

Effect of biofertilizers on growth and flowering of tuberose (*Polianthes tuberosa* L.) under Malwa region of M.P.

THESIS



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Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya

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In

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by

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CERTIFICATE - I

This is to certify that the thesis entitled “**Effect of biofertilizers on growth and flowering of tuberose (*Polianthes tuberosa* L.) under Malwa region of M.P.**” submitted in partial fulfillment of the requirements for the Degree of **MASTER OF SCIENCE in Floriculture and Landscape Architecture** of Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior is a record of the bona-side research work carried out by **Mr. Mukesh Dawar**, under my guidance and supervision. The subject of the thesis has been approved by the student’s Advisory Committee and the Director of Instruction.

No part of the thesis has been submitted for any other degree or diploma or has been published. All the assistance and help received during the course of these investigations has been acknowledged by the scholar.

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CERTIFICATE - II

This is to certify that the thesis entitled “**Effect of biofertilizers on growth and flowering of tuberose (*Polianthes tuberosa* L.) under Malwa region of M.P.**” submitted by **Mr. Mukesh Dawar**, to the Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior in partial fulfillment of the requirements for the degree of Master of Science in **HORTICULTURE** in the department of **Floriculture and Landscape Architecture** has been accepted after evaluation by the External Examiner and approved by the Student’s Advisory Committee after an oral examination on the same.

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(Mukesh Dawar)

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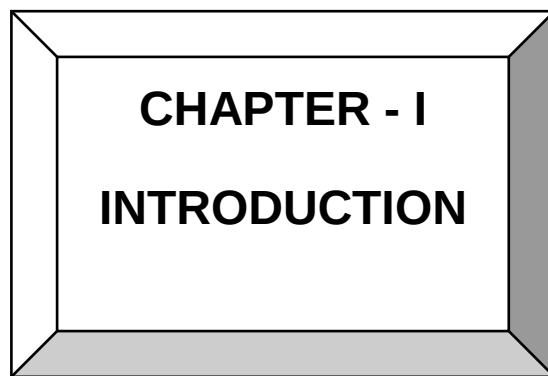
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List of Abbreviations/Symbols

Symbol	Abbreviation	Stands for
%		Percentage
/		Per
@		At the rate of
&		And
-	⁰ C	Degree Celsius
-	ANOVA	Analysis of variance
-	C.D.	Critical difference
-	Cm	Centimetre
-	Cv.	Cultivar
-	CV	Coefficient of Variance
-	d.f.	Degree of Freedom
-	DAP	Days After Planting
-	<i>et al.</i>	And others/associates
-	i.e.	That is
-	EC	Electrical conductivity
-	EMS	Error Mean Sum of Squares
-	Fig.	Figure
-	G	Gram
-	ha.	Hectare
-	K	Potassium
-	Kg	Kilogram
-	Max.	Maximum
-	Min.	Minimum
-	M	Metre
-	M.S.S.	Mean sum of squares
-	MSS	Mean Sum of Squares
-	M.P.	Madhya Pradesh
-	m ²	Metre square
-	No.	Number
-	N	Nitrogen
-	NS	Non significant
-	NPK	Nitrogen, Phosphorus and Potassium
-	P	Phosphorus
-	RBD	Randomised Block Design
-	R.H.	Relative humidity

-	RVSKVV	Rajmata Vijayaraje Scindia Krishi Vishwa Vidhyalaya
-	Sig.	Significant
-	SE(m) $\pm$	Standard Error of Mean
-	spp.	Species
-	SS	Sum of Squares
-	Var.	Variety
-	Viz.	(videlicet) Namely



CHAPTER - I
INTRODUCTION

CHAPTER - I

INTRODUCTION

Tuberose (*Polianthes tuberosa* L.) occupies a prime position among the commercially grown flower crops in India because of its potential for the cut flower trade as well as oil industries. Tuberose belongs to the family Amaryllidaceae and native to Mexico, from where it spread to different parts of the world during the 16th century (Trueblood 1973). It is grown in many tropical and subtropical parts of the world. In India, it is commercially grown in West Bengal, Karnataka, Tamilnadu and Maharashtra.

It is very popular among the flower growers due to its easy cultivation and longer keeping quality of spikes (Wasim *et al.* 2014). Tuberose has got a prime position, because of its attractiveness and sweet delightful fragrance. The flower spikes are excellent as cut flower for table decoration. It blooms profusely almost throughout the year and most artistic garlands and floral arrangements are made from its flowers. The natural flower oil of tuberose is one of the expensive raw materials for perfume industry. Tuberose is a half hardy, bulbous perennial perpetuating itself through the bulblets. Bulbs are made up of scales and leaf bases and the stem is a condensed structure which remains concealed within scales. Roots are adventitious and generally shallow. Numerous lanceolate leaves are green, narrow, linear, long and arise in rosette. The flowers have a funnel shaped perianth, waxy white about 25 mm long, single or double and borne in spike. 'Single' varieties are more fragrant than 'Double' type. The terminal flower spikes arising from the bulb produce flowers for a number of days. Fruit is a capsule.

Polianthes tuberosa Linn. has tuberous rootstock and a mass of basal foliage. The leaves are pale green, long, narrow and very dense. The leaves at the base are 30 to 40 cm long, 1.2 to 1.5 cm in width, sometimes, reddish near the base. The flowering stems are long and can reach a height of upto 100 cm, although 60 to 75 cm is normal. It is approximately top third of the stem which bears pure white waxy textured receme of blooms. The flowers are borne in pairs on a lax spike and are 3 to 6 cm length. The segments 1 to 2 cm long, tube long, narrow, funnel shaped slightly bent near the base.

Filaments are attached to upper part of corolla. Ovary is 3 celled, stigma 3, ovate falcate. Fruit crowned by the persistent perianth, seeds are flat (Farooqi *et al.* 2004).

Among the various agro techniques used in the commercial production of tuberose, optimum nutritional requirement have a great influence on the growth and yield. Therefore, growers would definitely be interested to know the optimum dose of nutritional requirement for maximum growth and production of tuberose.

Generally chemical fertilizers are applied for quick result to get more and more production but their unscrupulous use not only robs the soil, its texture, structure and nutrient status but also creates threat to soil health (Chaudhary, 2007). The use of only chemical fertilizers is not sufficient to the crop, because fertilizers containing major nutrients especially N may be lost through leaching or evaporation and P may be fixed in the soil in complex form and thus both N and P availability are in lesser quantity to the crop which may be insufficient for the plant to show its maximum potentiality for producing higher yield.

Therefore integrated nutrient management may be one of the possible solutions to solve this problem. In recent days biofertilizers have emerged as a supplement to mineral fertilizers and hold a promise to improve the yield as well as quality of crop.

The use of biofertilizers could reduce damage rather reclaim the soil health without hampering the flower yield and quality of crops.

Biofertilizers are less expensive, eco-friendly and sustainable and they do not require non renewable source of energy during their production. Biofertilizer usually consists of live or latent cells of micro-organisms which include biological nitrogen fixers, P-solubilizing, mineralization of nitrogen and transformation of several elements into available forms. VAM fungi, Azotobacter, Azospirillum and phosphate solubilizing bacteria are commonly applied biofertilizers in horticultural crops (Zaredost *et al.* 2014). Azotobacter and PSB (Phosphorus Solubilizing Bacteria) are the popular and important among the common biofertilizers used in horticultural crops. Azotobacter is a free living N fixing bacteria. PSB inoculants play an important role in making P available to plants because, these organisms solubilise phosphate in quantities in excess to their own requirement (Gour 1990).

A large portion of soluble inorganic phosphate applied to soil as chemical fertilizer is rapidly immobilized soon after application and becomes unavailable to plants (Chaudhary, 2007). The biofertilizers is most important among the factors, which effects efficiency of biological phosphorus fixation. The use of phosphate solubilizing bacteria as inoculants simultaneously increases P uptake by the plant and crop yield. Strains from the genera *Pseudomonas*, *Bacillus* and *Rhizobium* are among the most powerful phosphate solubilizers.

Azotobacter and *Azospirillum* are two important nitrogen fixer inoculants. *Azotobacter* is mesophilic, heterotrophic, aerobic and free living nitrogen fixing bacteria. These bacteria utilize atmospheric nitrogen gas for their cell protein synthesis. This cell protein is then mineralized in soil after the death of *Azotobacter* cells thereby contributing towards the nitrogen availability of the crop plants. Besides nitrogen fixation, *Azotobacter* is also known to synthesize biologically active growth promoting substances such as vitamins of B-group, indole acetic acid (IAA) and gibberellins. Use of *Azotobacter* alone or in combination improved the growth and yield of tuberose (Wange and Patil, 1994). The application of nitrogen and phosphorus fertilizer in combination of bio inoculants (*Azotobacter* and PSB) and FYM proved to be beneficial to fix the atmospheric nitrogen and solubilize fixed phosphorus in soil and also secrete growth substances like auxins, which stimulated the plant metabolic activities and photosynthetic efficacy leading better growth and development of plant.

Keeping in view the above facts and the paucity of research on these aspects in the Malwa region of Madhya Pradesh, the present study is proposed to be conducted with the following objectives.

1. To study the effect of *Azotobacter* and PSB on the vegetative growth of tuberose.
2. To study the effect of *Azotobacter* and PSB on flowering of tuberose.
3. To study the effect of biofertilizers on vase life of cut spikes of tuberose.

CHAPTER - II
REVIEW OF LITERATURE

Chapter - II

REVIEW OF LITERATURE

In this chapter, an attempt has been made to review the research work done so far in India and abroad by different research workers on the “**Effect of biofertilizers on growth and flowering of Tuberose (*Polianthes tuberosa* L.) under Malwa region of M.P.**” and related aspects have been briefly reviewed and presented in chronological order under following headings:

2.1 Growth parameters

2.2 Flowering parameters

2.3 Vase life parameters

2.1: Growth parameters

Tuberose

Kukde et al. (2006) conducted an experiment to study the effect of organic manures and biofertilizers on growth, flowering and yield of tuberose cv. Single. The results revealed that the tuberose bulb treated with Azotobacter and PSB at 2.5 g kg⁻¹ bulb gave maximum vegetative growth.

Chaudhary (2007) evaluated the effect of nitrogen, phosphorus and biofertilizers on plant growth and bulb production in tuberose and found that application of biofertilizers in combination with N at the rate of 100 Kg per hectare and P at the rate of 50 Kg per hectare proved to be equally effective to N at the rate of 200 Kg/ha and P at the rate of 100 Kg/ha in increasing the plant height, number of leaves per plant and advancing the sprouting of bulbs.

Yadav et al. (2008) observed number of bulbs per plant increased significantly with increasing levels of nitrogen along with biofertilizers.

Chaudhary (2009) studied the Influence of biofertilizers (Azotobacter, PSB and VAM), nitrogen doses (0, 50, 100 and 200 kg/ha) and phosphorus (0, 50, 100 and 200 kg/ha) alone and in combination were tested on the time taken for sprouting of bulbs, spike emergence and basal floret opening in tuberose cv. Double. The biofertilizers application with lower N and P doses advanced the sprouting of bulbs.

Kumar et al. (2012) observed that application of PSB and boron gave the better performance in comparison to control, while best were recorded under the combined application of PSB inoculation and boron at higher doses (PSB @ 200 g/l + Boron @ 0.6%).

Kumar et al. (2012) revealed that combined application of Azospirillum @ 3 g/plot and PSB @ 150 g/plot gave the better performance on all growth parameters studied as compared to other treatments (individual application of biofertilizers).

Hadwani et al. (2013) found significant result in ratoon tuberose cv. Duble with application of PSB @ 2 g/m² + Azotobacter @ 2 g/m² with respect to minimum days to sprouting, maximum plant height and plant spread at E-W and N-S.

Kashyap et al. (2014) studied the effect of biofertilizers (Azotobacter, PSB) along with the chemical fertilizers (N, P and K) on the growth of the tuberose. The growth parameters (plant height, number of leaves per plant, days taken for emergence of bulbs) increased significantly with the increasing levels of chemical fertilizers along with the biofertilizer applications. Chemical fertilizers N, P and K application @ 15, 11.2 and 9.3 g/m² respectively along with the biofertilizers gave significant higher growth parameters over rest of the treatment.

Taher et al. (2014) assessed the effects of nitrogen (N) fertilizer and phosphate solubilizing bacteria (PSB) on growth and quantitative traits of tuberose (*Polianthes tuberosa* L.) and observed that growth parameters were increased significantly by soil inoculation with PSB. Based on the results of this study, application of 200 kg/ha N and 10 kg/ha microbial fertilizer containing PSB resulted in the highest yield and quantitative traits for tuberose.

Wasim et al. (2014) conducted an experiment to evaluate the influence of biofertilizers on growth and flowering of tuberose (*Polianthes tuberosa* L.) cv. Mexican Single at different levels of inorganic fertilizers. The biofertilizers were applied once at the time of planting using bulb dip method for half an hour followed by shade drying before planting. All the biofertilizers significantly improved different vegetative characters as compared to control. Vegetative growth such as plant height, number of leaves, length and width of leaves were enhanced most effectively by Azotobacter treatment.

Meena et al. (2015) observed response of biofertilizers on growth parameters in tuberose cv. Phule Rajani. Application of Azotobacter @ 2 g plant⁻¹ + PSB @ 2 g plant⁻¹ + 60% recommended dose of NPK through inorganic fertilizers showed significant influence on plant height.

Gladiolus

Gudse et al. (2006) studied the effect of organic manures and biofertilizers with reduced doses of inorganic fertilizers on growth, yield and quality of gladiolus. The results revealed that plants receiving vermicompost @ 8 t ha⁻¹ + Azotobacter and PSB @ 25 kg ha⁻¹ each + 80% RDF significantly increased growth, attributes of gladiolus viz., plant height, number of leaves, when compared with RDF and other treatments. FYM 40 t ha⁻¹ + Azotobacter and PSB @ 25 kg ha⁻¹ each + 80% RDF and NeemCake 6 t ha⁻¹ + Azotobacter and PSB @ 25 kg ha⁻¹ each + 80% RDF also increased growth, yield and quality of gladiolus significantly over RDF.

Sharma et al. (2008) found in Gladiolus cv. White Prosperity that minimum days to sprouting, maximum plant height, number of leaves per plant, were recorded when plant were applied recommended doses of NPK along with vermicompost and dual inoculation of Azotobacter and PSB.

Dalve et al. (2009) studied the effect of biofertilizers on growth, flowering and yield of gladiolus. The treatments were comprised of Azotobacter and Azospirillum with reduced doses of nitrogen. Data indicated that growth parameters like number of leaves, plant height, were positively influenced by the application of both the biofertilizers in combination with nitrogen and it was maximum under 75% N + 100% PK (375:200:200 kg NPK ha⁻¹) + Azotobacter + Azospirillum. Thus there was 25% saving of nitrogenous fertilizer which was replaced by the biofertilizers.

Ali et al. (2014) found that all the vegetative and reproductive growth accomplished successfully by application of biofertilizers in gladiolus. So, in this experiment Biofertilizer has been identified as an alternative to chemical fertilizer in order to increase soil fertility and crop production in sustainable farming.

Baskaran et al. (2014) observed that early sprouting of corm was obtained by Azotobacter, maximum number of leaves was produced by Azospirillum, maximum plant height was obtained by phosphorus solubilizing bacteria (PSB). Application of

biofertilizers and commercial spray formulation products not only improved the qualitative and quantitative parameters but also improved the soil fertility and productivity.

Qasim et al. (2014) investigated the effect of microbial culture on growth and production of gladiolus cultivar White Prosperity, under field conditions. The microbial cultures were applied on the corm at planting time using the dip method followed by shade drying before planting. The results revealed that the gladiolus responded well to microbial culture and significant improvement was observed in different vegetative and leaf chemical composition of gladiolus. Among different treatments, considerable increase in vegetative attributes was observed when corms were treated with Azospirillum. Similarly, significant increase in total chlorophyll content, protein contents, total soluble sugars and accumulation of nutrients (N, P and K) was seen in leaves by Azospirillum application followed by Azotobacter.

Basoli et al. (2015) observed that application of 3/4th N, P and K + Azotobacter + PSB + KSB was found most effective in enhancing plant height, of gladiolus (*Gladiolus hybrida*). Maximum leaf area, were recorded with application of 1/2 N, P and K + Azotobacter + PSB + KSB. However, maximum number of leaves were obtained when plants were fertilized with 3/4th N, P and K + Azotobacter + PSB.

Panusuria and Chauhan (2015) conducted an experiment to investigate the effect of organic, inorganic and biofertilizer on growth, yield and quality of gladiolus cv. Psittacinus hybrid. Twelve treatment combinations of different nutritional sources were comprised with three replications. Results due to various treatments found significant. Application of FYM @ 20 t/ha + Azotobacter @ 4 kg/ha + PSB @ 4 kg/ha (T₃) was recorded for maximum plant height.

Salma et al. (2015) evaluated the efficacy and compatibility of different biofertilizers for nutrient management in gladiolus variety Advance Red. The biofertilizers used were three different rhizobacterial strains viz., *Azotobacter chroococcum*, *Pseudomonas* strain and PSB. The results revealed that at an early stage of growth (within 30 days of sprouting) co-inoculation of *Azotobacter chroococcum* with *Pseudomonas* strain either at 50% RDF or 75% RDF resulted in complete mortality of plants. However the biofertilizers performed well when applied

singly along with inorganic fertilizers. So it was suggested that a compatibility check has to be performed before recommending any biofertilizers inoculants as a nutrient package for the crop.

Dahlia

Sheergojri et al. (2013) evaluated the effect of three nitrogen levels (50, 75 and 100 kg ha⁻¹), two phosphorus levels (100 and 125 kg ha⁻¹) and three biofertilizers (*Bacillus* sp., *Pseudomonas* sp. and *Azotobacter* sp.) on vegetative and floral characteristics of dahlia (*Dahlia variabilis* Desf.) cv. 'Pink Attraction' and found that among the all treatment combinations evaluated, the application of 75 kg N ha⁻¹ + 100 kg P ha⁻¹ + *Azotobacter* gave maximum plant height, number of primary branches plant⁻¹, length of primary branches, leaf area.

2.2: Flowering parameters

Tuberose

Kukde et al. (2006) conducted an experiment to study the effect of organic manures and biofertilizers on growth, flowering and yield of tuberose cv. Single and reported that the tuberose bulb treated with *Azotobacter* and PSB at 2.5 g kg⁻¹ bulb gave early opening of first pair of florets and better flower quality parameter.

Yadav et al. (2008) observed the effect of nitrogen (0, 100, 200 and 300 kg/ha), plant spacing (20×20 cm, 20×25 cm and 20×30 cm) and biofertilizers (*Azotobacter* Phosphorus Solubilizing Bacteria and *Azospirillum*) on number of bulbs per plant, spike, length, duration of flowering and number of florets per spike in tuberose cv. Double. In case of biofertilizers all the biofertilizers significantly increased the spike length, duration of flowering and number of florets per spike over the control except *Azospirillum* in case spike length and duration flowering.

Chaudhry (2009) studied the influence of biofertilizers (No biofertilizer, *Azotobacter*, PSB and VAM), nitrogen doses (0, 50, 100 and 200 kg/ha) and phosphorus (0, 50, 100 and 200 kg/ha) alone and in combination were tested on the time taken for sprouting of bulbs, spike emergence and basal floret opening in tuberose cv. Double. The biofertilizers application with lower N and P doses show the advanced flowering.

Pandhare et al. (2009) studied the effect of bioinoculants with graded doses of inorganic fertilizers on flower quality and yield of tuberose. Use of bioinoculants with reduced doses of inorganic fertilizers significantly influenced the spike yield and quality of tuberose. The application of recommended 75% NP and 100%K i.e. 150:225:200 kg ha⁻¹ along with pre planting treatment of bulb with Azotobacter and PSB. Recorded The best results with respect of yield and yield contributing characters.

Lal et al. (2010) studied the effect of organic manures and biofertilizers on growth, flowering and bulb production in tuberose cv. Single. Tuberose cultivar Single when grown with PSB @ 1 kg/m² and 2 g/bulb, respectively, produced highest spike length, maximum number of spikes per plant.

Kumar et al. (2012) observed that combined application of Azospirillum @ 3 g/plot and PSB @ 150 g/plot gave the better performance on all flowering parameters as compared to other treatments (individual application of biofertilizers).

Hadwani et al. (2013) conducted an experiment to see the response of biofertilizers on ratoon tuberose cv. Double and observed that application of PSB @ 2 g/m² + Azotobacter @ 2 g/m² show the best results with respect to flowering, maximum length of spike, number of florets per spike, number of spikes per plant, number of spikes per net plot and number of spikes per hectare.

