RESPONSE OF JASMINE (*Jasminum auriculatum*) TO BIOFERTILIZER APPLICATION

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1. INTRODUCTION

Jasmine is one of the oldest fragrant flowers and is especially appreciated in India. The term jasmine is probably derived from the Persian word 'Yasmin' meaning 'fragrance'. Jasmines are widely grown in warm parts of southern Asia, Europe, Africa and the Pacific regions. It is the national flower of the Philippines adopted by its government in 1937. And, recently in 1990, Indonesian government also has adopted it as the national flower.

Jasmine belongs to the family Oleaceae. Although more than 2,000 species are known, 40 species have been identified in India and 20 are cultivated in South India (Bhattacharjee, 1980).

Jasmine can be grown in a variety of climate and soils. Generally, it prefers mid tropical climate for proper growth and flowering. Commercially grown important *Jasminum* species are *J. sambac, J. auriculutum*, *J. grandiflorum* and *J. multiflorum*.

In India, Jasmines are cultivated throughout the country. However, the largest area under Jasmine flower production is in Tamil Nadu followed by Karnataka. The annual production of flowers in India is worth more than Rs.120 million (Dadlani, 2004). Apart from internal trade, fresh flowers of jasmine are exported to Malaysia, Singapore and Srilanka.

In Karnataka, *Jasminum auriculatum* is grown in Huvinahadagali and Hagaribommanahalli taluks in Bellary District, Harpanahalli in Davangere District and to some extent in Lakkundi in Gadag District. It is grown in an area of 3,451 ha with an estimated production of nearly 20,244 tonnes of fresh flowers (Dadlani, 2004).

Hadagali mallige, locally known as "Vasane mallige", is a household name in Karnataka and its fragrance known around the world. Recently, Mysore mallige, Udupi mallige and Hadagali mallige have been registered under the Intellectual Property Rights (IPR) (Anon., 2007). The Geographical Indication (GI) status has provided executive rights to the local community to cultivate these three species and continue to grow for many more years. Department of Horticulture, Government of Karnataka is also promoting cultivation of these species to protect the rare plant species by conducting workshops to create more awareness.

J. auriculatum is commonly known as Malle, Mokggu, Mallai, Juhi, Jul and Ambus mallige. It is a scandent shrub having shiny leaves with minute lateral leaflets; leaves are mostly simple and occasionally trifoliate. The plants produce numerous star shaped white scented blooms and are very good as loose flowers. It bears flowers from spring to summer and in rainy season.

Jasmines are commercially grown for their fragrant and essential oil production. The bulk of the flowers is used as such in garlands and decorative bunches for religious offerings and a small quantity for the production of oils and attars. Jasmine concrete and absolute are used in high grade perfumes. It ranks next to rose in the order of importance. The annual production of jasmine concrete is more than15 tonnes in India, the largest producer being Egypt, followed by Morocco, India, Italy, France and China. Jasmine oil blends well with every floral scent imparting smoothness and elegance to the perfume composition. The essential oil in flowers is extracted through enfleurage which is widely used for production of Jasmine attars in India (Sharma *et al*., 1980). The usual yields are 0.30-0.35 per cent concrete and 45-55 per cent absolute.

Jasmine absolute is a viscous clear yellowish brown liquid possessing a delicate odour of fresh jasmine flowers. The approximate composition of jasmine flower oil obtained by enfleurage is benzeyl acetate 65.0 per cent, d-linalool 15.5 per cent, linalyl acetate 7.5 per cent, benzyl alcohol 6.0 per cent, jasmone 3.0 per cent, indole 2.5 per cent and methyl anthranilate 0.5 per cent. Benzyl benzoate, geraniol, nerol, terpineol, farnesol, nerolidol and p-cresol are also present in traces (Nigam and Misra, 1980).

There are some production constraints in jasmine cultivation. NPK requirement of Jasmine is rather very high. The recommended NPK fertilizer doses are 133:266:266 kg/ha for 1-2 year old plants and 266:532:532 kg/ha for 3-5 year old plant. Of late, chemical fertilizers have become expensive. Application of NPK chemical fertilizers can be reduced by using biofertilizers. This would not only sustain soil fertility but also reduce the cost of production of Jasmines. Hence, field experiments were conducted to study the effect of biofertilizers on Jasmine with the following objectives.

1. To assess the effect of different biofertilizers on growth and yield of jasmine
2. To assess the effect of biofertilizers on nutrient content in jasmine
3. To study the effect of biofertilizers on post harvest life and quality of jasmine flowers

2. REVIEW OF LITERATURE

There is an increasing need for the modification/manipulation of the traditional processes of nutrient management, to result in higher nutrient concentration and also to reduce environmental pollution. The use of biofertilizers like *Azospirillum*, Phosphate Solubilizing Bacteria (PSB), plant growth promoting microorganisms and biocontrolling microorganisms and organic manures like biocompost, farmyard manure (FYM) along with chemical fertilizers are known to reduce the cost of production and supplement the secondary and micronutrients to crops (Barker, 1975). The information on the use of biofertilizers and organic manures alone or in combination with inorganic fertilizers on jasmine, particularly *Jasminum auriculatum* is rather limited. Hence, the research findings pertaining to these aspects on other flower crops like chrysanthemum, marigold, China aster, *Gaillardia*, crossandra as well as some field crops have been reviewed and presented here under the following headings.

2.1 EFFECT OF BIOFERTILIZERS ON GROWTH AND YIELD OF JASMINE AND OTHER CROPS

2.1.1 Effect of *Azospirillum* on growth and yield

In a field trial with banana cv. Poovan, Jeeva (1987) reported that inoculation of *Azospirillum* along with nitrogenous fertilizers increased plant height, girth, total number of leaves, leaf area, sucker production, length of bunch, number of hands, fingers and total soluble solids.

Significant increase in dry weight of shoot and root biomass (90 and 50% respectively), total leaf area (90%) and root length (35%) were reported (Hadas and Okon, 1987) in eighteen days old tomato plants inoculated with *Azospirillum* as compared to un-inoculated plants.

The increase in growth characters like plant height in French marigold by *Azospirillum* inoculation were observed and this might be due to the added nitrogen to crop through associative symbiosis and increased production of growth hormones like NAA, GA and cytokinins (Balasubramanian, 1989).

In roses, the early flowering due to inoculation with *Azospirillum* was observed (Preethi *et al.,* 1999). This was due to induced cytokinin synthesis and rapid assimilation of photosynthates resulting in early transformation of the axillary bulb from vegetative to reproductive phase.

Mortley and Hill (1990) observed that the application of *Azospirillum* inoculant at 2, 4 and 6 weeks after planting increased the total and marketable yield of sweet potato by 12 per cent and 17 per cent respectively. And, 5 per cent and 22 per cent respectively in the second season.

Subbaiah (1990) reported that at 50 per cent of the recommended dose of nitrogen (60 kg/ha) and the seedling treatment with *Azospirillum* as well as soil application of *Azospirillum* recorded the highest agronomic nitrogen use efficiency indicating that, *Azospirillum* inoculation in tomato saved 50 per cent of the recommended dose of nitrogen.

Azospirillum alone was not sufficient to promote the growth, but the interaction effect of *Azospirillum* and nitrogen (80 kg/ha) had beneficial effect in improving the growth and nutrient uptake in cauliflower cv. Jawahar Moti. And, *Azospirillum* inoculation saved up to 50 per cent of recommended nitrogen (Kalyani *et al*., 1992).

Manonmani (1992) reported that in a field trial of gundumalli (*Jasminum sambac*), increased plant height, number of tertiary branches, shoot and leaf area, dry weight of root biomass, flower weight and yield were observed due to inoculation with *Azospirillum* along with nitrogenous fertilizer application.

Jeevajothi *et al.* (1993) reported that the dosage of 100:125:25 kg of NPK per ha along with the seed and soil application of *Azospirillum* increased the yield (117.2 tonnes/ha) in cabbage.

Sundaravelu and Muthukrishnan (1993) reported that in radish, seed treatment with GA along with *Azospirillum* inoculation enhanced the total number of leaves and leaf length when compared to plants from non-inoculated seeds.

Sweet potato cv. Co-3 registered higher tuber yield when treated with two third recommended dose of nitrogen (26 kg/ha) + 2 kg of *Azospirillum* per ha with vine dipping + 10 kg *Azospirillum* per ha as soil application (Yassin *et al*., 1994).

Karuthamani *et al.* (1995) observed an increase in vine length, flowering, sex ratio and yield (16.90 and 17.79 kg/plant) upon *Azospirillum* inoculation in pumpkin along with 9 kg N and 18 kg P per/ha during *rabi* and *kharif*, respectively.

Increase in number of bulblets (14.3/plant), flower stalks (23348 dozen/ha) and more money returns (1:3.73) in tuberose when inoculated with *Azsopirillum* was reported by Wange *et al.* (1995).

In Jathimalli cv. Co-2 of jasmine, there was increased corolla length, tube length, bud width, petal breadth, flower diameter and advanced flowering in the plants inoculated with *Azospirillum* (Vasanthi, 1994).

The yield parameters *viz.,* number of flowers per plant, diameter of flower, ten flower weight, stalk length and flower yield per plant were increased by inoculation with *Azospirillum* strains DAD-2 and DAD-11 in *Gaillardia* (Gadagi, 1999).

Prabhatkumar *et al.* (2003) obtained increase in vegetative growth of China aster by use of biofertilizers *viz.,* VAM+PSB which might be related in simulating nutrient uptake and biosynthesis of plant growth regulators, there by improving the growth and development process of the plant.

Binisha *et al.* (2002) revealed that the treatment combination of NPK along with *Azospirillum* was more effective in improving vegetative and floral characters of *Dendrobium* than NPK alone.

Tamil Vendan *et al.* (2004) reported that inoculation of *Azospirillum* with different levels of nitrogenous fertilizer significantly enhanced the growth and yield parameters in pearl millet. Nitrogen at 75 per cent with *Azospirillum* was sigificnatly higher in plant growth and grain yield parameters as compared to uninoculated control and inoculated control in pearl millet.

A field experiment was conducted by Gunadappagol *et al.* (2004) to study the effect of *Azospirillum* (ACD-15 and ACD-20) inoculation on nitrogen economy and yield of sorghum. The results revealed that *Azospirillum* strain ACD-20 combined with 75 per cent nitrogen fertilizer yielded the highest grain yield (1847 kg/ha), total dry matter (8030 kg/ha), per cent nitrogen content in sorghum plant (0.282%) and B:C ratio (4.77) compared to other treatments.

Effect of *Azospirillum* biofertilizer on sugarcane yield was studied in a field experiment by Gaddanakeri *et al.* (2004). The results revealed that the application of 75 per cent nitrogenous fertilizers with *Azospirillum* has yielded higher cane compared to 100 per cent RDN only. The higher yield was obtained (10% more) when *Azospirillum* was applied in two splits i.e. at planting and 45 days after planting compared to only one application either at planting or 45 days after planting @ 5 or 10 kg/ha.

An *in vivo* study was conducted by Tippannavar *et al.* (2004b) to study the response of *Azospirillum* (ACD-15 and ACD-20) inoculation along with reduced levels of nitrogenous fertilizer on the growth and yield of onion. The results revealed that both the strains (ACD-15 and ACD-20) individually as well as in combination with different levels of N increased the plant growth parameters *viz.,* plant height, number of leaves, fresh and dry weight of plant and bulb yield significantly over the uninoculated control. Among the different treatment combinations, the seed application of *Azospirillum* (ACD-20) along with 75 per cent RDN produced maximum yield (82 q/ha) and was at par with 100 per cent RDN (86 q/ha). Thus, they concluded that there was 25 per cent saving in nitrogenous fertilizers along with increased productivity, beneficial flora of soil and improved soil health.

2.1.2 Effect of Phosphate Solubilizing Bacteria (PSB) on growth and yield

The role of PSB as a biofertilizer is unique in making the fixed soil phosphorus available to plants. PSB produce plant growth regulating substances, which promote root growth.

Different mechanisms of mineral phosphate solubilization included synthesis of organic acids by phosphate solubilizing bacteria, CO_2 and H_2S production and chelation of other acids (Gaur, 1990).

The amount of organic acids liberated by these microorganisms is said to be roughly about five per cent of the carbohydrate consumed (Banik and Dey, 1982). It is also shown that solubilization of mineral phosphate by bacteria is the result of acidification by the direct oxidation of glucose or other aldose sugars (Goldstein, 1995).

Application of phosphobacteria along with inorganic fertilizers resulted in increase in flowers per spike and yield in crossandra (Ravichandran and Pappiah, 1995).

Hemavathi (1997) reported that higher number of flowers and flower yield per plant were obtained by applying PSB+75 per cent recommended NPK (225:300:150 kg/ha) in *Chrysanthemum*.

Combined application of 75 per cent recommended phosphorus + phosphobacteria gave the highest flower yield in gundumalli (Bhavanishankar and Vanagamudi, 1999).

Field experiments were conducted to study the response of inoculating efficient phosphate solubilizers on growth and yield of *rabi* sorghum. Application of phosphorus in the form of MRP in addition to inoculation with different P solubilizing biofertilizers enhanced the plant growth and different yield attributing parameters (Tippannavar *et al.*, 2004a).

2.1.3 Combined effect of *Azospirillum* and PSB on growth and yield

In a field trial with gundumalli (*Jasminum sambac*), Manonmani (1992) observed increased plant height, number of tertiary branches, shoot and leaf area, dry weight, biomass, flower weight and yield with the inoculation of *Azospirillum* and Phosphobacteria along with nitrogenous fertilizers application.

Premkumari and Balasubramanian (1993) studied the effect of combined inoculation of VAM and *Azospirillum* on the growth and nutrient uptake by coffee seedlings and the results indicated that the combined inoculation of *Gigaspora margarita* and *Azospirillum* significantly increased the shoot length, root length and total dry weight of the plants when compared with the uninoculated control. Uptake of P, N, Fe, Cu, Zn and Mn were also increased significantly.

Ravichandran and Pappiah (1995) reported that the application of *Azospirillum* and Phosphobacteria alone or in combination with inorganic fertilizers led to increased flowers per spike and yield in crossandra.

Santhi and Vijaykumar (1998) reported that in palmarosa, application of nitrogen @ 40 kg/ha with *Azospirillum* registered the maximum values for growth and yield attributing characters like number of leaves per plant, number of tillers per plant, leaf number, inflorescence number and fresh weight per plant. Herbage and oil yield per hectare were also higher in the combined application of *Azospirillum* with 30 kg N/ha which was equivalent to that was obtained with 40 kg N/ha application.

Sridar and Santhanakrisnan (1998) reported that the combined application of *P. fluorescens*, *T. viride* and *Azospirillum brasilense* registered the highest germination, shoot and root length, plant biomass and reduced disease incidence. The increase in plant growth and biomass may be due to the additive effect of growth promoting substances produced by all the three organisms and nitrogen fixation by *Azospirillum*.

Bhavanishankar and Vanagamudi (1999) reported that the combined application of 75 per cent recommended N as neem cake blended urea + *Azospirillum* recorded the highest flower yield in *Jasminum sambac* (1.560, 1.739 and 1.779 kg/plant, respectively in 1, 2 and 3 years after fertilizer application) 1 and 2 years after fertilizer application (1.445 and 1.607 kg/plant, respectively).

Chandrikapure *et al.* (1999) reported that African marigold produced significantly greater height in the treatment with 100 per cent N + *Azotobacter* + phosphate solubilizing bacteria and higher yield (58.46 q/ha) per ha in the treatment with *Azotobacter* + PSB + 75 per cent when compared to uninoculation with biofertilizers (19.23 q/ha).

The effect of biofertilizers (*Azospirillum* and phosphobacteria) and inorganic fertilizers in different combination in tuberose was studied by Swaminathan *et al.* (1999). Application of 120:65:62.5 kg NPK per ha + phosphobacteria + *Azospirillum* showed better results with respect to days to sprouting, fresh weight and dry weight per plant. This was due to better availability of nutrients for production of the bulbs.

The application of NPK at 45:45:37.5 mg per kg soil in pots along with combined inoculation of *Azospirillum* and VAM exhibited increased growth in respect of plant height (144.50 cm), number of leaves (156.20) and laterals per plant (28.30) in marigold (Rajdurai *et al.*, 2000).

The effect of biofertilizers and inorganic fertilizers on crossandra cv. Dindigul local was examined by Narasimha and Haripriya (2001). Number of spikes per plant, spike length, number of flowers per spike and flower yield per plant showed better results when 100 per cent NPK (75:50:125 kg/ha) + *Azospirillum* and phosphobacteria each at 2 kg/ha was used. The increased flower yield might be due to the indirect effect of more number of branches as stimulated and developed by the influence of inorganic fertilizers along with biofertilizers. Also, this treatment gave the highest flower yield (41.72 g/plant) with the maximum returns per rupee invested (1:3.5).

