RESPONSE OF TUBEROSE (*Polianthes tuberosa* L.) TO ORGANIC MANURES AND GROWTH PROMOTING MICROORGANISMS

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THESIS

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DECLARATION

I hereby declare that the thesis entitled **"Response of tuberose (*Polianthes tuberosa* L.) to organic manures and growth promoting microorganisms"** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, fellowship or other similar title, of any other University or Society.

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Certified that the thesis, entitled **"Response of tuberose (*Polianthes tuberosa* L.) to organic manures and growth promoting microorganisms"** is a record of research work done independently by **Mrs. Mini Sankar,** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to her.

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Introduction

1. INTRODUCTION

Tuberose (*Polianthes tuberosa* L.) is one of the most important bulbous ornamental plants, much adored for its colour, elegance and fragrance. Among the commercially cultivated flowers in India, tuberose occupies a prime position due to it's popularity as cut flower as well as loose flower. Tuberose concrete and absolute find extensive use in high grade perfumery and command a good price in the export market. The flower spikes are largely used for vase decoration and bouquet preparation. Loose flowers have great demand for making garlands and in floral ornaments. The flowers remain fresh for long time and stand long distance transport.

Tuberose is a native of Mexico and belongs to the family Amaryllidaceae. It is a half hardy bulbous perennial, perpetuating through bulblets. Stem is a condensed structure which remains concealed within scales. Roots are adventitious and shallow. Leaves are long, narrow, linear and arise in rosette. Waxy white flowers have funnel shaped perianth and are highly fragrant. Cultivars are grouped based on the number of petals as single type (flowers with one row of corolla segments), semi double type (with 2-3 rows of corolla segments) and double type (with more than three rows of corolla segments).

Tuberose can be successfully grown under warm humid areas having temperature around 30°C which makes it suitable for cultivation under Kerala condition. This has a high nutrient requirement and hence proper fertilization is essential for successful cultivation. Application of organic matter is beneficial for promoting growth and higher production of good quality spikes. Due to lack of availability of sufficient organic manures, growers are largely depending on chemical fertilizers. For taking ratoon crops, large quantities of fertilizers are to be applied in the same field, which leads to the loss of inherent soil properties in addition to the increased cost of production. Consistent and indiscriminate use of chemical fertilizers has caused deterioration of soil health, stagnation in productivity, insecurity of quality produces and other environmental hazards. Fertilizers make up only a few minerals, impede the uptake of other nutrients especially micronutrients and imbalance the whole mineral pattern. There are also problems of loss of applied fertilizers by way of leaching, volatilization and denitrification of nitrogen and fixation of phosphorus. Closed bud malady, where the floral buds, apparently on the healthy plants fail to open properly has been a great problem to the tuberose growers, may be due to micro nutrient deficiency. The use of inorganic manures is to be reduced to encourage soil health and also to control hike in the production cost.

Proper nutrient management plays a dominant role in exploiting the inherent yield potential of a crop. In flower production, crop management practices involving judicious combination of organic manures and growth promoting micro organism can be made viable and feasible for augmenting yield potential and quality flowers. Both organic manures and growth promoting micro organisms improve the soil quality, are ecofriendly, cost effective and do not require non renewable source of energy during their production. It is now imperative to find an integrated nutrient management schedule for tuberose for an optimum use of plant nutrients and to improve the yield and quality of flowers. Keeping this in view the study was conducted with the following objectives.

1. To standardize an optimum combination of organic manures and growth promoting microorganisms with minimum dose of chemical fertilizers for improving yield and quality of tuberose.

2. To study the response of tuberose to different sources of organic manures alone.

3. To work out the economics of the treatments under different nutrient management schedule.

4. To study the influence of the treatments on the soil properties.

Review of Literature

2. REVIEW OF LITERATURE

Tuberose is one of the most important ornamental bulbous plants valued for beauty and fragrance of flowers. It has a great economic potential for cut flower trade and in essential oil industry. Flower spikes are largely used for vase decoration and bouquet preparation where as loose flowers find significant place in making garlands and in floral ornaments.

Tuberose has a high nutrient requirement and hence proper fertilization is essential for its cultivation. Nutritional requirements vary with soil and climatic condition. But consistent and indiscriminate use of chemical fertilizers has caused serious damage to soil and ecology. Hence, a judicious combination strategy, including chemical fertilizers along with organic manures and growth promoting microorganisms may be helpful in increasing the productivity of tuberose. Literature pertaining to these aspects including those of related crops is reviewed here.

2.1 EFFECT OF NPK FERTILIZERS

Tuberose is a heavy feeder and it responds well to fertilizer application. Requirement of N, P and K for tuberose cultivation, through the application of chemical fertilizers has been worked out by various workers under different agro climatic conditions.

Bankar and Mukhopadhyay (1985) reported the experimental evidence for applied N, P_2O_5 and K_2O at 25-30: 60-80: 60-80 g m^{-2} and their effects on plant and floral characteristics of tuberose. Nitrogen had significant beneficial effect on all the parameters studied, whereas P had a significant effect on flower quality only. On the other hand, K had no significant effect. Survival of spike in the field was longest (22.8 days) with the highest N rate. Improvement of plant growth, spike yield, flower quality and enhanced daughter rhizome production as a result of increased N application was also reported by the same authors later (Bankar and Mukhopadhyay, 1986 and 1990).

Parthiban and Khader (1991) reported yield enhancement in terms of number of spikes per plant, number of flowers per spike and the highest flower yield by the application of NPK at the rate of 100:75:62.5 kg ha^{-1}.

Highest yield of flowers, lengthy spikes and longest duration of flowering were reported when NPK was applied at the rate of 200:75:125 kg ha^{-1}. (Gowda *et al*., 1991). As per Gopalakrishnan *et al*. (1995) highest number of flowers per spike and better flower diameter could be obtained when NPK was applied at the rate of 120:60:30 kg ha^{-1}. Increased rates of N, P and K resulted in taller plants with more number of leaves (Singh and Godara, 1995).

Singh and Uma (1996) recorded highest number of leaves per clump, more number of florets per spike and greater individual flower weight by the application of N at 250 kg ha^{-1}. Increasing the rate up to 350 kg ha^{-1}increased spike and rachis length but delayed flowering. Bulb yield of tuberose increased as N rate increased up to 30 g per plant, whereas P and K had little effect on the bulb yield as reported by Singh *et al*. (1996). Baruah and his co-workers (1998) compared the effects of different NPK rates on tuberose grown for cut flowers and the highest spike yields were obtained with the application of NPK at the rate of 80:40:60 g m^{-2}.

Bhuyan *et al*. (1998) reported highest number and weight of spikes, increased flower size, improved shelf life and vase life when K rate was increased up to 60 g m^{-2}. In field trials with different rates of N applications, a dose of 200 kg ha^{-1} produced maximum plant height, more number of spikes per plot and longest spikes with highest number of florets per spike when compared to other treatments (Singh, 2000).

In a field experiment, tuberose bulbs were supplied with different rates of N and P, maximum number of spikes per clump, more spike length, increased size and weight of bulbs were observed when rates of N increased up to 30 g m^{-2} and P up to 24 g m^{-2} (Kumar *et al*., 2002).

According to Kawarkhe and Jane (2002) parameters like plant height number of leaves per plant, number of spikes per plant, length of rachis and number of flowers per spike increased with increasing rates of N up to 250 kg ha^{-1}. Similar results were obtained for all the parameters when rate of P was increased up to 300 kg ha^{-1} except for plant height and number of leaves, which increased with increasing rates of P up to 350 kg ha^{-1}.

Best flower quality in terms of number of spikes per plant, number of florets per spike and longest spikes were recorded in tuberose by the application of NPK at the rate of 250: 200: 200 kg ha^{-1} along with planting of one bulb per spot (Patil and Reddy, 2002).

In an experiment with the application of different nitrogen levels in tube rose, nitrogen at 30 g m^{-2} was proved to be the best treatment for producing quality tuberose flowers (Bawedja, 2003).

In a field investigation (Yadav *et al.*, 2003) it was observed that addition of 100-150 kg N and 10 kg Zn per hectare was optimum for growth parameters like plant height, number of leaves and leaf area, whereas 200 kg N and 20 kg Zn per hectare was recorded best for spike production in tuberose.

Better vegetative growth was reported by the application of NPK at the rate of 20:20:20 g m^{-2} while addition of NPK at the rate of 20:15:20 g m^{-2} improved flower yield and quality according to Pal and Biswas (2005).

2.2 EFFECT OF ORGANIC SOURCES OF NUTRIENTS

Soil fertility management includes maintenance of essential plant nutrients in proportions and amounts for optimum growth of different crop species (Siddaramappa, 2004). Soil organic matter contains, retains and supplies all essential nutrients although in low and variable amounts. Organic manures supply essential plant nutrients and support the biological processes in soil. Continuous use of inorganic fertilizers and neglecting organic manures paved the way of deterioration of soil health and environmental quality. Therefore, addition of organic sources of nutrients along with inorganic fertilizers is necessary to reestablish the lost fertility of the soil. Since the experiments in these aspects are limited in the case of tuberose, cited here is the works carried in other crops.

2.2.1 Farm Yard Manure (FYM)

Good quality FYM is the most valuable organic matter applied to the soil. It consists of a decomposed mixture of cow dung, urine and remenants of straw and plant residues and other wastes of farm. FYM has a role in improvement of soil health as it contains macro and micro nutrients. It also improves soil tilth and aeration, increase water holding capacity, improves chemical properties and stimulates the activity of microorganisms in the soil.

In tuberose a flower yield of 12000 kg ha^{-1} was recorded by the application of FYM alone (Nambisan and Krishnan, 1983). Khader *et al*. (1985) reported highest flower yield in terms of number of flowers per spike and flower quality in crossandra when FYM was applied at 20 t per acre along with $N:P_2O_5:K_2O$ at 25:20:45 kg per acre and 0.5% Zn. In chrysanthemum highest flower yield was observed by the application of FYM at 5 kg m^{-2} and N: $P_2O_5:K_2O$ at 20:20:20 g m^{-2} (Chezhiyan *et al*., 1986).

Different organic manures were evaluated to study their effect on growth and flower yield of China aster. Addition of FYM 15 t ha^{-1} along with recommended dose of NPK was observed to be optimal for high flower yield (Sreenivas *et al.*, 1998, Sreenivas and Gowda, 1999).

Haripriya and Sriramachandrasekharan (2002) reported better growth and yield in marigold by the application of FYM together with lignite mine soil.

In an experiment to study the effect of different potting media on the rooting of Keikis bamboo orchid, a combination of FYM along with soil, sand and rice husk was proved to be the best for better root induction (Barman *et al.*, 2003). An increase in N content in flowers and shoot was observed in African Marigold with increasing levels of FYM and N (Singh *et al*., 2003).

Among the different media used for the cultivation of gerbera, a medium consisting of cocopeat and FYM in 1:1 ratio recorded maximum values for number of leaves, flowers per plant, flower diameter, vase life as well as earliest flowering (Anuje *et al*., 2004). Shankar and Dubey (2005) reported improved flowering and corm yield in gladiolus when 50 t of FYM ha^{-1} was applied together with 400:200:200 NPK ha^{-1}.

Ahmed (1993) reported that the yields of tomato was highest with FYM 19.01 t ha^{-1} followed by coirpith as compared to control plots. An increase in tuber yield was recorded in potato with increasing rates of FYM (Hassandokht and Kashi, 2000). In a field experiment using different organic manures in tomato, early flowering and high yield was obtained when FYM was applied along with biogas slurry (Renuka and Sankar, 2001).

In Brinjal, among the different organic manures applied, a combination of FYM and vermicompost was proved to be the best for highest fruit yield (Rao and Sankar, 2001). Better vegetative growth in terms of plant height and branches per plant and higher fruit yield were obtained in tomato by the application of FYM 38t ha^{-1} combined with NPK at 250:250:250 kg/ha (Krishna and Krishnappa, 2002). Naidu *et al*. (2002) recorded increased fruit yield and highest benefit cost ratio in brinjal when FYM was applied at the rate of 25 t ha^{-1} and NPK 75:35:0 kg ha^{-1}.

2.2.2 Vermicompost

Vermicompost is finely divided black granular peat like mass, with excellent porosity, aeration, drainage and moisture holding capacity. It supplies a suitable mineral balance, improves nutrient availability and can act as a complex fertilizer. Vermicomposting is a bio oxidation and stabilization process of organic materials which involve combined action of earth worms and mesophilic microorganisms. Feeding and excretory activities of earthworms generate vermicompost. There are several reports about the beneficial effects of vermicompost on growth and yield of flower crops.

In a field experiment in China aster, a higher yield of 11 t ha^{-1} was obtained by the application of vermicompost at the rate of 2.5 t ha^{-1} along with 75 per cent recommended dose of fertilizer or vermicompost at the rate of 5 t ha^{-1} along with 50 per cent recommended dose of fertilizers or with *in situ* vermiculture with 2000 earthworms per ha (Kulkarni *et al*., 1996).

Navarro *et al*. (2000) reported better vegetative growth and improved flower yield in terms of number of flowers and flower diameter and decrease in the incidence of crown rot and root rot in gerbera when vermicompost was incorporated at 20% with or without chemical fertilizers. An increase in number of leaves, leaf area, plant height, fresh weight of whole plant, length of spike and rachis, number of florets per spike and fresh weight of corm and cormels were observed in gladiolus by treatment with a combination of vermicompost at 10 t ha^{-1} and 80 per cent recommended NPK rate (Gangadharan and Gopinath, 2000). Vermicompost from sheep manure added at 50 per cent by volume was proved to be the most effective substrate amendment for better vegetative growth and flower production in chrysanthemum (Hidalgo and Harkess, 2002a).

The impact of application of vermicompost obtained from water hyacinth was assessed in terms of growth and flowering in crossandra and it was observed that application of vermicompost led to a significant improvement in morphological and yield attributes (Gajalakshmi and Abbasi, 2002).

Experiments conducted to evaluate earthworm castings (vermicompost) as a substrate for poinsettia production resulted that substrates with 25% vermicompost from sheep or cattle manure was highly suitable for better plant growth (Hidalgo and Harkess, 2002b).

Haripriya *et al*. (2004) recorded highest flower yield, number of flowers, fresh weight of flowers and number of petals per flower, in rose treated with vermicompost 200 g per plant along with 100% recommended dose of fertilizers.

Significant improvement in visual quality of turf grass was observed by the application of vermicompost obtained from paper wastes (Gardner, 2004).

2.2.3 Poultry manure

Poultry manure is a rich source of essential nutrients required for plant growth. Experiments conducted have been proved that poultry manure is very effective for growth and yield improvement in many crops.

Application of poultry manure was very effective for controlling the population of root knot nematode in *Celosia argentea* as per Babatola (1988). In a study to evaluate the effect of different growing media composition on cineraria, a composition of poultry manure, sewage sludge, sand and loam in 1:1:1:2 proved to be the best for enhanced growth and yield and a media composition of poultry manure sand and loam in 0.5:1:2 proportion was found to increase contents of chlorophyll, carbohydrates, nitrogen, phosphorus and potassium in addition to the improvement in vegetative growth and flower yield (Attaalla, 2003).

An improvement in plant growth, flower head production, nutrient content and essential oil content were observed in *Achillea millefolium* when 75 per cent poultry manure was applied (15 t ha^{-1}) combined with 25 per cent N as ammonium sulphate, 50 kg ha^{-1} (Aziz, 2004). Improved plant growth and flower yield were observed in rose by the application of poultrymanure 4 kg m^{-2} and NPK 25:20:15 g m^{-2} along with azotobacter (Singh *et al.*, 2006).

Adebayo *et al.* (1985) reported maximum dry matter accumulation in cowpea at the highest rate of poultry manure application. In okra application of 20 kg N/ha as ammonium sulphate and 20 kg N ha^{-1} as poultry manure was found to be the best for obtaining highest yield (Abusaleha and Shanmugavelu, 1988). Jose *et al*.

(1988) observed highest yield in brinjal by applying 50 kg N ha^{-1} as poultry manure and 50 kg N ha^{-1} as urea.

Silva and Vizzotto (1990) reported that treatment with poultry manure 20 t ha^{-1} together with N: P_2O_5:K_2O at 104:259:104 kg ha^{-1} was optimum for getting highest yield in tomato. An improved growth and fruit yield and a decline in nematode population was observed in tomato by the application of poultry manure at 4 t ha^{-1} and above (Chindo and Khan, 1990).

Highest plant height, leaf and stem fresh weight, dry matter content and early yield were observed in cucumber when plants were grown in a media containing poultry manure and FYM, along with foliar spray of Mn or Zn (Alphonse and Saad, 2000). In a trial using different organic fertilizers in chilli, poultry manure was found to be superior and a 1:1 ratio of poultry manure to inorganic fertilizers was proved to be the best for increasing yield and quality (Sharu and Meerabai, 2001).

Increased nutrient availability and chemical properties of the soil and better nutrient uptake in cucumber by the application of poultry manure was reported by Mali *et al.* (2005). Improvement in pod yield in bhendi by the application of poultrymanure was reported by Anim *et al.* (2005) and Sivakumar *et al.* (2005).

2.2.4 Coirpith compost

Coirpith compost is an effective organic source of nutrients to plant growth. In addition to the supply of essential nutrients, it also improves the water holding capacity of soil. There are several reports about the beneficial effect of coirpith compost on growth and yield of different crops.

Highest flower yield with remarkable vase life was reported in gerbera when plants were grown in a coirpith compost medium combined either with compost or vermicompost (Barrito and Jagtap, 2002).

In a study to evaluate the effect of different planting media on rooting of cuttings in carnation, highest sprout number were recorded in medium containing coirpith compost (Bharathy *et al*., 2003). Rajeevan *et al*. (2003) reported that coirpith can be used with sand and cowdung as a growing medium in Anthurium and it can also substitute cowdung if used along with sand and coconut husk in equal proportion. Better plant growth in foliage plants also was reported by the same workers when coirpith was used in equal proportion with sand and cowdung. Growing media containing different proportions of coirpith manure and coconut husk were found to enhance growth in foliage aroids and it was also observed that coconut husk could substitute cowdung in media mixed with sand.

Suharban *et al.* (2004) reported that a combination of coarse sand, coconut husk and coirpith in a 1:1:1 ratio and course sand, coconut husk, cowdung and coirpith in a 1:1:1 ratio were the best substrates for anthurium cultivation under green house.

In a study to evaluate the efficiency of coirpith as a substitute for FYM in okra, highest fruit yield was obtained when composted coirpith was applied at12 t ha^{-1} combined with 75 per cent of the NPK recommendation. Composted coirpith when applied alone also recorded 13 per cent yield increase over that of FYM (Pushpakumari and Geethakumari, 2001).

Hangarge *et al*. (2002) observed highest yield and nutrient uptake in chilli when coirpith compost was applied together with organic booster.

2.2.5 Biogas slurry

Biogas slurry is a liquid manure obtained after the evolution of biogas from the cowdung. Since cowdung undergoes a digestion process, slurry obtained will contain nutrients in easily available form. Biogas slurry has the most stimulative effect on the microbial counts and enrichment of the soil with ammonia. Studies conducted revealed that biogas slurry can be used as a substitute to inorganic fertilizers to maintain productivity and environmental quality.

Raviv *et al.* (1984) reported 12 per cent more good quality flowers in rose cv. Mercedes when grown in a medium containing 80 per cent fine tuff and 20 per cent dried slurry.

Biogas slurry was reported to be effective in reducing root knot nematode population and promoting growth and yield of tomato (Estefanous *et al.*, 1998). A trial conducted to evaluate the effect of different culture media on seed germination and growth of tomato seedlings revealed that, a treatment with biogas slurry and polyethylene recorded highest germination percentage, number of roots per seedling and root length while highest seedling height, shoot diameter, number of leaves per plant and fresh weight of leaves were recorded from biogas slurry alone (Pandey, 1998).Vigorous growth, early flowering and high yield were also reported in tomato by the application of biogas slurry along with FYM (Renuka and Sankar, 2001).

Geeta and Sreenivasa, (2002) observed highest plant height, plant dry biomass, shoot N concentration and fruit yield in bhindi, when plants were supplied with biogas slurry and N fertilizer.

In tomato, Jothi *et al.* (2003) reported that the plants amended with biogas slurry put up more vegetative growth and tended to flower and fruit much earlier than control. A decrease in severity of nematode attack was also observed by the application of biogas slurry.

2.2.6 Vermiwash

Vermiwash is the liquid fertilizer collected after the passage of water through a column of worm culture. It is a mixture of excretory products and mucous secretion of earthworms and micronutrients from organic matter which may be promoted as a potent liquid fertilizer for better growth and yield of plants. (Shwetha *et al.*, 2005). The vermiwash may be diluted with water in 1:1 ratio or it may be diluted with 10 per cent cow's urine which is an effective pesticide.

Karuna *et al.* (1999) observed the best growth in terms of number of suckers per plant, leaf size and yield of quality flowers by the application of 50 per cent earthworm exudates in anthurium. Significant improvement in growth and yield of tomato was reported by the application of vermiwash (Ranijasmine, 1999).

2.2.7 Panchagavya

Indian traditional knowledge system, a treasure trove of information recommends panchagavya to safe guard plants and soil microorganisms, from time immemorial. Panchagavya means the blend of five products from cow i.e. milk, curd, ghee, dung and urine. When used for agricultural purposes, in addition to the five basic ingredients, sugarcane juice, tender coconut water and ripe poovan bananas are added to panchagavya to accelerate fermentation process. Panchagavya is usually applied as 3 per cent foliar spray. Presence of growth regulatory substances such as IAA, GA and cytokinin, essential plant nutrients, naturally occurring effective microorganisms biofertilizers such as Azotobacter, Azospirillum and Phosphobacteria biocontrol agents like Pseudomonas detected in panchagavya can be attributed to it's efficacy as organic foliar nutrition.

Spraying of 6 percent panchagavyam along with 4 percent Manchurian mushroom tea was found to increase the number of florets per spike, duration of flowering and vase life in gladiolus (Bhalla *et al*., 2006a). Similar results were also reported in carnation by the spray of panchagavyam and Manchurian mushroom tea 3 percent each along with inorganic fertilizers (Bhalla *et al.*, 2006b).

Sridhar and Kumar (2004) reported the production of quality cotton lint in terms of weight and colour by spraying of cotton plants with 3 per cent panchagavya solution. Positive influence of panchagavya foliar spray on the number of grains and N uptake in maize and crude protein content and N uptake in sunflower was reported by Somasundaram *et al.* (2004). In rice enhanced plant growth and higher grain yield was observed by the application of panchagavya (Yadav and Lourduraj, 2005). Beneficial effect of panchagavya for growth and yield improvement in greengram and blackgram was reported by Britto and Girija (2006).

2.3 EFFECT OF PLANT GROWTH PROMOTING MICROORGANISMS

Plant growth promoting microorganisms include Biofertilisers and Biocontrol agents. They can be applied alone or in combination with organic manures and inorganic fertilizers.

2.3.1 Biofertilizers

Biofertilizers are biotropically active products containing active strains of specific bacteria, algae and fungi which alone or in combination may help in increasing crop productivity by way of biological nitrogen fixation solubilisation of insoluble fertilizer materials and by decomposition of plant residues (Verma and Bhattacharya, 1991).

2.3.1.1 AMF (Arbuscular mycorrhizal fungi)

Arbuscular mycorrhizal fungi (AMF) are beneficial soil microorganisms that form symbiotic association with fine roots of plants. The fungus biotropically colonizes root cortical tissues and extend their hyphae into surrounding soil, forming an important linkage between plants and their below ground environment. It has been recognized that mycorrhizal symbiosis play a key role in nutrient recycling in the ecosystem and also protects plants against environmental and cultural stresses. The beneficial effects of AMF on floricultural crops have been reported by many scientists.

In tuberose longest spikes with maximum number of florets were observed when AMF was applied in combination with 200 kg N and 100 kg P ha^{-1} (Singh and Godara, 2003).

Bagyaraj and Powell (1985) reported that marigold plants inoculated with *Glomus fasciculatum* showed an increase in plant height, flower, stem and root dry weight under pot culture conditions.

The influence of AMF on aster and salvia in worm cast amended soil was studied by Kale *et al*. (1987). The mycorrhizal root colonization was influenced by the amendment of worm cast and in turn the shoot P content and yield of those ornamentals were increased by AMF.

Wang *et al*. (1993) observed an increase in shoot number and root dry weight in gerbera plants inoculated with *Glomus intraradius* and *Glomus vesiculiferum*.

Experiments conducted by Duke *et al*. (1994) revealed that inoculation with *Glomus intraradius* increased the number of flower buds in zinnia. Chang and Wen (1994) reported that application of *Glomus mosseae* along with *Glomus etunicatum* induced an increase in lateral shoots, cut flower yield and advanced flowering in gerbera.

Plants inoculated with *Glomus etunicatum* showed a faster flowering rate when compared to control in Zinnia (Abournasr, 1996).

Field application of *Glomus intraradius* has resulted an increase in flower yield along with decrease in disease severity caused by *Fusarium oxysporum* in carnation (St. Arnard *et al*., 1997). A pot experiment in Crossandra has shown that use of oil cake 15 g per plant along with *Glomus mosseae* promoted plant growth and reduced the multiplication rate of nematodes (Nagesh and Reddy, 1997). Inoculation of AMF along with phosphate solubilizing bacteria has resulted in increased fresh weight, number of branches and number of flowers in Petunia along with an advanced flowering of 20-30 days (Wang and Ling, 1997).

Soroa *et al*. (1998a) observed that seed pelleting of snap dragon with *Glomus mosseae* increased plant growth. Similar results was reported in China Aster when seeds were inoculated with *Seutellospora pellucida* (Soroa *et al*., 1998b). Application of AM fungi *Gigaspora margarita* with phosphorus has shown an increase in plant height, number of branches and flower yield in China Aster as per Naik *et al*. (1998).

Gnanadevi and Haripriya (1999) observed that plants inoculated with *Glomus fasciculatum* increased the plant height and number of flowers per plant in chrysanthemum. In oriental lily inoculation of plants with AM fungi was helpful in increasing bulblet size (Wu *et al*., 1999). Reports by Pedraza *et al*. (2001) revealed that application of *Glomus mosseae* and *Acaulospora scrobiculata* increased the plant height, P, K, Cu and Zn content in leaves and N, Ca, Cu and Zn content in roots of gerbera. Scagel (2001) reported that application of AMF into rooting medium has increased the number of rooted cuttings and number of roots cuttings in rose.

Soil application of *Glomus fasciculatum* was found to increase the flower yield, flower diameter and also induced early flowering in gerbera (Soroa *et al*., 2003). Kumar *et al*. (2003) reported that application of AMF along with ¾ of the recommended dose of N and P, full K and phosphobacteria improved flower yield, flower diameter, flower weight and overall plant growth in China aster.

2.3.1.2 Azospirillum

Azospirillum is an associative symbiotic bacterium which lives in close association with the root system of plants. These bacteria colonizing the roots not only remain on the root surface but also a sizable population penetrates into the root tissues and lives in harmony with the plant. Making use of the root exudates of the plants azospirillum colonize in the root region in large numbers and fixes substantial amount of nitrogen. Several works have been carried out to study the effect of azospirillum on crop plants. Results from most of the studies have indicated that azospirillum can be used as a potential inoculant for flower crops.

Experiments conducted by Wange and Patil (1994) reported beneficial effects of azospirillum along with azotobacter in tuberose as increased number of flowers per stalk, flowering shoots and bulb yield.

Field trials conducted with 150 kg N along with azospirillum improved the cut flower yield, whereas application of azospirillium together with 50 kg N increased the bulb yield in tuberose (Wange *et al*., 1995).

A Mexican single cultivar of *Polianthes tuberose* treated with 120:65:62.5 kg NPK ha^{-1} along with azospirillum and phosphobacteria showed an increase in number of flowers per spike, flower weight, and highest spike lengths and yield of 3.08 t ha^{-1} (Swaminathan *et al*., 1999).

Balasubramanian (1989) reported that the azospirillum inoculated plants exhibited early flowering besides an extended crop period and higher flower yield in French Marigold.

Application of 60 kg N with azospirillum treatment during third month after planting and 1000 ppm ascorbic acid spray resulted in efficient use of photo assimilates, highest flower yield and flower diameter in crossandra. Earliest spike appearance and days to first harvest were observed in this crop by the application of nitrogen at 40 kg ha^{-1} along with azospirillum inoculation one month after planting (Ravichandran, 1991). Similar results were reported in African Marigold also when azospirillum was applied combined with Nitrogen 60 kg ha^{-1} and 1000 ppm ascorbic acid spray (Mariappan, 1992). Increase in plant height, number of tertiary branches, shoot and leaf area, dry weight of roots, flower weight and yield in *Jasminum sambac* were as a result of azospirillum application (Manomani, 1992).

In Marigold increased plant height, flower weight and yield were the results of treatment with 45:90:120 NPK g per plant and asozpirillum and phosphobacteria 20g each (Velmurugan, 1998).

Early flowering was observed in Edward rose by the application of Nitrogen at 25 kg ha^{-1} together with azospirillum, six months after planting. Application of N at 37.5 kg ha^{-1} with azospirillum six months after planting and ascorbic acid spray at 1000 ppm recorded the highest flower yield (Preethi *et al*., 1998).

Bhavanisanker and Vanangamudi (1999a) reported that application of 75 per cent N along with Azospirillum and 75 per cent P along with phosphobacteria have given the highest flower yield in Gundumalli at 10 months after planting. Highest flower yield per plant was reported by the combined application of 100 per cent N as urea together with azospirillum and 75 per cent P as superphosphate along with phosphobacteria, in Crossandra. (Bhavanisanker and Vanangamudi, 1999b).

Application of azospirillum in combination with 120 kg Nha^{-1}, 70 kg K_2O ha^{-1} and FYM 30 t ha^{-1} increased plant height, leaf area, number of spikes and number of flowers per spike in crossandra (Swaminathan and Sambandamurthi, 2000). Combination of azospirillum and 75:50:125 kg NPK ha^{-1} recorded highest flower yield in Crossandra as reported by Raju and Haripriya, (2001). Parthiban *et al*. (2001) recorded highest flower yield in Globe Amaranth when azospirillum was applied along with 200 kg N/ha and 20 t FYM.

Application of 75 per cent of the recommended NPK in combination with azospirillum and phosphate solubilizing bacteria resulted in better vegetative growth, more number of flowers per plant, increased flower diameter, stalk length, weight of single flowers and improved yield per plant in gaillardia (Rathode *et al*., 2002). Binisha *et al*. (2003) observed increased flower field and higher rooting percentage in orchids when azospirillum was applied along with 20:10:10 NPK.

2.3.1.3 Combined effect of AMF and azospirillum

Synergistic action of AMF with azospirillum have been reported by many scientists.

Balasubramanian (1989) reported increased growth response of marigold to the combined application of AMF and azospirillum even with the reduction of 25 per cent of recommended dose of NPK fertilizers.

Combined application of AMF and azospirillum along with 30:20:10 NPK and phosphobacteria was found to be helpful in increasing the yield of carnation (Gayathri, 1997).

Rajadurai and Beaulah (2000) reported that application of NPK at the rate of 45:45:37.5 kg ha^{-1} with combined inoculation of azospirillum and AMF exhibited increased growth in respect of plant height, number of leaves and laterals per plant in marigold.

An improvement in vegetative growth and flower yield was recorded in gladiolus by the combined application of AMF and azospirillum along with N and P (Kathiresan and Venkatesha, 2002).

Dendrobium cv. Sonia 17 showed an increase in number of flowers per spike when AMF and azospirillum were applied in combination with NPK 10:5:10 as 2 per cent foliar spray (Arumugan *et al*., 2003). Vaselife of gerbera was found to be improved by the combined application of AMF and azospirillum together with 50 per cent recommended N, P and full K (Gowda, 2003).

Higher bulb yield, more TSS and sulphur content in bellery onion was reported by the application of 112.5:112.5:112.5 kg N and P per ha along with azospirillum and AMF (Gurubatham *et al.*, 1989).

2.3.2 Biocontrol agents

Biocontrol agents are microorganisms used for 'Biological control' which is the reduction of the amount of inoculum or disease producing activity of a pathogen, accomplished by or through one or more organisms other than man (Cook and Baker, 1983). Several reports are available on the stimulating effect of biocontrol agents in promoting plant growth when used as either seed treatment or soil application. Increased growth response of crop plants in presence of biological control agents may be due to direct effect on the plant as biofertilizer or by control of some plant pathogens.

2.3.2.1 Trichoderma

Trichoderma is a fungal antagonist. It controls the diseases like foot rot wilt etc. and also stimulates plant growth. Important species are *Trichoderma* *harzianum, T. viride* etc. Many reports are available regarding the beneficial effect of *Trichoderma* on plant growth and yield of flower crops.

In tuberose, application of *Trichoderma harzianum* in combination with a neem based formulation of *Verticillium chamydosporium* before planting and subsequently once in 4 months decreased the incidence of root knot nematode and severity of nematode induced wilt disease (Rao *et al*., 2003).

Chang and Baker (1986) reported increased flower yield in chrysanthemum by the soil application of Trichoderma.

In gladiolus it was observed that combined application of *Trichoderma harzianum* and *Paecilomyces lilacinus* along with neem cake decreased the nematode infection and incidence of wilt caused by *Fusarium oxysporum* (Nagesh *et al*., 1998).

Among the four Trichoderma species (*T. viride, T. harzianum, T. hanatum, T. koningii*) screened for the management of sclerotium wilt of jasmine, *T. harzianum* was found to be the best in controlling the disease and improving the plant growth (Ramamoorthy *et al*., 2000). Reports by Paradikovic *et al.* (2000) reveal that application of TRI 003, a commercial formulation containing spores of *Trichoderma harzianum* was effective against *Fusarium* wilt and also resulted in improving the growth and development in gerbera.

Osuna *et al*. (2005) and Gracia *et al.* (2005) reported the application of commercial formulations of Trichoderma, T_7 and T_{17} and combined application of commercial Trichoderma formulations T_{28} and T_{18} in carnation as very effective to decrease the severity of vascular wilt caused by *F. oxysporum* F. sp. Dianthi.

2.3.2.2 Pseudomonas fluorescens

Pseudomonas fluorescens is a bacterial antagonist. It lives non symbiotically on the plant roots, produces growth hormones like IAA which stimulates plant growth. It was proved to be effective against, *Fusarium*, *Phytophthora*, *Pythium, Rhizoctonia* etc.

Sendhilvel *et al*. (2001) reported a decrease in the incidence of soft rot and increase in germinability in onion, when seeds were treated with FP7, a commercial formulation which contains *Pseudomonas fluorescens*. Improved management of *Meloidogyne incognita* was observed in tomato by the application of *Pseudomonas fluorescens* (Siddiqui and Mahmood, 2003). According to Selvaraj *et al*. (2003), application of *Pseudomonas fluorescens* along with green manuring, bio dynamic compost, biofertilizers, agnihotra ash and vermicompost improved growth of gerbera in terms of number of leaves, leaf length, leaf width, shoot weight, root weight, number of flowers, stalk length and shelf life of flowers.

2.4 CORRELATION STUDIES

Correlation analysis has a significant role in crop improvement programmes. The degree of interaction of many components which are intimately associated among themselves and with yield can be ascertained through precise estimation of genotypic and phenotypic correlations. Correlation study of various yield contributing factors have been conducted in many flower crops.

In tuberose length of scape, length of spike, diameter of flower, and flowers per spike exhibited a significant positive association with yield (Kannan *et al*, 1998).

Niranjanmurthy and Sreenivas (1997) reported a positive association of flower yield with number of flowers per spike, flower diameter and hundred flower weight in single type tuberose. Nagaraja *et al*. (1999) observed that number of leaves in tuberose had a significant positive correlation with spike length, rachis length, number of flowers per spike, duration of flowering, number of spikes per plant, number of suckers per plant and concrete content. Shamasundaran and Singh (2003) reported a high positive correlation of crop yield with plant height, spike length and flower diameter of tube rose.

In gladiolus a highest positive correlation of florets per spike was seen with rachis length, spike length and durability of spike. Spike length had a highly significant and strong positive association with plant height, rachis length and number of florets per spike (Aswath *et al.*, 1994; Deshraj *et al.*, 1998; Neeraj *et al.*, 2001; Nazir *et al.*, 2003).

Correlation studies in African Marigold revealed that yield of flowers per plant was significantly and positively correlated to plant height and plant spread in East-West and North-South directions (Mohanty *et al.*, 2003).

Materials and Methods

3. MATERIALS AND METHODS

The investigation on "Response of tuberose (*Polianthes tuberosa* L.) to organic manures and growth promoting microorganisms" was carried out at the Department of Pomology and Floriculture, College of Horticulture, Vellanikkara during 2003-2007.

3.1 LOCATION, CLIMATE AND SOIL OF THE SITE

The experiment was laid out at the research field of the Department of Pomology and Floriculture, College of Horticulture, Vellanikkara, Thrissur, located at an elevation of 22.5 m above mean sea level of 10°32' North latitude and 76°16' East longitude.

The area lies in a tropical monsoon climate. The weather is warm and humid. Normal weather of the area and the weather conditions prevailed during the experimental period are presented in Appendix-I. Soil of the experimental site is sandy loam in texture and acidic in reaction with a pH of 5.8, organic carbon 0.40 per cent, available N 100.50 kg ha $^{-1}$, available P 20.00 kg ha-^{1} and available K 84.00 kg ha^{-1}.

3.2 EXPERIMENTAL MATERIAL

Two tuberose varieties Prajwal and Vaibhav (Plate 3 and 4) released from the Indian Institute of Horticultural Research, Bangalore were used for the study. Prajwal is a cross between Shringar and Mexican Single. It is a single type having straight, tall and sturdy spikes with attractive slight pinkish flower buds. Vaibhav is a double type with flower buds having a greenish tinge. Both of these varieties are ideal for cut and loose flowers.

3.3 FIELD EXPERIMENTS

The research project consisted of three field experiments. Experiment 1 and 2 were carried out simultaneously followed by the third experiment (Plate 1 and 2). As per Package of Practices Recommendations: Crops (KAU, 2000) the dose of NPK for

Plate 1. General view of the experimental field (experiments 1 & 2)

Plate 2. General view of the experimental field (experiment 3)

tuberose is 100:50:50 kg ha^{-1} and FYM 30 t ha^{-1}. The treatments were fixed based on this fertilizer schedule.

3.4 DETAILS OF ORGANIC NUTRIENT RESOURCES USED IN THE STUDY

3.4.1 Organic manures

3.4.1.1 Farm yard manure

Farm yard manure is the product of decomposition of liquid and solid excreta of the live stock, stored in farm along with varying amounts of straws or other litter used as bedding. It contains 1.00 percent nitrogen.

3.4.1.2 Poultry manure

Poultry manure, the excreta of poultry, is a nutrient rich organic amendment and it is having a nitrogen content of 1.35 percent.

3.4.1.3 Vermicompost

Vermicompost is a product of bio oxidation and stabilization process of organic materials which involves the combined action of earthworm and mesophilic micro organisms. It is rich in nutrients with a nitrogen content of 1.6 percent.

3.4.1.4 Coir pith compost

It is an organic source of nutrients, which supplies the essential nutrients in addition to the improvement of water holding capacity of the soil and it contains 0.35 percent nitrogen.

3.4.1.5 Biogas slurry

Biogas slurry is the liquid manure obtained after the evolution of biogas from cowdung. It contains nutrients in easily available form and it has a nitrogen content of 0.08 percent.

3.4.2 Organic growth substances

3.4.2.1 Vermiwash

Vermiwash is a collection of excretory products and excess secretion of earth worms along with micronutrients from decomposed organic matter and it has a nitrogen status of 0.39 percent.

3.4.2.2 Panchagavyam

It is a unique combination of five products from cow (cow dung, urine, milk, curd and ghee) having beneficial effect on growth and yield of crops (0.025 percent).

Ingredients of Panchagavyam

1. Fresh cowdung	5 kg		1. Sugarcane juice	3 l
2. Cow's urine	3 l		2. Tender coconut water	3 l
3. Cow's milk	2 l	+	3. Banana fruits(poovan)	12 Nos.
4. Cow's curd	1 l			
5. Cow's ghee	100 g			

Panchagavyam can be kept for 2-3 months in earthen pots and should be stirred daily.

Three percent spray of panchagavyam was given at 15 days intervals.

3.4.3 Biofertilizers

AMF (Arbuscular mycorrhizal fungi) and *Azospirillum* sp. were used in the study. Three to five gram AMF was applied beneath each bulb. In the case of *Azospirillum* sp. bulbs were dipped in a slurry made of 500g in 50ml of water for 20 minutes.

3.4.4 Biocontrol agents

Pseudomonas fluorescens and *Trichoderma* sp. were included in the study. Bulbs were treated with a slurry of 250g of Pseudomonas *fluorescens* in 750 ml of water for 20 minutes. Tubers were dipped in a solution of 20g of *Trichoderma* sp. in one litre of water for 20 minutes.

3.5 DESIGN, LAYOUT AND TREATMENTS

3.5.1 Experiment 1

In experiment 1 different combinations of organic manures, biofertilizers and biocontrol agents were used along with chemical fertilizers with N equivalent to 100 kg nitrogen & 30t of FYM and N equivalent to 50 kg nitrogen & 30t of FYM.

No. of treatments - 16

T_1 - Absolute control

T_2 - 100:50:50 kg NPK ha^{-1} + 30 t FYM (as per KAU Package of Practices Recommendations: Crops, 2000)

T_3 - 100:50:50 kg NPK ha^{-1} + poultry manure 22.22 t ha^{-1} (Nitrogen equivalent to 30 t FYM)

T_4 - 100:50:50 kg NPK ha^{-1} + vermicompost 18.75 t ha^{-1} (Nitrogen equivalent to 30 t FYM)

T_5 - 100:50:50 kg NPK ha^{-1} + coirpith compost 85.71 t ha^{-1} (Nitrogen equivalent to 30 t FYM)

T_6 - 100:50:50 kg NPK ha^{-1} + 30 t FYM + AMF (soil application)

T_7 - 100:50:50 kg NPK ha^{-1} + 30 t FYM + *Azospirillum* sp. (Bulb treatment)

T_8 - 100:50:50 kg NPK ha^{-1} + 30 t FYM + AMF + *Azospirillum* sp.

T_9 - 100:50:50 kg NPK ha^{-1} + 30 t FYM + *Pseudomonas fluorescens* (Bulb treatment)

T_{10} - 100:50:50 kg NPK ha^{-1} + 30 t FYM + *Trichoderma* sp. (Bulb treatment)

T_{11} - 50 kg ha^{-1} N + P, K and 30 t FYM + AMF

T_{12} - 50 kg ha^{-1} N + P, K and 30 t FYM + *Azospirillum* sp.

T_{13} - 50 kg ha^{-1} N + P, K and 30 t FYM + AMF + *Azospirillum* sp.

T_{14} - 50 kg ha^{-1} N + P, K+ poultry manure 22.22 t ha^{-1} (Nitrogen equivalent to 30 t of FYM)

T_{15} - 50 kg ha^{-1} N + P, K + vermicompost 18.75 t ha^{-1} (Nitrogen equivalent to 30 t of FYM)

T_{16} - 50 kg ha^{-1} N + P, K + coirpith compost 85.71 t ha^{-1} (Nitrogen equivalent to 30 t FYM)

Half of the quantity of N, full P, K and full quantity of organic manures were given as basal dose. The remaining dose of N was given one month after planting.