Taher et al. (2014) assessed the effects of nitrogen (N) fertilizer and phosphate solubilizing bacteria (PSB) on growth and quantitative traits of tuberose (*Polianthes tuberosa* L.). Based on the results of this study, application of 200 kg/ha N and 10 kg/ha microbial fertilizer containing PSB resulted in the highest yield and quantitative traits for tuberose.

Wasim et al. (2014) conducted an experiment to evaluate the influence of biofertilizers on growth and flowering of tuberose (*Polianthes tuberosa* L.) cv. Mexican single at different levels of inorganic fertilizers and found significant variations among the treatments in respect of floral characters like number of spike per plant, number of florets per spike, length of spike, length of rachis, days require for first flowering, first floral spike to emerge and flowering duration. The floral parameters were found superior in 75 % RDF + Azotobacter + PSB (T₇) and 100 % RDF + Azotobacter + PSB (T₄). These experimental results revealed that the floral characters of tuberose could be

modified by the application of biofertilizers along with reducing level of inorganic fertilizers.

Meena et al. (2015) studied the response of integrated nutrient management on floral, bulb and economic parameters in tuberose cv. Phule Rajani. Application of Azotobacter @ 2 g plant⁻¹ + PSB @ 2 g plant⁻¹ + 60% recommended dose of NPK through inorganic fertilizers showed significant influence spike length, floret/spike, floret diameter, flower duration.

Rao et al. (2015) studied the influence of integrated nutrient management practices on growth and flower yield of Tuberose cv. Hyderabad Double. The treatments consist of combination of organics and bioinoculants along with different levels of NPK (100%, 75% and 50% RDF). Compared to 100 % RDF with FYM alone, application of 75% RDF in integration with farm yard manure (FYM), vermicompost (VC), Azospirillum (AZO) and phosphate solubilizing bacteria (PSB) has significantly yielded maximum number of spikes per plant with increased spike length, rachis length, number of florets per spike and also maximum number of bulbs per plant. B:C ratio ranged between 2.09 - 2.60 with its maximum exhibited by 75% RDF with FYM, VC, AZO and PSB followed by 50 % RDF with FYM, VC, AZO and PSB.

Gladiolus

Gudse et al. (2006) studied the effect of organic manures and biofertilizers with graded doses of inorganic fertilizers on growth, yield and quality of gladiolus. The results revealed that plants receiving vermicompost 8 t ha⁻¹ + Azotobacter and PSB @ 25 kg ha⁻¹ each + 80% RDF significantly increased growth, yield and quality attributes of gladiolus.

Sharma et al. (2008) grown gladiolus cv. w.p. under graded levels of chemical fertilizers in combination with farm yard manure, vermicompost and dual inoculation of biofertilizers (Azotobacter and PSB) to study the effect of integrated nutrient management on flower production and quality. The results showed that maximum spike length and number of florets per spike were recorded when plant were applied recommended doses of NPK along with vermicompost and dual inoculation of Azotobacter and PSB.

Dalve et al. (2009) studied the effect of biofertilizers on growth, flowering and yield of gladiolus. The treatments were comprised of Azotobacter and Azospirillum with graded doses of nitrogen. Results indicated that, use of biofertilizers with reduced doses of nitrogen significantly influenced the growth, flowering and yield of gladiolus. The flowering parameters like days required for emergence of spikes, days required for opening of first pair of florets, days required for 50% flowering, yield contributing characters like number of florets per spike, number of spikes per plant, number of spikes per plot and per hectare, were positively influenced by the application of both the biofertilizers in combination with nitrogen and it was maximum under 75% N + 100% PK (375:200:200kg NPK ha⁻¹) + Azotobacter + Azospirillum and at par with the treatment 100% NPK (500:200:200kg ha⁻¹ + Azotobacter + Azospirillum). Thus there was 25% saving of nitrogenous fertilizer which was replaced by the biofertilizers.

Dubey et al. (2010) worked on two gladiolus varieties viz. Jester and Sylvia with chemical and biofertilizers. The combined inoculation of gladiolus corms with AZT + PSB was found best for days to flowering, first floret diameter, florets remaining open and days to last floret opening among all the biofertilizer(s) treatments.

Chaudhari et al. (2013) observed that gladiolus corms when inoculated with AZT + PSB show the better performance with respect of spike emergence, number spike per plant over application of FYM @ 5 kg/m².

Ali et al. (2014) conducted a trial to see the effect of different biofertilizer on growth and flower quality characteristics of Gladiolus (*Gladiolus grandiflorus* L.). In this experiment Biofertilizer has been identified as an alternative to chemical fertilizer in order to increase soil fertility and crop production in sustainable farming.

Baskaran et al. (2014) studied the effect of various biofertilizers and commercial formulations on growth and development of gladiolus. The results showed that maximum diameter of floret was observed by PSB. Application of biofertilizers and commercial spray formulation products not only improved the qualitative and quantitative parameters but also improved the soil fertility and productivity.

Qasim et al. (2014) investigated the effect of microbial culture on growth and production of gladiolus cultivar White Prosperity. The results revealed that the gladiolus responded well to microbial culture and significant improvement was observed in

different flowering traits, composition of gladiolus. Among different treatments, considerable increase in reproductive attributes was observed when corms were treated with Azospirillum.

Singh et al. (2014) carried out a study in gladiolus (*Gladiolus grandiflorus* L.) cv. "White Prosperity". The experiment consisted of treatments [75% RDF, (NPK 225:150:150 kg/ha) + 2 Tonnes of Vermicompost + PSB, (2.5kg/ha) + Azotobacter, (2.5 kg/ha)] was found significant to induce early flowering, days required for visibility of first spike, days required for opening of the first flower.

Basoli et al. (2015) observed that application of 3/4th N, P and K + Azotobacter + PSB + KSB was found most effective in bud emergence, days taken to spike emergence, size of florets, length of spikes, rachis length, of gladiolus (*Gladiolus hybrida*). Maximum number of spikes/plot and number of florets/spike, number of florets/spike and number of florets opened/spike, were recorded with application of 1/2 N, P and K + Azotobacter + PSB + KSB. However, days taken for opening of first floret were obtained when plants were fertilized with 3/4th N, P and K + Azotobacter + PSB. Maximum duration of flowering was obtained with application of 3/4th N, P and K + Azotobacter + KSB.

Kumar et al. (2015) conducted an experiment to see the response of different source of nutrients in gladiolus (*Gladiolus hybridus* Hort.). Results revealed that using 50% RDF + 50% VC + 2.0 g/plant Azospirillum + 2.0 g/plant PSB, produced maximum number of florets, number of spikes per corm, diameter of flower, while maximum length of spike and rachis was produced by 50% RDF + 50% NeemCake + 2.0 g/plant Azospirillum + 2.0 g/plant PSB.

Dahlia

Sheergojri et al. (2013) evaluated the effect of three nitrogen levels (50, 75 and 100 kg ha⁻¹), two phosphorus levels (100 and 125 kg ha⁻¹) and three biofertilizers (*Bacillus* sp., *Pseudomonas* sp. and *Azotobacter* sp.) on floral characteristics of dahlia (*Dahlia variabilis* Desf.) cv. 'Pink Attraction'. Amongst the biofertilisers, *Azotobacter* proved superior in improving flower diameter, peduncle length and number of flowers plant⁻¹. *Azotobacter* showed significant improvement in various flower parameters.

Narcissus

Naggar (2010) evaluated the effect of applying compost and mineral NPK fertilizer 19:19:19 in presence or absence of biofertilizers Nitroline (containing *Azotobacter chroococcum* and *Azospirillum brasilense*) and Phosphorein (containing phosphate dissolving bacteria) on growth, flowering, bulbs production, total chlorophylls and mineral contents of *Narcissus Tazetta L.* plants. The results expressed that all biofertilizer treatment significantly increased most of the studied flowering parameters (number of flowers/spike, spike length and diameter).

2.3: Vase life parameters

Tuberose

Kukde et al. (2006) conducted an experiment to study the effect of organic manures and biofertilizers on growth, flowering and yield of tuberose cv. Single. The results revealed that the tuberose bulb treated with *Azotobacter* and PSB at 2.5 g kg⁻¹ bulb gave better flower quality parameter, maximum yield of flowers ha⁻¹ and also fresh weight of bulb plant⁻¹.

Pandhare et al. (2009) studied the effect of bioinoculants with graded doses of inorganic fertilizers on flower quality and yield of tuberose. Use of bioinoculants with reduced doses of inorganic fertilizers significantly influenced the spike yield and quality of tuberose. Significantly maximum yield and yield contributing characters like number of florets per spike and per plant, weight of loose flowers per plant were found with the application of 75% NP and 100%K i.e. 150:225:200 kg ha⁻¹ along with pre planting treatment of bulb with *Azotobacter* and PSB.

Lal et al. (2010) studied the effect of organic manures and biofertilizers on growth, flowering and bulb production in tuberose cv. Single. Tuberose cultivar Single when grown with PSB @ 1 kg/m² produced highest weight of bulbs per plant, i.e. clump weight and longevity of spikes.

Hadwani et al. (2013) conducted an experiment to see the response of biofertilizers on ratoon tuberose cv. Double and observed that application of ½ RDF + NeemCake @ 1 t/ha + PSB @ 1 g/m² + *Azotobacter* @ 1 g/m² show the best results with respect to longest vase life and *in situ* longevity of spike.

Taher et al. (2014) assessed the effects of nitrogen (N) fertilizer and phosphate solubilizing bacteria (PSB) on growth and quantitative traits of tuberose (*Polianthes tuberosa* L.) and observed that application of 200 kg/ha N and 10 kg/ha microbial fertilizer containing PSB resulted in the highest yield and quantitative traits for tuberose.

Wasim et al. (2014) conducted an experiment to evaluate the influence of biofertilizers on growth and flowering of tuberose (*Polianthes tuberosa* L.) cv. Mexican single with different levels of inorganic fertilizers. All the biofertilizers significantly improve different floral characters as compared to control. However, for quantitative and qualitative spike production PSB was found more effective.

Meena et al. (2015) conducted an experiment to find out the response of integrated nutrient management on floral, bulb and economic parameters in tuberose cv. Phule Rajani. Application of Azotobacter @ 2 g plant⁻¹ + PSB @ 2 g plant⁻¹ + 60% recommended dose of NPK through inorganic fertilizers showed significant influence on floret weight, spike weight with highest trends in this treatment, which was found better over the recommended dose of NPK through inorganic fertilizers + Azotobacter @ 2 g plant⁻¹ + PSB @ 2 g plant⁻¹.

Gladiolus

Chaudhari et al. (2013) reported that when corms of gladiolus (*Gladiolus grandiflorus* L.) cv. American Beauty were treated with AZT & PSB show the better performance with respect to weight of florets per spike.

Ali et al. (2014) conducted a trial to see the effect of different biofertilizer on growth and flower quality characteristics of Gladiolus (*Gladiolus grandiflorus* L.). Results showed that all reproductive growth accomplished successfully by application of biofertilizers. However, the treatment containing Azospirillum gained maximum Florets fresh weight than rest of the treatments. So, in this experiment Biofertilizer has been identified as an alternative to chemical fertilizer in order to increase soil fertility and crop production in sustainable farming.

Singh et al. (2014) carried out an investigation on flowering in gladiolus (*Gladiolus grandiflorus* L.) cv. "White Prosperity" and observed that treatment 75% RDF + 2 Tonnes of Vermicompost + PSB(2.5 kg/ha) + Azotobacter (2.5kg/ha) was found best with respect of vase life of longevity of spike.

Panusuria and chauhan (2015) conducted an experiment to investigate the effect of organic, inorganic and biofertilizer on growth, yield and quality of gladiolus cv. Psittacinus hybrid. Among all the treatments, application of 75% RDF + NeemCake @ 1 t/ha + Azoto. @ 2 kg/ha + PSB @ 2 kg/ha show the best results with respect to fresh weight of whole spikes, vase life and longevity of spike.

Dahlia

Sheergojri et al. (2013) evaluated the effect of three nitrogen levels (50, 75 and 100 kg ha⁻¹), two phosphorus levels (100 and 125 kg ha⁻¹) and three biofertilizers (Bacillus sp., Pseudomonas sp. and Azotobacter sp.) on vegetative and floral characteristics of dahlia (*Dahlia variabilis* Desf.) cv. 'Pink Attraction' the application of 75 kg N ha⁻¹ + 100 kg P ha⁻¹ + Azotobacter gave better results with respect to flower fresh weight and vase life.

CHAPTER - III
MATERIALS AND
METHODS

Chapter - III

MATERIALS AND METHODS

The experimental materials and criteria used for treatment evaluation during the course of investigation are being presented in this chapter. The field experiment entitled **“Effect of biofertilizers on growth and flowering of tuberose (*Polianthes tuberosa* L.) under Malwa region of M.P.”** was conducted during March to August 2016. Details of the methods and techniques followed in the experiment are given below.

3.1: Experimental Site

The experiment was laid out at the K.N.K. College of Horticulture, Mandsaur (M.P.) during March to August 2016. Mandsaur is situated in Malwa plateau in Western part of Madhya Pradesh at North latitude of 23.45° to 24.13° and 74.44° to 75.18° East longitudes and an altitude of 435.02 meters above mean sea level. This region falls under Agro climatic zone no.10 of the state.

3.2: Climate of the Region

Mandsaur belongs to sub-tropical climate having a temperature range of minimum 5°C and maximum 44°C in winter and summer, respectively. In this area, most of the rainfall is received during mid-June to mid September with occasional showers in winter. South-west monsoon is responsible for major portion of annual precipitation. The average rainfall is 797.6 mm. Meteorological data recorded during the period of investigation are presented in Table 3.1 and are graphically shown in Fig 3.1.

Table 3.1: Climatic variables of the period of investigation (March to August, 2016)

Number of Week		Temperature (°C)		Humidity (%)	Rainfall (mm)
		Min.	Max.		
09	01/03/16-07/03/16	17.7	33.7	64	01.3
10	08/03/16-14/03/16	18.0	34.2	64	-
11	15/03/16-21/03/16	17.9	34.5	60	-
12	22/03/16-28/03/16	20.4	36.6	63	-
13	29/03/16-04/04/16	21.6	38.6	59	-
14	05/04/16-11/04/16	20.9	39.5	60	-
15	12/04/16-18/04/16	21.5	39.9	56	-
16	19/04/16-25/04/16	19.3	35.6	46	-
17	26/04/16-02/05/16	23.4	42.4	47	-
18	03/05/16-09/05/16	25.2	41.4	49	-
19	10/05/16-16/05/16	27.2	41.3	53	-
20	17/05/16-23/05/16	27.8	43.4	43	-
21	24/05/16-30/05/16	27.1	40.7	53	-
22	31/05/16-06/06/16	28.2	41.8	60	-
23	07/06/16-13/06/16	27.5	41.8	70	-
24	14/06/16-20/06/16	26.8	37.9	77	01.7
25	21/06/16-27/06/16	24.8	35.4	82	47.2
26	28/06/16-04/07/16	24.1	34.2	83	103.4
27	05/07/16-11/07/16	23.3	32.6	78	94.2
28	12/07/16-18/07/16	23.8	29.7	84	60.9
29	19/07/16-25/07/16	25.6	30.4	81	24.2
30	26/07/16-31/07/16	21.8	24.1	61	27.7
31	01/08/16-07/08/16	23.7	28.2	86	130.1
32	08/08/16-14/08/16	22.8	28.2	85	103.3

Source: Meteorological observatory, College of Horticulture
Mandsaur,(M.P)

