tuberose due to different bulb size (Table 6). The highest diameter of individual bulb (1.86 cm) was recorded from B_3 which was followed (1.74 cm) by B_2, while the lowest (1.56 cm) was found from B_1 (Appendix VI). The observed results are in agreement with the findings of Mahanta and Paswan (1995) in tuberose.

Diameter of individual bulb f tuberose showed statistically significant variation due to different Depth of planting (Table 6). The highest diameter of individual bulb (1.88 cm) was found from D_2 whereas, the lowest (1.67 cm) was observed from D_1 which was statistically similar (1.77 cm) to D_3 (Appendix VI). Mahros (1999) reported that diameter of individual bulb was increased through shallow depth of planting.

Combined effect of different bulb size and depth of planting showed statistically significant variation in terms of diameter of individual bulb (Table 7).The highest diameter of individual bulb (1.96 cm) was observed from B_3D_2 and the lowest (1.60 cm) was recorded from B_1D_3 (Appendix VI).

4.14 Number of bulblet per plant

Number of bulblet per plant of tuberose showed statistically significant variation due to different bulb size (Table 8). The highest number of bulblet per plant (21.58) was recorded from B_3 which was followed (20.07) by B_2, while the lowest (18.53) was found from B_1 (Appendix VII). Ahmad *et al.* (2009)

observed that large bulb size resulted in maximum number of bulblet as compared to small and medium sized bulbs.

Different depth of planting showed statistically significant variation in terms of number of bulblet per plant of tuberose (Table 8) .The highest number of bulblet per plant (22.51) was found from D_2 which was closely followed (20.80) by D_3 whereas, the lowest (19.04) was observed from D_1 (Appendix VII). Similar results were reported by Sadhu *et al*. (2005).

Combined effect of different bulb size and depth of planting showed statistically significant variation in terms of number of bulblet per plant (Table 9).The highest number of bulblet per plant (23.73) was observed from B_3D_2 and the lowest (18.27) was recorded from B_1D_3 (Appendix VII).

4.15 Weight of bulblet per plant

Statistically significant variation was recorded in terms of weight of bulblet per plant of tuberose due to different bulb size (Table 8). The highest weight of bulblet per plant (142.56 g) was recorded from B_3 which was followed (134.25 g) by B_2, while the lowest (122.63 g) was found from B_1 (Appendix VII). This is in line with the findings of Ahmad *et al.*, (2009) in tuberose.

Weight of individual bulb of tuberose showed statistically significant variation due to different depth of planting (Table 8).The highest weight of bulblet per plant (144.35 g) was found from D_2 which was statistically similar (137.59 g) to D_3 whereas, the lowest (124.00 g) was observed from D_1 (Appendix VII). Sikder *et al*. (2002) reported that depth of planting has influence on weight of bulblet per plant.

Combined effect of different bulb size and depth of planting showed statistically significant variation in terms of weight of bulblet per plant (Table 9).The highest weight of bulblet per plant (150.90 g) was observed from B_3D_2 and the lowest (113.80 g) was recorded from B_1D_3 (Appendix VII).

Table 8. Effect of bulb size and depth of planting on bulblet characters, bulb and bulblet yield of tuberose

Treatment	Number of bulblet/plant	Weight of bulblet/plant (g)	Diameter of bulblet (cm)	Yield of bulb (t/ha)	Yield of bulblet (t/ha)
Bulb size					
B_1	18.53 c	122.63 c	1.12 c	14.02 c	7.35 c
B_2	20.07 b	134.25 b	1.28 b	19.12 b	9.77 b
B_3	21.58 a	142.56 a	1.39 a	21.53 a	11.51 a
$LSD_{(0.05)}$	1.409	7.952	0.084	2.379	1.060
Level of significance	0.01	0.01	0.01	0.01	0.01
Depth of planting					
D_1	19.04 c	124.00 b	1.24 b	16.25 b	8.20 c
D_2	22.51 a	144.35 a	1.41 a	20.49 a	10.91 a
D_3	20.80 b	137.59 a	1.30 b	17.93 b	9.52 b
$LSD_{(0.05)}$	1.409	7.952	0.084	2.379	1.060
Level of significance	0.01	0.01	0.01	0.05	0.01
CV(%)	6.78	5.88	6.29	7.08	5.88

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

Here,

B_1: Small size bulb
B_2: Medium size bulb
B_3: Large size bulb

D_1: 3 cm depth of planting
D_2: 5 cm depth of planting
D_3: 7 cm depth of planting

Table 9. Combined effect of bulb size and depth of planting on bulblet characters, bulb and bulblet yield of tuberose

Treatment	Number of bulblet/plant	Weight of bulblet/plant (g)	Diameter of bulblet (cm)	Yield of bulb (kg/plot)	Yield of bulblet (kg/plot)	Yield of bulb (t/ha)	Yield of bulblet (t/ha)
B_1D_1	19.27 bc	117.43 cd	1.26 b	2.42 d	1.20 d	13.48 d	6.66 d
B_1D_2	21.07 ab	136.65 ab	1.26 b	2.64 d	1.66 b	14.67 d	9.22 b
B_1D_3	18.27 c	113.80 d	1.17 b	2.50 d	1.11 d	13.90 d	6.17 d
B_2D_1	18.29 c	123.90 bcd	1.21 b	2.81 cd	1.35 d	15.62 cd	7.52 d
B_2D_2	21.63 ab	136.65 ab	1.27 b	4.02 ab	1.92 ab	22.33 ab	10.66 ab
B_2D_3	21.73 ab	148.97 a	1.28 b	3.49 bc	2.00 ab	19.42 bc	11.12 ab
B_3D_1	19.60 bc	130.67 bc	1.26 b	3.54 bc	1.87 ab	19.66 bc	10.42 ab
B_3D_2	23.73 a	150.90 a	1.52 a	4.40 a	2.31 a	24.46 a	12.86 a
B_3D_3	21.75 ab	136.76 ab	1.26 b	3.68 ab	2.03 ab	20.46 ab	11.26 ab
$LSD_{(0.05)}$	2.441	13.77	0.145	0.741	0.328	4.120	1.837
Level of significance	0.05	0.05	0.01	0.01	0.05	0.01	0.05
CV(%)	6.78	5.88	6.29	7.08	5.88	7.08	5.88

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

Here,

B_1: Small size bulb
B_2: Medium size bulb
B_3: Large size bulb

D_1: 3 cm depth of planting
D_2: 5 cm depth of planting
D_3: 7 cm depth of planting

4.16 Diameter of bulblet

Diameter of bulblet of tuberose showed statistically significant variation due to different bulb size (Table 8). The highest diameter of bulblet (1.39 cm) was recorded from B_3 which was followed (1.28 cm) by B_2, while the lowest (1.12 cm) was found from B_1 (Appendix VII). The present results are in agreement with the findings of Bankar and Mukhopadhyay (1990) who found that larger bulb produces larger diameter of bulblet.

Statistically significant variation was recorded in terms of diameter of bulblet of tuberose due to different depth of planting (Table 8). The highest diameter of bulblet (1.41 cm) was found from D_2 which was followed (1.30 cm) by D_3 whereas, the lowest (1.24 cm) was observed from D_1 (Appendix VII). Sikder *et al*. (2002) also reported the similar result.