Design	- Randomised Block Design (RBD)
No. of replications	- 3
Number plants per plot	- 36
Plot size	- 1.8 m^2
Spacing	- 20 x 25 cm
Variety used	- Prajwal (single)

The layout of the experiment is given in Fig. 1a.

3.5.2 Experiment 2

Experiment 2 was designed to study the effects of organic manures alone on tuberose and the treatment consisted of organic manures with N equivalent to 100 kg N and FYM 30 t ha^{-1}.

No. of treatments : 9

T_1 - Absolute control

T_2 - 100:50:50 kg NPK ha^{-1} + 30 t FYM (POP)

T_3 - FYM : 40 t ha^{-1} (Nitrogen equivalent to 30 t ha^{-1} + 100 kg N ha^{-1})

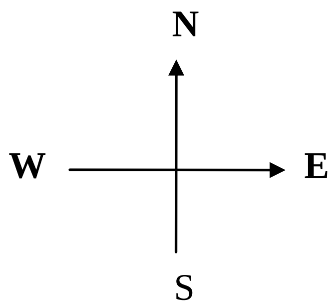
T_4 - Poultry manure : 29.63 t ha $^{-1}$ (Nitrogen equivalent to 30 t ha^{-1} + 100 kg N ha^{-1})

T_5 - Vermi compost : 25.00 t ha^{-1} (Nitrogen equivalent to 30 t ha^{-1} + 100 kg N ha^{-1})

T_6 - Coirpith compost : 114.29 t ha^{-1} Nitrogen equivalent to 30 t ha^{-1} + 100 kg N ha^{-1}

T_7 - Biogas slurry : Total quantity was calculated based on the crop requirement and applied in soil as monthly splits

Fig.1.a Lay out of the experiment 1



R_3 T_9	T_1	T_5	T_7	T_3	T_{13}	T_{16}	T_{12}	T_{11}	T_6	T_2	T_{10}	T_8	T_{14}	T_{15}	T_4
R_2 T_{10}	T_{15}	T_{16}	T_{12}	T_5	T_4	T_{11}	T_{14}	T_3	T_1	T_8	T_6	T_7	T_9	T_{13}	T_2
R_1 T_3	T_{13}	T_9	T_{10}	T_1	T_{16}	T_{12}	T_7	T_{15}	T_2	T_8	T_{11}	T_4	T_6	T_5	T_{14}

No. of treatments : 16
No. of replications : 3

No. of plants per plot : 36
Spacing : 20x25 cm

plot size : 1.2x1.5 m
Design : RBD

T_8 - Vermiwash : Total quantity was calculated based on the crop requirement and applied as equal splits as sprays

T_9 - Panchagavyam sprays

Full quantity of organic manures except biogas slurry, vermiwash and panchagavyam were given as basal

Design : Randomised Block Design (RBD)
No. of replications - 3
Number plants per plot - 36
Plot size - 1.8 m^2
Spacing - 20 x 25 cm
Variety used - Prajwal (single)

Lay out of the experiment 2 is given in Fig. 1b.

3.5.3 Experiment 3

Three promising treatments from experiment 1 and two treatments from experiment 2 were selected for experiment 3.

No. of treatments : 6

T_1 - 100:50:50 kg NPK ha^{-1} + Poultry manure 22.22t ha^{-1} (Nitrogen equivalent to 30 t FYM) (T_3 in experiment1)

T_2 - 50:50:50 kg NPK ha^{-1} + poultry manure 22.22 t ha^{-1} (Nitrogen equivalent to 30 t FYM (T_{14} in experiment 1)

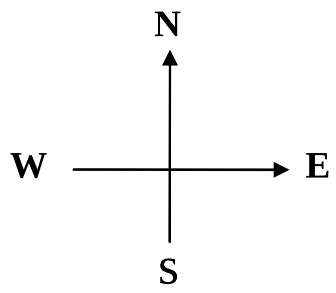
T_3 - 50:50:50 kg NPK ha^{-1} + coirpith compost 85.71 t ha^{-1} (Nitrogen equivalent to 30 t FYM) (T_{16} in experiment1)

T_4 - Poultry manure : 29.63 t ha^{-1} (Nitrogen equivalent to 30 t ha^{-1} + 100 kg N ha^{-1}) (T_4 in experiment2)

T_5 - Biogas slurry : 500 t ha^{-1} (Nitrogen equivalent to 30 t ha^{-1} + 100 kg N ha^{-1}) (T_7 in experiment 2)

T_6 - Absolute control

Fig.1.b Lay out of the experiment 2



R_3 T_1	T_6	T_8	T_5	T_2	T_7	T_4	T_9	T_3
R_2 T_5	T_9	T_3	T_1	T_6	T_2	T_8	T_4	T_7
R_1 T_2	T_7	T_4	T_3	T_8	T_9	T_6	T_1	T_5

No. of treatments : 9 **No. of plants per plot : 36** **Plot size : 1.2x1.5 m**
No. of replications : 3 **Spacing : 20x25 cm** **Design : RBD**

No. of replications : 4

Plot size : 1.8m^2

No. of plant per plot : 36

Spacing : 20 x 25 cm

Varieties used : Prajwal (single type) and Vaibhav (double type

Lay out of the experiment 3 is given in Fig. 1c.

3.6 FERTILIZERS USED

Urea (46 per cent) as nitrogen fertilizer, single superphosphate (18 per cent) as phosphatic fertilizer and muriate of potash (60 per cent) as potassium fertilizer, were used in experiments.

3.7 METHOD OF PLANTING

The selected field was ploughed and leveled. Weeds were removed. Beds of 1.8 m^2 size (1.5x1.2m) and 15 cm height at a distance of 50 cm in between were prepared. Basal treatments were given and tubers were planted on beds at a spacing of 20 x 25 cm.

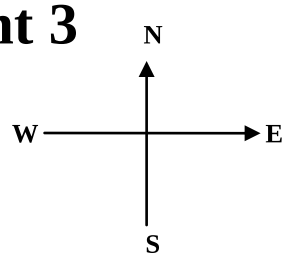
3.8 GENERAL MANAGEMENT

The plants were watered regularly during summer months. Weeding was done manually every month followed by earthing up. No serious pests and diseases were noticed during the experimental period.

3.9 OBSERVATIONS

Observations were recorded for first crop and the first ratoon crop for experiments 1 and 2 and first crop for experiment 3.

Fig.1.c Lay out of the experiment 3



Prajwal

T_2 R1	T_4	T_5	T_6	T_1	T_4
T_5 R2	T_3	T_6	T_2	T_3	T_1
T_6 R3	T_1	T_2	T_5	T_4	T_3
T_4 R4	T_3	T_5	T_6	T_1	T_2

Vaibhav

T_4 R_1	T_3	T_6	T_1	T_2	T_5
T_6 R_2	T_2	T_1	T_5	T_4	T_3
T_2 R_3	T_5	T_3	T_4	T_6	T_1
T_5 R_4	T_3	T_1	T_6	T_2	T_4

No. of treatments : 6
No. of replications : 4

No. of plants per plot : 36
Spacing : 20x25 cm

Plot size : 1.2x1.5 m
Design : RBD

Plate 3. Variety - Prajwal

Plate 4. Variety - Vaibhav

3.9.1 Preharvest studies

3.9.1.1 Vegetative characters

3.9.1.1.1 Percentage of sprouting

Number of tubers sprouted in each plot was recorded and the percentage of sprouting was worked out.

3.9.1.1.2 Plant height

Standing height of the plants from the ground level was measured and recorded in centimeters.

3.9.1.1.3 Plant spread

Spread of the plant in East-West and North-South directions were measured and expressed in centimeters.

3.9.1.1.4 Number of leaves

Total number of leaves present on the plant at the time of each observation was counted and recorded.

3.9.1.1.5 Leaf area

Leaf area was calculated following the method of Krishnan (2003).

LA = 1.5 ± 0.539 x l x b

l = leaf length

b = leaf breath

3.9.1.1.6 Number of tillers per hill

Number of plants produced from the tubers were recorded at monthly intervals.

3.9.1.2 Floral characters

3.9.1.2.1 Days taken for first spike emergence

Number of days taken from planting to the emergence of first spike was observed and noted.

3.9.1.2.2 Days to first floret opening

Time taken for the opening of the first floret in each spike was recorded in days.

3.9.1.2.3 Days to complete opening of the florets in a spike

Number of days taken for the complete opening of the florets of each spike in the field was observed.

3.9.1.2.4 Length and girth of spike

Length and girth of each spike was measured from the base and was expressed in centimeters.

3.9.1.2.5 Length of rachis

Length of rachis of each spike was recorded in centimeters.

3.9.1.2.6 Number of florets per spike

Total number of florets in each spike was observed.

3.9.1.2.7 Size of florets

The Diameter of each floret in a spike was measured and recorded in centimeters.

3.9.1.2.8 Longevity of floret

Longevity of floret in the field was noted and expressed in days.

3.9.1.2.9 Longevity of spike in the field

Number of days taken for 50 per cent of the florets to wilt in each spike was noted.

3.9.1.2.10 Duration of crop

Number of days taken for the wilting of first flower to the wilting of last flower in each plot was counted and recorded.

3.9.1.2.11 Yield of spikes per hill

Yield of spikes from each hill was noted and worked out as number of spikes per hill.

3.9.2 Postharvest studies

3.9.2.1 Yield of bulbs and bulblet

3.9.2.1.1 Size of bulbs and bulblets

Length and diameter of each bulb and bulblets in a hill were recorded in centimeters.

3.9.2.1.2 Number of bulbs and bulblets

Number of bulbs and bulblets from each hill was counted and recorded.

3.9.2.1.3 Weight of bulbs and bulblets

Weight of bulbs and bulblets in a hill was recorded in grams.

3.9.2.2 Post harvest spike characters

Spikes were harvested by cutting 15 cm from the base of the spike at the commercial stage of harvest, i.e., when the first pair of florets fully opened and were kept in vases with measured quantity of water and the following observations were taken.

3.9.2.2.1 Fresh weight of spike

Fresh weight of the spike was recorded in grams.

3.9.2.2.2 Days taken for opening of each floret

Number of days taken for opening of each floret in a spike was noted.

3.9.2.2.3 Number of florets opened at a time

Number of florets opened for a day were recorded.

3.9.2.2.4 Water uptake

The water uptake of each spike was noted by finding out the difference between initial water level and water level at 50 per cent wilt of florets in the spike and expressed in milliliters.

3.9.2.2.5 Vase life

Vase life of each spike was noted as number of days taken for 50 per cent of wilting of florets in each spike and recorded as number of days.

3.9.2.2.6 Geotropic bending of the spike

Geotropic bending of the spike was observed visually and recorded.

3.10 BENEFIT-COST RATIOS

Benefit- cost ratio of each treatment was worked out as follows,

$$\frac{\text{Gross return --------Net return}}{\text{Total cost of cultivation}}$$

3.11 CHEMICAL ANALYSIS

3.11.1 Soil analysis

Soil samples were collected before and after the conduct of each field experiment. The samples were chemically analysed to estimate the status of organic carbon, N, P and K using the following methods.

Table.1 Methods followed for soil analysis

Sl. No.	Nutrient estimated	Method followed	Reference
1	Organic Carbon (%)	Walkley and Black's rapidtitration method	Jackson (1958)
2	Available N (kg ha-1)	Alkaline permanganate method	Subbiah and Asija, (1956)
3	Available P (kg ha^{-1})	Bray-1 Extractant Ascorbic acid reductant method	Jackson (1958)
4	Available K (kg ha-1)	Neutral normal ammonium acetate extract using flame photometer	Jackson (1958)
5	pH	1:2.5 soil water ratio	Jackson (1958)

3.11.2 Estimation of nutrient content in plant

Representative samples of leaves and tubers were taken from each treatment at every month, up to the flowering stage, they were oven dried at 80^0C, powdered and chemically analysed for N, P and K using following methods.

Table 2. Methods followed for plant nutrient analysis

Sl. No	Nutrient estimated	Methods followed
1	Nitrogen (%)	Microkjeldhal distillation method
2	Phosphorous (%)	Vanadomolybdophosphoric yellow colour method using Spectronic 20
3	Potassium (%)	Diacid extract using flame photometer

Diacid extract was prepared by digesting plant samples with 9:4 mixture of nitric acid and perchloric acid (Wilde *et al.*, 1972).

3.11.3 Estimation of concrete content of flowers

The percentage of concrete obtained from the flowers of each treatment was estimated for Experiment 3.

Flowers just started to open were collected during morning (Guenther, 1952). Green perianth parts attached to corolla were removed and flowers were made into small pieces. Samples of 100g weight were taken and subjected to solvent extraction using food grade hexane with a boiling point of 60-70°C using soxhlet apparatus.

The extraction period was standardized as 3 hours. The solvent was recycled through the flower sample in soxhlet apparatus. A small portion of the sample was taken out and pressed on a filter paper at an interval of extraction. Recycling was continued till there is no oily tinge while pressing with filter paper. After extraction, the oil solvent mixture was taken in a pre weighed beaker. Then the solvent was distilled over a water bath. The semi solid waxy material obtained after the evaporation of solvent is the concrete. Then the final weight of the beaker with this concrete was taken. Weight of the concrete was calculated gravimetrically and expressed as percentage.

3.12 STATISTICAL ANALYSIS

Data were statistically analysed using the MSTAT C package. Treatment means were compared using DMRT.

Results

4. RESULTS

An experiment was carried out at the Department of Pomology and Floriculture, College of Horticulture, Vellanikkara during 2004-2007 to examine the response of tuberose (*Polianthes tuberosa* L.) to organic manures and growth promoting micro organisms. The study consisted of three experiments. Observations were recorded for main crop and first ratoon crop in Experiment 1 and 2. Third experiment was conducted with the five best selected treatments (three treatments from Experiment 1 and two from Experiment 2) along with the control using two varieties of tuberose (single type Prajwal and double type Vaibhav). The results of the experiments are presented below.

4.1 PLANT AND RATOON CROP OF EXPERIMENT I

4.1.1 Vegetative characters

The data related to the variation in vegetative characters as influenced by different treatments are presented in the Table 3 to 12. In the case of percentage of germination, plants in all the treatments showed cent per cent germination during plant and ratoon crop.

4.1.1.1 Plant height

Regarding the plant height, significant variation was observed among the treatments during the course of growth (Table 3). T_3 (100:50:50 kg NPK ha^{-1} + poultry manure 22.22 t ha^{-1}) and T_{14} (50 kg ha^{-1} N + P, K+ poultry manure 22.22 t ha^{-1}) were statistically superior in terms of plant height through out the growth period. Though T_{14} exhibited maximum plant height during initial period, T_3 recorded maximum value towards the end (48.17 and 54.58 cm). In ratoon crop T_3 recorded maximum plant height from second month onwards, closely followed by T_{14} (Table 4).

In general, T_3 and T_{14} exhibited significantly superior plant height through out the crop growth during plant as well as ratoon crop.

Table 3. Effect of organic manures and growth promoting microorganisms along with inorganic fertilizers on plant height (cm) – main crop

Treatment	Months of observation										
	1	2	3	4	5	6	7	8	9	10	11
T_1	17.73 ^{c}	19.93 ^{b}	25.47 ^{b}	27.77 ^{bc}	23.63 ^{abc}	19.33 ^{ab}	22.33^{abc}	24.37 ^{b}	29.08 ^{c}	33.83^{cde}	39.75^{bc}
T_2	21.02 ^{abc}	23.93 ^{ab}	28.49 ^{ab}	31.77 ^{abc}	27.02 ^{a}	22.60 ^{ab}	24.17 ^{abc}	27.23 ^{b}	31.37 ^{bc}	35.50 ^{cde}	37.17 ^{bc}
T_3	20.87 ^{abc}	24.57 ^{ab}	30.10 ^{ab}	34.10 ^{abc}	29.45 ^{a}	25.00 ^{a}	25.10 ^{ab}	27.27 ^{b}	37.72 ^{a}	48.17 ^{a}	54.58 ^{a}
T_4	19.22 ^{bc}	22.90 ^{ab}	26.25 ^{ab}	31.00 ^{bc}	27.25 ^{a}	21.67 ^{ab}	23.05 ^{abc}	26.15 ^{b}	29.78 ^{c}	39.92 ^{bc}	44.25 ^{bc}
T_5	19.16 ^{bc}	20.35 ^{ab}	25.02 ^{b}	27.27 ^{bc}	24.50 ^{ab}	22.27 ^{ab}	20.93 ^{bc}	27.79 ^{b}	30.73 ^{bc}	33.67 ^{bc}	37.67 ^{bc}
T_6	18.98 ^{bc}	20.20 ^{ab}	25.79 ^{b}	27.80 ^{abc}	24.33 ^{ab}	20.37 ^{ab}	24.30 ^{bc}	28.33 ^{ab}	31.29 ^{bc}	34.25 ^{cde}	37.00 ^{bc}
T_7	25.50 ^{bc}	22.62 ^{ab}	26.89 ^{b}	30.10 ^{abc}	25.17 ^{ab}	20.80 ^{ab}	25.32 ^{ab}	27.03 ^{b}	29.77 ^{c}	32.17 ^{e}	35.17 ^{bc}
T_8	19.37 ^{c}	18.97 ^{b}	27.87 ^{b}	31.06 ^{abc}	19.53 ^{bcd}	20.30 ^{ab}	24.23 ^{bc}	23.82 ^{b}	29.07 ^{c}	32.83 ^{de}	34.33 ^{c}
T_9	18.17 ^{c}	21.15 ^{ab}	25.57 ^{b}	28.67 ^{abc}	16.48 ^{d}	20.20 ^{ab}	23.50 ^{abc}	24.97 ^{b}	28.73 ^{c}	32.50 ^{e}	37.50 ^{bc}
T_{10}	17.09 ^{c}	21.75 ^{ab}	26.62 ^{b}	25.53 ^{c}	17.17 ^{cd}	20.36 ^{ab}	20.78 ^{bc}	25.37 ^{b}	29.18 ^{c}	33.00 ^{de}	35.42 ^{bc}
T_{11}	18.77 ^{bc}	20.30 ^{ab}	25.55 ^{b}	26.90 ^{bc}	16.50 ^{d}	19.40 ^{ab}	20.58 ^{bc}	25.80 ^{b}	30.87 ^{bc}	35.83 ^{cde}	37.25 ^{bc}
T_{12}	20.00 ^{bc}	19.30 ^{b}	25.69 ^{b}	27.60 ^{bc}	17.00 ^{cd}	18.30 ^{b}	19.30 ^{c}	24.94 ^{b}	29.35 ^{c}	33.67 ^{cde}	35.92 ^{bc}
T_{13}	19.40 ^{bc}	20.83 ^{ab}	27.70 ^{b}	27.50 ^{bc}	18.92 ^{bcd}	21.26 ^{ab}	25.95 ^{ab}	28.82 ^{ab}	34.49 ^{ab}	39.50 ^{bcd}	43.17 ^{bc}
T_{14}	24.54 ^{ab}	26.43 ^{a}	35.42 ^{a}	37.50 ^{a}	23.02^{abcd}	23.80 ^{ab}	26.40 ^{ab}	33.52 ^{a}	37.90 ^{a}	42.33 ^{b}	44.58 ^{b}
T_{15}	17.08 ^{c}	23.13 ^{ab}	29.47 ^{ab}	35.90 ^{ab}	19.27 ^{bcd}	21.60 ^{ab}	26.90 ^{a}	28.50 ^{ab}	33.17 ^{bc}	39.33 ^{bcd}	41.58 ^{bc}
T_{16}	20.97 ^{abc}	20.97 ^{ab}	25.80 ^{b}	27.37 ^{bc}	19.83 ^{bcd}	20.50 ^{ab}	23.02 ^{abc}	24.87 ^{b}	30.88 ^{bc}	36.75^{bcde}	40.67 ^{bc}

Treatments means having similar alphabets in superscript, do not differ significantly

Table 4. Effect of organic manures and growth promoting microorganisms along with inorganic fertilizers on plant height (cm) – ratoon crop

Treatment	Months of observation				
	1	2	3	4	5
T_1	14.58 ^{e}	25.28 ^{ef}	31.17 ^{bcd}	34.67 ^{cd}	33.50 ^{g}
T_2	24.62 ^{ab}	23.08 ^{f}	32.50 ^{bcd}	35.17 ^{cd}	37.83 ^{defg}
T_3	20.13 ^{bcde}	36.55 ^{a}	42.17 ^{a}	47.50 ^{a}	57.33 ^{a}
T_4	17.84 ^{cde}	24.89 ^{ef}	26.50 ^{ef}	28.33 ^{e}	34.58 ^{fg}
T_5	26.44 ^{a}	30.03 ^{bcd}	35.50 ^{b}	38.67 ^{c}	43.33 ^{bc}
T_6	16.79 ^{de}	19.62 ^{g}	24.00 ^{f}	28.33 ^{e}	34.08 ^{g}
T_7	22.85 ^{abcd}	27.05 ^{de}	29.17 ^{cde}	37.00 ^{cd}	43.00 ^{bcd}
T_8	16.76 ^{de}	22.75 ^{f}	28.08 ^{def}	33.00 ^{de}	36.67 ^{efg}
T_9	17.96 ^{cde}	29.89 ^{bcd}	32.33 ^{bcd}	36.67 ^{cd}	39.92 ^{cdef}
T_{10}	23.44 ^{bc}	28.92 ^{bcd}	33.17 ^{bc}	35.83 ^{cd}	39.67 ^{cdef}
T_{11}	17.87 ^{cde}	23.25 ^{f}	25.50 ^{ef}	36.50 ^{cd}	38.00 ^{defg}
T_{12}	21.15 ^{abcd}	26.75 ^{de}	28.17 ^{def}	35.83 ^{cd}	38.67 ^{cdefg}
T_{13}	16.75 ^{de}	27.81 ^{cde}	28.61 ^{cde}	31.60 ^{de}	35.58 ^{fg}
T_{14}	18.88 ^{bcde}	30.55 ^{bc}	39.67 ^{a}	44.17 ^{ab}	45.17 ^{b}
T_{15}	16.85 ^{de}	31.58 ^{b}	33.17 ^{bc}	35.00 ^{cd}	41.83 ^{bcde}
T_{16}	24.05 ^{ab}	29.17 ^{bcd}	31.67 ^{bcd}	40.00 ^{bc}	38.75 ^{cdef}

Treatments means having similar alphabets in superscript, do not differ significantly

4.1.1.2 Plant spread

Monthly variation in plant spread is presented in Table 5. No consistent pattern of variation was observed regarding the plant spread during the growth period. However, superiority of T_3 (100:50:50 kg NPK ha^{-1} + poultry manure 22.22 t ha^{-1}) in initial four months (18.32, 27.2, 29.03, 33.06 and 23.83 cm) and T_{14} (50 kg ha^{-1} N + P, K+ poultry manure 22.22 t ha^{-1}) towards the final months was noted in the case of spread in North South direction. Regarding the plant spread in East-West direction, even though there was no consistent pattern, superiority of T_3 was clear from the observation.

In the case of ratoon crop the treatment T_3 recorded maximum plant spread in both direction, throughout the growth period followed by the treatment T_{14} (Table 6).

In general, regarding the spread in both direction, T_3 was statistically superior followed by T_{14} both in plant and ratoon crop.

4.1.1.3 Number of leaves

There was significant variation in number of leaves during the growth period (Table 7). Leaf number increased progressively during the course of growth. From second to fourth month T_{14} recorded maximum number of leaves (15.52, 17.77 and 26.3). During subsequent months T_3 was superior in terms of this parameter.

For ratoon crop also number of leaves were maximum in treatment T_3, followed by T_{12} (50 kg ha^{-1} N + P, K and 30 t FYM + *Azospirillum* sp.) and T_{14} and minimum number of leaves were observed in T_1 (absolute control) during the growing season (Table 8).

Generally, T_3 and T_{14} exhibited superior effect in terms of number of leaves during crop growth.

Table 5. Effect of organic manures and growth promoting microorganisms along with inorganic fertilizers on plant spread (cm) – main crop

Treatments	Months of observation											
	1		2		3		4		5		6	
	NS	EW	NS	EW	NS	EW	NS	EW	NS	EW	NS	EW
T_1	14.94^{ab}	14.27^{abc}	20.57^{bcd}	20.47^{abc}	20.77^{bcde}	21.87^{abcd}	23.53^{bcde}	22.73^{cde}	18.00^{bc}	17.50^{cdef}	11.37^{b}	12.93^{a}
T_2	11.93^{b}	19.72^{a}	21.45^{bc}	19.38^{abcd}	24.82^{abc}	24.97^{abc}	27.37^{bc}	27.73^{bcd}	19.17^{abc}	24.17^{abcd}	12.50^{b}	14.33^{a}
T_3	18.32^{a}	15.40^{abc}	27.23^{a}	24.88^{a}	29.03^{a}	28.53^{a}	33.60^{a}	34.43^{a}	23.83^{a}	24.50^{ab}	15.00^{ab}	17.97^{a}
T_4	11.03^{b}	10.63^{c}	20.38^{bcd}	19.43^{abcd}	22.99^{abcd}	23.13^{abcd}	24.47^{bcde}	23.93^{bcde}	20.33^{abc}	19.67^{bcdef}	15.00^{ab}	15.33^{a}
T_5	12.77^{ab}	14.10^{abc}	21.35^{bc}	21.13^{abc}	14.13^{e}	15.23^{d}	20.03^{de}	17.87^{e}	16.50^{c}	15.40^{ef}	13.27^{ab}	15.13^{a}
T_6	14.23^{ab}	17.20^{abc}	15.87^{cd}	14.37^{de}	23.47^{abcd}	21.93^{abcd}	23.63^{bcde}	25.77^{bcd}	21.32^{abc}	22.17^{bcde}	14.70^{ab}	13.13^{a}
T_7	16.90^{ab}	17.20^{abc}	21.83^{abc}	24.83^{a}	26.37^{ab}	26.82^{ab}	29.17^{bc}	30.13^{ab}	21.92^{abc}	21.67^{bcdef}	15.20^{ab}	14.23^{a}
T_8	11.92^{b}	11.73^{bc}	16.97^{bcd}	18.93^{abcd}	19.65^{abcde}	20.30^{bcd}	21.60^{cde}	22.50^{cde}	16.58^{c}	20.50^{bcdef}	13.53^{ab}	15.37^{a}
T_9	12.97^{ab}	15.32^{abc}	18.90^{bcd}	15.71^{cde}	16.39^{de}	18.09^{cd}	19.73^{de}	21.80^{de}	18.75^{abc}	17.33^{def}	14.03^{ab}	14.00^{a}
T_{10}	16.55^{ab}	16.07^{abc}	14.60^{d}	12.70^{e}	19.55^{bcde}	18.09^{cd}	20.70^{cde}	22.40^{cde}	19.50^{abc}	18.50^{bcdef}	13.00^{ab}	15.70^{a}
T_{11}	11.63^{b}	11.93^{bc}	17.43^{bcd}	17.30^{cde}	18.47^{cde}	22.05^{abcd}	24.53^{bcde}	25.37^{bcd}	20.37^{abc}	20.00^{bcdef}	14.87^{ab}	15.60^{a}
T_{12}	15.69^{ab}	13.30^{abc}	21.79^{abc}	23.80^{ab}	24.70^{abc}	23.02^{abcd}	26.30^{bcde}	23.80^{bcde}	20.50^{abc}	19.17^{bcdef}	15.40^{ab}	15.46^{a}
T_{13}	15.57^{ab}	13.32^{abc}	21.41^{bc}	16.83^{cde}	18.47^{cde}	15.23^{d}	21.77^{cde}	17.03^{e}	16.50^{c}	15.15^{f}	14.40^{ab}	14.20^{a}
T_{14}	13.70^{ab}	17.47^{ab}	22.32^{ab}	20.70^{abc}	23.05^{abcd}	26.27^{ab}	28.43^{ab}	25.30^{bcd}	23.33^{ab}	24.33^{abc}	18.60^{a}	19.03^{a}
T_{15}	11.57^{b}	11.35^{b}	16.38^{bcd}	16.10^{cde}	22.49^{abcd}	27.03^{ab}	26.56^{bcd}	29.23^{abc}	22.83^{ab}	28.92^{a}	13.53^{ab}	14.33^{a}
T_{16}	15.93^{ab}	13.00^{bc}	16.93^{bcd}	18.72^{bcd}	19.32^{bcde}	20.80^{abcd}	21.80^{cde}	23.13^{bcde}	19.83^{abc}	22.33^{bcde}	16.70^{ab}	18.83^{a}

Treatments means having similar alphabets in superscript, do not differ significantly

Table 5. continued

Treatments	Months of observation									
	7		8		9		10		11	
	NS	EW	NS	EW	NS	EW	NS	EW	NS	EW
T_1	16.87^{cde}	17.54^{de}	25.05^{de}	22.70^{cd}	26.18^{d}	25.32^{e}	27.17^{d}	27.67^{c}	42.17^{abc}	29.33^{c}
T_2	17.80^{cde}	20.10^{bcde}	27.37^{bcde}	25.22^{abcd}	29.52^{cd}	28.08^{bcde}	31.67^{bcd}	31.00^{bc}	33.83^{bc}	34.33^{bc}
T_3	20.83^{abcd}	23.07^{abc}	30.37^{abcd}	28.92^{abc}	39.77^{b}	36.93^{a}	49.00^{a}	48.17^{a}	45.00^{ab}	51.67^{a}
T_4	24.29^{ab}	24.14^{ab}	31.73^{abc}	29.13^{ab}	35.37^{bc}	33.02^{abc}	39.00^{abcd}	36.50^{abc}	40.83^{abc}	39.83^{abc}
T_5	20.67^{bcd}	20.52^{bcde}	28.37^{bcde}	29.14^{ab}	34.18^{bcd}	34.02^{abc}	40.00^{abc}	36.73^{abc}	39.67^{abc}	41.08^{abc}
T_6	15.60^{de}	20.80^{bcde}	27.92^{bcde}	26.89^{abc}	28.96^{cd}	30.36^{abcde}	30.00^{cd}	34.17^{bc}	36.42^{abc}	32.83^{c}
T_7	18.73^{bcde}	19.82^{bcde}	25.87^{cde}	26.20^{abcd}	27.67^{cd}	27.19^{cde}	29.33^{cd}	29.17^{c}	36.08^{bc}	31.17^{c}
T_8	26.47^{a}	26.27^{a}	32.22^{ab}	31.13^{a}	33.36^{bcd}	32.65^{abcd}	34.50^{bcd}	34.17^{bc}	38.67^{abc}	34.50^{bc}
T_9	18.22^{cde}	17.83^{de}	28.00^{bcde}	24.80^{abcd}	31.00^{cd}	25.78^{de}	34.03^{bcd}	26.50^{c}	32.00^{bc}	33.67^{bc}
T_{10}	14.45^{e}	18.75^{cde}	22.73^{e}	20.45^{d}	28.44^{cd}	26.88^{cde}	34.17^{bcd}	35.00^{bc}	36.50^{abc}	36.58^{bc}
T_{11}	15.67^{de}	16.13^{e}	27.93^{bcde}	28.03^{abc}	31.13^{bcd}	29.27^{bcde}	34.33^{bcd}	30.50^{bc}	35.33^{bc}	34.00^{bc}
T_{12}	17.52^{cde}	17.12^{de}	25.25^{de}	25.20^{abcd}	28.20^{bcd}	31.85^{abcde}	31.17^{bcd}	38.50^{abc}	41.33^{abc}	34.58^{bc}
T_{13}	18.43^{cde}	19.22^{bcde}	27.07^{bcde}	26.17^{abcd}	27.00^{bcd}	27.13^{cde}	37.83^{abcd}	28.00^{c}	30.67^{c}	40.50^{abc}
T_{14}	21.70^{abc}	21.83^{abcd}	35.64^{a}	24.23^{bcd}	35.17^{bc}	35.27^{ab}	43.00^{ab}	43.00^{ab}	49.75^{a}	47.67^{ab}
T_{15}	21.87^{abc}	23.73^{abc}	27.47^{bcde}	27.50^{abc}	32.00^{bcd}	30.50^{abcde}	36.17^{bcd}	35.17^{bc}	41.75^{abc}	34.08^{bc}
T_{16}	18.17^{cde}	19.90^{bcde}	29.17^{bcd}	23.90^{bcd}	47.60^{a}	33.15^{abc}	37.17^{bcd}	34.50^{bc}	40.15^{abc}	40.92^{ab}

Treatments means having similar alphabets in superscript, do not differ significantly

Table 6. Effect of organic manures and growth promoting microorganisms

Treatment	Months of observation									
	1		2		3		4		5	
	NS	EW	NS	EW	NS	EW	NS	EW	NS	EW
T_{1}	47.50^{bcd}	20.50^{cd}	31.33^{bcd}	30.67^{def}	34.83^{cd}	36.83^{cde}	39.33^{cde}	44.17^{bcd}	47.50^{bc}	46.00^{cde}
T_{2}	47.14^{bcd}	22.68^{abcd}	27.50^{cdef}	29.67^{defg}	36.83^{bc}	33.67^{ef}	46.17^{b}	41.33^{def}	47.17^{bc}	47.50^{cd}
T_{3}	61.83^{a}	27.35^{a}	37.33^{a}	52.50^{a}	49.83^{a}	57.67^{a}	53.50^{a}	61.00^{a}	61.83^{a}	65.00^{a}
T_{4}	41.00^{cd}	22.71^{abcd}	28.22^{cdef}	35.33^{bcd}	31.83^{cde}	40.50^{bcd}	34.00^{f}	45.00^{bcd}	41.00^{cde}	45.00^{cde}
T_{5}	44.17^{bcd}	25.97^{a}	35.27^{ab}	39.83^{b}	39.67^{b}	44.83^{b}	41.67^{c}	47.17^{bc}	44.17^{cde}	41.83^{de}
T_{6}	41.83^{cd}	22.45^{abcd}	23.77^{f}	24.63^{g}	32.43^{cde}	30.33^{f}	34.50^{def}	36.67^{efg}	41.83^{cde}	41.50^{de}
T_{7}	51.33^{ab}	20.88^{bcd}	25.60^{ef}	27.11^{fg}	32.33^{cde}	31.08^{ef}	36.83^{cdef}	34.50^{g}	51.33^{b}	44.67^{cde}
T_{8}	38.33^{cd}	20.49^{cd}	26.48^{cdef}	30.72^{def}	32.00^{cde}	35.22^{def}	34.17^{ef}	37.33^{efg}	38.33^{de}	41.83^{de}
T_{9}	44.17^{bcd}	22.39^{abcd}	27.33^{cdef}	29.67^{efg}	32.00^{cde}	32.83^{ef}	35.33^{def}	36.50^{fg}	44.17^{cde}	48.83^{c}
T_{10}	44.33^{bcd}	19.64^{d}	30.78^{bcde}	31.33^{def}	33.67^{cde}	35.02^{def}	39.50^{cd}	37.83^{efg}	44.33^{cde}	42.00^{de}
T_{11}	46.33^{bcd}	20.58^{cd}	35.00^{ab}	34.33^{cde}	36.50^{bc}	35.17^{def}	41.00^{c}	40.50^{defg}	46.33^{bc}	44.00^{cde}
T_{12}	43.83^{bcd}	26.53^{a}	28.17^{cdef}	30.67^{def}	33.17^{cde}	32.67^{ef}	37.67^{cdef}	39.33^{defg}	43.83^{cdef}	40.50^{e}
T_{13}	38.00^{cd}	22.75^{abcd}	26.05^{cdef}	28.78^{efg}	28.78^{e}	32.17^{ef}	34.67^{def}	37.08^{efg}	38.00^{e}	40.75^{de}
T_{14}	58.33^{a}	25.85^{ab}	31.83^{bc}	39.17^{bc}	40.83^{b}	41.83^{bc}	48.50^{b}	48.67^{b}	58.33^{a}	58.17^{b}
T_{15}	44.67^{bcd}	19.77^{d}	26.33^{cdef}	37.17^{bc}	30.00^{de}	40.67^{bcd}	36.83^{cdef}	42.67^{cde}	44.67^{cd}	43.50^{cde}
T_{16}	41.83^{cd}	25.42^{abc}	27.50^{cdef}	31.17^{def}	28.83^{e}	31.83^{ef}	36.67^{cdef}	35.17^{g}	41.83^{cde}	42.33^{cde}

Treatments means having similar alphabets in superscript, do not differ significantly

Table 7. Effect of organic manures and growth promoting microorganisms along with inorganic fertilizers on number of leaves – main crop

Treatment	Months of observation										
	1	2	3	4	5	6	7	8	9	10	11
T_{1}	6.13^{bcd}	9.2^{cd}	13.82^{abcd}	17.57^{bcd}	19.08^{abcd}	15.10^{b}	23.27^{bcd}	27.93^{de}	33.83^{bc}	36.83^{c}	61.67^{b}
T_{2}	7.87^{abcd}	12.77^{abc}	14.13^{abcd}	18.77^{abcd}	18.00^{abc}	14.87^{b}	19.72^{cdef}	33.20^{cde}	35.50^{bc}	44.60^{c}	61.67^{b}
T_{3}	8.26^{abc}	14.8^{ab}	16.27^{abc}	20.60^{abc}	25.33^{a}	29.00^{a}	32.32^{a}	61.87^{a}	48.17^{a}	90.60^{a}	103.83^{a}
T_{4}	7.30^{bcd}	9.63^{cd}	13.44^{abcd}	16.33^{bcd}	15.00^{c}	13.97^{b}	23.68^{bcd}	34.03^{cd}	39.92^{bc}	39.25^{c}	51.17^{b}
T_{5}	5.80^{cd}	11.47^{abcd}	10.63^{cd}	16.77^{bcd}	16.00^{bc}	14.80^{b}	27.83^{abc}	30.00^{de}	33.67^{bc}	40.40^{c}	56.50^{b}
T_{6}	7.07^{bcd}	12.87^{abc}	11.80^{bcd}	12.43^{d}	12.17^{c}	12.80^{b}	15.00^{ef}	27.47^{de}	34.25^{bc}	42.02^{c}	58.50^{b}
T_{7}	7.27^{bcd}	12.71^{abc}	13.57^{abcd}	19.50^{abcd}	17.83^{abc}	17.17^{b}	22.13^{bcdef}	33.47^{cde}	32.17^{bc}	41.07^{c}	55.67^{b}
T_{8}	6.90^{bcd}	10.15^{cd}	12.02^{bcd}	16.50^{bcd}	19.50^{abc}	15.97^{b}	23.17^{bcde}	28.57^{de}	32.83^{bc}	37.10^{c}	55.83^{b}
T_{9}	5.57^{cd}	9.53^{cd}	10.30^{cd}	12.77^{cd}	12.50^{c}	13.40^{b}	19.75^{cdef}	30.30^{de}	32.50^{bc}	37.82^{c}	49.17^{b}
T_{10}	5.07^{d}	8.30^{cd}	9.33^{d}	15.23^{bcd}	14.00^{c}	14.00^{b}	14.00^{f}	19.97^{e}	33.00^{c}	30.57^{c}	45.83^{b}
T_{11}	6.10^{bcd}	9.59^{cd}	13.77^{abcd}	15.77^{bcd}	14.33^{c}	13.97^{b}	18.15^{def}	27.60^{de}	35.83^{bc}	35.42^{c}	51.67^{b}
T_{12}	7.63^{abcd}	11.73^{abcd}	19.32^{ab}	22.43^{ab}	19.67^{abc}	16.27^{b}	21.00^{bcdef}	29.67^{de}	33.67^{bc}	44.25^{c}	68.83^{b}
T_{13}	8.73^{ab}	10.97^{bcd}	13.55^{abcd}	18.87^{abcd}	18.00^{abc}	17.47^{b}	25.63^{abcd}	44.75^{bc}	39.50^{bc}	43.25^{c}	59.83^{b}
T_{14}	6.77^{bcd}	15.52^{a}	17.77^{ab}	26.30^{a}	22.67^{ab}	28.37^{b}	25.31^{abcd}	55.73^{ab}	42.33^{a}	72.72^{b}	99.17^{a}
T_{15}	5.50^{cd}	7.8^{d}	9.85^{cd}	13.30^{cd}	13.00^{c}	13.93^{b}	28.37^{ab}	31.63^{de}	39.33^{bc}	65.07^{b}	59.00^{b}
T_{16}	9.99^{a}	9.99^{cd}	11.13^{bcd}	19.77^{abcd}	19.67^{abc}	20.20^{b}	22.05^{bcdef}	32.05^{cde}	36.75^{b}	47.60^{c}	71.83^{b}

Treatments means having similar alphabets in superscript, do not differ significantly

Table 8. Effect of organic manures and growth promoting microorganisms along with inorganic fertilizers on number of leaves – ratoon crop

Treatment	Months of observation				
	1	2	3	4	5
T_1	18.64^{ij}	16.50^{f}	23.60^{g}	28.83^{g}	31.00^{e}
T_2	29.59^{de}	37.60^{bc}	41.42^{c}	45.17^{c}	37.17^{de}
T_3	46.67^{a}	51.33^{a}	61.50^{a}	65.33^{a}	99.67^{a}
T_4	21.13^{chij}	29.17^{de}	33.50^{def}	36.17^{ef}	53.50^{cd}
T_5	28.63^{cdef}	23.50^{e}	34.58^{def}	35.75^{ef}	51.67^{cde}
T_6	19.21^{hij}	32.22^{cd}	33.67^{def}	35.83^{ef}	49.83^{cde}
T_7	33.96^{cd}	29.95^{de}	32.17^{ef}	35.67^{ef}	47.50^{cde}
T_8	25.89^{efg}	34.33^{bcd}	38.50^{cde}	42.00^{cde}	47.83^{cde}
T_9	17.54^{ij}	27.89^{de}	29.17^{fg}	31.33^{fg}	38.50^{de}
T_{10}	15.83^{j}	40.67^{b}	42.67^{c}	47.00^{c}	45.50^{cde}
T_{11}	23.00^{fghi}	34.06^{bcd}	36.17^{cde}	37.50^{def}	48.67^{cde}
T_{12}	24.71^{efgh}	55.67^{a}	59.50^{ab}	63.33^{a}	61.67^{bc}
T_{13}	27.21^{ef}	38.00^{bc}	39.17^{cd}	42.00^{cde}	45.83^{cde}
T_{14}	40.53^{b}	51.50^{a}	54.50^{b}	57.33^{b}	75.50^{b}
T_{15}	19.13^{hij}	40.50^{b}	41.67^{c}	43.33^{cd}	51.00^{cde}
T_{16}	35.52^{bc}	32.33^{cd}	34.67^{def}	38.67^{de}	48.83^{cde}

Treatments means having similar alphabets in superscript, do not differ significantly

4.1.1.4 Leaf area

During initial months T_3 recorded maximum leaf area (181.5 and 622.3 cm^2) whereas in subsequent months T_{14} registered significantly higher leaf area and towards the final stage T_3 was superior in terms of this parameter (4367cm^2). When average performance is considered, leaf area was maximum in T_3, followed by T_{14} (50 kg ha^{-1} N + P, K+ poultry manure 22.22 t ha^{-1}) and T_{16} (50 kg ha^{-1} N + P, K + coirpith compost 85.71 t ha^{-1}).