**Fig. 3.1: Weekly meteorological observation during the study period
(March to August, 2016)**

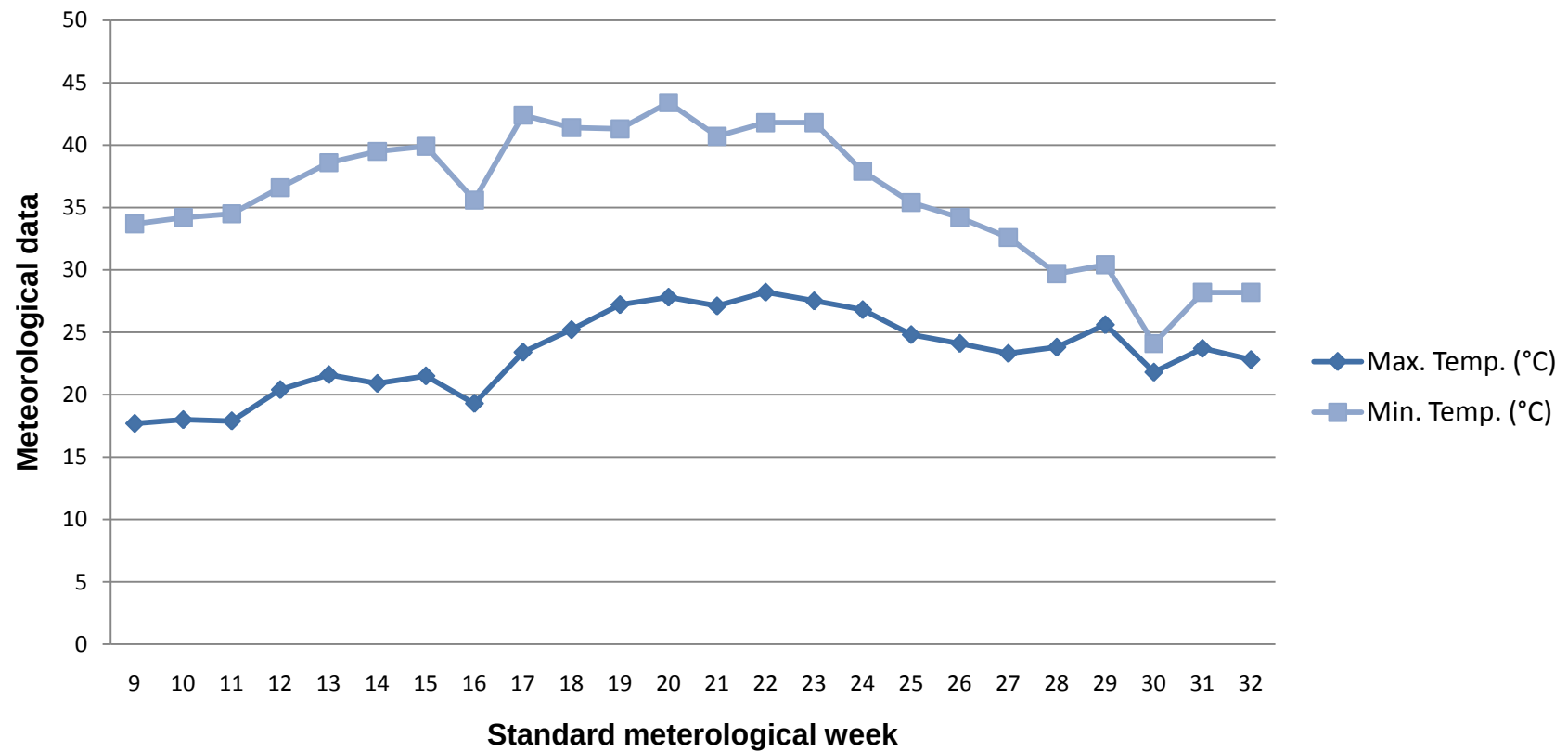


**Fig. 3.2: Weekly meteorological observation during the study period
(March to August, 2016)**

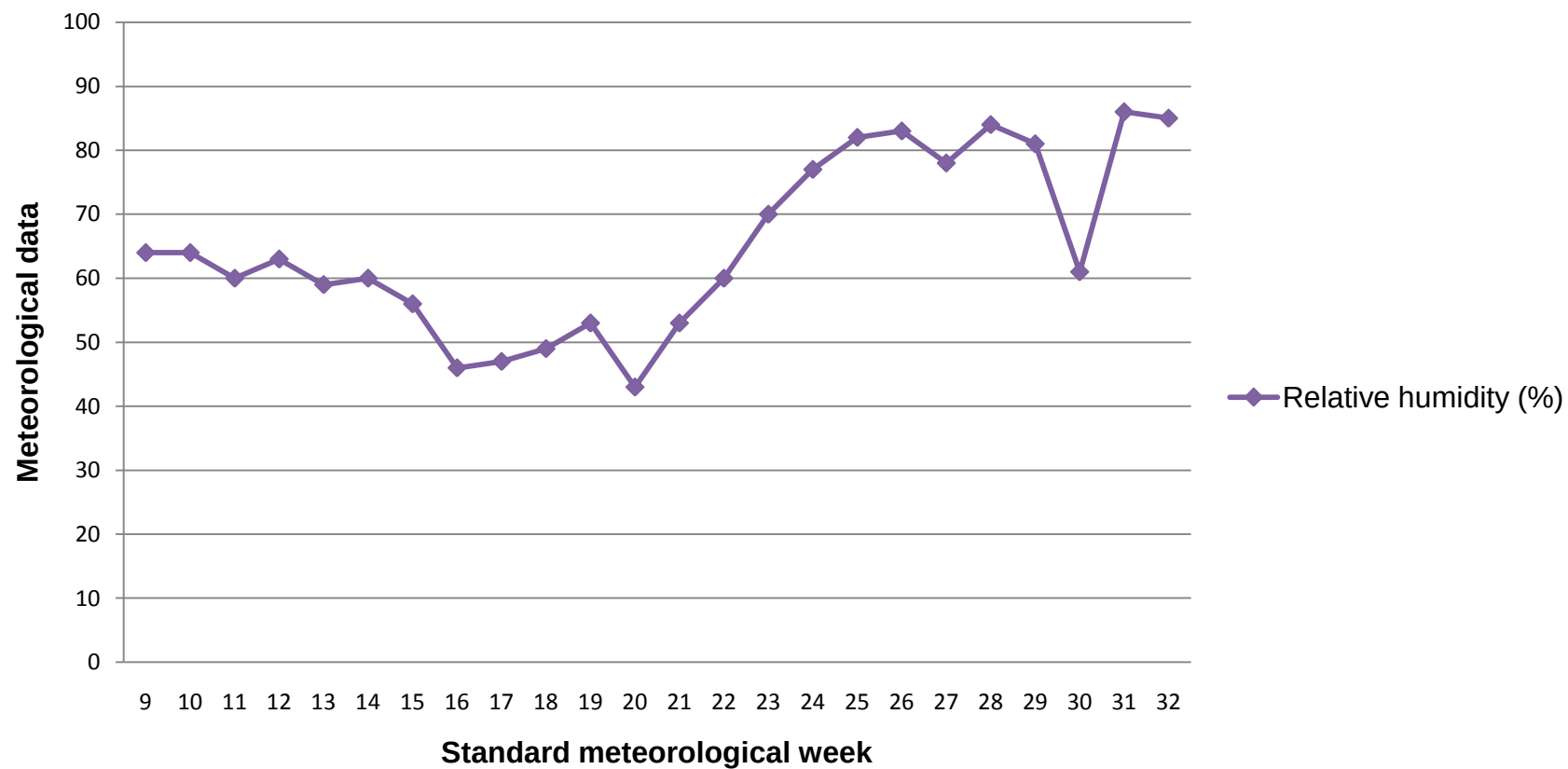
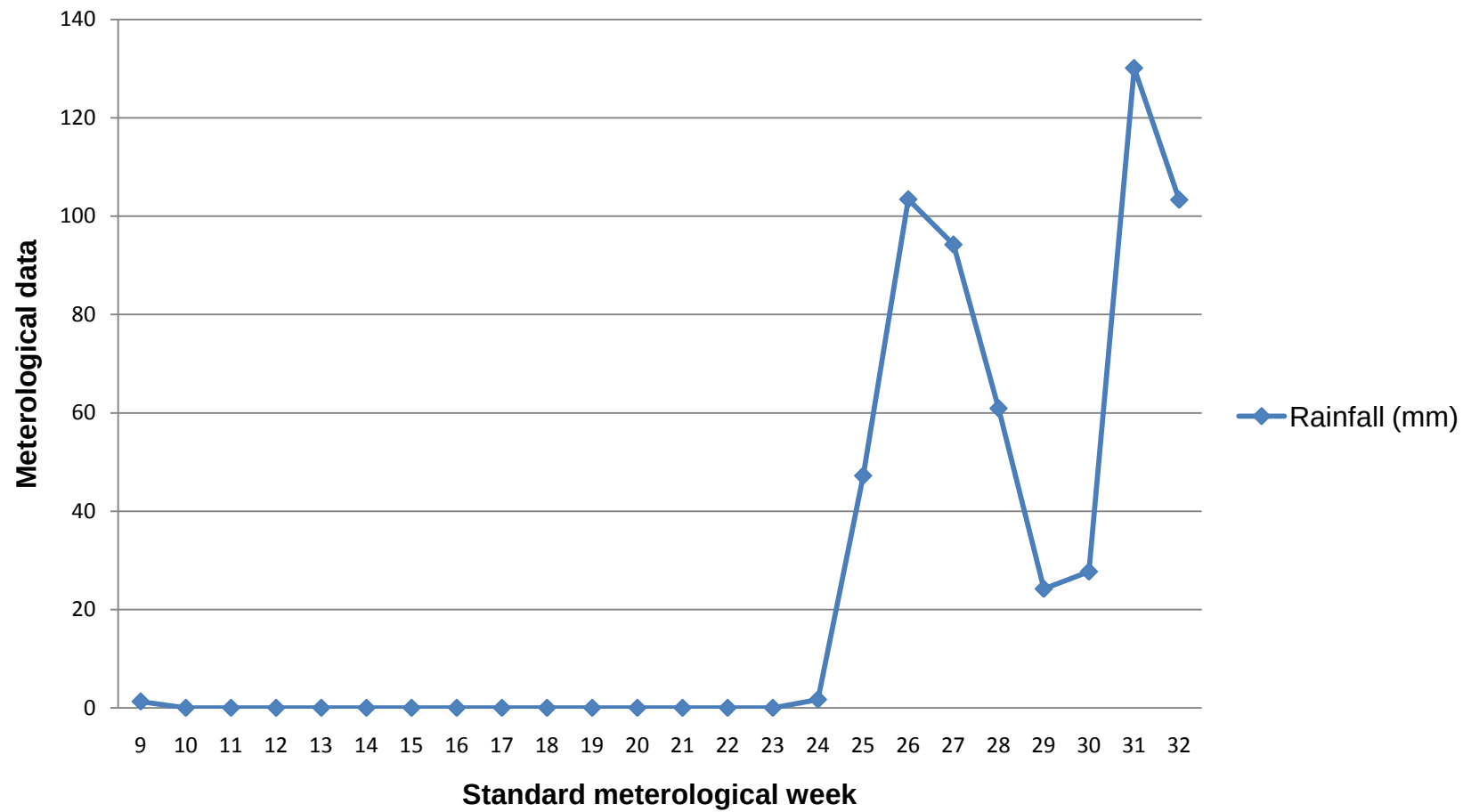


**Fig. 3.3: Weekly meteorological observation during the study period
(March to August, 2016)**



3.3: Experimental Details

K. N. K. College of Horticultur, Mandsaur (M.P.)

Name of crop	Tuberose
Variety	Shringar
Season	2015 - 2016
Design	RBD
No. of Treatments	08
Number of Replications	03
Number of Plots	24
Plot Size	1.50m × 1.50m
Total area	14.10m × 5.50m = (77.55m ²)
Date of planting	3 rd March, 2016

Table 3.2: Treatment details:

Treatment No.	Treatment Combinations
T₁	RDF + Azotobacter @ 2.0 kg/ha + PSB @ 2.0 kg/ha
T₂	RDF + Azotobacter @ 2.5 kg/ha + PSB @ 2.5 kg/ha
T₃	RDF + Azotobacter @ 3.0 kg/ha + PSB @ 3.0 kg/ha
T₄	RDF + Azotobacter @ 3.5 kg/ha + PSB @ 3.5 kg/ha
T₅	RDF + Azotobacter @ 4.0 kg/ha + PSB @ 4.0 kg/ha
T₆	RDF + Azotobacter @ 4.5 kg/ha + PSB @ 4.5 kg/ha
T₇	RDF + Azotobacter @ 5.0 kg/ha + PSB @ 5.0 kg/ha
T₈	RDF only

Fig. 3(2): Experimental design and layout

The description of design and layout is as follows:

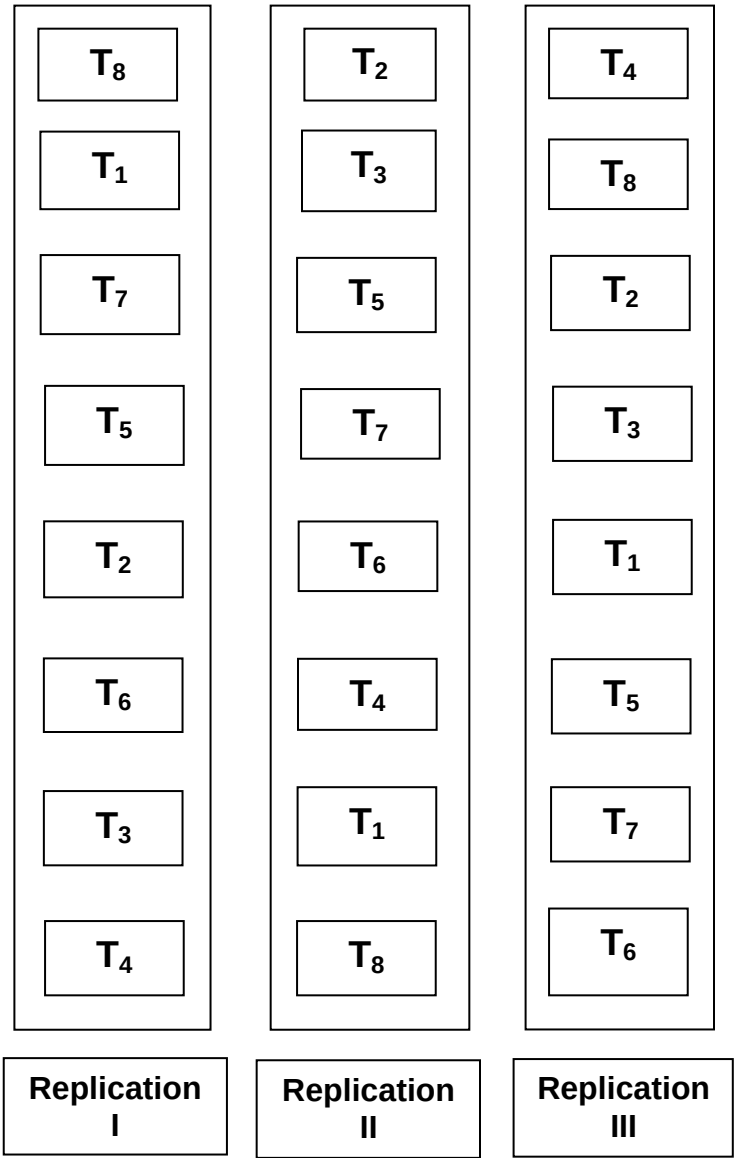
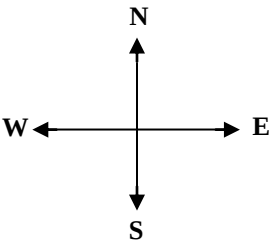




Plate 1:- View of experimental field

Table 3.3: Chemical analysis of soil

S. No.	Chemical	Contents	Remarks
1	Available nitrogen (kg/ha)	190	Low
2	Available P ₂ O ₅ (kg/ha)	12.50	Medium
3	Available K ₂ O (kg/ha)	320	Medium
4	pH	8.3	High
5	Electrical conductivity (mmhos/cm)	0.45	Normal

3.4: Source of planting material

The bulbs of tuberose were obtained from Department of Floriculture and Landscape Architecture, College of Horticulture, Mandsaur (M.P.).

3.5: Cultural practices

The details of cultural operations carried out during the course of investigation are furnished below.

3.5.1: Planting of tubers

One healthy bulb was planted in one pit. Before planting the bulb were dipped in fungicide carbendazim 2 g/litre of water for 15 minutes. Plants were planted at the centre of the pits. After planting, watering was done.

3.5.2: Irrigation

Irrigation was done at five to seven days interval from March to June.

3.5.3: Nutrient application

Nutrients were applied as full dose of P, K and half dose N at planting time and two split doses of N at 30 and 60 days after planting. Azotobacter and PSB were applied according to treatment.

3.5.4: Weeding:

Five hand weeding were given to remove the weeds during the entire growth period by Khurpi.

3.6: Observations recorded

3.6.1: Growth characteristics

3.6.1.1: Days taken to sprouting

The number of days taken for the bulb to sprout was counted starting from the day of planting and recorded.

3.6.1.2: Plant height (cm)

The height of the plant was measured from the ground level to the tip of the plant with the help of metre scale. The first observation was recorded at 45 days after planting and further at 15 days intervals.

3.6.1.3: Number of leaves per plant

Number of leaves per plant was counted and recorded. The first observation was recorded at 45 days after planting and further at 15 days intervals.

3.6.1.4: Leaf area per plant (cm²)

The leaf area per plant at blooming stage was measured using a leaf area metre.

3.7.2: Flowering characteristics

3.7.2.1: Days taken to spike emergence

The date when first spike emergence appeared on each tagged plant was noted and days to first spike emergence from the date of planting calculated and average values were worked out.

3.7.2.2: Days taken to flowering

Number of days taken from planting of bulbs to the blooming of first floret on each tagged plant were recorded.

3.7.2.3: Number of spikes per plant

Number of spikes per plant was counted and recorded.

3.7.2.4: Length of spike (cm)

Length of spike was calculated by measuring the length from the base of spike to the last of the florets.

3.7.2.5: Number of florets per spike

Number of florets present in each spike was counted and recorded.

3.7.2.6: Length of florets (cm)

Length of florets was measured by electronic digital calipers in cm, vertically at full bloom stage.

3.7.2.7: Diameter of florets (cm)

Diameter of floret was measured by electronic digital caliper in cm, horizontal at full bloom stage.

3.7.2.8: Flower duration (days)

The number of days from first floret open to the end of flowering was counted and recorded from the tagged plants and the average was calculated.

3.8.3: Vase life characteristics:

3.8.3.1: Vase life of cut spike (days)

The vase life of cut spikes was observed by placing them in distilled water and counting the number of days before senescence symptoms like wilting and shedding of florets occurred.

3.8.3.2: Fresh weight (g) of cut spike at harvest

The fresh weight of spikes immediately after harvest was recorded with the help of an electronic balance.

3.8.3.3: Fresh weight (g) of cut spike on 3rd day in vase

Cut spikes were removed from the distilled water on the 3rd day in the vase and weighed with the help of electronic balance.

3.8.3.4: Fresh weight (g) of cut spike on 6th day in vase

Cut spikes were removed from the distilled water on the 6th day in the vase and weighed with the help of electronic balance.

3.8.3.5: Fresh weight (g) of cut spike at senescence

Cut spikes were removed from the distilled water at senescence and weighed with the help of electronic balance.

Table 3.4: Statistical Analysis

To test significance of variation in the data obtained, the analysis of variance technique was adopted as suggested by Pance and Sukhatme (1984) for Randomized Block Design. The analysis of variance for different characteristics is presented in Appendix. The Skeleton of ANOVA as per design is as given in Table below:

S.V.	D.F.	SS	MSS	F cal.	F tab.
Treatment	7	TSS	TMS	TMS/EMS	
Replication	2	RSS	RMS	RMS/EMS	
Error	14	ESS	EMS		
Total	23				

The critical difference (C.D.) was calculated to assess the significance of difference between treatments, whenever the results were found significant through 'F' test, CD at 5 % level of significance was determined. S.Em. and CD are calculated using the following formula.

$$\text{S.Em. } \pm = \sqrt{\frac{\text{EMS}}{R}}$$

$$\text{CD} = \text{S.Em. } \pm \times \sqrt{2} \times t_{5\%}(\text{edf})$$

Where

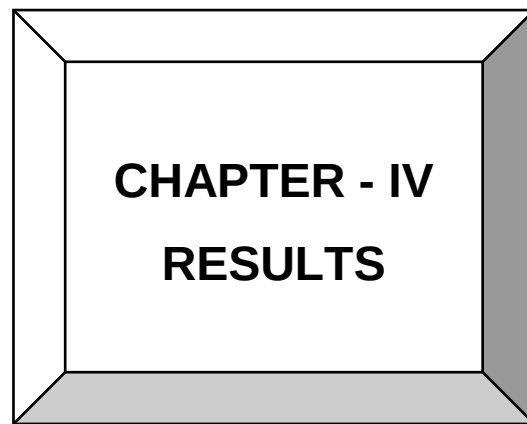
EMS : Error mean sum of squares

R : Replications

$t_{5\% (edf)}$: Table value at error degree of freedom

S. E m. $\pm$: Standard error of mean

CD : Critical difference



CHAPTER - IV
RESULTS

Chapter - IV

RESULTS

The results of the experiment entitled “**Effect of biofertilizers on growth and flowering of tuberose (*Polianthes tuberosa* L.) under Malwa region of M.P.**” have been presented in this chapter. The data pertaining to various characters were subjected to statistical analysis by using RBD. In support of the tabular representation of data, graphical representation has also been presented in this chapter to provide better comprehension of the characters.

A. 4.1: Growth parameters:

4.1.1: Days taken to sprouting

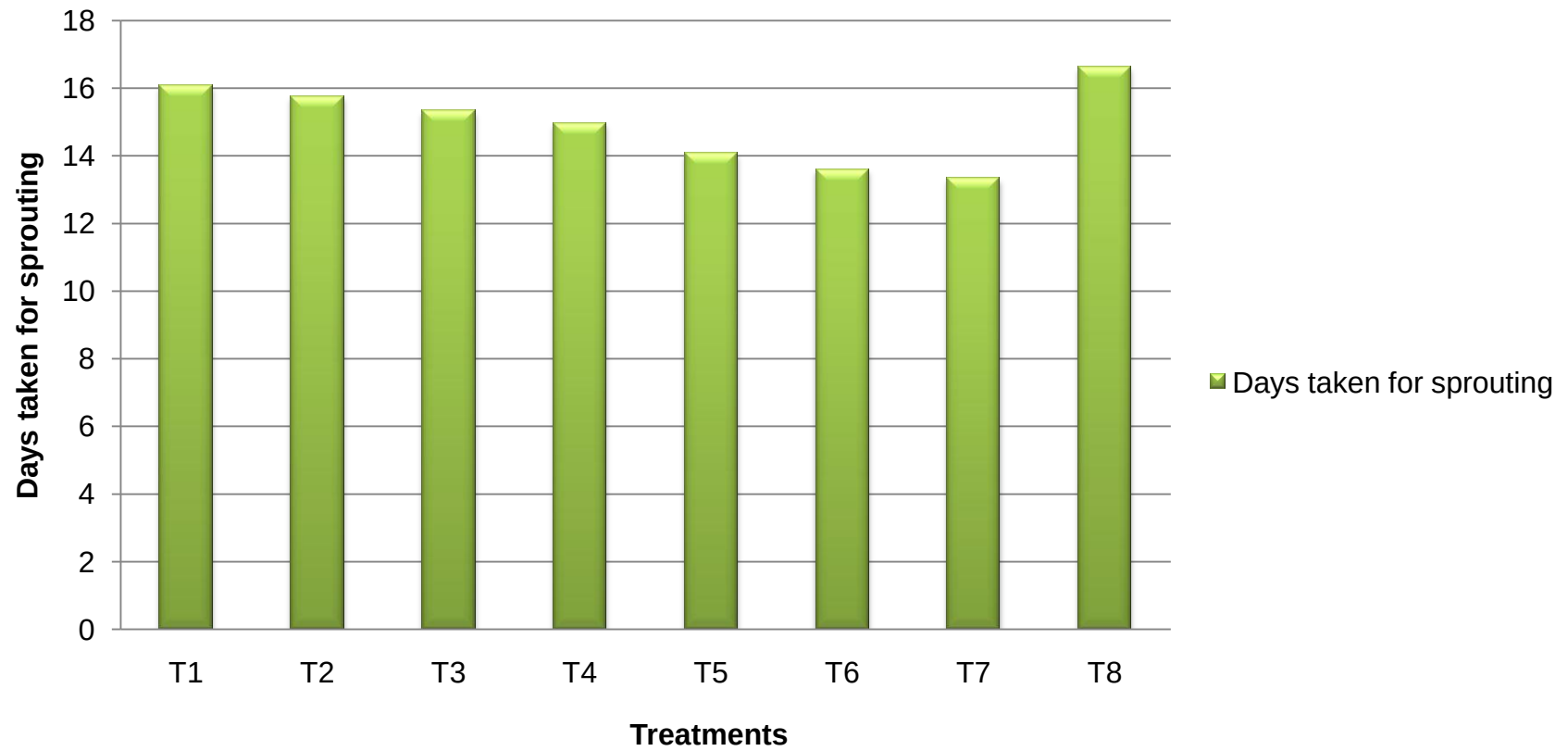
It is evident from Table 4.1 and Fig. 4.1 that the effect of biofertilizers on the number of days taken for sprouting was statistically non-significant.