The inoculation of Geranium with *Glomus fasciculatum*, *Trichoderma harzianum* and *Pseudomonas fluorescens* enhanced its growth and biomass yield as reported by Shivakumar *et al.* (2002).

In China aster, there was an increase in vegetative growth due to use of biofertilizers (VAM and phosphobacteria) (Prabhatkumar *et al.,* 2003). This was related to nutrient uptake and biosynthesis of plant growth regulators, thereby stimulating the growth and development process of the plant.

Gayathri *et al.* (2004) reported that increased plant height, number of leaves, higher number of branches and higher flower yield per plant were obtained with the application of 75 per cent NP + 100 per cent K + vermicompost + *Azotobacter* + PSB in statice (*Limonum caspia*).

Mahesh *et al.* (2004) reported that the seed treatment of tomato by consortium of bioagents (*Azospirillum*, PSB and *Trichoderma*) increased the number of leaves by 9 per cent, 16.98 per cent and 36.25 per cent after I, II and III weeks after sowing, compared to non-treated seeds.

Naik and Patil (2004) isolated different plant growth promoting rhizobacteria such as *Rhizobium, Azospirillum* and Phosphate solubilizers. The efficient isolates having beneficial traits such as N_2 fixation, phosphate solubilization, production of IAA, GA and bicontrol activity were used to study the effect individually and in combination with each other by inoculating to soybean. The results indicated that the combined application of three or more beneficial organisms exerted more favourable effect on growth and productivity of soybean than dual or single inoculations.

Padmadevi *et al.* (2004) reported that the application of *Azospirillum,* phosphate solubilizing bacteria and VAM along with inorganic nutrients and growth regulators brought about significantly higher effects on growth and flowering in Anthurium.

The report by Srivastava and Govil (2005) revealed that the biofertilizers *Azotobacter*, phosphate solubilizing bacteria (PSB), VA-mycorrhiza (VAM) and farmyard manure application improved different vegetative and floral characters of Gladiolus as compared to control. It was found that the treatment of corms with the biofertilizers increased the total rhizospheric bacteria population in gladiolus.

Application of *Azotobacter* + PSB + VAM proved to be the best combination for getting maximum plant height (14.18 cm), aerial biomass (65.96 g/plant), underground biomass (17.74 g/plant), rhizome yield (4.16 g/plant) and root yield (13.58 g/plant) of

Valeriana jatamansi. These growth and yield parameters were directly influenced by the increased nutrient content (3.51, 0.37 and 1.70% NPK, respectively) and nutrient uptake of this plant under the combination of *Azotobacter* + PSB + VAM (Salathia, 2005).

Shubha (2006) reported that the highest plant height, number of leaves, number of branches, flower bud initiation, flowering duration, flower yield per plant and xanthophyll yield were obtained with the application of *Azospirillum* + vermicompost + 75 per cent recommended dose of nitrogen and phosphorus in African marigold (*Tagetes erecta* L.).

Chaitra (2006) also observed increase in plant height, number of branches, leaf area and flower yield per plant with the application of biofertilizers (*Azospirillum* + PSB) + vermicompost + 50 per cent recommended dose of NPK fertilizers in China aster (*Callistephus chinensis* (L.) Nees).

2.2 EFFECT OF BIOFERTILIZERS ON FLOWER QUALITY

Biofertilizers can influence the longevity of flowers. This may be due to increased phosphorous uptake by plants and better development of water conducting tissues especially in mycorrhizal plants (Chang, 1990).

Gerbera plants colonized by *Glomus mossae* produced flowers, which lasted three days longer than flowers of non-mycorrhizal plants in the vase (Wen, 1991).

Hemavathi (1997) observed that chrysanthemum plants inoculated with VAM + 50 per cent recommended NPK increased the vase life of flowers compared to plants receiving recommended NPK.

In Gerbera, maximum vase life (12 days) was observed in flowers harvested from plants treated with *Azospirillum*, VAM and 50 per cent recommended nitrogen, phosphorus and potassium (Seetha, 1999).

2.3 EFFECT OF BIOFERTILIZERS ON NUTRIENT CONTENT

Seed bacterization with *Pseudomonas striata* and *Bacillus polymyxa* when used as single and mixed inoculants, increased the yield and P uptake in potato (Kundu and Gaur, 1980). When the phosphobacteria were inoculated together, the increase was 35.20 per cent followed by *Pseudomonas striata* (30.8%) and *B. polmyxa* (22.90%).

Alagawadi and Gaur (1988) reported that inoculation of *Rhizobium, P. striata* or *B. polymyxa* significantly increased nitrogen and phosphorus uptake by chickpea over control. The uptake was further enhanced with the application of 10 kg N and 60 kg P per ha. The highest N and P uptake was recorded in Rhizobium + 20 kg N and 60 kg P per ha.

Negi *et al.* (1991) observed higher nitrogen and phosphorus uptake in barley plants inoculated with *Azospirillum brasilense* in the presence of nitrogen and phosphorus fertilizers.

Rachewad *et al.* (1991) observed increased biomass production and P uptake in maize due to inoculation with *Bacillus polymyxa*. Inoculation effect was more pronounced in the presence of added P fertilizer. Increase in yield and P uptake of rice due to inoculation with phosphate soluiblizing microorganisms in combination with rock phosphate or single super phosphate has been reported (Anthoniraj *et al.*, 1997).

Field trials conducted by Alagawadi and Gaur (1992) revealed that a significant increase in yield and nutrient uptake of sorghum were obtained due to combined inoculation of *Azospirillum brasilense* and *Psuedomonas straita* or *Bacillus polymyxa* when compared to inoculation of individual organisms.

Prathibha *et al.* (1994) reported that there was a significant increase in the nutrient and dry matter yield of cotton due to combined inoculation of *Azospirillum* and *Pseudomonas striata* compared to treatment receiving single inoculation. Further, Prathibha *et al.* (1995) recorded significant increase in the yield of seed cotton due to combined inoculation of *Azospirillum* and *P. striata* as compared to single inoculation treatment.

Mahendran *et al.* (1996) revealed that two equal splits of 100 per cent NPK with biofertilizers such as *Azospirillum* and phosphobacterium significantly influenced the uptake of NPK by different plant parts of potato over treatment receiving recommended dose of fertilizers alone.

Thamizh and Nanjan (1998) stated that the combined application of *Azospirillum*, phosphobacteria and VAM with 75 per cent of recommended NPK recorded higher yield of potato (14.96 t/ha) which was 21 per cent higher than uninouclated control (11.93 t/ha).

Combination of 50 per cent N and P coupled with *Rhizobium* and phosphate solubilizing microorganisms increased plant height, number of branches, leaves/plant, number of pods/plant, grains/pod and pod yield significantly in garden pea compared to recommended levels of nutrients applied through chemical fertilizers only (Patel *et al.,* 1998).

2.4 EFFECT OF BIOFERTILIZERS ON BIOLOGICAL ACTIVITY OF SOIL

Soil is a living tissue with complex biochemical reactions going on regularly. Several enzymes in soil catalyze these biochemical reactions which are responsible for nutrient cycling in soils. The enzymes that are directly concerned with carbon, nitrogen and phosphorus cycles in soils are urease, dehydrogenase and phosphatases.

Urease is unique among soil enzymes since it affects the fate and performance of an important fertilizer (urea). For this reason, it has been studied more intensively than other soil enzymes.

Dehydrogenase in the soil is believed to be an intracellular enzyme mainly associated with microbial respiration. The dehydrogenase has potential advantage in that addition of substrate is not required in soil. For these reasons, it has been considered to be an index of indigenous soil microbial activity (Stevenson, 1959).

It is well known that enzymes play key roles in the transformation, recycling and availability of plant nutrients in soil. They are likely to be influenced by fertilizers and manures. Various enzyme activities were found to be maximum in FYM treatment. Higher rates of NPK fertilization enhanced the activities of soil enzymes and the effect was more pronounced with FYM in combination with fertilizers (NPK) (Singaram and Kamalakumari, 1993).

The application of mechanical plant compost clearly increase dynamic behaviour of enzymes and biomass C which are the indicators of the biological health of soil. This favourable effect on soil biological activity was noticeable with addition of mechanical plant compost. There was significant increase in soil microbial biomass carbon by the addition of mechanical plant compost (0-50 t/ha), the increase being 2.47 times under wheat and 2.32 times under soybean due to application of 10 to 50 t/ha of the compost. The dehydrogenase activity increased significantly with the application of mechanical plant compost under wheat and soybean (Manna and Ganguly, 1997).

Raj *et al.* (2004a) studied the effect of compost enriched with microbial consortium (*Aspergillus pleurotus, Trichoderma*) on tomato plants. The results revealed that total tomato fruit weight was increased (1.2 k g/bag) compared to only compost (0.86 kg) and normal method (0.43 kg) without compost. And, they observed the enhancement of microbial population, enzyme activities and microbial biomass C, N and P at 60 days after transplanting.

Raj *et al.* (2004b) reported that inoculation of P-solubilizers (*Aspergillus niger*) and *Azospirillum brazilense* in teak plants increased the plant height and biomass (27 cm and 25.88 g dry weight/plant, respectively). The biofertilizers also enhanced the microbial biomass and enzyme activities in root zone soil.

3. MATERIAL AND METHODS

The present investigation on the response of jasmine (*Jasminum auriculatum*) to biofertilizers was carried out in the Floriculture unit of the Department of Horticulture, College of Agriculture, University of Agricultural Sciences, Dharwad during 2007-08. The details of the materials used and the techniques adopted during the course of the experiment are furnished in this chapter.

3.1 GEOGRAPHICAL LOCATION OF THE EXPERIMENTAL SITE

Floriculture unit of the Department of Horticulture, Dharwad is situated in the Agro-climatic zone-8 (Northern transitional zone) of Karnataka state. Geographically, Dharwad is located at 15°-26' north latitude and 75°-07' east longitude and is at an altitude of 678 m above mean sea level (MSL).

A field experiment was conducted in three years old jasmine plantation in the Floriculture Unit (Plate 1). The meteorological data for the year 2007-08 recorded at the Meteorological Observatory, Agriculture College Farm, Dharwad are given in Appendix I.

3.1.1 Soil characteristics

The experimental site has red soil of the sandy clay type. The physico-chemical and microbiological characteristics of the soil are furnished in Appendix II.

3.2 EXPERIMENTAL TECHNIQUES

3.2.1 Design and experimental layout

The experiment was laid out by adopting Randomized Block Design (RCBD). The treatments in each replication were allotted randomly. The details are as follows.

Location	:	MARS, Dharwad
Treatments	:	6
Number of replications	:	6
Gross plot size	:	27.0 m x 3.0 m
Spacing	:	1.5 m x 1.5 m
Number of observation branches	:	10
Number of microbial inoculants	:	4

The lignite based cultures of *Azospirillum*, *Pseudomonas striata*, *Pseudomonas fluorescens* and *Trichoderma viridae* were obtained from the Department of Agricultural Microbiology, University of Agricultural Sciences, Dharwad and used @ 8 kg/ha each. FYM was applied uniformly to all the treatments @ 9.0 t per ha as per the package of practices.

The treatments imposed were as below.

Sl. No.	Treatment
1	T_1 – 100% RDF
2	T_2 – 75% RDF
3	T_3 – 50% RDF
4	T_4 – 100% RDF + Biofertilizers (microbial consortium)
5	T_5 – 75% RDF + Biofertilizers (microbial consortium)
6	T_6 – 50% RDF + Biofertilizers (microbial consortium)

Plate.1: General view of the field experiment on the university farm

Where,

RDF = Recommended dose of NPK (60:120:120 g/plant)

Microbial consortium

1. Nitrogen fixer = *Azospirillum* sp. (ACD-15 and ACD-20)
2. PSB = Phosphate solubilizing bacterium, *Pseudomonas striata*
3. PGPR = Plant growth promoting rhizobacterium, *Pseudomonas fluorescens* (WGUK 327 (2))
4. PGPF = Plant growth promoting fungus, *Trichoderma viridae*

3.2.2 Method of application

Calculated quantities of lignite based cultures were mixed with FYM and applied around each plant in a circular band (about 10 cm away), after pruning.

3.3 CULTURAL OPERATIONS

The normal cultural practices such as pruning, application of fertilizers, irrigation, weeding and plant protection measures followed are briefly described here under.

3.3.1 Pruning

In the beginning of the experiment, during the last week of November, the plants were pruned by removing dead, diseased and unwanted branches by cutting back all the bushes to a height of 25-35 cm from the ground level.

3.3.2 Fertilizer application

The plants were supplied with NPK fertilizers in split doses, once after the pruning (November, 2007) and second during March, 2008 in a circular band of about 30 cm around each plant in 15 cm deep furrows.

3.3.3 Weeding and irrigation

The plots were kept free from weeds by periodic hand weeding. Irrigations were given at an interval of 10-15 days throughout the period of experimentation, depending on the soil moisture status and climatic condition.

3.3.4 Plant protection

Timely and suitable plant protection measures were given to protect the experimental plants from the attack by pests and diseases.

3.3.5 Harvesting

The white buds were harvested daily in the morning. The first picking was in April month and continued upto June month.

3.4 FIELD EXPERIMENT ON A FARMER'S FIELD

Another field experiment was conducted on a farmer's field at Chigateri village (Plate 2). The design followed, treatments and replications maintained and the method of application of biofertilizers were same as those followed for the field experiment on the University farm.

Details of the farmer cultivating jasmine are as follows.

1. Name of the farmer	:	Shri K. Jayanagouda
2. Name of the village and address	:	Chigateri, Harapanahalli (Tq.), Davanagere (Dist.)
3. Growing jasmine since	:	3 years

4. Area under jasmine	:	36 guntas
5. Treatments	:	Six
6. Replications	:	Six
7. Spacing followed	:	2.0 m x 2.0 m
8. Gross plot	:	12.0 m x 12.0 m
9. Number of observation branches	:	10

3.5 COLLECTION OF DATA

3.5.1 Sampling procedure

The observations on various parameters of vegetative growth and flowering were recorded at four stages of plant growth *viz.,*

I stage	: Zero days after pruning
II stage	: 30 days after pruning
III stage	: 60 days after pruning
IV stage	: 90 days after pruning

For recording various biometric observations, ten branches at random from each plant were tagged and used for recording number of leaves, leaf area and chlorophyll content. However, the whole plant was considered for plant height, number of branches, days required for first bud initiation, first flowering, number of flowers, days for 50 per cent flowering and flower yield.

3.5.2 Observations on growth parameters

3.5.2.1 Plant height

The height of the plant was measured from the base to the growing tip of the shoot in cm at different stages of plant growth and the average worked out.

3.5.2.2 Number of braches

The total number of initial branches and primary branches were counted after pruning at different stages of growth and the average computed.

3.5.2.3 Plant canopy

The plant canopy was measured after pruning in cm at different stages of growth and the average worked out.

3.5.2.4 Number of leaves

The total number of leaves was counted after pruning in the randomly selected ten branches and the average worked out.

3.5.2.5 Leaf area

The leaf area was measured at 90 DAP using leaf area meter (L1-Cor Instruments, USA) and expressed as square centimeters by selecting 20 leaves at random from the entire plant.

3.5.2.6 Chlorophyll content

The chlorophyll content was measured by using a SPAD (Soil Plant Analysis Device) at different stages of growth by selecting ten leaves randomly at the centre of the branch and the average worked out.

Plate.2. General view of the field experiment on a farmer's field at chigateri village

3.6 OBSERVATIONS ON FLOWERING, FLOWER YIELD AND YIELD ATTRIBUTES

3.6.1 Days to first bud initiation

This parameter was recorded by counting the days from the date of pruning to the stage at which the first flower bud formation was started in each treatment plants.

3.6.2 Time taken to first flowering

This parameter was recorded by counting the number of days from the date of pruning to the stage at which the first flower bloomed in each plant.

3.6.3 Days to 50 per cent flowering

The number of days taken for 50 per cent of the flowering in each treatment plant was recorded by counting the days after pruning.

3.6.4 Number of flowers per plant

At peak flowering stage, number of flowers harvested daily from each treatment plant was averaged and recorded as the number of flowers per plant.

3.6.5 Weight of flowers per plant

At peak flowering stage, flowers were harvested and weight of the flowers from each treatment plant was recorded and averaged to get weight of flowers per plant.

3.6.6 Flower yield

The daily harvested flowers weight was recorded for 50 days and computed to get flower yield (g/plant).

3.6.7 Ten flower weight

The weight of ten buds was taken randomly from the plants during peak season of flowering and expressed in grams.

3.7 FLOWER QUALITY PARAMETERS

Ten marketable flowers from each treatment plant were randomly selected for recording the following observations.

3.7.1 Stalk length

The length of the stalk of the flower was measured from the base of the stalk to the neck of the flower by placing them on a graph sheet and expressed in centimeters.

3.7.2 Petal length

The length of the petal was measured by placing it on a graph sheet.

