INFLUENCE OF GROWTH REGULATORS ON GROWTH FLOWERING AND BULB PRODUCTION OF TUBEROSE

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ABSTRACT

The experiment was conducted at the Floriculture Field of Horticulture Research Centre, Bangladesh Agricultural Research Institute, Gazipur during February, 2014 to March, 2015 to investigate the effect of plant growth regulators on growth, flowering and bulb production of tuberose. There were ten treatments comprising of three concentrations of three growth regulators along with control (soaked in water) namely T_1 : Control, T_2 : GA_3 100, T_3 : GA_3 200, T_4 : GA_3 300, T_5 : BAP 100, T_6: BAP 200, T_7 : BAP 300, T_8 : CCC 250, T_9 : CCC 500 and T_{10} : CCC 1000 ppm respectively. The experiment was laid out in a Randomized Complete Block Design with three replications. Vegetative growth, flower and yield characteristics of tuberose were influenced significantly by different level of growth regulators. Early bulb sprouting, flowering and maximum plant height, number of leaves/plant, spike length, rachis length, vase life and yield of spikes per hectare was increased with $T_{4,}$ whereas T_5 treatment increased plants per hill as well as bulb and bulblet production in tuberose. Finally, this result showed that the use of GA_3 @ 300 ppm, and BA @ 100 ppm are best because it helps to increase growth, flowering (4.8 lacs spikes/ha) and bulb production (12.5 t/ha) of tuberose.

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The Author

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LIST OF ABBREVIATED TERMS

ABBREVIATIONS	FULL WORD
%	Percent
@	At the rate
AEZ	Agro Ecological Zone
ANOVA	Analysis of Variance
B	Boron
BA	Benzyladenine
BARI	Bangladesh Agricultural Research Institute
CCC	Cycocel
Cm	Centimeter
CV%	Percentage of Coefficient of Variation
DAP	Days After Planting
Df	Degrees of Freedom
DMRT	Duncan's Multiple Range Test
et al.	And others
etc.	Etcetera
FYM	Farm Yard Manure
GA_3	Gibberellic Acid
HRC	Horticulture Research Centre
K	Potassium
Kg	Kilogram
Max.	Maximum
mg/L	Miligram per Litre
MH	Maleic Hydrazide
Min.	Minimum
MoP	Muriate of Potash
NAA	Naphthalene Acetic Acid
^{O}C	Degree Celsius
ppm	Parts per million
RCBD	Randomized Complete Block Design
RDF	Recommended Dose of Fertilizer
RH	Relative Humidity
S	Sulphur
SAU	Sher-e-Bangla Agricultural University
t/ha	Tons per hectare
TSP	Triple Super Phosphate

CHAPTER I
INTRODUCTION

Tuberose (*Polianthes tuberose* L.), a member of Amaryllidaceae family is one of the most beautiful bulbous tropical flowering plant commonly called as *'Rajnigandha'* in Bengali which was originated in Mexico and grown on large scale in Asia. It is an important cut flower crop from aesthetic as well as commercial point of view. From Mexico, it spreaded out to the different parts of the world during the 16th century (Chopde *et al*., 2007). In Bangladesh, its commercial cultivation was introduced during 1980 by some pioneer and innovative farmers at Panishara union of Jhikorgacha thana under Jessore district near the Benapol border (Hoque *et al*., 1992). In the orient, where 'white' goes for virtue and purity, tuberose is much adored for its colour, elegance and fragrance (Mahanta *et al*.,1998). Tuberose occupies a very selective and special position to flower loving people. It has a great economic potential for cut flower trade and essential oil industry (Shanker *et al.*, 2010). Apart from ornamental value, tuberose is extensively utilized in medicines for headache, diarrhoea, rheumatism and allied pains (Kusuma, 2000).

Tuberose is very popular due to easy to grow and wider adaptability (Ranjon *et al.*, 2014). 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. The spike lasts long in vase for 10-15 days. Tuberose is planted in beds and borders and can also be grown as potted plants (Sathynarayana *et al*., 1994). It has a delightful fragrance and is the source of tuberose oil. The natural flower oil of tuberose is one of the most expensive raw material for perfume industry. To meet the ever increasing domestic market demand and to tap the export potential of fresh flowers and the value added products from tuberose, there is a need to

increase the productivity of this crop. In Bangladesh, for the last few years, tuberose has become a popular cut flower of its attractive fragrance and beautiful display in the vase. Now it has high demand in the market and its production is highly profitable (Mazed *et al.*, 2015). This flower crop possesses a great potential for export market specially during summer. An increase in flower production and improvement of spikes quality in this crop can be achieved by application of plant growth regulators.

To enhance yield and quality of any flower crop, various cultural management practices like good planting material, spacing, irrigation, plant protection, use of growth regulator etc. are required. The planting material i.e. bulb is the important factor which governs the growth and development of tuberose. The physiological functions inside the bulb are controlled by plant growth regulators. Plant growth regulators are the organic chemical compounds which modify or regulate physiological processes in an appreciable measure in plants when used in small concentrations. They are readily absorbed and move rapidly through tissues when applied to different parts of the plant. It has generally been accepted that many plant processes including senescence, are controlled through a balance between plant hormones interacting with each other and with other internal factors (Biswas, 2005). Although growth retarding chemicals did not increase the number of flowers, they produced flowers with compact shape, developed short stalk, flowers remained fresh for a longer period and they suppressed the height of the plant.

The potential use of growth regulators in flower production has created considerable scientific interest in recent years. Various research workers have reported that, the application of growth regulators helps to increase the yield of good quality spikes and bulbs in tuberose. Gibberellic acid has been reported to increase the plant height, leaves and shoots plant and improves the spike quality (Kirad *et al.*, 2001), stimulate flowering and increase the yield of tuberose spike

(Singha *et al*., 2008). Cycocel are very important plant growth regulators has been reported beneficial as it increased leaves, branch, flower yield and vase life and reduced vegetative growth without affecting initiation of flower bud and commencement of flowering (Singh and Desai, 2013). Similarly, benzyl adenine is a growth regulator reported to be useful for enhancing sprouting, increasing sprout plant and thereby yield of better quality bulbs. Thus, itis assumed that, application of BA, GA_3 and CCC either by bulb soaking, spraying or both can provide the better quality production of tuberose spikes and bulbs. There is a scope of flower, bulb and bulblet production of tuberose with the application of growth regulators like GA_3, Ethrel, Paclobutrazol, Auxins, Cytokinins etc. Application of optimum level of growth regulators may not only ensure better yield and quality of tuberose, as well as minimum wastage of growth regulators. With the expectation to all above, use of plant growth regulator for producing better quality crop is gaining much more importance which is highly beneficial not only for the producers and sellers but also for the consumers. In Bangladesh a few studies were done regarding the use of growth regulators for growth, flowering and bulb production of tuberose.

Considering the above mentioned facts, the present study was undertaken with the following objectives:

i. To find out the suitable growth regulators for maximum vegetative growth and flowers production of tuberose; and

ii. To find out the optimum dose of growth regulators for ensuring the higher bulb production of tuberose.

CHAPTER II
REVIEW OF LITERATURE

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

2.1 Literatures on growth regulators

Normal plant growth and development are regulated by naturally produced chemicals or endogenous plant hormones. Their role can often be substituted by application of synthetic growth regulating chemicals, which are becoming extremely important and valuable in the commercial control of crop growth in both agriculture and horticulture. The potential use of growth regulators in flower production has created considerable scientific interest in the recent years. Many studies have indicated that the application of growth regulators can affect the growth and development of flowers.

An experiment was conducted at the Horticultural research field of Bangabandhu Sheikh Mujibur Rahman Agricultural University, Salna, Gazipur by Jamil *et al*. (2015) to investigate the effect of plant growth regulators on flower and bulb production of Hippeastrum. There were ten treatments comprising of three concentrations of three growth regulators, viz. IAA (20, 60 and 100 ppm), ethrel (100, 300 and 500 ppm) and GA_3 (100, 300 and 500 ppm) along with control (soaked in water). The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Flower and bulb characteristics of Hippeastrum were influenced significantly by different levels of growth regulators. Application of IAA at 60 and 100 ppm and GA_3 at 100, 300 or 500 ppm twice as

foliar spray at an interval of 30 days promoted the number of bulblets on the treated plants. Ethrel at a concentration of 100 ppm increased the number of flowers per scape (4) and showed earliness in days to flower scape emergence (72.33 days) and first flower open (88.67 days). On the other hand, the biggest size of flower (15.14 cm × 12.44 cm) and flower space (40.28 cm × 21.95 cm) at harvest and the maximum days for flowering (11.50 days) were evident from plants treated with 500 ppm GA_3. The highest number of bulblets per plot (40.00), bulbs weight per plot (4056 g) along with bulb yield (40.56 t/ha) were also obtained in GA_3 at 500 ppm.

Three different levels (50 ppm, 75 ppm and 100 ppm) of each of BA, GA_3 NAA and Ethrel were applied to Carnation (*Dianthus caryophyllus* L.) cv. Chabaud Super Mix plants and the effect was compared to control plants (Maitra and NIlimesh *et al*., 2015). The effect of plant growth regulators on leaf length, leaf width and flower bud diameter of carnation were found statistically non-significant. Growth regulators had a profound effect on the plant height of carnation and the longest plants were recorded as a result of application of GA_3 @ 75 ppm (75.28 cm) whereas the shortest were from untreated plants (59.78 cm). GA_3 @ 100 ppm resulted highest number of side-shoots/plant (11.94). NAA at higher concentration (100 ppm) produced the highest number of leaves/shoot (25.34). Growth regulators delayed flowering. Control plants reached the Flower Bud Initiation (FBI) stage earliest (69.17 days). The earliest time period from FBI to Colour Showing stage was recorded with the application of GA3 at 75 ppm (25.67 days). The longest time period from Colour Showing stage to full bloom stage (5.50 days) and greater diameter of flowers (5.20 cm) were recorded with GA_3 @ 50 ppm treated plants. Control plants reached the full bloom stage earliest (4.33 days). Ethrel @ 100 ppm treated plants showed higher floriferousness (41.50 flowers/plant) and produced longest flowers (4.72 cm) with longest stalks (40.26 cm). The longest flower buds were obtained from control plants (2.88 cm). Plants treated with 100 ppm BA

showed higher fresh weight (262.43 g/100 flowers) and *in-situ* longevity (6.83 days) of flowers. Higher post-harvest longevity (5 days) of flowers was recorded with Ethrel @ 50 ppm treated plants.

A field experiment was conducted by Sainath *et al*. (2014) to study the effect of growth regulators on seed yield and quality in annual chrysanthemum (*Chrysanthemum coronarium* L.) during *kharif* 2008. Results revealed that spraying of Gibberellic acid @ 200 ppm induced early flowering followed by Gibberellic acid @ 100 ppm and similar trend was observed with tricontanol @ 1000 and 500 ppm. On the contrary, among the growth retardants, mepiquat chloride @ 1000 and 2000 ppm and cycocel @ 1000 and 2000 ppm delayed flowering as compared to the Gibberellic acid and tricontanol. Spraying of GA_3 @ 200 ppm significantly increased number of capitulum per plant, capitulum diameter, number of seeds per capitulum, dry weight of capitulum, 1000 seed weight and seed yield (per plant and per ha) as compared to control. Similarly, tricontanol @ 1000 and 500 ppm, mepiquat chloride @ 1000 and 2000 ppm and cycocel @ 1000 ppm and 2000 ppm also significantly improved the number of capitulum per plant, capitulum diameter, dry weight of capitulum, 1000 seed weight and seed yield (per plant and per ha) as compared to control. The seed quality parameters such as germination percentage, seedling length and vigour index and seedling dry weight were higher with lower electrical conductivity with GA_3 @ 200 ppm followed by GA_3 @ 100 ppm and similar observations were recorded with tricontanol @ 1000 ppm and 500 ppm. Among the growth retardants, mepiquat chloride @ 1000 ppm recorded significantly higher germination percentage, seedling length, vigour index and seedling dry weight with lower electrical conductivity followed by mepiquat chloride @ 2000 ppm and cycocel @ 1000 and 2000 ppm.

The experiment on effect of storage period and GA_3 soaking of tuberose bulbs on growth, flowering, flower yield and quality was conducted by Nilima *et al*. (2014) at Junagadh Agriculture University, Junagadh. The experiment was laid out in factorial randomized block design (FRBD) with three replications and four treatment combinations of storage comprising: S_0 - Fresh up lifted, S_1 - One month storage (up lifted during 2nd week of January, 2010), S_2 - Two months storage (up lifted during 2nd week of December, 2009), and S_3 - Three months storage (up lifted during 2nd week of November, 2009). These tuberose bulbs were planted in 3rd week of February, 2010 with four GA_3 soaking treatments for 12 hours, *viz.* G_0 - Control (soaking in distilled water), G_1 - 100 mg/L, G_2 - 200 mg/L and GA_3 - 300 mg/L. The bulbs soaked with different concentration of GA_3 were kept in shade for half an hour before planting. The results revealed that one month storage period after uplift of bulbs and GA_3 200 ppm soaking before planting treatments significantly improved growth parameters (days to sprouting, sprouting per cent age and plant height), and floral characters (days to spike emergence, days to first spike harvested and length of spike, number of florets per spike and diameter of floret) over a control treatment.

A research work was performed by Muhshid (2013) in Varmin Research Center, Iran on two varieties namely "White prosperity" and "Rose supreme" of gladiolus. The treatments were applied on the corm and cormel as follows; gibberellic acid at 4 levels (0, 25, 50,100) mg/L and ethephon at 4 levels (0, 100, 200, 400) mg/L. The result showed that the treatment GA_3 at 100 mg/L and ethephon at 100 mg/L on Rose Supreme variety had significant effect on the days to sprouting, spike length, rachis length, vase life, maximum number of flowers and weight of corm.