It can be observed from Table 4.1 that among biofertilizers dose T₇ (RDF + Azotobacter @ 5.0 kg/ha + PSB @ 5.0 kg/ha) recorded the earliest bulb sprouting (13.33 days) followed by T₆ (RDF + Azotobacter @ 4.5 kg/ha + PSB @ 4.5 kg/ha), T₅ (RDF + Azotobacter @ 4.0 kg/ha + PSB @ 4.0 kg/ha) and T₄ (RDF + Azotobacter @ 3.5 kg/ha + PSB @ 3.5 kg/ha), which recorded values of 13.60, 14.07 and 14.97 days respectively, while the most delayed sprouting (16.63 days) was recorded under T₈ (control).

Table 4.1: Effect of biofertilizers on the number of days taken for sprouting

Treatment	Treatment Combinations	Days taken for sprouting
T₁	RDF + Azotobacter @ 2.0 kg/ha + PSB @ 2.0 kg/ha	16.07
T₂	RDF + Azotobacter @ 2.5 kg/ha + PSB @ 2.5 kg/ha	15.77
T₃	RDF + Azotobacter @ 3.0 kg/ha + PSB @ 3.0 kg/ha	15.33
T₄	RDF + Azotobacter @ 3.5 kg/ha + PSB @ 3.5 kg/ha	14.97
T₅	RDF + Azotobacter @ 4.0 kg/ha + PSB @ 4.0 kg/ha	14.07
T₆	RDF + Azotobacter @ 4.5 kg/ha + PSB @ 4.5 kg/ha	13.60
T₇	RDF + Azotobacter @ 5.0 kg/ha + PSB @ 5.0 kg/ha	13.33
T₈	RDF only	16.63
S.Em.±		1.11
C.D. at 5%		3.37

Fig. 4.1: Effect of biofertilizers of days taken for sprouting



4.1.2: Plant height (cm)

Table 4.2 and Fig. 4.2 show the plant height (cm) recorded from 45 DAP to 90 DAP. It can be observed that there is a steady and continuous increase in plant height from 45 DAP to 90 DAP in all the treatments.

It is evident from the Table 4.2 that the biofertilizers treatments were statistically superior to T₈ (control) in terms of plant height (cm) recorded during all the stages of observation.

At 45 DAP, T₇ (RDF + Azotobacter @ 5.0 kg/ha + PSB @ 5.0 kg/ha) recorded the maximum plant height (26.42 cm) which was statistically similar to T₆ (RDF + Azotobacter @ 4.5 kg/ha + PSB @ 4.5 kg/ha) which recorded the value of 26.32 cm and superior to all other treatments. The minimum plant height (23.46 cm) at this stage was recorded by T₈ (control).

At 60 DAP the maximum plant height (34.00 cm) was recorded with T₇ (RDF + Azotobacter @ 5.0 kg/ha + PSB @ 5.0 kg/ha) followed by T₆ (RDF + Azotobacter @ 4.5 kg/ha + PSB @ 4.5 kg/ha), T₅ (RDF + Azotobacter @ 4.0 kg/ha + PSB @ 4.0 kg/ha) and T₄ (RDF + Azotobacter @ 3.5 kg/ha + PSB @ 3.5 kg/ha) which recorded values of 33.11 cm, 33.00 cm and 32.50 cm respectively. The minimum plant height (30.11 cm) at this stage was recorded by T₈ (control).

A similar trend was observed at 75 DAP with T₇ (RDF + Azotobacter @ 5.0 kg/ha + PSB @ 5.0 kg/ha) recording the maximum plant height (39.78 cm) followed by T₆ (38.53 cm), T₅ (38.34 cm) and T₄ (37.15 cm). However, T₆ (RDF + Azotobacter @ 4.5 kg/ha + PSB @ 4.5 kg/ha) and T₇ (RDF + Azotobacter @ 5.0 kg/ha + PSB @ 5.0 kg/ha) treatments were statistically at par with one another. The minimum plant height at this stage (35.37 cm) was recorded by T₈ (control).

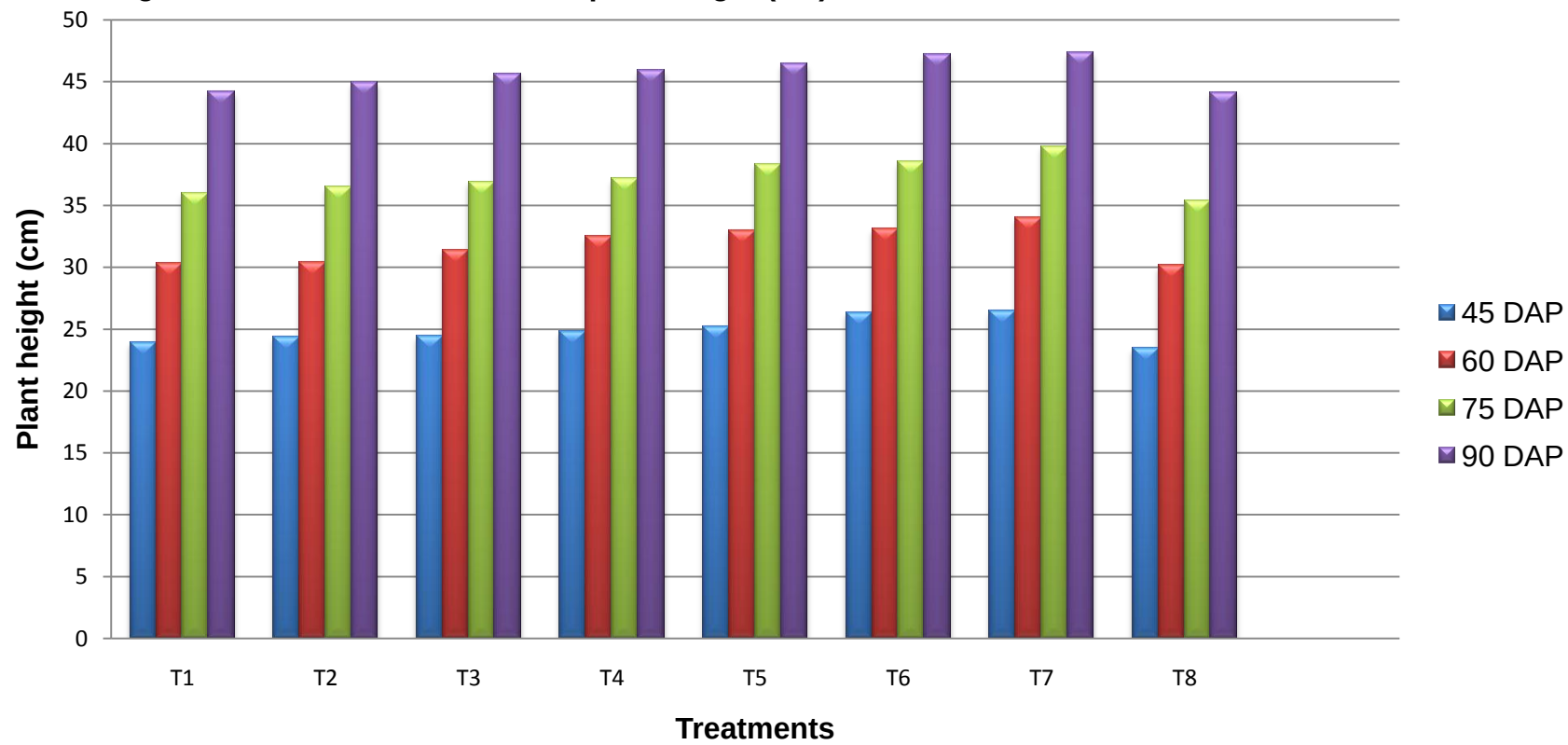
At 90 DAP also the maximum plant height (47.33 cm) was recorded with T₇ (RDF + Azotobacter @ 5.0 kg/ha + PSB @ 5.0 kg/ha) followed by T₆ (RDF + Azotobacter @ 4.5 kg/ha + PSB @ 4.5 kg/ha) and T₅ (RDF + Azotobacter @ 4.0 kg/ha + PSB @ 4.0 kg/ha), which recorded values of 47.23 cm and 46.40 cm respectively. These three

treatments show statistically similar with one another. The minimum plant height (44.14cm) at this stage was observed under T₈ (control).

Table 4.2: Effect of biofertilizers on plant height (cm)

Treatment	Treatment Combinations	Plant height (cm)			
		45 DAP	60 DAP	75 DAP	90 DAP
T ₁	RDF + Azotobacter @ 2.0 kg/ha + PSB @ 2.0 kg/ha	23.89	30.29	36.04	44.17
T ₂	RDF + Azotobacter @ 2.5 kg/ha + PSB @ 2.5 kg/ha	24.33	30.36	36.51	44.90
T ₃	RDF + Azotobacter @ 3.0 kg/ha + PSB @ 3.0 kg/ha	24.43	31.39	36.90	45.66
T ₄	RDF + Azotobacter @ 3.5 kg/ha + PSB @ 3.5 kg/ha	24.80	32.50	37.15	45.91
T ₅	RDF + Azotobacter @ 4.0 kg/ha + PSB @ 4.0 kg/ha	25.22	33.00	38.34	46.40
T ₆	RDF + Azotobacter @ 4.5 kg/ha + PSB @ 4.5 kg/ha	26.32	33.11	38.53	47.23
T ₇	RDF + Azotobacter @ 5.0 kg/ha + PSB @ 5.0 kg/ha	26.42	34.00	39.78	47.33
T ₈	RDF only	23.46	30.11	35.37	44.14
S.Em.±		0.37	0.19	0.45	0.31
C.D. at 5%		1.14	0.59	1.37	0.95

Fig. 4.2: Effect of biofertilizers on plant height (cm)



4.1.3: Number of leaves per plant

Table 4.3 and Fig. 4.3 show the number of leaves as influenced by biofertilizers recorded from 45 DAP to 90 DAP. It can be observed from the Table that the number of leaves showed a steady and continuous increase during all the stages of observation.

It is evident from the Table 4.3 that most of the treatments were significantly superior to T₈ (control) in terms of number of leaves per plant recorded during all the stages of observation.

At 45 DAP the maximum number of leaves (8.60) was recorded with T₇ (RDF + Azotobacter @ 5.0 kg/ha + PSB @ 5.0 kg/ha) followed by T₆ (RDF + Azotobacter @ 4.5 kg/ha + PSB @ 4.5 kg/ha) and T₅ (RDF + Azotobacter @ 4.0 kg/ha + PSB @ 4.0 kg/ha), which recorded values of 8.50 and 7.73 respectively. However, T₆ and T₅ were statistically at par with each other. The minimum number of leaves (6.20) at this stage was recorded under T₈ (Control).

At 60 DAP, the maximum number of leaves (15.60) was recorded by T₇ (RDF + Azotobacter @ 5.0 kg/ha + PSB @ 5.0 kg/ha) followed by T₆ (RDF + Azotobacter @ 4.5 kg/ha + PSB @ 4.5 kg/ha) and T₅ (RDF + Azotobacter @ 4.0 kg/ha + PSB @ 4.0 kg/ha), which recorded values of 15.12 and 15.11 respectively and all of these were statistically at par with each other. The minimum number of leaves (13.10) at this stage was recorded under T₈ (Control).

At 75 DAP, T₇ (RDF + Azotobacter @ 5.0 kg/ha + PSB @ 5.0 kg/ha) recorded the maximum number of leaves (23.03) followed by T₆ (RDF + Azotobacter @ 4.5 kg/ha + PSB @ 4.5 kg/ha) and T₅ (RDF + Azotobacter @ 4.0 kg/ha + PSB @ 4.0 kg/ha), which recorded values of 22.50 and 22.33. These treatments were statistically at par with one another. The minimum number of leaves per plant (20.10) at this stage was recorded with T₈ (Control).

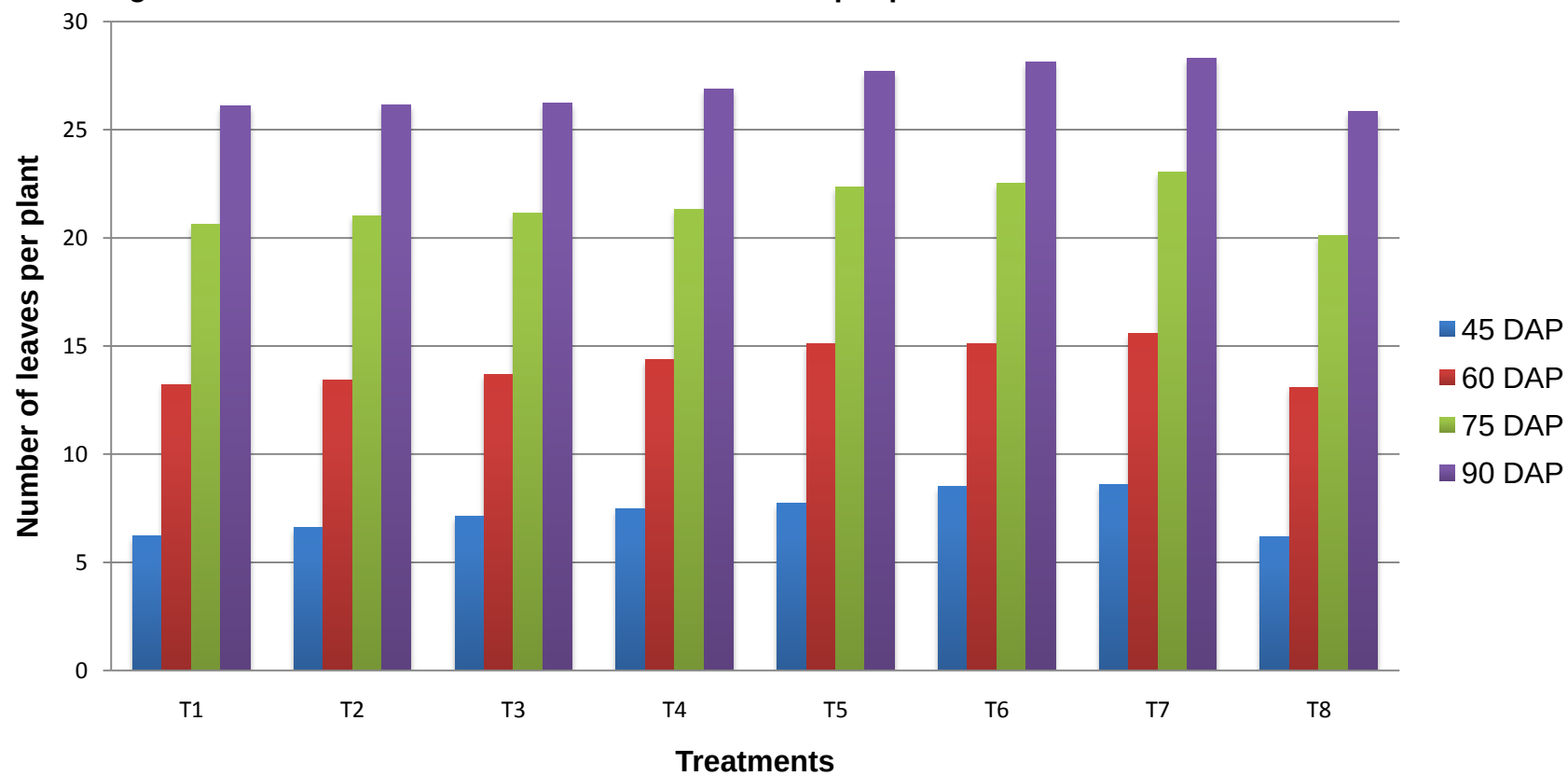
At 90 DAP also a similar trend was observed. The maximum number of leaves (28.30) was recorded with T₇ (RDF + Azotobacter @ 5.0 kg/ha + PSB @ 5.0 kg/ha) followed by T₆ (28.13) and T₅ (27.70), which were statistically at par with one another.

The minimum number of leaves per plant (25.83) at this stage was recorded under T₈ (Control).

Table 4.3: Effect of biofertilizers on the number of leaves per plant

Treatment	Treatment Combinations	Number of leaves			
		45 DAP	60 DAP	75 DAP	90 DAP
T₁	RDF + Azotobacter @ 2.0 kg/ha + PSB @ 2.0 kg/ha	6.23	13.23	20.63	26.10
T₂	RDF + Azotobacter @ 2.5 kg/ha + PSB @ 2.5 kg/ha	6.60	13.44	21.03	26.13
T₃	RDF + Azotobacter @ 3.0 kg/ha + PSB @ 3.0 kg/ha	7.13	13.68	21.13	26.23
T₄	RDF + Azotobacter @ 3.5 kg/ha + PSB @ 3.5 kg/ha	7.47	14.37	21.30	26.87
T₅	RDF + Azotobacter @ 4.0 kg/ha + PSB @ 4.0 kg/ha	7.73	15.11	22.33	27.70
T₆	RDF + Azotobacter @ 4.5 kg/ha + PSB @ 4.5 kg/ha	8.50	15.12	22.50	28.13
T₇	RDF + Azotobacter @ 5.0 kg/ha + PSB @ 5.0 kg/ha	8.60	15.60	23.03	28.30
T₈	RDF only	6.20	13.10	20.10	25.83
S.Em.±		0.30	0.18	0.25	0.22
C.D. at 5%		0.92	0.55	0.77	0.69

Fig. 4.3: Effect of biofertilizers on number of leaves per plant



4.1.4: Leaf area per plant (cm²)

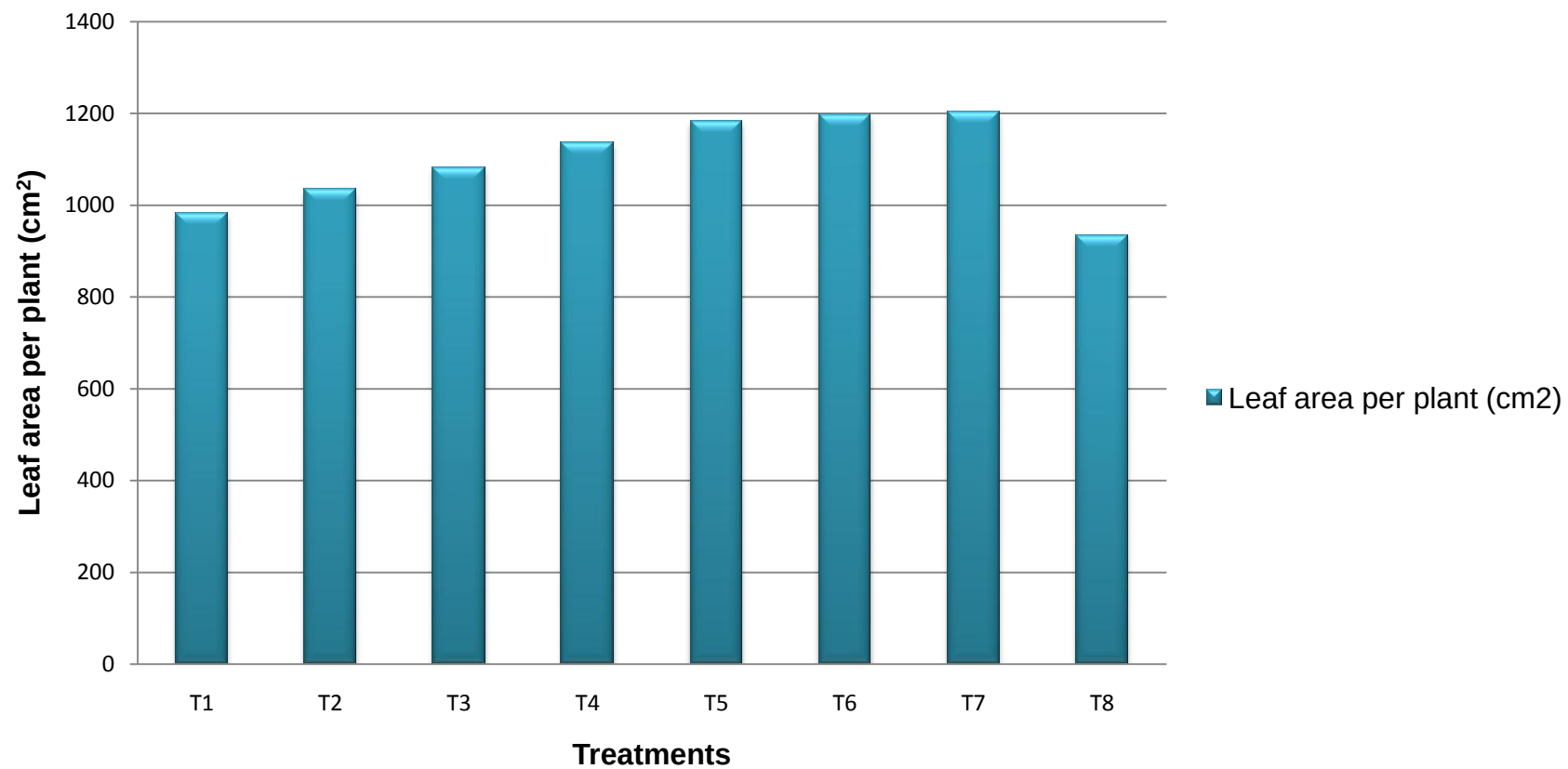
The data presented in Table 4.4 and Fig. 4.4 reveal that the effect of biofertilizers on leaf area per plant (cm²) was statistically significant.