3.7.3 Diameter of flower

Diameter of the flowers was measured at the point of maximum breadth and the average diameter in cm computed.

3.7.4 Shelf life of loose flowers

Ten randomly selected flowers in each treatment were kept in polyethylene bags with ventilation. Shelf life of the flowers was assessed by recording the number of hours up to which 50 per cent or more flowers maintained freshness without exhibiting brown pigmentation.

3.8 PLANT ANALYSIS FOR NPK CONTENT IN LEAVES

3.8.1 Sampling and preparation of samples

The leaf samples for NPK analysis were collected at two stages once before flowering and second at the time of application of second dose of NPK fertilizers to plants *i.e.* after 90 DAP. The leaves were washed thoroughly with tap water and then with distilled water and the water blotted out. The leaf samples were air dried for 24 h and then kept in brown paper bags with sufficient holes for aeration and dried in a hot air oven at 60℃ for 1 hour. The dried leaf samples were finely ground in a “Willey Mill”. This fine power was stored in air tight vials till the samples were used for chemical analysis.

3.8.2 Nitrogen

Nitrogen in leaves was estimated by Microkjeldahl’s method as illustrated by Jackson (1973) and expressed in percentage.

The samples were digested with 10 ml concentrated sulphuric acid in the presence of 200 mg catalyst mixture containing potassium sulphate, copper sulphate and selenium in the ratio 100:10:1. The samples were digested at 100℃ overnight and again at 400℃ for 90 min or till the samples became clear in the digestion tubes.

The digested samples were distilled in microkjeldhal assembly, in alkaline conditions by adding 15 ml of 40 per cent NaOH. The ammonia liberated during distillation was collected in 4 per cent boric acid containing mixed indicator and titrated against 0.05 N H_2SO_4. The percentage of nitrogen was calculated by recording the volume of acid run down.

3.8.3 Phosphorus

Phosphorus content in the leaves was estimated by vanadomolybdate method after acid digestion as detailed by Jackson (1973).

Five ml of aliquot of the plant digest was transferred into a 50 ml, volumetric flask. Ten ml of Vanadomolybdate reagent was added to samples and also to each standards, mixed thoroughly and the volume made upto 50 ml with distilled ater. After 30 minutes of colour development, the intensity of yellow colour was read in a spectrophotometer at 430 nm. The calibration curve (standard graph) of P standard was drawn by plotting the P-absorbance against P concentration. The P content in plant digest sample was determined by referring to the standard curve.

3.8.4 Potassium

The potassium content in the plant was estimated from triacid digested material using a flame photometer as described by Jackson (1973).

A known quantity of the aliquot or plant digest was transferred to a 50 ml volumetric flask and volume made upto with distilled water. The flame photometer reading was adjusted to zero with 0 ppm K standard solution and to 100 with 10 ppm K standard solution. The standard curve was drawn by plotting flame photometer readings on Y axis and concentration of K on x-axis. The concentration of K in diluted plant digested samples was arrived at by referring to the standard curve.

3.9 CHEMICAL ANALYSIS OF SOIL

Soil samples were collected after pruning of plants and before imposing treatments to the plants. These samples were analyzed for chemical properties such as pH, EC, available nitrogen, phosphorus and potassium.

3.9.1 Soil pH

Soil pH was determined in soil : water (1:2.5) suspension by using a digital pH meter (Jackson, 1973).

3.9.2 Electrical conductivity (EC)

After measuring the pH, the supernatant solution was used for measuring the electrical conductivity using a conductivity bridge and expressed in dS/m.

3.9.3 Available nitrogen

It was determined by alkaline potassium permanganate method. Soil samples were added with excess alkali and potassium permanganate solution. The ammonia evolved was absorbed in boric and was titrated against standard acid (Subbaiah and Asija, 1956).

3.9.4 Available phosphorus

The available phosphorus in the soil was extracted using the Brays-I reagent (0.03 N ammonium fluoride in 0.025 N HCl). The available P in the extract was estimated by chlorostannous reduced molybdophosphate blue colour method by taking OD at 660 nm in a spectrophotometer (Jackson, 1973).

3.9.5 Available potassium

The available potassium in the soil was extracted with neutral normal ammonium acetate solution and determined using a flame photometer (Elico model CL361) (Jackson, 1973).

3.10 MICROBIOLOGICAL ANALYSIS

3.10.1 Estimation of microbial population in the rhizosphere of jasmine grown in the experimental plot

Sample collection

Soil samples were collected from each treatment plot after pruning of jasmine plants and before imposing the treatments (*i.e.* at the initial stage) and at 90 DAP *i.e.*, before applying second dose of fertilizers.

The samples were analyzed for total bacteria, fungi, actimycetes by using nutrient agar, MRBA and Kuster's agar media respectively. The samples collected at 90 DAP were analyzed for P-solubilizers free living, N_2 fixers, *Trichoderma* and fluorescent pseudomonads on TCP medium, Norris N-free medium, TSM and King's B medium, respectively.

3.10.2 Estimation of microbial load in lignite based biofertilizers

All the biofertilizers used in the experimentation were analyzed for their respective microbial loads as done in 3.8.1. *Azospirillum* biofertilizer culture contained 5.0 x 10^7 cfu/g population, PSB culture – 4.7 x 10^7 cfu/g, *Trichoderma* culture – 3 x 10^5 cfu/g and *P. fluorescens* culture – 4.6 x 10^7 cfu/g.

3.10.3 Testing the compatibility of microbial inoculants

The microbial inoculants *viz., Azospirillum* sp. (ACD-15 and ACD-20), phosphate solubilizer (*Pseudomonas striata*). *Pseudomonas fluorescens* (WGUK 327(2) and *Trichoderma viridae* were purified by four way streaking and tested for compatibility amongst themselves before using them in the experimentation following the dual culture assay.

3.10.4 Enzyme activities

3.10.4.1 Dehydrogenase activity

Dehydrogenase activity in the soil samples were determined by following the procedure as described by Casida *et al.* (1964). Ten grams of soil and 0.2 g $CaCO_3$ were thoroughly mixed and dispensed in test tubes. To each tube was added one ml of 3 per cent aqueous solution of 2, 3, 5-triphenyl tetrazolium chloride (TTC), one ml of one per cent glucose solution and eight ml of distilled water which was sufficient to leave a thin film of water above the soil layer. The tubes were stopped with rubber cork and incubated at 30℃ for 24 hrs. At the end of incubation, the contents of the tube were rinsed down into a small beaker and a slurry made by adding 10 ml methanol. The slurry was filtered through Whatman No. 50 paper. Repeated rinsing of soil with one ml methanol was continued till the filtrate ran free of red colour. The colour sampled was measured at 485 nm against a methanol blank using Graphicord Shimadzu UV visible spectrophotometer (model UV-240). The concentrations of formazan in soil samples were determined by referring to a standard curve prepared by using graded concentration of formazan. The results were expressed as µg of triphenyl formazan (TPF) formed g^{-1} soil per day.

3.10.4.2 Urease activity

The procedure adopted to determine the urease activity of soil was essentially the same as adopted by Pancholy and Rice (1973) except that the ammonia liberated due to hydrolysis used in the reaction mixture was determined by nesslerization as described by Jackson (1973).

Ten grams each of freshly collected soil samples were placed in 100 ml capacity Erlenmeyer flasks to which one ml toluene was added and allowed to stand for 15 minutes to permit complete penetration into soil. Each of these flasks were added with 10 ml of phosphate buffer (pH 6.7) and 10 ml of 10 per cent urea solution. For control flasks, urea solution was replaced by equal quantity of distilled water. The contents of the flasks were well shaken for five minutes and incubated at 30℃ for 24 hrs. After incubation, the contents of the flasks were filtered through Whatman No. 42 filter paper. The remaining soil in the flask were added with 15 ml of 1 N KCl solution shaken for five minutes and filtered. The volume of the total filterate was made upto 100 ml in a volumetric flask using distilled water.

The amount of ammonia present in the filterate was determined by nesslerization. One ml filtrate of each sample was transferred to a 20 ml volumetric flask to which two ml of ten per cent sodium tartarte solution and 0.5 ml of Nessler's reagent were added. The volume was made upto 20 ml with distilled water.

The yellow colour developed after 30 minutes was measured at 410 nm using Graphicord Shimadzu UV-visible spectrophotometer (model UV 240) against the reagent blank.

3.10.4.3 Phosphatase activity

Phosphatase activity of soil samples was determined by following the procedure of Evazi and Tabatabai (1979). One gram of soil sample was placed in a 50 ml Erlenmeyer flask to which 0.2 ml toluene followed by 4 ml of modified universal buffer (pH 7.5) were added. One ml of P-nitrophenol phosphate solution made in modified universal buffer was added to the flasks and contents of the flasks were mixed by swirling for two minutes. The flasks were stoppered and incubated at 37℃ for one hour. After incubation, one ml of 0.5 M $CaCl_2$ and four ml of 0.5 M NaOH were added to the flask, swirled and filtered through Whatman No. 42 filter paper. The intensity of yellow colour developed was measured at 420 nm against the reagent blank using Graphicord Shimadzu UV-visible Spectrophotometer (Model UV-240).

Controls were maintained for each soil sample and were analyzed by following the same procedure described above except that the paranitrophenol phosphate solution was added after the addition of 0.5 M $CaCl_2$ and 0.5 M NaOH and just before filteration. The phosphatase activity in the soil samples was expressed as µg paranitrophenol formed per gram soil per hour with reference to the standard curve prepared by using graded concentrations of P-nitrophenol phosphate.

3.11 STATISTICAL ANALYSIS

The data were subjected to randomized block design and completely randomized block design analysis and interpretation of the data was carried out in accordance with Panse and Sukhatme (1985). The level of significant used in the 'F' and 't' test was P=0.05 and P=0.01 for RBD and CRD, respectively. The critical difference values were calculated whenever the F test values were significant.

4. EXPERIMENTAL RESULTS

Field experiments were conducted at the New Orchard, Horticulture Unit, College of Agriculture, University of Agricultural Sciences, Dharwad during 2007-08, to study the effect of biofertilizers on yield and quality of jasmine flowers. Experiment was also conducted on a farmer's field at Chigateri village, Harapanahalli Taluk, Bellary District. The results obtained in these experiments are presented under the following subheadings.

4.1 TESTING COMPATIBILITY OF THE MICROBIAL INOCULANTS USED

Various microbial inoculants used in the experimentation were tested for compatibility amongst themselves. It was observed that all the strains were compatible with each other.

4.2 EFFECT OF BIOFERTILIZERS ON GROWTH PARAMETERS OF JASMINE CROP

The data pertaining to growth parameters as influenced by the application of biofertilizers in combination with chemical fertilizers, such as height of plants and number of branches are presented in Table 1 and Fig. 1. Observations on number of leaves and plant canopy are presented in Table 2 and Fig. 1, and the data pertaining to leaf area and chlorophyll content in leaves are presented in Table 3a, Fig. 2 and 3.

4.2.1 Plant height

There was no significant difference in plant height due to application of biofertilizers at different levels of NPK fertilizers at 30, 60 and 90 days after pruning (DAP).

However, at 30 DAP, the highest plant height (58.50 cm/plant) was recorded in T_4 (100% RDF + biofertilizers) treatment and the next highest height (56.83 cm/plant) was recorded in T_5 (75% RDF + biofertilizers) treatment. The treatment receiving 50 per cent RDF recorded the lowest plant height (49.00 cm/plant).

At 60 days after pruning also, T_4 treatment receiving 100 per cent recommended dose of fertilizers + biofertilizers recorded the highest plant height (88.67 cm/plant) followed by the treatment T_1 (100% RDF). The treatment receiving 50 per cent RDF showed the least value of plant height (74.50 cm/plant).

The treatment T_4 receiving 100 per cent RDF + biofertilizer showed the best result (145.17 cm/plant) followed by treatment T_5 receiving 75 per cent RDF + biofertilizers, while the treatment T_3 receiving 50 per cent RDF recorded the lowest plant height (118.00) at 90 days after pruning (DAP).

4.2.2 Number of branches

The observations revealed that there was no significant difference amongst the treatments for number of branches at 30, 60 and 90 days after pruning.

However, the treatment T_3 (50% RDF) resulted in the highest result (133.67 branches/plant) followed by T_2 (75% RDF) treatment (123.83 branches/plant), while treatment T_5 (75% RDF+biofertilizer) showed the lowest branches at 30 days after pruning (DAP) (92.87).

At 60 days after pruning, the treatment T_2 receiving 75 per cent RDF showed the highest number of branches (170.17) followed by T_1 (100% RDF) treatment (155.17). And, the treatment T_6 (50% RDF + biofretilizer) showed the least number of branches (126.33).

The highest number of branches (195.17) was recorded in treatment T_2 which was followed by treatment T_4 and the lowest number of branches (152.67) was recorded in T_6 at 90 days after pruning (DAP).

Table 1. Effect of biofertilizers on plant height and number of branches of Jasmine

Treatment	Plant height in (cm/plant)				Number of branches per plant			
	0 DAP	30 DAP	60 DAP	90DAP	0 DAP	30 DAP	60 DAP	90DAP
T_1 (100% RDF)	30.50	56.33	85.33	140.00	64.17	117.67	155.17	179.67
T_2 (75% RDF)	31.50	55.00	77.67	137.67	86.50	123.83	170.17	195.17
T_3 (50% RDF)	28.83	49.00	74.50	118.00	65.17	133.67	142.33	169.67
T_4 (100% RDF+ biofertilizer)	32.33	58.50	88.67	145.17	61.00	116.33	149.33	187.33
T_5 (75% RDF+ biofertilizer)	30.67	56.83	80.67	140.50	51.00	92.83	128.67	164.17
T_6 (50% RDF+ biofertilizer)	32.67	55.00	78.00	124.50	39.83	98.50	126.33	152.67
S.Em.±	1.799	2.490	5.310	8.620	10.250	18.208	20.968	22.728
CD @ 5%	NS	NS	NS	NS	NS	NS	NS	NS

Note: DAP- Days After Pruning

Table 2. Influence of biofertilizers on number of leaves and plant canopy of Jasmine

Treatment	Plant canopy (cm/plant)				Number of leaves per branch			Number of leaves per plant		
	0 DAP	30 DAP	60 DAP	90 DAP	30 DAP	60 DAP	90 DAP	30 DAP	60 DAP	90 DAP
T_1	51.17	67.33	102.33	114.33	11.45	35.60	61.83	1349.3	5537.3	11080.2
T_2	49.67	69.02	84.67	96.67	11.22	34.60	60.87	1373.7	5901.2	12003.0
T_3	48.45	68.80	84.00	96.17	11.30	32.37	60.74	1513.1	4524.7	10409.6
T_4	55.25	73.00	103.67	115.67	11.71	37.20	62.12	1362.4	5768.3	11730.9
T_5	50.83	70.98	86.33	98.33	11.45	36.22	61.67	1061.2	4477.5	10121.2
T_6	49.33	69.07	85.00	97.17	11.34	34.05	60.92	1125.9	4206.0	9309.6
S.Em.±	4.085	4.568	8.042	8.023	0.28	4.17	1.80	214.16	964.41	1524.41
CD @ 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Note: DAP- Days After Pruning

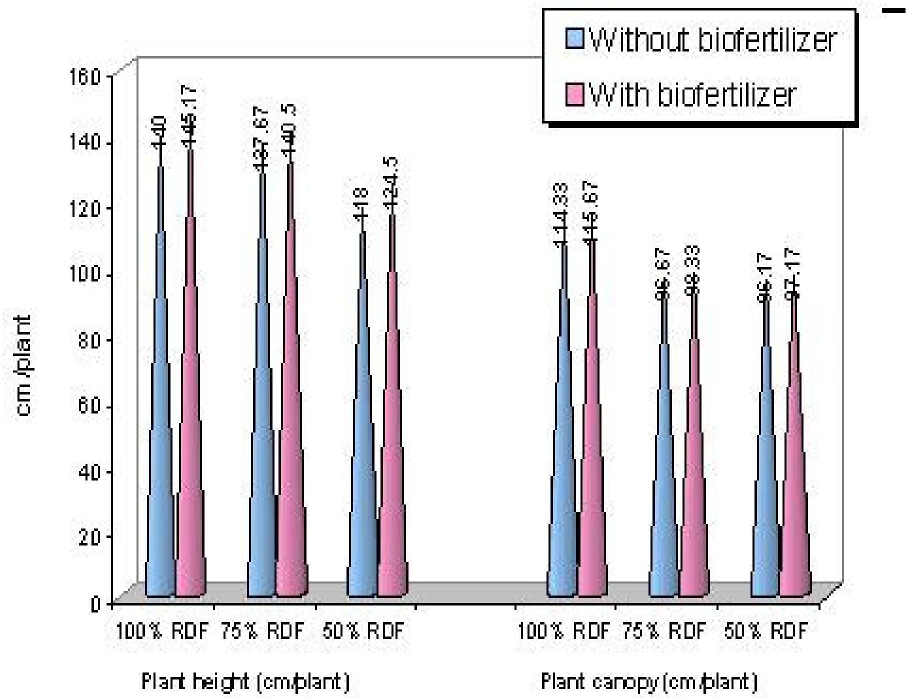


Fig.1. Effect of biofertilizer on plant height and plant canopy of jasmine at 90 DAP