For all the treatments except T_3 and T_{16} there was a reduction in leaf area during sixth month of observation (Table 9).

In ratoon crop, the treatment T_3 recorded maximum leaf area followed by T_{14} almost throughout the season (Table 10).

4.1.1.5 Number of tillers per hill

No consistent pattern of treatment effects on number of tillers could be observed. However, towards the final stage of observation, T_3 was superior followed by T_{12} (50 kg ha^{-1} N + P, K and 30 t FYM + *Azospirillum* sp.), T_8 (100:50:50 kg NPK ha^{-1} + 30 t FYM + AMF + *Azospirillum* sp.) and T_{14} (Table 11).

In ratoon crop, maximum number of tillers per hill were observed in T_3 followed by T_{14} and T_{12} throughout the growth period (Table 12).

In general, for all the treatments, a progressive increase in number of tillers per hill, during the course of growth could be observed.

4.1.2 Floral characters

Data pertaining to variation in floral characters are presented in Table 13 (main crop) and Table 14 (ratoon crop).

Table 9. Effect of organic manures and growth promoting microorganisms along with inorganic fertilizers on leaf area (cm^2) – main crop

Treatment	Months of observation										
	1	2	3	4	5	6	7	8	9	10	11
T_1	78.41^{ab}	181.10^{c}	234.40^{bcd}	305.80^{bc}	401.00^{ab}	197.90^{c}	508.00^{abc}	715.60^{c}	1033.00^{c}	1337.00^{d}	1918.00^{cd}
T_2	127.40^{ab}	279.80^{c}	260.90^{bcd}	400.00^{ab}	406.20^{ab}	208.10^{bc}	386.30^{bc}	736.20^{c}	1535.00^{bc}	2245.00^{bcd}	2351.00^{bcd}
T_3	181.50^{a}	622.30^{a}	379.10^{abc}	396.60^{ab}	464.90^{ab}	530.00^{a}	949.20^{a}	2410.00^{a}	3167.00^{a}	3396.00^{a}	4376.00^{a}
T_4	120.30^{ab}	172.70^{c}	227.80^{bcd}	311.20^{bc}	319.40^{b}	250.30^{abc}	637.20^{abc}	1159.00^{bc}	1300.00^{bc}	1547.00^{cd}	1935.00^{cd}
T_5	89.91^{ab}	224.90^{c}	204.70^{cd}	383.80^{abc}	416.80^{ab}	297.40^{abc}	674.90^{abc}	719.70^{c}	1378.00^{bc}	1866.00^{cd}	2383.00^{cd}
T_6	59.00^{b}	254.90^{c}	179.50^{c}	193.70^{c}	237.30^{b}	192.20^{c}	292.40^{c}	672.80^{c}	1332.00^{bc}	1695.00^{cd}	2133.00^{cd}
T_7	127.30^{ab}	339.40^{bc}	246.50^{bcd}	329.50^{bc}	429.40^{ab}	296.30^{abc}	555.50^{abc}	1128.00^{bc}	1773.00^{bc}	2056.00^{bcd}	2123.00^{cd}
T_8	86.11^{ab}	186.60^{c}	190.90^{d}	269.00^{c}	436.10^{ab}	224.60^{bc}	461.80^{abc}	721.60^{c}	1117.00^{c}	1548.00^{cd}	2127.00^{cd}
T_9	79.12^{ab}	193.60^{c}	211.00^{cd}	244.70^{c}	283.20^{b}	219.20^{bc}	421.80^{bc}	735.00^{c}	1424.00^{bc}	1794.00^{cd}	1813.00^{cd}
T_{10}	94.18^{ab}	201.00^{c}	172.00^{d}	282.90^{bc}	287.10^{b}	251.40^{abc}	325.00^{c}	538.70^{c}	1055.00^{c}	1491.00^{cd}	1747.00^{cd}
T_{11}	99.37^{ab}	178.90^{c}	216.90^{cd}	282.70^{bc}	260.00^{b}	195.50^{c}	343.90^{c}	650.10^{c}	1001.00^{c}	1331.00^{d}	1716.00^{cd}
T_{12}	149.60^{ab}	334.00^{bc}	399.60^{ab}	527.90^{ab}	473.10^{ab}	257.50^{abc}	358.40^{c}	781.60^{c}	1308.00^{bc}	1860.00^{bcd}	2381.00^{bcd}
T_{13}	140.30^{ab}	193.00^{c}	209.20^{cd}	299.00^{bc}	358.50^{ab}	323.50^{abc}	623.40^{abc}	1881.00^{ab}	1475.00^{bc}	1947.00^{bcd}	2071.00^{cd}
T_{14}	136.80^{ab}	544.90^{ab}	506.30^{a}	576.50^{a}	616.80^{a}	365.30^{abc}	870.40^{ab}	1413.00^{bc}	1730.00^{bc}	2875.00^{ab}	3704.00^{ab}
T_{15}	112.10^{ab}	175.30^{c}	182.60^{d}	280.50^{bc}	310.50^{b}	237.80^{abc}	654.80^{abc}	1180.00^{bc}	2058.00^{b}	1849.00^{bcd}	2331.00^{bcd}
T_{16}	180.50^{a}	191.50^{c}	208.90^{cd}	405.20^{abc}	405.20^{abc}	507.10^{ab}	776.00^{abc}	1095.00^{bc}	1758.00^{bc}	2421.00^{bc}	3218.00^{abc}

Treatments means having similar alphabets in superscript, do not differ significantly

Table 10. Effect of organic manures and growth promoting microorganisms along with inorganic fertilizers on leaf area (cm^2) - ratoon crop

Treatment	Months of observation				
	1	2	3	4	5
T_1	203.80^{a}	234.70^{e}	433.40^{d}	619.50^{f}	927.80^{e}
T_2	289.60^{cde}	673.50^{cd}	843.00^{cd}	1017.00^{def}	1215.00^{de}
T_3	522.20^{a}	1491.00^{a}	2066.00^{a}	2395.00^{a}	6878.00^{a}
T_4	291.90^{cde}	705.50^{cd}	925.40^{c}	1103.00^{de}	2802.00^{bcd}
T_5	415.60^{abc}	489.60^{cde}	800.70^{cd}	941.70^{def}	2994.00^{bc}
T_6	330.90^{cde}	639.60^{cd}	727.20^{bcd}	862.60^{def}	2005.00^{cde}
T_7	277.40^{cde}	586.80^{cde}	673.60^{cd}	846.20^{def}	2234.00^{cde}
T_8	229.40^{e}	548.00^{cde}	712.70^{cd}	849.60^{def}	1709.00^{cde}
T_9	343.80^{cde}	549.70^{cde}	646.80^{cd}	776.20^{ef}	1413.00^{cde}
T_{10}	308.90^{cde}	888.00^{c}	994.10^{bc}	1241.00^{cd}	2115.00^{cde}
T_{11}	241.20^{cde}	679.10^{cd}	783.00^{cd}	904.50^{def}	1434.00^{cde}
T_{12}	380.00^{cd}	1216.00^{ab}	1379.00^{b}	1626.00^{bc}	2473.00^{cde}
T_{13}	304.10^{cde}	826.40^{cd}	1008.00^{bc}	1212.00^{de}	2165.00^{cde}
T_{14}	388.20^{bc}	1272.00^{a}	1395.00^{b}	1715.00^{b}	4219.00^{cde}
T_{15}	218.60^{e}	872.50^{c}	1010.00^{bc}	1126.00^{de}	1809.00^{de}
T_{16}	517.00^{ab}	871.80^{bc}	1013.00^{bc}	1252.00^{cd}	1825.00^{e}

Treatments means having similar alphabets in superscript, do not differ significantly

Table 11. Effect of organic manures and growth promoting microorganisms along with inorganic fertilizers on number of tillers per hill – main crop

Treatment	Months of observation										
	1	2	3	4	5	6	7	8	9	10	11
T_1	0.86^{cde}	1.04^{def}	1.21^{cde}	1.21^{c}	1.25^{d}	1.35^{f}	1.46^{d}	1.96^{c}	2.04^{d}	2.12^{b}	2.26^{c}
T_2	1.14^{abcd}	1.08^{def}	1.29^{cde}	1.46^{bc}	1.60^{bcd}	1.82^{bcd}	1.95^{abc}	2.26^{abc}	2.29^{abcd}	2.32^{ab}	2.40^{bc}
T_3	1.12^{abcd}	1.44^{ab}	1.84^{a}	2.06^{a}	2.08^{a}	2.27^{a}	2.27^{a}	2.58^{ab}	2.58^{abc}	2.70^{a}	2.97^{a}
T_4	0.85^{cde}	0.97^{def}	1.05^{de}	1.14^{c}	1.50^{bcd}	1.79^{bcde}	1.92^{abc}	2.57^{ab}	2.67^{ab}	2.76^{a}	2.83^{abc}
T_5	1.03^{abcde}	0.97^{def}	1.43^{bc}	1.76^{ab}	1.81^{ab}	1.81^{bcde}	1.89^{abc}	2.29^{abc}	2.33^{abcd}	2.54^{ab}	2.57^{abc}
T_6	1.17^{abc}	1.15^{cde}	1.28^{cde}	1.46^{bc}	1.65^{bcd}	1.81^{bcd}	1.84^{bcd}	2.31^{abc}	2.38^{abcd}	2.40^{ab}	2.48^{abc}
T_7	1.35^{a}	1.45^{ab}	1.28^{cde}	1.62^{abc}	1.66^{bcd}	1.80^{bcd}	1.83^{bcd}	2.31^{abc}	2.36^{abcd}	2.42^{ab}	2.51^{abc}
T_8	0.93^{bcde}	1.09^{def}	1.54^{abc}	1.63^{abc}	1.77^{abc}	1.87^{bcd}	1.91^{abc}	2.32^{abc}	2.45^{abcd}	2.58^{ab}	2.79^{abc}
T_9	0.89^{cde}	1.03^{def}	1.43^{bc}	1.21^{c}	1.47^{bcd}	1.54^{def}	1.57^{cd}	2.18^{bc}	2.46^{abcd}	2.50^{ab}	2.52^{abc}
T_{10}	0.71^{e}	0.88^{ef}	1.23^{cde}	1.22^{c}	1.37^{cd}	1.43^{ef}	1.44^{d}	1.84^{c}	2.09^{cd}	2.43^{ab}	2.48^{bc}
T_{11}	0.82^{cde}	1.05^{def}	1.32^{cde}	1.49^{bc}	1.55^{bcd}	1.58^{cdef}	1.94^{abc}	2.11^{bc}	2.32^{abcd}	2.54^{ab}	2.57^{abc}
T_{12}	1.29^{ab}	1.42^{abc}	1.45^{bc}	1.49^{bc}	1.58^{bcd}	1.59^{cdef}	1.60^{cd}	1.96^{c}	2.23^{bcd}	2.65^{ab}	2.85^{ab}
T_{13}	0.94^{bcde}	1.27^{bcd}	1.30^{cde}	1.40^{bc}	1.63^{bcd}	1.69^{cd}	1.77^{cd}	2.12^{bc}	2.22^{bcd}	2.31^{ab}	2.40^{bc}
T_{14}	0.98^{abcde}	1.58^{a}	1.73^{ab}	1.82^{ab}	1.85^{ab}	1.92^{bc}	2.11^{ab}	2.74^{a}	2.77^{a}	2.78^{ab}	2.78^{abc}
T_{15}	0.77^{de}	0.83^{f}	1.01^{e}	1.23^{c}	1.52^{bcd}	1.63^{cdef}	1.81^{bcd}	2.35^{abc}	2.39^{abcd}	2.42^{ab}	2.55^{abc}
T_{16}	0.98^{abcde}	1.03^{def}	1.38^{cd}	1.49^{bc}	1.69^{abc}	2.00^{ab}	2.10^{ab}	2.26^{abc}	2.34^{abcd}	2.47^{b}	2.77^{abc}

Treatments means having similar alphabets in superscript, do not differ significantly

Table 12. Effect of organic manures and growth promoting microorganisms along with inorganic fertilizers on number of tillers per hill – ratoon crop

Treatment	Months of observation				
	1	2	3	4	5
T_1	1.61^{g}	2.03^{g}	2.16^{g}	2.38^{g}	2.70^{e}
T_2	2.17^{cde}	2.46^{ef}	2.66^{ef}	2.69^{f}	2.94^{cde}
T_3	2.97^{a}	3.42^{a}	3.64^{a}	3.78^{a}	3.78^{a}
T_4	1.90^{defg}	2.64^{def}	2.79^{def}	2.86^{def}	3.05^{cde}
T_5	1.99^{def}	2.70^{cdef}	2.89^{def}	2.92^{def}	2.97^{cde}
T_6	2.12^{cdef}	2.46^{ef}	2.60^{f}	2.67^{f}	2.73^{de}
T_7	2.25^{cd}	2.81^{cdef}	2.95^{cdef}	2.96^{def}	3.08^{cd}
T_8	2.19^{cde}	2.60^{def}	2.73^{def}	2.79^{def}	3.00^{cde}
T_9	1.82^{efg}	2.88^{bcde}	2.97^{cde}	3.03^{cde}	3.13^{c}
T_{10}	1.76^{fg}	2.38^{fg}	2.61^{ef}	2.76^{ef}	3.13^{c}
T_{11}	2.25^{bcd}	2.99^{abcd}	3.05^{cd}	3.08^{cd}	3.27^{bc}
T_{12}	2.08^{cdef}	3.29^{ab}	3.39^{ab}	3.51^{b}	3.51^{ab}
T_{13}	2.21^{cde}	2.67^{def}	2.86^{def}	2.95^{def}	3.00^{cde}
T_{14}	2.61^{b}	3.28^{ab}	3.41^{ab}	3.46^{b}	3.51^{ab}
T_{15}	2.06^{cdef}	3.13^{abc}	3.28^{bc}	3.28^{bc}	3.26^{bc}
T_{16}	2.41^{bc}	2.56^{def}	2.67^{ef}	2.71^{f}	3.19^{bc}

Treatments means having similar alphabets in superscript, do not differ significantly

4.1.2.1 Days taken for first spike emergence

Treatments differed significantly in days taken for the emergence of first spike. T_3 took minimum number of days for the first spike emergence (140.67 days) which was on par with T_{14} (151.33 days). Maximum number of days of 307.33 for the first spike emergence was observed in T_6 (100:50:50 kg NPK ha^{-1} + 30 t FYM + AMF) which was on par with T_{10} (100:50:50 kg NPK ha^{-1} + 30 t FYM + *Trichoderma* sp.), T_{11} (50 kg ha^{-1} N + P, K and 30 t FYM + AMF) and T_{13} (50 kg ha^{-1} N + P, K and 30 t FYM + AMF + *Azospirillum* sp).

In the ratoon crop T_7 (100:50:50 kg NPK ha^{-1} + 30 t FYM + *Azospirillum* sp.) exhibited earliest flowering in 119 days followed by plants in T_3 (124 days). Maximum number of days for first spike emergence was observed in T_1 (absolute control) (236.5).

4.1.2.2 Days taken for first floret opening

It was observed that number of days for the first floret opening ranged from 12.67 days in T_3 to 18.7 days in T_{15} (50 kg ha^{-1} N + P, K + vermicompost 41.09 t ha^{-1}) during the main crop.

In ratoon crop also T_3 took minimum number of days (13.50 days) which was on par with T_{10} (100:50:50 kg NPK ha^{-1} + 30 t FYM + *Trichoderma* sp.). This was followed by T_{14} and T_{16} (14.00 and 14.33 respectively). Maximum number of days for the opening of first floret was observed in T_{11} (50 kg ha^{-1} N + P, K and 30 t FYM + AMF) which was on par with T_4 (100:50:50 kg NPK ha^{-1} + vermicompost, 41.09 t ha^{-1}) (19.67 and 19.50 days respectively).

4.1.2.3 Days to complete opening of florets in a spike

Days to complete opening of the florets were maximum in T_2 (100:50:50 kg NPK ha^{-1} + 30 t FYM) which was on par with T_{14} (50 kg ha^{-1} N + P, K+ poultry manure 22.22 t ha^{-1}). Early completion of opening of florets was observed in T_9

(100:50:50 kg NPK ha^{-1} + 30 t FYM + *Pseudomonas fluorescens*) and T_{10} (100:50:50 kg NPK ha^{-1} + 30 t FYM + *Trichoderma* sp.) (10.33 days).

In ratoon crop, T_3 took maximum number of days for complete opening of the floret which was on par with T_7 (100:50:50 kg NPK ha^{-1} + 30 t FYM + *Azospirillum* sp.) (15.50 and 15.00 days respectively). Minimum number of days was recorded in T_9 and T_{11} (50 kg ha^{-1} N + P, K and 30 t FYM + AMF) (9.00 days).

4.1.2.4 Length of the spike

Length of the spike ranged from 69.35 cm in T_1 to 91.69 cm in T_3. This was followed by T_{14} and T_{16} (90.27 and 85.25 cm respectively). In ratoon crop also T_3 was significantly superior in terms of this parameter (91.75 cm) which was followed by T_8, T_{14} and T_{12} (85.58, 85.42 and 85.28 respectively). Minimum spike length of 78.35cm was recorded inT_1.

4.1.2.5 Girth of the spike

Regarding the girth of the spike, no significant variation was observed among the treatments in main crop. In ratoon crop maximum girth was noted in T_{16} (2.64 cm) and a minimum value of 2.23was observed in T_{13} (50 kg ha^{-1} N + P, K and 30 t FYM + AMF + *Azospirillum* sp.).

4.1.2.6 Length of rachis

Maximum length of rachis was observed in T_3 (34.94 cm) followed by the treatments T_{16}, T_{13} and T_{14} which were on par (30.68, 30.51 and 30.17 cm respectively). In ratoon crop also T_3 exhibited superiority in terms of this parameter (31.81) followed by T_4, T_{11}, T_{14} and T_{16} (25.23, 24.65, 24.48 and 24.27 cm respectively).

4.1.2.7 Number of florets per spike

Significant variation between treatments was observed in the case of number of florets per spike during the crop growth. T_3 had maximum number of florets per spike (40.58) followed by T_{16} and T_7 (38.38 and 37.75). Minimum number was observed in T_8 (26.05).

In ratoon crop also T_3 recorded significantly higher value in terms of this parameter (34.90) followed by T_{16} and T_{14} (34.03 and 32.42) and minimum of 26.70 was observed in T_5 (100:50:50 kg NPK ha^{-1} + coirpith compost).

4.1.2.8 Length of the corolla tube

Maximum length of the corolla tube (6.05 cm) was recorded in T_3 followed by T_{14} (5.92 cm) and minimum value was observed in T_{13} (50 kg ha^{-1} N + P, K and 30 t FYM + AMF + *Azospirillum* sp.) (5.01 cm).

In ratoon crop also, this parameter was maximum in T_3 (5.43 cm) and minimum was noticed in T_{13} (4.61cm).

4.1.2.9 Size of the floret

Significant variation was observed in size of florets during the course of growth. The values ranged from 3.21cm in T_5 to 4.23cm in T_{12} (50 kg ha^{-1} N + P, K and 30 t FYM + *Azospirillum* sp.).

For ratoon crop T_{14} exhibited maximum size of the floret 3.77cm and floret size was minimum in T_{13} (3.05 cm).

4.1.2.10 Longevity of the floret

Longevity of the floret was maximum in T_3 and T_{14} (3.53) which was statistically on par with T_{15} and T_2 (3.50 and 3.50 respectively). This was followed by T_{14} and T_{16} (3.42 and 3.53 respectively) and minimum value was recorded in T_7 (2.83).

In ratoon crop also T_3 was statistically superior in terms of longevity of floret recording the highest value of 3.5 days.

Table 13. Effect of organic manures and growth promoting microorganisms along with inorganic fertilizers on floral characters – main crop

Treat-ment	Days for 1st spike emergence	Days to 1st floret opening	Days to complete opening of the florets	Length of the spike (cm)	Girth of the spike (cm)	Length of rachis (cm)	Number of florets per spike	Length of the corolla tube (cm)	Size of floret (cm)	Longe-vity of the floret	Field life Of spike (days)	Duration of the crop (days)	Yield of spikes per hill
T_1	252.00^{cdef}	17.83^{a}	13.50^{bc}	74.21^{defg}	2.73^{a}	17.99^{b}	33.83^{bc}	5.43^{cde}	3.36^{bcd}	3.25^{abcd}	16.00^{de}	504.70^{g}	1.33^{b}
T_2	275.00^{abcdef}	15.33^{bc}	17.00^{a}	69.35^{g}	2.74^{a}	23.75^{b}	32.50^{bcd}	5.03^{ef}	3.23^{d}	3.50^{a}	17.50^{cd}	545.00^{c}	1.17^{b}
T_3	140.67^{g}	12.67^{e}	12.00^{de}	91.69^{a}	3.09^{a}	34.97^{a}	40.58^{a}	6.05^{a}	4.13^{ab}	3.53^{a}	21.33^{a}	638.30^{a}	2.42^{ab}
T_4	238.67^{ef}	13.00^{e}	14.00^{bc}	82.00^{abcdef}	2.86^{a}	26.01^{b}	32.75^{bc}	5.60^{bc}	3.33^{cd}	3.42^{ab}	17.00^{cd}	519.37^{def}	1.58^{b}
T_5	257.00^{bcdef}	16.00^{b}	13.00^{cd}	76.16^{cdefg}	3.07^{a}	27.71^{b}	33.50^{bc}	5.15^{def}	3.21^{d}	3.08^{cde}	17.83^{cd}	534.70^{d}	1.42^{b}
T_6	307.33^{ab}	13.00^{e}	11.33^{ef}	81.30^{bcdef}	2.98^{a}	24.50^{b}	31.67^{bcd}	5.37^{cdef}	3.88^{abcd}	3.00^{de}	14.50^{ef}	509.33^{ef}	1.08^{b}
T_7	244.33^{def}	13.33^{e}	14.67^{b}	73.12^{efg}	2.79^{a}	27.37^{b}	37.75^{ab}	5.53^{cd}	4.00^{abcd}	2.83^{e}	18.50^{bc}	533.03^{d}	1.50^{b}
T_8	289.00^{abcde}	13.50^{de}	12.00^{de}	72.23^{fg}	2.83^{a}	23.75^{b}	26.05^{d}	5.31^{cdef}	3.71^{abcd}	3.25^{abcd}	17.33^{cd}	496.70^{gh}	1.00^{b}
T_9	295.00^{a}	15.33^{bc}	10.33^{f}	84.62^{abcd}	2.81^{a}	25.00^{b}	32.92^{bc}	5.62^{bc}	4.12^{abc}	3.08^{cde}	12.67^{f}	532.30^{d}	1.08^{b}
T_{10}	307.00^{a}	12.83^{e}	10.33^{f}	83.35^{abcde}	2.98^{a}	24.13^{b}	30.58^{cd}	5.54^{bcd}	3.75^{abcd}	3.00^{de}	13.50^{f}	523.70^{de}	1.25^{b}
T_{11}	298.00^{a}	14.50^{bcde}	11.83^{de}	80.01^{bcdef}	2.96^{a}	25.02^{b}	32.00^{bcd}	5.28^{cdef}	3.88^{abcd}	2.92^{de}	13.67^{f}	527.30^{de}	0.92^{b}
T_{12}	293.67^{abcd}	15.17^{bcd}	11.33^{ef}	79.33^{cdefg}	2.91^{a}	25.92^{b}	30.75^{cd}	5.18^{def}	4.23^{a}	3.00^{cde}	14.00^{f}	504.37^{g}	1.17^{b}
T_{13}	298.33^{a}	15.50^{b}	13.67^{bc}	76.29^{cdefg}	2.79^{a}	30.51^{ab}	34.50^{abc}	5.01^{f}	3.56^{abcd}	3.17^{bcd}	13.67^{f}	522.03^{de}	1.25^{b}
T_{14}	151.33^{g}	14.33^{bcde}	16.00^{a}	90.27^{ab}	2.89^{a}	30.17^{ab}	36.58^{abc}	5.92^{ab}	3.65^{abcd}	3.53^{a}	20.00^{ab}	543.03^{c}	2.17^{ab}
T_{15}	298.33^{abc}	18.17^{a}	12.00^{de}	77.85^{cdefg}	2.85^{a}	26.81^{b}	31.58^{bcd}	5.18^{def}	3.36^{bcd}	3.50^{a}	17.33^{cd}	586.03^{b}	1.25^{b}
T_{16}	220.33^{f}	13.67^{cde}	14.00^{bc}	85.25^{abc}	2.91^{a}	30.68^{ab}	38.38^{ab}	5.41^{cde}	3.70^{abcd}	3.33^{abc}	17.33^{cd}	540.63^{c}	1.80^{b}

Treatments means having similar alphabets in superscript, do not differ significantly

Table 14. Effect of organic manures and growth promoting microorganisms along with inorganic fertilizers on floral characters – ratoon crop

Treat-ment	Days for 1st spike emergence	Days to 1st floret opening	Days to complete opening of floret in a spike	Length of the spike (cm)	Girth of the spike (cm)	Length of rachis (cm)	Number of florets per spike	Length of the corolla tube (cm)	Size of floret (cm)	Longe-vity of floret (days)	Field life of spike (days)	Duration of the crop (days)	Yield of spikes per hill
T_1	236.50^{a}	18.50^{ab}	13.00^{bc}	78.35^{e}	2.37^{def}	2.35^{de}	27.95^{efg}	4.87^{bcde}	3.25^{cdef}	2.50^{d}	10.50^{i}	432.50^{ab}	1.25^{fg}
T_2	139.00^{h}	16.00^{cd}	12.00^{d}	79.65^{de}	2.42^{cde}	20.83^{ef}	29.30^{def}	4.80^{cde}	3.18^{def}	3.00^{c}	14.00^{cde}	328.00^{f}	1.37^{fg}
T_3	124.00^{i}	13.50^{e}	15.50^{a}	91.75^{a}	2.41^{cdef}	31.81^{a}	34.90^{a}	5.43^{a}	3.46^{abcd}	3.50^{a}	18.00^{a}	435.30^{ab}	2.40^{a}
T_4	161.00^{f}	19.50^{a}	13.50^{b}	83.28^{bcde}	2.45^{bcde}	25.23^{b}	32.28^{bc}	5.26^{ab}	3.65^{ab}	3.00^{c}	12.35^{fgh}	426.00^{b}	2.00^{bcd}
T_5	136.30^{h}	16.00^{cd}	10.00^{f}	83.29^{bcde}	2.49^{abcde}	22.40^{de}	26.70^{g}	5.02^{abcde}	3.49^{abc}	3.00^{c}	13.00^{efg}	413.63^{bc}	1.83^{cd}
T_6	187.50^{e}	19.50^{a}	10.00^{ef}	85.23^{bc}	2.42^{cde}	21.33^{ef}	30.40^{cd}	4.79^{de}	3.13^{ef}	3.00^{c}	13.33^{def}	410.00^{c}	2.00^{bcd}
T_7	119.00^{i}	18.00^{ab}	15.00^{a}	84.50^{bcd}	2.50^{abcd}	19.98^{f}	29.05^{def}	5.13^{abcd}	3.37^{bcde}	3.00^{c}	14.50^{cd}	360.00^{d}	1.50^{ef}
T_8	215.70^{c}	15.33^{cde}	11.67^{d}	85.58^{b}	2.32^{def}	21.03^{ef}	27.50^{fg}	5.25^{abc}	3.52^{abc}	3.083^{c}	14.67^{c}	413.40^{bc}	1.17^{g}
T_9	224.30^{b}	19.00^{ab}	9.00^{f}	80.30^{cde}	2.43^{cde}	22.36^{de}	30.50^{cd}	5.20^{abcd}	3.53^{abc}	3.00^{c}	12.00^{gh}	438.30^{ab}	1.33^{fg}
T_{10}	138.30^{h}	14.00^{e}	12.00^{cd}	82.23^{bcde}	2.62^{ab}	21.97^{de}	29.28^{def}	4.77^{de}	3.37^{bcde}	3.00^{c}	14.33^{cd}	351.60^{de}	1.42^{fg}
T_{11}	136.70^{h}	19.67^{a}	9.00^{f}	83.22^{bcde}	2.41^{cdef}	24.65^{bc}	29.25^{def}	4.98^{abcde}	3.45^{bcd}	3.00^{c}	12.33^{fgh}	368.00^{d}	2.00^{bcd}
T_{12}	157.70^{h}	17.00^{bc}	10.00^{ef}	85.28^{bc}	2.31^{ef}	23.43^{bcd}	29.79^{de}	4.93^{bcde}	3.42^{bcde}	3.00^{c}	12.33^{fgh}	354.00^{de}	1.50^{ef}
T_{13}	146.00^{g}	19.00^{ab}	11.00^{de}	83.53^{bcd}	2.23^{f}	23.31^{cd}	30.14^{d}	4.61^{e}	3.05^{f}	3.00^{c}	14.50^{cd}	351.00^{de}	1.75^{de}
T_{14}	151.00^{a}	14.00^{de}	11.67^{d}	85.42^{bc}	2.57^{abc}	24.48^{bc}	32.42^{bc}	5.15^{abcd}	3.77^{a}	3.25^{b}	16.00^{b}	416.00^{bc}	2.25^{ab}
T_{15}	209.00^{d}	18.00^{ab}	9.50^{f}	83.60^{bcd}	2.36^{def}	20.60^{ef}	27.41^{fg}	4.65^{e}	3.40^{bcde}	3.08^{c}	11.50^{hi}	446.30^{a}	2.00^{bcd}
T_{16}	150.00^{a}	14.33^{de}	13.33^{b}	84.42^{bcd}	2.64^{a}	24.27^{bc}	34.03^{ab}	5.04^{abcde}	3.50^{abc}	3.00^{c}	13.00^{efg}	427.30^{b}	2.05^{bc}

4.1.2.11 Field life of spike

Both in main and ratoon crops, T_3 was statistically superior in terms of this parameter (21.33 and 18.00 days respectively) followed by T_{14} (20.00 and 16.00 days respectively).

4.1.2.12 Duration of the crop

Treatments differed significantly in terms of duration of the crop. Maximum duration of the crop was observed in T_3 (638 days) and minimum was observed in T_6 (202 days).

In the ratoon crop, duration of the crop was maximum in T_{14} (446.00 days) and minimum in T_9 (496.00 days).

4.1.2.14 Yield of spikes per hill

Significant variation was observed in the case of yield of spikes per hill during the crop growth. T_3 produced maximum number of spikes per hill (2.42 Nos.) which was on par with T_{14} (2.17 Nos.). This was followed by T_{16} (1.8 Nos.). Number of spikes per hill was minimum in T_{11} (0.92 Nos.).

In ratoon crop also T_3 was superior in spike production (2.4 Nos.) followed by T_{14} (2.25 Nos.) and T_{16} (2.05 Nos.).

4.1.3 Post harvest spike characters

Post harvest spike characters recorded for plant and ratoon crops of Experiment I are represented in Tables 15 and 16 and Plate 10

4.1.3.1 Fresh weight of the spike

T_{16} the treatment consisted of coirpith compost, was statistically superior to other treatments in terms of this parameter both in main crop and ratoon crop (53.66 and 51.33 g respectively), followed by T_3 (51.37 and 48.00 g).

4.1.3.2 Days taken for opening of each floret

T_{12} (50 kg ha^{-1} N + P, K and 30 t FYM + *Azospirillum* sp.) took maximum number of days (2.12 days) for opening of each floret which was on par with T_4 and T_{11} (2.08 and 2.07 days respectively). For ratoon crop, T_4 and T_7 were performing on par with maximum number of days for opening of each floret (2.08 days). Both in main and ratoon crop T_5 resulted in opening of florets in less number of days (1.17 and 1.67 days respectively).

4.1.3.3 Number of florets opened at a time

Number of florets opened at a time were maximum in T_{14} (2.77) followed by T_3 (2.53) and T_{16} (2.50).

During the ratoon crop also value was highest in T_{14} (2.78 days). Both in main and ratoon crop T_2 (100:50:50 kg ha^{-1} + FYM 30 t ha $^{-1}$) resulted in opening of minimum number of florets at a time (2 and 1.5 days).

4.1.3.4 Water uptake

T_9 and T_1 were on par recording the highest water uptake (49.00 and 48.67 ml respectively) and the minimum was in T_2 (37.50 ml).

In ratoon crop maximum water uptake was observed in T_3 (47.50 ml) followed by T_9 and T_{11} (46.17 and 45.83 ml respectively) and minimum in T_7 (34.83 ml).

4.1.3.5 Vase life

Maximum vase life of 10.00 days were observed in T_3 followed by T_{14} and T_{16} (8.67 and 8.33 days respectively) and vase life was minimum in T_1 (5.67 days).

For ratoon crop also T_3 recorded highest vase life (8.33 days) followed by T_{14} and T_{16} (8.00 days) and minimum vase life observed in T_{12} (6.00 days).

Plate 10. Effect of combination of organic manures and growth promoting microorganisms along with inorganic fertilizers on vase life

Plate 11. Effect of organic sources of nutrients on vase life

Plate 12. Effect of combination of organic manures and growth promoting microorganisms along with inorganic fertilizers on bulb characters

Plate 13. Effect of organic sources of nutrients on bulb characters

Table 15. Effect of organic manures and growth promoting microorganisms along with inorganic fertilizers on post harvest spike characters – main crop

Treatment	Fresh weight of spike (g)	Days taken for opening of each floret	No. of florets opened at a time	Total water uptake (ml)	Vaselife (days)
T_1	43.47^{de}	2.00^{ab}	1.83^{ef}	43.00^{cd}	7.00^{bc}
T_2	33.17^{hi}	2.00^{ab}	1.50^{f}	45.10^{abcd}	7.00^{bc}
T_3	48.00^{b}	2.00^{ab}	2.42^{abcd}	47.50^{a}	8.33^{a}
T_4	33.85^{hi}	2.08^{a}	2.17^{cde}	44.42^{bcd}	7.00^{bc}
T_5	39.33^{fg}	1.67^{c}	2.50^{abcd}	45.50^{abcd}	7.00^{bc}
T_6	45.50^{bcd}	2.00^{ab}	2.23^{cde}	42.83^{d}	7.00^{bc}
T_7	39.83^{fg}	2.08^{a}	2.58^{abc}	34.83^{e}	7.00^{bc}
T_8	35.33^{h}	2.00^{ab}	2.25^{bcd}	36.17^{e}	6.67^{cd}
T_9	44.83^{cde}	2.00^{ab}	2.08^{de}	46.17^{ab}	7.67^{ab}
T_{10}	43.08^{de}	2.00^{ab}	2.67^{ab}	45.00^{abcd}	7.00^{bc}
T_{11}	38.83^{g}	1.83^{bc}	2.37^{abcd}	45.83^{abc}	7.00^{bc}
T_{12}	32.25^{i}	2.00^{ab}	2.58^{abc}	44.50^{bcd}	6.00^{d}
T_{13}	39.51^{fg}	2.00^{ab}	2.25^{bcd}	45.33^{abcd}	7.83^{a}
T_{14}	46.50^{bc}	2.00^{ab}	2.78^{a}	44.67^{abcd}	8.00^{a}
T_{15}	42.00^{ef}	2.00^{ab}	2.17^{cde}	45.00^{abcd}	7.67^{ab}
T_{16}	51.33^{a}	2.00^{ab}	2.42^{abcd}	43.00^{cd}	8.00^{a}

Treatments means having similar alphabets in superscript, do not differ significantly

Table 16. Effect of organic manures and growth promoting microorganisms along with inorganic fertilizers on post harvest spike characters – ratoon crop

Treatment	No. of bulbs per hill	No. of bulblets per hill	Weight of bulbs per hill	Weight of bulblets per hill	Size of bulbs	Size of bulblets
T_1	15.00^{k}	27.33^{g}	195.30^{h}	31.67^{f}	6.20^{abcde}	3.30^{ijk}
T_2	17.33^{ij}	30.67^{f}	165.70^{jk}	20.67^{h}	5.13^{ef}	4.30^{cdef}
T_3	34.33^{b}	58.33^{a}	390.70^{a}	78.03^{a}	7.25^{abc}	4.25^{def}
T_4	17.83^{hij}	29.00^{fg}	216.70^{g}	40.00^{e}	7.45^{a}	2.95^{k}
T_5	37.00^{a}	35.33^{d}	365.00^{b}	50.67^{d}	6.00^{cde}	3.55^{hij}
T_6	16.33^{jk}	31.33^{ef}	182.70^{i}	40.00^{e}	5.75^{def}	4.70^{abcd}
T_7	20.67^{fg}	26.67^{g}	148.30^{l}	25.00^{g}	4.60^{f}	3.90^{fgh}
T_8	19.33^{gh}	35.00^{d}	179.30^{i}	24.67^{g}	4.66^{f}	3.50^{hij}
T_9	21.33^{f}	22.50^{h}	180.00^{i}	20.33^{h}	5.40^{def}	3.30^{ijk}
T_{10}	18.00^{hi}	35.00^{d}	220.00^{g}	48.33^{d}	6.10^{bcde}	4.47^{bcde}
T_{11}	21.00^{f}	22.00^{h}	173.30^{ij}	50.00^{d}	5.50^{def}	4.90^{ab}
T_{12}	27.83^{d}	49.33^{b}	160.00^{k}	59.33^{c}	5.05^{ef}	3.20^{jk}
T_{13}	21.00^{f}	38.00^{c}	244.00^{f}	64.33^{b}	7.35^{ab}	4.10^{efg}
T_{14}	27.33^{d}	47.67^{b}	259.00^{f}	79.33^{a}	7.37^{ab}	4.95^{a}
T_{15}	30.00^{c}	16.67^{i}	309.30^{c}	22.00^{gh}	6.55^{abcd}	3.70^{ghi}
T_{16}	24.67^{e}	33.35^{de}	271.70^{d}	63.67^{b}	6.25^{abcde}	4.75^{abc}

Treatments means having similar alphabets in superscript, do not differ significantly

4.1.4 Bulb characters

Data related to bulb characters are furnished in Table 17 and Plate 12.

4.1.4.1 Number of bulbs per hill

Treatments differed significantly in terms of number of bulbs per hill. Regarding this parameter, T_5 was superior to all other treatments (37.00 Nos.) followed by T_3 (34.33 Nos.) and minimum number of bulbs per hill was observed in T_1 (15.00 Nos.).

4.1.4.2 Number of bulblets per hill

Number of bulblets per hill ranged from 16.67 in T_{15} to 58.33 in T_3

4.1.4.3 Weight of bulbs per hill

T_3 was superior to all other treatments with regard to weight of bulbs per hill recording 390.70 g and minimum was observed in T_7 (148.30 g).

4.1.4.4 Weight of bulblets per hill

Maximum weight of bulblets per hill was observed in T_{14} (79.33 g) which was on par with T_3 (78.03 g) and minimum value was recorded in T_9 (20.33 g).

4.1.4.5 Size of bulbs

It was noticed that T_4 recorded maximum size of the bulb (7.45 cm) followed by T_{14} and T_{13} (7.37 and 7.35 cm respectively) whereas minimum size of bulbs was observed in T_7 and T_8 (4.60 cm).

4.1.4.6 Size of bulblets

Regarding the size of bulblets, T_{14} produced bulblets with maximum size (4.95 cm) and it was minimum in T_4 (2.95 cm).

Table 17. Effect of organic manures and growth promoting microorganisms along with inorganic fertilizers on bulb characters

Treatment	Fresh weight of spike (g)	Days taken for opening of each floret	No. of florets opened at a time	Total water uptake (ml)	Vaselife (days)
T_1	47.54^{abc}	1.67^{abc}	2.50^{abc}	48.67^{a}	5.67^{f}
T_2	26.93^{f}	1.67^{c}	2.00^{c}	37.50^{c}	8.00^{bcd}
T_3	51.37^{ab}	1.50^{bc}	2.53^{ab}	39.00^{c}	10.00^{a}
T_4	51.00^{ab}	2.08^{a}	2.37^{abc}	45.33^{ab}	9.00^{ab}
T_5	43.80^{bcd}	1.17^{c}	2.37^{abc}	45.33^{ab}	6.33^{def}
T_6	47.04^{abc}	1.83^{ab}	2.50^{abc}	47.33^{ab}	6.00^{ef}
T_7	40.67^{cde}	2.00^{ab}	2.25^{abc}	40.00^{c}	7.00^{cdef}
T_8	36.17^{e}	1.75^{ab}	2.15^{bc}	47.33^{ab}	8.00^{bcd}
T_9	50.04^{ab}	2.00^{ab}	2.50^{abc}	49.00^{a}	8.33^{abc}
T_{10}	49.83^{ab}	2.00^{ab}	2.33^{abc}	47.67^{ab}	8.00^{bcd}
T_{11}	34.83^{f}	2.07^{a}	2.17^{bc}	38.50^{c}	7.00^{cdef}
T_{12}	36.93^{de}	2.12^{a}	2.33^{abc}	46.00^{ab}	7.67^{bcde}
T_{13}	45.58^{bc}	2.00^{ab}	2.17^{bc}	46.67^{ab}	8.00^{bcd}
T_{14}	45.02^{bc}	2.00^{ab}	2.77^{a}	46.67^{ab}	8.67^{abc}
T_{15}	49.77^{ab}	1.92^{ab}	2.27^{abc}	47.33^{ab}	8.00^{bcd}
T_{16}	53.66^{a}	2.00^{ab}	2.50^{abc}	42.67^{bc}	8.33^{abc}

Treatments means having similar alphabets in superscript, do not differ significantly

4.1.5 Plant analysis

4.1.5.1 N content

N content of leaves and tubers estimated at monthly intervals up to flowering stage of experiment 1 is furnished in Table 18.

Irrespective of the treatments, progressive increase in N content of leaves till the last observation was noticed. Though treatment effect was not consistent, T_3 where plants received poultry manure along with NPK resulted in significantly superior values for this parameter.

In the case of N content of tubers, higher values were recorded by T_3 through out the growth period and T_5 the treatment with coir pith compost along with NPK resulted in lowest values.

Data pertaining to the N content of leaves and tubers of ratoon crop is presented in Table 19.

During initial months highest N content was noticed in $T_{16,}$ the treatment consisted of coir pith compost along with chemical fertilizers (1.59) and in T_3 (2.06, 2.89, and 2.80) during subsequent months. Generally N content was found to be increasing during the growth stage, and a reduction was noticed at flowering stage. In tubers also, T_3 was statistically superior (1.63, 2.50, 2.97, and 2.53) followed by T_{16} and T_{14} (50:50:50 kg ha^{-1} + poultry manure 22.22 t ha^{-1}) in terms of this parameter and the general trend was similar to that of leaves.