The effect of thiourea (TU), salicylic acid (SA), potassium nitrate (KNO_3) and gibbrrellic acid (GA_3) with two corm soaking periods on dormancy breaking and corm and cormel production of two gladiolus cultivars 'Darshan' and 'Dhiraj' was investigated by Padmalatha *et al*. (2013). The cultivar 'Darshan' recorded

significantly minimum number of days to sprouting and maximum percentage of sprouting over cv. 'Dhiraj'. Pre-planting soaking of corms for 24 h was significantly more influencing over 12 h soaking in decreasing the number of days to sprouting and increasing corm sprouting percentage and number of buds sprouted per corm. TU 2% and SA 150 ppm were highly effective in reducing the number of days taken for sprouting over control. TU 2%, SA 150 ppm, KNO_3 1.5% and GA_3 150 ppm significantly increased sprouting percentage of corms over control and recorded maximum number of sprouts per corm. The cultivar 'Dhiraj' recorded maximum corm size and weight, maximum number of small cormels and total number of cormels per plant over cv. 'Darshan' cv. 'Darshan' recorded higher number of big cormels. Soaking of corms for 24 h significantly improved corm and cormel attributes than 12 h soaking. SA 150 ppm and TU 2% were effective in increasing number of corms per plant. Maximum corm size and weight were recorded with SA 150 ppm and GA_3 150 ppm. Maximum number of big cormels per plant and cormel weight was recorded with TU 2%, GA_3 150 ppm and SA 150 ppm. Control recorded significantly more number of small cormels and total number of cormels per plant.

An experiment was carried out by Sudhakar and Kumar (2012) to study the effect of growth regulators on growth, flowering and corm production of Gladiolus cv. White Friendship in India. Four growth regulators, viz. GA_3, NAA, CCC and MH each at three concentrations in addition to water spray as control comprised thirteen treatments of this experiment. The experiment was laid out in a Randomized complete Block Design (RCBD) with three replication. The results revealed that the growth regulators application significantly influenced the growth and yield in gladiolus. The maximum number of florets/spike, spike length and rachis length were obtained with GA_3 @ 100 ppm as compared to rest of the treatments. Where as CCC @ 500 ppm was found the best in terms of corm and cormel production.

An investigation was carried out by Taha (2012) at the Nursery of Ornamental plants, Faculty of Agriculture, Minia University, Egypt to study the effect of different concentrations of gibberellins (GA_3), cycocel (CCC) and alar on the growth, flowering and bulb production of iris plants. In this study, the plants of iris were sprayed with three levels of each, viz. GA_3 (250, 500 and 750 ppm), CCC (250, 500 and 1000 ppm) and Alar (125, 250 and 500 ppm) including control (only water). Results showed that GA_3 @ 750 ppm increased number of flowers, flowering stalk diameter, fresh and dry weights of the flowering stalk, bulb and bulblet production compared to control and other treatments.

An experiment was conducted by Chopde (2011) to study the effect of growth regulators, viz. GA_3 and NAA on growth and flowering of three genotypes of gladiolus, viz. 'Phule Neelrekha', 'Phule Tejas' and 'Phule Ganesh' in split plot design at Nagpur, India. The results revealed that, the maximum leaves per plant and spikes per hectare, minimum days required for opening of first pair of florets and 50 per cent flowering were due to the variety 'Phule Tejas'. Whereas, the maximum total chlorophyll content of leaves before the f1owering and the maximum length of spike, distance between two florets, longevity of flower on plant and length and width of florets were observed under the variety 'Phule Ganesh'. However, effect of PGR was non-significant as regards leaves per plant and chlorophyll content of leaves. But significantly early opening of first floret and 50 per cent flowering and the maximum spike yield and spike quality parameters viz. length of spike, distance between two florets, longevity of flower on plant and length and width of florets were noted under the treatment of GA_3 150 ppm.

An experiment was conducted by Jinesh *et al.* (2011) at Anand Agricultural University, India. The treatments comprised of four growth regulators with their two levels of each, viz. GA_3 (25 and 50 mg/L), NAA (50 and 100 mg/L), Ethrel (100 and 200 mg/L) and CCC (250 and 500 mg/L) including control (only water).

The experiment was laid out in Randomized Block Design with nine treatments and three replications. The results revealed that treatment of GA_3 @ 50 mg/L took minimum days for corm sprouting as compared to control and rest of the treatments. Significantly the maximum plant height, leaf length and number of leaves per plant width were registered with the same treatment GA_3 @ 50 mg/L as compared to control. Where as CCC @ 250 mg/L gave maximum yield of corms and cormels by increasing the number and weight of corms and cormels per plant as compared to control.

Asil *et al.* (2011) shown that the effect of different chemical treatments on quantitative characteristics of tuberosa (cv. Goldorosht Mahallat) was investigated. This research was conducted in a factorial experiment based on Randomized Block design with 3 replications. The flowers were sprayed 40 and 50 days after planting, with various concentration of gibberellic acid (GA_3) and benzyladenine (BA) (0, 50 and 100 ppm). The results showed that early flowering, highest spike length, rachis length, and maximum flower number were with GA_3 at 100 ppm while BA at 50 ppm increased only vase life.

The present investigation was conducted by Kumar *et al*. (2011) at Horticulture Research Farm, Department of Horticulture, Choudhary Charan Singh University, Meerut. The experiment was laid out in Randomized Block Design, consisted of 9 treatments with control. Two growth regulators namely gibberellic acid (GA_3) and cycocel (CCC) were taken. There were four levels of GA_3, i.e. 200 ppm, 250 ppm, 300 ppm and 350 ppm and four levels of cycocel, i.e. 1200 ppm, 1600 ppm, 2000 ppm and 2400 ppm along with one control (water spray), were taken for both the growth regulators. Gibberellic acid application at 350 ppm was found most effective as it gave highest flower yield per plant, maximum fresh weight per flower and highest number of flowers per plant and earlier flower bud initiation and flowering and also increased number of leaves as well as with maximum

height of the plant. Cycocel application at 2400 ppm was found most effective as it gave highest number of leaves per plant and maximum number of main branches per plant. Application of cycocel 2000 ppm was also beneficial as it gave 28.71 per cent more flower yield (i.e. 229.68 g/plant) as compared to control (i.e. 178.44 g/plant) with increasing number of flowers per plant without affecting initiation of flower bud and commencement of flowering. Thus the present investigation clearly indicate that the application of gibberellic acid at 350 ppm was best treatment in all respect as it enhanced vegetative growth and flower. Further, cycocel at 2000 ppm was also beneficial as it increased flower yield and reduced vegetative growth without affecting initiation of flower bud and commencement of flowering.

Bhattacharjee (2010) conducted an experiment with gladiolus cv. Sylvia where corms were kept in GA_3 solutions for 24 hours in an attempt to find out the effect in growth, flowering and yield. It was revealed that the GA_3 @ 200 ppm treated corms sprouted and flowered earlier than the control corms. GA_3 @ 200 ppm also increased plant height, spike length, rachis length, flower yield and size of corms.

Singh and Shanker (2010) conducted an experiment to find out the effect of foliar spray of growth regulators in three doses each in GA_3 (50, 100 and 150 ppm), Kinetin (50, 100 and 150 ppm), NAA (50, 100 and 150 ppm), Ethrel (100, 200 ad 300 ppm) and SADH (100, 200 and 300 ppm) on the flowering of two cultivars of tuberose, viz. Shringar and Kalyani Double. Cultivar Shringar was superior in inducing early spike emergence, first floret opening and also produced maximum number of spikes/m^2. However, cv. Kalyani Double showed maximum number of florets, spike length and flowering duration. Among various treatments, GA_3 @ 150 ppm was observed best in inducing early spike emergence, opening of first floret, 50 per cent floret opening and maximum spike yield per square meter. The spikes characters, such as length of rachis and spike, number of florets per spike

increased significantly with the application of GA_3 @ 100 ppm. Maximum days to withering of first opened floret and flowering duration were observed with Kinetin @ 150 ppm. However, Ethrel @ 300 ppm exhibited delayed flowering, minimum flowering duration and reduced length of spike characters.

A study was conducted by Nejad and Etemadi (2010) to evaluate the effects of gibberellic acid (GA_3) on flower quality and flowering date of tuberose. Double cultivar tuberose bulbs, ranging from 6 to 7 cm in diameter were used. GA_3 solutions @ 100, 200 and 300 ppm were used. The bulbs were soaked before cultivation and bud sprouts were sprayed with GA_3 solutions at two stages of plant development. GA_3 application methods did not show significant differences on the evaluated characters, while significant variations were observed among various GA_3 concentrations. Comparing the date of flowering harvest indicated that the highest number of flowers was picked 3 to 4 weeks after flowering for both GA_3 application methods. The application of GA_3 @ 300 ppm by soaking the bulbs before cultivation significantly increased the number of flowering spike and flowering time.

Shanker *et al.* (2009) conducted an experiment to find out the effect of plant growth regulators on spike yield and bulb production of tuberose cv. Double at Main Experiment Station, Department of Horticulture, University of Agriculture and Technology, Faizabad (U. P.), India. Treatments including three levels of GA_3 at 100, 200 and 300 ppm, NAA at 100, 200 and 300 ppm and BA at 100, 150 and 200 ppm with one control (without growth regulators) were tried. Plant growth regulators were applied by foliar application 30 days after planting of tuberose bulb. Application of GA_3 300 ppm resulted increased length of spike, number of florets per spike, number of spike per clump, number of spike per hectare, number of bulb per clump, weight of bulb per clump and yield of bulb per hectare.

Chaudhary *et al.* (2007) carried out with two different plant growth regulators, namely GA_3 and NAA applied as foliar application 30 days after planting of tuberose bulb. The vegetative characters like number of sprout per bulb was manipulated with the application of NAA 300 ppm, besides this height of plant and number of leaves per clump was enhanced with the application of GA_3 300 ppm in cv. Double as compared to control. Application of 300 ppm GA_3 decreased the days taken to initiation of spike, opening of first florets and increase the duration of flowering compared to control.

Moazzam *et al.* (2009) conducted an experiment on effect of different chemical treatments on quantitative characteristics of tuberose (cv. Goldorosht Mahallat). This research was conducted in a factorial experiment based on block design with 3 replications. The plants were sprayed with various concentrations of gibberellic acid (GA_3) and benzyladenine (BA) (0, 100, and 200 ppm) 40 and 60 days after planting. The results showed that, spike, rachis and leaves length were highest with GA_3 at 100 ppm while BA no increase these traits compared to the control. GA_3 resulted in earlier flowering compared to the control. Highest diameter of floret and vase life of cut flower was recorded at BA (100) and (200) ppm, respectively.

Sarkar *et al.* (2009) conducted an experiment to study effect of growth regulators on growth and flowering in tuberose and the investigation was carried out with three different growth regulators, namely GA_3, IAA and NAA applied as dip treatments in two tuberose cultivars, viz. Calcutta Single and Calcutta Double. The vegetative characters like days required for sprouting was earliest with the application of 300 ppm GA_3 in both the cultivars. Besides, the important flower traits like vase-life, spike length, rachis length and flower yield increased with the application of 300 ppm GA_3 compared to the control. Even application of 300 ppm GA_3 as dip also enhanced the number of bulbs and bulblets per plant in both of the cultivars compared to the respective control.

A field experiment was conducted by Bharti and Ranjon (2009) to find out the effect of foliar spray of growth regulators in three doses each in GA_3 (100, 200 and 300 ppm), Kinetin (50, 100 and 200 ppm), NAA (50, 100 and 200 ppm), Ethrel (100, 200 and 300 ppm) and SADH (100, 200 and 300 ppm) on the flowering of two cultivars of tuberose, viz. Shringer and Kalyani Double. Cultivar 'Shringar' was superior in inducing early spike emergence, first floret opening and also produced maximum number of spikes/m^2. However, cv. Kalyani Double showed maximum number of florets, spike length and flowering duration. Among various growth regulator treatment, GA_3 (300 ppm) was observed best in inducing early spike emergence, opening of first floret, 50 percent floret opening and maximum spike yield per sq. meter. The spike characteristics, such as length of rachis and spike, number of florets per spike increased significantly with the application of GA_3 (200 ppm). Maximum days to withering of first opened floret and flowering duration were observed with Kinetin (200 ppm). However, Ethrel (300 ppm) exhibited delayed flowering and reduced length of spike and rachis characters.

Jitendra *et al.* (2009) studied the effect of vitalizer (GA_3) and nitrogenous fertilizer (urea) on growth and floral parameters in tuberose cv. Pearl Double. The experiment was conducted at Horticultural Research Farm, Department of Horticulture, C.C.S. University campus, Meerut, consisting of three levels of GA_3 (100 ppm, 200 and 300 ppm) and three levels of urea (55, 85 and 110 g/m^2). There are 9 treatment combinations replicated three times and laid out in factorial randomized block design. The results revealed that combined application of gibberellic acid (300 ppm) and nitrogenous fertilizer (urea) (85 g/m^2) showed the beneficial effect in different growth and flowering attributes viz., days taken for bulb sprouting, plant height, number of leaves/plant, number of floret/spike, rachis length, spike length and floret length but delay in appearance of initial spike and opening of first florets.

Singh *et al.* (2008) conducted an experiment in tuberose (*Polianthes tuberosa* L.) cv. Single by dipping the bulbs in different concentration of GA_3 and NAA (50, 100, 150 and 200) for 6 hours. GA_3 200 ppm was found to be the best for plant height, spike/clump, spike length, floret number/spike, inflorescence length and width, spike weight, for early emergence of spike, increased flowering duration and vase life. Bulb and bulblet production was also higher in the same treatment.

Devadanam *et al.* (2005) conducted an experiment in Parbhani, Maharashtra, India, to study the effect of foliar applied plant growth regulators on the flowering and vase life of tuberose. The treatments comprised: 50, 100 and 200 ppm GA_3; 100, 150 and 200 ppm NAA; 1000, 1500 and 2000 mg thiourea/litre. Foliar application was conducted at 30, 60 and 90 days after planting. GA_3 at 200 ppm gave the earliest number of days required for spike emergence (43.48) and longest vase life (11.35 days). Further, GA_3 @ 200 ppm gave maximum spike length (87.20 cm), spike girth (2.84 cm), rachis length (21.37 cm), floret length (6.56 cm) and floret diameter (3.88 cm).