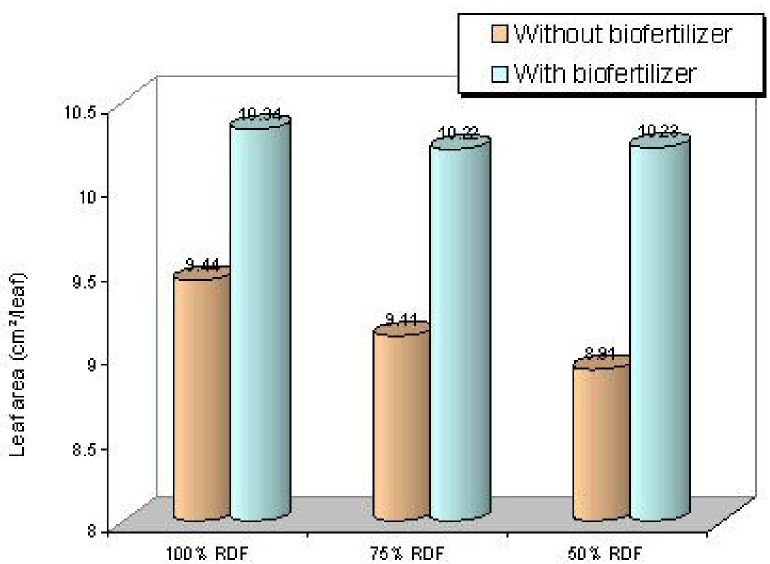


Fig.2.Effect of biofertilizers on leaf area of jasmine at 90 DAP

Table 3a. Effect of biofertilizers on leaf area and chlorophyll content in leaves of Jasmine

Treatment	Leaf area (cm^2/leaf)	Chlorophyll content (SPAD value)		
	90 DAP	30 DAP	60 DAP	90 DAP
T_1	9.44	22.76	56.80	67.90
T_2	9.11	22.22	57.78	66.08
T_3	8.91	22.11	55.14	64.93
T_4	10.34	24.01	60.90	71.10
T_5	10.22	23.36	59.93	69.20
T_6	10.23	23.14	59.42	68.25
S.Em.±	0.474	0.397	1.00	1.352
CD @ 5%	NS	1.155	2.90	3.937

Note: DAP- Days After Pruning

4.2.3 Plant canopy

The experimental data showed that there was no significant difference among the treatments as influenced by application of biofertilizers at 30, 60 and 90 days after pruning (DAP).

However, the treatment T_4 receiving 100 per cent RDF + biofertilizer recorded the highest plant canopy (73.00 cm) followed by T_5 (75% RDF + biofertilizer) (70.98) at 30 DAP. The treatment T_1 receiving 100 per cent RDF recorded the least (67.33 cm) plant canopy.

At 60 DAP also, the treatment T_4 (100% RDF + biofertilizers) was the best treatment with the plant canopy of 103.67 cm per plant. The second best was T_1 (100% RDF) treatment. The lowest plant canopy (84.0 cm) was shown by plants which received 50 per cent RDF (T_3).

The same trend was observed at 90 DAP also. T_4 (100% RDF + biofertilizers) showed the best result (115.67 cm) which was followed by T_1 (100% RDF) treatment, while the treatment T_3 (50% RDF) showed the lowest plant canopy (96.17 cm).

The data on plant height and number of branches of jasmine on per cent increase over initial values are furnished in Table 3b. In plant height, there was no different due to different treatments. T_1 remained superior at all days of sampling, although statistically on par with other treatments. In the number of branches also, there was no significant difference amongst the treatments. However, T_6 treatment (50% RDF + biofertilizers) was promising with the per cent increase over control of 157, 235 and 310 respectively at 30, 60 and 90 DAP. In case of plant canopy also, there was no significant difference amongst the treatments. T_2 was superior with 4.6 per cent increase over initial at 30 DAP and T_2 with 109.6 per cent and 134.5 per cent increase at 60 DAP and 90 DAP respectively.

4.2.4 Number of leaves per plant and per branches

The application of biofertilizers in combination with chemical fertilizers did not show any significant difference among the treatments for the number of leaves parameter.

However, at 30 DAP, the treatment T_4 (100% RDF + biofertilizers) showed the highest (11.71) number of leaves per branch. This was followed by treatments T_1 and T_2 with 11.45 leaves each. The lowest (11.22) value was recorded in treatment T_2 (75% RDF).

At 60 DAP, the treatment T_4 (100% RDF + biofertilizers) recorded the highest (37.20) number of leaves per branch and the treatment T_3 receiving 50 per cent RDF showed the lowest value (32.37).

At 90 days after pruning, similar trend was noticed as in case of 60 DAP. The plants receiving 100 per cent RDF + biofertilizers recorded the maximum number of leaves (62.12) which was followed by the plants receiving 100 per cent RDF. The treatment T_3 receiving 50 per cent RDF showed the lowest (60.74) number of leaves per branch.

The number of leaves per plant also did not differ significantly with the application of biofertilizers.

The treatment T_3 (50% RDF) recorded the highest value (1513.1), while the lowest number (1061.19) of leaves per plant were recorded in the treatment T_5 receiving 75 per cent RDF + biofertilizers at 30 days after pruning (DAP).

At 60 days after pruning, plants receiving 75 per cent recommended dose of fertilizer (T_2) showed the highest number of leaves per plant (5901.15) which was followed by treatment T_4 (100% RDF + biofertilizers) while the treatment T_6 receiving 50 per cent RDF + biofertilizers recorded the least number of leaves per plant (4206).

The treatment T_2 (75% RDF) recorded the best value (12,003.0) for number of leaves which was followed by T_4 (100% RDF + biofertilizers) with 11,730.9. The least (9,309.6) number of leaves per plant was recorded in T_6 (50% RDF + biofertilizers) at 90 days after pruning (DAP).

4.2.5 Leaf area

There was no significant difference amongst the treatments with respect to leaf area at 90 DAP. However, the highest leaf area of 10.34 cm^2 was obtained in the treatment T_4

Table 3b. Per cent increase over initial values of plant height, number of branches and plant canopy of Jasmine as influenced by biofertilizers

Treatment	Plant height (cm)			Number of branches			Plant canopy (cm)		
	Per cent increase over initial values								
	30 DAP	60 DAP	90 DAP	30 DAP	60 DAP	90 DAP	30 DAP	60 DAP	90 DAP
T_1	87.9	180.7	364.9	107	189	235	35.4	109.6	134.5
T_2	75.1	147.0	334.8	54	125	153	48.6	72.8	97.5
T_3	68.7	156.9	305.9	102	119	161	44.2	73.7	101.3
T_4	83.0	177.1	352.4	90	173	262	37.3	93.2	115.0
T_5	85.5	166.0	364.4	91	163	236	43.2	75.3	99.2
T_6	70.3	143.2	286.6	157	235	310	41.3	73.9	98.7
S.Em.±	6.749	16.327	26.579	25.126	44.845	57.998	13.564	15.668	16.547
CD @ 1%	NS	NS	NS	NS	NS	NS	NS	NS	NS

Note: DAP- Days After Pruning

receiving 100 per cent RDF + biofertilizers and this was followed by T_6 (50% RDF + biofertilizers) with 10.23 cm^2 per plant. And, the least leaf area (8.91 cm^2) was recorded in T_3 (50% RDF) treatment.

4.2.6 Chlorophyll content

The chlorophyll content of leaves differed significantly at 30 DAP and 90 DAP. Only at 60 DAP, there was no significant difference among the treatment due to the application of biofertilizers in combination with inorganic fertilizers.

At 30 DAP, the highest chlorophyll content (24.01 spade value) of leaves was obtained in the treatment T_4 receiving 100 per cent RDF + biofertilizers. This was followed by T_5 with 23.36 SPAD value and the least value (22.11) was recorded in T_3 (50% RDF) treatment.

Similar trend was observed at 90 DAP also. The treatment T_4 recorded the highest (71.10) chlorophyll content which was followed by T_5 and the lowest chlorophyll content (64.93) was recorded in T_3 (50% RDF) treatment. T_6 was found on par with T_1 with 68.25 and 67.90 SPAD units respectively.

However, the treatments did not show any significant differences at 60 days after pruning. The highest (60.63) chlorophyll content was observed in treatment T_4 and the lowest (55.60) was in T_3 treatment as in case of 30 DAP and 90 DAP.

4.3 EFFECT OF BIOFERTILIZERS ON FLOWERING AND YIELD OF JASMINE FLOWERS

The data on days taken for the appearance of the first flower bud, first flowering and 50 per cent flowering as influenced by combination of bioinoculants and inorganic fertilizers are presented in Table 4.

The data pertaining to number of flowers, weight of flowers, ten flower weight and total flower yield are presented in Table 5.

4.3.1 Days to first bud initiation

Significant differences were noticed among treatments with respect to appearance of the first flower bud.

The least number of days were required for bud initiation (108.33) in jasmine plants receiving 75 per cent RDF + biofertilizers which was followed by 108.50 days in T_6 (50% RDF + biofertilizers) treatment. Treatment T_1 (100% RDF) showed the highest number of days (114.83) which was on par with T_2 treatment.

4.3.2 Time taken to first flowering

There was a significant difference amongst different treatments with respect to time taken to first flowering.

Similar trend was noticed in the time taken to first flowering as in case of first bud initiation. The treatment T_5 receiving 75 per cent RDF + biofertilizers showed the least number of days taken for first flowering (114.83). However, treatments T_6 and T_4 were on par with T_5 treatment. T_1 treatment receiving 100 per cent RDF registered the highest number of days for first flowering (121.33).

4.3.3 Days to 50 per cent flowering

The observations revealed that there was significant differences among the treatments with respect to days taken to 50 per cent flowering.

T_4 plants receiving 100 per cent RDF + biofertilizers flowered early and took significantly least number of days to 50 per cent flowering (148.67). Treatments T_5 (75% RDF + biofertilizers) and T_6 (50% RDF + biofertilizers) showed on par results with that of treatment T_4. The highest number of days to 50 per cent flowering (157.33) was recorded in the plants receiving 50 per cent recommended dose of fertilizers. T_6 (150.83) was on par with T_1 (152.33).

Table 4. Influence of biofertilizers on flowering of Jasmine

Treatment	Days taken for bud initiation (DAP)	Days taken for first flowering (DAP)	Days taken for 50 per cent flowering (DAP)
T_1	114.83	121.33	152.33
T_2	114.33	120.83	155.83
T_3	113.83	120.33	157.33
T_4	110.00	116.50	148.67
T_5	108.33	114.83	150.17
T_6	108.50	115.00	150.83
S.Em.±	1.713	1.713	1.222
CD @ 5%	4.989	4.989	3.559

Note: DAP- Days After Pruning

Table 5. Effect of biofertilizer application on Jasmine yield parameters

Treatment	Number of flower/picking /plant at peak flowering	Weight of flower at peak flowering (g)	Total flower yield at the end of 50 days (g/plant)	Ten flowers weight (g)
T_1	60.3	4.92	235	0.82
T_2	60.0	4.70	222	0.78
T_3	59.4	4.49	211	0.76
T_4	62.1	5.56	264	0.90
T_5	60.5	5.24	246	0.87
T_6	59.5	4.96	231	0.83
S.Em.±	0.552	0.041	1.52	0.004
CD @ 5	1.609	0.121	4.42	0.012

4.3.4 Number of flowers per plant

There existed a significant difference amongst treatments in the number of flowers per plant parameter.

T_4 treatment plants (receiving 100 per cent RDF + biofertilizers) produced the highest number of flowers (62.1/plant) which was on par with treatment T_5 (75% RDF + biofertilizers) with 60.5 flowers. The lowest (59.4) number of flowers were produced in treatment T_3 (50% RDF). T_6 was on par with T_1 treatment.

4.3.5 Weight of flower

Significant differences among the treatments were observed in the weight of flowers per plant parameter.

The treatment T_4 (100% RDF + biofertilizers) recorded the maximum weight of flowers 5.56 g/plant which was followed by treatment T_5 with 5.248 g/plant. The treatment T_3 (50% RDF) recorded the lowest weight of flowers (4.49 g/plant). T_1 and T_6 was on par with each other.

4.3.6 Flower yield

The observations showed significantly different values pertaining to flower yield per plant.

The treatment T_4 (receiving 100 per cent recommended dose of fertilizers + biofertilizers) resulted in the highest flower yield (0.264 g/plant) which was followed by treatment T_5 with 0.246 g/plant. The least yield of 0.211 g/plant was recorded in T_3 treatment. And, T_6 was on par with T_1 treatment (Plate 3).

4.3.7 Ten flower weight

The data pertaining to ten flower weight showed that there was a significant difference amongst treatments.

The treatment T_4 (receiving 100 per cent recommended dose of fertilizers + biofertilizers) resulted in the highest ten flower weight (0.90 g). The treatment T_5 (75% RDF + biofertilizer) was the next best with 0.87 g. While the treatment T_3 (50% RDF) recorded the lowest ten flower weight (0.76 g). T_1 was on par with T_6 treatment.

4.4 EFFECT OF BIOFERTILIZERS ON NPK CONTENT IN LEAVES

The observations pertaining to NPK nutrient content in leaves due to the application of application of biofertilizers in combination with inorganic fertilizers are presented in Table 6 and Fig. 4.

4.4.1 Nitrogen content in leaves

N content in leaves was estimated at 90 DAS *i.e.* before flower bud initiation. The data revealed that the application of biofertilizers significantly enhanced nitrogen content in leaves.

The treatment receiving 100 per cent RDF + biofertilizers (T_4) showed the greatest N content in leaves (4.05%), and the second highest (3.63%) was recorded in treatment T_5 receiving 75 per cent RDF + biofertilizers. While the treatment T_3 (50% RDF) showed the lowest (2.87%) N content in leaves.

4.4.2 P content in leaves

The data on the P content in leaves showed significant differences among the treatments.

The treatment T_4 (100% RDF + biofertilizers) recorded the maximum P content (0.20%) which was followed by treatment T_5 (75% RDF + biofertilizers). With 0.19 per cent, whereas the treatment T_3 (150% RDF) showed the lowest P content (0.16%). T_6 was o par with T_1.

Table 6. Effect of biofertilizers on NPK content of Jasmine leaves

Treatment	N content (%)	P content (%)	K content (%)
T_1	3.49	0.18	2.05
T_2	3.08	0.17	1.84
T_3	2.87	0.16	1.58
T_4	4.05	0.20	2.17
T_5	3.63	0.19	2.04
T_6	3.15	0.18	1.86
S.Em.±	0.041	0.004	0.011
CD @ 1%	0.158	0.016	0.042

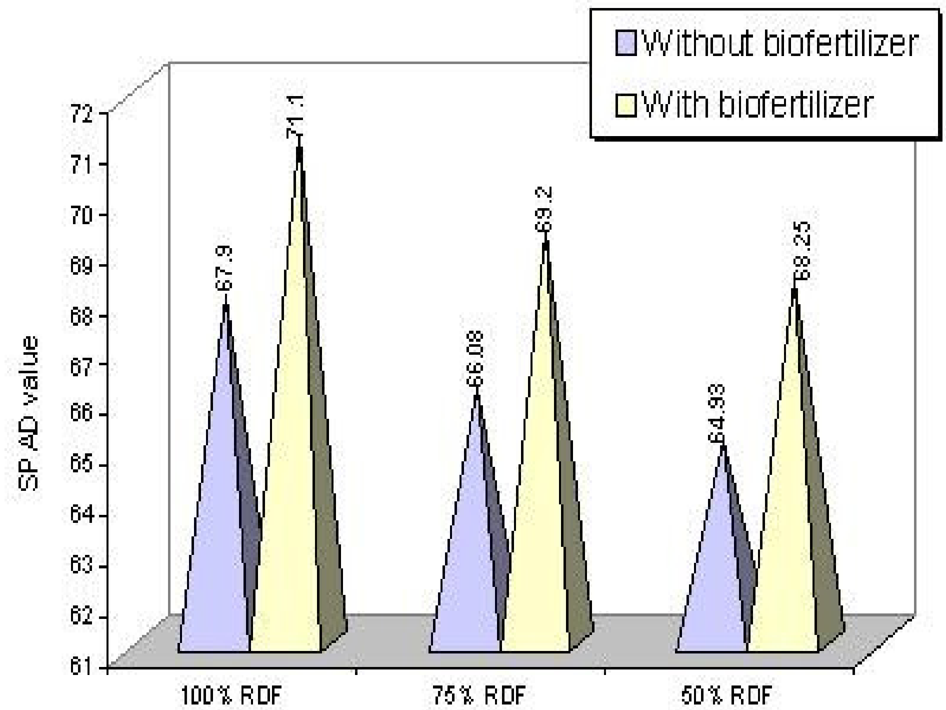


Fig.3. Effect of biofertilizers on chlorophyll content in leaves at 90 DAP

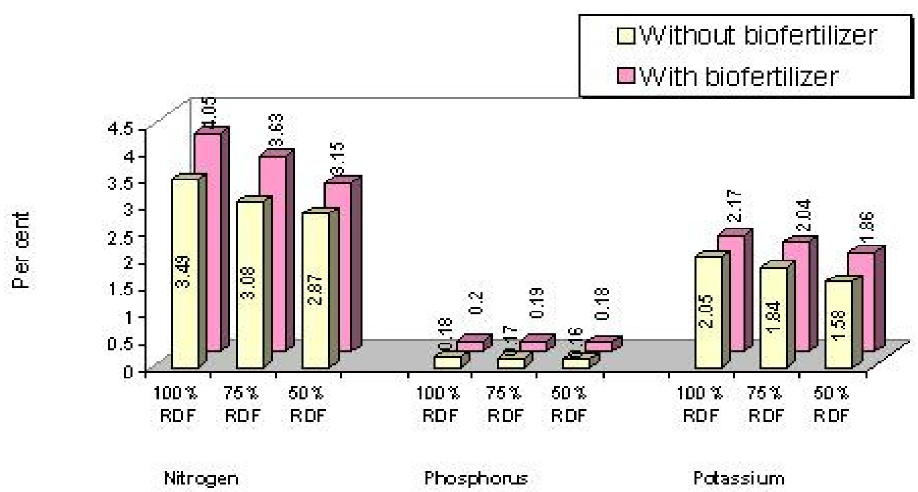


Fig.4. Effect of biofertilizers on NPK content in jasmine leaves

T_1: 100% RDF

T_6 50% RDF+biofertilizers

Plate.3. Comparison of T_1 and T_6 treatments

4.4.3 Potassium content in leaves

The application of biofertilizers significantly increased the K content of jasmine leaves.