4.1.5.2 Variation in P content

Even though there was no consistent pattern of variation in P content, T_5 (100:50:50 kg NPK ha^{-1} + coirpith compost, nitrogen equivalent to 30 t FYM) recorded significantly highest values during the major period of growing season. For tubers, during the initial period highest P values was observed in T_6 (100:50:50 kg NPK ha^{-1} + 30 t FYM + AMF). No significant pattern of variation could be observed

Table 18. Effect of organic manures and growth promoting microorganisms along with inorganic fertilizers on N content of leaves and tubers (%) – main crop

	Months of observation															
	Leaf								Tuber							
	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
T_1	1.28^{de}	1.34^{i}	1.52^{k}	1.60^{k}	1.61^{j}	2.63^{ef}	2.71^{f}	2.27^{cde}	0.72^{g}	1.17^{e}	1.39^{ij}	1.62^{i}	1.67^{gh}	1.71^{def}	2.26^{de}	2.13^{bcdefg}
T_2	1.40^{c}	1.76^{f}	1.89^{j}	2.00^{ij}	2.43^{gh}	2.68^{de}	2.73^{ef}	2.39^{bc}	0.95^{de}	1.17^{e}	2.20^{b}	2.40^{c}	2.50^{c}	2.51^{bc}	2.56^{c}	2.43^{b}
T_3	1.39^{c}	2.56^{b}	3.40^{a}	3.45^{a}	3.47^{a}	3.10^{a}	3.03^{b}	2.48^{bc}	1.63^{a}	1.82^{a}	3.02^{a}	3.05^{a}	3.53^{a}	3.60^{a}	3.70^{a}	3.30^{a}
T_4	1.18^{fg}	2.34^{c}	2.70^{d}	2.75^{de}	2.77^{def}	2.70^{j}	2.68^{j}	2.39^{g}	1.51^{b}	1.62^{b}	1.80^{d}	2.05^{e}	2.65^{b}	2.68^{b}	2.73^{b}	2.27^{bcd}
T_5	1.49^{b}	1.56^{h}	2.30^{gh}	2.87^{cde}	2.87^{cde}	2.47^{ef}	2.47^{g}	2.43^{bc}	0.84^{f}	1.43^{c}	1.56^{f}	1.86^{f}	1.92^{f}	1.94^{def}	1.99^{f}	2.15^{bcdef}
T_6	0.83^{i}	1.12^{l}	1.84^{j}	2.03^{i}	2.08^{i}	2.08^{h}	2.00^{h}	3.00^{a}	0.78^{fg}	0.97^{gh}	1.48^{gh}	1.79^{g}	1.87^{f}	1.87^{def}	2.28^{de}	2.17^{bcde}
T_7	1.12^{a}	1.37^{i}	1.45^{k}	1.79^{jk}	1.80^{j}	2.77^{cde}	2.71^{ef}	2.38^{bcd}	0.78^{fg}	0.95^{gh}	1.78^{d}	1.79^{g}	1.88^{f}	0.78^{g}	1.93^{f}	1.87^{efg}
T_8	0.89^{i}	2.22^{d}	2.24^{gh}	2.50^{fg}	2.55^{fg}	2.88^{bcd}	2.90^{cd}	2.72^{ab}	0.76^{fg}	0.89^{h}	1.59^{ef}	2.01^{e}	2.08^{e}	2.13^{cde}	2.17^{e}	2.03^{defg}
T_9	1.24^{ef}	1.37^{i}	2.02^{ij}	2.21^{hi}	2.25^{hi}	2.13^{h}	2.19^{h}	1.99^{def}	0.84^{f}	0.95^{gh}	1.88^{c}	2.03^{e}	2.13^{e}	2.20^{bcd}	2.35^{d}	2.13^{bcdefg}
T_{10}	1.12^{a}	1.18^{k}	2.52^{ef}	2.69^{ef}	2.72^{ef}	1.83^{i}	1.80^{i}	1.73^{f}	0.97^{de}	1.06^{f}	1.17^{k}	1.62^{j}	1.63^{h}	1.63^{ef}	1.69^{g}	1.50^{h}
T_{11}	1.37^{c}	1.68^{g}	2.75^{cd}	2.77^{de}	2.73^{ef}	2.77^{cde}	2.79^{ef}	1.90^{ef}	1.01^{d}	1.23^{de}	1.65^{e}	1.87^{f}	1.92^{f}	2.07^{cde}	2.27^{de}	2.07^{cdefg}
T_{12}	1.24^{ef}	1.28^{j}	2.40^{fg}	2.90^{cde}	2.88^{cde}	2.30^{gh}	2.42^{g}	1.94^{ef}	0.92^{e}	1.01^{fg}	1.46^{hi}	1.81^{g}	1.84^{f}	1.86^{def}	1.92^{f}	1.82^{fgh}
T_{13}	1.18^{fg}	2.34^{c}	2.96^{bc}	3.10^{bc}	3.08^{bc}	2.73^{cde}	2.93^{c}	2.70^{ab}	0.83^{f}	1.40^{c}	1.55^{fg}	1.68^{h}	1.74^{g}	1.82^{def}	1.86^{e}	1.80^{gh}
T_{14}	1.34^{cd}	2.71^{a}	3.13^{b}	3.20^{b}	3.27^{ab}	2.78^{cde}	2.82^{de}	2.47^{bc}	1.01^{d}	1.29^{d}	1.46^{hi}	2.50^{b}	2.52^{bc}	2.55^{bc}	2.58^{c}	2.45^{b}
T_{15}	1.04^{h}	1.18^{k}	2.16^{hi}	2.36^{gh}	2.40^{gh}	2.93^{bc}	2.97^{c}	2.61^{abc}	1.12^{c}	1.28^{d}	1.34^{j}	1.40^{j}	1.53^{i}	1.53^{f}	1.57^{g}	1.49^{h}
T_{16}	1.65^{a}	1.88^{e}	2.93^{bc}	2.97^{bcd}	2.98^{cd}	3.08^{ab}	3.15^{b}	2.38^{bcd}	0.61^{h}	0.68^{i}	1.18^{k}	2.12^{d}	2.28^{d}	2.43^{bc}	2.50^{c}	2.40^{bc}

Treatments means having similar alphabets in superscript, do not differ significantly

Table 19. Effect of organic manures and growth promoting microorganisms along with inorganic fertilizers on N content of leaves and tubers (%) – ratoon crop

Treatments	Months of observation							
	Leaf				Tuber			
	1	2	3	4	1	2	3	4
T_{1}	1.20^{bcdef}	1.43^{g}	1.85^{i}	1.57^{g}	1.17^{ef}	1.57^{h}	1.68^{g}	1.58^{hi}
T_{2}	1.25^{abcdef}	2.07^{a}	2.46^{f}	2.43^{bcd}	1.15^{ef}	1.72^{g}	2.02^{c}	1.88^{d}
T_{3}	1.45^{abc}	2.06^{a}	2.89^{a}	2.80^{a}	1.63^{a}	2.50^{a}	2.97^{a}	2.53^{a}
T_{4}	1.09^{def}	2.05^{a}	2.63^{cd}	2.50^{abcd}	1.50^{b}	2.40^{b}	2.05^{c}	2.00^{c}
T_{5}	1.53^{ab}	2.01^{a}	2.82^{ab}	2.63^{ab}	1.41^{c}	2.00^{e}	2.06^{c}	1.80^{de}
T_{6}	1.02^{ef}	1.68^{cde}	2.20^{h}	2.23^{cde}	1.55^{b}	1.50^{i}	1.87^{d}	1.70^{fg}
T_{7}	1.08^{def}	1.23^{h}	1.77^{i}	1.63^{g}	0.97^{h}	1.02^{j}	1.72^{fg}	1.63^{gh}
T_{8}	0.96^{f}	1.70^{cd}	2.50^{ef}	1.88^{fg}	1.23^{d}	1.80^{f}	2.07^{c}	2.00^{c}
T_{9}	1.24^{abcdef}	1.87^{b}	2.32^{gh}	1.83^{fg}	0.95^{h}	1.78^{f}	1.87^{d}	1.76^{ef}
T_{10}	1.16^{cdef}	1.60^{def}	2.83^{ab}	2.52^{abcd}	1.07^{g}	1.82^{f}	1.77^{ef}	1.52^{i}
T_{11}	1.36^{abcde}	1.49^{fg}	2.70^{bcd}	2.43^{bcd}	1.25^{d}	1.68^{g}	1.88^{d}	1.83^{de}
T_{12}	1.25^{abcdef}	1.86^{b}	2.42^{f}	2.02^{ef}	1.12^{efg}	2.02^{de}	2.08^{c}	1.82^{de}
T_{13}	1.27^{abcdef}	1.80^{bc}	2.37^{fg}	2.80^{a}	1.11^{fg}	1.50^{i}	1.80^{de}	1.63^{gh}
T_{14}	1.40^{abcd}	1.56^{ef}	2.36^{fg}	2.70^{ab}	1.09^{g}	2.33^{c}	2.53^{b}	2.22^{b}
T_{15}	1.33^{cdef}	1.40^{g}	2.60^{cde}	2.21^{de}	1.25^{d}	2.07^{d}	1.55^{h}	1.33^{j}
T_{16}	1.59^{a}	2.07^{a}	2.73^{bc}	2.56^{abc}	1.27^{d}	2.46^{a}	2.53^{b}	2.22^{b}

Treatments means having similar alphabets in superscript, do not differ significantly

during subsequent months. In general, for all the treatments, content of P was higher during initial growth stage, followed by a reduction, both in leaves and tubers (Table 20).

For ratoon crop, T_{12} (50 kg ha^{-1} N+ P, K+30 t FYM+ *Azospirillum* sp.) was statistically superior with high P content in leaves, whereas T_3 resulted in higher values in tubers (0.27, 0.24 and 0.69) followed by T_{16} (Table 21).

4.1.5.4 K content

Treatment with vermicompost along with NPK (T_4) recorded significantly higher value of K content in leaves during first month. In general, K content of leaves exhibited a decrease up to 5th month and there after progressive increase in values. Treatment effect did not follow a specific pattern. However, towards the second half of life period, T_5 (NPK + coirpith compost) recorded highest values (Table 22). No consistent pattern of variation among treatments observed in K content of tubers. In general, the values exhibited progressive increase from 4th month onwards.

For ratoon crop, maximum K content of leaves were observed in T_{14} in initial stage (4.53) and T_1 (absolute control) registered maximum value in subsequent months (3.07 and 2.77), whereas T_{13} (50 kg ha^{-1} N + P, K and 30 t FYM + AMF + *Azospirillum* sp.) recorded significantly highest K content of leaves during final stage (2.80) (Table 23). Regarding K content of tubers, no consistent variation was observed during the course of growth.

4.1.6 Soil analysis

Data pertaining to the post harvest soil properties is furnished in Table 24.

4.1.6.1 pH

Significantly higher $_{P}$H value was recorded in T_9 (100:50:50 kg NPK ha^{-1} + 30 t FYM + *Pseudomonas fluorescens*) (6.53) followed by T_{11} (6.47) and the least value was observed in T_4 (5.7).

4.1.6.2 Organic carbon

T_3 was statistically superior is this parameters (0.75) and minimum value was observed in T_1, T_6 and T_{15} (0.50).

4.1.6.3 Available nitrogen

There was significant variation between treatments in terms of this parameter ranged from 112.7 in T_1 to 168.7 in T_3.

4.1.6.4 Available P

Regarding available P, significantly highest value was observed in T_3 (24.33) and lowest P content was observed in treatments under T_1 (9.33).

4.1.6.5 Available K

Treatments exhibited less statistical variation regarding this parameters with a maximum value of 400 (T_1, T_2, T_4, T_5, T_6, T_7, T_{12}, T_{14} and T_{15}) and the minimum value was recorded by T_{11} (136.7).

4.1.7 Effect of treatments on over all performance

As far as overall performance is considered the vegetative parameters like plant height, number of leaves and number of tillers per hill were found to be significantly improved in treatments under T_3 followed by T_{14} (treatments consisted of poultry manure along with chemical fertilizers). T_{16} also exhibited superiority in terms of parameters like number of leaves and number of tillers per hill (Table 25 and Fig. 2).

Regarding floral characters, T_3 was significantly superior having lengthy spikes with more number of flowers and producing more number of spikes per hill. T_{16} closely followed T_3 in terms of parameters like length of rachis, number of florets per

Table 20. Effect of organic manures and growth promoting microorganisms along with inorganic fertilizers on P content of leaves and tubers (%) – main crop

	Months of observation															
	Leaf								Tuber							
	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
T_1	0.38^{bcd}	0.23^{abcd}	0.17^{de}	0.16^{bc}	0.15^{ab}	0.15^{ab}	0.24^{a}	0.09^{f}	0.23^{bcdef}	0.23^{ab}	0.16^{a}	0.09^{ab}	0.09^{a}	0.76^{b} (0.08)	0.08^{abc}	0.76^{b} (0.08)
T_2	0.23^{h}	0.20^{bcd}	0.18^{bcde}	0.14^{c}	0.12^{b}	0.13^{ab}	0.09^{b}	0.10^{ef}	0.27^{abc}	0.17^{bcd}	0.15^{a}	0.08^{ab}	0.09^{a}	0.74^{b} (0.05)	0.04^{c}	0.80^{ab} (0.14)
T_3	0.31^{cdef}	0.26^{ab}	0.19^{bcde}	0.18^{bc}	0.12^{b}	0.11^{b}	0.07^{b}	0.12^{def}	0.26^{abcd}	0.16^{cd}	0.14^{a}	0.11^{ab}	0.10^{a}	0.76^{b} (0.07)	0.07^{abc}	0.81^{ab} (0.15)
T_4	0.30^{def}	0.24^{ab}	0.18^{cde}	0.16^{bc}	0.12^{b}	0.12^{b}	0.07^{b}	0.11^{ef}	0.20^{def}	0.15^{d}	0.13^{a}	0.12^{ab}	0.13^{a}	0.79^{b} (0.13)	0.12^{a}	0.81^{ab} (0.15)
T_5	0.41^{a}	0.26^{ab}	0.24^{ab}	0.24^{a}	0.18^{a}	0.19^{a}	0.09^{b}	0.12^{def}	0.24^{bcdef}	0.21^{abc}	0.17^{a}	0.13^{ab}	0.10^{a}	0.77^{b} (0.09)	0.07^{abc}	0.86^{a} (0.25)
T_6	0.38^{ab}	0.24^{abc}	0.19^{bcde}	0.14^{c}	0.13^{ab}	0.13^{ab}	0.07^{b}	0.13^{def}	0.30^{a}	0.26^{a}	0.17^{a}	0.09^{ab}	0.09^{a}	0.75^{b} (0.06)	0.05^{bc}	0.84^{ab} (0.21)
T_7	0.27^{defgh}	0.25^{ab}	0.16^{e}	0.15^{bc}	0.14^{ab}	0.14^{ab}	0.13^{ab}	0.14^{cdef}	0.27^{ab}	0.25^{a}	0.16^{a}	0.07^{b}	0.07^{a}	0.74^{b} (0.06)	0.04^{c}	0.78^{b} (0.11)
T_8	0.32^{bcde}	0.27^{a}	0.23^{abcd}	0.18^{bc}	0.17^{ab}	0.15^{ab}	0.11^{ab}	0.13^{def}	0.18^{f}	0.17^{bcd}	0.11^{a}	0.12^{ab}	0.12^{a}	0.77^{b} (0.09)	0.07^{abc}	0.76^{b} (0.08)
T_9	0.28^{defg}	0.25^{ab}	0.26^{a}	0.20^{ab}	0.17^{ab}	0.15^{ab}	0.18^{ab}	0.23^{a}	0.18^{f}	0.17^{bcd}	0.16^{a}	0.13^{ab}	0.13^{a}	0.78^{b} (0.11)	0.10^{abc}	0.81^{ab} (0.15)
T_{10}	0.29^{defg}	0.25^{ab}	0.24^{abc}	0.20^{ab}	0.16^{ab}	0.16^{ab}	0.20^{ab}	0.21^{ab}	0.22^{bcdef}	0.18^{bcd}	0.11^{a}	0.11^{ab}	0.10^{a}	0.77^{b} (0.09)	0.08^{abc}	0.77^{b} (0.09)
T_{11}	0.26^{efgh}	0.17^{d}	0.18^{cde}	0.16^{bc}	0.15^{ab}	0.14^{ab}	0.14^{ab}	0.16^{bcde}	0.19^{ef}	0.16^{cd}	0.12^{a}	0.09^{ab}	0.09^{a}	0.76^{b} (0.09)	0.08^{abc}	0.77^{b} (0.10)
T_{12}	0.36^{abc}	0.18^{cd}	0.19^{bcde}	0.17^{bc}	0.13^{ab}	0.12^{b}	0.11^{ab}	0.12^{def}	0.22^{bcdef}	0.17^{bcd}	0.13^{a}	0.09^{ab}	0.09^{a}	0.76^{b} (0.09)	0.09^{abc}	0.81^{ab} (0.38)
T_{13}	0.25^{fgh}	0.18^{d}	0.18^{cde}	0.18^{bc}	0.17^{ab}	0.15^{ab}	0.16^{ab}	0.19^{abc}	0.26^{abcd}	0.24^{a}	0.16^{a}	0.14^{a}	0.09^{a}	0.77^{b} (0.09)	0.08^{abc}	0.81^{ab} (0.15)
T_{14}	0.24^{gh}	0.18^{cd}	0.16^{e}	0.17^{bc}	0.15^{ab}	0.15^{ab}	0.14^{ab}	0.13^{cdef}	0.26^{abcd}	0.26^{a}	0.15^{a}	0.14^{ab}	0.13^{a}	0.79^{b} (0.12)	0.11^{ab}	0.82^{ab} (0.18)
T_{15}	0.26^{fgh}	0.25^{ab}	0.19^{bcde}	0.18^{bc}	0.15^{ab}	0.15^{ab}	0.13^{ab}	0.13^{def}	0.25^{abcde}	0.18^{bcd}	0.12^{a}	0.11^{ab}	0.09^{a}	0.89^{a} (0.34)	0.06^{abc}	0.79^{ab} (0.12)
T_{16}	0.28^{defgh}	0.25^{ab}	0.17^{e}	0.17^{bc}	0.15^{ab}	0.14^{ab}	0.14^{ab}	0.17^{bcd}	0.21^{cdef}	0.18^{bcd}	0.13^{a}	0.13^{ab}	0.12^{a}	0.78^{b} (0.11)	0.09^{abc}	0.82^{ab} (0.18)

Treatments means having similar alphabets in superscript, do not differ significantly

Table 21. Effect of organic manures and growth promoting microorganisms along with inorganic fertilizers on P content of leaves and tubers (%) – ratoon crop

Treatments	Months of observation							
	Leaf				Tuber			
	1	2	3	4	1	2	3	4
T_{1}	0.41^{a}	0.19^{efgh}	0.16^{e}	0.17^{e}	0.82^{b} (0.17)	0.16^{de}	0.15^{bcd}	0.55^{abcd}
T_{2}	0.33^{bc}	0.19^{fgh}	0.18^{cde}	0.21^{bcde}	0.88^{b} (0.27)	0.21^{abcd}	0.19^{b}	0.62^{ab}
T_{3}	0.35^{b}	0.26^{bcd}	0.18^{de}	0.20^{cde}	0.92^{a} (0.35)	0.27^{a}	0.24^{a}	0.69^{a}
T_{4}	0.29^{cd}	0.23^{cdefgh}	0.17^{de}	0.24^{abcd}	0.91^{b} (0.34)	0.23^{abc}	0.17^{bc}	0.54^{abcd}
T_{5}	0.32^{bc}	0.25^{cdef}	0.19^{cde}	0.18^{de}	0.87^{b} (0.27)	0.23^{abc}	0.16^{bc}	0.54^{abcd}
T_{6}	0.26^{d}	0.22^{cdefgh}	0.17^{e}	0.18^{de}	0.82^{b} (0.18)	0.17^{cde}	0.15^{bcd}	0.65^{a}
T_{7}	0.27^{cd}	0.19^{gh}	0.20^{cde}	0.23^{abcde}	0.79^{b} (0.13)	0.12^{e}	0.12^{cd}	0.44^{bcd}
T_{8}	0.35^{b}	0.25^{cdefg}	0.23^{bcd}	0.26^{abc}	0.86^{b} (0.23)	0.17^{cde}	0.12^{cd}	0.46^{bcd}
T_{9}	0.27^{cd}	0.27^{bc}	0.22^{bcde}	0.22^{abcde}	0.87^{b} (0.25)	0.18^{bcde}	0.18^{bc}	0.52^{abcd}
T_{10}	0.32^{bc}	0.25^{bcde}	0.21^{bcde}	0.24^{abcd}	0.79^{b} (0.13)	0.13^{e}	0.10^{d}	0.37^{d}
T_{11}	0.26^{d}	0.20^{defgh}	0.18^{cde}	0.20^{cde}	0.84^{b} (0.21)	0.16^{de}	0.13^{bcd}	0.41^{cd}
T_{12}	0.35^{b}	0.34^{a}	0.26^{ab}	0.27^{ab}	0.87^{b} (0.25)	0.22^{abc}	0.12^{cd}	0.45^{bcd}
T_{13}	0.27^{cd}	0.25^{cdef}	0.24^{abc}	0.21^{cde}	0.81^{b} (0.16)	0.15^{de}	0.13^{bcd}	0.44^{bcd}
T_{14}	0.25^{d}	0.25^{cdefg}	0.19^{cde}	0.21^{cde}	0.92^{a} (0.36)	0.26^{a}	0.16^{bcd}	0.51^{abcd}
T_{15}	0.27^{cd}	0.18^{h}	0.18^{de}	0.22^{bcde}	0.86^{b} (0.24)	0.23^{ab}	0.14^{bcd}	0.43^{cd}
T_{16}	0.33^{bc}	0.31^{ab}	0.22^{bcde}	0.21^{cde}	0.92^{a} (0.35)	0.25^{a}	0.19^{b}	0.57^{abc}

Treatments means having similar alphabets in superscript, do not differ significantly; $\sqrt{X + 0.5}$ transformed values, original values in parenthesis

Table 22. Effect of organic manures and growth promoting microorganisms along with inorganic fertilizers on K content of leaves and tubers (%) – main crop

	Months of observation															
	Leaf								Tuber							
	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
T_{1}	2.46^{j}	1.64^{i}	1.60^{m}	1.40^{h}	1.64^{f}	2.00^{hi}	2.40^{f}	3.51^{c}	1.57^{h}	1.32^{b}	0.56^{ef}	0.78^{f}	1.44^{a}	1.49^{b}	1.60^{b}	1.68^{de}
T_{2}	5.42^{b}	1.98^{h}	1.97^{j}	1.12^{i}	1.88^{e}	2.37^{cd}	2.71^{cd}	3.83^{b}	2.36^{a}	0.54^{fgh}	0.73^{b}	1.09^{c}	1.04^{e}	1.57^{a}	1.74^{a}	1.87^{b}
T_{3}	3.90^{def}	2.44^{def}	1.76^{l}	1.94^{f}	2.52^{a}	2.54^{b}	2.69^{cde}	2.80^{e}	2.21^{abc}	1.38^{a}	0.86^{a}	1.03^{d}	1.04^{e}	1.15^{ef}	1.32^{def}	1.60^{ef}
T_{4}	6.40^{a}	3.06^{b}	2.06^{i}	1.99^{ef}	2.06^{d}	2.14^{fgh}	2.12^{g}	2.71^{ef}	2.35^{a}	0.77^{c}	0.56^{ef}	1.04^{d}	1.08^{d}	1.17^{e}	1.40^{cd}	2.03^{a}
T_{5}	2.80^{hij}	2.26^{g}	1.88^{k}	2.06^{def}	2.59^{a}	2.98^{a}	3.29^{a}	3.92^{a}	2.33^{ab}	0.60^{e}	0.86^{a}	1.09^{c}	1.13^{c}	1.29^{d}	1.33^{de}	1.83^{bc}
T_{6}	2.92^{ghij}	2.80^{c}	2.29^{f}	2.22^{bc}	2.24^{c}	2.97^{a}	3.00^{b}	3.12^{d}	1.55^{h}	0.67^{d}	0.85^{a}	0.93^{e}	0.77^{i}	1.02^{g}	1.27^{ef}	1.43^{g}
T_{7}	2.60^{ij}	2.44^{def}	2.22^{g}	1.61^{g}	1.80^{e}	2.03^{ghi}	2.16^{g}	2.50^{h}	2.08^{cde}	0.49^{hi}	0.60^{cde}	0.93^{e}	0.64^{k}	0.76^{i}	0.85^{hi}	1.53^{fg}
T_{8}	3.81^{def}	2.58^{d}	1.61^{m}	1.68^{g}	1.84^{e}	1.88^{i}	1.92^{h}	2.24^{i}	1.15^{i}	0.46^{i}	0.58^{def}	1.29^{a}	0.56^{l}	0.73^{i}	0.75^{i}	1.20^{h}
T_{9}	3.50^{fgh}	2.54^{de}	1.42^{n}	1.29^{h}	2.28^{bc}	2.33^{cde}	2.52^{def}	3.04^{d}	1.84^{fg}	0.55^{efgh}	0.63^{cd}	0.81^{f}	0.85^{g}	1.11^{f}	1.20^{f}	1.83^{bc}
T_{10}	4.56^{cd}	2.40^{efg}	2.44^{d}	2.23^{bc}	2.08^{d}	2.86^{a}	3.04^{b}	3.12^{d}	1.73^{g}	0.76^{c}	0.57^{ef}	0.80^{f}	0.69^{j}	0.89^{h}	0.97^{gh}	1.80^{bcd}
T_{11}	3.67^{efg}	3.40^{a}	2.50^{c}	2.41^{a}	2.40^{b}	2.46^{bc}	2.54^{cdef}	2.63^{fg}	2.04^{de}	0.59^{ef}	0.57^{ef}	0.69^{h}	0.78^{hi}	0.88^{h}	0.99^{g}	2.05^{a}
T_{12}	3.78^{def}	2.33^{fg}	2.14^{h}	2.08^{de}	2.00^{d}	2.32^{cde}	2.36^{f}	2.50^{h}	1.57^{h}	0.56^{efg}	0.53^{f}	0.73^{g}	0.81^{h}	1.17^{e}	1.19^{f}	1.22^{h}
T_{13}	4.78^{bc}	2.53^{de}	2.40^{de}	2.32^{ab}	2.40^{b}	2.46^{bc}	2.50^{def}	2.80^{e}	2.17^{bcd}	0.52^{gh}	0.57^{ef}	0.94^{e}	1.00^{f}	1.25^{d}	1.39^{cde}	1.73^{cd}
T_{14}	4.41^{cde}	2.76^{c}	2.56^{a}	2.40^{a}	2.36^{bc}	2.48^{bc}	2.48^{ef}	2.50^{h}	2.33^{ab}	0.66^{d}	0.64^{c}	0.92^{e}	1.08^{d}	1.20^{e}	1.33^{de}	1.44^{g}
T_{15}	3.38^{fghi}	2.49^{def}	2.36^{e}	2.16^{cd}	2.05^{d}	2.25^{def}	2.48^{ef}	2.60^{g}	1.99^{ef}	0.77^{c}	0.56^{ef}	1.03^{d}	1.04^{e}	1.50^{b}	1.57^{bc}	1.56^{efg}
T_{16}	4.96^{bc}	2.80^{c}	2.14^{h}	2.08^{de}	2.10^{d}	2.17^{efg}	2.75^{c}	4.00^{a}	1.11^{i}	0.67^{d}	0.66^{c}	1.23^{b}	1.27^{b}	1.43^{c}	1.48^{bc}	1.75^{bcd}

Treatments means having similar alphabets in superscript, do not differ significantly

Table 23. Effect of organic manures and growth promoting microorganisms along with inorganic fertilizers on K content of leaves and tubers (%) – ratoon crop

Treatments	Months of observation							
	Leaf				Tuber			
	1	2	3	4	1	2	3	4
T_1	3.05^{g}	3.07^{a}	2.77^{a}	2.62^{cd}	0.80^{f}	1.53^{f}	0.75^{h}	1.67^{de}
T_2	2.42^{j}	2.17^{f}	2.23^{def}	2.40^{def}	1.69^{bc}	2.33^{ab}	1.08^{efgh}	1.70^{cd}
T_3	3.71^{b}	2.49^{e}	2.34^{bcd}	2.31^{ef}	1.59^{c}	2.27^{b}	1.37^{bcde}	1.47^{g}
T_4	3.20^{f}	2.50^{cde}	2.33^{bcd}	2.50^{cde}	1.67^{bc}	2.30^{ab}	1.33^{cde}	1.83^{bc}
T_5	2.54^{i}	2.50^{cde}	2.21^{defg}	2.43^{def}	1.47^{d}	2.09^{c}	1.37^{bcde}	1.50^{fg}
T_6	3.74^{b}	2.72^{bcd}	2.45^{bc}	2.52^{cde}	1.26^{e}	1.75^{e}	1.47^{abcd}	1.69^{de}
T_7	2.63^{i}	2.43^{e}	2.03^{gh}	2.48^{de}	1.63^{c}	1.97^{cd}	0.96^{fgh}	1.45^{g}
T_8	3.53^{c}	2.73^{bc}	2.47^{bc}	2.50^{cde}	1.34^{e}	1.27^{g}	1.25^{cdef}	1.38^{gh}
T_9	3.70^{b}	2.47^{de}	2.53^{b}	2.60^{cd}	1.67^{bc}	2.06^{c}	1.57^{abc}	1.88^{ab}
T_{10}	3.80^{b}	2.47^{de}	2.35^{bcd}	2.69^{bc}	1.26^{e}	1.85^{de}	1.17^{defg}	1.63^{def}
T_{11}	3.42^{cd}	2.50^{cde}	2.00^{h}	2.42^{def}	1.23^{e}	2.27^{b}	0.86^{gh}	1.83^{bc}
T_{12}	2.77^{h}	2.53^{cde}	2.10^{efgh}	2.51^{cde}	1.58^{c}	1.82^{de}	0.83^{gh}	1.26^{h}
T_{13}	3.50^{c}	2.70^{bcd}	2.08^{fgh}	2.80^{a}	1.27^{e}	1.88^{de}	1.03^{efgh}	1.53^{efg}
T_{14}	4.53^{a}	2.50^{cde}	2.31^{cd}	2.50^{cde}	1.69^{bc}	2.23^{b}	1.30^{cdef}	1.50^{fg}
T_{15}	3.35^{de}	2.47^{de}	2.33^{bcd}	2.60^{cd}	1.77^{b}	2.43^{a}	1.70^{ab}	2.00^{a}
T_{16}	3.25^{ef}	2.90^{b}	2.21^{cde}	2.33^{ef}	2.09^{a}	2.03^{c}	1.78^{a}	1.77^{bcd}

Treatments means having similar alphabets in superscript, do not differ significantly

Table 24. Effect of organic manures and growth promoting microorganisms along with inorganic fertilizers on post harvest soil properties

Treatments	pH	Organic carbon (%)	Available N (kg ha^{-1})	Available P (kg ha^{-1})	Available K (kg ha^{-1})
T_1	5.78^{hi}	0.50^{e}	112.7^{e}	9.33^{f}	400.00^{a}
T_2	6.13^{e}	0.65^{b}	134.4^{c}	12.67^{d}	400.00^{a}
T_3	6.30^{d}	0.75^{a}	168.7^{a}	24.33^{a}	360.5^{bc}
T_4	5.70^{i}	0.61^{c}	166.00^{a}	22.67^{d}	400.00^{a}
T_5	6.37^{c}	0.60^{c}	134.40^{c}	12.67^{b}	400.00^{a}
T_6	6.33^{cd}	0.50^{e}	112.70^{e}	12.00^{d}	400.00^{a}
T_7	5.77^{hi}	0.65^{b}	146.30^{b}	9.67^{f}	400.00^{a}
T_8	5.87^{g}	0.65^{b}	145.60^{b}	13.97^{c}	359.30^{bc}
T_9	6.53^{a}	0.51^{e}	113.50^{e}	14.47^{c}	399.00^{a}
T_{10}	5.70^{i}	0.54^{d}	120.90^{d}	14.47^{c}	164.30^{d}
T_{11}	6.47^{b}	0.55^{d}	123.90^{d}	12.00^{d}	136.70^{e}
T_{12}	5.83^{gh}	0.60^{c}	135.10^{c}	11.60^{de}	400.00^{a}
T_{13}	6.03^{f}	0.51^{e}	113.50^{e}	11.43^{de}	358.00^{c}
T_{14}	6.5^{a}	0.65^{b}	146.30^{b}	17.47^{b}	400.00^{a}
T_{15}	6.47^{b}	0.50^{e}	112.70^{c}	11.83^{d}	400.00^{a}
T_{16}	6.10^{e}	0.60^{c}	143.90^{b}	10.43^{ef}	369.30^{b}

Treatments means having similar alphabets in superscript, do not differ significantly

Table 25. Treatment effect on over all performance

Treat-ment	Plant height (cm)	Number of leaves	Leaf area (cm^2)	Number of tillers per hill	Length of the spike (cm)	Length of rachis (cm)	Number of florets per spike	Field life (days)	Yield of spikes per hill	Duration of the crop (days)
T_1	29.17	24.03	628.20	1.45	74.21	7.99	33.83	1.33	16.00	196.00
T_2	28.20	25.55	812.35	1.73	69.35	23.75	32.50	1.17	17.50	189
T_3	32.41	41.00	1533.87	2.03	91.69	34.97	40.58	2.42	21.33	311.30
T_4	28.31	23.97	725.45	1.61	82.00	26.01	32.75	1.50	17.00	2650
T_5	26.30	23.99	785.37	1.69	76.16	27.71	33.50	1.42	17.83	277.33
T_6	26.60	22.40	658.35	1.67	81.30	24.50	31.67	1.08	14.50	270.00
T_7	27.32	24.78	854.90	1.74	73.12	27.37	37.75	1.50	18.50	241.00
T_8	25.55	23.50	669.88	1.72	72.23	23.75	26.05	1.00	17.33	197.70
T_9	25.22	21.24	674.42	1.53	84.62	25.00	32.92	1.08	12.67	214.00
T_{10}	26.30	19.03	585.93	1.36	83.35	24.13	30.58	1.25	13.50	213.3
T_{11}	25.25	22.02	435.52	1.58	80.01	25.02	32.00	0.92	13.67	231.30
T_{12}	24.64	26.77	604.18	1.73	79.33	25.92	30.75	1.17	14.00	196.30
T_{13}	27.95	27.32	695.90	1.68	76.29	30.51	34.50	1.25	13.67	205.00
T_{14}	32.31	37.51	1212.64	2.03	90.27	30.17	36.58	2.17	20.00	265.00
T_{15}	28.72	26.07	837.42	1.60	77.85	26.81	31.58	1.25	17.33	237.30
T_{16}	26.51	27.37	1015.13	1.77	85.25	30.68	38.38	1.58	17.33	288.50

Experiment – 1

Fig.2 Effect of combination of organic manures and growth promoting microorganisms on vegetative characters

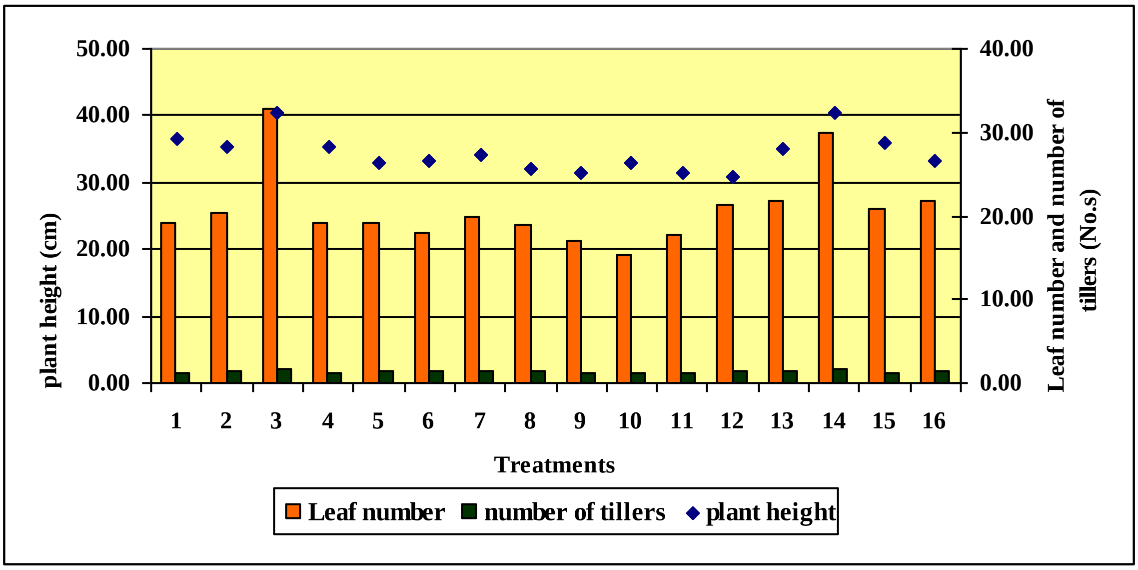


Fig.3 Effect of combination of organic manures and growth promoting microorganisms on floral characters

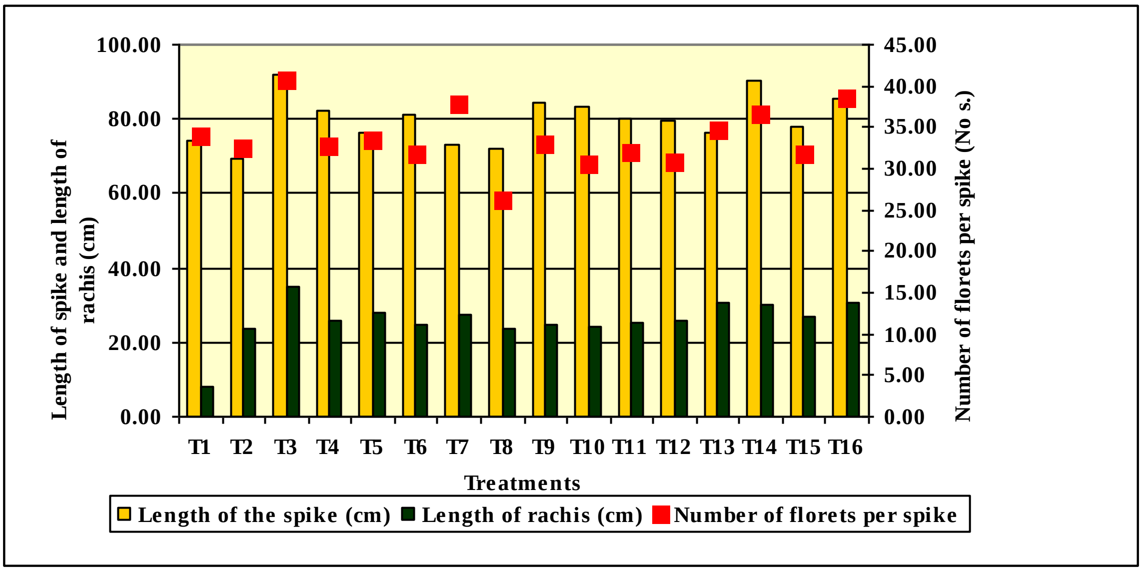


Fig.4 Effect of combination of organic manures and growth promoting microorganisms on yield of spikes per hill

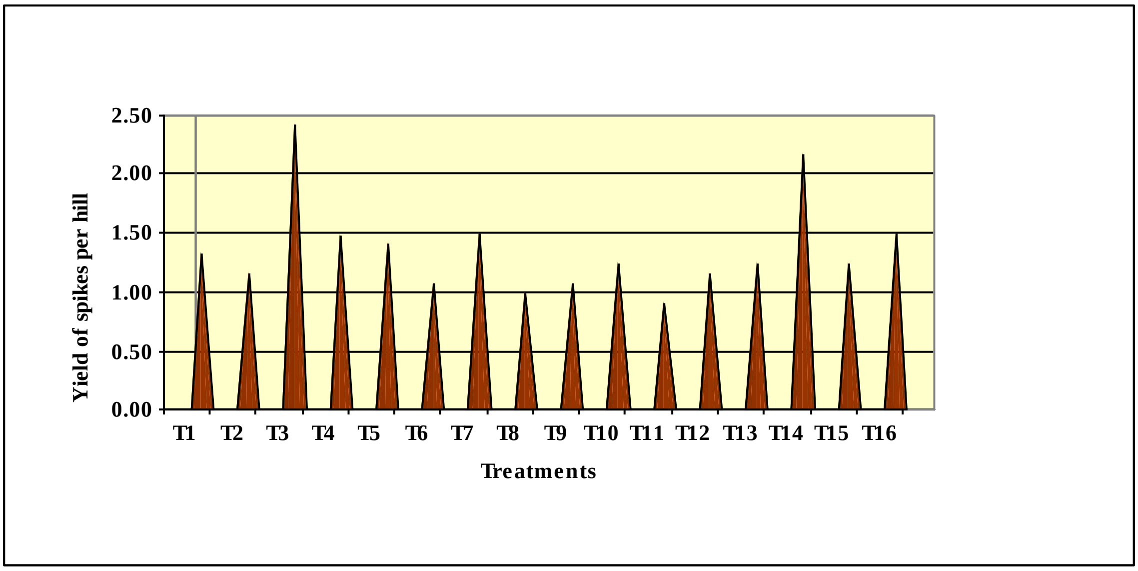
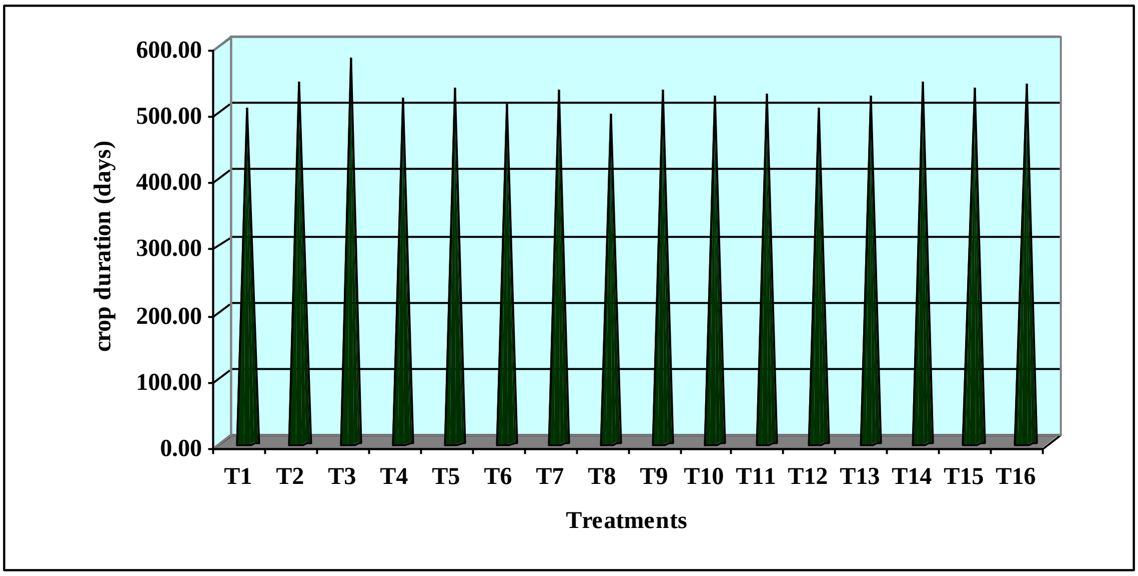


Fig.5 Effect of combination of organic manures and growth promoting microorganisms on duration of the crop



spike and duration of the crop where as T_{14} was next to T_3 in length of spike, yield of spikes per hill and field life (Plates.5, 6, 7 and Fig.3, 4 and 5).