Combined effect of different bulb size and depth of planting showed statistically significant variation in terms of diameter of bulblet (Table 9).The highest diameter of bulblet (1.52 cm) was observed from B_3D_2 and the lowest (1.17 cm) was recorded from B_1D_3 (Appendix VII).

4.17 Yield of bulb per plot

Different bulb size showed statistically significant variation in terms of yield of bulb per plot of tuberose (Figure 6). The highest yield of bulb per plot (3.87 kg) was recorded from B_3 which was followed (3.44 kg) by B_2, while the lowest yield of bulb per plot (2.52 kg) was found from B_1 (Appendix VII). Ahmad *et al.* (2009) observed that large bulb size resulted in maximum yield of bulb as compared to small and medium sized bulbs.

Yield of bulb per plot of tuberose showed statistically significant variation due to different depth of planting (Figure 7). The highest yield of bulb per plot (3.68 kg) was found from D_2 whereas, the lowest yield of bulb per plot (2.92 kg) was observed from D_1 which was statistically similar (3.22 kg) to D_3 (Appendix VII). Similar trend of results were reported by Mahros (1999) in tuberose.

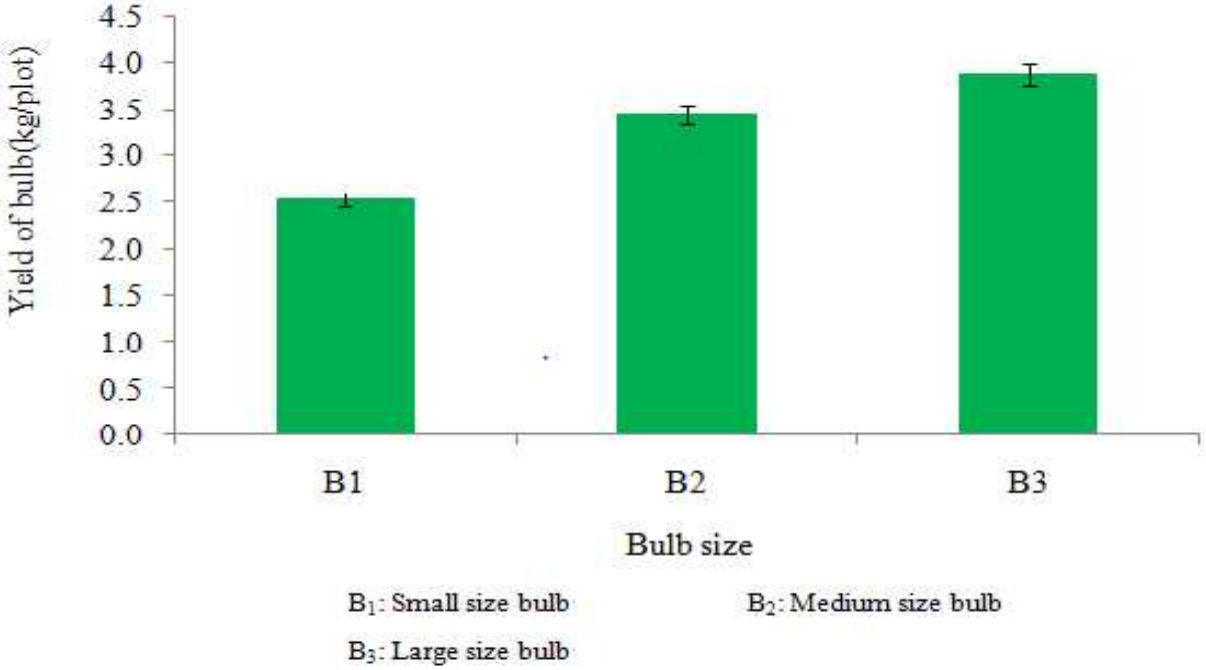


Figure 6. Effect of bulb size on yield of bulb per plot of tuberose. Vertical bars reporesnt LSD value at 5% level of significance

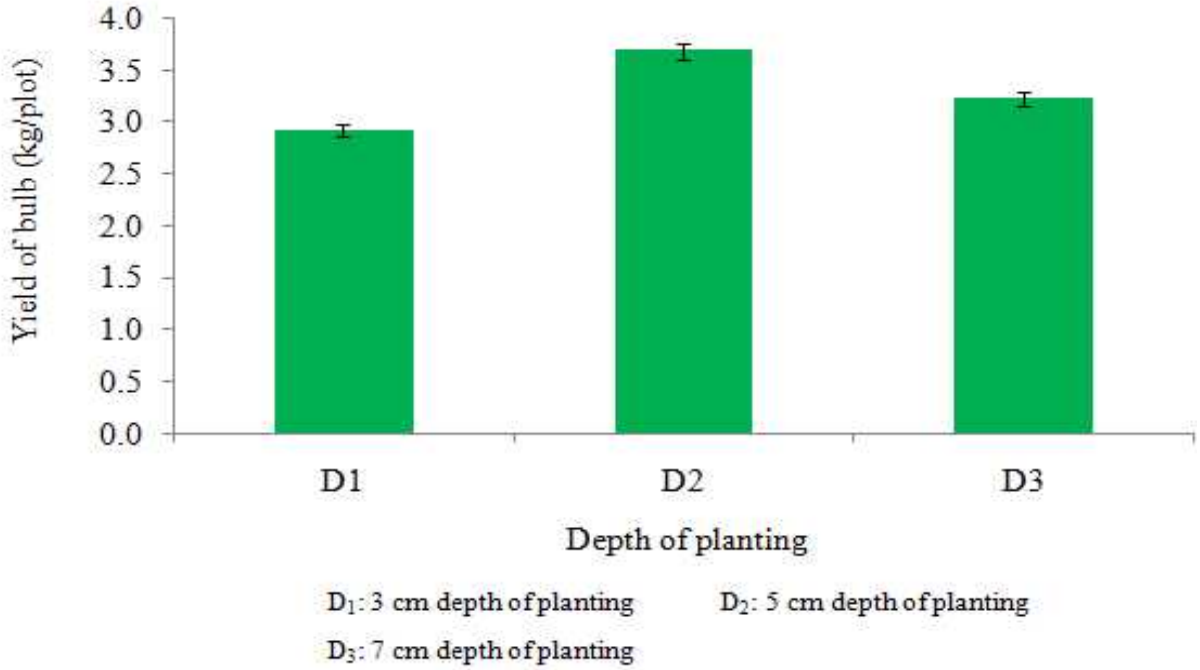


Figure 7. Effect of depth of planting on yield of bulb per plot of tuberose. Vertical bars reporesnt LSD value at 5% level of significance

Combined effect of different bulb size and depth of planting showed statistically significant variation in terms of yield of bulb per plot (Table 9).The highest yield of bulb per plot (4.40 kg) was observed from B_3D_2 and the lowest (2.42 kg) was recorded from B_1D_1 (Appendix VII).

4.18 Yield of bulblet per plot

Statistically significant variation was recorded in terms of yield of bulblet per plot of tuberose due to different bulb size (Figure 8). The highest yield of bulblet per plot (2.07 kg) was recorded from B_3 which was followed (1.76 kg) by B_2, while the lowest (1.32 kg) was found from B_1 (Appendix VII). Reddy and Singh (1997) reported that yield of bulblet varies with the size of bulb.