The treatment T_4 receiving 100 per cent RDF + biofertilizers showed the highest K content (2.17%) which was followed by treatment T_1 (100% RDF) with 2.05 per cent whereas, the treatment receiving 50 per cent RDF showed the lowest K content (1.58%).

4.5 EFFECT OF BIOFERTILIZERS ON JASMINE FLOWER QUALITY PARAMETERS

The observations recorded for the flower characteristics *viz.,* stalk length, petal length, diameter of flower and shelf life of loose flowers as influenced by the application of biofertilizers in combination with inorganic fertilizers are presented in Table 7, Fig. 5, Fig. 6 and Plate 4. These observations were taken at peak flowering stage.

4.5.1 Stalk length

The stalk length differed significantly due to the application of biofertilizers. The highest stalk length (2.08 cm) was recorded in T_4 (100% RDF + biofertilizer) treatment which was followed by T_5 and T_6 treatments with 2.05 cm each. The treatment T_1 (100% RDF) recorded the lowest stalk length of 1.82 cm. T_6 was significantly higher than T_1.

4.5.2 Petal length

The biofertilizer application significantly improved the petal length. The treatment T_4 (100% RDF + biofertilizer) showed the highest petal length (1.28 cm) which was followed by treatments T_5 and T_6 with 1.27 cm each. Whereas the treatment T_1 (100% RDF) showed the lowest petal length (1.12 cm). T_6 (1.27 cm) was significantly higher than T_1 (1.12 cm).

4.5.3 Diameter of flowers

The diameter of flowers differed significantly due to biofertilizer application. The treatment T_5 (75% RDF + biofertilizer) recorded the highest diameter of flowers (2.57 cm). The treatments T_4 and T_6 were on par with T_5 treatment with 2.52 cm each.

The treatment T_3 receiving 50 per cent recommended dose of fertilizers recorded the lowest diameter of flowers (2.27 cm). T_6 and T_1 were on par with each other.

4.5.4 Shelf life of loose flowers

The application of biofertilizers showed a significant influence on shelf life of loose flowers.

The treatment T_5 (75% RDF + biofertilizers) resulted in the highest shelf life (52.67 h). This was on par with T_4 (100% RDF + biofertilizer) with a shelf life of 51.83 h. While the treatment T_3 recorded the lowest shelf life of loose flowers of 42.33 h. T_1 and T_6 were found on par with each other.

4.6 EFFECT OF BIOFERTILIZERS ON RHIZOSPHERE MICROBIAL POPULATION AND ENZYME ACTIVITIES

The effect of biofertilizers in combination with inorganic fertilizers on the rhizosphere microbial population of jasmine are presented in Table 8. While, their influence on enzyme activities are presented in Table 9.

4.6.1 Enumeration of microbial population in the rhizosphere of jasmine

The rhizosphere microbial population were significantly improved due to the application of biofertilizers in jasmine.

The highest bacterial population was observed in T_5 treatment (149.17 10^6 cfu/g), although on par with T_4 and T_6, whereas the least (45.00×10^6) colonization was found in the T_2 (75% RDF) treatment.

Table 7. Characteristics of Jasmine flowers as influenced by biofertilizer application at peak flowering

Treatment	Stalk length (cm)	Petal length (cm)	Diameter of flowers (cm)	Shelf life of loose flowers at ambient temperature (h)
T_1	1.82	1.12	2.32	47.00
T_2	1.87	1.17	2.37	44.17
T_3	1.85	1.17	2.27	42.33
T_4	2.08	1.28	2.52	51.83
T_5	2.05	1.27	2.57	52.67
T_6	2.05	1.27	2.52	44.83
S.Em.±	0.066	0.034	0.073	2.293
CD @ 5%	0.192	0.098	0.211	6.679

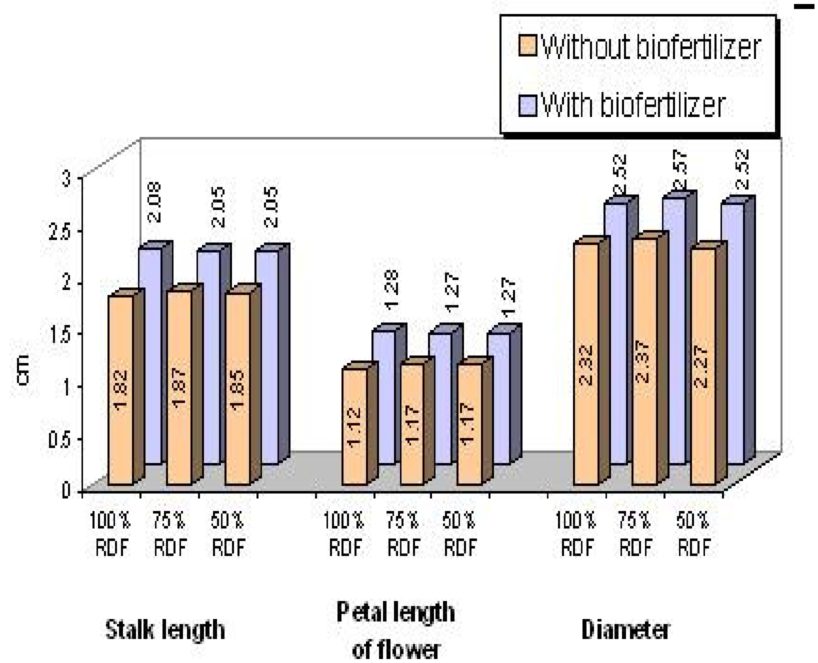


Fig.5. Influence of biofertilizer on floral characters of jasmine flowers

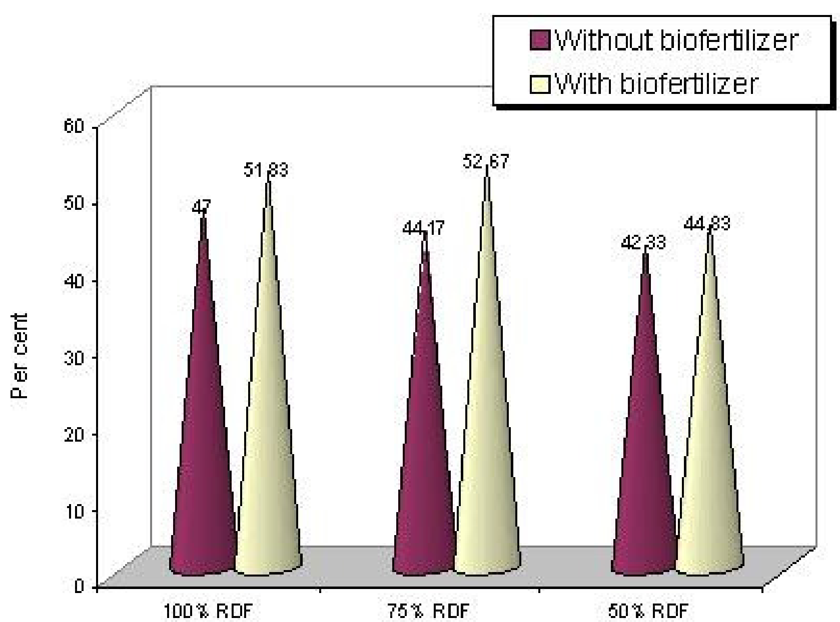
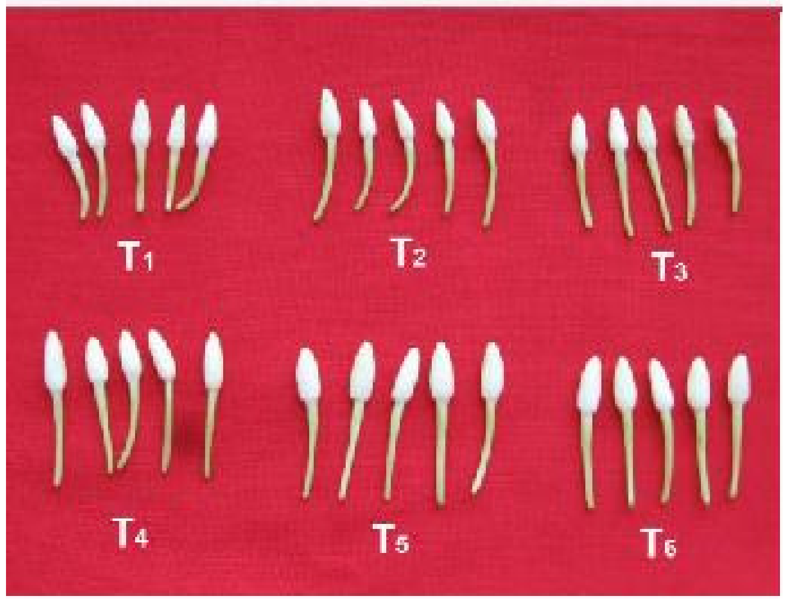
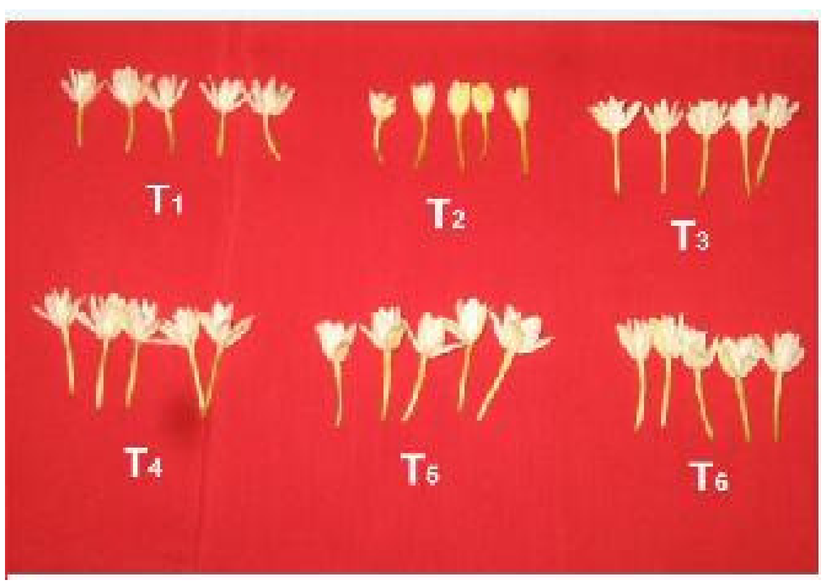


Fig.6. Influence of biofertilizer on shelf life of jasmine flowers



Flower buds



Bloomed flowers

Plate.4 Effect of biofertilizers on floral characteristics of jasmine

Table 8. Effect of biofertilizers on rhizosphere microbial population (cfu/g soil) at 90 DAP

Treatment	Bacteria (cfu x 10^6)	Fungi (cfu x 10^4)	Actinomycetes (cfu x 10^3)	Free living N_2 fixers (cfu x 10^5)	PSB (cfu x 10^5)	Fluorescent pseudomonads (cfu x 10^5)	*Trichoderma* sp. (cfu x 10^3)
T_1	47.50	9.67	72.00	10.2	13.5	9.0	5.8
T_2	45.00	10.50	73.33	9.3	13.3	9.5	5.3
T_3	47.33	10.00	68.67	9.7	13.7	9.5	6.5
T_4	144.67	24.50	60.67	62.7	72.3	43.5	7.5
T_5	149.17	26.33	89.00	62.0	71.8	42.2	8.2
T_6	148.00	23.83	90.00	64.8	74.8	44.2	9.8
S.Em.±	8.171	0.979	3.330	0.585	0.490	0.396	0.356
CD @ 1%	31.779	3.807	12.950	2.276	1.904	1.538	1.385

Note: DAP- Days After Pruning

Table 9. Influence of biofertilizers on soil enzymes in the rhizosphere of Jasmine

Treatment	Urease activity ($\mu g/NH_4$-N g soil/day)			Dehydrogenase activity (µg TPF/g soil/day)			Phosphatase activity (µg p-nitrophenol/ g soil/h)		
	30 DAP	60 DAP	90 DAP	30 DAP	60 DAP	90 DAP	30 DAP	60 DAP	90 DAP
T_1	44.6	56.3	60.5	4.33	5.80	6.72	22.38	25.23	26.29
T_2	43.5	54.6	57.4	4.40	5.54	6.79	21.97	24.10	25.12
T_3	42.3	54.2	56.3	4.47	5.18	6.64	21.52	23.39	24.41
T_4	47.2	60.9	67.0	4.87	6.03	7.97	24.72	30.66	37.28
T_5	45.8	60.0	64.3	4.92	5.99	7.93	23.60	28.57	36.51
T_6	45.1	59.0	62.7	5.18	5.95	7.84	23.34	27.05	35.66
S.Em.±	0.40	0.21	0.35	0.082	0.041	0.047	0.327	0.661	0.687
CD @ 1%	1.567	0.833	1.358	0.317	0.160	0.182	1.272	2.572	2.673

Note: DAP- Days After Pruning

With respect to fungi also, the treatment T_5 (receiving 75 per cent RDF + biofertilizers) recorded the highest value (26.33 x 10^4 cfu/g). This was on par with T_4 and T_6 treatments. The lowest population (9.67 x 10^4) was observed in T_1.

The colonization of actinomycetes was found the highest (90 x 10^3 cfu/g soil) in the treatment T_6 receiving 50 per cent RDF + biofertilizers which was on par with T_5 (75% RDF + biofertilizers), while the treatment T_4 (100% RDF + biofertilizers) showed the least colonization (60.67 x10^3 cfu/g).

Free living nitrogen fixers were found significantly higher (64.8 x 10^5 cfu/g) in T_6 which was on par with T_4 with (62.7 x 10^5/g soil), and the treatment T_2 (75% RDF) possessed the least population (9.3 x 10^5/g).

Phosphate solubilzing bacterial population significantly differed amongst the treatments. The same trend was followed, here also as in case of nitrogen fixers. The treatment T_6 (50% RDF+biofertilizers) showed maximum population 74.8 x 10^5/g. This was followed by T_4 treatment (100% RDF + biofertilizers) with a population of 72.3 x 10^5/g soil. The treatment T_2 showed the least population of 13.3 x 10^5/g soil.

The population of fluorescent pseudomonads different significantly due to treatment effects. The highest population of 44.2 cfu 10^5/g of soil was found in T_6 (50% RDF + biofertilizers) treatment, which was followed by treatment T_4 (100% RDF + biofertilizers), while the treatment T_1 (100% RDF) showed the least population (9.0 x 10^5 cfu/g soil).

There was a significant difference in the population of *Trichoderma* sp. due to different treatments. T_6 exhibited the highest population of 9.8 x 10^3 per g soil. The next highest was 8.2 x 10^3 per g soil in T_5. The least population (5.3 x 10^3) was observed in T_2 treatment.