Padaganur *et al.* (2005) conducted an experiment with plant growth regulators: GA_3, paclobutrazol and maleic hydrazide at three different concentrations (100, 200 and 300 ppm) in tuberose (cv. Single) to evaluate the best concentration that aids in realising higher flower production in tuberose. GA_3 @ 300 ppm increased the plant height, number of leaves, number of spike and rachis and flower yield whereas maleic hydrazide and paclobutrazol @ 300 ppm reduced all these parameters compared to control.

The effect of bulb size (<2, 2-3, and 3 cm, corresponding to small, medium and large bulbs) and pretreatment of bulbs with GA_3 [gibberellic acid] and CCC [chlormequat] on the yield of *Polianthes tuberosa* were studied by Satya and Shukla (2005) in Bakewar, Etawah, Uttar Pradesh, India. The highest number of

flowers per spike and number of bulbs and bulblets per clump were obtained with large bulbs treated with 400 ppm GA_3. Large bulbs treated with 400 ppm CCC gave also the highest weight of flowers per spike.

Sanap *et al.* (2004) conducted a field experiment at Pune, Maharashtra, India to evaluate the effects of GA_3 (100, 200 and 300 ppm) and CCC (100, 200 and 300 ppm) on tuberose cv. Single. Foliar spraying of the growth regulators was performed at 40, 55 and 70 days after planting. Data were recorded for various growth (number of leaves, leaf length and leaf breath) and flowering characters (days to flower spike emergence, days to flowering and days from spike emergence to flower harvest). All growth regulator treatments were significantly superior to the control (water spray), with GA_3 300 ppm and CCC at 200 ppm sprays giving optimum growth and earliest flowering.

Singh *et al.* (2003) conducted an experiment in Meerut, Uttar Pradesh, India on tuberose (*Polianthes tuberosa* L) cv. Double. The treatments comprised of GA_3, IAA and BAP @ 100, 200 and 300 ppm each on flowering and yield of tuberose. The number of flowers, spike length, rachis length and longevity of the whole spike were highest for bulbs dipped in 300 ppm GA_3 for 24 hours before planting. Large bulbs treated with 100-200 ppm BAP gave highest number of bulbs and bulb weight.

Bose *et al*. (2003) conducted an experiment to study the effects of GA_3 in flowering and quality characteristics of gladiolus cv. 'Erovision'. Corms were soaked in solutions of 0 (control), 50 and 100 ppm GA_3 for 1 hour and were planted in field. GA_3 at 100 ppm shortened the time from planting to harvest and increased flowering percentage, spike length, the number of flowers per spike and diameter of flower stems.

Gaur *et al*. (2003) investigated the effects of GA_3 and IAA, both applied at 25, 50, 100 or 200 ppm, on the growth, flowering and corm production of gladiolus cv. Eurovision in Kanpur, Uttar Pradesh, India. High GA_3 @ 200 ppm and low IAA @ 25 ppm concentrations combindly improved plant height, number and size (width and length) of leaves, promoted earliness in spike emergence, colour break in the first floret and flowering, increased the length of spikes, number of florets per spike, size of florets, longevity of spikes and the number, weight and diameter of corms and cormels. The highest values for all parameters were recorded with GA_3 at 200 ppm with 25 ppm IAA.

An experiment was conducted by El-Keltawi *et al.* (2003) for spraying of GA_3 which stimulated both growth and flowering in tuberose. It increased plant height 9.8%, plant fresh weight by 16%, root dry weight 8.6%, floret number/plant by 7.5%, spike and rachis length by 10% of the control.

Tuberose 'Single' plants were sprayed 3 times before spike emergence, first at 40 days after planting and subsequently at fortnightly intervals, with gibberellic acid (GA_3) at 0, 25, 50, 75 or 100 mg/L and (Ethrel) at 0, 500, 1000, 1500 or 2000 mg/L (Mukhopadhyay and Bankar, 2003). The plant height was reduced with increasing concentrations of Ethrel spray. The GA_3 spray, in general, increased spike length and floret numbers per spike. The length of the rachis also increased slightly with GA_3 spray at 75 mg/L. Ethrel spray at higher concentrations reduced spike and rachis length and also floret numbers. Longevity (duration of flowering) of spike in the field improved with 100 mg/L Ethrel. Both GA_3 and Ethrel spray inhibited bulb production at all concentrations.

Prasad *et al*. (2002) conducted an experiment in Uttar Pradesh, India to study the effect of gibberellic acid at (0, 250 and 500 ppm) on the growth and flowering of gladiolus cultivars. GA_3 at 250 ppm increased plant height, leaf number, spike length, rachis length, floret number in Tropic Seas.

Naggar and Sharf (2002) conducted an experiment to identify the effects of gibberellic acid (GA_3 0, 100, 200, and 300 mg/L) on tuberose (*Polianthes tuberosa* L.) cv. Double in Alexandria, Egypt. The bulbs were soaked in GA_3 for 24 hours before planting. The application of 300 mg GA_3/litre resulted early flowering, highest plant height, longest spike and rachis length maximum number of bulb, bulblet and floret. Bulb treated with GA_3 at 300 ppm also exhibited the longest flowering duration.

Manisha *et al.* (2002) studied tuberose (*Polianthes tuberosa* L.) cv. Single in Varanasi, Uttar Pradesh, India. Treatments comprised of a control and foliar sprays of gibberellic acid (GA_3) at 100, 150 and 200 ppm at 40, 60 and 80 days after planting. Treatment with GA_3 at all concentrations promoted the height of all plants and increased the number of leaves per plant with 150 ppm application. Approximately 5 days early appearance of floral bud over control was also observed with this treatment. Application of GA_3 @ 150 ppm significantly increased the spike and rachis length. Among the 3 concentrations of GA_3 used, 150 ppm was found the most superior in case of bulb and bulblet production.

Chaitra (2005) conducted an experiment of identify the effects of gibberellic acid (GA_3) at 0, 100, 200 and 300 mg/litre) on tuberose (*P. tuberosa* cv. Double). The bulbs were soaked in GA_3 for 24 hours before planting. The application of 200 - 300 mg GA_3/litre resulted in the earliest flowering, greatest plant height, production of maximum leave, spike, florets, bulb and bulblet per clump.

Tiwari and Singh (2002) observed an experiment to identify the effects of bulb size, i.e. large (>1.5 cm diameter), medium (1.0-1.5 cm), and small (<1.00cm) and preplanting soaking in gibberellic acid (GA_3) at 50, 100 150, 200 and 250 ppm on the growth flowering, and yield of tuberose in India. Plants raised from large bulbs (>1.5 cm) with 200 ppm GA_3 had the greatest plant height, number of

leaves/clump, rachis length, spike length, floret/spike, spikes/plant and showed the earliest flowering. Large bulbs soaked in 200 ppm GA_3 also showed significant increase in flowering duration of tuberose.

Wankhede *et al.* (2002) conducted an experiment to study the effect of gibberellic acid with bulb soaking treatment and foliar spray on growth, flowering and yield of tuberose (*Polianthes tuberosa* L.). They reported that GA_3 @ 150 ppm for bulb soaking treatment and 200 ppm of GA_3 as a foliar spray showed significant increase in plant height, number of leaves, number of florets/spike and number of spikes/plant under study. Early sprouting, early emergence to flower stalk and early opening of the first pair of florets were also recorded by foliar spray at 200 ppm GA_3.

In a greenhouse experiment Yang *et al.* (2002) conducted on experiment on *P. tuberosa* and soaked bulbs with GA_3 (40 and 80 ml/litre) at 4^0C for 30 days or at 30^0C for 15 days before planting. The bulb treated with low temperature had high spouting rates. The low temperature 4^oC combined with gibberellic acid @ 80 ml/litre increased the flowering rate. The highest flowering rate was over 95% with an average of 62%.

An experiment was conducted by Kirad *et al*. (2001) at Madhya Pradesh, India to determine the effect of plant growth regulators (GA_3 at 50, 100 and 150 ppm; NAA at 25, 50 and 100 ppm; and cycocel at 2000, 4000 and 6000 ppm) on gladiolus cv. White Prosperity. Plant growth regulators were applied by dipping for 12 h or spraying 40 days after planting. The earliest sprouting was obtained with GA_3 at 100 ppm. GA_3 at 100 ppm (dipping + spraying) resulted in the highest leaf plant, spike and rachis number and maximum flowering duration.

Dutta *et al*. (2001) conducted an experiment at Pune, Maharashtra, India to determine the effects of gibberellic acid (GA_3) treatment on the corm germination of 10 gladiolus hybrids. Corms of each hybrid were dehusked and cleaned prior to soaking in GA_3 solution at 100, 150 and 200 ppm and water for 24 h. GA_3 @ 200 ppm significantly increased the percentage of corm germination and reduced the number of days required for germination compared with other and control treatments. Corm germination values of 62.8 and 64.4% 66.5 were obtained with GA_3 at 100, 150 and 200 ppm, respectively.

In a trail by Sanap *et al.* (2000) at Pune, tuberose plants were sprayed with 100, 200 or 300 ppm GA_3 or CCC 40, 55 and 70 days after planting spike length, rachis length and flower yield was highest when 200 ppm GA_3 was used.

Chaphale *et al*. (2000) conducted a field experiment at Nagpur, India in which tuberose was planted on 25 July, 25 August and 25 September and given 0, 50, 100 or 150 ppm GA_3. Highest spike and rachis length, early opening of the first pair of florets, flower yield and maximum flowering duration of tuberose cv. Single was obtained by 25 July planting and 150 ppm GA_3.

Khattab *et al*. (2000) presoaked the corms of gladiolus before planting in GA_3 50 or 100 ppm for 24h in Alexandria, Egypt. GA_3 influenced the maximum flowering, yield quality of gladiolus.

In a field trial at Kanpur, Uttar Pradesh, India, Prakash *et al*. (1999) investigated the effect of GA_3 on the floral parameters of gladiolus. Gladiolus cultivars were treated with 0, 100 and 150 ppm GA_3 and investigated effects on flower parameters viz. time of flowering, inflorescence length, spike length, rachis length and number of florets per spike, flowering duration etc. GA_3 treatment at 150 ppm followed by 100 ppm improved all the floral traits in gladiolus.

Bulb of *Polianthes tuberosa* L. cv. Single were treated with GA_3 (100 or 200 ppm), Cycocel [chlormequat] (2000 or 4000 ppm) and Ethrel (ethephon) (1000 or 2000 ppm) for growth and flowering of tuberose (Devendra *et al.,* 1999). GA_3 at 200 ppm enhanced bulb sprouting, decreasing the number of days required for sprouting (20.83) in the control to 12.03. Foliar application of 200 ppm GA_3 also significantly increased plant height, spike length, flower diameter, floret number per spike, vase life and flower yield compared to the other treatments and the control.

Dalal *et al.* (1999) conducted a field experiment to study the influence of N application rate (0, 50, 60 or 70 kg/ha) and gibberellic acid (GA_3) concentration (0, 10, 20 or 40 ppm) on flower quality of *P. tuberosa.* The optimum N application rate was70 kg/ha; rachis length, flower stalk length, flower weight and vase life were 30.68 cm, 88.78 cm, 89.14 g/plant and 12.74 days, respectively. The optimum concentration of GA_3 was 40 ppm; rachis length, flower stalk length, flower weight and vase life were 30.93 cm, 91.06 cm, 106.14 gm/plant and 12.94 days, respectively. The interaction between N and GA_3 was significant only in respect of weight of flowers per plant.

Singh (1999) noted the effects of gibberellic acid (GA_3 at 100 and 200 ppm), ethephon (200 and 400 ppm) and kinetin (50 and 100 ppm) on the growth, flowering and yield of tuberose (*Polianthes tuberosa*) cv. Double in Medziphema, Nagaland, India. The plant growth regulators were applied as foliar sprays 40 days after planting. The second application was conducted 3 weeks after the initial spraying. All growth regulators improved the performance of tuberose compared with the control. GA_3 at 200 ppm produced the tallest plants with the highest number of leaves per plant, maximum spike length, highest number of florets and floret weight per plant. This treatment likewise resulted in the longest flowering duration also. The number of bulbs per plant and bulb weight per plant were

highest in plants treated with 100 ppm kinetin. Plants treated with ethephon (400 ppm) exhibited the earliest flowering.

Manoj and Singh (2000) conducted an experiment in India on tuberose (*Polianthes tuberosa*) cv. Double. The treatments comprised of GA_3, BAP and NAA at 100, 200 and 300 ppm each spraying and dipping for growth, flowering and yield of tuberose. The number of flowers, flower length and longevity of the whole spike were highest for bulbs dipped in 300 ppm GA_3 for 24 hour before planting. Spike length and rachis length were also highest in bulbs dipped with 300 ppm GA_3. BAP at 200 ppm (dipping + spraying) increased the number, weight, diameter and bulb yield of tuberose.

Nagaraja *et al.* (1999) conducted an experiment to investigate the effect of growth regulators on the growth and flowering and yield of tuberose. The tuberose bulbs were soaked for 24 hour in solutions of GA_3, Ethrel (ethephon) or BA each at 100, 200, 300 and 500 ppm and then planted in a randomized block design. All treatments influenced growth, flowering and bulb characteristics. A higher percentage of sprouting and earlier flowering was observed compared to the control with GA_3 at 300 and 500 ppm being particularly effective. Plant height was greatest with GA_3 at 100 ppm while ethrel at all concentrations reduced plant height compared to the control. The number of spikes/plant and flowering duration were enhanced by GA_3 at 300 ppm. Length of flowering was greatest with ethrel at 500 ppm. BA and GA_3 at 100 -200 ppm increased bulb number, bulblet number and bulb weight.

Pal and Chowdhury (1998) observed significant effect on sprouting, growth, flowering and corm yield when corms of gladiolus cv. Tropic Sea were dipped in water or an aqueous solution of GA_3 (100, 200 or 400 ppm) or ethrel (200, 500 or 1000 ppm) for 12 or 24 hours. Corm soaking for 24 hours in 200 ppm GA_3 gave the longest spike length (94.0 cm), while 12 hours in 400 ppm GA_3 resulted in the

longest spike field life (16.0 days). Individual corm weight and volume were the greatest with 100 ppm GA_3 for 12 hours. Number of corms produced per plant was the greatest (2.1) in the treatment of corms with 400 ppm GA_3 for 24 hours.