It is evident from Table 4.4 that the maximum leaf area per plant (1202.80cm²) was recorded with T₇ (RDF + Azotobacter @ 5.0 kg/ha + PSB @ 5.0 kg/ha) followed by T₆ (RDF + Azotobacter @ 4.5 kg/ha + PSB @ 4.5 kg/ha), T₅ (RDF + Azotobacter @ 4.0 kg/ha + PSB @ 4.0 kg/ha) and T₄ (RDF + Azotobacter @ 3.5 kg/ha + PSB @ 3.5 kg/ha), which recorded values of 1196.47 cm², 1182.60 cm² and 1135.73 cm² respectively. However, the treatments T₆ and T₅ were statistically at par with each other. The minimum leaf area per plant (934.67cm²) was recorded with T₈ (control).

Table 4.4: Effect of biofertilizers on Leaf area per plant (cm²)

Treatment	Treatment Combinations	Leaf area per plant (cm²)
T₁	RDF + Azotobacter @ 2.0 kg/ha + PSB @ 2.0 kg/ha	982.27
T₂	RDF + Azotobacter @ 2.5 kg/ha + PSB @ 2.5 kg/ha	1035.40
T₃	RDF + Azotobacter @ 3.0 kg/ha + PSB @ 3.0 kg/ha	1082.53
T₄	RDF + Azotobacter @ 3.5 kg/ha + PSB @ 3.5 kg/ha	1135.73
T₅	RDF + Azotobacter @ 4.0 kg/ha + PSB @ 4.0 kg/ha	1181.60
T₆	RDF + Azotobacter @ 4.5 kg/ha + PSB @ 4.5 kg/ha	1196.47
T₇	RDF + Azotobacter @ 5.0 kg/ha + PSB @ 5.0 kg/ha	1202.80
T₈	RDF only	934.63
S.Em.±		6.83
C.D. at 5%		20.74

Fig. 4.4: Effect of biofertilizers on leaf area per plant (cm²)



B. 4.2: Flowering parameters:

4.2.1: Days taken to spike emergence

The data presented in Table 4.5 and Fig. 4.5 reveal that the effect of biofertilizers on days taken to spike emergence was statistically significant.

It is evident from the Table 4.5 and Fig. 4.5 that the earliest spike emergence (122.33 days) was recorded with T₇ (RDF + Azotobacter @ 5.0 kg/ha + PSB @ 5.0 kg/ha) followed by T₆ (RDF + Azotobacter @ 4.5 kg/ha + PSB @ 4.5 kg/ha), T₅ (RDF + Azotobacter @ 4.0 kg/ha + PSB @ 4.0 kg/ha) and T₄ (RDF + Azotobacter @ 3.5 kg/ha + PSB @ 3.5 kg/ha), which recorded values of 123.60 days, 124.60 days and 124.77 days respectively. The most delayed spike emergence (126.27 days) was recorded with T₈ (control).

4.2.2: Days taken to flowering

The data presented in Table 4.5 and Fig. 4.6 reveal that the effect of biofertilizers on days taken to flowering was statistically significant.

It is evident from the Table 4.5 and Fig. 4.6 that the earliest days taken to flowering (133.43 days) was recorded with T₇ (RDF + Azotobacter @ 5.0 kg/ha + PSB @ 5.0 kg/ha) followed by T₆ (RDF + Azotobacter @ 4.5 kg/ha + PSB @ 4.5 kg/ha), T₅ (RDF + Azotobacter @ 4.0 kg/ha + PSB @ 4.0 kg/ha) and T₄ (RDF + Azotobacter @ 3.5 kg/ha + PSB @ 3.5 kg/ha), which recorded values of (133.77 days), (134.13 days) and (135.00 days) respectively. However, T₆ (RDF + Azotobacter @ 4.5 kg/ha + PSB @ 4.5 kg/ha) and T₇ (RDF + Azotobacter @ 5.0 kg/ha + PSB @ 5.0 kg/ha) treatments were statistically at par with one another. The most delayed days taken to flowering (136.87 days) was recorded with T₈ (control).

4.2.3: Number of spikes per plant

The data presented in Table 4.5 and Fig. 4.7 reveal that the effect of biofertilizers on number of spikes per plant was statistically significant.

It can be seen from the Table 4.5 and Fig. 4.7 that the maximum number of spikes per plant (1.88) was recorded with T₇ (RDF + Azotobacter @ 5.0 kg/ha + PSB @

5.0 kg/ha) followed by T₆ (RDF + Azotobacter @ 4.5 kg/ha + PSB @ 4.5 kg/ha) and T₅ (RDF + Azotobacter @ 4.0 kg/ha + PSB @ 4.0 kg/ha), which recorded values of 1.77 and 1.40 respectively. However, T₆ (RDF + Azotobacter @ 4.5 kg/ha + PSB @ 4.5 kg/ha) and T₇ (RDF + Azotobacter @ 5.0 kg/ha + PSB @ 5.0 kg/ha) treatments were statistically at par with one another. The minimum number of spikes per plant (1.00) was recorded with T₈ (control).

4.2.4: Length of spike (cm)

The data presented in Table 4.5 and Fig. 4.8 reveal that the effect of biofertilizers on length of spike (cm) was statistically significant.

It is evident from the Table 4.5 that the maximum length of spike (77.17 cm) was recorded with T₇ (RDF + Azotobacter @ 5.0 kg/ha + PSB @ 5.0 kg/ha) followed by T₆ (77.03 cm) and T₅ (76.80 cm) and all of these three treatments were statistically at par with each other. The Minimum length of spike (74.13 cm) was recorded under T₈ (control).

Table 4.5: Effect of biofertilizers on the number of days taken to spike emergence, days taken to flowering, number of spikes per plant and length of spikes (cm)

Treatment	Treatment Combinations	Days taken to spike emergence	Days taken to flowering	Number of spikes per plant	Length of spike (cm)
T₁	RDF + Azotobacter @ 2.0 kg/ha + PSB @ 2.0 kg/ha	125.80	136.53	1.20	74.53
T₂	RDF + Azotobacter @ 2.5 kg/ha + PSB @ 2.5 kg/ha	125.33	136.37	1.27	75.27
T₃	RDF + Azotobacter @ 3.0 kg/ha + PSB @ 3.0 kg/ha	125.10	135.93	1.33	75.40
T₄	RDF + Azotobacter @ 3.5 kg/ha + PSB @ 3.5 kg/ha	124.77	135.00	1.37	76.13
T₅	RDF + Azotobacter @ 4.0 kg/ha + PSB @ 4.0 kg/ha	124.60	134.13	1.40	76.80
T₆	RDF + Azotobacter @ 4.5 kg/ha + PSB @ 4.5 kg/ha	123.60	133.77	1.77	77.03
T₇	RDF + Azotobacter @ 5.0 kg/ha + PSB @ 5.0 kg/ha	122.33	133.43	1.88	77.17
T₈	RDF only	126.27	136.87	1.00	74.13
S.Em.±		0.27	0.24	0.08	0.15
C.D. at 5%		0.83	0.73	0.26	0.48

Fig. 4.5: Effect of biofertilizers on days taken to spike emergence

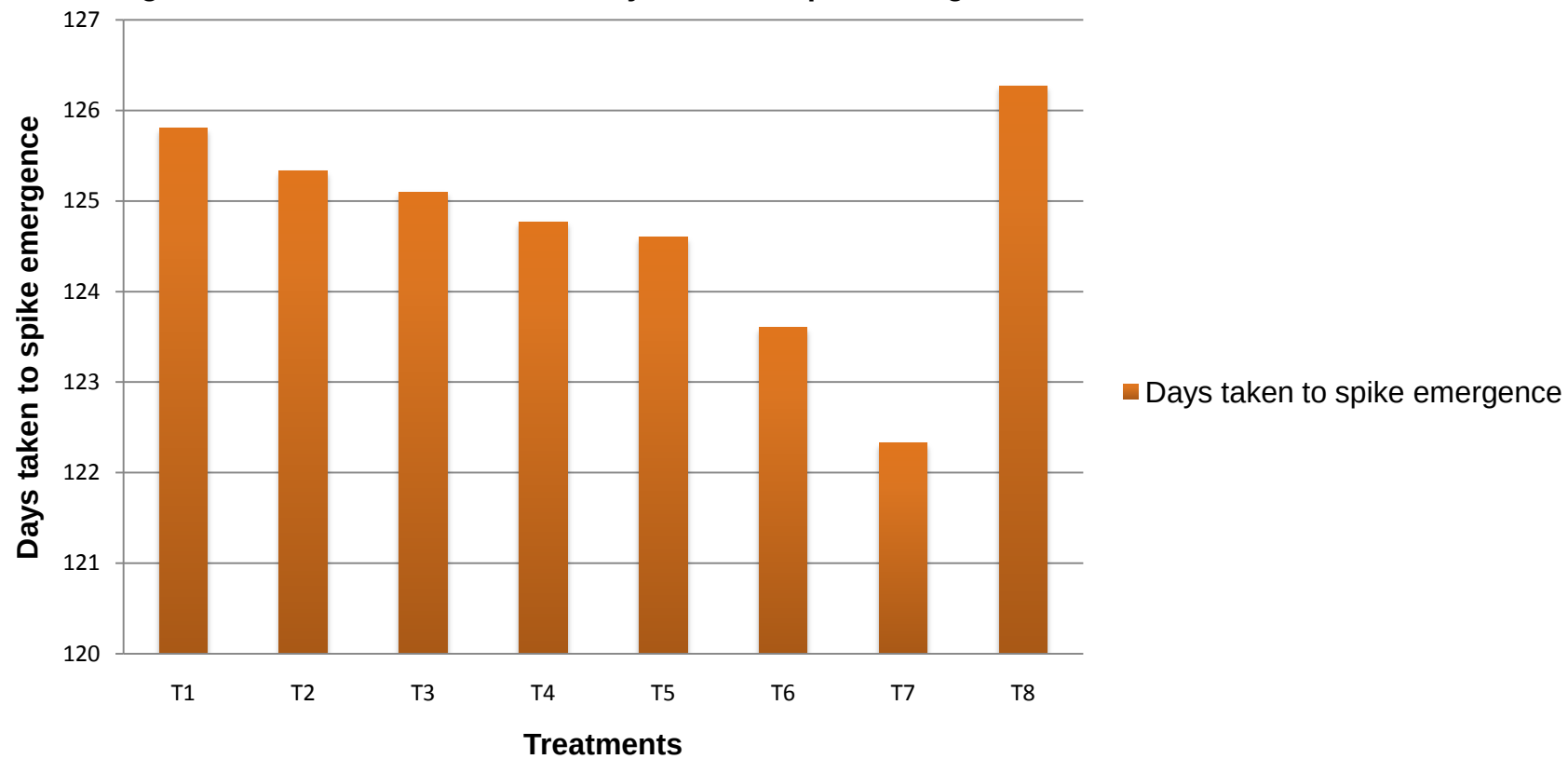


Fig. 4.6: Effect of biofertilizers on days taken to flowering

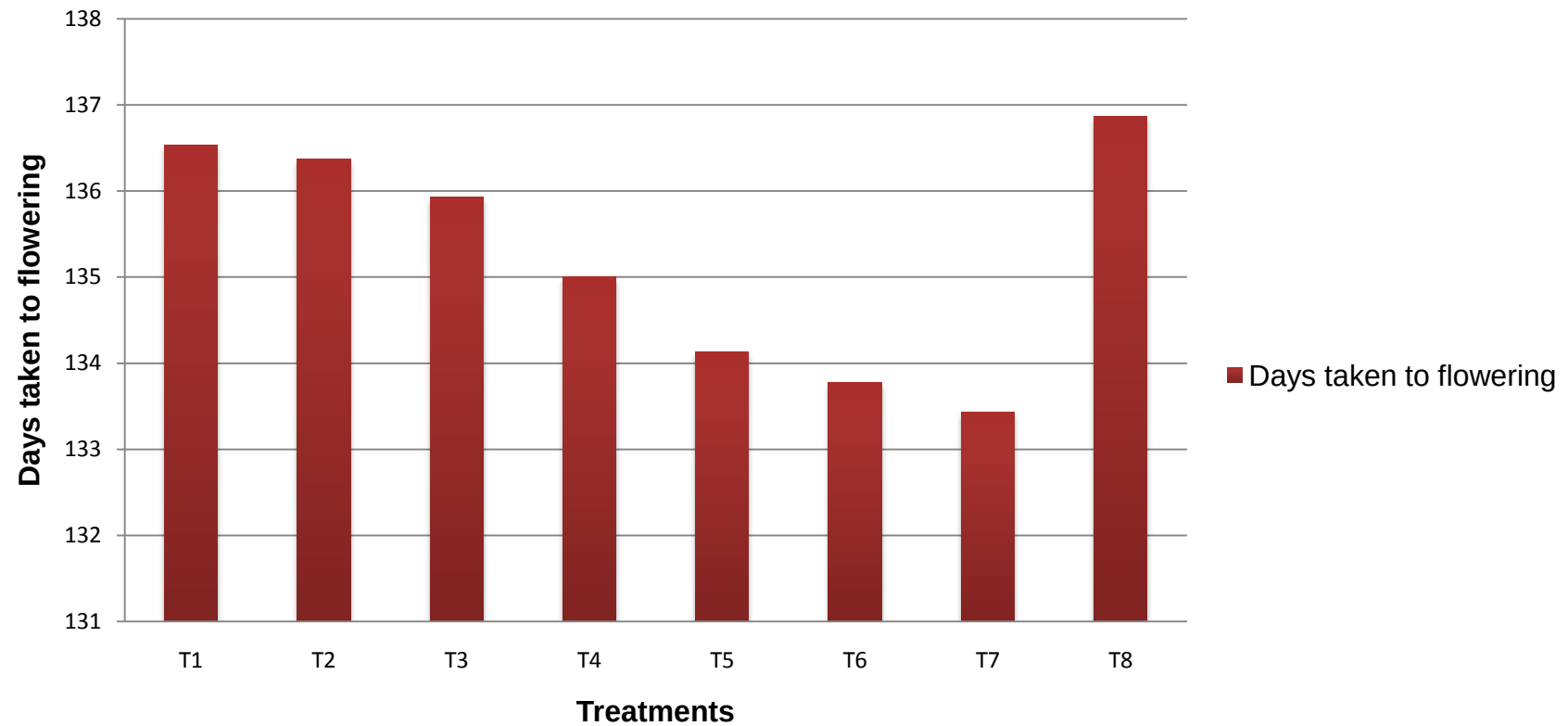


Fig. 4.7: Effect of biofertilizers on number of spikes per plant

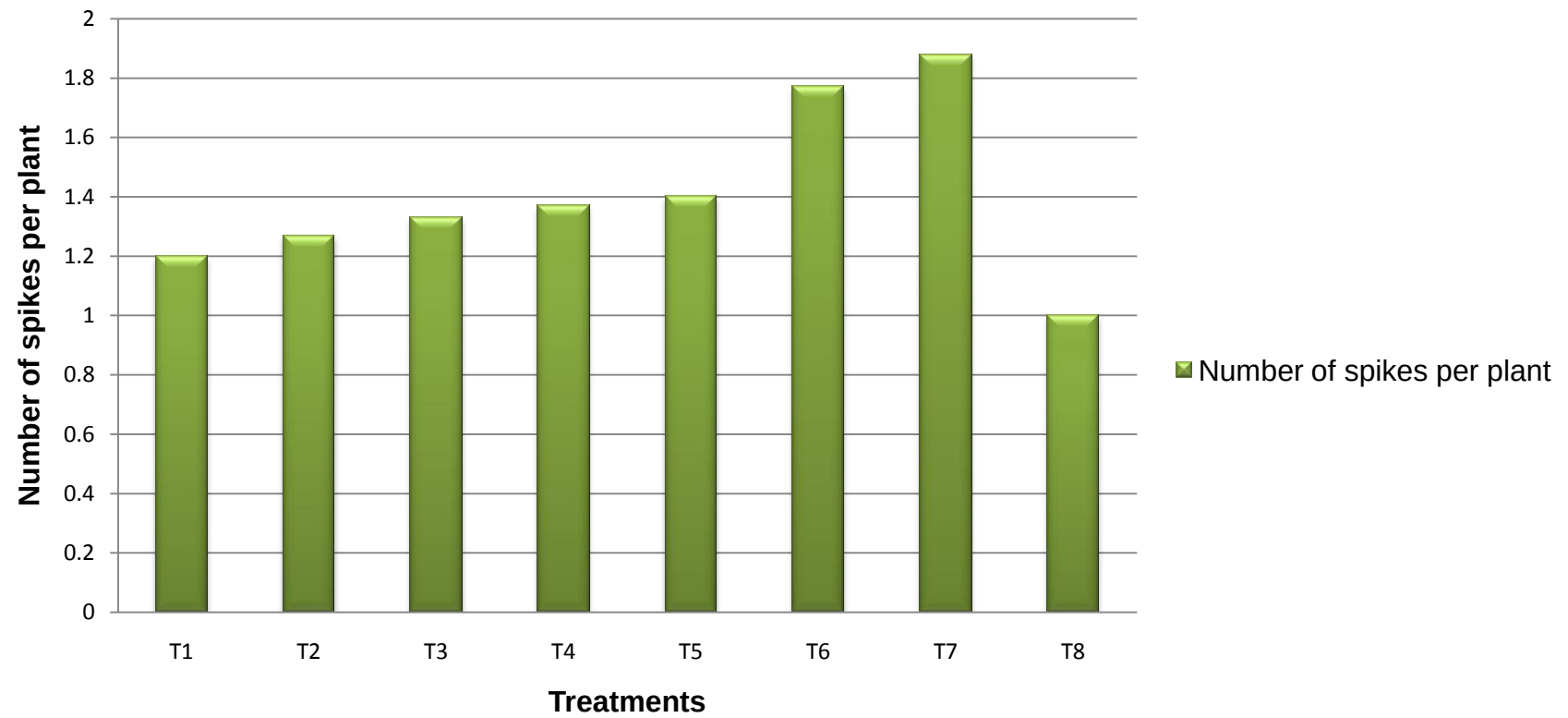
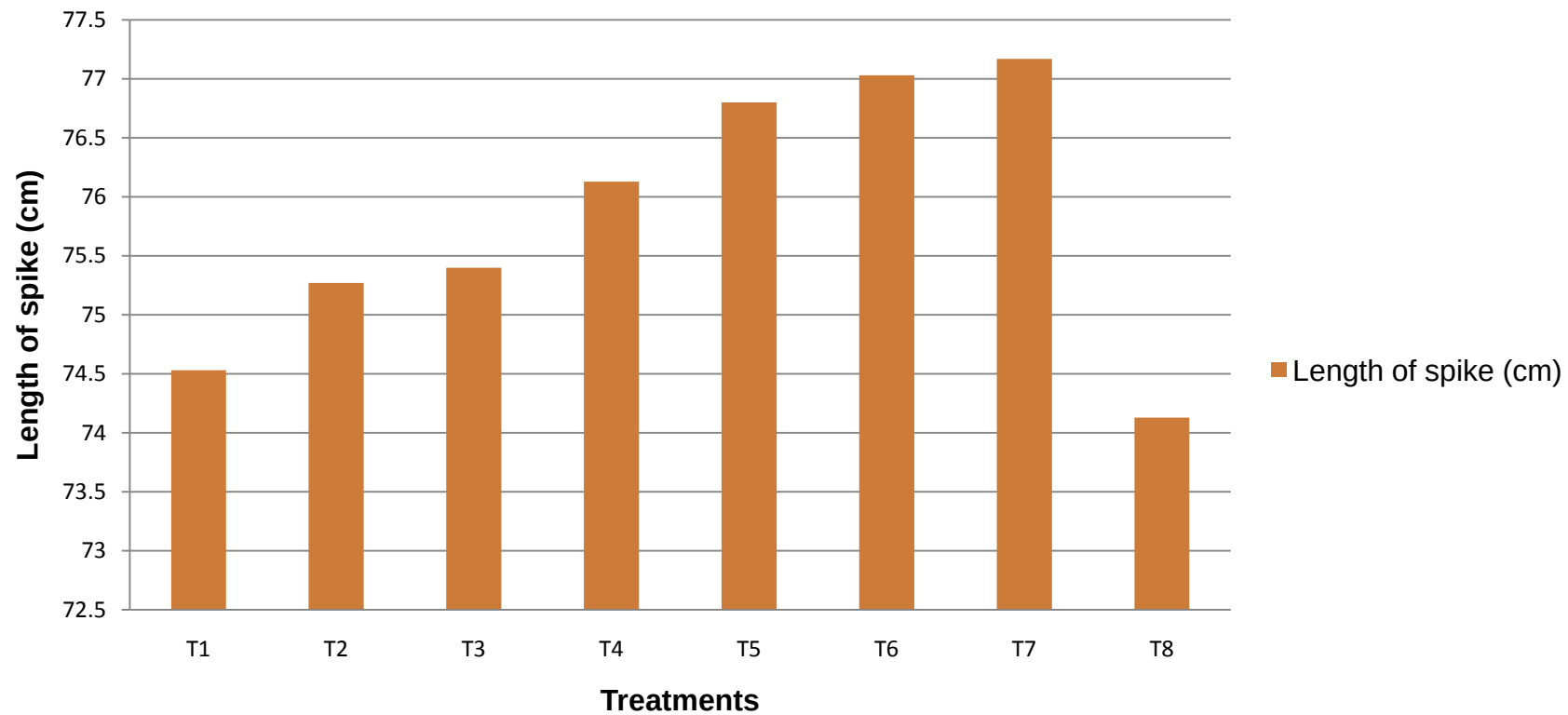


Fig. 4.8: Effect of biofertilizers on length of spike (cm)



4.2.5: Number of florets per spike

The data presented in Table 4.6 and Fig. 4.9 reveal that the effect of biofertilizers on number of florets per spike was statistically significant.