Different depth of planting showed statistically significant variation in terms of yield of bulblet per plot of tuberose (Figure 9). The highest yield of bulblet per plot (1.96 kg) was found from D_2 which was statistically similar (1.71 kg) to D_3 whereas, the lowest (1.47 kg) was observed from D_1 (Appendix VII). The observation is similar to the findings of Sadhu *et al*. (2005) in tuberose.

Combined effect of different bulb size and depth of planting showed statistically significant variation in terms of yield of bulblet per plot (Table 9).The highest yield of bulblet per plot (2.31 kg) was observed from B_3D_2 and the lowest (1.11 kg) was recorded from B_1D_3 (Appendix VII).

4.19 Yield of bulb per hectare

Yield of bulb per hectare of tuberose showed statistically significant variation due to different bulb size (Table 8). The highest yield of bulb per hectare (21.53 ton) was recorded from B_3 which was followed (19.12 ton) by B_2, while the lowest (14.02 ton) was found from B_1 (Appendix VII). The result of the present experiment is in agreement with the findings of Banker and Mukhopadhyay (1990) reported that highest yield was attained from large sized bulb of tuberose.

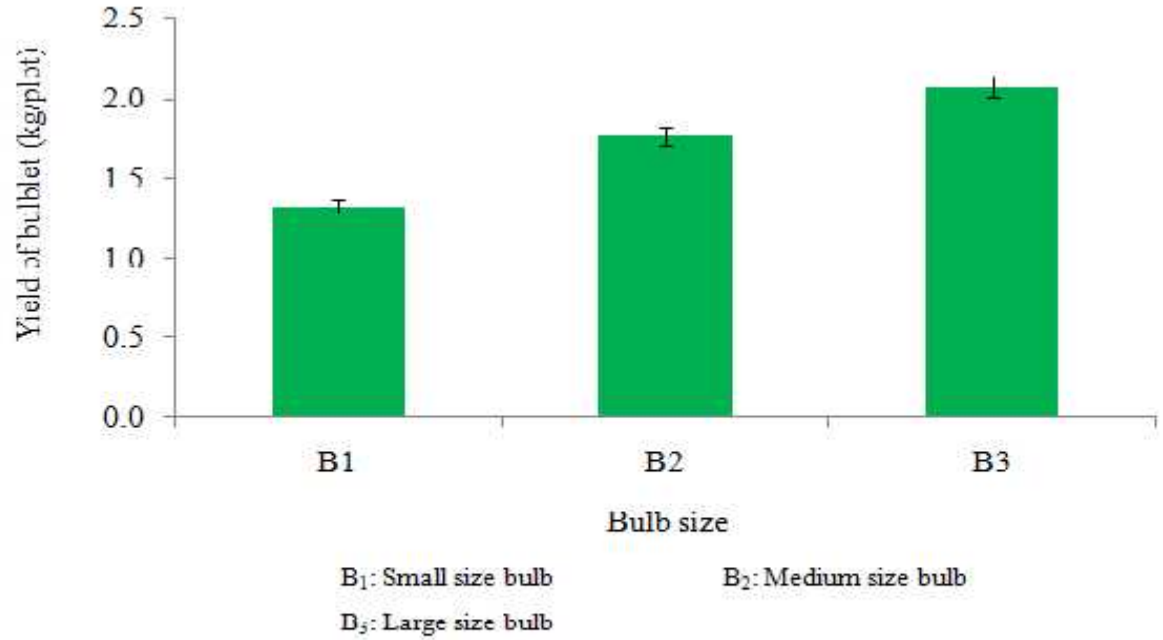


Figure 8. Effect of bulb size on yield of bulblet per plot of tuberose. Vertical bars represent LSD value at 5% level of significance

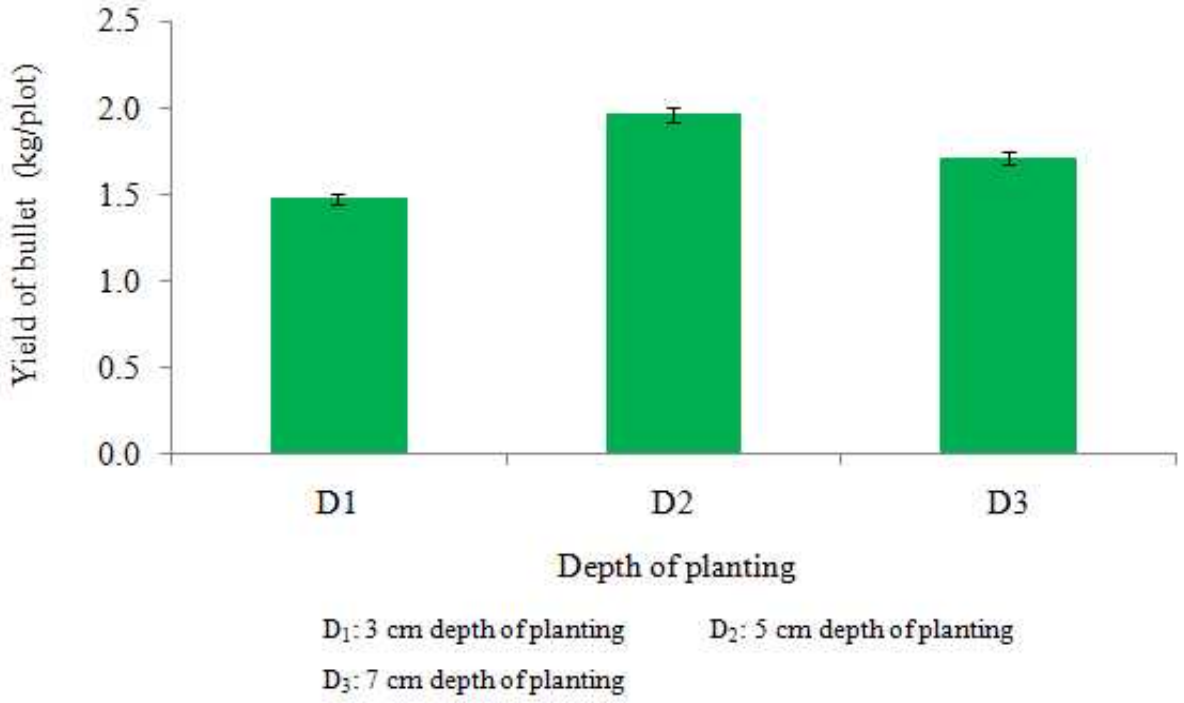


Figure 9. Effect of depth of planting on yield of bulblet per plot of tuberose. Vertical bars reporesnt LSD value at 5% level of significance

Statistically significant variation was recorded in terms of yield of bulb per hectare of tuberose due to different depth of planting (Table 8). The highest yield of bulb per hectare (20.49 ton) was found from D_2 whereas, the lowest (16.25 ton) was observed from D_1 which was statistically similar (17.93 ton) to D_3 (Appendix VII). Similar results were reported by Sadhu *et al*. (2005).

Combined effect of different bulb size and depth of planting showed statistically significant variation in terms of yield of bulb per hectare (Table 9).The highest yield of bulb per hectare (24.46 ton) was observed from B_3D_2 and the lowest (13.48 ton) was recorded from B_1D_1 (Appendix VII).