Rama *et al.* (1998) conducted an experiment in India on tuberose (*Polianthes tuberosa* L) cv. Double. The treatments comprised of GA_3 and BAP @ 100, 200 and 300 ppm each. The number of flowers and flower yield were highest for plants sprayed in 200 ppm GA_3 at 30 days after planting. Spike length and rachis were also highest in bulbs sprayed with 200 ppm GA_3. However, BAP at 100 ppm increased the longevity of the whole spike and number, weight and diameter of tuberose bulb.

Reddy and Singh (1997) carried out an experiment on tuberose with GA_3, BA and CCC @ 200 and 300 ppm each for maximizing flowering and yield. Tuberose plants treated with GA_3 (gibberellic acid) at 300 ppm were found early to flower. Plants treated with growth retardants CCC @ 300 ppm were late to complete their first flowering. Application of GA_3, BA @ 200 ppm increased spike length and flower yield while CCC @ 200 ppm reduced spike length and yield. BA @ 200 ppm exhibited the longest flowering duration.

When gladiolus cultivar cv. White Oak corms were treated with GA_3 @ 200 ppm for 24h before plantings at Katrain, India, Sindhu and Verma (1996) observed that the number of days taken for sprouting was decreased, while plant height, spike length, floret number, flower yield, corm size and diameter increased.

Preeti *et al.* (1997) observed a field experiment at Biswanath college of Agriculture, Sonitpur, Assam, India, to study the effects of pre-planting treatment of bulbs of *P. tuberosa* L. (cv. Single) with GA_3 (50, 100 or 200 ppm) and Ethrel [ethephon] (100, 200 or 400 ppm) on growth and yield of tuberose. Ethrel @ 200 ppm prompted the early appearance of flower spikes and promoted the number of

flower spikes, but reduced the number of bulbs production/plant. Treatment with GA_3 at 200 ppm produced the highest number of floret/spike, maximizing flower yield and vase life.

Deotale *et al.* (1995) observed that chrysanthemum (cv. Raja) was sprayed with GA_3 @ 100-200 ppm 30 and 60 days after planting. Spraying with 100 ppm GA_3 produced the heaviest (2.15g) and largest (6.42 cm diameter) flowers with prolong vase life (15 days).

Belorkar *et al.* (1993) studied a field experiment of tuberose in India to study the effect of soaking the bulbs for 24 h in gibberellic acid (0, 10, 20 or 40 ppm) followed by N fertilizer treatment (0, 50, 60 or 70 kg/ha) in the field. Gibberellic acid soak at 40 ppm with 70 kg N/ha was the best combination yielding highest rachis, spike, vase life as well as flower yield.

In an investigation, Mahesh and Misra (1993) studied the effect of gibberellic acid (200, 500 and 1000 ppm) on gladiolus cv. Snow Princess. Significant changes in growth and flowering were obtained for many parameters. GA_3 at 200 ppm increased the plant height from 87.39 to 91.94 cm and number of florets/spike from 10.19 to 10.67.

While working on implication of gibberellic acid on gladiolus corm cv. Sylvia at Kanpur, India, Misra *et al.* (1993) stated that GA_3 application at 0, 50, 100, 200 or 400 ppm enhanced vegetative growth, flowering and number of corm and cormels produced, but adversly affected individual corm weight. GA_3 at 200 ppm reduced the time of 1^{st} and plant emergence % of flowering. It was concluded that, apart from corm size, GA_3 at 100 and 200 ppm gave encouraging results in respect of spike length, rachis length, floret number, spike yield etc.

Leena *et al.* (1992) carried out an experiment in Kerala, India on Gladiolus (cv. Friendship) with BAP (100 and 200 ppm), NAA (100 and 200 ppm), CCC (Cholormequat 250 or 500 ppm) or GA_3 (50 or 100 ppm) applied a foliar spray at 4,

6 and 8 weeks after planting. Control plants were sprayed with normal water. The 100 ppm GA_3 treatment resulted with the greatest plant growth and earliest flowering. The highest spike length, rachis length and number of floret/spike were obtained with the 50 ppm GA_3 treatment. The greatest corm weight (70.20 gm) and size (71.00 cm^2) were obtained with the 100 ppm NAA treatment. The greatest number and weight of cormels (43.33 and 17.57 g, respectively) were obtained with 200 ppm BAP and 500 ppm CCC treatment.

Arora *et al*. (1992) carried out an experiment to investigate the effect of GA_3 (5, 10, 25, 50, 75 or 100 mg/l) on growth and subsequent production of corm and cormel in 3 gladiolus cultivars (Aldebaran, Pusa Suhagin and Mayur). After treatment, corms were planted and observations were made on the number of days to sprouting, floral diameter and weight of corms and number, diameter and weight of cormels produced from corm. GA_3 at 100 mg/l accelerated sprouting of corms by 4.2, 4.6 and 4.8 days in cvs. Aldebaran, Pusa Suhagin and Mayur, respectively. Corm weight and diameter were increased by in Mayur when treated with GA_3 at 100 mg/l. Production of cormel was not significantly increased by GA_3 application although there was an increased in their diameter and weight.

Suh and Kwack (1990) while working with corm treated with GA_3 (200 ppm) observed the process of big corm formation in gladiolus. Corms were treated with growth regulator viz. 200 ppm GA_3 for 6 hour before planting, increased the number and weight of corms in gladiolus. They also noticed that with the use of corm treated with GA_3 @ 200 ppm produced maximum number of good quality longest spike.

In an experiment, Nilimesh and Roychowdhury (1989) studied the effect of growth regulating chemicals in growth and flower yield of gladiolus where corms (2.5-2.7 cm diameter) were soaked for 6 hours in GA_3 (50 or 100 ppm). GA_3 treatment irrespective of concentration increased plant height, flower stalk length and yield

of corms per unit area and decreased the days required to 50% spike initiation and percentage of lodging plant.

Dhua *et al*. (1987) reported that tuberose (*Polianthes tuberosa*) is an important cut flower crop. Using bulbs with a diameter between 1.5-2.0 cm and bulbs were kept at 4-10^{0}C for 10-30 days and soaking in GA_3 (100-200 mg/L) or thiourea (100-2000 mg/L) solution for 6 hours improved plant growth and increased the yield of spikes and flower quality.

Mukhopadhyay and Bankar (1986) conducted an experiment to investigate the influence of pre-planting soaking of corm with gibberellic acid that modified growth and flowering of gladiolus cultivar 'Friendship'. Corms were soaked in solutions of 0, 10, 50, 100, 250 and 500 ppm GA_3 for 24 hours. Treatment with 250 ppm GA_3 increased the length of spike and rachis. It also increased the number of floret and flower yield GA_3 @ 100 ppm increased number and size of corm and cormel.

Effect of different chemicals (Thiourea at 1000 and 2000 ppm, ethrel at 100 and 200 ppm, gibberellic acid at 50 and 100 ppm or KNO_3 at 2000 ppm) in germination, growth, flowering and corm yield of gladiolus cv. Psittacnus hybrid were studied by Roychoudhuri *et al*. (1985) at Kalyani, India. Corms were soaked in solutions of several chemicals and were planted out. GA_3 @ 50 ppm increased the spike and rachis length and GA_3 @ 100 ppm was effective in increasing the leaf number, floret number and yield.

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

Chemical treatment of corms with GA_3 was found to be an effective technique to enhance growth, flowering, corm and cormel formation of gladiolus cv. Friendship at Bangalore, India as reported by Bhattacharjee (1984). GA_3 at 50 and 100 ppm increased the vegetative growth, improved corm size and weight, induced more cormel production, stimulated spike and rachis length, accelerated floret size and number of flower per spike and lengthened the life of the spike. In a study, Dua *et al*. (1984) observed improved flower quality and better corm multiplication when the corms of gladiolus cv. Sylvia were soaked with 100 ppm GA_3 before planting.

Yadav *et al.* (1984) studied the effect of large bulb sizes (3.1-3.5 cm in diameter) with GA_3 300 ppm produced maximum growth and flower production of tuberose (*Polianthes tuberosa* cv. Single). Patil *et al.* (1984) noted that large bulb size with GA_3 200 ppm influenced early flowering and gives higher yield of spikes and bulb.

According to Biswas *et al.* (1983), the highest number of floret/spike and longest spike and rachis were obtained after foliar application of GA_3 at 100 ppm in tuberose. Flower yield and vase life also increased with GA_3 @ 100 ppm.

Mukhopadhyay and Banker (1983) sprayed the plants cv. Single with GA_3 at 25-100 ppm or Ethephon at 500 to 2000 ppm. They observed that increasing concentration of Ethephon @ 2000 ppm reduced the plant height. GA_3 100 ppm increased the spike length and floret number/spike. Duration of flowering in the field was also improved with GA_3 at 100 ppm.

EL-Meligy (1982) claimed significant effect of GA_3 on flower and corm formation while conducting a field trial with the gladiolus cultivar ‘Eurovision’. Corms were soaked in solutions of GA_3 at 0-500 ppm. The controls were soaked in water. Soaking in GA_3 at 500 ppm gave a cormel yield of more than 1-5 times higher than control. Flower colour was also deeper in the treated plants due to higher anthocyanin content.

Jana and Biswas (1982) reported that the shortest time of flower opening occurred in tuberose plants treated with 100 ppm GA_3 and the greatest number of flowering spike was on plants treated with 1000 ppm SADH.

Pathak *et al.* (1980) found that soaking of bulb in GA_3, ethrel, kinetin and thiourea solutions before planting improved the growth and flowering of tuberose. Among the different chemicals used, GA_3 and thiourea proved more effective than others. Thiourea promoted plant height and leaf number while GA_3 improved flowering. Treatments with GA_3 at 200 ppm caused earliest flowering and gave the maximum yield of spikes and bulb.

According to Ramaswamy *et al.* (1979) application of certain growth substance has been found to influence the growth and flowering of tuberose. Soaking of sprouting bulbs for 1 hour in solution of 200 ppm GA_3 or 400 ppm CCC increased spike length and earliest flowering. Flower yield and vase life also increased with GA_3 @ 200 ppm.

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

Rees (1975) noted that growth and development behaviour of bulbous plant is also regulated either by a single or by an interaction of several endogenous hormones like gibberellins, auxin, cytokinin, ethylene and abscisic acid. They play a major role in directing the movement of organic metabolites in establishing and growth of plants.

CHAPTER III

MATERIALS AND METHODS

An experiment was conducted to study the Influence of growth regulators on growth, flowering and bulb production of tuberose during March 2014 to February 2015 at the Floriculture Research Field, Horticulture Research Centre of Bangladesh Agricultural Research Institute (BARI), Gazipur. The details of the experiment and techniques adopted during the course of investigation are presented in this chapter.

3.1 Experimental site

The location of the site was about 35 km North of Dhaka city with $24^0 09'$ N latitude and $90^0 26'$ E longitude and elevation of 8.40 m from the sea level.

3.2 Agro-ecological Zone

The experimental field belongs the Agro-ecological zone of AEZ-28 under Modhupur Tract.

3.3 Soil

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

3.4 Climate

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

3.5 Experimental material

Medium size (2.0-2.5 cm diameter) bulb of BARI Tuberose-1 was selected as experimental materials. The single ever blooming Mexican Tuberose is one of the most fragrant of cultivated plants. This wonderful cut flower bears clusters of waxy, white tube-shaped flowers from early to late summer. The flowers are beautiful but it is their sweet, rich fragrance that steals the show.

Plate 1. Medium size bulbs in BARI Tuberose-1

3.6 Treatment of the experiment

The experiment was designed to study the effect of growth regulators on flowering, yield and vase life of tuberose. The experiment consisted of ten treatments, which are as follows:

T_1 : Control (Without growth regulators)
T_2 : GA_3 100 ppm
T_3 : GA_3 200 ppm
T_4 : GA_3 300 ppm
T_5 : BAP 100 ppm
T_6: BAP 200 ppm
T_7 : BAP 300 ppm
T_8 : CCC 250 ppm
T_9 : CCC 500 ppm
T_{10} : CCC 1000 ppm

3.7 Preparation of plant growth regulator (BAP, GA_3 & CCC) stock solutions

Stock solution of BAP, GA_3 and CCC was prepared by dissolving 1000 mg of each growth regulators in 1000 ml of water to get 1000 ppm. BAP was first

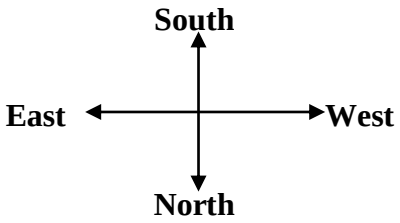
dissolved by few drops of HCl and CCC and GA_3 were dissolved by few drops of ethyl alcohol and the volume was made up to 1000 ml with distilled water and stored in Erlenmeyer flask. Required concentrations for the experiment were prepared following the dilution factor $V_1S_1 = V_2S_2$ where, V_1= Volume of the stock solution, S_1= Strength of the stock solution, V_2= Volume of the resultant solution and S_2 = Strength of the resultant solution. A control solution also prepared only by adding with normal water.

3.8 Design and Layout

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

R_1	R_2	R_3
T_2	T_4	T_{10}
T_1	T_3	T_9
T_{10}	T_2	T_8
T_9	T_1	T_7
T_8	T_{10}	T_6
T_7	T_9	T_5
T_6	T_8	T_4
T_5	T_7	T_3
T_4	T_6	T_2
T_3	T_5	T_1

Figure 1. Layout of the experiment



Plot size = 1.8 m × 1.5 m
Plot to plot distance = 60 cm
Block to block distance = 80 cm
Plant spacing = 30 cm × 20 cm
T_1: Control (Without growth regulators)
T_2 : $GA_3$100 ppm
T_3 : GA_3 200 ppm
T_4 : GA_3 300 ppm
T_5 : BAP 100 ppm
T_6: BAP 200 ppm
T_7 : BAP 300 ppm
T_8 : CCC 250 ppm
T_9 : CCC 500 ppm and
T_{10} : CCC 1000 ppm

3.9 Land preparation

The experimental plot was first opened on last week of February 2014 with a power tiller for sun curing for 7 days before next ploughing. The land was then

ploughed and cross ploughed several times using power tiller to obtain a good tilth. Ploughing was followed by laddering for breaking large soil clods and for leveling the land surface. The weeds and stubbles were removed from the land just after laddering with special care to remove the rhizomes of mutha grass.