4.2 MAIN AND RATOON CROP OF EXPERIMENT 2

4.2.1 Vegetative characters

Data pertaining to vegetative characters of main and ratoon crop of experiment 2 are presented in Tables 26 to 35.

4.2.1.1 Plant height

Regarding the plant height, there was significant variation among the treatments (Table 26). During major part of the growth period, treatment T_4 (Poultry manure, 29.63 t ha^{-1}) was found to be the best as it recorded maximum plant height, followed by T_7 (Biogas slurry 500 t ha^{-1}). In the case of ratoon crop also T_4 and T_7 were statistically superior in this parameter during the growth period (Table 27).

4.2.1.2 Plant spread

In the case of plant spread in North- South as well as East-West directions, T_4 exhibited significantly highest values followed by T_7 through out the growth period (Table 28).

In the case of ratoon crop also, maximum plant spread was observed in T_4 in both directions during the course of growth (Table 29).

In general, it was observed that, for all the treatments there was a reduction in plant spread during sixth month of observation in both the directions. Thereafter an increasing trend in plant spread was noticed.

4.2.1.3 Number of leaves

Treatments differed significantly in the case of number of leaves during the growth period. Highest number of leaves were observed in treatment T_4 followed by T_7 in main and ratoon crop during the course of growth. (Tables 30 and 31).

Superior treatments from experiment 1

Plate 5. T_3 - 100:50:50 kg NPK ha^{-1} + poultry manure 22.22 t ha^{-1}

Plate 6. T_{14} - 50 kg ha^{-1} N + P, K+ poultry manure 22.22 t ha^{-1}

Plate 7. T_{16} - 50 kg ha^{-1} N + P, K + coir pith compost 85.71 t ha^{-1}

Table 26. Effect of organic sources of nutrients on plant height (cm) – main crop

Treatment	Months of observation										
	1	2	3	4	5	6	7	8	9	10	
T_1	11.97^{e}	17.49^{d}	23.5^{a}	26.25^{abc}	28.67^{a}	17.08^{bc}	20.87^{bc}	17.42^{cd}	23.06^{b}	25.72^{bc}	28.75^{b}
T_2	14.42^{cde}	17.75^{cd}	22.03^{a}	22.03^{cd}	28.67^{a}	14.58^{c}	20.25^{bc}	17.57^{bcd}	21.20^{b}	23.93^{c}	27.00^{b}
T_3	15.75^{bcd}	20.33^{abcd}	19.10^{a}	24.75^{bcd}	25.10^{a}	20.92^{ab}	19.00^{bcd}	18.92^{bc}	22.80^{b}	24.33^{c}	26.75^{b}
T_4	19.68^{a}	22.58^{ab}	25.29^{a}	30.75^{a}	31.14^{a}	20.92^{ab}	22.33^{b}	24.83^{a}	31.97^{a}	34.00^{a}	41.17^{a}
T_5	16.81^{abc}	21.66^{abc}	19.57^{a}	25.79^{abc}	27.67^{a}	19.03^{bc}	18.37^{cd}	20.92^{b}	27.52^{ab}	30.33^{abc}	34.17^{ab}
T_6	15.80^{bcd}	19.33^{bcd}	22.05^{a}	27.95^{ab}	30.33^{a}	21.17^{ab}	22.17^{bc}	19.58^{bc}	27.75^{ab}	31.87^{ab}	36.42^{ab}
T_7	18.72^{ab}	23.54^{a}	21.37^{a}	26.87^{abc}	29.17^{a}	24.42^{a}	27.50^{a}	19.92^{bc}	25.67^{b}	28.83^{abc}	32.58^{ab}
T_8	12.55^{de}	16.55^{d}	21.50^{a}	20.31^{d}	23.50^{a}	16.12^{bc}	15.75^{d}	15.08^{d}	22.60^{b}	26.17^{bc}	30.17^{ab}
T_9	13.70^{cde}	18.75^{bcd}	23.18^{a}	25.67^{abc}	28.13^{a}	19.28^{bc}	18.95^{bcd}	17.80^{bcd}	22.42^{b}	24.33^{c}	27.08^{b}

Treatments means having similar alphabets in superscript, do not differ significantly

Table 27. Effect of organic sources of nutrients on plant height (cm) – ratoon crop

Treatment	Months of observation				
	1	2	3	4	5
T_1	19.88^{bc}	20.08^{bc}	25.17^{b}	28.00^{de}	24.08^{ef}
T_2	14.24^{d}	17.50^{bc}	18.50^{c}	27.17^{e}	26.67^{def}
T_3	19.13^{bc}	22.27^{b}	23.28^{bc}	33.00^{bc}	30.17^{cd}
T_4	28.59^{a}	31.67^{a}	36.17^{a}	44.00^{a}	34.92^{bc}
T_5	14.08^{d}	17.58^{bc}	20.42^{bc}	27.42^{e}	28.83^{de}
T_6	21.97^{b}	28.75^{a}	34.50^{a}	35.50^{b}	34.58^{bc}
T_7	23.50^{b}	27.58^{a}	35.25^{a}	44.00^{a}	41.58^{a}
T_8	14.20^{d}	16.08^{c}	24.42^{b}	31.17^{cd}	39.33^{ab}
T_9	15.85^{cd}	16.58^{c}	23.00^{bc}	33.50^{bc}	22.67^{f}

Treatments means having similar alphabets in superscript, do not differ significantly

Table 28. Effect of organic sources of nutrients on plant spread (cm) – main crop

Treatments	Months of observation											
	1		2		3		4		5		6	
	NS	EW	NS	EW	NS	EW	NS	EW	NS	EW	NS	EW
T_1	8.83^{d}	17.99^{c}	13.00^{e}	17.08^{cd}	18.74^{a}	21.80^{a}	15.92^{c}	17.33^{b}	24.58^{ab}	17.58^{a}	7.77^{c}	10.43^{abc}
T_2	11.87^{d}	17.52^{ab}	20.25^{cd}	22.08^{bcd}	21.57^{a}	19.72^{a}	20.23^{bc}	21.50^{ab}	28.00^{ab}	27.08^{a}	9.08^{bc}	8.00^{c}
T_3	17.43^{bc}	16.07^{b}	24.54^{bc}	21.83^{bcd}	22.82^{a}	23.47^{a}	26.83^{ab}	22.83^{ab}	33.47^{a}	31.83^{a}	7.42^{c}	9.00^{bc}
T_4	25.27^{a}	22.97^{a}	28.92^{ab}	27.92^{ab}	27.37^{a}	27.63^{a}	30.25^{a}	29.75^{a}	33.25^{a}	30.75^{a}	13.33^{ab}	13.25^{ab}
T_5	20.17^{b}	22.33^{a}	23.58^{bc}	23.42^{bc}	23.83^{a}	20.80^{a}	21.42^{abc}	24.08^{ab}	26.67^{ab}	24.17^{a}	11.42^{abc}	10.75^{abc}
T_6	13.63^{cd}	14.42^{b}	17.10^{de}	17.91^{cd}	23.43^{a}	25.65^{a}	23.00^{abc}	24.17^{ab}	26.33^{ab}	26.25^{a}	12.08^{abc}	12.08^{abc}
T_7	17.02^{bc}	18.06^{ab}	31.92^{a}	33.92^{a}	27.57^{a}	24.73^{a}	25.08^{ab}	23.33^{ab}	27.83^{ab}	27.00^{a}	14.17^{a}	13.83^{a}
T_8	9.54^{d}	11.98^{bc}	16.78^{de}	19.29^{cd}	22.93^{a}	25.57^{a}	23.90^{abc}	28.17^{ab}	19.08^{b}	21.08^{a}	9.67^{abc}	10.03^{abc}
T_9	12.06^{d}	13.23^{bc}	17.33^{de}	14.93^{d}	25.10^{a}	25.13^{a}	21.17^{bc}	26.85^{ab}	30.66^{ab}	31.27^{a}	9.08^{bc}	8.50^{c}

Treatments means having similar alphabets in superscript, do not differ significantly

Table 28. continued

Treatments	Months of observation									
	7		8		9		10		11	
	NS	EW	NS	EW	NS	EW	NS	EW	NS	EW
T_1	7.75^{d}	10.50^{b}	17.17^{bc}	19.83^{abc}	22.53^{b}	23.33^{a}	25.03^{b}	25.00^{a}	28.17^{b}	27.25^{a}
T_2	11.75^{bcd}	10.83^{b}	17.33^{bc}	15.75^{c}	23.83^{ab}	22.86^{a}	27.17^{ab}	26.00^{a}	30.67^{ab}	30.00^{a}
T_3	9.92^{cd}	10.67^{b}	24.58^{a}	24.00^{a}	26.58^{a}	26.83^{a}	28.67^{ab}	28.67^{a}	30.67^{ab}	30.08^{a}
T_4	18.83^{a}	18.17^{a}	19.92^{abc}	20.08^{abc}	26.58^{a}	28.17^{a}	29.83^{a}	32.33^{a}	33.33^{a}	37.08^{a}
T_5	12.42^{bcd}	11.75^{b}	21.33^{ab}	21.48^{ab}	24.70^{ab}	25.54^{a}	26.17^{ab}	26.67^{a}	28.33^{b}	29.67^{a}
T_6	14.00^{abc}	14.08^{ab}	20.75^{ab}	19.50^{abc}	24.33^{ab}	23.60^{a}	26.67^{ab}	28.00^{a}	27.67^{b}	33.17^{a}
T_7	16.25^{ab}	17.42^{a}	21.08^{ab}	18.25^{bc}	24.33^{ab}	23.17^{a}	27.33^{ab}	28.00^{a}	31.67^{ab}	30.67^{a}
T_8	10.67^{bcd}	10.25^{b}	15.17^{c}	15.58^{c}	21.42^{b}	24.92^{a}	24.50^{b}	29.33^{a}	27.92^{b}	34.50^{a}
T_9	10.75^{bcd}	11.08^{b}	17.00^{bc}	15.92^{c}	24.75^{ab}	23.50^{a}	28.50^{ab}	27.67^{a}	33.00^{a}	31.67^{a}

Treatments means having similar alphabets in superscript, do not differ significantly

Table 29. Effect of organic sources of nutrients on plant spread (cm) – ratoon crop

Treatments	Months of observation									
	1		2		3		4		5	
	NS	EW	NS	EW	NS	EW	NS	EW	NS	EW
T_1	21.71^{abc}	25.33^{ab}	24.83^{d}	26.67^{c}	31.50^{c}	33.67^{b}	35.00^{b}	38.33^{bc}	32.33^{cd}	37.33^{e}
T_2	21.90^{abc}	22.77^{abc}	31.25^{abc}	34.17^{ab}	36.83^{b}	38.67^{ab}	39.50^{b}	41.17^{ab}	36.00^{d}	39.67^{de}
T_3	23.34^{ab}	22.42^{abc}	29.22^{abcd}	28.33^{c}	32.83^{bc}	33.17^{b}	36.00^{b}	35.33^{bc}	43.33^{ab}	43.17^{bc}
T_4	24.71^{a}	28.52^{a}	34.08^{a}	36.00^{a}	44.67^{a}	41.17^{a}	46.33^{a}	44.75^{a}	47.33^{a}	47.00^{a}
T_5	15.06^{d}	19.12^{bc}	29.50^{abcd}	30.00^{bc}	35.00^{bc}	34.33^{ab}	37.50^{b}	36.17^{bc}	37.83^{cd}	39.50^{de}
T_6	25.92^{a}	28.00^{a}	32.58^{ab}	35.08^{ab}	36.50^{bc}	37.25^{ab}	39.67^{b}	39.00^{abc}	41.00^{bc}	45.83^{ab}
T_7	23.88^{a}	24.27^{abc}	31.42^{ab}	30.58^{abc}	37.00^{b}	34.58^{ab}	37.67^{b}	35.75^{bc}	39.67^{bcd}	41.67^{cd}
T_8	18.34^{bcd}	18.20^{c}	28.33^{bcd}	27.75^{c}	31.83^{bc}	32.50^{b}	34.67^{b}	33.42^{c}	39.83^{bcd}	43.17^{bc}
T_9	17.05^{cd}	21.50^{bc}	26.33^{cd}	26.17^{c}	32.83^{bc}	32.17^{b}	37.33^{b}	36.83^{bc}	37.83^{cd}	37.50^{e}

Treatments means having similar alphabets in superscript, do not differ significantly

4.2.1.4 Leaf area

Regarding the leaf area, significant variation was observed through out the course of growth. During the initial growth period T_4 (Poultry manure 29.63 t ha^{-1}) recorded highest value followed by T_7 in subsequent months. Generally, there was a reduction in leaf area in sixth month of observation and there after an increase was observed in terms of this parameter for all the treatments (Table 32).

For ratoon crop, leaf area was maximum in T_7 during initial growth period (450.00 cm^2). T_4 and T_7 were performing on par with maximum leaf area towards the final growth stage (Table 33).

4.2.1.5 Number of tillers

During the initial months of observation, no significant variation was observed in number of tillers and in subsequent months T_4 the treatment consisted of poultry manure produced maximum number of tillers (1.81, 1.82, 1.89, 1.93 and 1.99 respectively) (Table 34).

In ratoon crop also T_4 and T_7 produced maximum number of tillers per hill (Table 35).

Generally T_4 and T_7 produced maximum number of tillers during both the seasons.

4.2.2 Floral characters

Variation in floral characters are furnished in Table 36 (main crop) and Table 37 (ratoon crop of Experiment 2).

4.2.2.1 Days for first spike emergence

Earliest spike emergence was noticed in T_4 (119.33 days) which was on par with T_7 (160.33 days) and all other treatments were statistically on par with respect to this parameter.

In the case of ratoon crop also T_4 took minimum number of days (141.70 days) for the emergence of first spike.

4.2.2.2 Days to first floret opening

Significant variation was observed in the case of days to first floret opening. Minimum was observed in T_7 (15.67 days) which was on par with T_2 (15.83 days) (100:50:50 kg NPK ha^{-1} + 30 t FYM) and maximum delay in first floret opening was noticed in T_9 (panchagavya spray) (19.67).

During the ratoon crop T_7 and T_6 (Coirpith compost + 100 kg N ha^{-1}) resulted in early opening of floret.

4.2.2.3 Days to complete opening of florets in the spike

Floret opening was completed in maximum number of days in T_4 and T_7 (12.67 and 12.33 days respectively). In ratoon crop also T_4 was superior in terms of this parameter (14.00 days).

4.2.2.4 Length of the spike

Longest spikes of 86.17 cm and 85.5 cm were produced in treatments consisted of biogas slurry and poultry manure (T_7 and T_4 respectively) in the main crop. Same treatments resulted in longest spikes during ratoon crop also (79.73 cm and 82.13 cm). Shortest spikes were seen in T_9 (50 cm) and in T_1 (67.53) during main and ratoon crop.

4.2.2.5 Girth of the spike

Girth of the spike ranged from 1.67 cm in T_9 to 3.03 cm in T_8 (vermi wash spray) in main crop and for the ratoon crop, T_2 resulted in maximum girth of the spike (2.5 cm) where as T_1 gave minimum value (1.85 cm) which was on par with T_9 (1.88 cm).

4.2.2.6 *Length of the rachis*

T_7 was statistically superior in terms of length of rachis (26.33 cm) followed by T_4 and T_6 (24.00 cm) and shortest length of rachis was observed in T_1 (15.67 cm). During the ratoon crop the trend was different. T_4 registered significantly highest rachis length (27.51 cm) followed by T_7 (26.00 cm) and shortest rachis length of 17.63 observed in T_9.

4.2.2.7 *Number of florets per spike*

Both in plant and ratoon crops T_4 had maximum number of florets per spike (41.33 and 32.33 respectively) followed by T_7 (39.00 and 28.67 respectively). Minimum number of florets was observed in T_9 (22.00) for main crop and in T_5 (20.00) for ratoon crop.

4.2.2.8 *Length of the corolla tube*

No significant variation was observed among the treatments except in T_9 which recorded minimum length of the corolla tube (3.6 cm).

During ratoon crop T_2, T_4, T_6 (treatment consisted of coir pith compost) and T_7 were performing on par with maximum length of the corolla tube (5.00 cm) and T_8 resulted in minimum value (4.42 cm).

4.2.2.9 *Size of the floret*

Both in plant and ratoon crop T_7 (3.97 and 3.72 cm respectively) and T_4 (3.83 and 3.58 cm respectively) recorded maximum size of the floret and minimum size was noticed in T_9 (2.03 and 2.43 cm respectively).

4.2.2.10 *Longevity of the floret*

No significant variation in floret longevity was observed among the treatments, for main crop but in ratoon T_4, T_5 (treatment consisted of vermicompost),

T_6 and T_7 were performing on par with maximum longevity of the floret. Longevity was minimum in T_9 (2.33 days).

4.2.2.11 Field life of spike

During plant and ratoon crops maximum field life of spike was under T_4 (15.30) followed by T_7 (14.33 and 12.33 days respectively). T_1 resulted in early wilting of the florets in 8.83 in main crop and 9.00 days in ratoon crop.

4.2.2.12 Duration of the crop

Crop duration was the maximum (528.33 days) for the plants under T_4 followed by T_7 (520.33 days) and was minimum in T_8 (458.37 days).

During ratoon crop also T_4 recorded maximum duration of the crop (498.00 days) followed by T_7 (483.00 days) and minimum duration was observed in T_1 (369.00 days).

4.2.2.13 Yield of spikes per hill

Plants under treatment T_4 produced maximum number of spikes per hill both in main and ratoon crops (1.42 and 2.17). Spike production was minimum in T_9 for both the crops (0.17 and 1.00).

4.2.3 Post harvest spike characters

Post harvest spike characters are given in Tables 38 (main crop) and 39 (ratoon crop) and Plate 11.

4.2.3.1 Fresh weight of the spike

T_7 (treatment with Biogas slurry) registered maximum fresh weight of the spike both in main crop and ratoon crop (51.80 and 50.00 g respectively) and

Table 30. Effect of organic sources of nutrients on number of leaves – main crop

Treatment	Months of observation										
	1	2	3	4	5	6	7	8	9	10	11
T_1	6.27^{ab}	7.38^{ab}	14.58^{bc}	15.17^{cd}	16.42^{b}	9.58^{c}	11.67^{c}	17.83^{bcd}	31.83^{b}	38.83^{b}	46.17^{a}
T_2	4.10^{b}	7.08^{a}	7.33^{d}	10.58^{d}	16.92^{b}	9.75^{c}	11.00^{c}	18.75^{bcd}	32.33^{b}	39.33^{b}	46.50^{a}
T_3	6.57^{ab}	8.00^{a}	11.13^{cd}	21.92^{abc}	25.12^{ab}	9.42^{c}	11.58^{c}	27.67^{ab}	39.33^{ab}	44.83^{ab}	51.17^{a}
T_4	8.70^{a}	11.83^{a}	23.00^{a}	25.08^{ab}	27.92^{a}	18.83^{ab}	21.08^{ab}	26.75^{abc}	46.33^{a}	56.33^{a}	66.50^{a}
T_5	8.95^{a}	11.08^{a}	20.02^{ab}	21.40^{abc}	22.42^{ab}	12.25^{c}	14.50^{bc}	26.33^{abcd}	39.08^{ab}	46.50^{ab}	54.67^{a}
T_6	6.96^{ab}	7.92^{ab}	18.93^{ab}	17.17^{bcd}	18.17^{b}	14.00^{bc}	19.83^{ab}	20.75^{abcd}	38.83^{ab}	36.17^{b}	57.33^{a}
T_7	5.30^{ab}	8.17^{ab}	16.49^{bc}	26.50^{a}	27.42^{a}	21.42^{a}	23.25^{a}	31.33^{a}	42.50^{ab}	47.67^{ab}	55.00^{a}
T_8	5.30^{ab}	5.83^{b}	16.13^{bc}	13.50^{cd}	17.17^{b}	12.17^{c}	11.42^{c}	16.50^{d}	30.67^{b}	36.67^{b}	45.00^{a}
T_9	4.60^{ab}	8.93^{ab}	11.50^{cd}	17.75^{bcd}	19.10^{ab}	11.50^{c}	12.00^{c}	16.92^{cd}	32.67^{ab}	40.50^{b}	49.17^{a}

Treatments means having similar alphabets in superscript, do not differ significantly

Table 31. Effect of organic sources of nutrients on number of leaves – ratoon crop

Treatment	Months of observation				
	1	2	3	4	5
T_1	10.50^{f}	22.00^{d}	24.83^{c}	33.67^{cd}	26.67^{d}
T_2	12.23^{ef}	22.17^{d}	24.67^{c}	37.00^{c}	32.83^{cd}
T_3	17.27^{cde}	30.28^{bc}	32.00^{bc}	38.17^{c}	46.67^{ab}
T_4	29.21^{a}	34.17^{ab}	36.33^{ab}	50.67^{a}	53.50^{a}
T_5	19.60^{bcd}	21.17^{d}	25.25^{c}	35.83^{cd}	37.33^{bcd}
T_6	23.21^{abc}	41.50^{a}	43.17^{a}	44.50^{b}	38.83^{bcd}
T_7	25.79^{ab}	32.17^{bc}	43.33^{a}	49.17^{a}	53.00^{a}
T_8	23.06^{abc}	30.83^{bc}	32.33^{bc}	37.17^{c}	39.83^{bc}
T_9	14.21^{def}	24.33^{d}	28.33^{bc}	31.17^{d}	44.00^{abc}

Treatments means having similar alphabets in superscript, do not differ significantly

Table 32. Effect of organic sources of nutrients on leaf area (cm^2) - main crop

Treatment	Months of observation										
	1	2	3	4	5	6	7	8	9	10	11
T_1	53.820^{c}	113.213^{f}	139.927^{f}	337.770^{d}	525.607^{g}	238.597^{efg}	327.907^{e}	897.717^{a}	924.097^{efg}	1010.770^{f}	1256.710^{g}
T_2	39.273^{b}	135.257^{e}	171.323^{e}	446.923^{cde}	520.153^{g}	233.467^{def}	306.390^{f}	422.290^{def}	892.043^{f}	1270.753^{def}	1641.677^{cde}
T_3	72.153^{bcd}	167.033^{d}	172.113^{e}	717.107^{bcd}	972.180^{d}	244.087^{d}	319.110^{efg}	531.260^{cdef}	983.433^{e}	1282.503^{d}	1619.893^{c}
T_4	155.113^{a}	336.900^{a}	668.057^{a}	881.943^{b}	1573.873^{a}	641.110^{ab}	716.683^{b}	540.820^{cde}	1342.083^{b}	2188.897^{a}	2502.860^{ab}
T_5	118.610^{ab}	202.673^{c}	311.580^{bcd}	784.823^{bc}	1327.120^{b}	304.643^{c}	542.613^{c}	744.917^{bcd}	1187.597^{c}	1466.650^{c}	1853.840^{b}
T_6	81.720^{bc}	131.130^{e}	354.653^{bc}	483.550^{c}	921.310^{def}	318.390^{bcde}	482.403^{d}	442.973^{d}	1004.033^{d}	1439.340^{cde}	1801.297^{bcd}
T_7	97.887^{b}	247.427^{b}	591.807^{b}	1037.290^{a}	1190.327^{c}	677.190^{a}	740.987^{a}	771.297^{b}	1451.43^{a}	1735.933^{b}	2633.653^{a}
T_8	50.823^{c}	88.397^{g}	154.643^{efgh}	282.847^{e}	692.427^{e}	322.587^{b}	231.443^{g}	358.723^{e}	688.833^{g}	965.123^{g}	1377.797^{f}
T_9	72.117^{bcd}	92.^{213fgh}	233.083^{d}	324.827^{def}	596.930^{b}	235.067^{def}	297.757^{fg}	551.880^{c}	816.217^{fgh}	1124.600^{e}	1510.963^{e}

Treatments means having similar alphabets in superscript, do not differ significantly

Table 33. Effect of organic sources of nutrients on leaf area (cm^2) – ratoon crop

Treatment	Months of observation				
	1	2	3	4	5
T_1	141.80^{c}	226.30^{d}	398.00^{c}	721.60^{cd}	389.60^{c}
T_2	123.10^{c}	294.90^{d}	492.70^{cd}	836.50^{cd}	717.30^{bc}
T_3	252.60^{bc}	514.60^{bcd}	712.20^{bcd}	953.60^{bc}	1175.00^{b}
T_4	393.90^{ab}	752.20^{ab}	904.80^{abc}	1738.00^{a}	2038.00^{a}
T_5	217.10^{c}	245.00^{d}	467.60^{cd}	723.00^{cd}	1173.00^{b}
T_6	442.40^{a}	905.70^{a}	1105.00^{ab}	1154.00^{b}	1189.00^{b}
T_7	450.00^{a}	704.00^{abc}	1259.00^{a}	1645.00^{a}	2520.00^{a}
T_8	252.70^{c}	455.70^{cd}	569.70^{cd}	1168.00^{b}	755.10^{bc}
T_9	135.90^{c}	295.50^{d}	523.20^{cd}	594.00^{d}	666.70^{bc}

Treatments means having similar alphabets in superscript, do not differ significantly

Table 34. Effect of organic sources of nutrients on number of tillers per hill – main crop

Treatment	Months of observation										
	1	2	3	4	5	6	7	8	9	10	11
T_1	1.02^{a}	1.09^{a}	1.28^{ab}	1.42^{ab}	1.45^{c}	1.48^{c}	1.52^{b}	1.99^{bc}	2.03^{b}	2.53^{a}	2.56^{ab}
T_2	0.81^{a}	1.12^{a}	1.16^{b}	1.33^{ab}	1.48^{c}	1.57^{bc}	1.57^{b}	2.61^{a}	2.62^{a}	2.63^{a}	2.65^{ab}
T_3	0.95^{a}	1.15^{a}	1.20^{b}	1.42^{ab}	1.56^{bc}	1.61^{bc}	1.70^{ab}	2.49^{ab}	2.58^{ab}	2.64^{a}	2.70^{ab}
T_4	1.37^{a}	1.48^{a}	1.81^{a}	1.82^{a}	1.89^{a}	1.93^{a}	1.99^{a}	2.48^{ab}	2.55^{ab}	2.65^{a}	2.86^{a}
T_5	0.87^{a}	1.41^{a}	1.48^{ab}	1.48^{ab}	1.49^{c}	1.75^{abc}	1.79^{ab}	2.31^{abc}	2.31^{ab}	2.31^{a}	2.38^{b}
T_6	1.11^{a}	1.14^{a}	1.51^{ab}	1.64^{ab}	1.67^{abc}	1.70^{abc}	1.75^{ab}	2.03^{bc}	2.29^{ab}	2.29^{a}	2.33^{b}
T_7	0.91^{a}	1.14^{a}	1.63^{ab}	1.75^{a}	1.87^{ab}	1.99^{a}	2.12^{a}	2.44^{ab}	2.47^{ab}	2.51^{a}	2.52^{ab}
T_8	1.07^{a}	1.07^{a}	1.35^{ab}	1.38^{ab}	1.44^{c}	1.62^{bc}	1.69^{b}	1.86^{c}	2.04^{b}	2.36^{a}	2.39^{b}
T_9	0.98^{a}	1.09^{a}	1.70^{ab}	1.70^{a}	1.70^{abc}	1.81^{ab}	1.85^{ab}	1.97^{bc}	2.12^{ab}	2.36^{a}	2.42^{ab}

Treatments means having similar alphabets in superscript, do not differ significantly

Table 35. Effect of organic sources of nutrients on number of tillers per hill – ratoon crop

Treatment	Months of observation				
	1	2	3	4	5
T_1	1.22^{e}	1.82^{c}	2.16^{c}	2.16^{c}	2.34^{bc}
T_2	1.29^{de}	1.82^{c}	1.95^{c}	2.12^{c}	2.23^{c}
T_3	1.55^{cde}	1.87^{c}	2.04^{c}	2.08^{c}	2.48^{bc}
T_4	2.18^{a}	2.85^{a}	2.85^{a}	3.16^{a}	3.31^{a}
T_5	1.91^{abc}	2.20^{b}	2.26^{c}	2.28^{c}	2.69^{b}
T_6	2.06^{ab}	2.38^{b}	2.52^{b}	2.55^{b}	2.71^{b}
T_7	2.11^{ab}	2.94^{a}	2.94^{a}	3.05^{a}	3.21^{a}
T_8	1.70^{bcd}	2.22^{b}	2.27^{bc}	2.31^{c}	2.38^{bc}
T_9	1.56^{cde}	1.87^{c}	2.16^{c}	2.16^{c}	2.42^{bc}

Treatments means having similar alphabets in superscript, do not differ significantly

Table 36. Effect of organic sources of nutrients on floral characters – main crop

Treat-ment	Days for 1st spike emergence	Days to 1st floret opening	Days to complete opening of floret	Length of the spike (cm)	Girth of the spike (cm)	Length of rachis (cm)	Number of florets per spike	Length of the corolla tube (cm)	Size of floret (cm)	Longe-vity of floret (days)	Field life of spike (days)	Duration of the crop (days)	Yield of spikes per hill
T_1	330.67^{a}	18.00^{b}	12.33^{a}	61.00^{ab}	2.83^{a}	15.67^{cd}	24.33^{bc}	4.93^{a}	3.03^{ab}	2.92^{b}	8.83^{d}	518.37^{ab}	0.42^{bc}
T_2	336.00^{a}	15.83^{d}	10.00^{bcd}	63.00^{ab}	2.87^{a}	17.50^{bcd}	24.00^{bc}	5.00^{a}	3.10^{ab}	3.00^{ab}	10.17^{c}	485.00^{b}	0.33^{bc}
T_3	327.00^{a}	17.33^{b}	10.67^{b}	78.17^{ab}	2.80^{a}	23.67^{ab}	28.67^{abc}	5.20^{a}	3.30^{ab}	3.08^{ab}	8.50^{d}	481.00^{bc}	0.67^{bc}
T_4	119.33^{b}	17.00^{bc}	12.67^{a}	85.50^{a}	2.63^{ab}	24.00^{ab}	41.33^{a}	5.42^{a}	3.83^{a}	3.25^{ab}	15.30^{a}	528.33a	1.42^{a}
T_5	326.67^{a}	16.33^{cd}	8.67^{de}	74.00^{ab}	2.77^{ab}	21.17^{abc}	27.33^{abc}	5.43^{a}	3.17^{ab}	3.00^{ab}	13.00^{b}	487.97^{b}	0.50^{bc}
T_6	331.33^{a}	16.00^{d}	10.33^{bc}	68.33^{ab}	2.63^{ab}	24.00^{ab}	28.00^{abc}	5.23^{a}	3.13^{ab}	3.33^{ab}	12.67^{b}	484.33^{b}	0.50^{bc}
T_7	160.33^{b}	15.67^{d}	10.67^{b}	86.17^{a}	2.97^{a}	26.33^{a}	39.00^{a}	5.33^{a}	3.97^{a}	3.17^{ab}	14.33^{a}	520.33^{ab}	0.92^{ab}
T_8	301.67^{a}	18.00^{b}	9.00^{cde}	84.00^{a}	3.03^{a}	19.83^{abc}	30.67^{ab}	5.33^{a}	3.27^{ab}	3.00^{ab}	12.67^{b}	458.37^{c}	0.42^{bc}
T_9	372.00^{a}	19.67^{a}	8.00^{e}	50.00^{b}	1.67^{b}	18.17^{d}	22.00^{bc}	3.60^{b}	2.03^{b}	3.08^{ab}	11.67^{b}	519.70^{ab}	0.17^{c}

Treatments means having similar alphabets in superscript, do not differ significantly

Table 37. Effect of organic sources of nutrients on floral characters – ratoon crop

Treat-ment	Days taken for 1st spike emergence	Days to 1st floret opening	Days to complete opening of floret in a spike	Length of the spike (cm)	Girth of the spike (cm)	Length of rachis (cm)	Number of florets per spike	Length of the corolla tube (cm)	Size of floret (cm)	Longe-vity of floret (days)	Field life of spike (days)	Duration of the crop (days)	Yield of spikes per hill
T_1	180.00^{b}	17.00^{b}	12.33^{ab}	67.53^{b}	1.85^{e}	20.43^{cd}	25.33^{bc}	4.50^{bc}	3.00^{b}	2.50^{b}	9.00^{d}	369.00^{cd}	1.00^{b}
T_2	214.30^{a}	15.83^{c}	8.33^{b}	69.42^{b}	2.50^{a}	22.08^{bc}	25.50^{bc}	5.00^{a}	3.17^{b}	2.62^{b}	10.00^{cd}	417.00^{b}	1.00^{b}
T_3	166.70^{c}	18.00^{b}	9.00^{b}	68.00^{b}	2.13^{d}	19.54^{cd}	25.33^{bc}	4.92^{ab}	3.15^{b}	2.90^{a}	9.33^{d}	415.00^{b}	1.25^{b}
T_4	141.70^{d}	17.50^{b}	14.00^{a}	82.13^{a}	2.27^{bc}	27.51^{a}	32.33^{a}	5.00^{a}	3.58^{a}	3.00^{a}	15.30^{a}	498.00^{a}	2.17^{a}
T_5	186.70^{b}	17.50^{b}	9.33^{b}	68.77^{b}	2.30^{b}	20.93^{cd}	20.00^{d}	4.62^{abc}	3.00^{b}	3.00^{a}	11.00^{c}	399.40^{c}	1.02^{b}
T_6	162.30^{c}	15.33^{c}	8.33^{b}	69.60^{b}	2.30^{b}	22.43^{bc}	26.33^{b}	5.00^{a}	3.25^{b}	3.00^{a}	12.33^{b}	411.60^{b}	2.00^{a}
T_7	161.00^{c}	15.33^{c}	9.33^{b}	79.73^{a}	2.30^{b}	26.00^{ab}	28.67^{b}	5.00^{a}	3.72^{a}	3.00^{a}	12.33^{b}	483.30^{ab}	2.00^{a}
T_8	214.30^{a}	17.67^{b}	8.00^{b}	71.33^{b}	2.20^{cd}	19.67^{cd}	22.67^{cd}	4.42^{c}	2.53^{c}	2.50^{b}	9.33^{d}	410.00^{b}	1.00^{b}
T_9	217.30^{a}	21.00^{a}	12.00^{ab}	68.08^{b}	1.88^{e}	17.63^{d}	26.08^{bc}	4.55^{abc}	2.43^{c}	2.33^{c}	10.00^{cd}	408.30^{bc}	1.00^{b}

Treatments means having similar alphabets in superscript, do not differ significantly

minimum values was noticed in T_2 both plant and ratoon crops (29.67 and 30.67 g respectively).

4.2.3.2 Days taken for opening of each floret

Regarding the days taken for opening of each floret, not much significant variation was observed among the treatments. Treatment T_2 (FYM alone) resulted in significantly lower values (1.67) which was on par with T_1. For ratoon crop T_5 (treatment consisted of vermicompost) and T_8 (vermiwash spray) were performing on par with maximum number of days for opening of each floret (2.25 and 2.17 days). As in main crop T_2 took minimum number of days for opening of each floret in ratoon crop also.

4.2.3.4 Number of florets opened at a time

In main and ratoon crops number of florets opened at a time was significantly higher in T_7 (3.00 and 2.92). T_1 (absolute control) and T_8 (vermi wash spray) recorded minimum values for this parameter in main and in ratoon crops respectively.

4.2.3.5 Water uptake

Total water uptake was maximum in T_4 (47.17 ml) during main crop and in T_5 (46.67ml) for ratoon crop. Minimum water uptake was observed in T_3 (during main crop (34.77 ml) and in T_6 (33.83 ml) during ratoon crop.

4.2.3.6 Vase life

Same trend in terms of vase life was observed in main and ratoon crops. Treatment T_4 (treatment with biogas slurry) was the best with longest vase life during both crops recording 9.00 and 8.67 days respectively. Minimum vase life was recorded by T_9 during both the crops (5.93 and 6.0 days).

4.2.4 Bulb characters

Bulb characters are furnished in Table 40 and Plate 13.

Table 38. Effect of organic sources of nutrients on post harvest spike characters – main crop

Treatment	Fresh weight of the spike (g)	Days taken for opening of each floret	No. of florets opened at a time	Total water uptake (ml)	Vase life (days)
T_1	44.50^{b}	1.83^{ab}	1.83^{d}	45.50^{a}	6.00^{d}
T_2	29.67^{e}	1.67^{b}	2.00^{cd}	37.17^{c}	8.00^{b}
T_3	38.83^{cd}	2.00^{a}	2.50^{b}	34.77^{c}	7.00^{c}
T_4	39.72^{c}	2.00^{a}	2.15^{bcd}	46.17^{a}	9.00^{a}
T_5	35.83^{d}	2.00^{a}	2.00^{d}	44.50^{ab}	7.33^{c}
T_6	37.40^{cd}	1.92^{a}	2.37^{bc}	28.67^{d}	7.33^{c}
T_7	51.80^{a}	2.00^{a}	3.00^{a}	41.17^{b}	8.00^{b}
T_8	37.17^{cd}	2.00^{a}	1.90^{d}	36.50^{c}	6.17^{d}
T_9	31.83^{e}	2.00^{a}	2.00^{cd}	35.80^{c}	5.93^{d}

Treatments means having similar alphabets in superscript, do not differ significantly

Table 39. Effect of organic sources of nutrients on post harvest spike characters – ratoon crop

Treatment	Fresh weight of the spike (g)	Days taken for opening of each floret	No. of florets opened at a time	Total water uptake (ml)	Vase life (days)
T_1	43.33^{b}	1.67^{b}	2.08^{cd}	43.00^{b}	7.00^{c}
T_2	30.67^{e}	1.67^{b}	2.00^{cd}	34.67^{d}	7.83^{b}
T_3	42.50^{bc}	2.00^{ab}	2.25^{c}	35.33^{d}	7.67^{b}
T_4	36.17^{d}	2.00^{ab}	2.12^{cd}	45.17^{b}	8.67^{a}
T_5	36.83^{d}	2.25^{a}	2.62^{b}	47.67^{a}	7.00^{c}
T_6	48.67^{a}	2.00^{ab}	2.08^{cd}	33.83^{d}	7.00^{c}
T_7	50.00^{a}	2.00^{ab}	2.92^{a}	39.83^{c}	7.83^{b}
T_8	38.50^{cd}	2.17^{a}	1.93^{d}	38.83^{c}	6.67^{c}
T_9	31.67^{e}	2.00^{ab}	2.00^{cd}	35.33^{d}	6.00^{d}

Treatments means having similar alphabets in superscript, do not differ significantly

4.2.4.1 Number of bulbs per hill

Treatments differed significantly in terms of number of bulbs per hill. T_4 was significantly superior to all other treatments with regard to this parameter producing 59.0 bulbs per hill. Minimum number of bulbs per hill was observed in T_8 (10.67).

4.2.4.2 Number of bulblets per hill

Maximum number of bulblets per hill was observed in T_7 (biogas slurry) (104.3) followed by T_5 (treatment consisted of vermicompost) (87.33) and minimum number of bulblets per hill was produced by T_2 (15.00).

4.2.4.3 Weight of bulbs per hill

T_7 recorded maximum weight of bulbs per hill (525.7) followed by T_4 (466.00) and minimum weight of bulbs per hill was observed in T_9 (119.3 g).

4.2.4.4 Weight of bulblets per hill

T_7 was found to have maximum weight of bulblets per hill (140.7 g) followed by T_5 (112.70 g) and weight of bulblets per hill was minimum in T_1 (20.67 g).

4.2.4.5 Size of bulbs

T_6, T_7, T_5 and T_1 were performing on par with respect to the size of bulbs and T_9 produced smallest bulbs (4.50 cm).

4.2.4.6 Size of bulblets

Regarding the size of bulblets, T_5 and T_8 were performing on par producing larger bulblets (4.75 and 4.70 cm respectively). No significant variation was observed among other treatments.

Table 40. Effect of organic sources of nutrients on bulb characters

Treatment	No. of bulbs	No. of bulblets	Weight of bulbs	Weight of bulblets	Size of bulbs (cm)	Size of bulblets (cm)
T_1	25.00^{e}	17.67^{g}	120.00^{h}	20.67^{h}	5.90^{a}	4.05^{b}
T_2	40.00^{c}	15.00^{h}	259.30^{e}	40.67^{f}	5.20^{b}	4.25^{ab}
T_3	56.67^{b}	40.67^{c}	241.70^{f}	45.33^{f}	5.00^{bc}	3.75^{b}
T_4	59.00^{a}	34.33^{d}	466.00^{b}	82.00^{c}	5.00^{bc}	3.80^{b}
T_5	31.67^{d}	87.33^{b}	279.70^{d}	112.70^{b}	6.00^{a}	4.75^{a}
T_6	40.67^{c}	26.33^{f}	321.00^{c}	56.00^{d}	6.40^{a}	3.80^{b}
T_7	42.00^{c}	104.30^{a}	525.70^{a}	140.70^{a}	6.10^{a}	4.00^{b}
T_8	10.67^{f}	32.67^{e}	160.70^{g}	55.33^{d}	5.20^{b}	4.70^{a}
T_9	12.00^{f}	18.67^{g}	119.30^{h}	25.67^{g}	4.50^{c}	3.60^{b}

Treatments means having similar alphabets in superscript, do not differ significantly

4.2.5 Plant analysis

4.2.5.1 N Content

T_4 (treatment with Poultry manure) was superior in terms of N content of leaves during major part of growth period and at final growth stage T_6 (coir pith compost alone) exhibited statistical superiority in this parameter (2.46). Treatment variation was not consistent as far as N content of tubers is concerned, though T_3, T_5, and T_6 exhibited superiority at different times (Table 41).

Both in leaves and tubers a progressive increase in N content up to flowering stage was observed during the growth period. Generally N content in leaves and tubers followed same trend, showing initial increase and reduction in values at final stage of crop growth.

T_4 (Poultry manure alone) expressed its superiority in terms of this parameter during the major part of the growth period both in leaves and tubers (Table 42). Minimum N content was seen in T_8 (vermiwash sprays) for leaves and in T_9 for tubers (Panchagavyam sprays).

4.2.5.2 P Content

General trend in P content of leaves and tubers were similar during the growth period. The values dicreased up to 7^{th} month and at the last stage exhibited an increase which coincided with the flowering stage.

T_3 (FYM, 40 t ha^{-1}) had maximum P content of leaves during initial two months (0.26) and T_5 (Vermi compost, 25.00 t ha^{-1}) exhibited significantly higher values in later months.

In tubers statistical variation between treatments with respect to P content was very less. However, T_4 had an upper status with respect to the value (Table 43).