4.20 Yield of bulblet per hectare

Different bulb size showed statistically significant variation in terms of bulblet per hectare of tuberose (Table 8). The highest yield of bulblet per hectare (11.51 ton) was recorded from B_3 which was followed (9.77 ton) by B_2, while the lowest (7.35 ton) was found from B_1 (Appendix VII). The present results are in agreement with the findings of Banker and Mukhopadhyay (1990) reported that the highest yield of bulblet was attained from large size of bulb of tuberose.

Different depth of planting showed statistically significant variation in terms of yield of bulblet per hectare of tuberose (Table 8). The highest yield of bulblet per hectare (10.91 ton) was found from D_2 which was closely followed (9.52 ton) by D_3 whereas, the lowest (8.20 ton) was observed from D_1 (Appendix VII). Ali and Akbari (2012) reported that increasing of yield with more value economically, the best planting depth of 6 cm for cultivation of tuberose flowers.

Combined effect of different bulblet size and depth of planting showed statistically significant variation in terms of yield of bulblet per hectare (Table 9).The highest yield of bulblet per hectare (12.86 ton) was observed from B_3D_2 and the lowest (6.17 ton) was recorded from B_1D_3 (Appendix VII).

4.21 Economic analysis

Input costs for land preparation, seed cost, nutrient sources, irrigation and manpower required for all the operations from planting to harvesting of tuberose flower, bulb and bulblet were recorded for unit plot and converted into cost per hectare. Price of tuberose flower, bulb and bulblet was considered as per market rate. The economic analysis presented under the following headings-

4.21.1 Gross return

The combination of bulb size and planting depth showed different gross return. The highest gross return (983,800 Tk. /ha) was obtained from B_3D_2 and the second highest gross return (936,270 Tk. /ha) was found in B_2D_2. The lowest gross return (642,760 Tk. /ha) was obtained from B_1D_1 (Table 10).

4.21.2 Net return

In case of net return different treatments combination showed different net return. The highest net return (609,189 Tk. /ha) was found from B_3D_2 and the second highest net return (574,315 Tk. /ha) was obtained from B_2D_2. The lowest (293,461 Tk. /ha) net return was obtained B_1D_1 (Table 10).

4.21.3 Benefit cost ratio

In the combination of bulb size and depth of planting highest benefit cost ratio (2.63) was noted from B_3D_2 and the second highest benefit cost ratio (2.59) was estimated from B_2D_2. The lowest benefit cost ratio (1.84) was obtained from B_1D_1 (Table 10). From economic point of view, it was apparent from the above results that the combination of B_3D_2 was more profitable than rest of the combination.

Table 10. Cost and return of tuberose cultivation as influenced by bulb size and depth of planting

Treatment	Cost of production (Tk./ha)	Yield of bulb (t/ha)	Price of bulb (Tk.)	Yield of bulblet (t/ha)	Price of bulblet	Tuberose (‘000)	Price of cut flower	Gross return (Tk./ha)	Net return (Tk./ha)	Benefit cost ratio
B_1D_1	349299	13.48	94360	6.66	46620	250.89	501780	642760	293461	1.84
B_1D_2	349299	14.67	102690	9.22	64540	305.11	610220	777450	428151	2.23
B_1D_3	349299	13.90	97300	6.17	43190	286.28	572560	713050	363751	2.04
B_2D_1	361955	15.62	109340	7.52	52640	284.56	569120	731100	369145	2.02
B_2D_2	361955	22.33	156310	10.66	74620	352.67	705340	936270	574315	2.59
B_2D_3	361955	19.42	135940	11.12	77840	328.61	657220	871000	509045	2.41
B_3D_1	374611	19.66	137620	10.42	72940	316.67	633340	843900	469289	2.25
B_3D_2	374611	24.46	171220	12.86	90020	361.28	722560	983800	609189	2.63
B_3D_3	374611	20.46	143220	11.26	78820	338.00	676000	898040	523429	2.40

Here,

B_1: Small size bulb

B_2: Medium size bulb

B_3: Large size bulb

D_1: 3 cm depth of planting

D_2: 5 cm depth of planting

D_3: 7 cm depth of planting

Price of tuberose: Tk. 2000.00/thousand
Price of bulb and bulblet: Tk. 7000/ton

CHAPTER V

SUMMARY AND CONCLUSION

The study was conducted at the Horticultural Farm of Sher-e-Bangla Agricultural University, Dhaka during the period from April 2013 to February 2014. The experiment consisted of two factors. Factor A: Three levels of bulb size: B_1- Small size, B_2 -Medium size, B_3 - Large size and Factor B: Three levels of depth of planting: D_1- 3 cm, D_2 - 5 cm and D_3- 7 cm respectively. The experiment was laid out in a Randomized Complete Block Design with three replications.

In case of bulb size, at 30, 45, 60, 75, 90 and 105 DAP the tallest plant (26.94, 35.16, 43.15, 45.01, 48.90 and 51.42 cm) was recorded from B_3, while the shortest plant (23.22, 29.12, 38.09, 41.22, 44.35 and 46.54 cm) from B_1. At 30, 45, 60, 75, 90 and 105 DAP the maximum number of leaves per plant (5.71, 7.91, 11.11, 12.89, 13.78 and 14.24) was observed from B_3, while the minimum number (4.75, 6.54, 9.57, 11.12, 11.85 and 12.34) from B_1. The maximum days (67.00) required from planting to emergence of spike was recorded from B_2, while the minimum days (63.11) were found from B_3. The maximum days (82.11) required from planting to flowering of spike was recorded from B_2, while the minimum days (78.56) were found from B_3. The highest flowering plant (90.26%) was recorded from B_3, while the lowest (80.27%) was found from B_1. The highest length of flower stalk at harvest (85.82 cm) was recorded from B_3, while the lowest (75.32 cm) was found from B_1. The highest Length of rachis at harvest (30.96 cm) was recorded from B_3, while the lowest (27.13 cm) was found from B_1. The highest number of florets per spike (13.55) was recorded from B_3, while the lowest number (11.32) was found from B_1. The highest number of spikes per plot (60.91) was recorded from B_3, while the lowest number (50.50) from B_1. The highest number of spike per hectare (338.65 thousand) was recorded from B_3, while the lowest number (280.76 thousand) from B_1. The highest weight of individual bulb

(262.35 g) was recorded from $B_{3,}$ while the lowest weight (224.23 g) was found from B_1. The highest thickness of individual bulb (5.92 cm) was recorded from $B_{3,}$ while the lowest thickness (4.17 cm) from B_1. The highest diameter of individual bulb (1.86 cm) was recorded from $B_{3,}$ while the lowest diameter (1.56 cm) was found from B_1. The highest number of bulblet per plant (21.58) was recorded from $B_{3,}$ while the lowest number (18.53) from B_1. The highest weight of bulblet per plant (142.56 g) was recorded from $B_{3,}$ while the lowest weight (122.63 g) from B_1. The highest diameter of bulblet (1.39 cm) was recorded from $B_{3,}$ while the lowest diameter (1.12 cm) from B_1. The highest yield of bulb per plot (3.87 kg) was recorded from $B_{3,}$ while the lowest yield (2.52 kg) from B_1. The highest yield of bulblet per plot (2.07 kg) was recorded from $B_{3,}$ while the lowest yield (1.32 kg) from B_1. The highest yield of bulblet per hectare (21.53 ton) was recorded from $B_{3,}$ while the lowest yield of bulblet (14.02 ton) from B_1. The highest yield of bulb per hectare (11.51 ton) was recorded from $B_{3,}$ while the lowest yield (7.35 ton) from B_1.