It is evident from the Table 4.6 and Fig. 4.9 that the maximum number of florets per spike (27.37) was recorded with T₇ (RDF + Azotobacter @ 5.0 kg/ha + PSB @ 5.0 kg/ha) followed by T₆ (RDF Azotobacter @ 4.5 kg/ha + PSB @ 4.5 kg/ha), T₅ (RDF + Azotobacter @ 4.0 kg/ha + PSB @ 4.0 kg/ha) and T₄ (RDF + Azotobacter @ 3.5 kg/ha + PSB @ 3.5 kg/ha), which recorded values of 27.30, 26.50 and 26.10 respectively. However, T₇, T₆ and T₅ were statistically at par with each other. The minimum number of florets per spike (24.43) was recorded under T₈ (control).

4.2.6: Length of florets (cm)

The data presented in Table 4.6 and Fig. 4.10 reveal that the effect of biofertilizers on length of florets (cm) was statistically significant.

It can be seen from the Table 4.6 and Fig. 4.10 that the maximum length of florets (3.84 cm) was recorded with T₇ (RDF + Azotobacter @ 5.0 kg/ha + PSB @ 5.0 kg/ha) followed by T₆ (RDF + Azotobacter @ 4.5 kg/ha + PSB @ 4.5 kg/ha), T₅ (RDF + Azotobacter @ 4.0 kg/ha + PSB @ 4.0 kg/ha) and T₄ (RDF + Azotobacter @ 3.5 kg/ha + PSB @ 3.5 kg/ha), which recorded values of 3.63cm, 3.63cm and 3.40 cm respectively. The minimum length of florets (3.10 cm) was recorded under T₈ (control).

4.2.7: Diameter of florets (cm)

The data presented in Table 4.6 and Fig. 4.11 reveal that the effect of biofertilizers on diameter of florets (cm) was statistically significant.

It can be observed from the Table 4.6 and Fig. 4.11 that the maximum diameter of florets (3.60 cm) was recorded with T₇ (RDF + Azotobacter @ 5.0 kg/ha + PSB @ 5.0 kg/ha) followed by T₆ (RDF + Azotobacter @ 4.5 kg/ha + PSB @ 4.5 kg/ha) and T₅ (RDF + Azotobacter @ 4.0 kg/ha + PSB @ 4.0 kg/ha) which recorded values of 3.54 cm and 3.44cm respectively and all of these three treatments were statistically at par with each other. The minimum diameter of florets (2.41 cm) was recorded with T₈ (control).

4.2.8: Flower duration (days)

The data presented in Table 4.6 and Fig. 4.12 reveal that the effect of biofertilizers on flower duration (days) was statistically significant.

It is evident from the Table 4.6 and Fig. 4.12 that the maximum flower duration (19.00 days) was recorded with T₇ (RDF + Azotobacter @ 5.0 kg/ha + PSB @ 5.0 kg/ha) followed by T₆ (RDF + Azotobacter @ 4.5 kg/ha + PSB @ 4.5 kg/ha) and T₅ (RDF + Azotobacter @ 4.0 kg/ha + PSB @ 4.0 kg/ha), which recorded values of (18.50 days) and (18.33 days) respectively and all of these three treatments were statistically at par with each other. The minimum flower duration (15.33 days) was recorded under T₈ (control).

Table 4.6: Effect of biofertilizers on the number of florets per spike, length of florets (cm), diameter of florets (cm) and flower duration (days)

Treatment	Treatment Combinations	Number of florets per spike	Length of florets (cm)	Diameter of florets (cm)	Flower duration (days)
T ₁	RDF + Azotobacter @ 2.0 kg/ha + PSB @ 2.0 kg/ha	24.87	3.20	2.67	15.77
T ₂	RDF + Azotobacter @ 2.5 kg/ha + PSB @ 2.5 kg/ha	25.53	3.28	2.64	16.13
T ₃	RDF + Azotobacter @ 3.0 kg/ha + PSB @ 3.0 kg/ha	25.95	3.31	3.11	17.37
T ₄	RDF + Azotobacter @ 3.5 kg/ha + PSB @ 3.5 kg/ha	26.10	3.40	3.25	17.90
T ₅	RDF + Azotobacter @ 4.0 kg/ha + PSB @ 4.0 kg/ha	26.50	3.63	3.44	18.33

T₆	RDF + Azotobacter @ 4.5 kg/ha + PSB @ 4.5 kg/ha	27.30	3.63	3.54	18.50
T₇	RDF + Azotobacter @ 5.0 kg/ha + PSB @ 5.0 kg/ha	27.37	3.84	3.60	19.00
T₈	RDF only	24.43	3.10	2.41	15.33
S.Em.±		0.34	0.05	0.08	0.23
C.D. at 5%		1.04	0.16	0.26	0.70

Fig. 4.9: Effect of biofertilizers on number of florets per spike

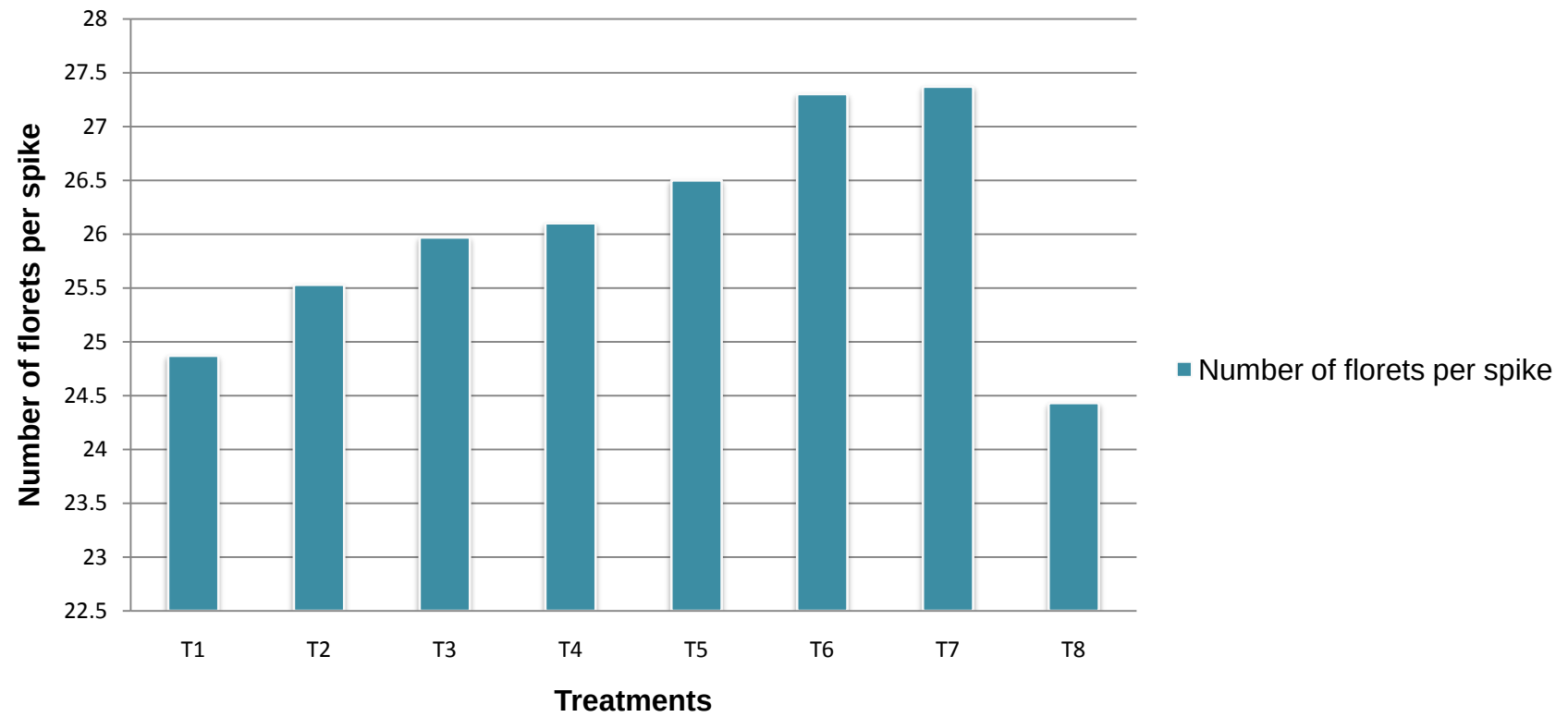


Fig. 4.10: Effect of biofertilizers on length of florets (cm)

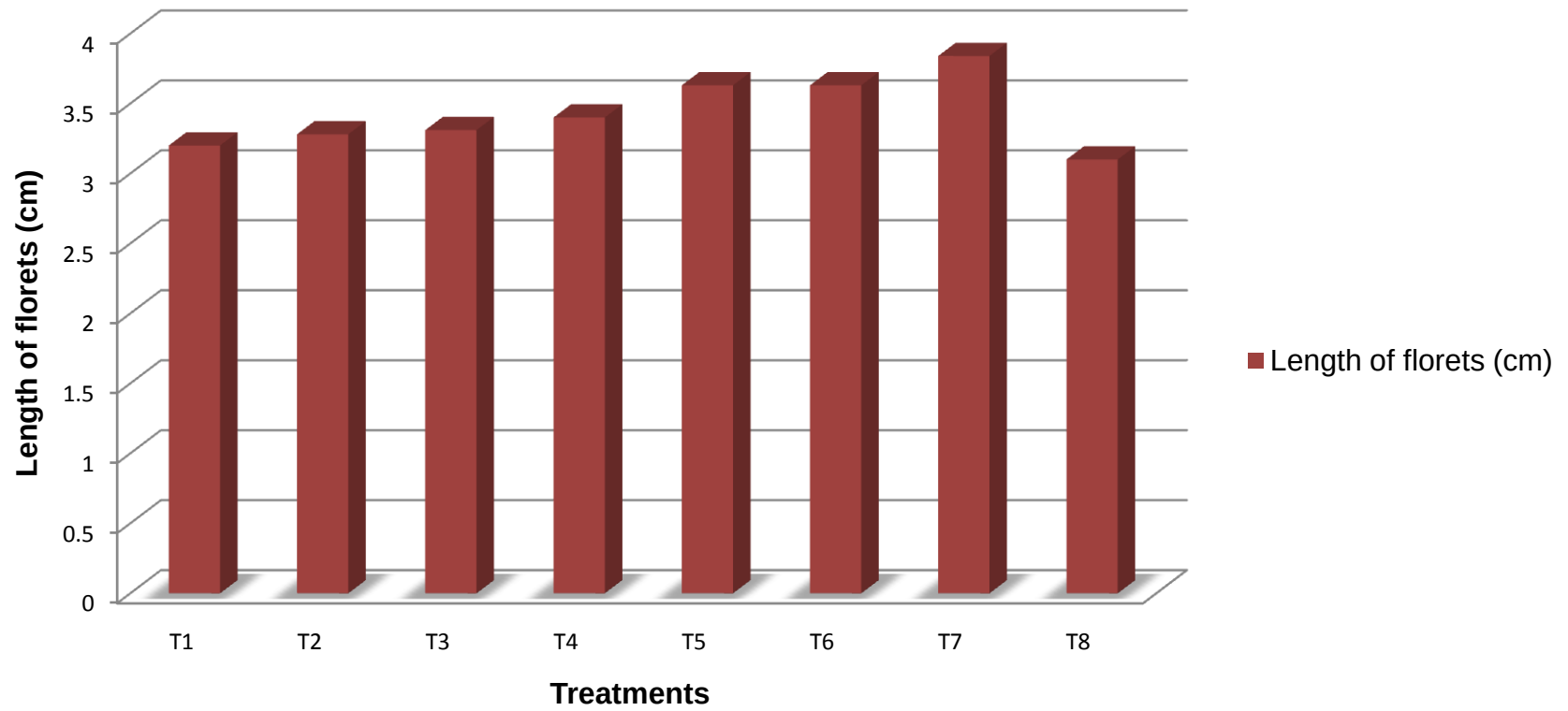


Fig. 4.11: Effect of biofertilizers on diameter of florets (cm)

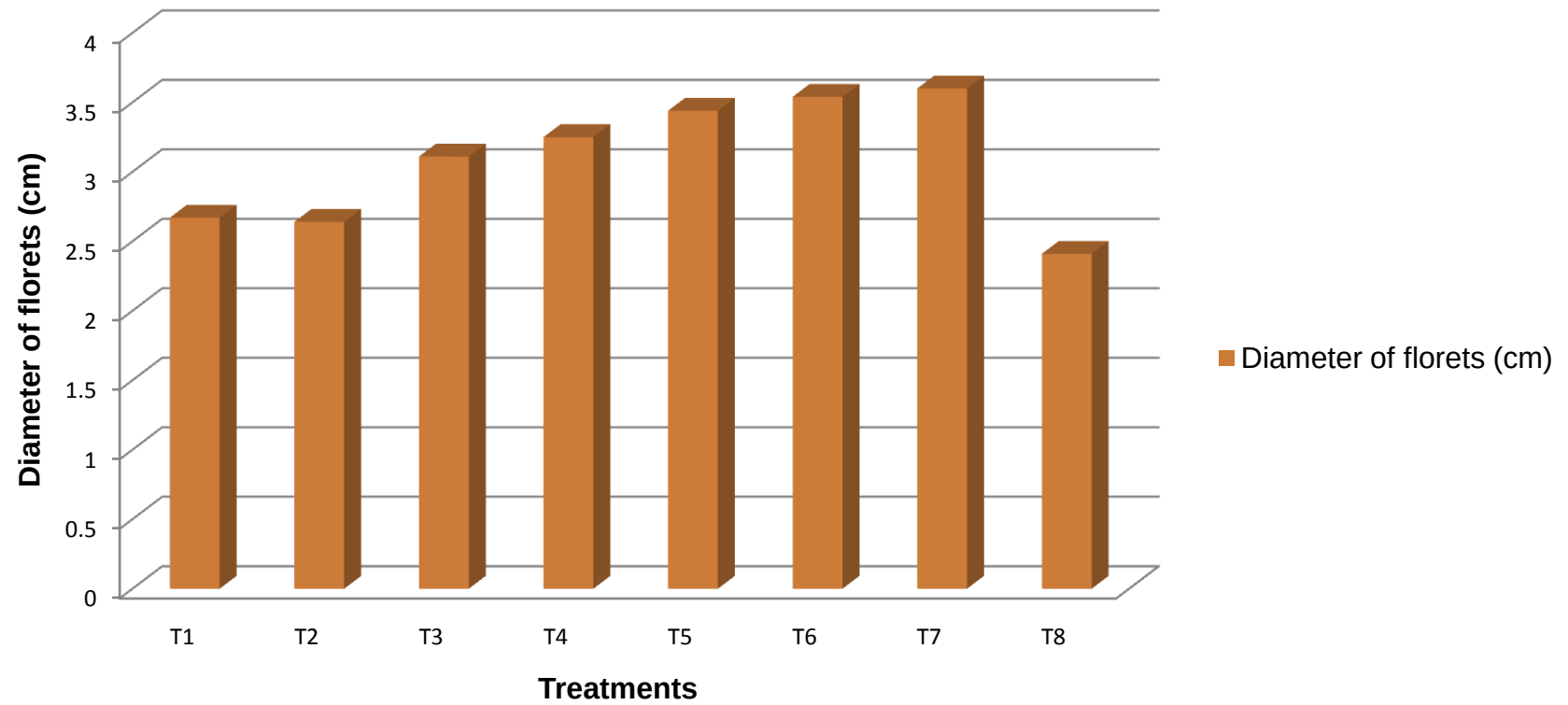
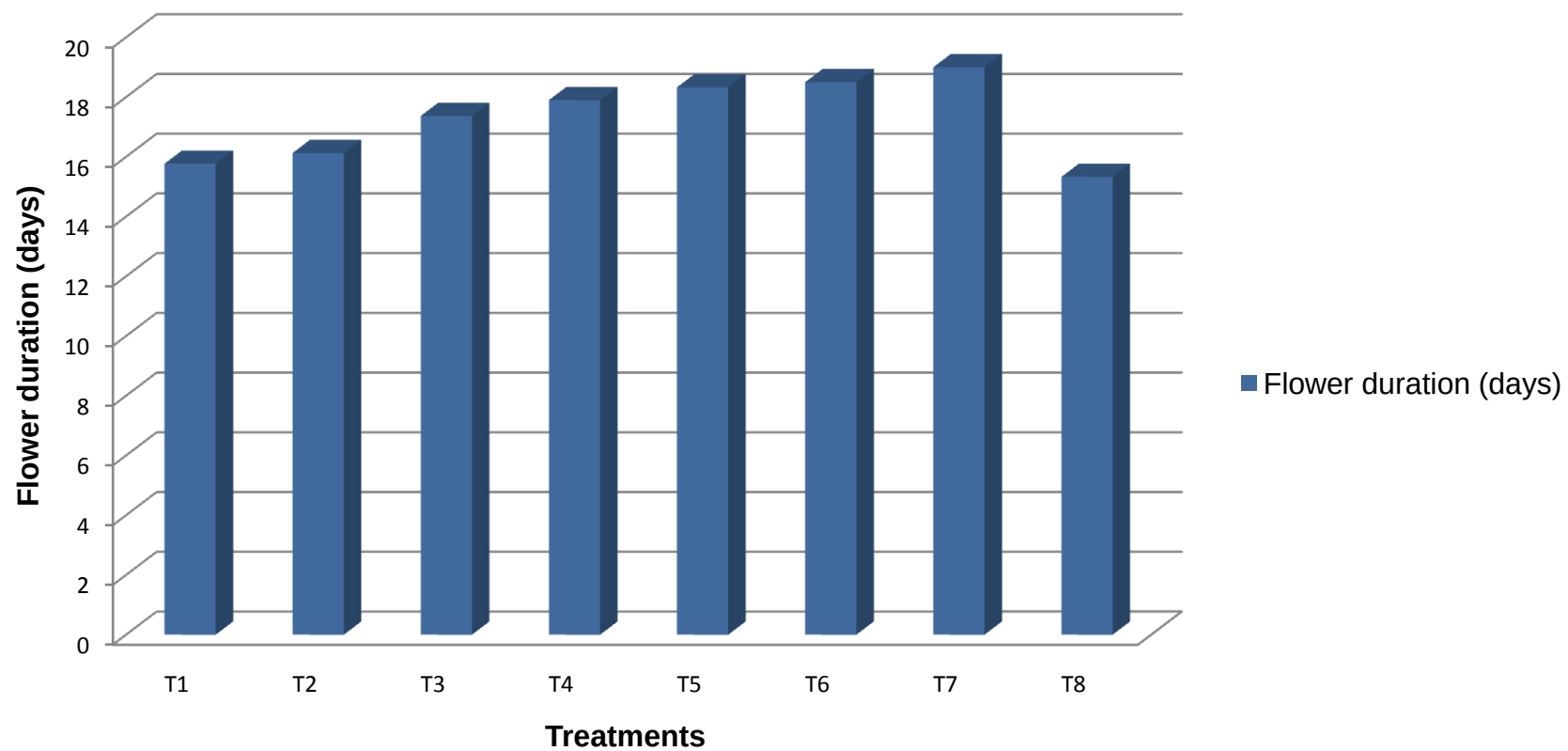


Fig. 4.12: Effect of biofertilizers on flower duration (days)



C.4.3: Vase life parameters:

4.3.1: Vase life of cut spike (days)

It can be observed from Table 4.7 and Fig. 4.13 that the effect of biofertilizers on vase life of cut spike was statistically significant.