In ratoon crop T_3 (treatment with FYM) recorded maximum value for P content of leaves in initial three months and T_4 (Poultry manure 29.63 t ha^{-1}) and T_5

Table 41. Effect of organic sources of nutrients on N content of leaves and tubers (%) – main crop

	Months of observation															
	Leaf								Tuber							
	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
T_1	1.39^{ab}	1.43^{b}	1.54^{c}	1.83^{b}	1.79^{c}	1.82^{de}	2.01^{d}	1.47^{f}	0.50^{cd}	0.94^{de}	1.46^{f}	1.50^{d}	1.51^{e}	1.81^{d}	1.92^{f}	1.50^{f}
T_2	1.32^{b}	1.41^{b}	1.45^{d}	1.73^{c}	1.84^{c}	1.85^{d}	2.13^{c}	2.26^{bc}	0.36^{e}	1.06^{c}	1.79^{c}	1.50^{d}	1.81^{cd}	1.92^{bc}	2.20^{e}	2.12^{c}
T_3	1.12^{cd}	1.25^{c}	1.41^{d}	1.64^{d}	1.69^{d}	1.68^{f}	2.50^{a}	2.31^{b}	1.06^{b}	0.96^{d}	1.67^{d}	1.97^{a}	1.98^{a}	2.02^{a}	2.42^{cd}	2.35^{b}
T_4	1.46^{a}	1.53^{a}	1.58^{c}	2.30^{a}	2.39^{a}	2.45^{a}	2.43^{a}	1.88^{d}	1.13^{a}	1.67^{a}	1.19^{h}	1.90^{b}	1.90^{b}	1.99^{a}	2.59^{b}	2.02^{d}
T_5	0.89^{f}	1.36^{b}	1.57^{c}	1.69^{a}	1.73^{d}	1.78^{e}	1.86^{e}	1.86^{d}	0.343^{e}	0.89^{e}	1.97^{a}	1.24^{f}	1.25^{g}	1.32^{f}	1.96^{f}	1.63^{e}
T_6	1.19^{c}	1.54^{a}	1.69^{b}	1.68^{cd}	1.69^{d}	2.03^{c}	2.43^{a}	2.46^{a}	0.35^{e}	0.96^{d}	1.78^{c}	1.80^{c}	1.80^{cd}	1.97^{ab}	3.30^{a}	2.96^{a}
T_7	1.18^{c}	1.40^{b}	1.58^{c}	1.91^{b}	2.00^{b}	2.19^{b}	2.48^{a}	1.83^{de}	0.56^{c}	0.78^{f}	1.85^{b}	1.85^{bc}	1.85^{bc}	1.98^{ab}	2.45^{c}	2.40^{b}
T_8	1.06^{de}	1.15^{d}	1.22^{e}	1.26^{e}	1.53^{e}	1.69^{f}	1.91^{e}	1.79^{e}	0.28^{f}	1.09^{c}	1.51^{e}	1.52^{d}	1.78^{d}	1.89^{c}	2.31^{de}	2.12^{c}
T_9	1.02^{e}	1.43^{b}	1.43^{d}	1.86^{b}	2.00^{b}	2.24^{b}	2.33^{b}	2.24^{c}	0.46^{d}	1.19^{b}	1.34^{g}	1.39^{e}	1.39^{f}	1.49^{e}	2.17^{e}	2.15^{c}

Treatments means having similar alphabets in superscript, do not differ significantly

Table 42. Effect of organic sources of nutrients on N content of leaves and tubers (%) – ratoon crop

Treatments	Months of observation							
	Leaf				Tuber			
	1	2	3	4	1	2	3	4
T_1	1.43^{b}	1.48^{e}	1.73^{c}	1.60^{c}	0.84^{c}	1.53^{d}	1.68^{g}	1.58^{e}
T_2	1.39^{b}	2.00^{a}	2.07^{a}	1.95^{a}	0.55^{e}	1.80^{b}	2.00^{e}	2.00^{c}
T_3	1.23^{c}	1.79^{bc}	1.87^{bc}	1.60^{c}	1.02^{b}	1.50^{d}	2.02^{e}	2.16^{b}
T_4	1.53^{a}	1.70^{cd}	2.05^{a}	2.00^{a}	1.12^{a}	1.88^{a}	2.87^{a}	2.53^{a}
T_5	1.23^{c}	1.47^{e}	1.53^{d}	1.45^{e}	0.47^{f}	1.70^{c}	1.87^{f}	1.53^{e}
T_6	1.15^{d}	1.63^{d}	1.57^{d}	1.60^{c}	0.38^{g}	1.52^{d}	2.23^{d}	1.80^{d}
T_7	1.19^{cd}	1.67^{d}	1.78^{bc}	1.80^{b}	0.64^{d}	1.83^{ab}	2.73^{b}	2.00^{c}
T_8	1.08^{e}	1.23^{f}	1.57^{d}	1.50^{de}	0.35^{g}	1.53^{d}	2.34^{c}	2.03^{c}
T_9	1.01^{f}	1.85^{b}	1.88^{b}	1.53^{d}	0.45^{f}	1.50^{d}	1.87^{f}	2.00^{c}

Treatments means having similar alphabets in superscript, do not differ significantly

(treatment with vermi compost) during final growth stage. No consistent pattern of variation was observed regarding the P content of tuber, however T_4 had superior effects in terms of this parameter during initial and final stages of crop growth (Table 44).

4.2.5.3 K Content

Same pattern was seen in terms of K content in leaves and tubers during the growth period, showing decrease up to 6^{th} month and progressive increase there after.

T_4 (treatment consisting of Poultry manure) registered significantly higher value both in leaves and tubers during major part of growth period. (Table 45).

In ratoon crop, even though there was no consistent pattern of variation, among treatments, T_5 (treatment with Vermi compost) had highest K content of leaves during initial and final growth and T_4 exhibited superiority with respect to this parameter in tubers (Table 46).

4.2.6 Soil analysis

Data pertaining to the treatment effect on post harvest soil properties is presented in the Table 47.

4.2.6.1 $_P$H

T_9 (panchagavyam spray), T_1 (treatment with FYM) and T_8 (vermiwash spray) were statistically on par with higher $_P$H values (6.47, 6.43 and 6.40) and T_4 recorded a minimum value of 6.07 in the parameters.

4.2.6.2 Organic carbon

T_4 and T_7 (treatment consisted of poultry manure and biogas slurry respectively) exhibited significantly higher organic carbon content of the soil (0.90 and 0.86 percentage) and the least value was noticed in T_1 (0.50).

Table 43. Effect of organic sources of nutrients on P content of leaves and tubers (%) – main crop

	Months of observation															
	Leaf								Tuber							
	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
T_1	0.11^{c}	0.10^{d}	0.06^{c}	0.06^{abc}	0.05^{ab}	0.05^{ab}	0.05^{bc}	0.19^{cd}	0.13^{c}	0.12^{a}	0.03^{c}	0.03^{a}	0.02^{a}	0.02^{a}	0.73^{b} (0.04)	0.07^{b}
T_2	0.16^{bc}	0.11^{d}	0.06^{c}	0.09^{ab}	0.08^{ab}	0.08^{a}	0.08^{b}	0.25^{abc}	0.21^{ab}	0.18^{a}	0.12^{ab}	0.06^{a}	0.05^{a}	0.05^{a}	0.74^{ab} (0.05)	0.07^{b}
T_3	0.26^{a}	0.26^{a}	0.13^{ab}	0.02^{c}	0.02^{b}	0.02^{b}	0.02^{c}	0.28^{a}	0.22^{ab}	0.13^{a}	0.03^{c}	0.11^{a}	0.03^{a}	0.03^{a}	0.73^{b} (0.03)	0.09^{b}
T_4	0.16^{bc}	0.15^{cd}	0.12^{ab}	0.12^{a}	0.08^{ab}	0.08^{a}	0.08^{b}	0.17^{d}	0.26^{a}	0.16^{a}	0.07^{bc}	0.05^{a}	0.05^{a}	0.04^{a}	0.74^{ab} (0.05)	0.19^{a}
T_5	0.15^{bc}	0.13^{d}	0.08^{bc}	0.07^{abc}	0.10^{a}	0.10^{a}	0.25^{a}	0.26^{ab}	0.21^{ab}	0.17^{a}	0.11^{ab}	0.03^{a}	0.03^{a}	0.02^{a}	0.77^{ab} (0.09)	0.19^{a}
T_6	0.18^{b}	0.22^{ab}	0.17^{a}	0.10^{ab}	0.09^{a}	0.09^{a}	0.09^{b}	0.23^{abc}	0.16^{bc}	0.13^{a}	0.08^{abc}	0.07^{a}	0.06^{a}	0.05^{a}	0.75^{ab} (0.06)	0.09^{b}
T_7	0.21^{ab}	0.20^{bc}	0.13^{ab}	0.12^{a}	0.08^{ab}	0.09^{a}	0.087^{b}	0.11^{e}	0.21^{ab}	0.14^{a}	0.09^{abc}	0.06^{a}	0.05^{a}	0.05^{a}	0.75^{ab} (0.06)	0.06^{b}
T_8	0.17^{bc}	0.16^{cd}	0.13^{ab}	0.11^{ab}	0.05^{ab}	0.07^{ab}	0.080^{b}	0.21^{bcd}	0.19^{b}	0.16^{a}	0.14^{a}	0.06^{a}	0.06^{a}	0.06^{a}	0.90^{a} (0.05)	0.10^{b}
T_9	0.18^{b}	0.16^{cd}	0.06^{c}	0.05^{bc}	0.05^{ab}	0.06^{ab}	0.097^{b}	0.17^{d}	0.20^{ab}	0.14^{a}	0.07^{bc}	0.07^{a}	0.06^{a}	0.08^{a}	0.77^{ab} (0.09)	0.16^{a}

Treatments means having similar alphabets in superscript, do not differ significantly

Table 44. Effect of organic sources of nutrients on P content of leaves and tubers (%) – ratoon crop

Treatments	Months of observation							
	Leaf				Tuber			
	1	2	3	4	1	2	3	4
T_1	0.11^{b}	0.09^{d}	0.07^{b}	0.19^{ab}	0.13^{d}	0.09^{d}	0.08^{a}	0.09^{b}
T_2	0.16^{ab}	0.11^{cd}	0.10^{b}	0.20^{ab}	0.18^{bcd}	0.17^{abc}	0.09^{a}	0.10^{ab}
T_3	0.19^{a}	0.25^{a}	0.20^{a}	0.21^{ab}	0.22^{ab}	0.16^{abc}	0.09^{a}	0.90^{b}
T_4	0.17^{ab}	0.16^{bc}	0.12^{b}	0.25^{a}	0.25^{a}	0.17^{ab}	0.06^{a}	0.15^{a}
T_5	0.15^{ab}	0.13^{cd}	0.10^{b}	0.25^{a}	0.18^{bcd}	0.18^{ab}	0.09^{a}	0.10^{ab}
T_6	0.17^{ab}	0.23^{a}	0.10^{b}	0.22^{ab}	0.19^{abc}	0.17^{abc}	0.10^{a}	0.90^{b}
T_7	0.20^{a}	0.20^{ab}	0.08^{b}	0.18^{b}	0.19^{bcd}	0.19^{a}	0.06^{a}	0.70^{b}
T_8	0.16^{ab}	0.15^{bc}	0.08^{b}	0.20^{ab}	0.14^{cd}	0.12^{bcd}	0.10^{a}	0.10^{ab}
T_9	0.17^{ab}	0.16^{bc}	0.09^{b}	0.18^{b}	0.13^{d}	0.11^{cd}	0.08^{a}	0.08^{b}

Treatments means having similar alphabets in superscript, do not differ significantly

Table 45. Effect of organic sources of nutrients on K content of leaves and tubers (%) – main crop

	Months of observation															
	Leaf								Tuber							
	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
T_1	3.59^{b}	2.33^{d}	2.25^{c}	1.81^{d}	1.80^{c}	1.90^{b}	2.22^{a}	2.50^{a}	0.99^{f}	0.73^{de}	0.46^{e}	0.44^{f}	0.36^{e}	0.74^{c}	0.72^{d}	0.86^{e}
T_2	3.50^{c}	2.03^{e}	1.50^{e}	1.53^{e}	1.53^{f}	1.55^{d}	1.54^{de}	1.56^{e}	1.45^{cd}	1.00^{b}	0.85^{a}	0.56^{d}	0.45^{d}	0.84^{b}	0.85^{c}	0.70^{ef}
T_3	3.25^{d}	2.40^{c}	2.32^{b}	2.05^{b}	1.33^{h}	1.50^{d}	1.50^{e}	2.12^{d}	1.89^{a}	0.82^{c}	0.72^{bc}	0.48^{ef}	0.52^{c}	0.72^{c}	0.74^{d}	0.82^{e}
T_4	3.98^{a}	2.75^{a}	2.69^{a}	2.50^{a}	2.05^{a}	2.03^{a}	2.01^{c}	2.35^{b}	1.88^{a}	1.85^{a}	0.74^{b}	0.72^{b}	0.73^{a}	1.05^{a}	1.03^{a}	1.12^{b}
T_5	3.17^{de}	2.42^{c}	2.23^{c}	1.76^{d}	1.73^{d}	2.01^{a}	2.07^{b}	2.36^{b}	1.41^{d}	0.86^{c}	0.84^{a}	0.80^{a}	0.56^{b}	0.76^{c}	0.77^{d}	0.96^{d}
T_6	3.12^{e}	2.76^{a}	1.49^{e}	1.39^{f}	1.36^{h}	1.36^{e}	1.37^{f}	2.50^{a}	1.76^{b}	0.82^{c}	0.67^{c}	0.52^{de}	0.52^{c}	0.66^{d}	0.97^{b}	1.00^{cd}
T_7	2.84^{f}	2.66^{b}	1.86^{d}	1.86^{c}	1.65^{e}	1.66^{c}	1.50^{e}	1.73^{e}	1.26^{e}	0.74^{d}	0.52^{d}	0.46^{ef}	0.45^{d}	0.29^{e}	0.64^{e}	0.76^{ef}
T_8	1.92^{h}	1.25^{g}	1.12^{f}	1.91^{c}	1.89^{e}	2.02^{a}	2.24^{a}	2.25^{c}	0.86^{g}	0.08^{ef}	0.68^{bc}	0.65^{c}	0.52^{c}	0.66^{d}	1.01^{ab}	1.06^{c}
T_9	2.44^{g}	1.45^{f}	1.46^{e}	1.48^{e}	1.45^{g}	1.53^{d}	1.59^{d}	1.58^{f}	1.53^{c}	0.65^{f}	0.53^{d}	0.44^{f}	0.50^{c}	1.02^{a}	1.05^{a}	1.33^{a}

Treatments means having similar alphabets in superscript, do not differ significantly

Table 46. Effect of organic sources of nutrients on K content of leaves and tubers (%) – ratoon crop

Treatments	Months of observation							
	Leaf				Tuber			
	1	2	3	4	1	2	3	4
T_1	1.25^{e}	1.05^{f}	1.01^{g}	1.53^{fg}	0.85^{d}	0.57^{f}	0.45^{c}	0.75^{d}
T_2	2.07^{d}	1.39^{e}	1.43^{e}	1.59^{f}	1.23^{c}	0.92^{d}	0.56^{bc}	0.66^{e}
T_3	2.43^{c}	1.34^{e}	2.12^{a}	1.87^{d}	1.53^{abc}	1.07^{b}	0.64^{bc}	0.68^{e}
T_4	3.05^{a}	2.23^{a}	1.27^{f}	1.48^{g}	1.77^{a}	1.23^{a}	0.76^{b}	1.23^{a}
T_5	3.13^{a}	1.63^{d}	1.66^{d}	2.13^{a}	1.45^{abc}	0.56^{f}	0.57^{bc}	0.80^{d}
T_6	2.70^{b}	1.67^{d}	1.78^{c}	2.00^{b}	1.57^{ab}	1.24^{a}	1.12^{a}	1.24^{a}
T_7	2.73^{b}	2.24^{a}	1.66^{d}	1.96^{c}	1.27^{bc}	1.12^{b}	1.08^{a}	1.08^{b}
T_8	2.54^{c}	2.05^{b}	1.92^{b}	1.87^{d}	0.68^{d}	0.82^{e}	0.45^{c}	1.00^{c}
T_9	2.43^{c}	1.76^{c}	1.65^{d}	1.68^{e}	1.48^{abc}	1.00^{c}	1.00^{a}	1.02^{c}

Treatments means having similar alphabets in superscript, do not differ significantly

4.2.6.3 Available N

T_4 was statistically superior with higher N content of soil (191.9 Kg ha^{-1}) and minimum value was observed in T_9 (113.0).

4.2.6.4 Available P

T_7 recorded maximum content of available P (17.47 Kg ha^{-1}) and the treatments under T_9 registered lowest value in this parameter (7.00 Kg ha^{-1}).

4.2.6.5 Available K

Even though there was no much significant variation between the treatments, a maximum value of 400 Kg ha^{-1} was observed in treatments except T_5, T_8 and T_9 which recorded comparatively lower values (367.00, 178.70 and 128.70 respectively).

4.2.7 Effect of treatments on overall performance

As far as vegetative characters are concerned T_4 (poultry manure) and T_7 (biogas slurry) recorded highest values through out the course of growth (Plates 8 and 9 and Fig.6, 7, 8 and 9). T_4 exhibited superiority in terms of floral characters like number of florets per spike, yield of spikes per hill, field life and duration of the crop where as length of spike and rachis was significantly higher in T_7 through out the growth period (Table 48).

4.3 EXPERIMENT 3

4.3.1 Vegetative characters

Data related to the monthly variation in vegetative characters are represented in Tables 49 to 58 (Fig.10 and 14).

4.3.1.1 Plant height

Data pertaining to variation in plant height of variety Prajwal is presented in the Table 49. Progressive increase in height was noticed up to seventh month of

Table 47. Effect of organic sources of nutrients on post harvest soil properties

Treatments	pH	Organic carbon (%)	Available N ($kg\ ha^{-1}$)	Available P ($kg\ ha^{-1}$)	Available K ($kg\ ha^{-1}$)
T_1	5.93[d]	0.50[d]	113.5[e]	8.57[d]	400.00[a]
T_2	6.23[b]	0.60[c]	138.90[c]	7.60[e]	400.00[a]
T_3	6.20[b]	0.80[b]	169.50[b]	7.40[e]	400.00[a]
T_4	6.3[b]	0.90[a]	191.90[a]	13.70[b]	400.00[a]
T_5	6.10[d]	0.60[c]	123.90[d]	6.67[e]	367.00[b]
T_6	6.13[cd]	0.80[b]	168.70[b]	12.17[b]	400.00[a]
T_7	6.5[a]	0.86[a]	188.00[a]	17.47[a]	400.00[a]
T_8	6.40[ab]	0.80[b]	169.50[b]	7.40[e]	178.70[d]
T_9	6.47[ab]	0.80[b]	113.00[e]	7.00[f]	128.70[e]

Treatments means having similar alphabets in superscript, do not differ significantly

Table 48. Effect of organic sources of nutrients on overall performance

Treat-ment	Plant height (cm)	Number of leaves	Leaf area (cm^2)	Number of tillers per hill	Length of the spike (cm)	Length of rachis (cm)	Number of florets per spike	Field life (days)	Yield of spikes per hill	Duration of the crop (days)
T_1	21.89	19.61	511.47	1.67	61.00	15.67	24.33	8.83	0.42	187.70
T_2	20.80	18.52	552.69	1.78	63.00	17.50	24.00	10.17	0.33	249.00
T_3	21.61	23.34	643.72	1.82	78.17	23.67	28.67	8.50	0.67	154.00
T_4	27.70	30.21	1049.85	2.08	85.50	24.00	41.33	15.30	1.42	409.00
T_5	23.80	25.20	804.10	1.78	74.00	21.17	27.33	13.00	0.50	161.30
T_6	24.95	23.28	678.25	1.77	68.33	24.00	28.00	12.67	0.50	153.00
T_7	25.33	27.73	1015.93	1.94	86.17	26.33	39.00	14.33	0.92	360.00
T_8	20.00	19.12	473.97	1.66	84.00	19.83	30.67	12.67	0.42	156.70
T_9	21.75	20.42	532.33	1.79	50.00	18.17	22.00	11.67	0.17	147.70

Experiment – 2

Fig.6 Effect of organic sources of nutrients on vegetative characters

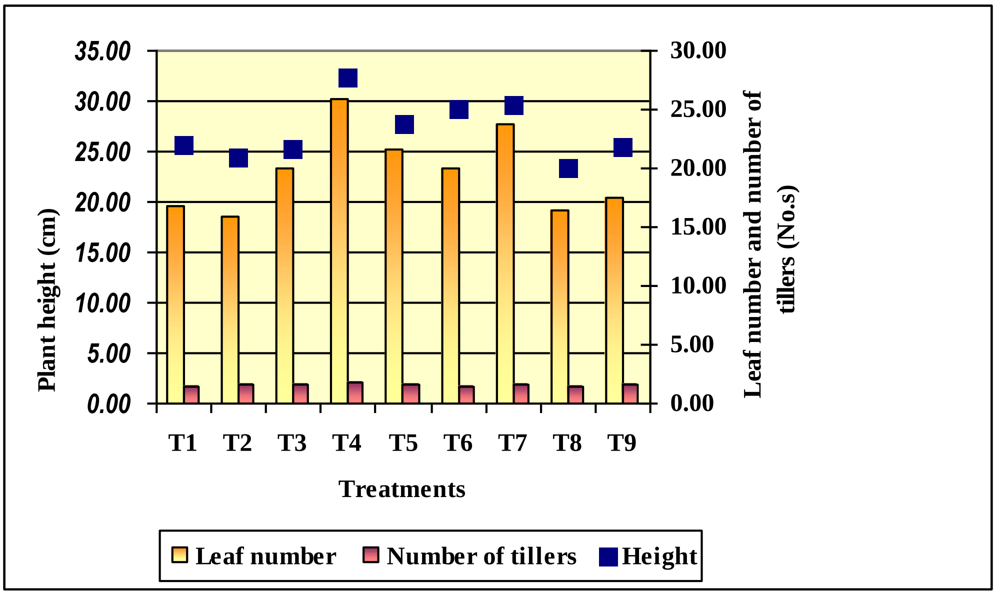


Fig.7 Effect of organic sources of nutrients on floral characters

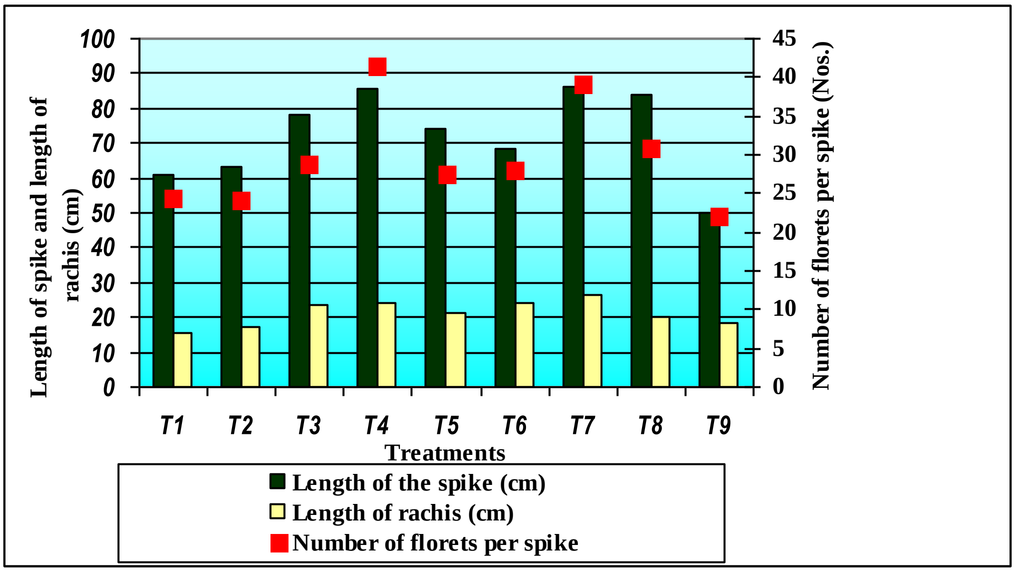


Fig.8 Effect of organic sources of nutrients on yield of spikes per hill

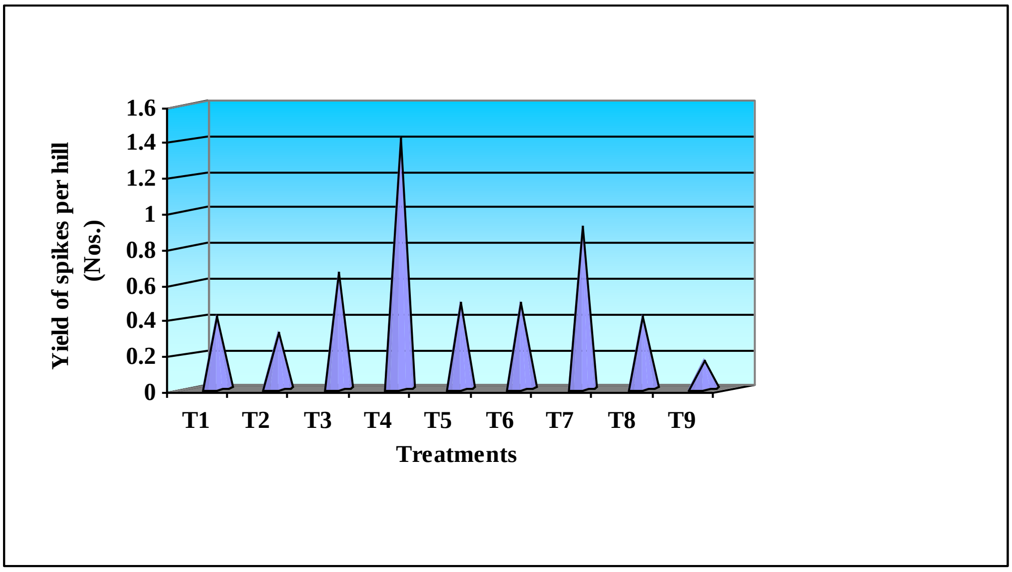
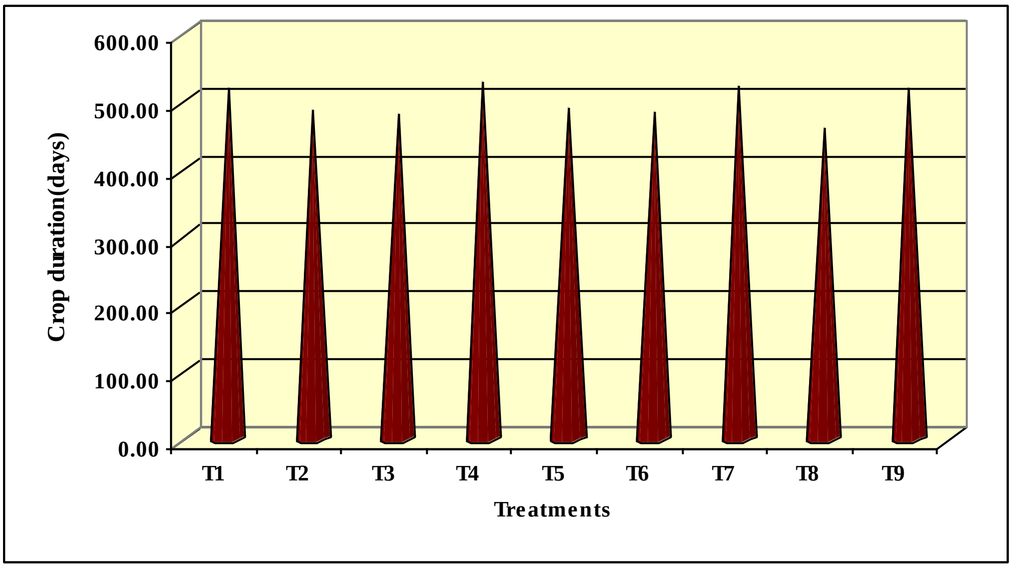


Fig.9 Effect of organic sources of nutrients on duration of the crop



observation, irrespective of the treatments and afterwards decreased values were recorded which coincide with the flowering period.

In general, during the major growing periods, treatments T_1 (100:50:50 kg NPK ha^{-1} + Poultry manure 22.22 t ha^{-1}) and T_4 (Poultry manure 29.63 t ha^{-1}) were found to result in taller plants. However statistical variation between treatments became lesser during the second half of the growth period.

In Vaibhav variety also almost the same trend was observed in terms of plant height during the growth period. Values increased up to seventh month of observation and reduced afterwards. Generally, treatments consisted of poultry manure either alone or in combination with chemical fertilizers (T_4, T_1 and T_2) and treatment with biogas slurry (T_7) were superior in this parameter through out the crop growth (Table 50).

4.3.1.2 Plant spread

Regarding the plant spread differential performance was observed among the treatments during various months of crop growth (Table 51). For Prajwal, there was a progressive increase in spread in both direction up to certain month of observation and there after a decreasing trend was noticed. In general, T_4 and T_5 (treatment consisted of biogas slurry) were statistically superior in terms of this parameter during major period of crop growth.

Same pattern of plant spread was observed in Vaibhav also T_2 (50:50:50 kg NPK ha^{-1} + poultry manure 22.22 t ha^{-1}) was statistically superior in terms of spread in both direction followed by T_1 (100:50:50 kg ha^{-1}NPK + poultry manure 22.22 t ha^{-1}), T_4 and T_5 during the course of growth (Table 52).

4.3.1.3 Number of leaves

Variety Prajwal, exhibited no significant variation among the treatments during most of the growth period. Generally, a reduction in number of leaves were observed towards the end of the growth period (Table 53).

Superior treatments from experiment 2

Plate 8. T_4 - Poultry manure 29.63 t ha $^{-1}$

Plate 9. T_7 - Biogas slurry 500 t ha^{-1}

Table 49. Treatment effect on plant height (cm) - Prajwal

Treatment	Months of observation									
	1	2	3	4	5	6	7	8	9	10
T_1	20.44[a]	25.96[a]	28.80[a]	29.99[a]	32.85[ab]	50.36[a]	50.44[a]	34.60[a]	32.41[a]	26.88[ab]
T_2	18.44[a]	23.50[ab]	25.97[abc]	25.89[ab]	33.75[ab]	52.32[a]	53.19[a]	33.10[a]	31.41[a]	27.63[a]
T_3	16.34[a]	21.07[b]	23.55[cd]	25.16[b]	32.91[ab]	41.10[b]	42.53[b]	29.92[a]	25.44[a]	23.75[ab]
T_4	18.94[a]	23.52[ab]	28.32[ab]	29.72[a]	36.38[a]	51.59[a]	52.91[a]	32.47[a]	30.25[a]	22.88[b]
T_5	18.72[a]	22.19[ab]	25.22[bcd]	26.78[ab]	33.49[ab]	52.53[a]	54.38[a]	28.85[a]	27.25[a]	24.63[ab]
T_6	16.72[a]	20.42[b]	22.50[d]	25.88[ab]	29.57[b]	37.44[b]	41.41[b]	35.01[a]	30.75[a]	23.44[ab]

Treatments means having similar alphabets in superscript, do not differ significantly

Table 50. Treatment effect on plant height (cm) - Vaibhav

Treatment	Months of observation									
	1	2	3	4	5	6	7	8	9	10
T_1	22.97^{ab}	24.88^{b}	29.10^{a}	32.87^{ab}	36.07^{a}	42.88^{b}	46.72^{ab}	40.96^{ab}	36.77^{a}	27.75^{a}
T_2	25.34^{a}	26.38^{a}	29.92^{a}	34.94^{a}	35.19^{ab}	48.73^{a}	50.47^{a}	45.17^{a}	35.81^{ab}	24.00^{a}
T_3	22.31^{ab}	24.05^{c}	25.50^{bc}	32.60^{ab}	33.44^{ab}	41.70^{bc}	43.67^{ab}	37.85^{b}	35.44^{bc}	25.75^{a}
T_4	21.78^{b}	22.82^{e}	26.64^{abc}	33.00^{ab}	33.63^{ab}	48.42^{a}	49.89^{a}	40.82^{ab}	31.32^{bc}	24.38^{a}
T_5	22.35^{b}	23.74^{d}	28.94^{ab}	34.60^{a}	35.38^{ab}	46.58^{ab}	48.57^{ab}	45.22^{a}	37.75^{a}	29.31^{a}
T_6	21.84^{b}	22.73^{e}	24.06^{c}	28.45^{b}	29.25^{b}	37.45^{c}	39.32^{c}	35.66^{b}	30.10^{c}	24.63^{a}

Treatments means having similar alphabets in superscript, do not differ significantly

In Vaibhav also there was a progressive increase in this parameter and a reduction was observed towards the final stage. However, T_2 (50:50:50 kg NPK ha^{-1} + poultry manure 22.22 t ha^{-1}) was found to be superior in major part of the growth period (Table 54).

4.3.1.4 Leaf area

Variety Prajwal, did not show much significant variation among the treatments with respect to leaf area during the course of growth. In general treatment T_1 was found to be the best recording the maximum values during the entire growing season which was statistically superior during 3^{rd}, 6^{th}, 7^{th} and 8^{th} month of observation (Table 55). In Vaibhav leaf area was maximum and statistically superior in T_2 during major period of growth (Table 56).

4.3.1.5 Number of tillers per hill

Variety Vaibhav produced more number of tillers per hill than Prajwal during the entire growth period. However, in both varieties there existed no significant variation among the treatments with respect to this parameter (Table 57 and 58).

4.3.2 Floral characters

Data pertaining to the variation in floral characters are presented in Table 59, Fig.11 to 13 and Plates 14,15 and 16 (variety Prajwal) and Table 60, Fig.15-17 and Plates 17, 18 and 19 (variety Vaibhav).

4.3.2.1 Days for first spike emergence

Treatments under T_4, T_1 and T_5 (treatments consisted of poultry manure and biogas slurry) were performing on par with earliest spike emergence in Prajwal variety giving the values as 231.3, 234.3 and 234.8 days respectively and delayed spike emergence was noticed in T_6 (absolute control) in this variety (257.3 days).

Table 51. Treatment effect on plant spread (cm) - Prajwal

Treatments	Months of observation									
	1		2		3		4		5	
	NS	EW	NS	EW	NS	EW	NS	EW	NS	EW
T_1	33.85^{b}	36.75^{d}	37.81^{ab}	39.07^{e}	47.44^{ab}	43.38^{d}	51.44^{ab}	44.31^{b}	47.56^{a}	38.94^{a}
T_2	36.16^{ab}	39.41^{c}	38.28^{ab}	41.97^{d}	50.61^{a}	47.25^{c}	55.56^{a}	41.16^{d}	48.69^{a}	38.38^{a}
T_3	34.17^{b}	39.60^{c}	35.57^{b}	44.16^{c}	41.08^{b}	50.13^{b}	46.63^{b}	36.25^{e}	38.88^{b}	37.75^{b}
T_4	40.10^{a}	41.63^{b}	42.22^{a}	46.57^{b}	50.44^{ab}	52.28^{a}	55.19^{ab}	42.54^{c}	44.50^{a}	35.63^{b}
T_5	35.14^{b}	44.41^{a}	36.52^{ab}	48.13^{a}	49.38^{ab}	47.38^{c}	54.13^{ab}	46.81^{a}	46.13^{a}	35.00^{b}
T_6	36.03^{ab}	35.60^{e}	39.22^{ab}	37.66^{f}	44.80^{ab}	47.14^{c}	50.28^{ab}	40.06^{d}	45.69^{a}	34.44^{b}

Treatments means having similar alphabets in superscript, do not differ significantly

Table 52. Treatment effect on plant spread (cm) - Vaibhav

Treatments	Months of observation									
	1		2		3		4		5	
	NS	EW	NS	EW	NS	EW	NS	EW	NS	EW
T_1	27.13^{a}	27.94^{a}	28.28^{a}	28.24^{a}	51.10^{a}	48.94^{ab}	42.14^{a}	37.65^{ab}	39.19^{a}	35.00^{a}
T_2	24.91^{ab}	24.56^{ab}	26.13^{a}	28.44^{a}	49.13^{a}	50.85^{a}	34.75^{a}	44.81^{a}	32.00^{a}	39.50^{a}
T_3	21.16^{b}	22.75^{b}	23.63^{a}	25.82^{a}	46.35^{a}	43.49^{b}	38.96^{a}	36.44^{ab}	36.19^{a}	33.00^{a}
T_4	24.66^{ab}	26.84^{a}	25.03^{a}	27.17^{a}	51.00^{a}	47.06^{ab}	38.13^{a}	33.79^{b}	32.31^{a}	31.25^{a}
T_5	24.78^{ab}	24.66^{ab}	27.41^{a}	27.06^{a}	49.25^{a}	48.69^{ab}	37.19^{a}	40.25^{ab}	34.75^{a}	38.63^{a}
T_6	24.34^{ab}	24.59^{ab}	24.97^{a}	26.59^{a}	42.86^{a}	43.24^{b}	36.13^{a}	37.90^{ab}	33.75^{a}	34.81^{a}

Treatments means having similar alphabets in superscript, do not differ significantly

Table 53. Treatment effect on number of leaves - Prajwal

Treatments	Months of observation									
	1	2	3	4	5	6	7	8	9	10
T_1	5.938[a]	11.94[a]	24.14[a]	25.00[a]	28.56[a]	36.10[a]	37.20[b]	44.19[a]	34.66[a]	20.13[a]
T_2	5.750[a]	11.44[a]	14.78[b]	20.56[a]	27.00[a]	28.28[b]	31.97[a]	37.75[a]	26.28[a]	20.63[a]
T_3	5.438[a]	8.842[a]	14.19[b]	22.31[a]	24.81[a]	29.00[ab]	30.97[a]	40.19[a]	28.88[a]	17.63[a]
T_4	5.875[a]	10.00[a]	14.63[b]	22.53[a]	26.84[a]	32.63[ab]	34.91[a]	39.00[a]	29.81[a]	17.13[a]
T_5	6.938[a]	11.91[a]	14.66[b]	23.59[a]	25.88[a]	32.44[ab]	33.53[a]	37.22[a]	25.41[a]	16.88[a]
T_6	5.063[a]	7.875[a]	12.44[b]	20.63[a]	24.59[a]	27.32[b]	29.97[a]	33.97[a]	22.59[a]	14.38[a]

Treatments means having similar alphabets in superscript, do not differ significantly

Table 54. Treatment effect on number of leaves - Vaibhav

Treatments	Months of observation									
	1	2	3	4	5	6	7	8	9	10
T_1	30.50^{b}	35.06^{ab}	43.84^{a}	47.35^{ab}	51.35^{a}	56.81^{ab}	60.75^{a}	49.50^{a}	39.40^{ab}	29.75^{ab}
T_2	34.31^{a}	35.38^{ab}	43.79^{a}	52.38^{a}	54.00^{a}	61.05^{a}	63.13^{a}	51.89^{a}	41.40^{a}	26.00^{b}
T_3	35.25^{a}	38.81^{a}	42.78^{a}	43.25^{b}	47.45^{a}	51.94^{b}	54.03^{ab}	47.58^{ab}	41.63^{a}	27.38^{b}
T_4	26.38^{c}	32.91^{b}	40.04^{a}	44.75^{ab}	46.66^{a}	55.42^{ab}	60.56^{a}	44.53^{ab}	36.34^{ab}	29.50^{ab}
T_5	36.19^{a}	37.69^{ab}	44.63^{a}	45.03^{ab}	46.56^{a}	59.19^{ab}	61.06^{a}	48.00^{ab}	44.31^{a}	34.50^{a}
T_6	25.75^{c}	27.56^{c}	31.67^{b}	35.51^{c}	37.81^{b}	42.38^{c}	45.88^{b}	37.00^{b}	29.39^{b}	23.00^{b}

Treatments means having similar alphabets in superscript, do not differ significantly

Table 55. Treatment effect on leaf area (cm^2) - Prajwal

Treatments	Months of observation								
	1	2	3	4	5	6	7	8	9
T_1	111.90[a]	388.30[a]	637.70[a]	704.90[a]	851.30[a]	2249.00[a]	2505.00[a]	2237.00[a]	1382.00[a]
T_2	113.70[a]	377.80[a]	444.40[ab]	608.70[a]	847.50[a]	1491.00[bc]	1853.00[ab]	1612.00[ab]	957.70[a]
T_3	90.97[a]	200.80[a]	349.20[b]	591.60[a]	685.50[a]	1252.00[bc]	1462.00[bc]	1475.00[ab]	934.90[a]
T_4	104.90[a]	288.20[a]	453.50[ab]	822.90[a]	978.00	1869.00[ab]	2073.00[ab]	1865.00[ab]	1124.00[a]
T_5	109.90[a]	318.70[a]	343.60[b]	609.60[a]	715.50[a]	1637.00[ab]	1774.00[bc]	1706.00[ab]	911.40[a]
T_6	66.78[a]	193.70[a]	266.80[b]	437.20[a]	625.00[a]	955.60[c]	1112.00[c]	1127.00[b]	643.80[a]

Treatments means having similar alphabets in superscript, do not differ significantly

Table 56. Treatment effect on leaf area (cm^2) - Vaibhav

Treatments	Months of observation								
	1	2	3	4	5	6	7	8	9
T_1	630.50^{bc}	704.50^{abc}	1035.00^{a}	1103.00^{b}	1272.00^{b}	1948.00^{a}	2259.00^{a}	1442.00^{ab}	1071.00^{a}
T_2	903.10^{a}	841.30^{a}	1164.00^{a}	1433.00^{a}	1630.00^{a}	1922.00^{a}	2263.00^{a}	1707.00^{a}	1215.00^{a}
T_3	588.20^{c}	667.00^{abc}	717.10^{bc}	764.40^{c}	1103.00^{b}	1514.00^{b}	1885.00^{a}	1163.00^{b}	1028.00^{ab}
T_4	569.90^{c}	619.70^{bc}	901.70^{ab}	1073.00^{b}	1174.00^{b}	1815.00^{ab}	2179.00^{a}	1278.00^{b}	956.90^{ab}
T_5	796.40^{ab}	805.60^{ab}	1064.00^{a}	1072.00^{b}	1166.00^{b}	1962.00^{a}	2185.00^{a}	1339.00^{ab}	1093.00^{a}
T_6	453.90^{c}	495.10^{c}	508.80^{c}	599.00^{c}	686.40^{c}	939.80^{c}	1409.00^{b}	690.10^{c}	661.30^{b}

Treatments means having similar alphabets in superscript, do not differ significantly

Table 57. Treatment effect on number of tillers per hill - Prajwal

Treatments	Months of observation									
	1	2	3	4	5	6	7	8	9	10
T_1	0.91[a]	1.00[a]	1.17[a]	1.38[a]	1.45[a]	1.70[a]	1.72[a]	1.88[a]	2.04[a]	2.04[a]
T_2	0.75[a]	0.75[a]	1.01[a]	1.29[a]	1.43[a]	1.74[a]	1.81[a]	1.99[a]	2.03[a]	2.03[a]
T_3	0.75[a]	0.83[a]	0.92[a]	1.30[a]	1.41[a]	1.76[a]	1.85[a]	2.09[a]	2.12[a]	2.12[a]
T_4	0.71[a]	0.83[a]	1.23[a]	1.51[a]	1.59[a]	1.72[a]	1.81[a]	1.99[a]	2.03[a]	2.03[a]
T_5	0.75[a]	0.75[a]	0.97[a]	1.29[a]	1.34[a]	1.59[a]	1.71[a]	2.04[a]	2.04[a]	2.04[a]
T_6	0.79[a]	0.84[a]	1.13[a]	1.33[a]	1.43[a]	1.55[a]	1.69[a]	2.07[a]	1.96[a]	1.96[a]

Treatments means having similar alphabets in superscript, do not differ significantly

Table 58. Treatment effect on number of tillers per hill - Vaibhav

Treatments	Months of observation									
	1	2	3	4	5	6	7	8	9	10
T_1	2.13[a]	2.25[a]	2.39[a]	2.41[a]	2.47[a]	2.52[a]	2.59[a]	2.64[a]	2.69[a]	2.69[a]
T_2	2.10[a]	2.25[a]	2.48[a]	2.52[a]	2.55[a]	2.66[a]	2.69[a]	2.73[a]	2.79[a]	2.79[a]
T_3	2.07[a]	2.18[a]	2.28[a]	2.34[a]	2.42[a]	2.49[a]	2.54[a]	2.62[a]	2.64[a]	2.64[a]
T_4	1.99[a]	2.15[a]	2.36[a]	2.46[a]	2.55[a]	2.61[a]	2.67[a]	2.71[a]	2.79[a]	2.79[a]
T_5	2.09[a]	2.18[a]	2.33[a]	2.39[a]	2.42[a]	2.48[a]	2.57[a]	2.59[a]	2.61[a]	2.61[a]
T_6	1.92[a]	2.05[a]	2.24[a]	2.33[a]	2.35[a]	2.41[a]	2.51[a]	2.58[a]	2.67[a]	2.67[a]

Treatments means having similar alphabets in superscript, do not differ significantly

For variety Vaibhav (double) no significant difference was noticed in this parameter except in T_6 which took maximum number of days for the emergence of first spike (262.3 days).