For planting depth, at 30, 45, 60, 75, 90 and 105 DAP, the tallest plant (27.27, 35.24, 43.38, 45.20, 49.48 and 52.13 cm) was found from D_2, whereas the shortest plant (25.33, 31.81, 40.66, 43.15, 47.18 and 49.25cm) from D_1. At 30, 45, 60, 75, 90 and 105 DAP, the maximum number of leaves per plant (5.89, 8.00, 11.31, 12.96, 13.80 and 14.60) was recorded from D_2, whereas, the minimum number (5.16, 7.31, 10.53, 12.09, 12.84 and 13.04) from D_1. The maximum days (66.67) required from planting to emergence of spike was recorded from $D_{1,}$ whereas, the minimum days (63.33) was found from D_2. The maximum days (81.78) required from planting to flowering of spike was observed from D_1, whereas, the minimum days (78.44) was found from D_2. The highest flowering plant (91.00%) was found from D_2 whereas, the lowest flowering plant (84.28%) from D_1. The highest length of flower stalk at harvest (86.56 cm) was found from $D_{2,}$ whereas, the lowest length (79.99 cm) from $D_{1.}$ The highest length of rachis at harvest (31.58 cm) was found from $D_{2,}$ whereas, the lowest length (29.32 cm) from $D_{1.}$ The highest number of florets per spike

(13.71) was found from D_2 whereas, the lowest number (12.67) from D_1. The highest number of spikes per plot (61.09) was found from D_2 whereas, the lowest number (51.09) from D_1. The highest number of spike per hectare (339.69 thousand) was found from D_2, whereas, the lowest number (284.04 thousand) from D_1. The highest weight of individual bulb (263.67 g) was found from D_2, whereas, the lowest weight of individual bulb (239.39 g) from D_1. The highest thickness of individual bulb (4.99 cm) was found from D_2 whereas, the lowest thickness (4.22 cm) was observed from D_3. The highest diameter of individual bulb (1.88 cm) was found from D_2 whereas, the lowest diameter (1.67 cm) from D_1. The highest number of bulblet per plant (22.51) was found from D_2, whereas, the lowest number (19.04) from D_1. The highest weight of bulblet per plant (144.35 g) was found from D_2, whereas, the lowest weight (124.00 g) from D_1. The highest diameter of bulblet (1.41 cm) was found from D_2, whereas, the lowest diameter (1.24 cm) was observed from D_1. The highest yield of bulb per plot (3.68 kg) was found from D_2 whereas, the lowest yield of bulb per plot (2.92 kg) was observed from D_1. The highest yield of bulblet per plot (1.96 kg) was found from D_2, whereas, the lowest yield of bulblet per plot (1.47 kg) was observed from D_1. The highest yield of bulb per hectare (20.49 ton) was found from D_2 whereas, the lowest yield of bulb per hectare (16.25 ton) was observed from D_1. The highest yield of bulblet per hectare (10.91 ton) was found from D_2, whereas, the lowest yield of bulblet per hectare (8.20 ton) was observed from D_1.

Due to combined effect of bulb size and planting depth, at 30, 45, 60, 75, 90 and 105 DAP the tallest plant (28.34, 37.20, 45.51, 46.63, 51.81 and cm) was observed from B_3D_2 whereas the shortest plant (23.60, 29. 35, 38.96, 42.46, 45.49 and 47.39 cm) was recorded from B_1D_3. At 30, 45, 60, 75, 90 and 105 DAP The maximum number of leaves per plant (6.13, 8.53, 11.80, 13.53, 14.60 and 15.80) was obtained from B_3D_2, whereas the minimum number (4.67, 6.93, 10.13, 11.73, 11.80 and 12.53) was found from B_1D_3. The maximum days (74.00) required from planting to emergence of spike was observed from B_2D_3

and the minimum days (58.67) was recorded from B_3D_2. The maximum days (84.67) required from planting to flowering of spike was observed from B_2D_1 and the minimum days (76.00) was recorded from B_3D_2. The highest flowering plant (96.20%) was observed from B_3D_2 and the lowest flowering plant (82.90%) was recorded from B_3D_1. The highest length of flower stalk at harvest (92.36 cm) was observed from B_3D_2 and the lowest length of flower stalk at harvest (77.13 cm) was recorded from B_1D_3. The highest length of rachis at harvest (34.01 cm) was observed from B_3D_2 and the lowest length of rachis at harvest (25.47 cm) was recorded from B_1D_3. The highest number of florets per spike (14.35) was observed from B_3D_2 and the lowest number of florets per spike (12.15) was recorded from B_1D_3. The highest number of spikes per plot (64.98) was observed from B_3D_2 and the lowest number of spikes per plot (45.12) was recorded from B_1D_1. The highest number of spike per hectare (361.28 thousand) was observed from B_3D_2 and the lowest number of spike per hectare (250.89 thousand) was recorded from B_1D_1. The highest weight of individual bulb (288.47 g) was observed from B_3D_2 and the lowest weight of individual bulb (216.72 g) was recorded from B_1D_3. The highest thickness of individual bulb (6.58 cm) was observed from B_3D_2 and the lowest thickness of individual bulb (4.05 cm) was recorded from B_1D_3. The highest diameter of individual bulb (1.96 cm) was observed from B_3D_2 and the lowest diameter of individual bulb (1.60 cm) was recorded from B_1D_3. The highest number of bulblet per plant (23.73) was observed from B_3D_2 and the lowest number of bulblet per plant (18.27) was recorded from B_1D_3. The highest weight of bulblet per plant (150.90 g) was observed from B_3D_2 and the lowest weight of bulblet per plant (113.80 g) was recorded from B_1D_3. The highest diameter of bulblet (1.52 cm) was observed from B_3D_2 and the lowest diameter of bulblet (1.17 cm) was recorded from B_1D_3. The highest yield of bulb per plot (4.40 kg) was observed from B_3D_2 and the lowest yield of bulb per plot (2.42 kg) was recorded from B_1D_1. The highest yield of bulblet per plot (2.31 kg) was observed from B_3D_2 and the lowest yield of bulblet per plot (1.11 kg) was recorded from B_1D_3. The highest yield of bulb per hectare (24.46 ton) was

observed from B_3D_2 and the lowest yield of bulb per hectare (13.48 ton) was recorded from B_1D_1.The highest yield of bulblet per hectare (12.86 ton) was observed from B_3D_2 and the lowest yield of bulblet per hectare (6.17 ton) was recorded from B_1D_3.

The combination of bulb size and planting depth the highest gross return (Tk. 983,800) was obtained from B_3D_2 and the lowest gross return (Tk. 642,760) was obtained from B_1D_1. The highest net return (Tk. 609,189) was found from B_3D_2 and the lowest (Tk. 293,461) net return was obtained B_1D_1. The highest benefit cost ratio (2.63) was noted from B_3D_2 and the lowest benefit cost ratio (1.84) was obtained from B_1D_1.