It can be seen from Table 4.7 and Fig. 4.13 that the longest vase life of cut spike (10.53 days) was recorded with T₇ (RDF + Azotobacter @ 5.0 kg/ha + PSB @ 5.0 kg/ha) followed by T₆ (RDF + Azotobacter @ 4.5 kg/ha + PSB @ 4.5 kg/ha) and T₅ (RDF + Azotobacter @ 4.0 kg/ha + PSB @ 4.0 kg/ha) which recorded values of 9.67 days and 9.33 days respectively. However, these three treatments were statistically at par with one another. The shortest vase life of cut spike (7.33 days) was recorded with T₈ (control).

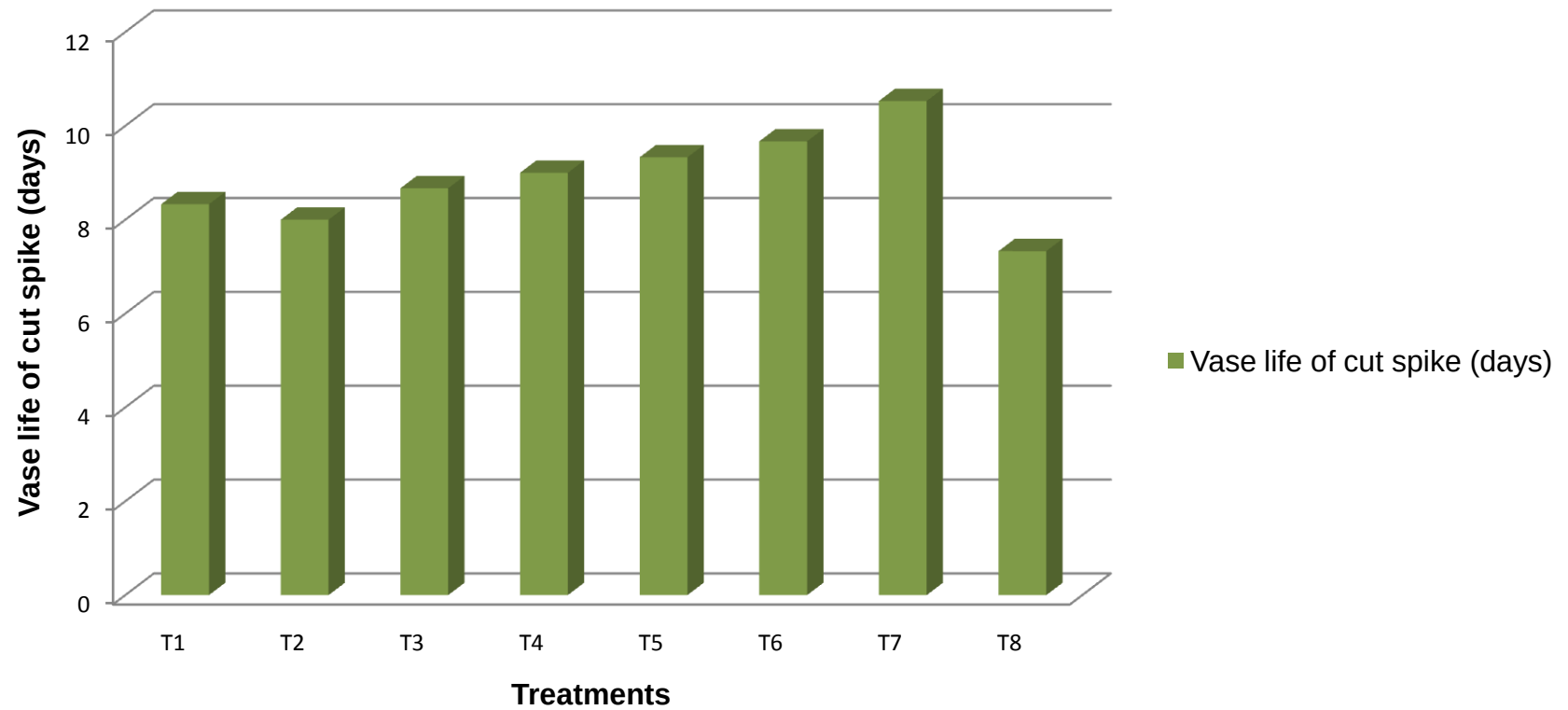
Table 4.7: Effect of biofertilizers on vase life of cut spike

Treatment	Treatment Combinations	Vase life of cut spike (days)
T₁	RDF + Azotobacter @ 2.0 kg/ha + PSB @ 2.0 kg/ha	8.33
T₂	RDF + Azotobacter @ 2.5 kg/ha + PSB @ 2.5 kg/ha	8.00
T₃	RDF + Azotobacter @ 3.0 kg/ha + PSB @ 3.0 kg/ha	8.67
T₄	RDF + Azotobacter @ 3.5 kg/ha + PSB @ 3.5 kg/ha	9.00
T₅	RDF + Azotobacter @ 4.0 kg/ha + PSB @ 4.0 kg/ha	9.33
T₆	RDF + Azotobacter @ 4.5 kg/ha + PSB @ 4.5 kg/ha	9.67
T₇	RDF + Azotobacter @ 5.0 kg/ha + PSB @ 5.0 kg/ha	10.53
T₈	RDF only	7.33
S.Em.±		0.47
C.D.at 5%		1.44



Plate 2:- Vase life study in the laboratory

Fig. 4.13: Effect of biofertilizers on vase life of cut spike (days)



4.3.2: Fresh weight (g) of cut spike at harvest

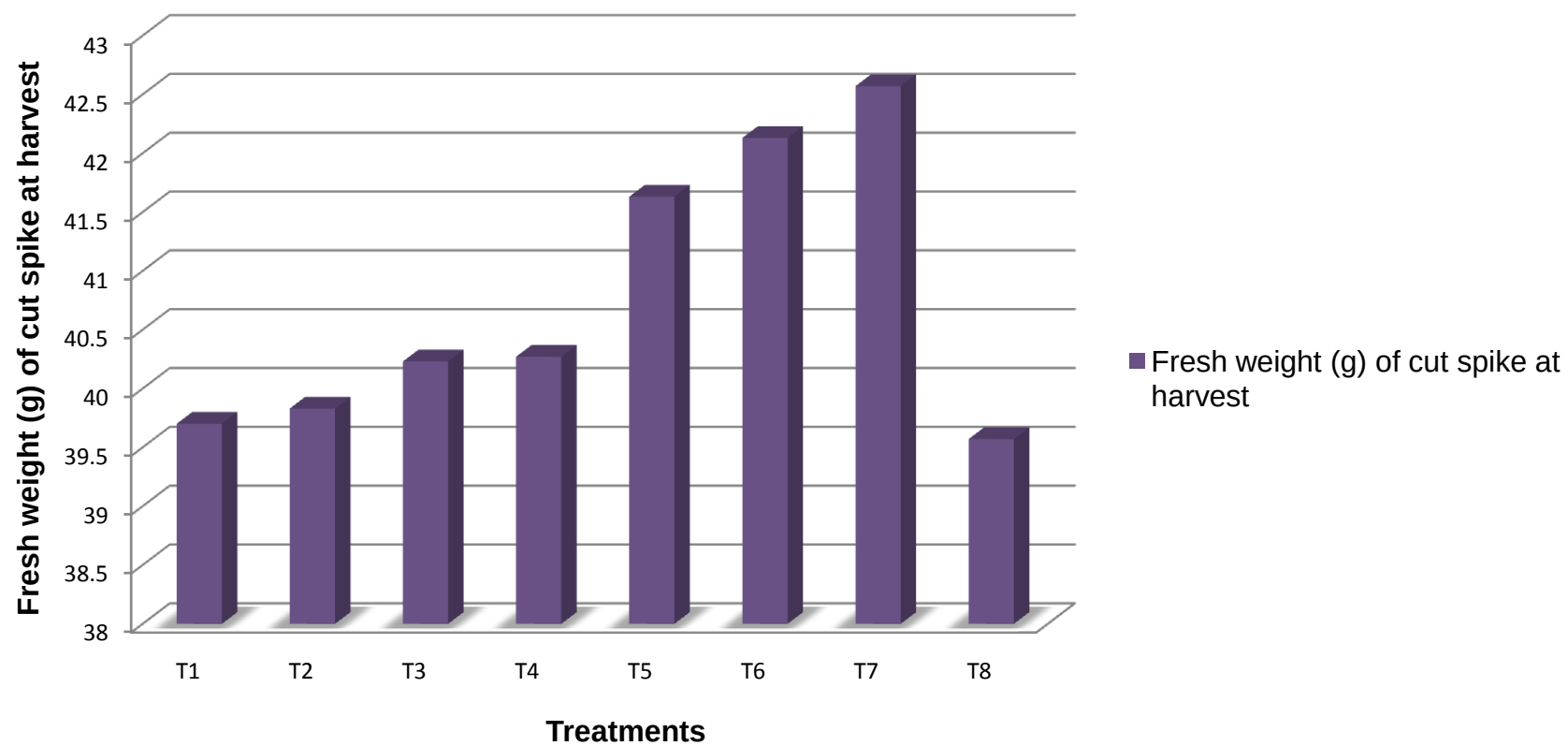
It can be observed from Table 4.8 and Fig. 4.14 that the effect of biofertilizers on fresh weight of cut spike at harvest was statistically significant.

The maximum fresh weight of cut spike (42.57 g) at harvest was recorded with T₇ (RDF + Azotobacter @ 5.0 kg/ha + PSB @ 5.0 kg/ha) followed by T₆ (42.13 g) and T₅ (41.63 g). However, these three treatments were statistically at par with each other. The minimum fresh weight of cut spike (39.57 g) was recorded with T₈ (control).

Table 4.8: Effect of biofertilizers on fresh weight (g) of cut spikes at harvest

Treatment	Treatment Combinations	Fresh weight of cut spike at harvest
T₁	RDF + Azotobacter @ 2.0 kg/ha + PSB @ 2.0 kg/ha	39.70
T₂	RDF + Azotobacter @ 2.5 kg/ha + PSB @ 2.5 kg/ha	39.83
T₃	RDF + Azotobacter @ 3.0 kg/ha + PSB @ 3.0 kg/ha	40.23
T₄	RDF + Azotobacter @ 3.5 kg/ha + PSB @ 3.5 kg/ha	40.27
T₅	RDF + Azotobacter @ 4.0 kg/ha + PSB @ 4.0 kg/ha	41.63
T₆	RDF + Azotobacter @ 4.5 kg/ha + PSB @ 4.5 kg/ha	42.13
T₇	RDF + Azotobacter @ 5.0 kg/ha + PSB @ 5.0 kg/ha	42.57
T₈	RDF only	39.57
S.Em.±		0.32
C.D. at 5%		0.99

Fig. 4.14: Effect of biofertilizers on fresh weight (g) of cut spike at harvest



4.3.3: Fresh weight (g) of cut spikes on 3rd day in vase, on 6th day and at senescence

It can be observed from the Table 4.9 and Fig. 4.15 that the effect of biofertilizers on fresh weight of cut spikes on 3rd day in vase, 6th day in vase and at senescence was statistically.

On 3rd day in vase T₇ (RDF + Azotobacter @ 5.0 kg/ha + PSB @ 5.0 kg/ha) recorded the maximum fresh weight of cut spike (44.57 g), followed by T₆ (44.20 g) and T₅ (43.67 g). However, these three treatments were statistically at par with each other. The minimum fresh weight of cut spike (41.30 g) was recorded with T₈ (control).

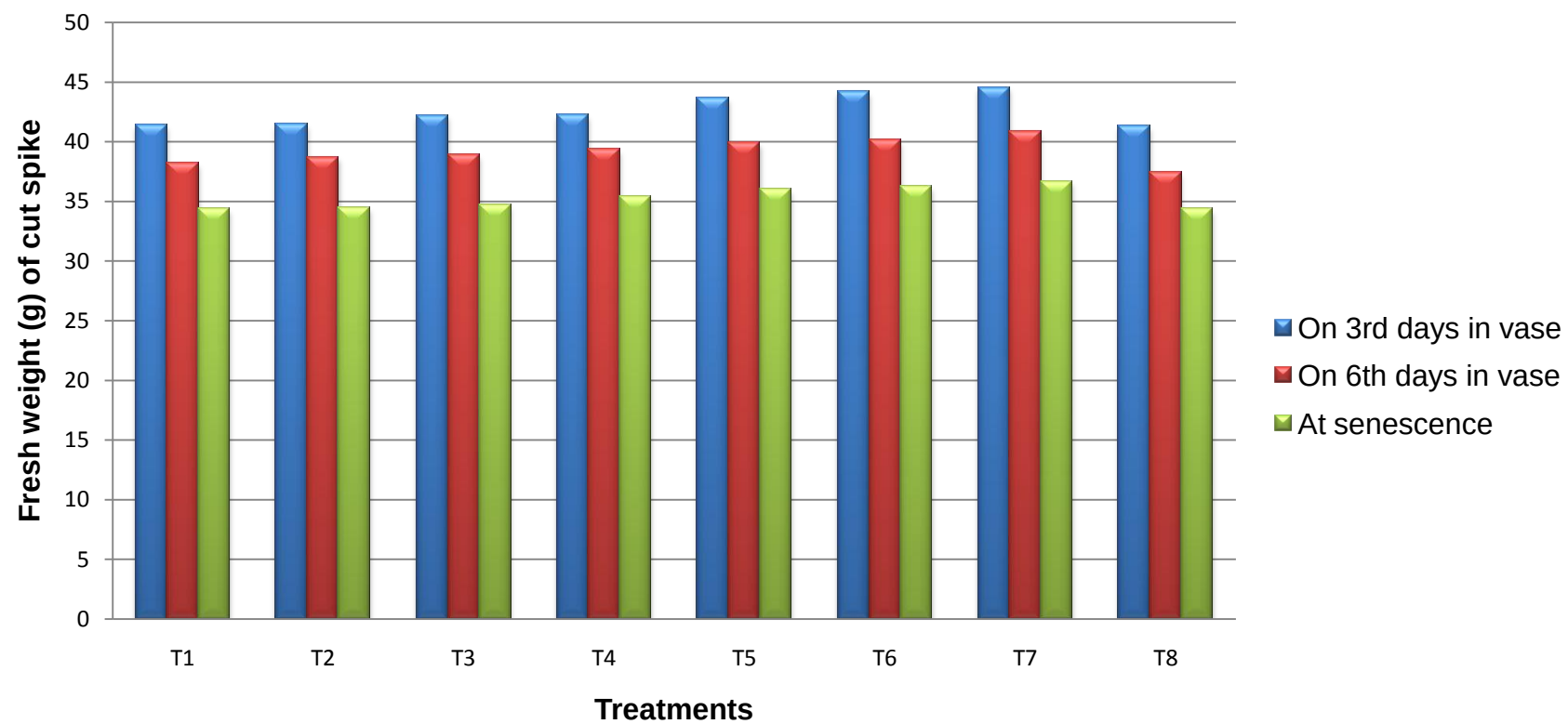
On 6th day in vase T₇ (RDF + Azotobacter @ 5.0 kg/ha + PSB @ 5.0 kg/ha) recorded the maximum fresh weight of cut spike (40.90 g), followed by T₆ (40.10 g) and T₅ (39.93 g). However, these three treatments were statistically at par with each other. The minimum fresh weight of cut spike at senescence (37.43g) was recorded with T₈ (control).

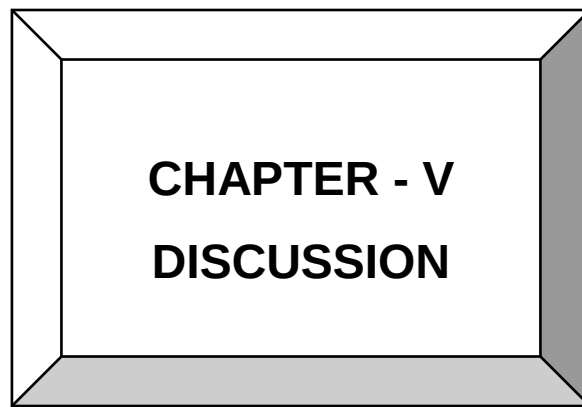
At senescence, the maximum fresh weight of cut spike (36.70 g) was recorded in T₇ (RDF + Azotobacter @ 5.0 kg/ha + PSB @ 5.0 kg/ha) followed by T₆ (36.23 g) and T₅ (36.03 g) and all of these three treatments were statistically at par with each other. The minimum fresh weight of cut spike (34.33g) was recorded with T₈ (control).

Table 4.9: Effect of biofertilizers on fresh weight (g) of cut spikes on 3rd day in vase, on 6th day and at senescence

Treatment	Treatment Combinations	Fresh weight (g) of cut spike on 3rd days in vase	Fresh weight (g) of cut spike on 6th days in vase	Fresh weight (g) of cut spike at senescence
T₁	RDF + Azotobacter @ 2.0 kg/ha + PSB @ 2.0 kg/ha	41.43	38.17	34.37
T₂	RDF + Azotobacter @ 2.5 kg/ha + PSB @ 2.5 kg/ha	41.50	38.73	34.43
T₃	RDF + Azotobacter @ 3.0 kg/ha + PSB @ 3.0 kg/ha	42.23	38.93	34.77
T₄	RDF + Azotobacter @ 3.5 kg/ha + PSB @ 3.5 kg/ha	42.27	39.37	35.40
T₅	RDF + Azotobacter @ 4.0 kg/ha + PSB @ 4.0 kg/ha	43.67	39.93	36.03
T₆	RDF + Azotobacter @ 4.5 kg/ha + PSB @ 4.5 kg/ha	44.20	40.10	36.23
T₇	RDF + Azotobacter @ 5.0 kg/ha + PSB @ 5.0 kg/ha	44.57	40.90	36.70
T₈	RDF only	41.30	37.43	34.33
S.Em.±		0.34	0.35	0.32
C.D. at 5%		1.04	1.08	0.99

Fig. 4.15: Effect of biofertilizers on fresh weight (g) of cut spike on 3rd day, on 6th day, at senescence





CHAPTER - V
DISCUSSION

Chapter - V

DISCUSSION

In this chapter an attempt has been made to evaluate the possible reasons of the variability obtained due to treatment differences in the present investigation entitled **“Effect of biofertilizers on growth and flowering of tuberose (*Polianthes tuberosa* L.) under Malwa region of M.P.”** The findings described in the preceding chapter have been critically discussed here in detail.

5.1: Growth parameters:

5.1.1: Days taken to sprouting

The number of days taken to sprouting was affected by various biofertilizer treatments. Among the biofertilizer treatments, T₇ (RDF + Azotobacter @ 5.0 kg/ha + PSB @ 5.0 kg/ha) recorded the earliest bulb sprouting, while the most delayed bulb sprouting was recorded by T₈ (control).

In combination with PSB and Azotobacter that contributed much for the improvement in sprouting of bulbs. These results are in conformity with the findings of Chaudhary (2009) in tuberose cv. Double, Mukhopadhyay *et al.* (1986) and Singh *et al.* (1996).

The decrease in sprouting period might be due to early absorption of nitrogen and phosphorus through the surface of the bulbs or by primary roots which might have stimulated early sprouting. Biofertilizers would have played a role in increasing the efficient availability of nitrogen and phosphorus which is helpful in sprouting. It is a well known fact that the biofertilizers improve availability of nutrients to the bulbs which activates the physiological processes and further help in germination (Kumar *et al.*, 2001) and Mohandas (1999).

5.1.2: Plant height (cm)

In the present study the maximum plant height (cm) during the different stages of observation was recorded with the application of T₇ (RDF + Azotobacter

@ 5.0 kg/ha + PSB @ 5.0 kg/ha), while the minimum plant height (cm) was recorded with T₈ (control).

The increase in plant height may be due to favourable action of biofertilizers (Azotobacter) which resulted in more availability of nitrogen and certain growth substances like auxins, gibberellins, vitamins and organic acids secreted by bioinoculants. The effect of Azotobacter on plant height in tuberose was also confirmed by the work carried out by Ajimuddin (2002) and Yadav *et al.* (2005).