3.10 Application of manure and recommended fertilizer doses

The entire amount of cowdung, P, K, S, B and Zn were applied during final plot preparation. N was applied in three installments at 45, 65 and 65 days after planting of bulbs.

Recommended Manure and fertilizer doses

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

Source: Halder *et al*. (2007)

3.11 Planting of bulbs

Bulbs were thoroughly treated with fungicide Provex for 5 minutes and planted at a depth of 7 cm in furrows on March, 2014. Spacing was maintained at 30 cm from row to row and 20 cm from plant to plant.

3.12 Intercultural operation

3.12.1 Weeding

Weeding was done periodically whenever necessary.

3.12.2 Treatment of bulb with NAA, GA_3 and CCC hormones

Medium size bulbs were soaked for 24 hours in growth regulator solutions and also in water as per the treatment schedule. The soaked bulb were dried in shade for 3-4 hours and then planted.

3.12.3 Irrigation

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

3.12.4 Mulching

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

3.12.5 Earthing up

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

3.12.6 Selection and tagging of plants

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

3.12.7 Harvesting

The spikes of tuberose were harvested from May to July, 2014 at the tight bud stage and when three basal flower buds showed color so that these may easily open indoors one by one (Misra *et al*., 1993). Bulbs and bulblets were harvested on February, 2015 when the leaves also started yellowing (Bose *et al*., 2003).

3.13 Plant protection measure

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

3.14 Data collection

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

3.14.1 Plant height

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

3.14.2 Leaves/plant

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

3.14.3 Plant/hill

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

3.14.4 Plant spread

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

3.14.5 Days required to 80% visible spike

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

3.14.6 Spike length

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

3.14.7 Rachis length

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

3.14.8 Floret number

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

3.14.9 Spike weight

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

3.14.10 Vase life

For good vase life, cut flowers placed in fresh water immediately after harvest. The flower spikes were harvested at late afternoon with sharp and then carried out to the Horticulture Research Centre Laboratory, BARI, Joydebpur, Gazipur and placed in the glass bottles partially filled with 100 ml fresh water to study the vase life of tuberose and expressed in days.

3.14.11 Flower yield

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

3.14.12 Bulb number

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

3.14.13 Bulblet number

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

3.14.14 Bulb diameter

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

3.14.15 Bulblet weight

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

3.14.16 Bulb yield

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

3.14.17 Bulblet yield

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

3.15 Statistical Analysis

The recorded data on different parameters were statistically analyzed using 'MSTAT-C' software to find out the significance of variation resulting from the experimental treatments. The mean for the treatments was calculated and analysis of variance for each of the characters was performed by F (variance ratio) test. The differences between the treatment means were evaluated by Duncan's Multiple Range Test (DMRT) according to Steel *et al*. (1997) at 5% level of probability. The analysis of variance (ANOVA) of data on different characters of tuberose is given in Appendix III-V.

CHAPTER IV

RESULTS AND DISCUSSION

Results of this experiment and their discussion have been presented in this chapter in accordance with the parameters studied. Analyses of variances (ANOVA) for different characters have been shown in Appendix III-VI. The effect of plant growth regulators (BAP, GA_3 and CCC) on the growth, yield and quality of tuberose have been shown in Tables, Figures and Plates. The results of the study have been presented and discussed under the following headings.

4.1 Plant height

Plant height of tuberose differed significantly due to the application of different concentration of growth regulators at days after planting of 30, 60, 90 and 110 (Appendix III).

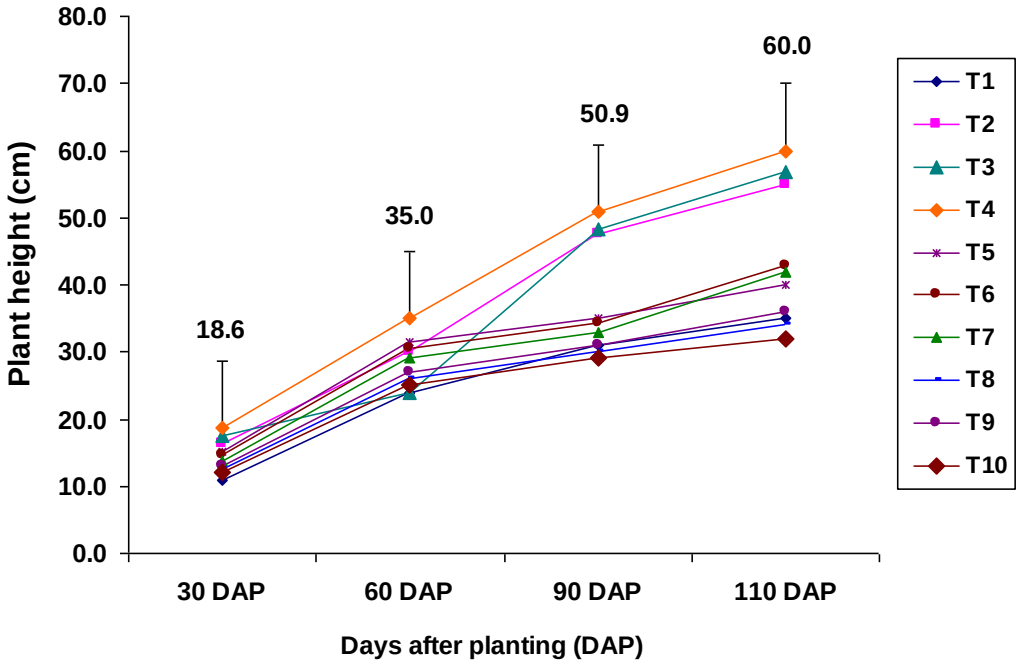


Figure 2. Effect of growth regulator on plant height of tuberose at different days after planting

T_1 : Control (Without growth regulators), T_2 : GA_3 100 ppm, T_3 : GA_3 200 ppm, T_4 : GA_3 300 ppm, T_5 : BAP 100 ppm, T_6: BAP 200 ppm, T_7 : BAP 300 ppm, T_8 : CCC 250 ppm, T_9 : CCC 500 ppm and T_{10} : CCC 1000 ppm

At 30, 60, 90 and 110 DAP, the tallest plant (18.6, 35.0, 50.9 and 60.0 cm) was found from T_4 (GA_3 300 ppm) followed by T_3 (GA_3 200 ppm) and T_2 (GA_3 100 ppm). Whereas, the shortest plant (11.0, 24.0, 30.9 and 35.0 cm) was observed from T_1 for the same DAP, respectively (Figure 2). Application of GA_3 might have resulted in cell division and cell elongation resulting in enhanced plant height. The observed results are in agreement with Chopde *et al*.(2015) and Singh and Shanker (2010) in tuberose.

4.2 Sprouting of bulb

The variation among the growth regulator treatments in respect of days to sprouting of bulb per plant was found significant (Table 1). The bulbs under T_4 (GA_3 300 ppm) took minimum time (20 days) followed by T_3 (GA_3 200 ppm) (22days) to sprouting, while the bulbs of T_1 (control) required maximum time (26 days). This is in line with the findings of earliness in bulb sprouting when GA_3 spraying GA_3 @ 200-300 ppm by Reddy *et al*., (2000) in tuberose flowers.

4.3 Leaves/clump

Different levels of growth regulators showed a statistically significant variation for number of leaves/clump at harvest under the present trial (Appendix III). With the increases level of GA_3 100 ppm to 300 ppm number of leaves/clump represents an increasing trend (Table 1). The maximum (62.5) number of leaves/clump at harvest was recorded from T_4 (GA_3 300 ppm). On the other hand the minimum number (42.0) of leaves/clump was recorded in control condition (T_1). The observation is similar to the findings of Nilima *et al*. (2014) in tuberose. These variations in number of leaves per clump might be due to the fact that GA_3 improves the physiological efficiency of the plant such as improvement of rate of photosynthesis, control of transpiration and photorespiration, efficient water and nutrient uptake, control of leaf senescence thus inducing resistant to environmental stress and ultimately increasing the harvest index.

4.4 Number of plant per hill

The number of plant per hill was influenced by the application of different growth regulators and the effect was statistically significant. BAP at 100 ppm produced the highest number of plants per hill (10.0) followed by 200 ppm (9.0 plant) while control treatment produced (4.0 plant) lowest number of plant. Application of BAP causing cell division resulting in enhanced plant per hill (Bhattacharjee, 2010; Asil *et al.,* 2011)

Table 1 : Effect of growth regulators on vegetative growth of BARI Tuberose -1

Treatments	Sprouting of bulb (days)	Leaves/clump	Plant/hill	Plant spread (cm)
T_1	26.0 a	42.0 e	4.0 c	13.5 c
T_2	23.0ab	57.0 b	7.0 b	20.0 ab
T_3	22.0 ab	60.0 ab	8.0 ab	20.5ab
T_4	20.0 b	62.5 a	8.5ab	22.0 a
T_5	23.0 ab	55.0 bc	10.0 a	19.0 ab
T_6	24.0 ab	54.2 bc	9.0ab	18.6 ab
T_7	24.0ab	52.0 c	7.5 ab	17.5 b
T_8	24.0ab	47.5 d	7.0 b	15.7 bc
T_9	24.0ab	50.0 cd	6.0 bc	16.0 bc
T_{10}	24.0ab	44.0 de	5.5 bc	15.0 bc
LSD (0.05)	**2.1**	**1.6**	**1.8**	**2.0**
CV (%)	**8.7**	**9.9**	**10.5**	**11.6**

T_1 : Control (Without growth regulators), T_2 : GA_3 100 ppm, T_3 : GA_3 200 ppm, T_4 : GA_3 300 ppm, T_5 : BAP 100 ppm, T_6: BAP 200 ppm, T_7 : BAP 300 ppm, T_8 : CCC 250 ppm, T_9 : CCC 500 ppm and T_{10} : CCC 1000 ppm

4.5 Plant spread

The plant spread of tuberose plant is an important morphological character that influences the yield, because it is correlated with photosynthesis by the higher leaf area. There were significant differences among the treatment in respect of plant

spread (Table 1). Maximum plant spread (22.0cm) was recorded in T_4 (GA_3 300 ppm) which was statistically different from other treatments. The minimum plant spread (13.5cm) was observed in control. Emami *et al.* (2011) and Taha (2012) have also reported similar results. The plant spread was found maximum with T_4 treatment might be due to getting efficient water and nutrient uptake resulting higher vegetative growth compared to other treatments.

Table 2 : Effect of growth regulators on floral parameters in BARI Tuberose -1

Treatments	Days to 80% spike initiation	Spike length (cm)	Rachis length (cm)	Floret number	Spike weight (g)	No. of open florets	Flower durability (days)
T_1	83.5ab	70.0 d	25.0 c	33.0 d	54.0 d	23.0 b	14.0 c
T_2	80.0 b	82.5 ab	32.0 ab	43.8 ab	65.0 ab	25.4 ab	16.0 bc
T_3	77.0 bc	83.0ab	33.2 ab	45.0 ab	67.0 ab	26.0 ab	17.0 bc
T_4	75.0 c	85.0 a	35.0 a	47.0 a	69.0 a	28.0 a	18.0 b
T_5	78.0 bc	75.5 cd	29.0 bc	42.0 b	68.8 a	25.0 ab	23.0 a
T_6	79.0 ab	73.0 cd	28.0 bc	40.0 bc	66.5 ab	24.6 ab	20.0b
T_7	82.0 ab	72.0 cd	27.0 bc	39.0 bc	64.0 b	24.0 ab	17.0 b c
T_8	84.0 ab	73.4 cd	28.0 bc	38.0 c	61.40 bc	23.8 ab	16.0 bc
T_9	84.6ab	75.0 c	27.0 bc	37.0 cd	62.0 bc	23.6 ba	18.0 b
T_{10}	86.0 a	72.0 cd	26.0 bc	36.0 cd	60.0 c	23.4 ab	17.0 bc
LSD (0.05)	**1.3**	**1.5**	**1.8**	**2.1**	**2.3**	**1.2**	**2.0**
CV (%)	**10.2**	**9.5**	**9.8**	**10.7**	**11.0**	**12.5**	**8.6**

T_1 : Control (Without growth regulators), T_2 : GA_3 100 ppm, T_3 : GA_3 200 ppm, T_4 : GA_3 300 ppm, T_5 : BAP 100 ppm, T_6: BAP 200 ppm, T_7 : BAP 300 ppm, T_8 : CCC 250 ppm, T_9 : CCC 500 ppm and T_{10} : CCC 1000 ppm

4.6 Days to 80% spike initiation

Various growth regulators significantly influenced the time required to complete 80% spike initiation of the plant. Early spike initiation (75 days) was observed in T_4 (GA_3 @ 300 ppm) followed by T_3 (GA_3 @ 200 ppm) (77 days).On the other hand plants sprayed with CCC 250-1000ppm took longer time than control. It is

evident that spike initiation enhanced with GA_3treatments. Reddy *et al.* (1997) observed the similar result in tuberose as GA_3 at 200-300 ppm induced earliest flowering in cv. Single tuberose. Enhancement of flowering with the application of GA_3 has also been reported by Misra *et al.* (1993) in gladiolus and Kumar *et al.* (2011) in marigold also.

4.7 Spike length

Growth regulators had significant effects on the length of spike in tuberose. The highest spike length (85.0 cm) was obtained from the plants sprayed with 300 ppm GA_3 followed by 200 ppm GA_3 (83.0 cm) whereas the length was minimum (70.0 cm) in the treatment T_1 (control) (Plate 2). The results are more or less similar to the findings of Sarkar *et al.* (2009) who reported that the spike length of tuberose was increased when plants sprayed with 300 ppm GA_3.