Conclusion

Considering the above discussion it may be concluded that

- In the experiment, large size bulb was more effective than small bulb.
- Bulb planting at 5 cm depth gave better performance to produce tuberose.
- During the investigation, large size bulb with 5 cm depth of planting was found best for growth, flowering and yield of tuberose.
- Other different combinations of bulb size and depth of planting may be investigated.
- Considering the situation of the present experiment, further studies might be conducted in different agro-ecological zones (AEZ) of Bangladesh for regional adaptability and other performances.

REFERENCES

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

Ahmad, I., Ahmad, T. M., Asif, M., Saleem and Akram, A. 2009. Effect of bulb size on growth, flowering and bulblet production of tuberose. *Sarhad J. Agric*., **25** (3): 391-397.

Ali, T. and Akbari, R. 2012. Effect of planting depth, bulb size and their interactions on growth and flowering of tuberose. *American-Eurasian, J. Agric & Environ. Sci*., **12**(11): 1452-1456.

Anjum, M. A., Naveed, F., Shakeel, F. and Amin, S. 2001. Effect of some chemicals on keeping quality and vase life of tuberose (*Polianthes tuberosa* L.) cut flowers. *Pakistan J. Res*., **12**(1): 01-07.

Anonymous. 1989. Annual Report 1987-88. Bangladesh Agricultural Research Institute. Joydebpur, Gazipur. P. 133.

Ara, K. A., Sharifuzzaman, S. M. and Ahmed, S. 2009. Floriculture in Bangladesh. A paper presented on Expert Consultation Meeting of Floriculture. Kunming, China. pp. 9-20.

Arya, J. K. and Singh, P. V.2006. Vegetative growth as influenced by planting depth and spacing in Tuberose (*Polianthes tuberosa* L.) CV. Single *International Journal of Plant Sciences* .,**1** (1) : 95-96.

Asad, M.H., Sajid, M.,2014. Response of Tuberose (*Polianthes tuberosa*) to Potassium and Planting Depth. *Journal of Biology, Agriculture and Healthcare*.,4(11), 2014.

Bankar, G. J. and Mukhopadhya, A. 1990. Effect of bulb size, depth of planting and spacing on the production of flower and bulb in tuberose. *Indian J. Hort*., **37**: 425-430.

Bose, T. K., Maiti, R. G., Dhua, R. S. and Das, P. 1999. Tuberose. In: Floriculture and Landscaping. Nayaprakash, Calcutta, India. pp. 505-514.

Dalal, S. R., Dalal, N. R. and Rajurkar, D. W. 1999. Effect of nitrogen levels and bulb size on quality of flower stalk of tuberose. *Soil and crops*., **9**(1): 88-90.

De Hertogh, A. and Nard, M. Le. 1998. The physiology of flower bulbs. Elsevier, **177**: 183-187.

FAO .1988.Production Year Book . Food and Agriculture Organization of the United Nations. Rome, Italy.190-193.

Farrag, I. A. 1994. Effect of seed sowing depth and seedling planting depth on growth, yield and quality of onion. *Assuit J. of Agril. Sci*. **25** (5): 195-204 [Cited from Hort. Abst.,66 (5): 506,1996].

Hagiladi, A., Umiel, Y., Ozeri, R., Matan, E. 1992. The effect of planting depth on emergence and development of some geophytic plants. *Acta Hort*., 325: 131-137.

Halder, N. K., Siddiky, M. A., Ahmed, R. R., Sharifuzzaman, S. M. and Ara, K. A. 2007. Performance of tuberose as Influenced by Boron and Zinc. *South Asian J. Agric.*, **2** (1&2): 51-56.

Hoque, A. M. M. , Mannan, M. A., Rafiuddin, M. A., Hossain, E. and Akhtar, M. S. 1992. Effect of size and number of bulbs per hill on the yield of tuberose (*Polianthes tuberosa* L.). *Bangladesh Hort*., **20**(1): 81-83.

Hussain, M.A, Aminn, N., Ayub, G. and Sajid, M. 2014. Response of tuberose (*Polianthes tuberosa*) to potassium and planting depth. *J. Biol. Agric. & Healthcare*. **4**(11): 106-110.

Incalcaterra, G. 1992. Effects of planting depth and density on gladiolus crom production. *Colture Protette,* **21**: 83-94.

Kumar, A. and Singh, R. P. 1998. Effect of bulb size on bulb and bulblet production of tuberose (*Polianthes tuberosa* L.). *South Indian Hortic*., **46** (3): 294-298.

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

Mahanta, P. and Paswan, L. 1995. Effect of bulb size and spacing on growth, flowering and bulb production of tuberose (*Polianthes tuberosa* L.) cv. Single. *Hort. J*., **8**(1): 75-83.

Mahanta, P., Paswan, L. and Siddique, A. B. 1998. Effect of bulb size on growth and flowering of tuberose (*Polianthes tuberosa* L.). cv. Single. *Annals Agric. Bio. Res*., **3**(1): 35-38.

Mahros, O. M. 1999. Response of *Polianthes tuberosa* L. to different growing media, planting depth and size of bulbs. *J. Agril. Sci.*, **30**(3): 133-154.

Mane,P. K., Bankar,G.J. ; Makne, S. S. 2003 . Influence of spacing, bulb size and depth of planting on flower yield and quality of tuberose (*Polianthes tuberosa L.*) cv. 'Single'. *Indian Journa of Agricultural Research.* 2003; 41(1): 71-74

Mattos, J. R., Simao, S., Braga, R. L. C., Campos, H. and Moteiro, C. S. 1984. Influence of depth on the propagation of gladiolus Andr. Cv. Snow Princes. *Acta Hort*., **41**(2): 495-507.

Misra, M., Mohapatra, A. and Mohanty, C. R. 2000. Effect of fertilizer and spacing on tuberose. Proceedings of the national symposium on Indian floriculture in the new millennium. Lal Bagh, Bangalore., pp. 338-339.

Mitra, M. and Singh, S. 1998. Response of tuberose to bulbsize and nutrient management. International conference on biodiversity, livelihood and climate change in the Himalaya. Department of Bot., Tribhuvan Univ., India held on 12- 14 Dec, 2010.

Mottos, J. R., Braga, R. L. C. and Campos, H. 1983. A study of gladiolus cultivars at two planting depths. *Agril. J*., **40**: 473-495.

Mukhopadhyay, A. 1998. Importance of nitrogen nutrition for *Polianthes tuberose* L, in India. *Journal-of-Horticultural-Sciences*. 2002; **31**(1/2): 52-54

Patel, M.M., Parmar ,P. B.and Parmar ,B.R. 2006 .Effect of trogen, Phosphorus and Spacing on growth and flowering of tuberose.(*Polianthes tuberosa L*) cv Single.*Indian . J. Orn. Hort*.9(4):286-289.

Patil, J. D., Patil, B. A., Chugule, B. B. and Bhat, N. R. 1987. Effect of bulb size and spacing on stalk and flower yield in tuberose (*Polianthes tuberosa* L.) cv. Single. *Curr. Res*., **3**(2): 81-82.

Raja, K. and Palanisamy, V. 2000. Effect of bulb size on growth, flowering and bulb yield in tuberose (*Polianthes tuberosa* L.) cv. Single. *South Indian Hort*., **50**(2): 122-124.

Rao, D. V. R., Reddy, K. B. and Naidu, L. N. 1992. Effect of bulb size and depth of planting on growth and flowering of tuberose cv. Single. *South Indian Hort*., **40**(5): 298-300.