The increase in plant height might be due to the increased availability of nitrogen and phosphorus by using biofertilizers as nitrogen is a constituent of protein which is essential for the formation of protoplasm thus improving the cell division, cell enlargement and ultimately increase the plant height. Singh (1992) has reported a significant effect of nitrogen and phosphorus on plant height of tuberose and Chaudhary (2007) also confirms these results. They also reported that the use of biofertilizers along with increased levels of inorganic fertilizers (N, P and K) increases the plant height in tuberose.

5.1.3: Number of leaves per plant

In the present study the maximum number of leaves per plant during the different stages of observation was recorded with the application of T₇ (RDF + Azotobacter @ 5.0 kg/ha + PSB @ 5.0 kg/ha), while the minimum number of leaves per plant was recorded with T₈ (control).

Similar observation was recorded by Yadav *et al.* (2005) on Tuberose cv. Double. The PSB, Azotobacter or Azospirillum alone or in combination produces growth promoting substances such as IAA or GA like substances Vit B₁₂, thiamine, riboflavin (B₂) etc which might have helped to increase number of leaves.

All these factors contribute to cell multiplication, cell enlargement and differentiation which could have resulted in better photosynthesis and ultimately exhibited better vegetative growth. Thus the number of leaves in the treatment increased significantly in comparison to control. Srivastava and Govil (2007) reported increased number of leaves in gladiolus cv American Beauty with the application of biofertilizers viz Azotobacter, PSB and VAM.

These results are in accordance with that of Shivalingappa (1998), Ajimuddin (2002), Yadav *et al.* (2005) who also recorded similar results in tuberose due to Azotobacter inoculation.

5.1.4: Leaf area per plant (cm²)

In the present study the maximum leaf area per plant (cm²) was recorded with the application of T₇ (RDF + Azotobacter @ 5.0 kg/ha + PSB @ 5.0 kg/ha), while the minimum leaf area per plant (cm²) was recorded with T₈ (control).

The effect of PSB on increasing the number of leaves is in accordance with the results obtained by Barman *et al.* (2003) in tuberose. These growth promoting substances might have resulted in increased cell division and elongation leading to enhanced leaf expansion, thus leading to increase in the leaf area. These findings were similar to that of Mostafa (2002) in *Calendula officinalis*.

5.2: Flowering parameters:

5.2.1: Days taken to spike emergence

In the present study the earliest first spike emergence was recorded with the application of T₇ (RDF + Azotobacter @ 5.0 kg/ha + PSB @ 5.0 kg/ha), while the most delayed first spike emergence was recorded with T₈ (control).

The similar results in respect to earliness to spike emergence due to application of biofertilizers were also reported in tuberose by Barman *et al.* (2003).

This may be due to the fact that application of biofertilizers alone and in combination with inorganic fertilizers supplies the nutrients to the plants, which prolonged the vegetative growth and spike emergence. These findings are in accordance with the results of Dalve *et al.* (2009) in gladiolus.

The increment in flowering parameters might be due to that proper availability of phosphorus during vegetative growth towards the better effect on developing flowering parameters. Similar findings were also observed by Barman *et al.*, (2003) in tuberose.

5.2.2: Days taken to flowering

In the present study the earliest days taken to flowering was recorded with the application of T₇ (RDF + Azotobacter @ 5.0 kg/ha + PSB @ 5.0 kg/ha), while the most delayed days taken to flowering was recorded with T₈ (control).

Similar observations were recorded by Chopde *et al.* (2007) who had reported that the soil application of (vermicompost + Azotobacter + PSB) significantly induced early flowering in tuberose as compared to other treatments.

The earliness in floret opening may be attributed to the presence of biofertilizers which result into easy uptake of nutrients and simultaneous transport of growth promoting substances like gibberellins and cytokinins to the buds. Ultimately, they resulted in better sink for faster mobilization of photosynthates and early transformation of plant parts from vegetative to reproductive phase. These results were in line with the findings in marigold (Chandrikapure *et al.* 1999).

5.2.3: Number of spikes per plant

In the present study the maximum number of spikes per plant was recorded with the application of T₇ (RDF + Azotobacter @ 5.0 kg/ha + PSB @ 5.0 kg/ha), while the minimum number of spikes per plant was recorded with T₈ (control).

Several workers have also reported higher number of spikes per plant by the application of biofertilizers in tuberose (Wange and Patil 1994, Shivalingappa 1998, Azimuddin 2002).

The increase in number may be due to possible role of biofertilizers through atmospheric nitrogen fixation, better root proliferation, uptake of nutrients and water, more photosynthesis enhanced food accumulation and increased ability towards cell division which might have resulted in better plant growth and subsequently higher number of spikes and florets. These findings were in line with those of Kathiresan and Venkatesha (2002) and Godse *et al.* (2006) in gladiolus.

5.2.4: Length of spike (cm)

In the present study the maximum length of spikes (cm) was recorded with the application of T₇ (RDF + Azotobacter @ 5.0 kg/ha + PSB @ 5.0 kg/ha), while the minimum length of spikes (cm) was recorded with T₈ (control).

This may be due to the increasing N uptake by the plants and Azotobacter was responsible for the enhance absorption of N. Nitrogen is the constituent of protein, which is essential for the formation of protoplasm, thus, enhancing the cell division and its enlargement, which ultimately results in better vegetative and reproductive growth. Swaminathan *et al.* (1999), Yadav *et al.* (2005) also reported higher spike length in tuberose and Gayithri *et al.* (2004) in statice.

The results of the study are also in agreement with the findings of Barman *et al.* (2003) they reported significant improvement in flower production and flower quality in terms of spike length and number of flowers per spike in tuberose with the application of Azotobacter along with FYM.

5.2.5: Number of florets per spike

In the present study the maximum number of florets per spike was recorded with the application of T₈ (RDF + Azotobacter @ 5.0 kg/ha + PSB @ 5.0 kg/ha), while the minimum number of florets per spike was recorded with T₈ (control).

The increase in number may be due to possible role of biofertilizers through atmospheric nitrogen fixation, better root proliferation, uptake of nutrients and water, more photosynthesis enhanced food accumulation and increased ability towards cell division which might have resulted in better plant growth and subsequently higher number of spikes and florets. These findings were in line with those of Kathiresan and Venkatesha (2002) and Godse *et al.* (2006) in gladiolus, Barman *et al.* (2003), Yadav *et al.* (2005) in tuberose and Gayithri *et al.* (2004) in statice.

This may be due to increased availability of nutrients for plant growth and development and presence of cytokinin which promotes cell division and expansion which resulted in better sink for faster mobilization of photosynthates and early transformation of plant parts from vegetative to reproductive phase and this resulted in opening of more number of florets in gladiolus by Bosali *et al.* (2014).

5.2.6: Length of florets (cm)

In the present study the maximum length of florets (cm) was recorded with the application of T₇ (RDF + Azotobacter @ 5.0 kg/ha + PSB @ 5.0 kg/ha), while the minimum length of florets (cm) was recorded with T₈ (control).

The improved floral characters might be due to increased availability of N and P required for flower development as Azotobacter fixes nitrogen and PSB makes the insoluble phosphorus available by secreting organic acids, mainly Pseudomonas (Dave and Patel, 2003).

The increment in flowering parameters might be due to that proper availability of phosphorus during vegetative growth towards the better effect on developing flowering parameters. Similar findings were also observed by Barman *et al.*, (2003) in tuberose and Narasimharaju & Haripriya (2001) in Crossandra.

5.2.7: Diameter of floret (cm)

In the present study the maximum diameter of floret (cm) was recorded with the application of T₇ (RDF + Azotobacter @ 5.0 kg/ha + PSB @ 5.0 kg/ha), while the minimum diameter of floret (cm) was recorded with T₈ (control).

Azotobacter which provides more amounts of nitrogen by fixing it through atmosphere. Similarly, PSB helped in increasing phosphorus availability by releasing enzymes. Phosphate in soil which helps the plant in healthy growing condition resulting into the production of flower having more diameter and stalk length. Likewise maximum diameter of flower with the application of biofertilizers along with recommended dose of NPK was reported by Ravichandran (1991) in crossandra, Deshmukhet *al.* (2008) in gaillardia.

These results are in close conformity with the findings of Patil and Reddy (2002) in tuberose.

5.2.8: Flower duration (Days)

In the present study the maximum flower duration (days) was recorded with the application of T₇ (RDF + Azotobacter @ 5.0 kg/ha + PSB @ 5.0 kg/ha), while the minimum flower duration (days) was recorded with T₈ (control).

The increase in flowering duration can be attributed to increased protein synthesis, rapid nutrient mobilization and prevention of chlorophyll degradation due to the sufficient amount of nutrients (N, P and K) availability in this treatment due to combined application of biofertilizers and chemical doses. Chopde *et al.* (2007) in tuberose reported similar results.

Many workers like Barman *et al.* (2003) in tuberose and Gayithri *et al.* (2004) in statice observed the early flowering in inoculated plants compared to other treatments. Since P is an important element required at the time of flowering and PSB is known to enhance the availability of P due to convert insoluble to soluble form (Rasal *et al.* 2004), it might have resulted in early spike emergence and flowering.

5.3: Vase life parameters:

5.3.1: Vase life of cut spike (days):

In the present study the longest vase life of cut spike (days) was recorded with the application of T₇ (RDF + Azotobacter @ 5.0 kg/ha + PSB @ 5.0 kg/ha), while the shortest vase life of cut spike (days) was recorded with T₈ (control).

Increment in vase life might be due to reduction in ethylene synthesis which has a harmful effect for flower life. Biofertilizers regulate nutrient uptake process and prolonged vase phenomenon. Our findings are harmony with Khan *et al.* (2009).

5.3.2 Fresh weight (g) of cut spike at harvest:

In the present study the maximum fresh weight (g) of cut spike at harvest was recorded with the application of T₇ (RDF + Azotobacter @ 5.0 kg/ha + PSB @ 5.0 kg/ha), while the minimum fresh weight of cut spike at harvest was recorded with T₈ (control).

Fresh weight of flowers increased due to biological fixation of nitrogen and phosphorus in root portion of plants resulting in absorption of more nutrients and its utilization. These findings are in accordance with the results of Bhalla *et al.* (2006), who stated that application of biofertilizers like Azotobacter/Azospirillum, Phosphate solubilizing bacterium enhanced the flower fresh weight in carnation.

5.3.3: Fresh weight (g) of cut spike on 3rd day in vase, on 6th day and at senescence

The effect of biofertilizers on fresh weight of cut spike on 3rd day in vase, 6th day in vase and at senescence was found statistically significant.

The maximum fresh weight (g) of cut spike on 3rd day 6th day in vase and at senescence was recorded with the application of T₇ (RDF + Azotobacter @ 5.0 kg/ha + PSB @ 5.0 kg/ha), while the minimum increase fresh weight of cut spike on 3rd day 6th day in vase and at senescence was recorded with T₈ (control).

The regular supply of nutrients leads to more vegetative growth leading to increase in photosynthetic area, which in turn resulted in more synthesis and accumulation of photosynthates portioning to the developing flower. Presence of growth promoting substances such as auxin, gibberellins and cytokinin due to presence of biofertilizers would have also contributed in development and accumulation of dry matter in the flower. The results are in agreement with findings of Swaminathan *et al.* (1999) in tuberose.

Similar findings were observed by Yadav *et al.* (2005) in tuberose, and Singh *et al.* (2006) in rose.

CHAPTER - VI
SUMMARY, CONCLUSION
AND SUGGESTIONS FOR
FURTHER WORK

Chapter - VI

SUMMARY, CONCLUSIONS AND SUGGESTIONS FOR FURTHER WORK

6.1: Summary

The present investigation entitled “**Effect of biofertilizers on growth and flowering of tuberose (*Polianthes tuberosa* L.) under Malwa region of M.P.**” was conducted during the period of March 2016 to August 2016 at the Department of Floriculture and Landscape Architecture, K.N.K. College of Horticulture, Mandsaur (M.P.) Rajmata Vijayaraje Scindia Krishi Vishwavidyalaya, Gwalior (M.P.).

The experiment was laid out in Randomized Block Design with three replications. The observations on different growth, flowering, and vase life parameters were recorded and the results obtained are summarized below.

6.1.1: Growth parameters:

In the present investigation among the different biofertilizers treatments studied, the earliest bulb sprouting (days) as well as maximum plant height (cm), maximum number of leaves per plant and maximum leaf area (cm²) were recorded by T₇ (RDF + Azotobacter @ 5.0 kg/ha + PSB @ 5.0 kg/ha), while the most delayed bulb sprouting as well as minimum plant height (cm), minimum number of leaves per plant and minimum leaf area (cm²) were recorded by T₈ (control).

6.1.2: Flowering parameters:

Among biofertilizers, T₇ (RDF + Azotobacter @ 5.0 kg/ha + PSB @ 5.0 kg/ha) recorded the earliest spike emergence, days taken to flowering, maximum number of spikes per plant, maximum length of spike (cm), maximum number of florets per spike, maximum length of florets (cm), maximum diameter of florets (cm) and maximum flower duration, while the most delayed days taken to spike emergence, days taken to flowering, minimum number of spikes per plant, minimum length of spike (cm), minimum number of florets per spike, minimum length of florets (cm), minimum diameter of florets (cm) and minimum flower duration were recorded with T₈ (control).

6.1.3: Vase life parameters:

Among different biofertilizers treatments, the longest vase life of cut spike (days), maximum fresh weight of cut spike at harvest, maximum fresh weight (g) of cut spike on 3rd day in vase, maximum fresh weight (g) of cut spike on 6th day in vase and maximum fresh weight (g) of cut spike at senescence were recorded by T₇ (RDF + Azotobacter @ 5.0 kg/ha + PSB @ 5.0 kg/ha), while the shortest vase life of cut spike (days), minimum fresh weight (g) of cut spike at harvest, minimum fresh weight (g) of cut spike on 3rd day in vase, minimum fresh weight (g) of cut spike on 6th day in vase and minimum fresh weight (g) of cut spike at senescence were recorded by T₈ (control).

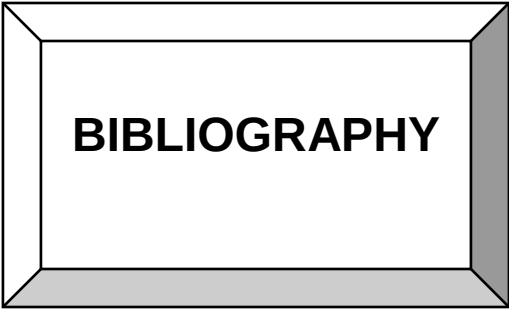
6.2: Conclusions

The different biofertilizers treatments had significant influence on the growth, flowering and vase life characteristics of tuberose in the present study. Among the different biofertilizers treatments, the treatment T₇ (RDF + Azotobacter @ 5.0 kg/ha + PSB @ 5.0 kg/ha) showed the best result in terms of all parameters like, days taken for sprouting, plant height (cm), number of leaves per plant and leaf area (cm²), earliest spike emergence, days taken to flowering, the maximum number of spike per plant, the maximum length of spike (cm), the highest number of florets per spike, the maximum length of floret (cm), the maximum diameter of floret (cm) and the longest flower duration (days), longest vase life of cut spike (days), the maximum fresh weight (g) of cut spike at harvest, the maximum fresh weight (g) of cut spike on 3rd day in vase; on 6th day in vase and at senescence, while the minimum performance were recorded with respect of all parameters under control (T₈) condition.

6.3: Suggestions for further work

1. Since it was the first year of the trial it is suggested that, findings of the present study must be tested over years and locations for confirmation.
2. The response of more cultivars of tuberose to biofertilizers Malwa condition may be studied.

3. More number of biofertilizers with different dose may be tested for improving quality of cut flowers and bulb production.
4. Effect of biofertilizers in different method of application may be tested on growth, flowering and vase life parameters of tuberose.



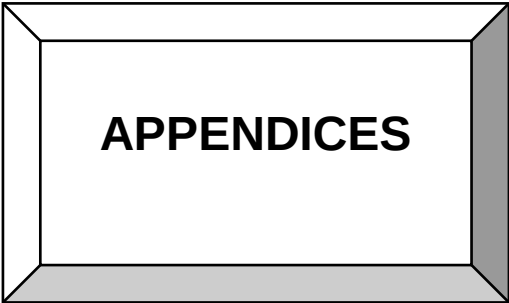
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APPENDICES

Appendix - I: Analysis of variance for the number of days taken for sprouting

Source of variation	D.F.	Mean sum of squares
		Number of days taken for sprouting
Replication	2	5.26292
Treatment	7	4.33185
Error	14	3.70863
Total	23	

Appendix - II: Analysis of variance for plant height (cm)

Source of variation	D.F.	Mean sum of squares			
		Plant height (cm)			
		45 DAP	60 DAP	75 DAP	90 DAP
Replication	2	0.04983	0.02424	0.87885	0.09983
Treatment	7	3.45771	6.80418	6.38026	4.69037
Error	14	0.42701	0.11543	0.61542	0.29601
Total	23				

Appendix - III: Analysis of variance for the number of leaves per plant

Source of variation	D.F.	Mean sum of squares			
		Number of leaves per plant			
		45 DAP	60 DAP	75 DAP	90 DAP
Replication	2	0.72792	0.05158	0.12167	0.13625
Treatment	7	2.66167	4.41886	3.06357	2.97042
Error	14	0.27935	0.1002	0.19643	0.15863
Total	23				

Appendix - IV: Analysis of variance for leaf area per plant (cm²)

Source of variation	D.F.	Mean sum of squares
		Leaf area per plant (cm ²)
Replication	2	44.7083
Treatment	7	31442.3
Error	14	140.291
Total	23	

Appendix - V: Analysis of variance for days taken to spike emergence, days taken to flowering, number of spike per plant and length of spike (cm)

Source of variation	D.F.	Mean sum of squares			
		Days taken to spike emergence	Days taken to flowering	Number of spike per plant	Length of spike (cm)
Replication	2	0.14625	0.13167	0.00823	0.02542
Treatment	7	5.21619	5.47899	0.25344	3.9969
Error	14	0.22815	0.17738	0.02371	0.07637
Total	23				

Appendix - VI: Analysis of variance for number of florets per spike, length of florets (cm), diameter of florets (cm) and flower duration (days)

Source of variation	D.F.	Mean sum of squares			
		Number of florets per spike	Length of florets (cm)	Diameter of florets (cm)	Flower duration (days)
Replication	2	0.10292	0.00912	0.00462	0.19042
Treatment	7	3.33214	0.19201	0.62532	5.71786
Error	14	0.35482	0.00842	0.02334	0.16375
Total	23				

Appendix - VII: Analysis of variance for vase life of cut spike (days) and fresh weight (g) of cut spike at harvest

Source of variation	D.F.	Mean sum of squares	
		Vase life of cut spike (days)	Fresh weight (g) of cut spike at harvest
Replication	2	0.20042	0.17042
Treatment	7	3.03405	5.16661
Error	14	0.68137	0.35804
Total	23		

Appendix - VIII: Analysis of variance for fresh weight (g) of cut spike on 3rd day in vase, fresh weight (g) of cut spike on 6th day in vase and fresh weight (g) of cut spike at senescence

Source of variation	D.F.	Mean sum of squares		
		Fresh weight (g) of cut spike		
		On 3 rd day in vase	On 6 th day in vase	at senescence
Replication	2	0.32667	0.83042	0.00542
Treatment	7	4.21595	3.74708	2.66476
Error	14	0.32095	0.38137	0.32351
Total	23			



VITA

The author of this thesis **Mukesh Dawar** was born on 01 July 1989 at Alirajpur District (M.P.). He passed High School Examination in the year 2006 from M.P. Board, Bhopal from Govt.H.S.School Sondwa, District Jhabua (M.P) and Senior Secondary Examination in the year 2008 from M.P. Board Bhopal from Govt.H.S.School Sondwa, District Jhabua (M.P). With 42.6% and 65.11 % marks respectively.

He joined College of Agriculture, Gwalior in 2010 and completed B.Sc. (Agri.) in the year 2014 with 1st division securing an OGPA of 6.55 on 10 point scale.

After graduation, he joined M.Sc. (Horticulture) in College of Horticulture, Mandsaur specialization in Floriculture and Landscape Architecture. He has completed the entire course requirement for the above said Master Degree in the year 2017-18 with an OGPA of 6.62 on a 10 point scale.

He was allotted an interesting research problem entitled “**Effect of biofertilizers on growth and flowering of tuberose (*Polianthes tuberosa* L.) under Malwa resion of M.P.**” of his choice for thesis work, which has been duly completed by him and presented in the form of this thesis.

(Mukesh Dawar)