4.3.2.2 Days to first floret opening

Minimum number of days for opening of first floret was noticed in T_3 (12.75 days) which was on par with T_1 (12.88 days) for Prajwal. Delayed opening of first floret was recorded by T_6 (17.13 days). Opening of first floret in Vaibhav took place in minimum days in T_4 and maximum in T_5 (18.01 days).

4.3.2.3 Days to complete opening of the florets in the spike

Maximum days for the complete opening of the florets in the spike was recorded by T_4 (16.00 days) in variety Prajwal and in variety Vaibhav, T_1 took maximum number of days (20.630) for this process. Complete opening of the florets happened in minimum days in T_5 (treatment consisted of biogas slurry) for variety Prajwal (12.38 days) and in T_6 for Vaibhav.

4.3.2.4 Length of the spike

In the case of variety Prajwal (single), T_1, T_4 and T_5 were performing on par with maximum spike length (96.08, 96.78 and 94.22 cm respectively) whereas in Vaibhav (double) maximum value was observed in $T_{1,}$ the treatment consisted of poultry manure along with full recommended dose of nitrogen (90.51 cm). In both varieties small spikes were noticed in T_6 (85.73 and 75.21 cm respectively) (Plates 20 and 21).

4.3.2.5 Girth of the spike

Girth of the spike was maximum in T_4 (3.12 cm) and minimum in T_6 (2.56 cm) for variety Prajwal (single), whereas no significant variation among treatments were observed for the variety Vaibhav.

4.3.2.6 Length of rachis

A maximum rachis length of 35.21 cm was recorded by T_1 for variety Prajwal where as T_1 and T_2 (treatments consisted of poultry manure along with chemical fertilizers) were performing on par with maximum values in Vaibhav (43.03 and 43.79 cm respectively). In both the varieties small rachis was noticed in T_6 (25.29 and 31.13 cm respectively).

4.3.2.7 Number of florets per spike

Regarding number of florets per spike T_1, T_4 and T_5 were performing on par with maximum number of florets per spike (42.2, 42.55, 40.35 respectively) for Prajwal. For variety Vaibhav maximum number of florets were noticed in T_1 and T_2 (47.07 and 46.72). In both varieties plants under T_6 (absolute control) produced minimum number of florets per spike.

4.3.2.8 Length of corolla tube

No significant variation among treatments was noticed in length of corolla tube, for variety Prajwal (single), whereas T_1 resulted in superior values for variety Vaibhav.

4.3.2.9 Size of the floret

As far as size of floret is considered, no significant variation among treatments was observed for variety Prajwal. For variety Vaibhav T_1 and T_5 were performing on par with bigger florets (3.39 and 3.37 cm respectively). Floret size was the minimum in T_6 (2.77 cm) for this variety.

4.3.2.10 Longevity of the florets

T_1, T_2 and T_4 were performing on par with statistically equal values for longevity of the florets for variety Prajwal (3.5, 3.40 and 3.44 respectively). For Vaibhav T_4 was superior to other treatments recording 3.60 days for floret opening.

4.3.2.11 Field life of spike

T_4 and T_1 recorded statistically highest value in terms of this parameter in Prajwal (17.88 and 17.75 days respectively). Field life was maximum in T_2 (50:50:50 kg NPK ha^{-1} + poultry manure 22.22 t ha^{-1}) for Vaibhav (26.63 days).

4.3.2.12 Duration of the crop

Crop duration was the maximum (462.60 days) in T_1 and minimum (439.30 days) in T_6 for the variety Prajwal.

For the variety Vaibhav maximum crop duration was observed in T_4 followed by T_2 (455.60 and 453.10 days respectively). Crop duration was minimum in T_6 (390.60 days).

4.3.2.13 Yield of spikes per hill

T_4, T_5, T_1 and T_2 were statistically equal in terms of number of spikes per hill for the variety Prajwal.

For Vaibhav T_4, T_2 and T_1 were statistically on par in terms of yield of spikes per hill. In both the varieties minimum spike production was observed in T_6.

4.3.2.14 Concrete content

Significant variation between treatments were observed in concrete content of flowers. Both in Prajwal and Vaibhav T_5 (treatment with biogas slurry) was statistically superior in terms of this parameter (0.42 and 0 .74 respectively) whereas T_6 recorded minimum value in both the varieties.

4.3.3 Post harvest spike characters

Data pertaining to the post harvest spike characters are presented in Table 61 (Prajwal) and Table 62 (Vaibhav).

4.3.3.1 Fresh weight of the spike (g)

Regarding the fresh weight of the spike T_4 and T_2 were found to be statistically on par (59.18 and 54.92 g) for variety Prajwal whereas, in Vaibhav, T_3 (50:50:50 kg NPK ha^{-1} + coirpith compost 85.71 t ha^{-1}) recorded maximum fresh weight of the spike (54.19 g). In both the varieties, minimum fresh weight of the spike was noted in T_6 (absolute control).

4.3.3.2 Days taken for opening of each floret

As far as days taken for opening of each floret is considered, in both the varieties no significant variation was observed among the treatments though in general values were higher for Vaibhav variety.

4.3.3.3 Number of florets opened at a time

T_2 and T_1 (treatments with poultry manure and chemical fertilizers) recorded superior values for the number of florets opened at a time (2.59 and 2.50 respectively) for variety Prajwal. In variety Vaibhav no significant variation was observed between treatments in this parameter.

4.3.3.4 Water uptake

Total water uptake was maximum in T_2 (44.50 ml) and T_6 (22.75 ml) in Prajwal and Vaibhav respectively.

4.3.3.5 Vase life

In variety Prajwal the treatments T_1, T_2 and T_4 recorded same values for vase life of spikes (9.13 days). Minimum vase life of 6.25 days was noted in T_6.

For variety Vaibhav, T_1 was statistically superior in terms of this parameter (10.25 days) followed by T_4 (9 days). Vase life was minimum in T_6 (7.38 days) for this variety.

4.3.4 Bulb characters

Post harvest bulb characters are presented in Table 63 (Prajwal) and Table 64 (Vaibhav).

4.3.4.1 Number of bulbs per hill

T_4 (Poultry manure alone) produced maximum number of bulbs per hill (31.5) in Prajwal. In Vaibhav (T_1 and T_4 produced large number of bulbs per hill. For both of the varieties bulb production was minimum T_6.

4.3.4.2 Number of bulblets per hill

In Prajwal T_5 (treatment with biogas slurry) was found to produce highest number of bulblets per hill whereas in Vaibhav T_2 and T_4 resulted in more number (24.25 and 24.00 respectively). Bulblets production were minimum in T_6 (absolute control) for both of the varieties.

4.3.4.3 Weight of bulbs

Highest value for weight of bulbs was observed in T_1 (332.08) for the Prajwal and in T_4 (176.30) for Vaibhav.

4.3.4.4 Weight of bulblets

As far as weight of bulblets was concerned treatments T_5 (153.8g) and T_4 (57.75g) were statistically superior in Prajwal and Vaibhav respectively.

4.3.4.5 Size of bulbs

Size of the bulbs was maximum in T_1 (7.33 cm) for the variety Prajwal and minimum bulb size in T_6 (4.20 cm). In Vaibhav T_1 and T_4 were performing on par with maximum size of the bulbs (6.03 and 5.63 cm respectively) whereas bulb size was minimum in T_5 (4.38 cm).

Table 59. Treatment effect on floral characters - Prajwal

Treat-ment	Days taken for 1st spike emergence	Days to 1st floret opening	Days to complete opening of floret in a spike	Length of the spike (cm)	Girth of the spike (cm)	Length of rachis (cm)	Number of florets per spike	Length of the corolla tube (cm)	Size of floret (cm)	Longe-vity of floret (days)	Field life of spike (days)	Duration of the crop (days)	Yield of spikes per hill	Concrete content
T_1	234.3[c]	12.88[d]	15.38[ab]	96.08[a]	2.86[ab]	35.21[a]	42.20[a]	5.48[a]	3.44[a]	3.50[a]	17.75[a]	462.60[a]	1.75[a]	0.28[b]
T_2	238.3[bc]	14.13[c]	14.75[bc]	92.10[ab]	2.79[bc]	30.64[ab]	38.41[ab]	5.43[a]	3.100[a]	3.44[a]	15.50[b]	451.10[b]	1.58[a]	0.24[c]
T_3	250.0[ab]	12.75[d]	14.13[c]	87.66[bc]	2.65[bc]	28.06[bc]	34.76[b]	5.33[a]	3.243[a]	3.06[b]	15.00[bc]	440.00[c]	1.08[b]	0.11[d]
T_4	231.3[c]	14.63[c]	16.00[a]	96.78[a]	3.12[a]	30.87[ab]	42.55[a]	5.57[a]	3.367[a]	3.44[a]	17.88[a]	443.10[c]	1.83[a]	0.30[b]
T_5	234.8[c]	15.88[b]	11.75[d]	94.22[a]	2.94[ab]	30.55[ab]	40.35[a]	5.29[a]	3.47[a]	3.125[b]	14.38[c]	439.80[cd]	1.75[a]	0.42[a]
T_6	257.3[a]	17.13[a]	12.38[d]	85.73[c]	2.56[c]	25.29[c]	34.53[b]	5.00[a]	3.26[a]	3.00[b]	14.88[bc]	439.30[cd]	1.063[b]	0.09[d]

Treatments means having similar alphabets in superscript, do not differ significantly

Table 60. Treatment effect on floral characters - Vaibhav

Treat-ment	Days taken for 1st spike emergence	Days to 1st floret opening	Days to complete opening of floret in a spike	Length of the spike (cm)	Girth of the spike (cm)	Length of rachis (cm)	Number of florets per spike	Length of the corolla tube (cm)	Size of floret (cm)	Longe-vity of floret (days)	Field life of spike (days)	Duration of the crop (days)	Yield of spikes per hill	Concrete content
T_1	230.0^{b}	17.00^{ab}	20.63^{a}	90.51^{a}	2.50^{a}	43.03^{a}	47.07^{a}	5.040^{a}	3.392^{a}	3.50^{ab}	25.50^{ab}	451.00^{ab}	2.325^{a}	0.45^{b}
T_2	231.8^{b}	17.63^{ab}	18.50^{b}	90.26^{ab}	2.525^{a}	43.79^{a}	46.72^{a}	4.825^{ab}	3.137^{ab}	3.313^{ab}	26.63^{a}	453.10^{a}	2.50^{a}	0.43^{b}
T_3	233.3^{b}	16.63^{b}	19.38^{ab}	80.81^{bc}	2.398^{a}	32.46^{c}	40.28^{abc}	4.622^{ab}	3.112^{ab}	2.475^{d}	22.63^{b}	402.10^{c}	1.625^{c}	0.36^{c}
T_4	234.8^{b}	14.63^{c}	19.88^{ab}	88.67^{ab}	2.572^{a}	39.30^{ab}	45.32^{ab}	5.012^{ab}	3.370^{a}	3.60^{a}	25.50^{ab}	455.60^{a}	2.563^{a}	0.38^{c}
T_5	229.3^{b}	18.01^{a}	15.25^{c}	84.39^{abc}	2.608^{a}	35.04^{bc}	39.30^{bc}	4.840^{ab}	3.287^{ab}	2.743^{cd}	18.50^{c}	442.60^{b}	2.00^{b}	0.74^{a}
T_6	262.3^{b}	17.63^{ab}	12.38^{d}	75.21^{c}	2.280^{a}	31.13^{c}	34.27^{c}	4.465^{b}	2.773^{b}	3.00^{bc}	17.13^{c}	390.60^{d}	1.250^{d}	0.22^{d}

Treatments means having similar alphabets in superscript, do not differ significantly

Experiment – 3

Fig.10 Treatment effect on vegetative characters (Prajwal)

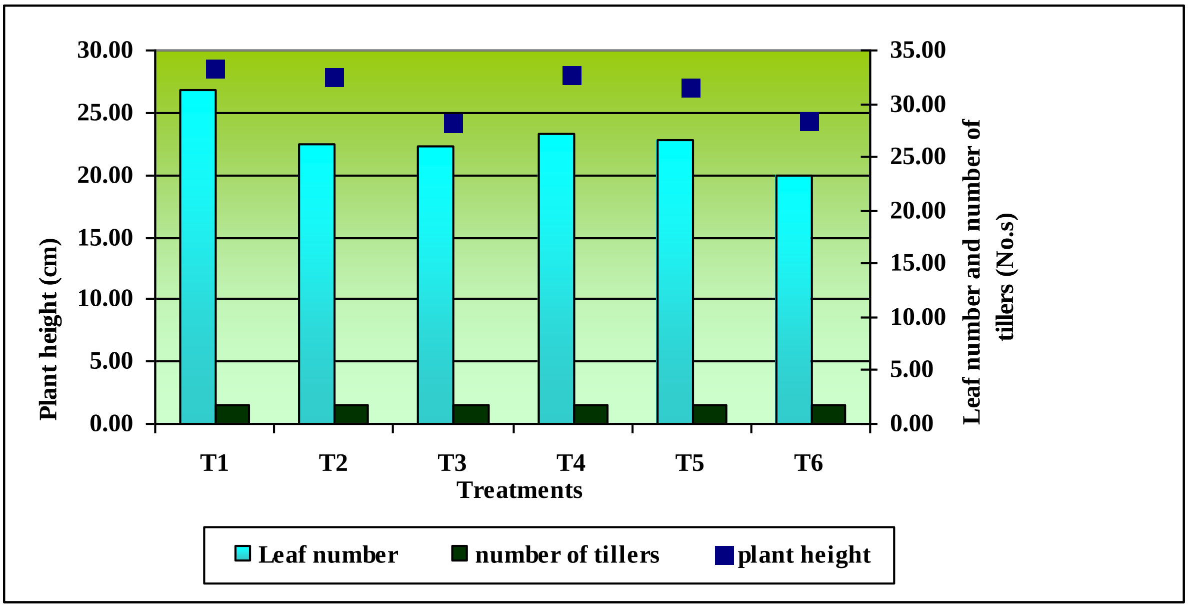


Fig.11 Treatment effect on floral characters (Prajwal)

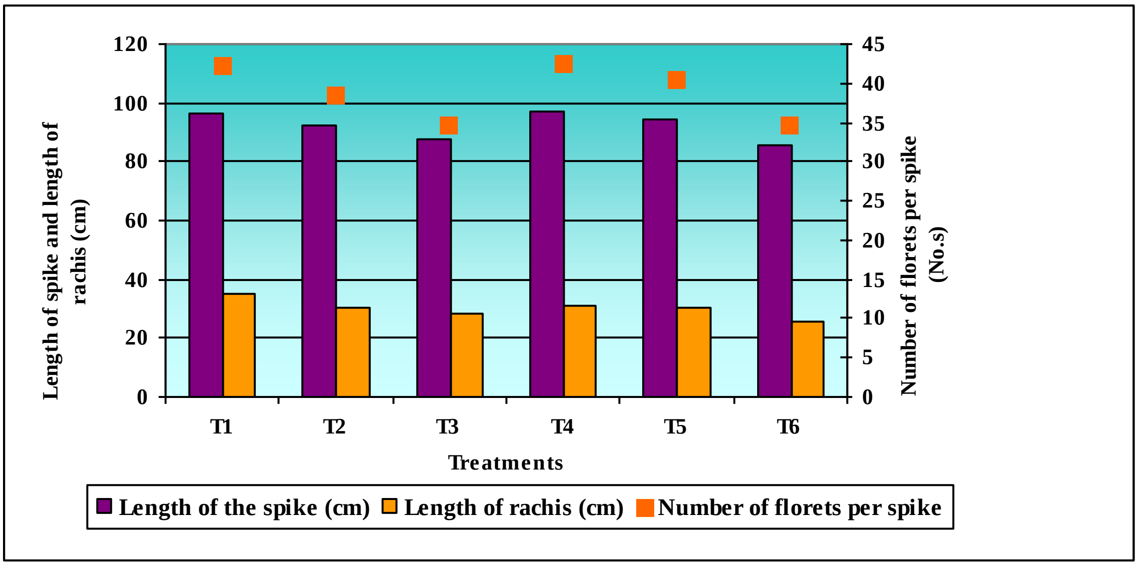


Fig.12 Treatment effect on yield of spikes per hill (Prajwal)

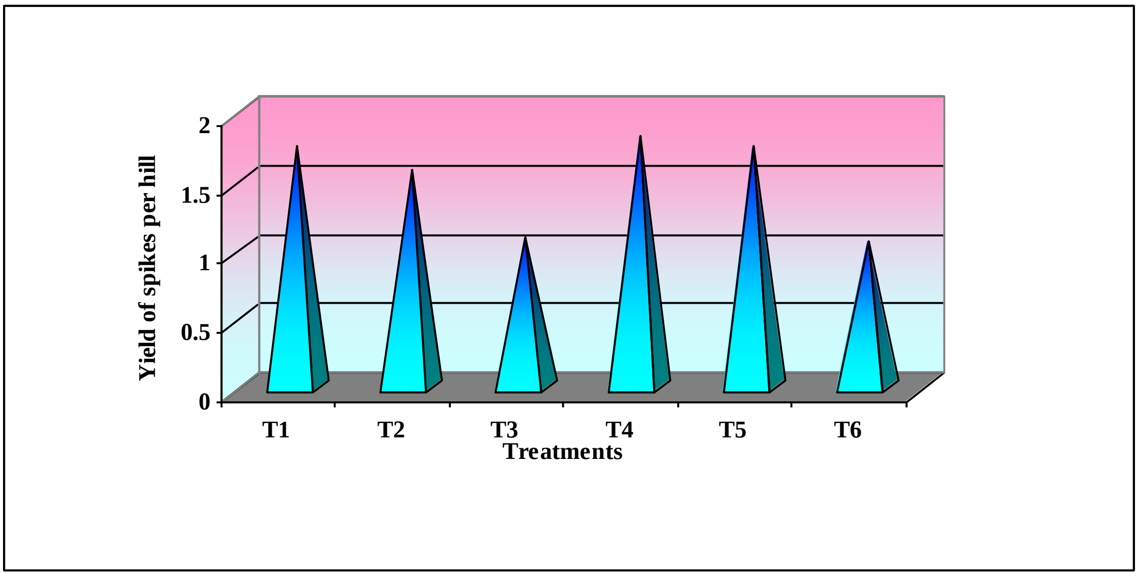


Fig.13 Treatment effect on duration of the crop (Prajwal)

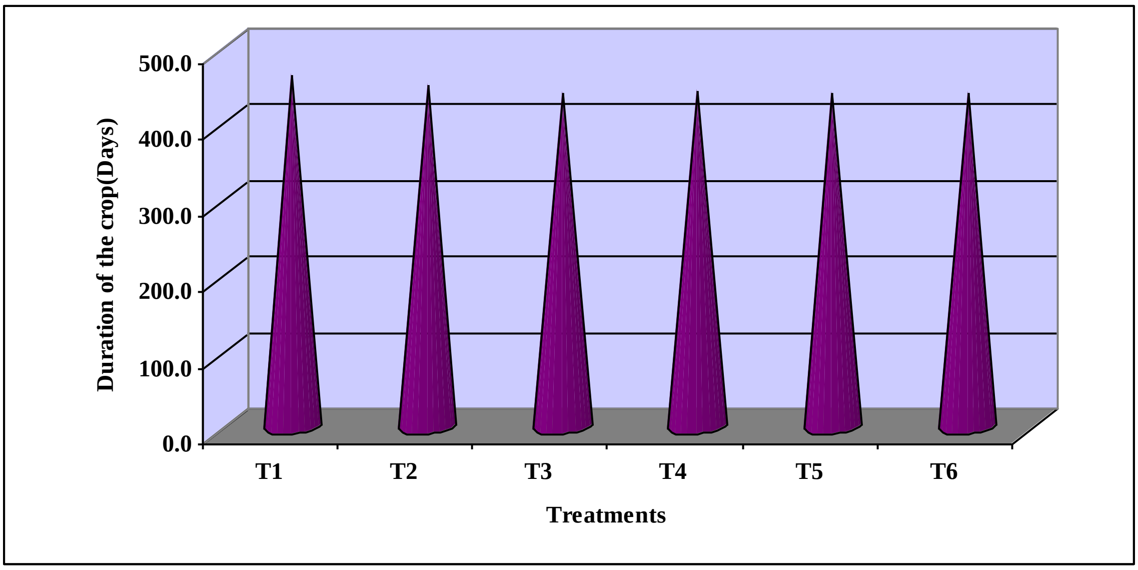


Fig.14 Treatment effect on vegetative characters (Vaibhav)

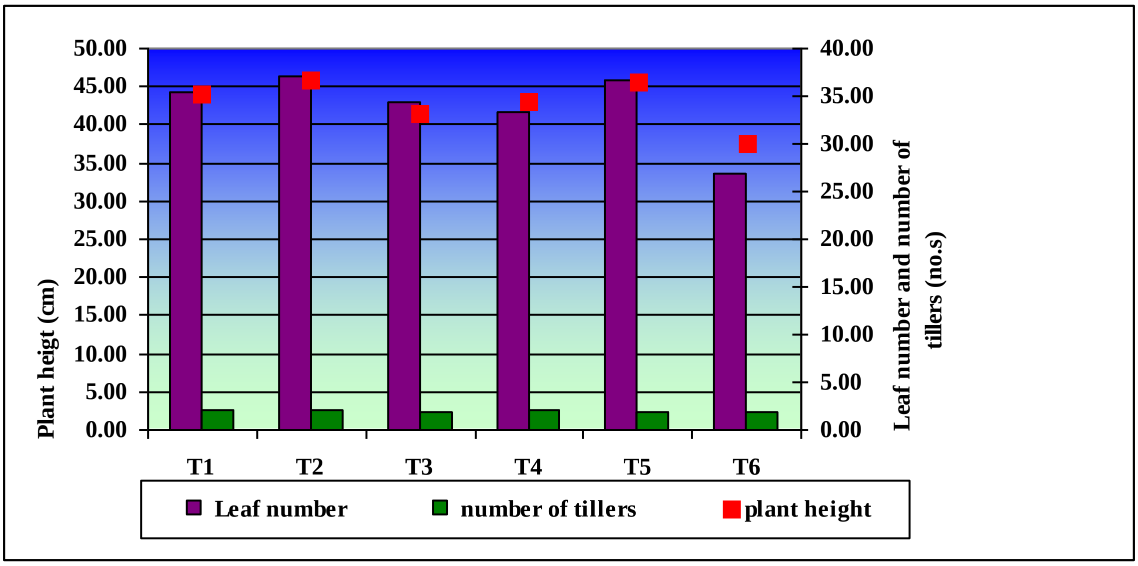


Fig.15 Treatment effect on floral characters (Vaibhav)

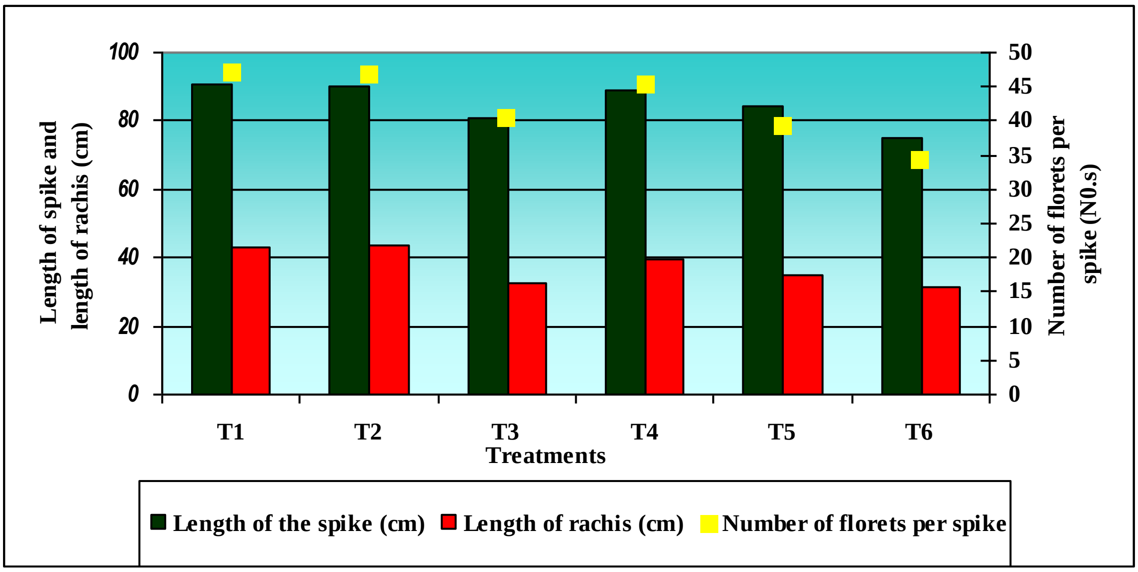


Fig.16 Treatment effect on Yield of spikes per hill (Vaibhav)

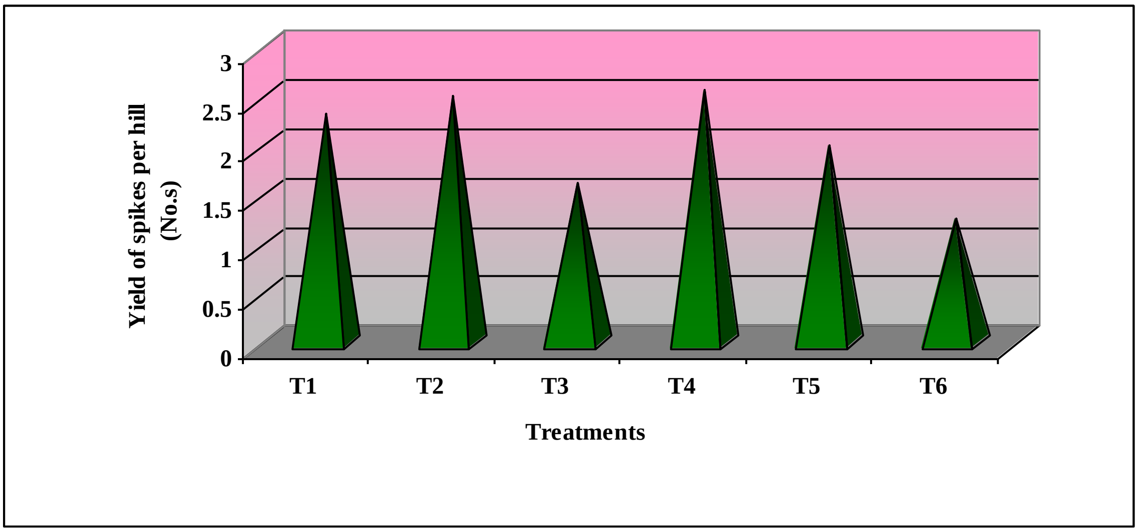
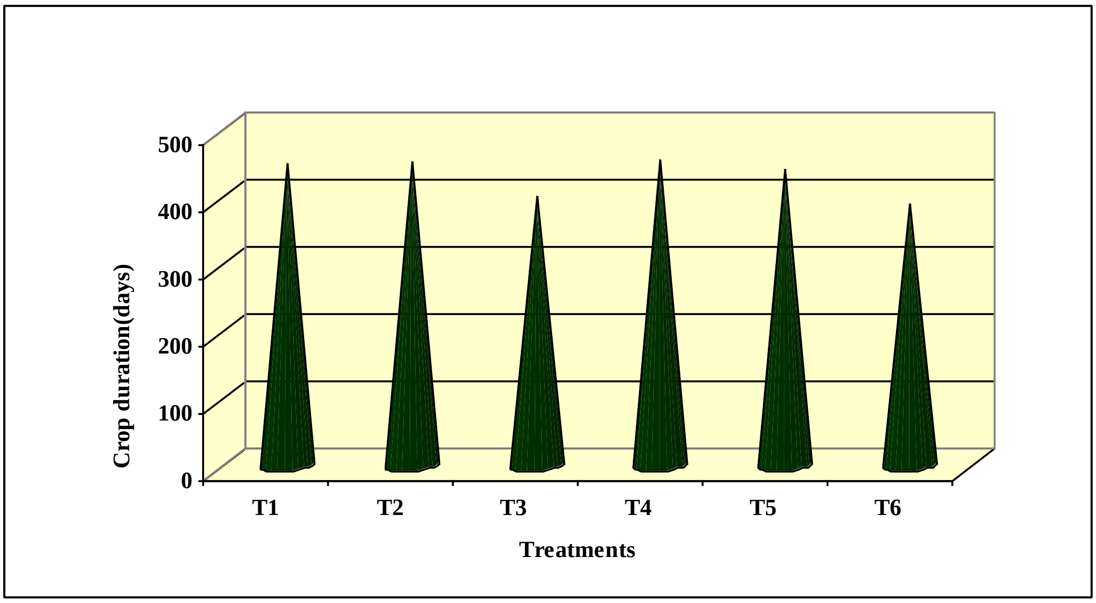


Fig.17 Treatment effect on Duration of the crop (Vaibhav)



Experiment 3

Superior treatments – Prajwal

Plate 14. T_1 - 100:50:50 kg ha^{-1} NPK + poultry manure 22.22 t ha^{-1}

Plate 15. T_2 - 50 kg ha^{-1} N+P, K + poultry manure 22.22 t ha^{-1}

Plate 16. T_4 - poultry manure 29.63 t ha^{-1}

Experiment 3

Superior treatments – Vaibhav

Plate 17. T_1 - 100:50:50 kg ha^{-1} NPK + poultry manure 22.22 t ha^{-1}

Plate 18. T_2 - 50 kg ha^{-1} N + P, K + poultry manure 22.22 t ha^{-1}

Plate 19. T_4 - poultry manure 29.63 t ha^{-1}

Plate 20. Treatment effect on spike length - Prajwal

Plate 21. Treatment effect on spike length - Vaibhav

Table 61. Treatment effect on post harvest spike characters - Prajwal

Treatment	Fresh weight of the spike (g)	Days taken for opening of each floret	No. of florets opened at a time	Total water uptake (ml)	Vase life (days)
T_1	48.75[b]	1.88[a]	2.50[a]	32.88[d]	9.13[a]
T_2	54.92[a]	2.00[a]	2.59[a]	44.50[a]	9.13[a]
T_3	49.88[b]	1.88[a]	2.06[b]	40.63[b]	8.12[ab]
T_4	59.18[a]	1.94[a]	2.39[ab]	36.45[c]	9.13a
T_5	45.88[b]	2.00[a]	2.31[ab]	41.63[ab]	7.88[b]
T_6	38.88[c]	1.94[a]	2.00[b]	35.75[cd]	6.25[bc]

Treatments means having similar alphabets in superscript, do not differ significantly

Table 62. Treatment effect on post harvest spike characters - Vaibhav

Treatment	Fresh weight of the spike (g)	Days taken for opening of each floret	No. of florets opened at a time	Total water uptake (ml)	Vase life (days)
T_1	41.91^{cd}	2.25^{a}	2.06^{a}	20.13^{ab}	10.25^{a}
T_2	41.53^{cd}	2.24^{a}	2.13^{a}	13.50^{de}	8.50^{bc}
T_3	54.19^{a}	2.19^{a}	1.94^{a}	15.75^{cd}	7.75^{cd}
T_4	48.31^{b}	2.19^{a}	2.13^{a}	17.38^{bc}	9.00^{b}
T_5	44.22^{bc}	2.08^{a}	2.03^{a}	11.50^{e}	7.50^{d}
T_6	38.65^{d}	2.00^{a}	1.94^{a}	22.75^{a}	7.38^{d}

Treatments means having similar alphabets in superscript, do not differ significantly

Table 63. Treatment effect on bulb characters - Prajwal

Treatment	No. of bulbs per hill	No. of bulblets per hill	Weight of bulbs (g)	Weight of bulblets (g)	Size of bulbs (cm)	Size of bulblets (cm)
T_1	29.25^{b}	42.50^{b}	332.00^{a}	84.25^{b}	7.33^{a}	3.71^{b}
T_2	28.25^{c}	40.00^{c}	285.00^{b}	64.50^{c}	4.64^{c}	3.74^{ab}
T_3	21.25^{d}	31.50^{e}	253.80^{d}	47.00^{d}	4.69^{c}	3.94^{a}
T_4	31.50^{a}	35.25^{d}	275.80^{bc}	83.00^{b}	5.33^{b}	2.95^{c}
T_5	21.50^{d}	95.50^{a}	265.80^{cd}	153.80^{a}	5.53^{b}	3.06^{c}
T_6	18.25^{e}	20.75^{f}	148.80^{e}	54.50^{d}	4.20^{d}	2.56^{d}

Treatments means having similar alphabets in superscript, do not differ significantly

Table 64. Treatment effect on bulb characters - Vaibhav

Treatment	No. of bulbs per hill	No. of bulblets per hill	Weight of bulbs (g)	Weight of bulblets (g)	Size of bulbs (cm)	Size of bulblets (cm)
T_1	16.75^{a}	20.50^{b}	161.30^{b}	31.75^{d}	6.03^{a}	3.25^{b}
T_2	14.88^{b}	24.25^{a}	154.80^{b}	41.75^{c}	4.69^{bc}	2.67^{c}
T_3	11.75^{d}	18.75^{bc}	100.80^{d}	40.50^{c}	5.00^{b}	3.58^{a}
T_4	16.75^{a}	24.00^{a}	176.30^{a}	57.75^{a}	5.63^{a}	3.69^{a}
T_5	13.50^{c}	20.50^{b}	170.80^{b}	47.75^{b}	4.38^{c}	3.46^{ab}
T_6	8.88^{e}	17.25^{c}	104.00^{d}	20.75^{e}	4.50^{bc}	2.53^{c}

Treatments means having similar alphabets in superscript, do not differ significantly

4.3.4.6 Size of bulblets

T_3 was found to result in large bulblets (3.94 cm long) and T_6 in smallest ones in Prajwal.

For the variety Vaibhav (double) bulblet size was maximum in T_4 (3.69) and minimum was noticed in T_6 (2.53 cm).

4.3.5 Plant analysis

4.3.5.1 N content

Plants under, T_1 (100:50:50 kg NPK ha^{-1} + poultry manure 22.22 t ha^{-1}) was found to have maximum N content of leaves closely followed by T_4 (Poultry manure alone) through out the course of growth (Table 65). Regarding the nitrogen content of tubers also T_1 had significantly higher values through out the growth period and the least values were observed in T_6 (absolute control).

For variety Vaibhav, statistical superiority in terms of N content was exhibited by T_4 and T_2 (50:50:50 kg NPK ha^{-1} + poultry manure 22.22 t ha^{-1}) during initial and later stages of growth respectively. For tubers T_4 registered superior values of N content through out the crop growth (Table 66). Generally, in all the treatments, leaves were found to have higher N content than tubers.

4.3.5.2 P content

In variety Prajwal, T_1 (100:50:50 kg NPK ha^{-1} + Poultry manure 22.22 t ha^{-1}) recorded significantly higher P content during initial period (0.51) and there after maximum values were observed in T_2 (50:50:50 kg NPK ha^{-1} + poultry manure 22.22 t ha^{-1}). For tubers, no significant variation was observed among the treatments during early period. However, during the last two stages T_6 (absolute control) was found to be superior to other treatments (Table 67).

For variety Vaibhav, maximum value for P content was observed in T_4, (Poultry manure 29.63 t ha^{-1}) during initial three months of observation and towards

Table 65. Treatment effect on in N content of leaves and tubers (%) - Prajwal

Treatments	Months of observation							
	Leaf				Tuber			
	1	2	3	4	1	2	3	4
T_1	2.16[a]	2.18[a]	2.33[a]	2.35[a]	1.12[a]	1.64[a]	2.07[a]	2.15[a]
T_2	1.79[c]	1.96[b]	1.88[b]	1.89[c]	1.06[b]	1.29[b]	1.97[b]	1.77[c]
T_3	1.68[d]	1.59[c]	1.78[c]	1.65[d]	0.77[c]	1.08[d]	1.69[c]	1.90[b]
T_4	1.92[b]	2.01[b]	2.35[a]	2.35[a]	1.13[a]	1.23[c]	2.02[a]	1.54[d]
T_5	1.46[e]	1.56[c]	2.27[a]	2.05[b]	1.12[a]	1.28[b]	1.27[d]	1.26[e]
T_6	1.44[e]	1.44[d]	1.57[d]	1.48[e]	1.03[b]	0.97[e]	0.85[e]	1.02[f]

Treatments means having similar alphabets in superscript, do not differ significantly

Table 66. Treatment effect on N content of leaves and tubers (%) - Vaibhav

Treatments	Months of observation							
	Leaf				Tuber			
	1	2	3	4	1	2	3	4
T_1	1.46^{b}	1.64^{d}	2.06^{c}	2.00^{c}	1.21^{d}	1.24^{c}	1.84^{c}	1.84^{bc}
T_2	1.21^{d}	1.29^{f}	2.36^{a}	2.15^{a}	1.20^{d}	1.21^{c}	1.96^{b}	1.95^{b}
T_3	1.14^{e}	1.46^{e}	1.79^{e}	1.63^{f}	1.36^{c}	1.46^{b}	1.25^{e}	1.21^{d}
T_4	1.56^{a}	2.13^{a}	2.13^{b}	2.13^{b}	1.54^{a}	1.63^{a}	2.23^{a}	2.09^{a}
T_5	1.26^{c}	1.84^{b}	1.92^{d}	1.80^{d}	1.47^{b}	1.61^{a}	1.73^{d}	1.75^{c}
T_6	1.14^{e}	1.73^{c}	1.74^{f}	1.76^{e}	0.87^{e}	1.14^{d}	1.23^{e}	1.23^{d}

Treatments means having similar alphabets in superscript, do not differ significantly

Table 67. Treatment effect on P content of leaves and tubers (%) - Prajwal

Treatments	Months of observation							
	Leaf				Tuber			
	1	2	3	4	1	2	3	4
T_1	0.51^{a}	0.48^{a}	0.31^{bc}	0.31^{c}	0.17^{a}	0.10^{a}	0.08^{d}	0.18^{bc}
T_2	0.45^{b}	0.35^{b}	0.37^{a}	0.47^{a}	0.16^{a}	0.13^{a}	0.13^{d}	0.18^{bc}
T_3	0.28^{c}	0.25^{c}	0.21^{e}	0.25^{d}	0.19^{a}	0.13^{a}	0.11^{cd}	0.19^{bc}
T_4	0.46^{b}	0.35^{b}	0.34^{ab}	0.36^{b}	0.17^{a}	0.12^{a}	0.07^{d}	0.15^{c}
T_5	0.28^{c}	0.25^{c}	0.25^{de}	0.27^{cd}	0.18^{a}	0.09^{a}	0.65^{b}	0.21^{b}
T_6	0.28^{c}	0.28^{c}	0.28^{cd}	0.29^{cd}	0.14^{a}	0.09^{a}	0.76^{a}	0.88^{a}

Treatments means having similar alphabets in superscript, do not differ significantly

Table 68. Treatment effect on P content of leaves and tubers (%) - Vaibhav

Treatments	Months of observation							
	Leaf				Tuber			
	1	2	3	4	1	2	3	4
T_1	0.26^{b}	0.23^{b}	0.21^{b}	0.24^{a}	0.21^{a}	0.17^{b}	0.18^{c}	0.16^{b}
T_2	0.24^{c}	0.22^{bc}	0.19^{c}	0.20^{c}	0.21^{a}	0.08^{e}	0.08^{e}	0.18^{b}
T_3	0.24^{c}	0.22^{bc}	0.20^{c}	$0.21b^{c}$	0.18^{bc}	0.16^{c}	0.21^{b}	0.23^{a}
T_4	0.35^{a}	0.33^{a}	0.23^{a}	0.20^{c}	0.20^{ab}	0.18^{a}	0.26^{a}	0.26^{a}
T_5	0.19^{d}	0.17^{d}	0.12^{d}	0.12^{d}	0.20^{ab}	0.09^{d}	0.15^{d}	0.16^{b}
T_6	0.23^{c}	0.21^{c}	0.21^{b}	0.22^{b}	0.18^{c}	0.09^{d}	0.07^{f}	0.08^{c}

Treatments means having similar alphabets in superscript, do not differ significantly

the final stage T_1 was superior (0.24). In tubers T_1 and T_2 were on par with maximum value (0.21) during the first month where as during the rest of the growth period T_4 registered significantly higher values of P content (Table 68).

In leaves and tubers of both varieties P content was more during the last stages of crop growth coinciding with the peak flowering period.

4.3.5.3 K content

In variety Prajwal, even though there was no consistent pattern of variation of K content of leaves, T_3 (50:50:50 kg NPK ha^{-1} + coirpith compost 85.71 t ha^{-1}), T_4 (Poultry manure, 29.63 t ha^{-1}) and T_5 (Biogas slurry) exhibited superiority through out the growth period (Table 69). For tubers T_2 (50:50:50 kg NPK ha^{-1} + poultry manure 22.22 t ha^{-1}) was statistically significant during the first month of observation (2.24) and T_1 (100:50:50 kg NPK ha^{-1} + Poultry manure 22.22 t ha^{-1}) registered maximum values during the following months.

For variety Vaibhav, T_3 (treatment consisted of coir pith compost) was found to have highest K content of leaves through out the crop growth and no consistent pattern of variation was observed in K content of tubers (Table 70).

4.3.6 Soil analysis

Data related to the effect of treatment on soil properties is presented in Tables 71 and 72.

4.3.6.1 pH

In Prajwal higher pH value was observed in T_3 (treatment with coir pith compost) (6.35) and a value of 6.35 was noted in treatments under T_2 in Vaibhav pH values was minimum in T_1 for Prajwal and in T_5 for Vaibhav.