Reddy, B. S. and Singh, S. K. 1997. Effect of planting materials and fertilizer levels on growth and flower yield of tuberose (*Polianthes tuberosa* L.) cv. Double., *J. Agric. and Biol. Sci*., **1**(1) : 45-50.

Reddy, B. S., Kartar, S. and Gangadharappa, P. M. 1998. Tuberose cv. Double as affected by different bulb size and spacing. *Karnataka J. Agril. Sci.*, **114**: 436-440.

Sadhu, M. K., Das, P.C. 2005 .Effect of bulb size, planting density and depth of planting on growth, flowering and bulb production of tuberose P*olianthes tuberosa* Linn.) *Indian Journal of Horticulture*.Volume:35.Issue:2

Sadhu, M. K. and Bose, T. K. 1978. Tuberose for most artistic garland. *Indian Hort.*, **18**: 17-21.

Sathyanarayana, R. B., Singh, K. and Reddy, B. S. 1994. Studies on effect of bulb size in tuberose. *Advance Agril. Res*., **2**: 123-130.

Sikder, M., F. Mondal, D. Mohammed, M.S. Alam and M.B.Amin.2002. Effect of spacing and depth of planting on growth and yield of onion. *J. Agrofor. Environ.* **4** (2): 105-108.

Singh, P.V. 1999. Effect of spacing, depth and time of planting on growth, flowering and bulb production of tuberose cv. Double. *J. Ornamental Hort.*, **2**(2): 127-130.

Steel, R. G. D., Torrie J. H. and Dickey D. A. 1997. Principles and Procedures of Statistics. A Biometric Approach. 3rd ed. Mc Graw Hill Book Co. Inc., New York. pp. 107-109.

Suleyman, k. and Mahmood, k. 2014.Effect of planting depths on some agronomic characteristics of *Allium tuncelianum.*Scientific Papers. Series B, Horticulture. Vol. LIX, 2013.

Syamal, M. M., Rajput, C.B.S. and Singh, S.P. 1987. Effect of corm size and planting distance and depth of planting on the growth and flowering of gladiolus. *Res. Dev. Rep*., **13**: 10-12

Tiwari, J. K. and Singh, R. P. 2002. Effect of pre-planting GA3 treatment on tuberose. *J. Orn. Hort*., **5**: 44-55.

Vinceljak, T. M. 1990. The effect of corm size on corm yield of gladiolus cultivars. *Acta Hort*, **55**: 379-392.

Yadav, L. P., Bose, T. K. and Meity, R. G. 1984. Effect of bulb size on growth and flowering of tuberose. *Progressive Hort*., **16**: 203-213.

APPENDICES

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

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Horticulture Farm , SAU, Dhaka
AEZ	Madhupur 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

B. Physical and chemical properties of the initial soil

Characteristics	Value
% Sand	27
% Silt	43
% clay	30
Textural class	Silty-clay
pH	6.2
Organic carbon (%)	0.45
Organic matter (%)	1.18
Total N (%)	0.03
Available P (ppm)	20.00
Exchangeable K (me/100 g soil)	0.10

Source: SRDI

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

Month (2013)	*Air temperature (°c)		*Relative humidity (%)	*Rain fall (mm) (total)	*Sunshine (hr)
	Maximum	Minimum			
April	33.4	23.2	67	78	8.3
May	36.7	20.3	70	205	7.7
June	35.4	22.5	80	577	4.2
July	36.0	24.6	83	563	3.1
August	36.0	23.6	81	319	4.0
September	34.8	24.4	81	279	4.4

* Monthly average,

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

Appendix III. Analysis of variance of the data on plant height at different days after planting (DAP) of tuberose as influenced by bulb size and depth of planting

Source of variation	Degrees of freedom	Mean square					
		Plant height (cm) at					
		30 DAP	45 DAP	60 DAP	75 DAP	90 DAP	105 DAP
Replication	2	0.418	6.633	2.464	0.008	3.198	0.927
Bulb size (A)	2	10.037*	33.097*	21.235*	9.796*	14.553*	19.199*
Depth of planting (B)	2	8.485*	27.188*	17.040*	9.527*	15.343*	18.688*
Interaction (A×B)	4	7.049*	24.032*	12.208*	8.177*	8.742*	13.260*
Error	16	2.342	7.420	4.447	2.531	3.998	5.048

*: Significant at 0.05 level of probability

Appendix IV. Analysis of variance of the data on number of leaves per plant at different days after planting (DAP) of tuberose as influenced by bulb size and depth of planting

Source of variation	Degrees of freedom	Mean square					
		Number of leaves per plant at					
		30 DAP	45 DAP	60 DAP	75 DAP	90 DAP	105 DAP
Replication	2	0.031	0.010	0.144	0.161	0.055	0.046
Bulb size (A)	2	0.724*	1.175*	1.130*	1.797*	3.775**	3.290**
Depth of planting (B)	2	1.293**	1.086*	1.424*	1.690*	2.161*	5.468**
Interaction (A×B)	4	0.458*	0.970*	0.686*	0.781*	1.841*	3.273**
Error	16	0.149	0.247	0.302	0.355	0.575	0.489

**: Significant at 0.01 level of probability: *: Significant at 0.05 level of probability

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

Source of variation	Degrees of freedom	Mean square					
		Days required from planting to emergence of spike	Days required from planting to flowering	Flowering plant (%)	Length of flower stalk at harvest (cm)	Length of rachis at harvest (cm)	Number of spikelets per spike
Replication	2	0.111	1.148	9.611	3.001	1.226	0.132
Bulb size (A)	2	38.111*	30.259*	81.263*	109.023*	13.520*	2.140*
Depth of planting (B)	2	30.333*	31.259*	104.640*	97.527*	12.713*	2.582*
Interaction (A×B)	4	119.278**	23.870*	71.249*	91.067*	31.597**	1.590*
Error	16	7.903	6.856	21.911	24.953	3.149	0.530

**: Significant at 0.01 level of probability: *: Significant at 0.05 level of probability

Appendix VI. Analysis of variance of the data on number of leaves per plant at different days after planting (DAP) of tuberose as influenced by bulb size and depth of planting

Source of variation	Degrees of freedom	Mean square				
		Number of spike per plot	Number of spike per hectare (‘000)	Weight of individual bulb (g)	Thickness of individual bulb (cm)	Diameter of individual bulb (cm)
Replication	2	0.371	11.924	12.044	0.266	0.001
Bulb size (A)	2	226.981*	7004.004*	1969.858*	3.630*	0.108**
Depth of planting (B)	2	246.303*	7584.178*	1334.358*	3.254*	0.102**
Interaction (A×B)	4	177.593*	5480.017*	3519.467**	1.367*	0.026*
Error	16	52.836	1630.808	318.753	0.579	0.010

**: Significant at 0.01 level of probability: *: Significant at 0.05 level of probability

Appendix VII. Analysis of variance of the data on number of leaves per plant at different days after planting (DAP) of tuberose as influenced by bulb size and depth of planting