4.6.2 Enzyme activity

The data pertaining to biological activity of rhizosphere soil at 30, 60 and 90 days after pruning as influenced by the application of biofertilizers are given in Table 9 and Fig. 7.

4.6.2.1 Urease activity

There was significant difference amongst treatments in the urease activity in the rhizosphere of jasmine at all days of estimation. At 30 DAP, the highest urease activity (47.2 μg/NH_4-N g^{-1} soil/day) was observed in the rhizosphere of plants receiving T_4 treatment. This was followed by T_5 with 45.8 μg/NH_4-N g^{-1} soil/day. T_3 exhibited the least activity (42.3 μg/NH_4-N g^{-1} soil/day).

At 60 DAP, the treatment T_4 (100% RDF + biofertilizers) recorded the highest activity of urease (60.9) which was followed by T_5 (75% RDF) biofertilizers treatments, and the treatment T_3 (50% RDF) recorded the least urease activity in rhizosphere soil (54.2). T_6 was significantly higher than T_1.

At 90 DAP also, T_4 (100% RDF + biofertilizers) exhibited the highest activity (67.0) and the next highest activity (64.3) was recorded in treatment T_5 (75% RDF + biofertilizers). And, T_3 receiving 50 per cent RDF recorded the lowest urease activity (56.3). T_6 was significantly higher than T_1.

4.6.3.2 Dehydrogenase activity (DHA)

Significant differences were observed in DHA due to inoculation of biofertilizers at all days of estimation. At all periods of analysis, T_6 possessed significantly higher enzymatic activities than T_1. At 30 DAP, T6 treatment recorded the maximum dehydrogenase activity (5.18 μg TPF/g soil/day), which was followed by T_5 (75% + biofertilizers) treatment with 4.92 μg TPF/g soil/day. The lowest DHA activity (4.33) was recorded in T_1.

At 60 DAP, T_4 treatment showed the highest dehydrogenase activity (6.03). The next best treatment was T_5 with 5.99 DHA, whereas the treatment T_3 (50% RDF) recorded the least dehydrogenase activity (5.18).

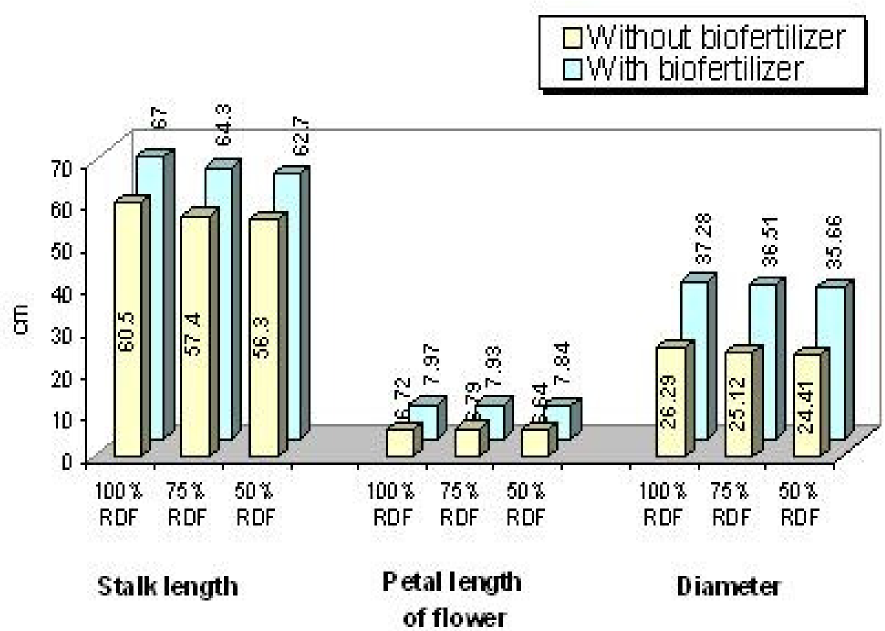


Fig.7. Effect of biofertilizer on enzymatic activities in the rhizosphere of jasmine

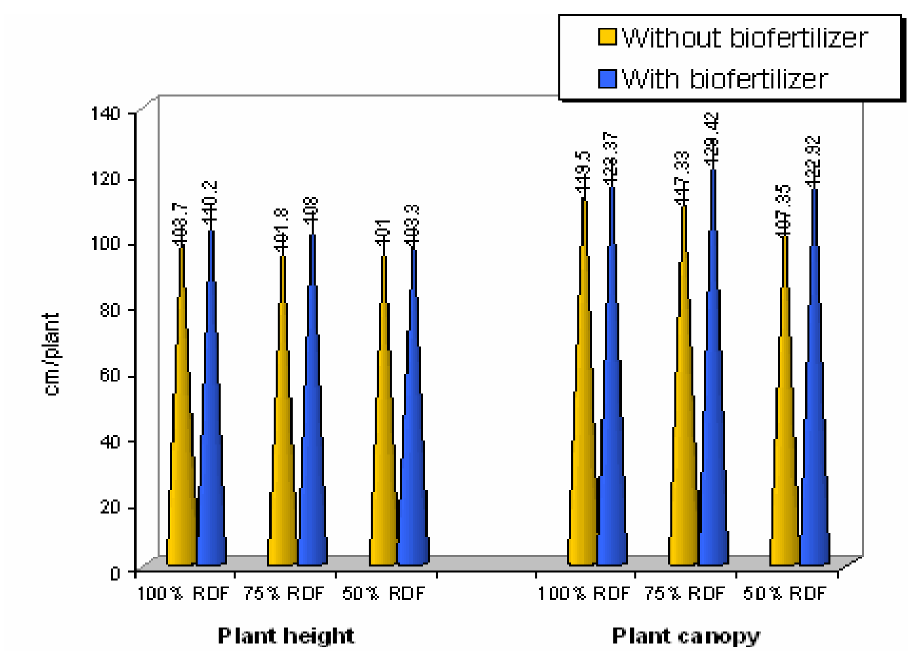


Fig.8. Influence of biofertilizer on growth parameters of jasmine on a farmer's field at 50 DAP

Similar trend was observed at 90 days after pruning also. The treatment T_4 showed the best DHA (7.97). The second highest was noticed in the treatment T_5, whereas the treatment T_3 recorded the least DHA (6.64).

4.6.2.3 Phosphatase activity

There was significant difference in phosphatase activity due to the influence of biofertilizers. The data revealed that the plants receiving 100 per cent RDF + biofertilizers (T_4) showed significantly higher phosphatase activity (24.72 µg P-nitrophenol/g soil/h) at 30 DAP. This was followed by T_5 (75% + biofertilizers) treatment with 23.60, and the least activity (21.52) was found in T_3 treatment. T_6 was on par with T_1.

Similar observations were made at 60 DAP. T_4 resulted in the highest activity (30.66) and the second highest was seen in T_5 treatment, while the treatment T_3 recorded the least activity of phosphatase (5.18). T_6 and T_1 were on par with each other

At 90 DAP also, the treatment T_4 showed the maximum activity (37.28) and T_3 showed the least activity (24.41). T_6 exhibited significantly higher activity than T_1.

4.7 EFFECT OF BIOFERTILIZERS ON GROWTH PARAMETERS OF JASMINE ON FARMERS FIELD AT CHIGATERI VILLAGE

The data pertaining to the plant height and number of branches per plant due to the influence of application of biofertilizers in combination with chemical fertilizers are furnished in Table 10 and Fig.8.

4.7.1 Plant height

There was no significant difference amongst the treatments at zero and 50 days after pruning. However, the highest plant height (110.2 cm) was recorded in treatment T_4 which was followed by T_6. The lowest plant height (101.0 cm) was recorded in T_3.

4.7.2 Number of branches

The data revealed that there was significant difference due to the application of biofertilizers.

T_1 resulted in the highest number of branches per plant (226.7). This was followed by T_4 with 222.3 branches. The least number of branches (145.5) were produced by T_3. At 50 DAP, T_6 was on par with T_1.

4.7.3 Number of leaves per plant

The results pertaining to number of leaves as influenced by application of biofertilizers in combination with chemical fertilizers are furnished in Table 11.

It can be seen from the table that there was significant difference amongst treatments at 50 DAP.

The treatment T_4 produced the highest number of leaves (9619.75 per plant) followed by treatment T_1 (100% RDF) which produced 8695.16 leaves per plant. And, the treatment T_3 (50% RDF) resulted in the least number of leaves per plant (5447.57). T_6 was on par with T_1.

4.7.4 Plant canopy

The observations recorded for plant canopy due to the application of biofertilizers are presented in Table 11a.

The data revealed that there was no significant difference among the treatments at both initial stage and 50 days after pruning.

However, at 50 days after pruning, the treatment T_5 showed the best plant canopy of 129.42 cm. The next highest plant canopy of 123.37 cm was produced by T_4 treatment. The least canopy of 117.33 cm was observed in the T_2 treatment.

The data on plant height and number of branches per plant and jasmine on per cent increase over initial values are presented in Table 11b. In plant height at 50 DAP, there was

Table 10. Effect of biofertilizers on plant height and number of branches of Jasmine on a farmer's field at Chigateri village

Treatment	Plant height (cm)		Number of branches per plant	
	0 DAP	50 DAP	0 DAP	50 DAP
T_1	58.5	103.7	62.8	226.7
T_2	58.2	101.8	61.5	190.2
T_3	58.0	101.0	56.2	145.5
T_4	59.8	110.2	56.8	222.3
T_5	58.8	108.0	56.8	201.2
T_6	58.9	103.3	53.0	174.7
S.Em.±	1.5	3.4	3.380	16.534
CD @ 5%	NS	NS	9.845	48.158

Note: DAP- Days After Pruning

Table 11a. Influence of biofertilizers on number of leaves and plant canopy of Jasmine on a farmer's field at Chigateri village

Treatment	Number of leaves (per plant)		Plant canopy (cm/plant)	
	0 DAP	50 DAP	0 DAP	50 DAP
T_1	38.52	8695.16	70.53	119.50
T_2	37.49	7080.01	70.10	117.33
T_3	37.37	5447.57	70.00	107.35
T_4	43.34	9619.75	73.00	123.37
T_5	42.21	8491.53	77.20	129.42
T_6	40.96	7107.56	76.53	122.92
S.Em.±	3.02	794.03	3.70	6.06
CD @ 5%	NS	2312.68	NS	NS

Note: DAP- Days After Pruning

Table 11b. Per cent increase over initial values of plant height, number of branches, number of leaves and plant canopy of Jasmine as influenced by biofertilizers on a farmer's field at Chigateri village

Treatment	Plant height (cm)	Number of branches/plant	Number of leaves	Plant canopy (cm)
	Per cent increase over initial values			
	50 DAP	50 DAP	50 DAP	50 DAP
T_1	77.3	262.3	22566.7	70.60
T_2	74.9	201.0	18916.7	71.23
T_3	74.7	163.0	14450.0	53.48
T_4	83.9	290.4	22133.3	71.17
T_5	83.8	252.6	20016.7	68.81
T_6	75.6	228.9	17366.7	63.76
S.Em.±	4.804	17.052	1653.446	5.180
CD @ 5%	NS	49.665	4815.826	NS

Note: DAP- Days After Pruning

Table 12. Effect of biofertilizers on flower characters on a farmer's field at Chigateri village at peak flowering

Treatment	Stalk length (cm)	Petal length (cm)	Diameter of flower (cm)	Ten flower weight (g)
T_1	2.06	1.35	2.87	0.87
T_2	1.97	1.28	2.69	0.83
T_3	1.89	1.25	2.50	0.78
T_4	2.28	1.36	2.91	0.90
T_5	2.10	1.39	2.98	0.83
T_6	2.02	1.41	3.03	0.80
S.Em.±	0.02	0.03	0.05	0.02
CD @ 5%	0.07	0.08	0.13	0.07

no difference due to treatments. However, T_4 exhibited the highest increase in the plant height of 83.9 per cent over the initial. When compared with and without biofertilizers, biofertilizers had a positive influence at all the levels of NPK. Regarding number of branches, there was significant difference due to treatments. Again T_4 promising with the highest per cent increase over initial (*i.e.* 290.4%). T_6 was on par with T_1 and T_2 but significantly higher than T_3.

Regarding number of leaves there was significant difference, T_1 was the superior treatment, T_6 was on par with T_2, T_3 and T_5. Regarding plant canopy, there was no significant difference T_2 brought about the highest increment of 71.23 per cent.

4.8 EFFECT OF BIOFERTILIZERS ON FLOWER CHARACTERS ON FARMER'S FIELD AT CHIGATERI VILLAGE

4.8.1 Flower quality parameters

The observations on the flower quality parameters *viz.,* stalk length, petal length, diameter of flower and ten flower weight due to the application of biofertilizers are furnished in Table 12.

4.8.2 Stalk length

The stalk length differed significantly due to the influence of biofertilizers in combination with chemical fertilizers at peak flowering stage. The highest stalk length of 2.28 cm was recorded in T_4 treatment. The next highest length (2.10 cm) was produced in T_5, which was on par with T_1, while treatment T_3 (50% RDF) showed the least stalk length (1.89 cm). T_6 was on par with T_1.

4.8.3 Petal length

The application of biofertilizers with different levels of NPK fertilizers resulted in significantly different petal lengths. The highest petal length (1.41 cm) was produced in T_6 treatment which was on par with T_5 with 1.39 cm petal length. And, T_3 resulted in the least value of 1.25 cm. T_6 was on par with T_1.

4.8.4 Diameter of flower

Biofertilizer application brought about significant differences amongst the treatments.

The highest diameter (3.03 cm) was recorded in T_6 treatment which was followed by 2.98 cm in T_5, while the lowest diameter of 2.50 cm was recorded in T_3 treatment. T_6 was significantly higher than T_1.

4.8.5 Ten flower weight

The observations revealed that these were significant differences due to the inoculation of biofertilizers.

The highest ten flower weight (0.90 g) was recorded in plants receiving 100 per cent RDF + biofertilizers (T_4) which was followed by T_1 (100% RDF) treatment with 0.87 g. The lowest weight of 0.78 g was noticed in T_3 treatment.

5. DISCUSSION

In the universe of flowers used for their fine precious scent used in perfumes, no other blossom stands alone as ubiquitous as jasmine, with the possible exception of rose. Commercial floriculture, particularly cultivation of jasmine is being taken up by large number of farmers. Jasmine is a perennial crop and requires heavy doses of chemical fertilizers which further increase with the age of the plant. In the recent past, more interest is evinced about sustainable agriculture. Escalating cost of inorganic fertilizers and the environmental pollution that they cause when applied in excess have called for the use of natural resources as a supplementary source to achieve targeted agricultural production. The use of cost effective and ecofriendly biofertilizers, replacing a part of the recommended inorganic fertilizer, is one of the steps towards sustainable agriculture and is necessary in jasmine cultivation also whose nutrients requirement is very high. The combined application of chemical, bio and organic fertilizers may be useful in the production of quality flowers as well.

Hence, in this regard, field experiments were laid out on the University farm as well as on a farmer's field to study the effects of biofertilizers at different doses of chemical fertilizers on yield and quality of jasmine flowers. The results obtained are discussed in this chapter.

5.1 EFFECT OF BIOFERTILIZERS ON PLANT GROWTH PARAMETERS OF JASMINE

The biofertilizer consortium used consisted of *Azospirillum* sp. (ACD-15, ACD-20) a free living N_2 fixer, *Pseudomonas striata*, a P-soluiblizer, *P. fluorescens* (WGUK 327(2)), a plant growth promoting rhizobacterium and *Trichoderma viridae,* a phytohormone producing fungus. Different levels of recommended NPK *i.e.* 100 per cent, 75 per cent and 50 per cent were tested with and without biofertilizer application.

In general, various growth parameters like plant height, number of branches, number of leaves, plant canopy and leaf area were improved due to the application of biofertilizers in combination with chemical fertilizers in field experiments, both on the University farm and the farmer's field.

Biofertilizer application enhanced plant height at all stages of growth compared to chemical fertilizer application alone. And, the highest plant height was observed in the plants receiving 100 per cent NPK + biofertilizers (T_4 treatment). Similar trend was observed even in the experiment on the farmer's field.

Increased cell elongation and cell multiplication due to enhanced nutrient uptake by plants following inoculation of *Azospirillum* and P-solubilizing bacteria (PSB) probably caused the increased plant height (Preethi *et al.*, 1999).

This can also be attributed to the production of plant growth promoting substances in the vicinity of roots by the inoculated microorganisms. *Azospirillum* ACD-15 and ACD-20 strains, used in our study, produced copious amounts of IAA and GA (Amitha and Savalagi, 2004). Plant growth promoting factors like IAA, GA and cytokinin like substances are also known to be produced by PSB (Gowda, 2004 and Jagadish, 2006) and fluorescent pseudomonads (Suneesh, 2004; Indira and Bagyraj, 1997). And, IAA is known to be involved in root initiation, cell division and cell enlargement (Salisbury, 1994).