Table 69. Treatment effect on K content of leaves and tubers (%) - Prajwal

Treatments	Months of observation							
	Leaf				Tuber			
	1	2	3	4	1	2	3	4
T_1	3.71^b	2.36^c	1.95^c	2.46^d	2.13^b	1.53^a	1.65^a	1.78^a
T_2	3.53^c	2.55^b	2.35^b	2.42^d	2.24^a	1.07^c	0.88^d	1.36^c
T_3	3.53^c	2.75^a	2.77^a	2.68^b	1.13^e	0.64^e	0.96^c	1.53^b
T_4	3.87^a	2.75^a	2.09^c	2.45^d	1.76^c	1.23^b	1.00^c	1.44^c
T_5	2.76^d	2.59^b	2.74^a	3.23^a	1.36^d	1.23^b	1.13^b	1.24^d
T_6	2.49^e	2.43^c	1.93^d	2.55^c	1.01^f	0.86^d	0.53^e	0.92^e

Treatments means having similar alphabets in superscript, do not differ significantly

Table 70. Treatment effect on K content of leaves and tubers (%) - Vaibhav

Treatments	Months of observation							
	Leaf				Tuber			
	1	2	3	4	1	2	3	4
T_1	2.48^{b}	2.17^{b}	1.74^{c}	2.84^{ab}	2.00^{b}	1.86^{a}	1.51^{b}	1.64^{a}
T_2	1.95^{d}	1.66^{d}	1.46^{e}	1.72^{d}	1.83^{c}	1.75^{b}	1.23^{d}	1.21^{c}
T_3	2.75^{a}	2.51^{a}	2.03^{a}	3.05^{a}	1.53^{e}	1.33^{d}	1.34^{c}	1.38^{b}
T_4	2.76^{a}	2.04^{c}	2.05^{a}	2.64^{b}	2.08^{a}	1.66^{c}	1.24^{d}	1.26^{c}
T_5	2.13^{c}	2.07^{c}	1.79^{b}	2.03^{c}	1.63^{d}	1.67^{c}	1.65^{a}	1.66^{a}
T_6	2.01^{d}	1.73^{d}	1.67^{d}	1.93^{cd}	0.95^{f}	0.86^{e}	0.65^{e}	0.65^{d}

Treatments means having similar alphabets in superscript, do not differ significantly

Table 71. Treatment effect on post harvest soil properties - Prajwal

Treatments	pH	Organic carbon (%)	Available N (kg ha^{-1})	Available P (kg ha^{-1})	Available K (kg ha^{-1})
T_1	6.30^{a}	0.65^{a}	144.50^{a}	34.55^{a}	1164.0^{b}
T_2	6.08^{ab}	0.51^{b}	112.60^{b}	25.13^{b}	157.50^{c}
T_3	6.35^{a}	0.46^{c}	102.00^{c}	13.82^{e}	74.750^{e}
T_4	6.40^{a}	0.51^{b}	113.70^{b}	20.45^{c}	105.30^{d}
T_5	6.00^{b}	0.50^{b}	112.00^{b}	15.77^{d}	167.80^{a}
T_6	6.33^{a}	0.45^{c}	101.40^{c}	11.70	64.00^{f}

Treatments means having similar alphabets in superscript, do not differ significantly

Table 72. Treatment effect on post harvest soil properties - Vaibhav

Treatments	pH	Organic carbon (%)	Available N (kg ha^{-1})	Available P (kg ha^{-1})	Available K (kg ha^{-1})
T_1	6.30^{a}	0.60^{b}	133.8^{b}	34.25^{a}	133.80^{b}
T_2	6.30^{a}	0.60^{b}	133.80^{b}	35.00^{a}	134.00^{b}
T_3	5.68^{c}	0.60^{b}	124.80^{c}	11.40^{b}	124.30^{c}
T_4	6.35^{a}	0.60^{b}	133.80^{b}	34.50^{a}	133.00^{b}
T_5	6.18^{b}	0.65^{a}	144.50^{a}	12.00^{b}	144.5^{0}
T_6	5.20^{d}	0.60^{b}	124.30^{c}	10.00^{c}	124.80^{c}

Treatments means having similar alphabets in superscript, do not differ significantly

4.3.6.2 Organic carbon

Regarding organic carbon, a maximum value of 0.65 percentage was observed under T_1 in Prajwal and T_5 (treatment with biogas slurry) in Vaibhav.

4.3.6.3 Available N

In Prajwal T_1 was statistically superior in this parameter, where as in VaibhavT_5 recorded the maximum value (144.5 kgha^{-1}). T_6 recorded the least value in both the varieties.

4.3.6.4 Available P

Available P was maximum in T_1 for Prajwal (34.55 kgha^{-1}) and in T_2 (35.00 kgha^{-1}) for Vaibhav. Treatments under T_6 registered minimum value in this parameter, in both the varieties.

4.3.6.5 Available K

Regarding this parameter, significantly higher values were observed in T_5 forboth the values (167.8 kgha^{-1} in prajwal and 144.5 kgha^{-1} in vaibhav).

4.4 CORRELATION STUDIES

4.4.1 Correlation between NPK content of leaves and floral characters

Correlation between NPK content of leaves and floral characters of Prajwal (single) is furnished in the Table 73 and Vaibhav (double) in Table 74.

In both the varieties a higher positive correlation of N content of leaves was observed with length of spike, length rachis, girth of spike, number of florets per spike and yield of spikes per hill. No significant correlation could be observed between P and K content with floral characters.

Table 73. Correlation between nutrient content and vegetative characters

	N	P	K	Length of spike	Length of rachis	Girth of spike	No of flowers	Spike number
N	1	0.209	-0.091	0.784**	0.679**	0.607**	0.735**	0.809**
P		1	-0.272	0.223	0.072	0.141	0.230	0.351
K			1	0.007	0.051	0.052	-0.017	0.072

Table 74. Correlation between nutrient content and floral characters

	N	P	K	Length of spike	Length of rachis	Girth of spike	No of flowers	Spike number
N	1	0.474*	-0.238	0.598**	0.706**	0.283	0.580**	0.813**
P		1	0.409*	0.186	0.206	-0.007	0.280	0.327
K			1	0.047	-0.028	-0.032	0.159	-0.017

Table 75. Correlation between vegetative and floral characters

	Height	No of leaves	Leaf area	No of tillers	Length of spike	Length of rachis	Girth of spike	No of flowers	Yield of spike per hill
Height	1	0.940	0.955**	0.971**	0.87**	0.820**	0.231	0.765*	0.964**
No of Leaves		1	0.959**	0.889**	0.785*	0.708	0.359	0.630	0.915
Leaf area			1	0.933**	0.858**	0.838**	0.432	0.659	0.934**
No of tillers				1	0.904**	0.853**	0.334	0.611	0.892**
Length of spike					1	0.900**	0.352	0.745	0.780*
Length of rachis						1	0.535	0.707	0.837**
Girth of spike							1	0.041	0.339
No of flowers								1	0.760*
Yield of spike per hill									1

4.4.2 Correlation between vegetative and floral characters

Correlation between vegetative and floral characters of tuberose is furnished in Table 75.

A highly significant and positive correlation of plant height was observed between length of spike, length rachis, number of flowers and yield of spikes per hill. Numbers of leaves and leaf area were significantly and positively correlated with yield of spikes per hill.

Correlation with in vegetative characters indicated a high positive and significant correlation of plant height and number of leaves with leaf area and number of tillers. There was a significantly positive correlation between leaf area and number of tillers.

As far as floral characters are concerned, length of spike was significantly and positively correlated with length of rachis and yield of spikes per hill. A highly significant positive correlation was observed between length of rachis and yield of spikes per hill. There was a significant positive correlation between number of flowers and yield of spikes per hill.

4.5 TREATMENT EFFECTS ON ECONOMICS OF CULTIVATION

As far as economics of cultivation is concerned, application of poultry manure alone recorded maximum net income with high B/C ratio (Rs.743830.00/ha and 3.20/ha respectively) followed by T_1 (poultry manure with full recommended quantity of nitrogen). The least net income of Rs.260796.00/ha and B/C ratio of 1.00/ha were observed in T_6 (absolute control) in Prajwal.

In Vaibhav, treatment with poultry manure alone (T_4) had highest net income and B/C ratio (Rs.828325.00/ha and 2.5/ha respectively). A B/C ratio of 2.40/ha was observed in T_1 (poultry manure with inorganic fertilizers). Minimum net income and B/C ratio (Rs.236040.00/ha and 0.65/ha respectively) were recorded by T_6 (Table 76).

Table 76. Benefit-cost ratio of different treatments

Treatments	Single (Prajwal)		Double (Vaibhav)	
	Net income (Rs.)/ha	B/C ratio/ha	Net income (Rs.)/ha	B/C ratio/ha
T_1	675672.00	2.90	795671.00	2.40
T_2	635569.00	2.70	733822.00	2.30
T_3	326677.00	1.05	474922.00	1.50
T_4	743830.00	3.20	828325.00	2.50
T_5	385100.00	1.18	522595.00	1.22
T_6	260796.00	1.00	236040.00	0.65

Discussion

5. DISCUSSION

Among the ornamental bulbous plants, which are valued for beauty and fragrance of their flowers, tuberose occupies a very selective and special position. It has great economic potential in cut flower trade and essential oil industry (Sadhu and Bose, 1973). Due to their great demand, it is currently cultivated in most of the tropical and sub tropical countries of the world. Tuberose is a heavy feeder and highly exhausting crop and responds well to the application of organic and inorganic nutrients. However large scale use of chemical fertilizers causes pollution and deterioration of soil structure, in addition to the problems of losses of applied fertilizers by way of leaching, volatilization and denitrification of nitrogen and fixation of phosphorus (Vishwanath, 2002). Use of organic manures and growth promoting micro organisms in combination with minimum quantity of chemical fertilizers offers a great opportunity to increase the crop production with less negative effects.

The present experiment was conducted at the Department of Pomology and Floriculture, College of Horticulture, Vellanikkara to study the response of tuberose (*Polianthes tuberosa* L.) to organic manures and growth promoting micro organisms. The study consisted of three experiments. Experiment 1 included sixteen treatments which were the combinations of chemical fertilizers either with organic manures or with growth promoting microorganisms. Experiment 2 with nine different treatments was carried out simultaneously. Three best treatments from former experiment and two from latter one were selected for conducting the third experiment using two tuberose varieties one each of single (Prajwal) and double (Vaibhav) types. The results of the present investigation are discussed here under.

5.1 VEGETATIVE CHARACTERS

Vegetative characters like plant height, number of leaves, leaf area, plant spread and number of tillers have significant influence on the total yield potential of tuberose. In the experiment for comparing different combinations of organic manures or growth promoting micro organisms along with chemical fertilizers (Experiment 1), treatments with poultry manure (T_3 and T_{14}) in combination with inorganic fertilizers resulted in better vegetative growth, during the major parts of growth period. Same trend was clear in the ratoon crop also. In the experiment with different sources of organic manures also (Experiment 2) application of poultry manure resulted in augmented values for vegetative parameters. Among the other treatments, combination of coir pith compost and inorganic fertilizers (T_{16} of Experiment 1) and biogas slurry (T_7 of Experiment 2) were found to be influencing vegetative parameters positively.

When best treatments of the initial experiments were compared also the beneficial effect of poultry manure was clear from the results, in terms of improved vegetative growth. In both single and double varieties the trend was almost the same.

The beneficial effect of poultry manure in improving vegetative growth may be due to higher availability of essential plant nutrients rapid mineralization and more balanced C/N ratio (Shelke *et al*., 2001, Prabhakaran, 2003 and Mali *et al*., 2005). Significant increase in plant height, leaf area and leaf emergence rate by the application of poultry manure was reported by Ndabuaku and Kassim (2003). The predominant form of N in poultry manure is uric acid that readily transforms to ammoniacal form which is easily available for plants. When poultry manure is supplemented with inorganic fertilizers, it might have helped microorganisms in the faster decomposition of organic manures, there by increasing availability of nutrients especially nitrogen which helps in protein synthesis and ultimately resulting higher growth rate (Sivakumar, 2005 and Zublena, 2007).

Application of coir pith compost plus inorganic fertilizers and biogas slurry alone were the second set of treatments which influenced vegetative growth parameters positively. Improvement of vegetative growth by the application of coirpith compost may be due to the supply of essential plant nutrients and increased water holding capacity of the soil. The beneficial effect of coirpith compost is well documented in the findings of Barrito and Jagtap (2002) Miller and Langhans (1990), Rajeevan *et al*. (2003) and Bharathy *et al*. (2003). In biogas slurry there is a stimulative effect on microbial count and enrichment of soil with ammonia and also nutrients are in easily available form. All these might be attributed to better growth by the application of biogas slurry. Raviv *et al*. (1984) reported the positive influence of biogas slurry in rose.

In the present investigation, vegetative growth was documented in terms of above mentioned parameters at monthly intervals during the course of growth of plants. Plant height values in general exhibited progressive increase initially followed by a decrease in sixth month which can be attributed to the drooping of leaves in summer months. The values of plant spread registered an opposite trend showing increased values during final stages of growth, due to the drooping of leaves.

Number of leaves in any crop showed progressive increase during the initial growth period up to certain months in general followed by a decrease which coincided with the flowering season. In tuberose inflorescence is produced from central meristematic tissue and further leaf production is ceased from that hill. More over total number of leaves did not show drastic reduction, infact slight increase towards the final stages of observation may be attributed to the production of leaves in new tillers.

5. 2 FLORAL CHARACTERS

5.2.1 Yield attributes

In tuberose yield attributes mainly included early flowering, days for first floret opening, field life of spike, crop duration and number of spikes obtained from a plant. Days taken for first spike emergence indicates early or delayed flowering. In Experiment 1, early emergence of spike was observed in treatments consisted of poultry manure and inorganic fertilizers (T_3 and T_{14}). Plants under these treatments flowered in 140.67 and 151.33 days (Table 13). The positive influence of these treatments was also reflected in days taken for first floret opening. A significant improvement in the parameters like field life of spikes and crop duration were observed in treatments with poultry manure. Yield of spikes per hill is the most important among the yield attributes, which decides the profitability of the crop. In the experiment 1, yield of spikes per hill varied from 0.92 to 2.42 in plant crop and 1.17 to 2.40 in ratoon crop, the number observed being maximum in T_3 (100:50:50 kg ha^{-1} NPK + poultry manure) and minimum in T_{11} (50 kg ha^{-1} N + P, K and 30 t FYM + AMF) and T_8 (100:50:50 kg NPK ha^{-1} + 30 t FYM + AMF + *Azospirillum* sp.) in plant and ratoon crops respectively. Among the other treatments, T_{14} (50 kg ha^{-1} N, +P, K and poultry manure) and T_{16} (50 kg ha^{-1} N, +P, K and biogas slurry) were superior with respect to this parameter.

From the trial with organic manures alone (Experiment 2), it could be observed that spikes emerged at the earliest in treatments under poultry manure and biogas slurry (T_4 and T_7 respectively). Biogas slurry had a superior effect on days to first floret opening, compared to other treatments. The parameters like field life of spike and crop duration were found to be increased by the application of poultry manure and biogas slurry. Regarding the spike production, an improvement was noticed under poultry manure, followed by biogas slurry.

In Experiment 3, early flower induction was noticed under T_4 (poultry manure alone) for single variety where as T_2 (poultry manure with half quantity of nitrogen) was superior in terms of this parameter for double variety. Same result was observed regarding field life of spike also. Crop duration was significantly increased by the application of poultry manure in combination with chemical fertilizers (T_1 in Prajwal and T_4 in Vaibhav). Crop duration ranged from 439.30 days to 462.60 days in Prajwal (T_6 and T_1 respectively) and 390.60 days from 455.60 days in Vaibhav (T_6 and T_4 respectively). Application of poultry manure alone resulted in production of more number of spikes in both the varieties.

Early emergence of spike in treatments with poultry manure might be due to increased availability of N from this organic source. A balanced supply of N promotes translocation of phytohormones to shoot which probably induce early flower formation (Marschner, 1983; Banker and Mukhopadhyay, 1990). In the case of yield attributes, there was well documentation of positive influence of poultry manure, biogas slurry and coir pith compost. The beneficial effect on improving these parameters might be due to better plant growth by the increased availability of nutrients and accelerated mobility of photosynthates from source to sink as influenced by the growth hormones released or synthesized from these manures (Sivakumar *et al*., 2005). With regard to the yield parameters all the treatments exhibited positive influence over control which indicate that tuberose responds well to organic and inorganic fertilizers. However, among the treatments poultry manure alone and in combination with chemical fertilizers were proved to be the best might be due to the beneficial effect of poultry manure as mentioned earlier.

5.2.2 Quality parameters

Apart from the production of more spikes, qualitative parameters also are significant as far as a cut flower like tuberose is concerned**.** Among the quality parameters, length of the spike, length of rachis and number of florets per spike are important characters which contribute to the beauty of the spike.

In the first experiment, T_3 (poultry manure with full recommended dose of nitrogen) resulted in the production of lengthy spikes with more number of flowers of bigger size. T_{14} (treatment with half recommended dose of nitrogen) and T_{16} (coir pith compost with half recommended dose of nitrogen) were also found to have positive influence in these parameters. Smallest spikes were resulted in T_2 (100:50:50 kg ha^{-1} NPK+ FYM) and T_1 (absolute control) in plant and ratoon crops respectively. Number of spikes also exhibited the same trend, more being inT_3 and minimum in T_8 (treatment consisted of *Azospirillum* sp.) and T_5 (treatment consisted of coir pith compost) in plant and ratoon crops respectively.

As far as the effect of organic manures alone is concerned, poultry manure was superior in terms of parameters like length of spike and number of florets per spike followed by T_7 (biogas slurry). Longer rachis and bigger florets were resulted in plants treated with biogas slurry.

In a number of flower crops panchagavya application has been reported to be beneficial for over all improvement (Somasundaram *et al*., 2004). Application of panchagavya was tried in the present study also. The results were not encouraging since there was no positive response by the plants in terms of vegetative as well as floral characters. More over the flowering of plants treated with this formulation was delayed (372.00 and 217.00 days in plant and ratoon crops respectively) than the control. In the study panchagvya was applied alone as a treatment as sprays at weekly interval. Most of the reports where positive reports are resulted were carried out with panchagavya in combination with other organic manures. The lack of positive response obtained in the present study might be due to this factor.

In the third experiment treatment with poultry manure alone was superior in terms of quality parameters in Prajwal. In Vaibhav T_1 (poultry manure with full recommended dose of nitrogen) had positive influence on these parameters.

Tuberose is valued as a source of essential oil due to the presence of pleasant and high grade volatile compound. In the present study flowers from experiment .3 were subjected to extraction of concrete which gives an indication of essential oil content. Concrete estimated represents the crude form of essential oil. Concrete of flowers was more in plants treated with biogas slurry in both single and double types treatments exhibited significant variation with respect to this parameter. Minimum concrete could be obtained from T_6 (absolute control). Improvement in concrete content under different treatments especially with biogas slurry might be due to growth and yield improvement as a result of more availability of nitrogen and increased oxidizing and reducing capacity of oils in the flower petals reported by Sharga and Motilal, 1983.

Beneficial effect of poultry manure and biogas slurry on quality parameters might be due to fast release of nutrients from these manures, which resulted in increased plant growth, more production and translocation of photosynthates to flowering parts resulting the production of lengthy spikes with more number of flowers. These results are in accordance with the findings of Singh *et al*. (2006) who reported an improvement in vegetative growth and flower yield of rose by the application of poultry manure along with biofertilizers and chemical fertilizers. From the correlation studies a highly significant positive correlation of plant height was observed between length of spike, length of rachis, number of flowers and yield of spikes per hill. There was a highly significant positive correlation of number of leaves and leaf area with yield of spikes per hill. Treatments with poultry manure alone and in combination with inorganic fertilizers resulted in improved yield parameters could be attributed to the positive correlation of these to the vegetative characters like plant height, number of leaves and leaf area which were all positively influenced by these treatments. A highly positive correlation of nitrogen content of leaves was also observed with length of spike, length of rachis, number of flowers and yield of spikes per hill. More nitrogen content of leaves under treatment with poultry manure was also observed in the present study. This can also be counted as a reason for the influence of this organic source on the yield attributes of tuberose.

In the present investigation application of growth promoting microorganisms such as AMF, *Azospirillum* sp., *Trichoderma* sp. and *Pseudomonas fluorescens*, in combination with in organic fertilizers resulted in slight improvement of the yield and quality parameters when compared with the treatments including poultry manure, coir pith compost and biogas slurry. This might be due to acidic nature of the soil, which hinders the activity of these organisms.

5. 3 POST HARVEST SPIKE CHARACTERS

Fresh weight is an important feature which indicates the freshness and moisture content of the spike. In Experiment 1, T_{16} (coir pith compost with half the recommended dose of nitrogen) recorded maximum value for this parameter. Number of florets opened at a time decides the attractiveness of the spike. Vase life is the most important post harvest character which decides the longevity of the spike in vase. In Experiment 1 vase life of spikes varied from 5.67 days in control (T_1) to 10.00 days in T_3 (poultry manure with full recommended dose of nitrogen). Both number of florets opened at a time and vase life were found to be the best in treatments with poultry manure and coir pith compost (T_3, T_{14} and T_{16}).

In Experiment 2, superior effect of biogas slurry was observed in terms of parameters like fresh weight of the spike and number of florets opened at a time whereas vase life was significantly increased in treatment under poultry manure (Tables 38 and 39).

A marked improvement in post harvest spike characters like fresh weight of the spike, number of florets opened at a time and vase life was observed by the application of poultry manure alone or in combination with chemical fertilizers. In the Experiment 3 also the trend was the same in both single and double varieties.

Indirect effect of poultry manure or coir pith compost when supplied with chemical fertilizers is reflected in post harvest spike characters of tuberose. Faster release of nitrogen from poultry manure might have caused enhanced growth and production of healthy spikes which in turn improved the post harvest spike qualities also in tuberose (Yadav *et al.*, 1985; Gowda *et al.*, 1991).

Maximum fresh weight by the application of coir pith compost might be due to easy availability of nutrients which caused better plant growth and more mobilization of metabolites from vegetative parts to floral parts which ultimately resulted in an improvement of this parameter (Marschner, 1983). Improvement of plant growth by the application of poultry manure or coir pith compost along with chemical fertilizers might have led to the production of healthy spikes with more number of flowers. Increased flower number in the spike might have contributed to opening of more number of flowers at a time and improvement of vase life of the spike.

5. 4 POST HARVEST BULB CHARACTERS

Post harvest bulb characters like number of bulbs and bulblets, weight of bulbs and bulblets were found to be positively influenced by treatment of inorganic fertilizers with poultry manure and coir pith compost (T_3 and T_5 respectively).

All the treatments with different organic sources (Experiment 2) resulted in increased yield of large sized bulbs. However, use of poultry manure and biogas slurry as nutrient sources were proved to be superior to others from the results obtained, in terms of bulb yield as well as bulb measurements.

Among the treatments with organic manures alone, treatment with poultry manure (T_4) and biogas slurry (T_7) had superior effect on bulb characters. Similar trend was noticed in ratoon also.

In the third experiment, the parameters like number of bulbs and bulblets, weight of bulbs and bulblets and size of bulbs and bulblets were found to be increased by the application of treatments consisting of poultry manure either alone or in combination with chemical fertilizers and also by biogas slurry. The favourable effect of these manures might be due to increased availability of nitrogen which might have caused improvement in number and size of bulbs together with the weight improvement of bulbs. Further the positive influence of these organic sources on bulb characters might be due to increased photosynthetic activity of plants resulted from increased leaf production and leaf area as evidenced from the effects of these treatments on such parameters causing high dry matter accumulation and its greater mobilization in to the bulbs. Similar results with organic manures increasing weight and size of bulbs as well as production of more number of bulblets were reported by Potti and Arora, 1986; Kumar *et al*., 1998.

5.5 PLANT ANALYSIS

Estimation of NPK in leaves and tubers was carried out during the course of crop growth in all the three experiments.

The results very clearly indicated that application of poultry manure either alone or in combination with in organic fertilizers caused increased nitrogen content during the major stages of observation. In single variety Prajwal poultry manure alone was enough to register superior nutrient content where as in double variety Vaibhav, poultry manure in combination with in organic fertilizers was proved to be superior. Highest N content of leaves and tubers in treatments containing poultry manure might be due to the release of N at higher levels from poultry manure which was readily available to plants and uric acid contained in the poultry manure, having 60 per cent N which is in the ammoniacal form helps in the efficient utilization by the plants. This will result in better plant growth and yield as per Abusaleha and Shanmuga Velu, 1988; Nirmala *et al*., 2000; Shelke *et al*., 2001 and Mali *et al*., 2005).

Regarding the P content of leaves and tubers, highest value was observed in treatments containing poultry manure in all the experiments. Poultry manure is having low C/P ratio which helps in easy extractability of available P to plants which ultimately resulted in higher P content of leaves and tubers. Similar results were also reported by Kaistha *et al*. (1997) and Waven *et al*. (1993).

With respect to K content of leaves and tubers, treatment of coir pith compost along with inorganic fertilizers was found to have (50 kg N + P, K + coirpith compost 85.71 t ha^{-1}) maximum K content of leaves. This might be due to easy availability of K from the coir pith compost (Hangarge *et al*., 2002). For tubers maximum K content was observed in treatment under poultry manure along with full recommended dose of nitrogen. The highest K content of tubers by the addition of poultry manure might be due to the increased N and P availability from poultry manure which in turn increased the K availability to plants. This is in accordance with the findings of Mali *et al*. (2005).

5.6 SOIL PROPERTIES

Tuberose has high nutrient requirement and addition of large quantities of inorganic fertilizers for growth and yield improvement led to the loss of inherent soil properties which necessitates proper nutrient management by including organic manures.

In the present study a positive influence on soil properties like pH, organic carbon content, available N, available P and available K were noted in treatments under poultry manure (either in combination with chemical fertilizers or alone) and biogas slurry. The increased availability of N and P with the addition of poultry manure might be due to low C/P ratio. N and P present in these manures get easily mineralized in to available forms which in turn increased the availability of K (Waven and Fonteno, 1993; Kaistha *et al*., 1997). Addition of organic matter as a result of these treatments might have increased the organic carbon content of soil. Tuberose is a crop which requires a soil pH of 6.5 to 7.5 for it’s successful cultivation (Sadhu and Bose, 1973). An increase in soil pH as a result of poultry manure application might have increased the availability of nutrients resulted in increased growth and yield.

5.7 ECONOMICS OF CULTIVATION

With respect to economics of cultivation, highest B/C ratio and net income were observed in treatments under poultry manure alone in both the varieties. The highest B/C ratio due to these treatments might be due to cheap cost of poultry manure and highest yield obtained as a result of its application. Treatments with biogas slurry and coir pith compost resulted in better gross income however the poor B/C ratio indicates their less cost effectiveness. High B/C ratio by the application of poultry manure in brinjal was reported by Prasanna, (1998) and Karmachandran, (2003).

Poultry manure either alone or in combination with chemical fertilizers was proved to be the best for growth and yield improvement in tuberose. In the present investigation, poultry manure was applied either alone or in combination with inorganic fertilizers. Effect of composted form of poultry manure in tuberose is worth studying. In this study, influence of panchagavya spray on growth and yield of tuberose was tested. Even though there are several reports about beneficial effects of panchagavya, the performance under this treatment was very poor compared to others. Studies can be conduced to evaluate the synergistic action of panchagavya along with organic manures and growth promoting microorganism. Tuberose oil is used in high grade perfumery and it is having great demand in export market. Development of low cost technologies for essential oil extraction will be worthful for tuberose growers.

Summary

6. SUMMARY

A study was conducted at Department of Pomology and Floriculture, College of Horticulture, Vellanikkara, to examine the response of tuberose (*Polianthes tuberosa* L.) to organic manures and growth promoting microorganisms. The study consisted of three different experiments. The salient findings are summarized below.

Experiment 1 consisted of sixteen different treatments which were the combinations of organic manures or growth promoting microorganisms along with inorganic fertilizers and conducted in single type variety Prajwal.

- Vegetative parameters like plant height, number of leaves and number of tillers per hill were found to be significantly improved in T_3 (100:50:50 kg ha^{-1} NPK + Poultry manure) followed by T_{14} (50:50:50 kg ha^{-1} NPK + Poultry manure. Treatment with coirpith compost along with half the recommended dose of nitrogen (T_{16}) also exhibited superiority in terms of above parameters.

- As far as floral characters are concerned T_3 had positive influence on days taken for first spike emergence, first floret opening, field life of the spike and duration of the crop. In all these parameters T_{14} also recorded it's superiority next to T_3. Quality attributes of the spike such as length of the spike, length of the rachis, number of florets per spike and length of corolla tube exhibited improvement under T_3 and T_{14} where as regarding length of rachis, girth of the spike and number of florets per spike were better under T_{16}. In addition to the above treatments, combination of *Azospirillum* sp. along with chemical fertilizers (T_7 and T_{12}) had positive influence on number of florets per spike and size of the floret. More number of spikes per hill was also recorded in plants applied with poultry manure along with full recommended dose of nitrogen (T_3).

- Among the post harvest spike characters, maximum vase life was observed in T_3 followed by T_{14} and T_{16}. Treatment with coirpith compost

(T_{16}) was found to be positively influencing fresh weight of the spike. Opening of more number of florets at a time was observed in T_{14}.

- Post harvest bulb characters like weight of bulbs and bulblets and size of bulblets were significantly improved by the treatment with poultry manure (T_3 and T_{14}) whereas treatment consisted of coirpith compost (T_5) and vermicompost (T_{15}) had beneficial effects on number of bulbs and number of bulblets per hill respectively.

- In plant nutrient analysis, the superiority of T_3 was reflected in nitrogen content of leaves and tubers followed by T_{14} and T_{16}. Eventhough there was no consistent pattern of K content of leaves and tubers, a higher value of this parameter in treatment with vermicompost (T_4) during the initial months and superiority of T_5 (100:50:50 kg ha^{-1} NPK + coirpith compost) towards final stage was observed.

- Soil properties like EC, organic carbon content, available nitrogen and P were found to be improved by the application of poultry manure along with chemical fertilizers (T_3).

- As far as the over all performance is concerned the treatments T_3 (100:50:50 kg ha^{-1} NPK + Poultry manure), T_{14} (50:50:50 kg ha^{-1} NPK + Poultry manure) and T_{16} (50:50:50 kg ha^{-1} NPK + coirpith compost) were observed as superior in terms of vegetative growth growth and yield attributes. The same trend was observed in ratoon also.

Experiment 2 was carried out simultaneously for finding out the effect of different organic manures alone on performance of single type tuberose (Prajwal).

- A marked improvement in vegetative parameters like plant height, plant spread, number of leaves, leaf area and number of tillers per hill were observed by the application of poultry manure (T_4). The superiority of T_7 (treatment with biogas slurry) was also reflected in terms of this parameter next to T_4.

- Application of poultry manure (T_4) also resulted in early emergence of first spike, maximum field life of the spike and crop duration in turn with extended flowering time. Superiority of T_7 was reflected in length of the spike and rachis and size of the floret, whereas T_4 exhibited superiority in number of florets per spike. Yield enhancement in terms of number of spikes per hill was observed by the application of poultry manure (T_4) followed by T_7 (treatment with biogas slurry).

- Regarding post harvest spike characters, fresh weight of the spike and number of florets opened at a time were the best in treatments consisting of biogas slurry, whereas T_4 (treatment with poultry manure) was superior with respect to vase life of the spike.

- Among the post harvest bulb characters, significant improvement in weight of bulbs and bulblets were recorded by the application of biogas slurry (T_7). Number of bulbs per hill was maximum in T_4 (treatment with poultry manure) whereas improvement in number of bulblets per hill was observed in T_7. Bigger sized bulbs were obtained by the application of coirpith compost (T_6) and bulblet size was maximum in T_5 (treatment with vermicompost).

- Significantly higher value of nitrogen content of leaves and tubers were observed in treatments receiving poultry manure. Treatments with FYM recorded maximum P content of leaves during initial months and T_5 (vermicompost) was superior in this parameters towards the last stage and P content of tubers exhibited no significant pattern of variation. Regarding K content of leaves and tubers, treatment with poultry manure (T_4) exhibited superiority during major part of growth period.

- Soil analysis revealed the superiority of T_4 and T_7 in terms of EC, organic carbon, available N, P and K.

- In general treatment with poultry manure (T_4) and biogas slurry (T_7 recorded highest values in terms of vegetative harvests. T_4 exhibited superiority in terms of number of florest per spike yield of spikes per hill, field life and duration of the crop, whereas T_7 had positive influence in terms of length of spike and rachis throughout the growth period.

  Three best treatments from experiment I and two from experiment 2, were selected for conducting third experiment, using two tuberose varieties (Prajwal and Vaibhav).

- Vegetative characters like plant height, number of leaves and leaf area were found to be significantly improved by the application of poultry manure along with inorganic fertilizers (100:50:50 kg ha^{-1} NPK + Poultry manure (T_1) in Prajwal and 50:50:50 kg ha^{-1} NPK (T_2) in Vaibhav). T_2 exhibited superiority in plant spread in both the varieties.

- Yield attributes like days to first spike emergence, field life of spike and number of spikes per hill and quality parameters like length and girth of the spike and number of flowers per spike were positively influenced by treatment with Poultry manure alone (T_4) in Prajwal, whereas crop duration was maximum in T_1 (100:50:50 kg ha^{-1} NPK + Poultry manure). In Vaibhav earliest spike emergence was noticed in T_5 (biogas slurry). Among yield attributes, T_4 produced maximum number of spikes per hill. T_2 (50:50:50 kg ha^{-1} NPK + Poultry manure) exhibited superiority in terms of field life of spike and crop duration. Quality parameters like length of the spike and number of flowers per spike were found to be significantly improved in T_1 (100:50:50 kg ha^{-1} NPK + Poultry manure). Regarding concrete content of flowers, T_5 (biogas slurry) exhibited superiority in terms of this parameters in both the varieties.

- Among the post harvest characters, T_4 (treatment with Poultry manure) recorded maximum value of fresh weight of the spike in Prajwal, whereas application of coirpith compost in combination with inorganic fertilizers (T_3)

resulted in higher values in Vaibhav. Treatments consisting of poultry manure along with inorganic fertilizers exhibited opening of more number of flowers at a time in Prajwal, whereas no significant pattern of variation was observed in Vaibhav. Regarding vase life, application of poultry manure either in combination with chemical fertilizers or alone had superiority in Prajwal (T_1, T_2 and T_4) and in Vaibhav, T_1 recorded maximum value in this parameters.

- In the case of post harvest bulb characters treatment with poultry manure alone (T_4) recorded maximum value for number of bulbs per hill in both the varieties. Treatment with biogas slurry (T_5) produced highest number of bulblets per hill in Prajwal whereas in Vaibhav, application of poultry manure either alone or in combination with inorganic fertilizers resulted in better performance. Maximum weight of bulbs and bulblets were recorded in T_1 (100:50:50 kg ha^{-1} NPK + Poultry manure) and T_4 (Poultry manure) respectively in Prajwal, whereas T_4 registered higher value in this parameters. Bigger sized bulbs were produced by T_1 in both the varieties whereas larger sized bulblets were observed in T_3 (treatment consisted of coirpith compost) in Prajwal and in T_4 in Vaibhav.

- In plant analysis, treatments consisted of poultry manure either alone or in combination with inorganic fertilizers (T_4, T_1 and T_2) recorded highest value of N and P content of leaves and tubers in both the varieties. T_3 had highest K content of leaves in both the varieties. Treatments consisted of poultry manure (T_1 and T_2) registered maximum values of K content of tubers in Prajwal whereas no consistent pattern of variation was observed regarding this parameters in Vaibhav.

- From the soil analysis, it could be observed that the properties like EC, organic carbon content, available N, P and K were significantly improved by the application of poultry manure either alone or in combinations with inorganic fertilizers (T_4, T_1 and T_2) and also by the treatment with biogas slurry (T_7).

Correlation study revealed a high positive correlation of N content of leaves with length of spike and rachis, girth of spike, number of flowers per spike and yield of spikes per hill. No significant correlation was observed between P and K content of leaves and floral characters. Correlation between vegetative and floral characters indicated a highly significant positive correlation of plant height with length of spike and rachis, number of flowers per spike and yield of spike per hill. Number of leaves and leaf area were significantly and positively correlated with yield of spikes per hill.

Regarding the economics of cultivation, T_1 (100:50:50 kg ha^{-1} NPK + Poultry manure) recorded maximum net income and highest B/C ratio followed by T_4 (treatment with Poultry manure alone) in Prajwal. In Vaibhav T_4 (treatment with poultry manure alone) had highest B/C ratio followed by T_1 and T_2 (50:50:50 kg ha^{-1} NPK + Poultry manure).

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Appendix

APPENDIX – 1

Nutrient content of different organic manures used in the study

Sl No.	Organic manure used	N (%)	P (%)	K (%)	Ca (%)	Mg (%)
1	FYM	1.00	0.20	0.65	2.25	0.06
2	Poultry manure	1.35	0.31	0.78	1.06	0.04
3	Vermi compost	1.60	0.73	0.38	1.11	0.06
4	Coir pith compost	0.35	0.06	0.14	0.21	0.03
5	Biogas slurry	0.08	0.02	0.86	0.20	0.03
6	Vermi wash	0.39	0.02	0.32	0.11	0.04
7	Panchagavya	0.02	0.21	0.23	0.25	-

APPENDIX – 2

2005 – Mean monthly weather data

Parameters	Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec
Mean Max Temp (^{0}C)	33.2	35.1	35.7	33.7	33.6	30.0	28.7	29.9	29.4	31.0	30.7	31.5
Mean Min Temp (^{0}C)	22.6	22.3	24.6	24.8	25.0	23.5	23.0	23.3	23.3	23.2	22.9	22.1
Mean RH (%)	56	53	63	74	72	86	88	82	85	80	72	66
Rain fall (mm)	7.6	0.0	0.0	171.4	89.2	711.4	727.5	346.5	416.1	178.4	11.6	3.2

2006 – Mean monthly weather data

Parameters	Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec
Mean Max Temp (^{0}C)	32.5	34.3	34.8	33.4	31.8	29.9	29.5	29.9	29.4	31.0	30.7	31.5
Mean Min Temp (^{0}C)	22.6	22.3	23.8	24.7	24.3	23.6	23.3	23.1	23.3	23.2	22.9	22.1
Mean RH (%)	57	51	68	75	79	84	85	83	84	79	72	57
Rain fall (mm)	0.0	0.0	95.2	86.2	675.5	608.6	519.0	550.6	522.2	323.7	79.5	0

2007 – Mean monthly weather data

Parameters	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
Mean Max Temp (^{0}C)	32.5	34.0	36.0	35.1	32.8	30.1	28.4	29.8	29.6	31.0	31.7	31.5
Mean Min Temp (^{0}C)	22.0	22.2	24.4	25.0	24.6	23.5	22.9	22.8	23.0	23.0	23.7	23.6
Mean RH (%)	54	55	63	69	76	84	88	84	86	79	67	56
Rain fall (mm)	0.0	0.0	0.0	61.0	240.5	826.5	1131.9	549.7	765.9	383.8	24.8	8.7

RESPONSE OF TUBEROSE (*Polianthes tuberosa* L.) TO ORGANIC MANURES AND GROWTH PROMOTING MICROORGANISMS

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ABSTRACT OF THE THESIS

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ABSTRACT

Tuberose is one of the most important bulbous plants, much adored for its colour, elegance and fragrance. Among the commercially cultivated flowers in India tuberose occupies a prime position due to its popularity as cut flower as well as loose flower. It has got great potential in perfume industry also owing to the presence of much valued essential oil. The flower spikes are largely used for vase decoration and bouquet preparation and loose flowers for making garlands and in floral ornaments.

The mineral nutrition status can affect the yield and quality of any crop. Tuberose being rich in nutritional status, extracts high amount of nutrients from the soil. Application of huge quantities of fertilizers in the same field becomes essential for taking the ratoon crops and this may lead to destruction of soil properties in addition to increased cost of production.

It is now imperative to find an integrated nutrient management schedule for tuberose for an optimum and economic use of plant nutrients to reduce the cost of production and to improve the yield and quality of the flowers.

The study consisted of three experiments. Experiment 1 included sixteen different treatments which were the combinations of organic manures and growth promoting microorganisms along with inorganic fertilizers. In Experiment 2, effect of different organic manures alone on growth and yield of tuberose was studied. Single variety Prajwal was used for both the trials. Three superior treatments from Experiment 1 and two from Experiment 2 were selected for conducting the third experiment using single variety Prajwal and double variety Vaibhav.

In Experiment 1, the treatments 100:50:50 kg ha^{-1} NPK + poultry manure 22.2 t ha^{-1} (T_3), 50:50:50 kg ha^{-1} NPK + poultry manure 22.2 t ha^{-1} (T_{14}) and 50:50:50 kg ha^{1} NPK+ coirpith compost 85.71 t ha^{-1} (T_{16}) exhibited superiority in terms of vegetative and floral characters. In experiment with different organic manures (Experiment 2)

treatment with poultry manure alone (T_4) and biogas slurry alone had positive influence on both growth and yield attributes.

In third experiment it could be observed that all the vegetative parameters were significantly improved by the application of 100:50:50 kg ha^{-1} NPK + poultry manure 22.2 t ha^{-1} (T_1) in Prajwal and 50:50:50 kg ha^{-1} NPK+ poultry manure 22.2 t ha^{-1} (T_2) in Vaibhav. Yield attributes like days to first spike emergence, field life of the spike, number of spikes per hill and quality parameters like length and girth of the spike, length of rachis and number of flowers per hill were positively influenced by treatment with poultry manure alone (29.63 t ha^{-1}) in Prajwal. In Vaibhav also treatment with poultry manure alone (29.63 t ha^{-1}) produced highest number of spikes per hill, where as quality parameters of the spike were improved by the application of poultry manure along with inorganic fertilizers. (100:50:50 kg ha^{-1} NPK + poultry manure 22.2 t ha^{-1}). Concrete content of flowers (which indicates the percentage of essential oil) improved in T_5 (biogas slurry alone) in both the varieties. The superiority of the treatment with poultry manure was also reflected in post harvest studies. From plant nutrient analysis, it could be observed that poultry manure either alone (29.63 t ha^{-1}) or in combination with chemical fertilizers (100:50:50 kg ha^{-1} NPK + poultry manure 22.2 t ha^{-1} and 50:50:50 kg ha^{-1} NPK + poultry manure 22.2 t ha^{-1}) recorded highest N and P content of leaves and tubers in both the varieties, where as treatment of coir pith compost along with inorganic fertilizers exhibited maximum K content. Soil properties like pH, organic carbon, available N, P and K were found to be improved by the treatment consisting of poultry manure.

Regarding the economics of cultivation, treatment with poultry manure alone (29.63 t ha^{-1}) recorded maximum net income and highest B/C ratio in both the varieties (3.2 in Prajwal and 2.5 in Vaibhav) followed by 100:50:50 kg ha^{-1} NPK + Poultry manure 22.2 t $ha-^{1}$and 50:50:50 kg ha^{-1} NPK + poultry manure 22.2 t ha^{-1}

Considering overall performance, application of poultry manure at the rate of 29.63 t $ha-^{1}$ as basal dose was proved to be highly beneficial for growth and yield improvement in tuberose.