Source of variation	Degrees of freedom	Mean square						
		Number of bulblet/plant	Weight of bulblet/plant (g)	Diameter of bulblet (cm)	Yield of bulb (kg/plot)	Yield of bulblet (kg/plot)	Yield of bulb (t/ha)	Yield of bulblet (t/ha)
Replication	2	0.028	45.636	0.002	0.007	0.026	0.214	0.811
Bulb size (A)	2	10.828**	1093.474**	0.057**	1.135**	0.630**	35.020**	19.440**
Depth of planting (B)	2	27.041**	966.636**	0.065**	0.769*	0.557**	23.722*	17.185**
Interaction (A×B)	4	5.417*	226.054*	0.030**	2.027**	0.130*	62.568**	4.019*
Error	16	1.988	63.326	0.007	0.184	0.036	5.667	1.126

**: Significant at 0.01 level of probability: *: Significant at 0.05 level of probability

Appendix VIII. Production cost of tuberose per hectare

A. Input cost

Treatment	Labour cost	Ploughing cost	Corm Cost	Irrigation Cost	Pesticides	Manure and fertilizers				Sub Total (A)
						Cowdung	Urea	TSP	MP	
B_1D_1	45000.00	25000.00	30000.00	15000.00	10000.00	15000.00	3000.00	16000.00	10800.00	169800.00
B_1D_2	45000.00	25000.00	30000.00	15000.00	10000.00	15000.00	3000.00	16000.00	10800.00	169800.00
B_1D_3	45000.00	25000.00	30000.00	15000.00	10000.00	15000.00	3000.00	16000.00	10800.00	169800.00
B_2D_1	45000.00	25000.00	40000.00	15000.00	10000.00	15000.00	3000.00	16000.00	10800.00	179800.00
B_2D_2	45000.00	25000.00	40000.00	15000.00	10000.00	15000.00	3000.00	16000.00	10800.00	179800.00
B_2D_3	45000.00	25000.00	40000.00	15000.00	10000.00	15000.00	3000.00	16000.00	10800.00	179800.00
B_3D_1	45000.00	25000.00	50000.00	15000.00	10000.00	15000.00	3000.00	16000.00	10800.00	189800.00
B_3D_2	45000.00	25000.00	50000.00	15000.00	10000.00	15000.00	3000.00	16000.00	10800.00	189800.00
B_3D_3	45000.00	25000.00	50000.00	15000.00	10000.00	15000.00	3000.00	16000.00	10800.00	189800.00

B_1: Small size bulb
B_2: Medium size bulb
B_3: Large size bulb

D_1: 3 cm depth of planting
D_2: 5 cm depth of planting
D_3: 7 cm depth of planting

Appendix VIII. Contd.

B. Overhead cost (Tk./ha)

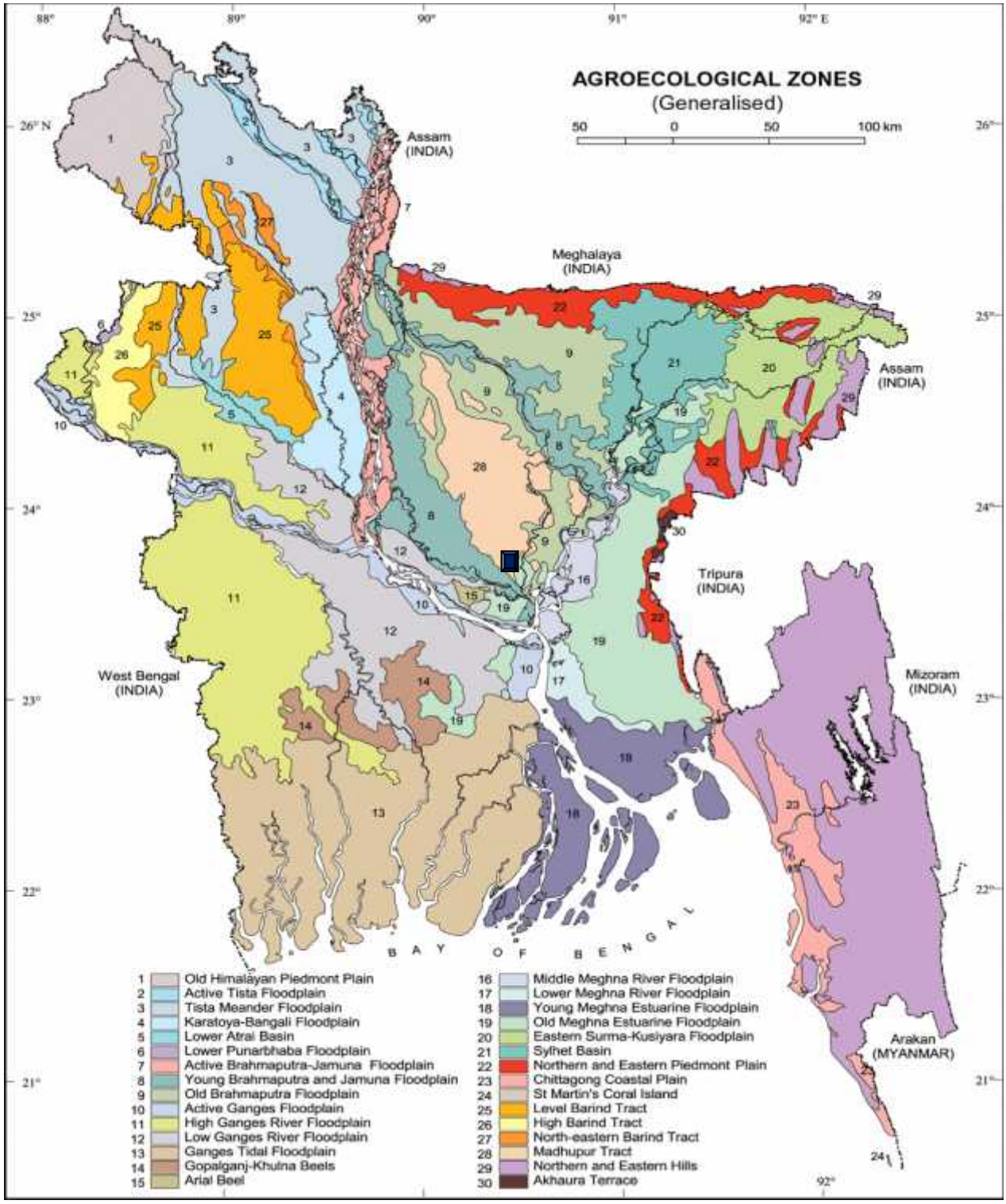
Treatment	Cost of lease of land for 12 months (12% of value of land Tk. 10,00000/year	Miscellaneous cost (Tk. 5% of the input cost	Interest on running capital for 12 months (Tk. 12% of cost/year	Sub total (Tk) (B)	Total cost of production (Tk./ha) [Input cost (A)+ overhead cost (B)]
B_1D_1	120000	22074	37425	179499	349299
B_1D_2	120000	22074	37425	179499	349299
B_1D_3	120000	22074	37425	179499	349299
B_2D_1	120000	23374	38781	182155	361955
B_2D_2	120000	23374	38781	182155	361955
B_2D_3	120000	23374	38781	182155	361955
B_3D_1	120000	24674	40137	184811	374611
B_3D_2	120000	24674	40137	184811	374611
B_3D_3	120000	24674	40137	184811	374611

B_1: Small size bulb D_1: 3 cm depth of planting

B_2: Medium size bulb D_2: 5 cm depth of planting

B_3: Large size bulb D_3: 7 cm depth of planting

Appendix IX: Map showing the experimental site under study



Experimental site