Inoculation technology, which encourages proliferation of pre-selected efficient microorganisms in association with crop plants is known to enhance plant growth and nutrient uptake. In the recent past, it has been documented that inoculation with more than one microorganism benefits crops by enhancing the synergistic action of the associates in growth and nutrient uptake (Subba Rao *et al.*, 1985).

Significant increase in plant height and spread due to combined application of *Azospirillum*, PSB and inorganic fertilizers has been reported earlier in crossandra (Narashima Raju and Haripriya, 2001) and gundumalli (Manonmani, 1992). Similar results were obtained by the application of *Azotobacter* + PSB + VAM in *Valeriana jatamansi* (Salathia, 2005) and gladiolus (Srivastava and Govil, 2005) as well.

Although non-significant, in general, biofertilizer application increased the number of jasmine branches per plant, in the farmer's field experiment. T_6 (50% RDF + biofertilizer) was on par with T_1 (100% RDF), indicating a saving of cost on NPK fertilizers by 50 per cent (Fig. 9). This could be explained by the activities of the inoculants *viz.,* nitrogen fixation, release of Pi from insoluble phosphates, production of phytohormones *etc.* with simultaneous uptake of nutrients by the inoculated plants. PGPS produced by *Azospirillum* are known to be involved in breaking of apical dominance, resulting in higher number of branches (Parvatham *et al.*, 1989).

Although non-significant, number of leaves and plant canopy and leaf area were higher in plants treated with biofertilizers along with chemical fertilizers when compared to chemical fertilizers alone. This may be due to better availability of nutrients and congenial conditions created, in the vicinity of root zone by the biofertilizers to absorb more nutrients, besides production of bioactive substances by *Azospirillum* (Dhanpal *et al.*, 1978). In the farmer's field experiment, number of leaves in T_6 was on par with that of T_1 indicating T_6 as a promising treatment.

The leaf area of the plant plays an important role in photosynthetic activity, as it intercepts more of radiant energy from sunlight. The maximum leaf area in jasmine was observed due to application of biofertilizers along with different levels of NPK fertilizers. A leaf area of 10.23 cm^2 per plant was recorded in T_6 treatment (50% RDF + biofertilizer) which is on par with T_1 (100% RDF) with 9.44 cm^2 per plant. Increased leaf area in these treatments could be attributed to enhanced cell division and cell elongation by the production of bio-active substances produced by *Azospirillum*, PSB, *P. fluorescens* and *T. viridae*. Inbar *et al.* (1994) reported growth promotion in cucumber and pepper seedlings due to inoculation with *Trichoderma harzianum*. They observed 23.8 and 17.2 per cent increase in seedling height, 96.1 and 50.0 per cent in leaf area and 24.7 and 28.6 per cent in plant dry weight in cucumber and pepper respectively due to inoculation with *T. harzainum*. Similar findings were also made by Jeeva (1987) in banana, Manonmani (1992) in jasmine and Prabhatkumar *et al.* (2003) in china aster. The results of our experiments are in confirmation with the findings of Gayathri *et al.* (2004) also who reported that combined application of biofertilizers, vermicompost with inorganic fertilizers significantly increased the number of leaves, leaf area and stem girth in *Limonium*.

The effect of biofertilizers on chlorophyll content of jasmine leaves was assessed. It is evident from the results that biofertilizer application significantly increased chlorophyll content in jasmine leaves both at 30 DAP and 90 DAP. It was significantly higher in the treatment T_4 (100% RDF + biofertilizers) when compared to T_1 (100% RDF) treatment. It was interesting to note that the treatment T_6 (50% RDF + biofertilizer) was on par with the treatment T_1 (100% RDF), showing a saving of 50 per cent chemical fertilizers.

Increase in chlorophyll content is due to increase in nitrogen content which is the chief constituent of protein and protoplasm resulting in increased photosynthetic activity. Cytokinin produced by microbial inoculants might have become a greater sink to attract nutrients like Mg, Fe and K which, in turn have resulted in greater synthesis of chlorophyll (Lalitha *et al.*, 2004). The increased chlorophyll content might also be due to enhanced stomatal conductance, photosynthesis and transpiration (Hayman, 1983).

5.2 EFFECT OF BIOFERTILIZERS ON FLOWERING AND YIELD OF JASMINE

The influence of biofertilizers on floral characteristics, quality and yield of jasmine were also evaluated.

The results of the experiment showed that the inoculation of biofertilizers significantly influenced the quality parameters of jasmine flowers. Treatment of plants with biofertilizers had a significant effect on various floral characteristics *viz.,* time taken for bud initiation, days taken for first flowering and 50 per cent flowering, stalk and petal length and shelf life of flowers (Plate 5). Plants receiving 50 per cent recommended dose of NPK fertilizer + biofertilizers took significantly lesser number of days for bud initiation (108.5 days), first flowering (115.00 days) and 50 per cent flowering (150.83 days) in comparison to T_1 (100% RDF) (Fig. 9). This treatment is promising, as it saves 50 per cent chemical fertilizers.

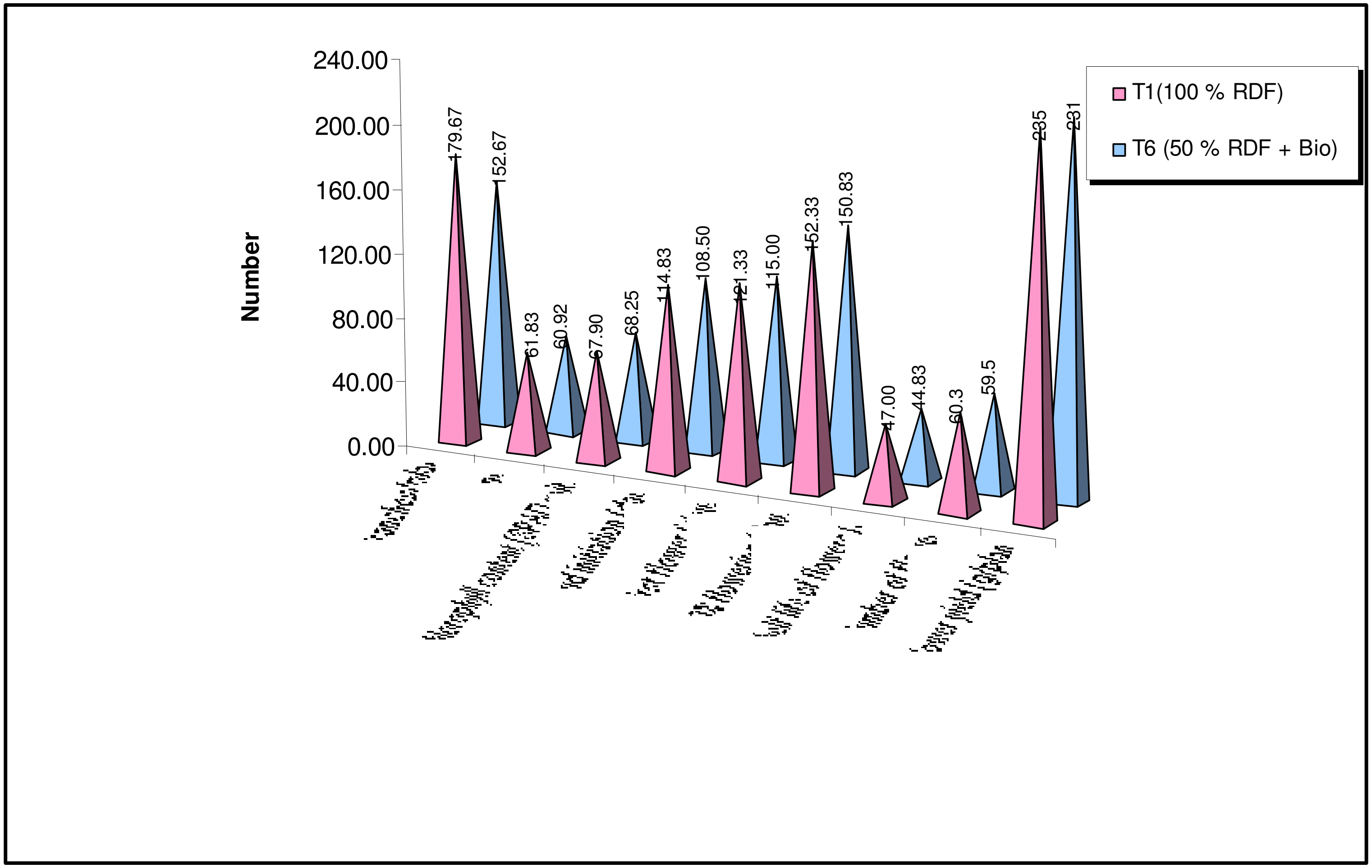


Fig.9. Comparison of 100% RDF+biofertilizers with respect to vegetative growth, quality and yield of jasmine

The earliness of bud initiation in biofertilizer-inoculated plants may be ascribed to easy uptake of nutrients and simultaneous transport of growth promoting substances like cytokinin to the axillary buds, resulting in breakage of apical dominance. Ultimately, this has resulted in a better sink for faster mobilization of photosynthates and early transformation of plant parts from vegetative to reproductive phase. Our results are in line with the findings of many other scientists in jasmine (Vasanthi, 1994), marigold (Chandrikapure *et al.*, 1999), crossandra (Narasimha Raju and Haripriya, 2001), *Limonium* (Gayathri *et al.*, 2004), china aster (Chaitra, 2006), Zinnia (Chang, 1989), gerbera (Wen, 1991) and China aster (Mantur, 1988), who have endorsed the effect of N and P along with biofertilizers in the advancement of flowering.

Significantly higher stalk and petal length were produced in treatment T_6 (50% RDF + biofertilizer) as compared to 100 per cent NPK. Thus substituting NPK fertilizers by biofertilizers to the extent of 50 per cent (Fig. 10). Similar observations were made in the farmer's field also. The significant increase in these floral characters might be due to the production of auxins by microbial inoculants which brought about an increase in cell division and cell elongation as observed by Preethi *et al.* (1990) in rose and Velmurugan (1998) in African marigold. The cell enlargement which occurred as a result of plasticitiy of cell wall is known to reduce wall pressure around the cell wall and, therefore, pressure caused by osmotic forces in the vascular sap led to entry of water in to the cell. This results in cell enlargement and thereby improves floral characters (Padmadevi *et al.*, 2004). Similar effects of *Azospirillum* and PSB on tuberose spike length of have been reported by Swaminathan *et al.* (1999) and Wange *et al.* (1995).

Parvatham and Vijayan (1989) observed that *Azospirillum* treated bhendi plants flowered earlier, produced higher number of flowers and ultimately the number of fruits. They attributed the increase in flowers and fruits to the vigorous vegetative growth resulting from increased activity of phytohormones produced by *Azospirillum*. Increase in fruit length, girth and volume could be due to the increased photosynthetic activity which, in turn, might have favored an increased accumulation of dry matter and also efficient partitioning of photosynthates towards the sink.

In jasmine, flowers having higher diameter are preferred. The treatments tested differed significantly with respect to flower diameter. Flower diameter in plants treated with 50 per cent RDF + biofertilizers (T_6) was on par with T_1 treatment. This may be ascribed to early breaking of apical dominance followed by easy and better translocation of nutrients to flowers, which are brought about by the activity of beneficial microorganisms in the biofertilizer formulations.

Another fascinating observation was the significant influence of biofertilizers the post harvest behaviour of jasmine flowers. Besides saving NPK, biofertilizers improved shelf life of loose flowers (Fig. 9). The highest shelf life of loose flowers (52.67 h) was recorded in T_5 (75% RDF + biofertilizers). This accounts to 33.34 per cent increase over T_1 (100% RDF). Further T6 treatment (50% RDF + biofertilizers) was on par with T1 treatment (100% RDF). Similar beneficial effects of biofertilizers and vermicompost on shelf life have been reported in marigold (Anuradha *et al.*, 1990; Mashaldi, 2000).

Inoculation of jasmine plants with biofertilizers had a significant impact on flower yield. An average 10 per cent increase in flower yield were obtained due to biofertilizers at different levels of NPK tested. Plants receiving 75 per cent RDF + biofertilizers yielded about 5 per cent higher than plants receiving 100 per cent RDF. And, 50 per cent RDF + biofertilizers treatment (T_6) resulted in flower production on par with 100 per cent RDF (T_1), showing a saving of chemical fertilizers by 50 per cent (Fig. 9).

The increase in number of flowers may be explained by the role of *Azospirillum* though atmospheric nitrogen fixation, better root proliferation, uptake of nutrients and water, higher leaf number and area. Higher photosynthesis enhanced food accumulation which might have resulted in better plant growth and subsequently higher number of flowers per plant and hence, more flower yield per plant. Besides this, increase in flower yield may be attributed to increased availability and uptake of phosphorus (Kundu and Gaur, 1980). And, the beneficial effects of *Pseudomonas fluorescens* might have played a secondary role in increasing the flower yield.

Plate.5. Improvement in flower quality due to biofertilizer application

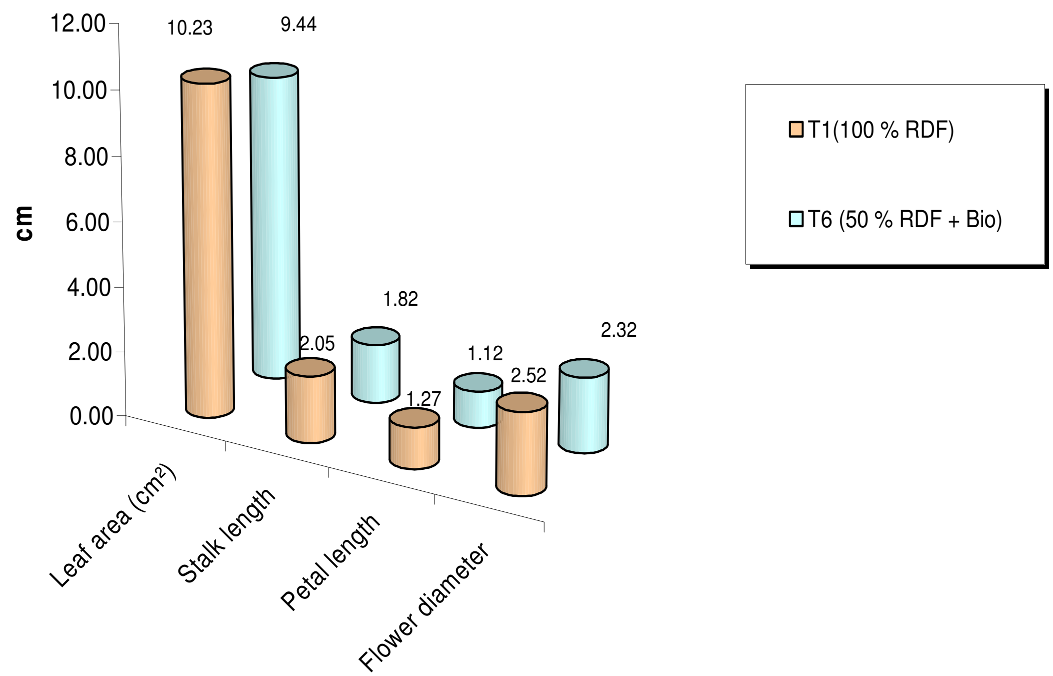


Fig. 10. Comparison of 100% RDF with 50% RDF + biofertilizers with respect to floral characters of jasmine

Fig.10. Comparison of 100% RDF with 50% RDF+ biofertilizers with respect to floral characters of jasmine

Similarly, Narasimha Raju and Haripriya (2001) obtained higher flower yield in crossandra with the combination of *Azospirillum*, PSB and 100 per cent NPK. Chandrikapure *et al.* (1999) obtained similar results in marigold. The higher flower yield due to application of biofertilizers in combination with vermicompost and recommended dose of NPK has been reported in *Limonium* also (Gayathri *et al.*, 2004).

5.3 EFFECT OF BIO-FERTILIZERS ON NPK CONTENT IN JASMINE LEAVES

The concentration of NPK content in jasmine leaves were significantly enhanced due to biofertilizer application in combination with different levels of NPK. It showed higher per cent of NPK in leaves compared to their respective treatments of NPK without biofertilizers.

T_4 (100% RDF with biofertilizers) increased NPK content by 16 per cent when compared to T_1 (100% RDF). T_5 (75% RDF + biofertilizers) treatment resulted in NPK content on par with T_1 (100% RDF), besides saving 25 per cent cost On chemical fertilizers. T_6 was on par with T_1 with respect to P content in leaves (Fig. 11). The enhanced NPK content in leaves may be attributed to the inoculated *Pseudomonas striata* and *Pseudomonas fluorescens* (both are 'P' solubilizers), which mediated the release of phosphorous from insoluble phosphate. *Azospirillum*-inoculated plants exhibited a higher foliar N content besides enhanced P, K and Fe content in marigold (Balasubramanian, 1989), P, N, Fe, Cu, Zn, and Mn content in coffee (Premkumari and Balasubramanian, 1993).