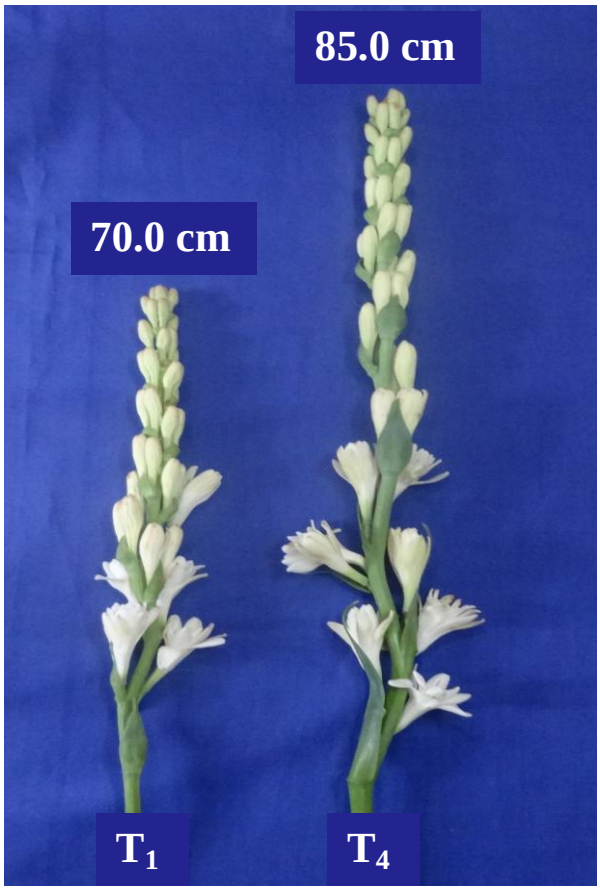


Plate 2. Effect of growth regulators on spike length of tuberose

T_1 : Control (Without growth regulators), T_2 : GA_3 100 ppm, T_3 : GA_3 200 ppm, T_4 : GA_3 300 ppm, T_5 : BAP 100 ppm, T_6: BAP 200 ppm, T_7 : BAP 300 ppm, T_8 : CCC 250 ppm, T_9 : CCC 500 ppm and T_{10} : CCC 1000 ppm

4.8 Rachis length

The results of the present experiment revealed that variation in rachis length due to the effect of growth regulator was statistically significant. The highest rachis length (35.0 cm) was produced from the plants sprayed with 300 ppm GA_3 followed by 200 ppm GA_3 (33.2 cm) as shown in Table2. Bharti and Ranjon(2009) reported that GA_3 stimulated the assimilate movement towards the inflorescence at the expense of bulbs which resulted in the better quality spike. Bhattacharjee (1984) also reported that rachis length increased when the plant were sprayed with GA_3. The lowest performance (25.0 cm) was found in control (without growth regulator) (Plate 3).

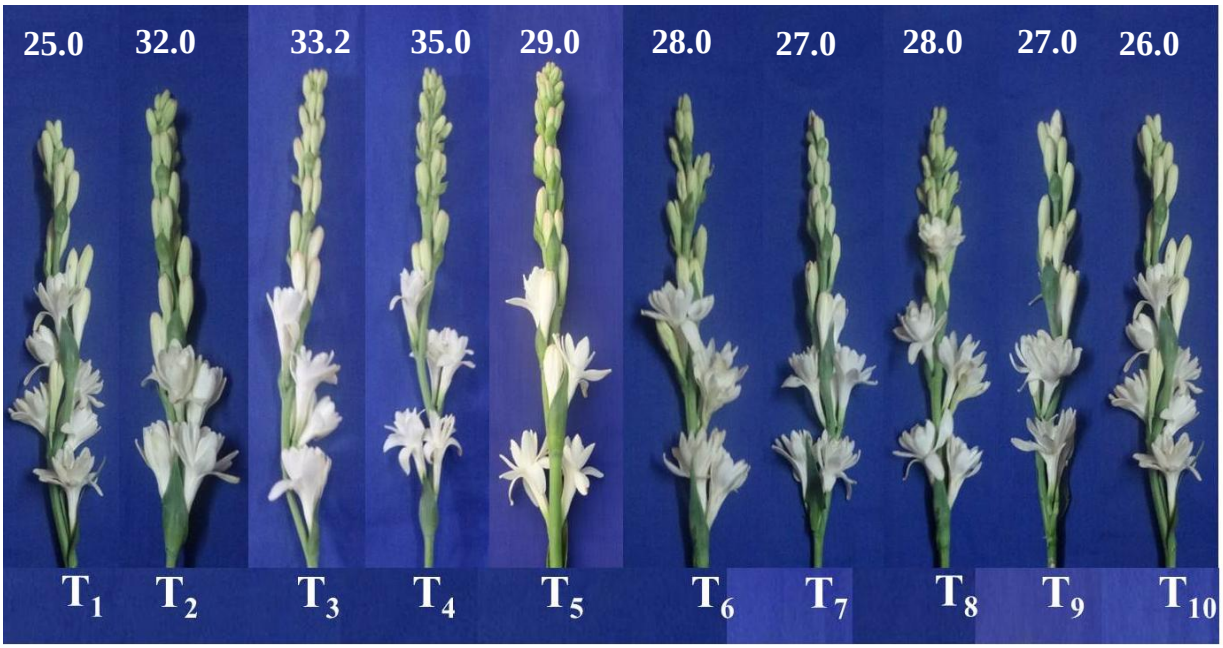


Plate 3. Effect of growth regulators on rachis length of tuberose

T_1 : Control (Without growth regulators), T_2 : GA_3 100 ppm, T_3 : GA_3 200 ppm, T_4 : GA_3 300 ppm, T_5 : BAP 100 ppm, T_6: BAP 200 ppm, T_7 : BAP 300 ppm, T_8 : CCC 250 ppm, T_9 : CCC 500 ppm and T_{10} : CCC 1000 ppm

4.9 Number of florets per spike

The floret number is in important parameter of tuberose. The different growth regulator treatments had significant effect on the number of florets per spike. The maximum number of florets per spike (47.0) was obtained from plant sprayed with 300 ppm GA_3. The minimum number of florets per spike (33.0) was produced in control plots (Figure 3). The result agreed with the findings of Devadanam *et al.* (2005) and Padaganur *et al.* (2005) who concluded that GA_3 increased the number of florets per spike in tuberose.

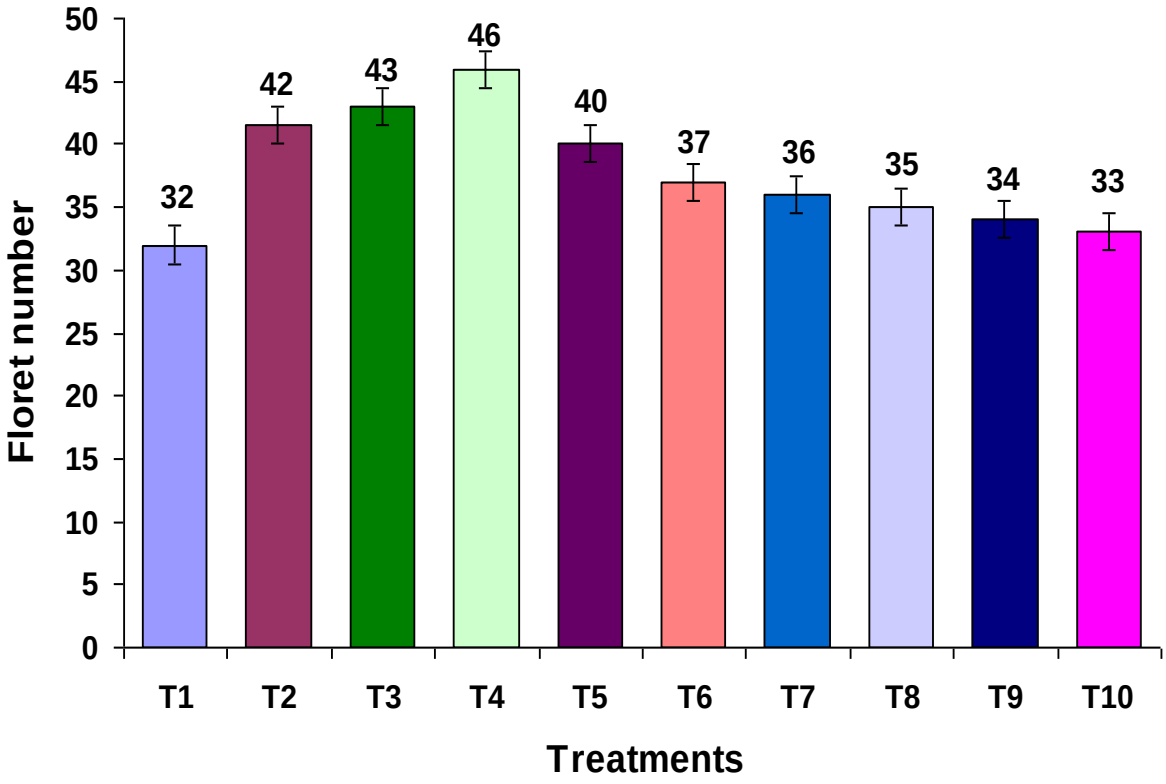


Figure 3. Effect of growth regulators on floret per spike of tuberose

T_1 : Control (Without growth regulators), T_2 : GA_3 100 ppm, T_3 : GA_3 200 ppm, T_4 : GA_3 300 ppm, T_5 : BAP 100 ppm, T_6: BAP 200 ppm, T_7 : BAP 300 ppm, T_8 : CCC 250 ppm, T_9 : CCC 500 ppm and T_{10} : CCC 1000 ppm

4.10 Spike weight

Growth regulators significantly influenced of spike weight. The results showed that spike weight was increased with the increase in concentration of GA_3. GA_3 at 300 ppm gave the maximum weight (69.0 g) of spike while control showed minimum weight (54.0 g) of spike (Table 2).

4.11 Number of open florets per plant

The number of open florets per plant was influenced by the application of different growth regulators and the effect was statistically significant. Gibberelic acid at 300 ppm produced the highest number of open florets per plant (27.0) while the lowest number of open florets (23.0) was obtained from control (Table 2).

4.12 Vase life

There was significant variation among the different growth regulator treatments in respect of vase life in spike. Plant sprayed with 300 ppm GA_3 showed maximum vase life (11 days). On the other hand, the minimum vase life (8 days) was found in control (without growth regulator). This is in line with the findings of Singh and Shanker (2010) in tuberose.

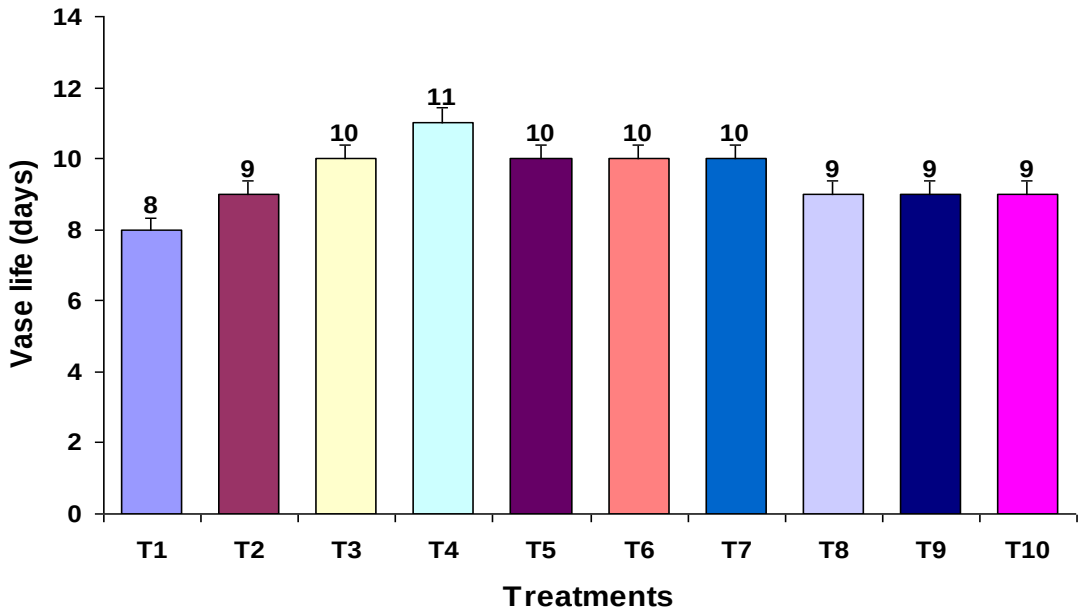


Figure 4. Effect of growth regulator on vase life of tuberose

T_1 : Control (Without growth regulators), T_2 : GA_3 100 ppm, T_3 : GA_3 200 ppm, T_4 : GA_3 300 ppm, T_5 : BAP 100 ppm, T_6: BAP 200 ppm, T_7 : BAP 300 ppm, T_8 : CCC 250 ppm, T_9 : CCC 500 ppm and T_{10} : CCC 1000 ppm

4.13 Flower yield

Growth regulators significantly influenced yield of spike. The results showed that total flower was increased with the increase in concentration of GA_3.GA_3 at 300 ppm gave the highest yield per hectare (4.8 lacs spikes/ha) followed by GA_3 200 ppm (4.5 lacs spikes/ha) while the lowest yield (3.0lacs spikes/ha) of tuberose was observed in control (without growth regulator). These findings are in agreement with those of Jana and Biswas (1982) and Dhua *et al.* (1987) in tuberose and Mashesh and Mishra (1993) in gladiolus.

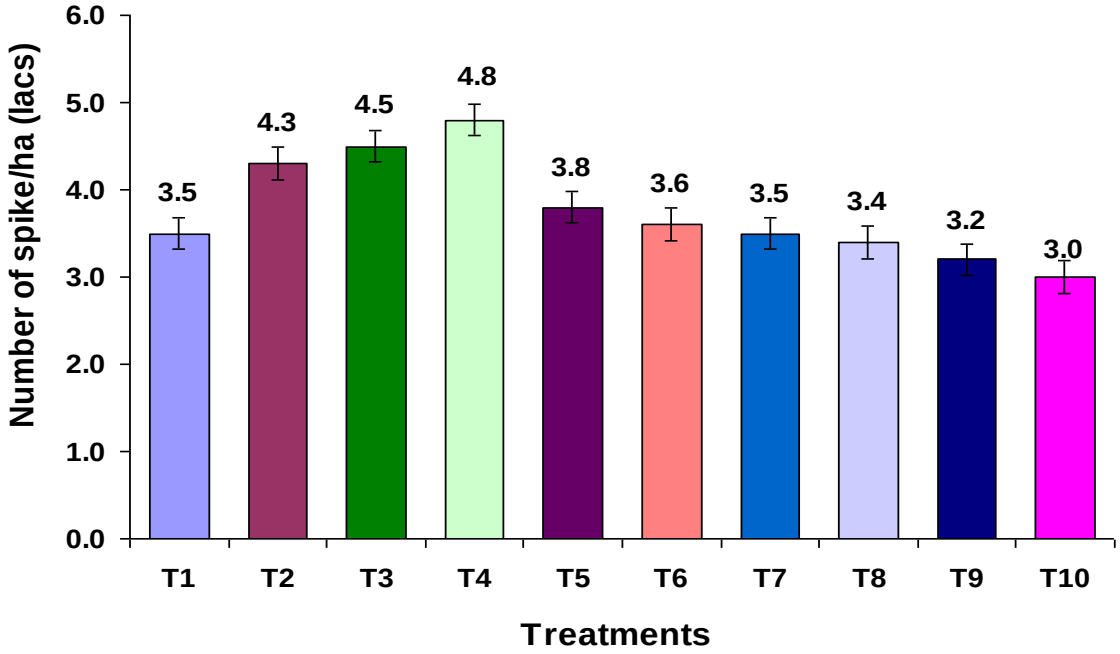


Figure 5. Effect of growth regulator on flower yield of tuberose

T_1 : Control (Without growth regulators), T_2 : GA_3 100 ppm, T_3 : GA_3 200 ppm, T_4 : GA_3 300 ppm, T_5 : BAP 100 ppm, T_6: BAP 200 ppm, T_7 : BAP 300 ppm, T_8 : CCC 250 ppm, T_9 : CCC 500 ppm and T_{10} : CCC 1000 ppm

4.14 Number of bulb per plant

The number of bulb per plant was influenced by the application of different growth regulators and the effect was statistically significant. BAP at 100 ppm showed the highest number of bulb per plant (5.0) while the lowest number of bulb (2.0) was obtained from control (Table 3). These results are in accordance with the results of Jitendra *et al*. (2009) in tuberose.

4.15 Number of bulblet per plant

The different growth regulator treatments had significant effect on the number of bulblet per plant. The maximum number of bulblet per plant (25.0) was obtained in T_4 when plants sprayed with 100 ppm BAP followed by 200 ppm BAP (Plate 4). The minimum number of bulblet per plant (14.5) was produced in control (without growth regulator). The result agreed with the findings of Singh *et al.* (2003) who concluded that BAP @ 100 ppm increased the number of bulblet per plant in tuberose.

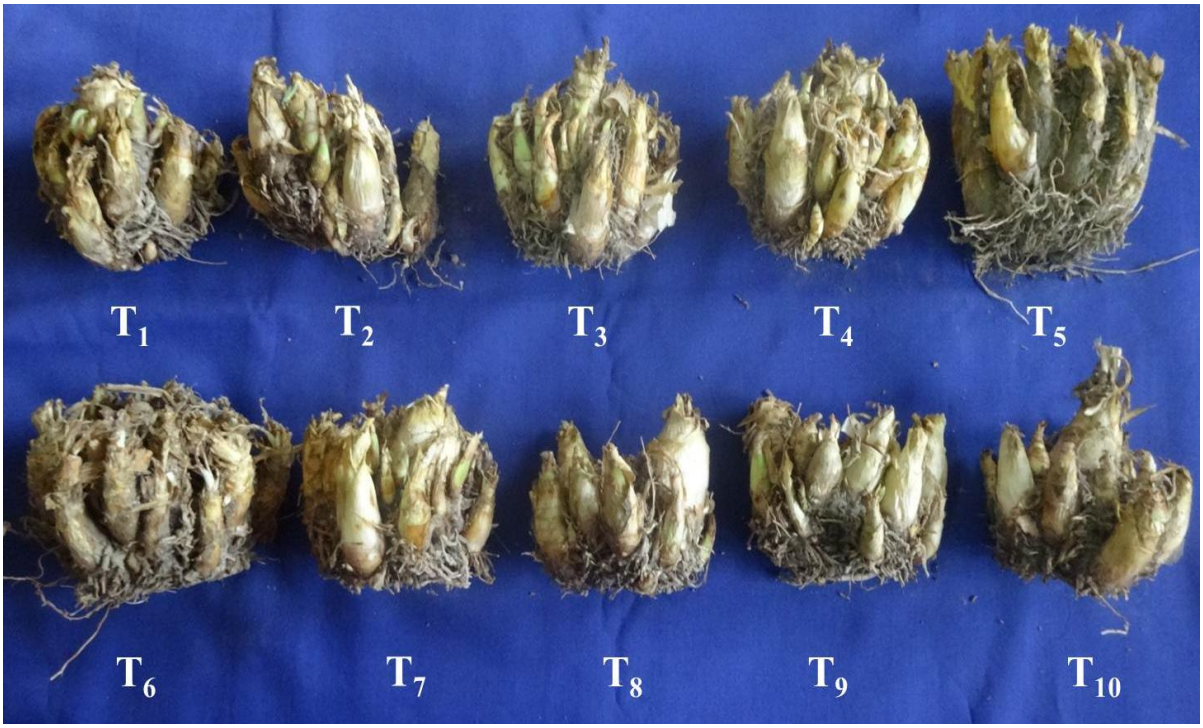


Plate 4 . Effect of growth regulators on bulblet yield of tuberose

T_1 : Control (Without growth regulators), T_2 : GA_3 100 ppm, T_3 : GA_3 200 ppm, T_4 : GA_3 300 ppm, T_5 : BAP 100 ppm, T_6: BAP 200 ppm, T_7 : BAP 300 ppm, T_8 : CCC 250 ppm, T_9 : CCC 500 ppm and T_{10} : CCC 1000 ppm

4.16 Bulb diameter

Growth regulators had significant effect on the bulb diameter. The highest diameter (3.5 cm) was produced in T_4 (GA_3 @ 300 ppm) followed by 200 ppm GA_3 (3.0 cm) as shown in Plate 5. Arora *et al.* (1992) reported that GA_3 stimulated the assimilate movement towards the bulb which resulted in the better quality bulb. Kirad *et al.* (2001) also reported increased bulb diameter when the plants were sprayed with GA_3. The lowest performance (1.5cm) was found in control (without growth regulator).The observation is similar to the findings of Mukhopadhyay and Bankar (2003) in gladiolus.

Table 3 : Effect of growth regulators on bulb and bulblets characters in BARI Tuberose - 1

Treatments	Bulb number/ plant	Bulblet number/plant	Bulb diameter (cm)	10 bulblet wt. (g)
T_1	2.0 b	14.5 c	1.5 b	50.0 f
T_2	3.5 ab	18.0 bc	2.8 ab	73.4 bc
T_3	3.7 ab	19.0 bc	3.0 ab	76.0 ab
T_4	4.0 ab	21.0 ab	3.5 a	80.0 a
T_5	5.0 a	25.0 a	2.7 ab	72.0 bc
T_6	4.5 ab	23.0 a	2.6 ab	75.0 b
T_7	3.6 ab	20.0 b	2.5 ab	70.0 c
T_8	3.3 ab	19.0 bc	2.3 ab	65.0 d
T_9	3.2 ab	22.0 ab	2.2 ab	62.0 d
T_{10}	2.8 ab	20.0 b	2.1 ab	60.0 e
LSD (0.05)	**1.1**	**1.6**	**1.3**	**2.1**
CV (%)	**15.0**	**14.3**	**11.5**	**10.8**

T_1 : Control (Without growth regulators), T_2 : GA_3 100 ppm, T_3 : GA_3 200 ppm, T_4 : GA_3 300 ppm, T_5 : BAP 100 ppm, T_6: BAP 200 ppm, T_7 : BAP 300 ppm, T_8 : CCC 250 ppm, T_9 : CCC 500 ppm and T_{10} : CCC 1000 ppm

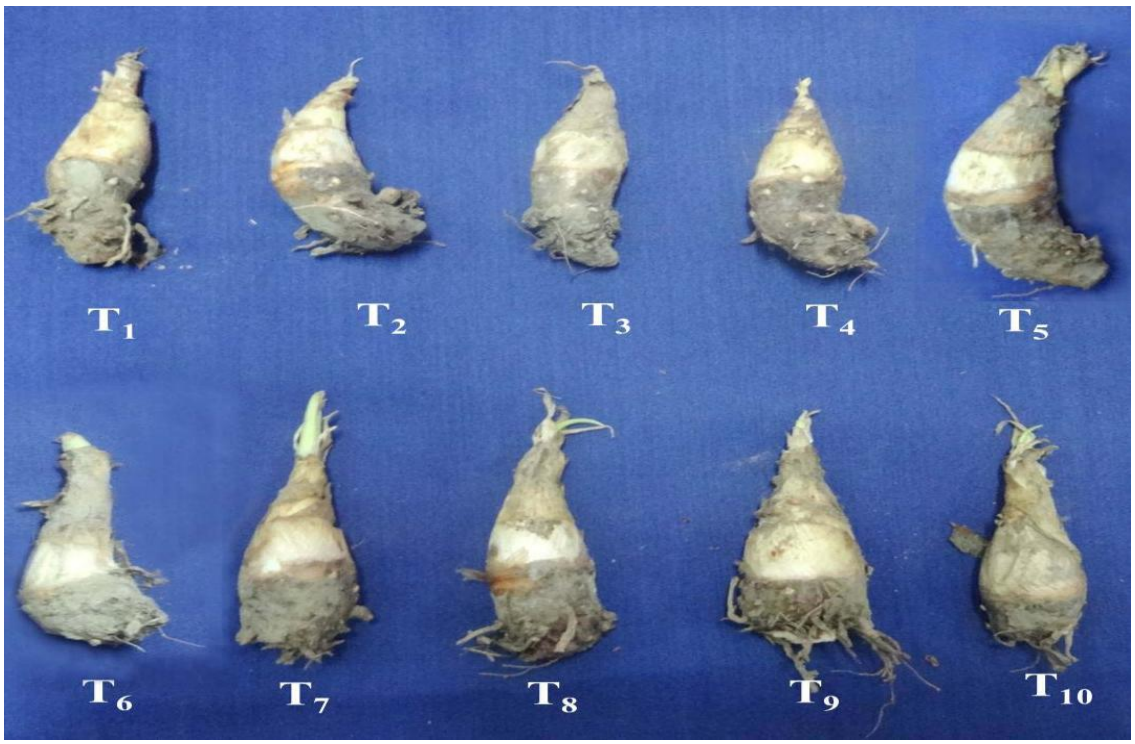


Plate 5. Effect of growth regulators on bulb diameter of tuberose

T_1 : Control (Without growth regulators), T_2 : GA_3 100 ppm, T_3 : GA_3 200 ppm, T_4 : GA_3 300 ppm, T_5 : BAP 100 ppm, T_6: BAP 200 ppm, T_7 : BAP 300 ppm, T_8 : CCC 250 ppm, T_9 : CCC 500 ppm and T_{10} : CCC 1000 ppm

4.17 Bulblet weight

Growth regulators significantly influenced of bulblet weight (Table 3). The results showed that 10 bulblet weights were increased with the increase in concentration of GA_3. GA_3 at 300 ppm gave the maximum weight (80.0 g) of bulb while control showed minimum weight (50.0 g).

4.18 Yield of bulb

Due to application of different levels of growth regulator showed a statistically significant variation in terms of yield of bulb (Appendix VI). Increasing the level of GA_3, yield of bulb showed an increasing trend under the trial upto 300 ppm (Plate 4). The highest (12.5 t/ha) yield of bulb was recorded in the treatment T_4 at 300 ppm GA_3. On the other hand the lowest (8.0 t/ha) yield of bulb was recorded in the plot with control condition. Similar trend of results were reported by Sanap *et al.* (2000) in tuberose.

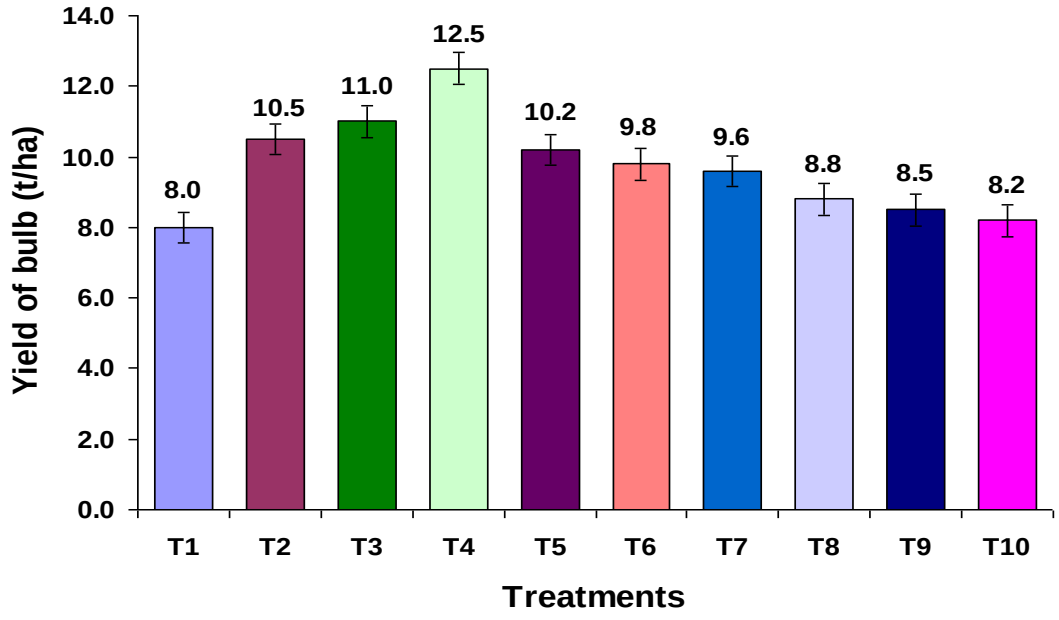


Figure 6. Effect of growth regulators on bulb yield of tuberose

T_1 : Control (Without growth regulators), T_2 : GA_3 100 ppm, T_3 : GA_3 200 ppm, T_4 : GA_3 300 ppm, T_5 : BAP 100 ppm, T_6: BAP 200 ppm, T_7 : BAP 300 ppm, T_8 : CCC 250 ppm, T_9 : CCC 500 ppm and T_{10} : CCC 1000 ppm

4.19 Yield of bulblet

Due to application of different levels of growth regulator showed a significant variation in terms of yield of bulblet (Appendix VI). The highest (16.0 t/ha) yield of bulblet was recorded in the level of GA_3 at 300ppm GA_3, on the other hand the lowest (12.0 t/ha) yield of bulblet was recorded in the plot with control condition (Figure 6). The present results are in agreement with the findings of Reddy *et al*. (1998) who reported that the highest yield of bulblet obtained when using GA_3 at 300ppm.