The nutrient uptake is favourably influenced by *Azospirillum* inoculation. *Azospirillum* has the ability for better root induction in the inoculated plants mainly due to the production of growth hormones. As a result, such plants are capable of absorbing more and more available nutrients from the soil which, in turn, result in better establishment of seedlings and their subsequent growth (Govindan and Purushothaman, 1984). Similar observations were made by Hemavathi (1997) in chrysanthemum and Shubha (2006) in marigold. The beneficial effect of PSB on nutrient uptake has been reported in tuberose also (Swaminathan *et al.*, 1999). The strains of *Azospirillum* and PSB gave similar results in China aster (Chaitra, 2006). Improvement in NPK content and their uptake due to *Azospirillum* + PSB inoculation were obtained by Shivakrishnaswamy (2001) in sugarcane and due to PGPR inoculation by Kirankumar (2007) in tomato.

IAA producing PGPR strains are believed to increase root growth and length resulting in greater root surface area which enables plants to access more nutrients from soil (Vessey, 2003). Application of PGPR in apricot increased the nutrient element composition of leaves *viz*., N, P, K, Ca and Mg (Esitken *et al*., 2003).

5.4 EFFECT OF BIOFERTILIZERS ON RHIZOSPHERE MICROBIAL POPULATION AND ENZYME ACTIVITIES

Effects of biofertilizers on rhizosphere microbial population were significantly different amongst the treatments. Higher colonization of microorganisms were seen in the rhizosphere of biofertilizer-applied plants compared to uninoculated plant rhizospheres at 90 DAP. In general,the bacterial population in the biofertilizer-applied plant rhizosphere were three times higher than those in the uninoculated rhizosphere. Similarly, fungal poplation were improved by over two times, essentially due to inoculation with three bacteria and one fungus in the form of biofertilizers. Although significant, the actinomyte population did not increase tremendously as no actinomycete was inoculated artificially.

The highest population of actinomycetes was seen in T_6 (50% RDF + biofertilizer) treatment compared to all other treatments. Whereas, the highest colonization of bacteria and fungi were seen in the rhizosphere of plants which received 75 per cent recommended dose of chemical fertilizers + biofertilizers when compared to all other treatments.

The population of the functionally important microorganisms, inoculated in the rhizosphere, were tremendously increased. Nitrogen fixers and P-solubilizers were increased by five to six times, obviously due to their inoculation.

The treatment T_6 (50% RDF + biofertilizers) showed the highest population of N_2 fixers, PSB, *P. fluorescens* and *Trichoderma viridae* when compared to all other treatments.

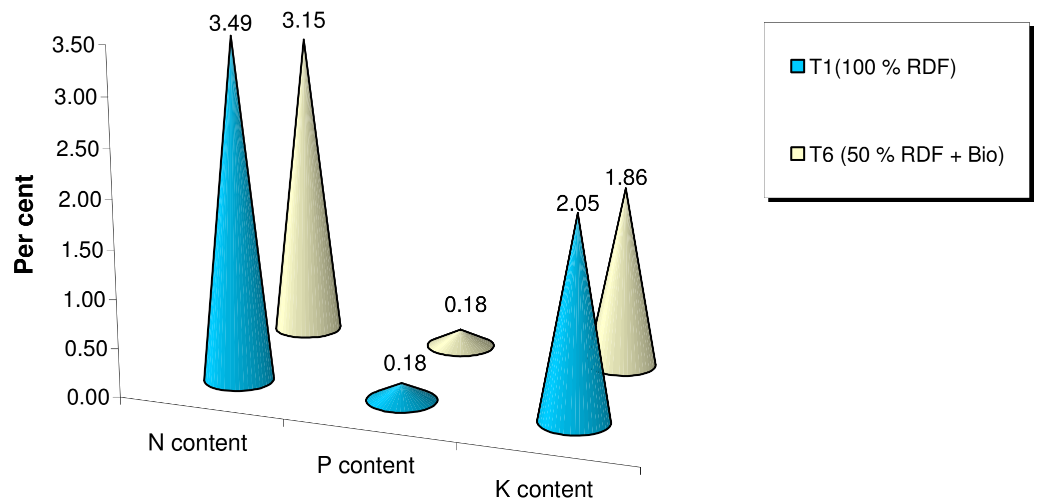


Fig. 11. Comparison of 100% RDF with 50% RDF + biofertilizer with respect to NPK content in jasmine leaves

Fig.11. Comparison of 100% RDF with 50% RDF+biofertilizer with respect to NPK content in jasmine leaves

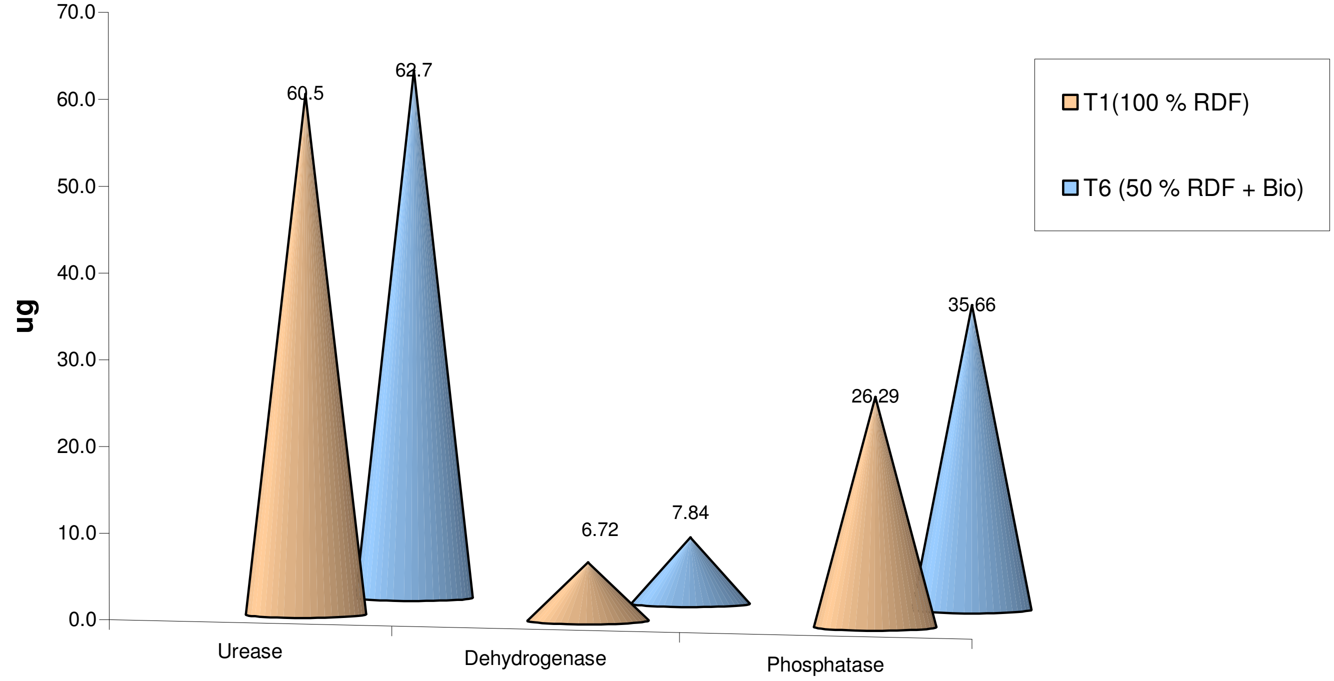


Fig. 12. Comparison of 50% RDF + biofertilizer and 100% RDF with respect to enzymatic activities in the rhizosphere of jasmine

Fig.12. Comparison of 50% RDF+biofertilizer and 100% RDF with respect to enzymatic activities in the rhizosphere of jasmine

Application of different levels of N and P in combination with biofertilizers was found to increase the respective microbial colonization significantly in African marigold (Rajadurai *et al.*, 2000).

The increase in rhizosphere microflora may be attributed to the multiplication of the strains in the rhizosphere, utilizing root exudates produced by the plants (Shivakrishnaswamy, 2001). Similar increased *Azospirillum* population upon inoculation under field conditions was noticed in sugarcane by Shankaraiah *et al.* (1996) also. Increased population of the inoculated strains of PSB were noticed in the rhizosphere of sugarcane by Yadav and Singh (1990), by Jisha (1993) in sorghum, Prathibha (1993) in cotton, Gadagi (1996) in sunflower and Savitha (1996) in chickpea.

The enzymatic activities in the rhizosphere soil are directly correlated with the total microbial population. An increase in the activities of all the enzymes was noticed, as the age of the plants was increased up to 90 DAP. The treatment T_6 (50% RDF + biofertilizers) exhibited significantly higher enzymatic activities at all stages and in all enzymes, when compared to T_1 (100% + RDF) (Fig. 12).

These observations are in accordance with the findings of Singaram and Kamalakumari (1995) and Ferran *et al.* (1993) who observed dehydrogenase activity increasing with the rhizosphere microflora. Chendrayan *et al.* (1980) were also of the opinion that the increase in dehydrogenase activity was mainly due to the higher microbial population as a result of FYM application.

Thus, the treatment T_6 (50% NPK + biofertilizer) could be rated as the best treatment combination. It promoted the rhizosphere colonization of general groups of microorganisms as well as functionally important microorganisms, leading to higher enzymatic activities resulting in enhanced nutrient uptake which led to increased growth, yield and quality of jasmine flowers.

The findings of the present field experiments have clearly brought out the positive effects of biofertilizers on yield and quality of jasmine. The application of biofertilizer consortium consisting of *Azospirillium*, *Pseudomonas striata,* bacteria *Psuedomonas fluorescens* and *Trichoderma viridae* has promoted growth and yield of jasmine flowers, enhanced NPK content in leaves and improved floral characteristics including shelf life. However, its effect on the quality of jasemine oil needs to be assessed. Biofertilizer application along with 50 per cent NPK fertilizers was as effective as 100 per cent NPK fertilizer application in all the parameters. Thus resulting in a net saving of input on chemical fertilizers by 50 per cent.

6. SUMMARY AND CONCLUSIONS

Field experiments were conducted one each on the University Farm and a farmer's field at Chigateri village, Harapanahalli Taluk, Davanagere District. The effect of biofertilizers on growth, yield, quality and nutrient content in Jasmine were assessed in presence of different levels of chemical fertilizers. The biofertilizers used included the lignite based cultures of *Azospirillum*, *Pseudomonas striata*, *Pseudomonas fluorescens* and *Trichoderma viridae*. The salient features of the findings are outlined below.

1. Biofertilizer application enhanced various growth parameters at all stages of growth compared to chemical fertilizer application alone.
2. Application of biofertilizers along with 50 per cent NPK brought about results on par with 100 per cent NPK fertilizer with respect to chlorophyll content, floral characteristics such as days taken to 50 per cent flowering, number and weight of flowers per plant, diameter of flowers, ten flower weight and flower yield per plant and shelf life of flowers, indicating replacement of NPK chemical fertilizers to the extent of 50 per cent.
3. Biofertilizer application improved chlorophyll content by 4.7 per cent when compared to 100 per cent RDF.
4. Inoculation of biofertilizers influenced the post harvest behaviour of jasmine flowers. Besides saving NPK, biofertilizers improved shelf-life of the loose flowers by over 33 per cent when compared to 100 per cent NPK treatment.
5. Flower diameter and stalk length which govern the quality were increased by 8.6 per cent and 11.2 per cent respectively due to T_6 treatment, 50 per cent RDF + biofertilizers.
6. T_6 treatment improved jasmine petal length by 13.4 per cent when compared to T_1.
7. T_6 treatment substituted 50 per cent NPK without sacrificing flower yield.
8. Biofertilizer application improved the total microbial population in the rhizosphere by several times. T_6 treatment resulted in the highest colonization of N_2 fixers, P-soluiblizers, *P. fluorescens* and *T. viridae* in the rhizopshere of jasmine when compared to all other treatments.
9. In addition to 50 per cent savings on chemical fertilizers, About 10 per cent increase in flower yield was obtained due to T_6 treatment.
10. T_6 treatment exhibited significantly higher enzymatic activities at all stages and in all enzymes when compared to T_1 treatment (100% RDF).

Thus, the field experiments have indicated that the application of biofertilizer consortium has brought about positive effects on vegetative growth, yield, quality and shelf-life of jasmine and rhizosphere microbial population. Its application along with 50 per cent NPK chemical fertilizers was as effective as 100 per cent NPK fertilizer application in all the parameters, indicating a net saving of chemical fertilizers by 50 per cent.

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APPENDIX I

Monthly Meteorological data for the year 2007 and average of the past 58 years (1950-2007) of Main Agricultural Research Station, University of Agricultural Sciences, Dharwad

Months	Rainfall (mm)		Temperature (°C)				Relative humidity (%)	
			Mean maximum		Mean minimum			
	2007	1950-2007	2007	1950-2007	2007	1950-2007	2007	1950-2007
January	Trace	0.02	30.4	29.97	14.0	13.84	72	55.67
February	0.0	0.37	31.9	32.28	15.7	15.61	67	50.67
March	12.8	24.67	35.3	35.28	19.7	16.87	49	48.67
April	86.4	170.51	36.7	50.07	21.4	20.15	55	58
May	65.0	137.71	34.6	34.77	21.3	21.07	61	62.67
June	220.1	157.99	29.7	29.76	21.3	21.19	80	78.33
July	211.2	205.69	27.0	27.71	21.1	20.80	85	85.67
August	176.0	116.95	27.1	26.8	20.5	20.10	85	84
September	18.08	129.92	27.2	28.42	20.3	19.80	83	81.33
October	74.8	85.87	29.7	29.89	19.4	18.87	68	71
November	54.0	53.8	29.5	29.58	15.1	16.29	53	63
December	Trace	1.8	29.0	29.13	14.6	12.81	65	59
Total	1081.1	726.81	-	-	-	-	-	-
Average	-	-	30.68	31.97	18.7	18.12	-	-

APPENDIX II

Characteristics of the soil from the experimental site

Sl. No.	Particulars	Value obtained	Method adopted
1.	Physical properties		
	Clay (%)	47.96	Piper (1966)
	Silt (%)	8.06	Piper (1966)
	Coarse sand (%)	19.15	Piper (1966)
2.	Chemical properties		
	pH (1:2.5)	6.7	pH meter (Jackson, 1973)
	EC (dS/m)	0.22	EC Bridge method
	Average N (kg/ha)	264.52	Modified Kjeldhal's method
	Average P (kg/ha)	10.82	Bray's method (Jackson, 1973)
	Average K (kg/ha)	245.35	Flame photometer method (Muhr *et al.*, 1965)
3.	Microbiological properties		
	Population of		
	Bacteria	14×10^6 cfu/g soil	
	Fungi	2×10^4 cfu/g soil	
	Actinomycetes	52.5×10^3 cfu/g soil	

RESPONSE OF JASMINE (*Jasminum auriculatum*) TO BIOFERTILIZER APPLICATION

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ABSTRACT

Field experiments were conducted one each on the University Farm and a farmer's field at Chigateri village, Harapanahalli Taluk, Davanagere District to study the effect of biofertilizers on growth, yield, quality and nutrient content in Jasmine with different levels of chemical fertilizers. The biofertilizers used included the lignite based cultures of *Azospirillum*, *Pseudomonas striata*, *Pseudomonas fluorescens* and *Trichoderma viridae*.

Biofertilizer application enhanced various growth parameters at all stages of growth compared to chemical fertilizer application alone. Application of biofertilizers along with 50 per cent NPK brought about results on par with 100 per cent NPK fertilizer with respect to chlorophyll content, floral characteristics such as days taken to 50 per cent flowering, number and weight of flowers per plant, diameter of flowers, ten flower weight, flower yield per plant and shelf life of flowers, indicating replacement of NPK chemical fertilizers to the extent of 50 per cent. Biofertilizer application improved chlorophyll content by 4.7 per cent, shelf-life of the loose flowers by over 33 per cent when compared to 100 per cent NPK treatment. Flower diameter, stalk length and petal length were increased by 8.6 per cent, 11.2 per cent and 13.4 per cent respectively due to T_6 treatment (50% RDF+biofertilizers). Biofertilizer application improved the total microbial population in the rhizosphere by several times. T_6 treatment resulted in the highest colonization of N_2 fixers, P-soluiblizers, *P. fluorescens* and *T. viridae* in the rhizopshere of jasmine when compared to all other treatments. In addition to 50 per cent savings on chemical fertilizers, about 10 per cent increase in flower yield was obtained due to T_6 treatment. T_6 treatment exhibited significantly higher activities of urease, dehydrogenase and phosphatase at all stages when compared to T_1 treatment (100% RDF).