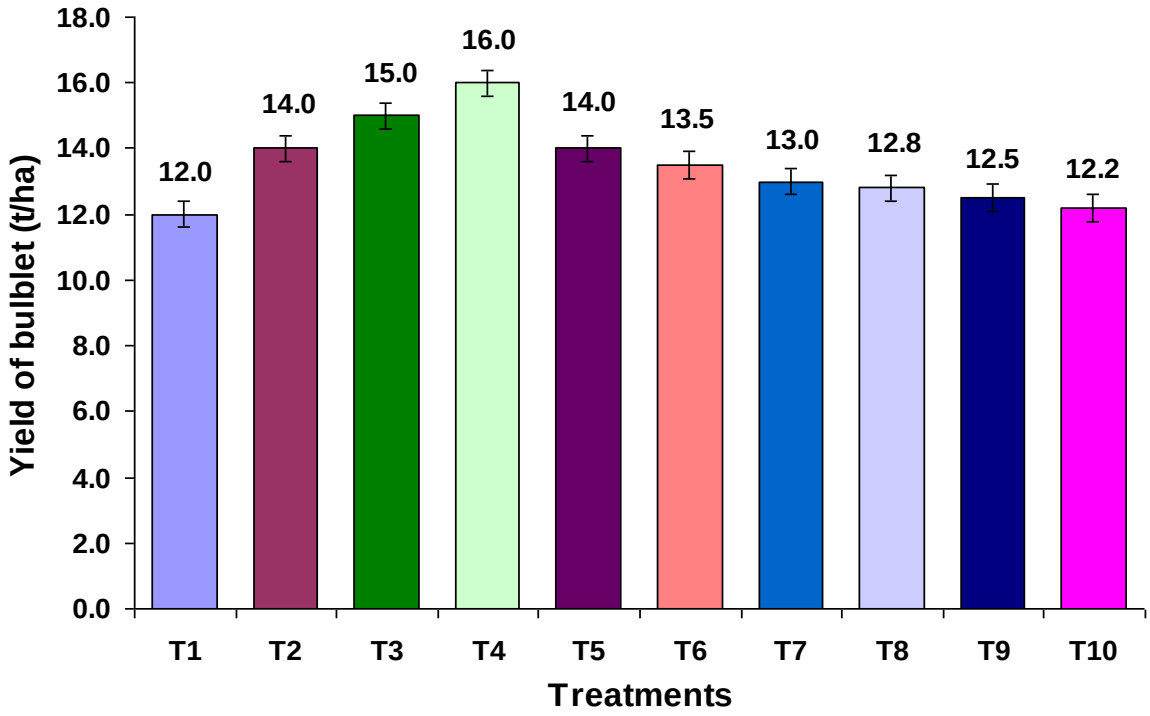


Figure 7. Effect of growth regulator on bulblet yield of tuberose

T_1 : Control (Without growth regulators), T_2 : GA_3 100 ppm, T_3 : GA_3 200 ppm, T_4 : GA_3 300 ppm, T_5 : BAP 100 ppm, T_6: BAP 200 ppm, T_7 : BAP 300 ppm, T_8 : CCC 250 ppm, T_9 : CCC 500 ppm and T_{10} : CCC 1000 ppm

CHAPTER V
SUMMARY AND CONCLUSION

Summary

An experiment was carried out at Floriculture Experimental Field of Horticulture Research Centre (HRC), Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur during March 2014 to February 2015 to study the growth, flower and bulb production of tuberose as influenced by growth regulators namely T_1 : Control (Without growth regulators), T_2 : GA_3 100 ppm, T_3 : GA_3 200 ppm, T_4 : GA_3 300 ppm, T_5 : BAP 100 ppm, T_6: BAP 200 ppm, T_7 : BAP 300 ppm, T_8 : CCC 250 ppm, T_9 : CCC 500 ppm and T_{10} : CCC 1000 ppm. The experiment was laid out in a Randomized Complete Block Design with three replications. The unit plot size was 1.8 m × 1.5 m accommodating 45 plants per plot. Spacing was maintained at 30 cm from row to row and 20 cm from plant to plant. The spikes of tuberose were harvested from May to July, 2014 at the tight bud stage and when three basal flower buds showed colour so that these may easily open indoors one by one. Bulbs and bulblets were harvested on February, 2015 when the leaves also started yellowing.

Data were collected from 10 randomly selected plants of each unit plot. Observation were made on plant emergence (%), plant height, days to sprouting, number of leaves, number of plant per hill, plant spread, spike length, rachis length, number of florets per spike, spike weight, days to 80% flowering, vase life, flower yield, number of bulb, bulblet number, 10 bulblet weight, bulb and bulblet yield etc.

Analysis of variance revealed that all the studied growth, yield (flowering as well as bulb and bulblet production) and yield contributing characters of tuberose varied significantly at 5% level of probability due to influence of various growth

regulators. Plant height of tuberose differed significantly due to the application of different concentration of growth regulators at days after planting of 30, 60, 90 and 110. At 30, 60, 90 and 110 DAP, the tallest plant (18.6, 35.0, 50.9 and 60.0 cm) was found from T_4 (GA_3 300 ppm) followed by T_3 (GA_3 200 ppm) and T_2 (GA_3 100 ppm). Whereas, the shortest plant (11.0, 24.0, 30.9 and 35.0 cm) was observed from T_1 for the same DAP, respectively. The variation among the growth regulator treatments in respect of days to sprouting of bulb per plant was found significant. The bulbs under T_4 (GA_3 300 ppm) took minimum time (20 days) followed by T_3 (GA_3 200 ppm) (22 days) to sprouting, while the bulbs of T_1 (control) required maximum time (25 days).

Different levels of growth regulators showed a statistically significant variation for number of leaves/clump, plants/hill, plant spread at harvest under the present trial. With the increases level of GA_3 100 ppm to 300 ppm number of leaves/clump represents an increasing trend. The maximum (62.5) number of leaves/clump at harvest was recorded from T_4 (GA_3 300 ppm). On the other hand the minimum number (42.0) of leaves/clump was recorded in control condition (T_1). BAP at 100 ppm produced the highest number of plants per hill (10.0) followed by 200 ppm BAP (9.0 plant) while control treatment produced (4.0 plant) lowest number of plant. The plant spread of tuberose plant is an important morphological character that influences the yield, because it is correlated with photosynthesis by the higher leaf area. Maximum plant spread (22.0 cm) was recorded in T_4 (GA_3 300 ppm) which was statistically different from other treatments.

Various growth regulators significantly influenced the time required to complete 80% spike initiation of the plant. Plant treated with GA_3 (300 and 200 ppm) required minimum number (75 and 78) of days respectively to 80% spike initiation. On the other hand CCC 250-1000 ppm took longer time than control.

Growth regulators had also significant effects on the length of spike and rachis in tuberose. The highest spike length (85.0 cm) and rachis length (35.0 cm) were obtained from the plants treated with 300 ppm GA_3 followed by 200 ppm GA_3 (83.0 cm) and (33.2 cm) whereas the length was minimum (70.0 cm) and (25.0 cm) in the treatment T_1 (control).

The floret number is an important parameter of tuberose. The different growth regulator treatments had significant effect on the number of florets per spike, spike weight and flower durability. The maximum number of florets per spike (46) was obtained from plants treated with 300 ppm GA_3 followed by 200 ppm GA_3 (43). The minimum number of florets per spike (32) was produced in control plots. GA_3 at 300 ppm gave the maximum weight (69.0 g) of spike while control showed minimum weight (54.0 g) of spike. The number of open florets per plant was influenced by the application of different growth regulators and the effect was statistically significant. GA_3 at 300 ppm showed the highest number of open florets per plant (28.0) while the lowest number of open florets (23.0) was obtained from control. Spikes obtained from plants treated with 300 ppm GA_3 showed maximum vase life (11 days). On the other hand, the minimum vase life (8 days) was found from the spikes treated with control (without growth regulator).

Growth regulators significantly influenced yield of spike. The results showed that total flower was increased with the increase in concentration of GA_3. GA_3 at 300 ppm gave the highest yield per hectare (4.8 lacs spikes/ha) followed by GA_3 200 ppm (4.5 lacs spikes/ha) while the lowest yield (3.0 lacs spikes/ha) tuberose was observed in control (without growth regulator). Application of different levels of growth regulator showed a statistically significant variation in terms of yield of bulb and bulblet. The highest (12.5 t/ha and 16.0 t/ha) yield of bulb and bulblet was recorded in the treatment T_4 at 300 ppm GA_3. On the other hand the lowest (8.0 t/ha and 12.0 t/ha) yield of bulb and bulblet was recorded with control condition.

The number of bulb and bulblet per plant was influenced by the application of different growth regulators and the effect was statistically significant. BAP at 100 ppm showed the highest number of bulb and bulblet per plant (5.0 and 25.0) followed by BAP at 200 ppm (4.5 and 23.0) while the lowest number of bulb and bulblet (2.0 and 14.5) was obtained from control.

Growth regulators had also significant effect on bulb diameter and bulblet weight. The highest bulb diameter (3.5 cm) and weight of 10 bulblet (80.0 g) were obtained from the plants treated with 300 ppm GA_3 followed by 200 ppm GA_3 (3.0 cm and 76.0 g). The lowest performance was found from the plants treated with control (without growth regulator).

Conclusion

- Application of GA_3 @ 300 ppm is suitable for higher growth and yield of spike in tuberose cultivation.

- Application of BA @ 100 ppm is also suitable for increasing production of plants per hill as well as bulb and bulblet production of tuberose.

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APPENDICES

Appendix I. Mean monthly weather data during March 2014 to February 2015

Year	Month	Air temperature (°C)		Relative Humidity (%)	Rainfall (mm)
		Max.	Min.		
2014	March	31.42	25.98	69.15	06.40
2014	April	32.10	29.00	75.00	57.50
2014	May	31.33	27.42	76.15	250.10
2014	June	32.00	29.15	64.10	377.50
2014	July	31.20	25.95	85.00	361.50
2014	August	30.86	25.75	86.40	590.00
2014	September	31.50	27.00	86.50	208.45
2014	October	29.75	26.80	85.28	183.40
2014	November	26.22	22.75	80.17	07.50
2014	December	19.90	15.45	89.05	0.00
2015	January	14.22	10.55	90.03	000.0
2015	February	23.75	18.81	86.63	06.49

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

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

Year	p^H	Total N	OM	Ca	Mg	K
		%		Meq/100g		
2014	6.1	0.077	1.46	4.76	1.97	0.15
Critical level				2.0	0.8	0.2

Appendix II. Cont'd.

Year	p^H	P	S	B	Cu	Fe	Mn	Zn
		µg/g						
2014	6.1	15	38	0.32	6.0	232	10	3.30
Critical level		14	14	0.2	1.0	10.0	5.0	2.0

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

Appendix III. Analysis of variance of the data on plant height of tuberose as influenced by growth regulators

Source of variation	Degrees of freedom	Mean sum of square			
		Plant height (cm) at			
		30 DAP	50 DAP	70 DAP	90 DAP
Replication	2	2.652	2.506	0.205	0.257
Treatment	9	40.256*	54.151*	89.541*	251.701*
Error	18	0.512	2.56	4.25	2.518

*: Significant at 5% level of probability

Appendix IV. Analysis of variance of the data on different plant characters of tuberose as influenced by growth regulators

Source of variation	Degrees of freedom	Mean sum of square			
		Days to sprouting	Leaf number	Plant spread	Plants/hill
Replication	2	5.68	25.10	03.15	02. 26
Treatment	9	110.25*	310.18*	204.90*	313.40*
Error	18	6.10	8.90	5.64	07.85

* = Significant at 5% level of probability

Appendix V. Analysis of variance of the data on different flower characters of tuberose as influenced by growth regulators

Source of variation	Degrees of freedom	Mean sum of square					
		Days to 80% spike initiation	Spike length	Rachis length	Floret number	Spike weight	Flower durability
Replication	2	07.18	19.25	15.21	12. 50	10.42	12.56
Treatment	9	570.25*	290.10*	487.54*	12.25*	285.07*	113.10*
Error	18	5.60	5.52	3.46	4.60	3.89	4.50

* = Significant at 5% level of probability

Appendix VI. Analysis of variance of the data on different bulb characters of tuberose as influenced by growth regulators

Source of variation	Degrees of freedom	Mean sum of square						
		Bulb number	Bulb diameter	Bulb weight	Bulblet number	Bulblet weight	Yield of bulb	Yield of bulblet
Replication	2	0.78	11.45	15.24	2.39	25.00	0.08	0.09
Treatment	9	1.56*	12.50*	18.78*	17.74*	45. 10*	18.15*	24.58*
Error	18	0.05	4.25	11.21	12.55	6.46	6.72	5.91

* = Significant at 5% level of probability