# REGULATION OF GROWTH AND FLOWERING IN TUBEROSE *Polianthes tuberosa* Linn.

By

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**THESIS**

**Submitted in partial fulfilment of the requirement for the degree of**

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# DECLARATION

I hereby declare that this thesis entitled **"Regulation of growth and flowering in tuberose *Polianthes tuberosa* Linn."** is a bonafide record of research work done by me during the course of research and that the thesis has not been 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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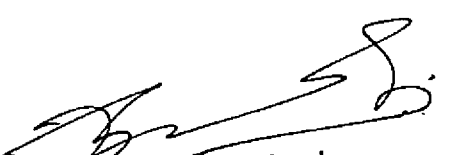

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Certified that this thesis, entitled "**Regulation of growth and flowering in tuberose *Polianthes tuberosa* Linn.**" is a record of research work done independently by Sri.M.Muralee Manohar, under my guidance and supervision and that it has not been previously formed the basis for the award of any degree, diploma, fellowship or associateship to him.

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We, the undersigned members of the Advisory Committee of **Sri. M. Muralee Manohar**, a candidate for the degree of **Master of Science in Horticulture**, with major in **Pomology and Floriculture**, agree that the thesis entitled **"Regulation of growth and flowering in tuberose *Polianthes tuberosa* Linn."** may be submitted by Sri. M. Muralee Manohar, in partial fulfilment of the requirement for the degree.

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Dedicated to my beloved parents

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Muralee Manohar, M.

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# INTRODUCTION

# INTRODUCTION

In the orient, where 'white' goes for virtue and purity, tuberose is much adored for its colour, elegance and fragrance. It is extensively cultivated in many tropical and subtropical parts of the world including France, Italy, South Africa and USA. In India, tuberose (*Polianthes tuberosa* Linn.) occupies a prime position because of its popularity as cut flower, loose flower as well as for its potential in perfume industry. The flower spikes are largely consumed for vase decoration and bouquet preparation and the florets for making garland and floral ornaments.

The common tuberose (*Polianthes tuberosa* Linn.) is unknown in a wild state and was never found anywhere except under cultivation. In view of spectacular growth and flowering of tuberose in the Indian environment and the spread of its culture through the length and breadth of the country, it is hard to believe that this is a Mexican introduction in the sixteenth century.

The genus *Polianthes* belongs to the family Amarillidaceae and has about a dozen of herbaceous species. The most popular and economically important species is *Polianthes tuberosa*, which is an erect herb with stout and short bulbs, bright green leaves, sessile funnel-shaped flowers, waxy white perianth segments six, bent slightly near the base, filaments attached on upper part of corolla, and fragrant. The most prominent groups of cultivars are 'Single', 'Semidouble', 'Double' and 'variegated'. Single flowered tuberose with high essential oil content ranging from 0.08 to 0.10 per cent is most outstanding amongst the existing cultivars in India. The double-flowered cultivar is exclusively grown for the cut flower trade. These cultivars are assessed based on their flower quality and yield by various workers in India under different climatic conditions.

Tuberose has a good demand in the market. With the improvement in the standard of living, the demand is increasing by leaps and bounds. To meet this

demand of fresh flowers, high flower production per unit area is essential. This can be achieved to a great extent by the manipulation of growth and flowering through cultural practices. Nutrient application plays a major role in the production of good quality spikes and in enhancing the yield. The manurial requirement of tuberose varies with climatic conditions and soil type. Although tuberose cultivation has become popular, experimental evidences on their nutritional requirement are meagre under Kerala condition.

The major elements like nitrogen, phosphorus and potassium greatly influence the growth and flower production. Hence a study on nutritional aspects becomes necessary to ensure quality blooms in tuberose. Applications of certain bioregulators like gibberellins, cytokinins and auxins were also found to regulate the growth and developmental behaviour of tuberose. This necessitates the studies on bioregulator application. Keeping this in view the present investigation was undertaken with the following objectives:

1) To study the effect of major nutrients on the growth parameters and floral characters of tuberose.
2) To assess the influence of bioregulators on growth and development as well as flowering in tuberose.

# REVIEW OF LITERATURE

# REVIEW OF LITERATURE

Tuberose is one of the most important bulbous ornamentals of tropical and subtropical areas. They are commercially cultivated for cut and loose flower trade, and also for the extraction of the highly valued natural flower oil. Because of their lingering delightful fragrance and charm, they are adorned with romantic vernacular names in India like Gulcheri, Glushaboo (Hindi), Rajanigantha (Bengali) and Sukandaraji, Nelasampengi (Telegu). To meet the increasing demand of fresh flowers, a high flower production per unit area is essential. Nutrient application plays a major role in the production of good quality spikes. Although tuberose cultivation has become popular, experimental evidences on their nutritional requirements and bioregulators are meagre under Kerala condition. Literature pertaining to these aspects including those of the related crops are reviewed here.

## 2.1 Nutrition

*Polianthes tuberosa* has a high nutrient requirement and hence proper fertilization is essential for its cultivation. Nutritional requirement varies with the soil and climate. Application of sufficient amount of organic manure helps in proper establishment of the crop. At the time of soil preparation, application of cowdung manure or farm yard manure at the rate of 20 to 50 tonnes per hectare, depending upon the climatic conditions and soil type, is recommended (Nambisan and Krishnan, 1983).

### 2.1.1 Effect of chemical fertilizers

In an experiment conducted by Cirrito (1972), the most effective of several NPK rates tested was the highest, viz., 240 kg N, 240 kg $P_2O_5$ and 360 kg $K_2O$ per ha.

Sand culture experiments were conducted by Jana *et al.* (1974) in dahlia and tuberose plants which received either three times as much or only one-tenth of the N, P or K in the sand nutrient solution. In dahlias, N and P deficiencies reduced plant height and induced foliar symptoms. Branching and flowering were increased by high N and suppressed by low N. In tuberose, high N and P increased the number of leaves, bulbs, spikes and flowers. Nitrogen and P deficiencies suppressed flowering and low K reduced the number of flowers on the spike.

The effect of manuring on the enlargement of bulbs of tuberose was studied by Cirrito (1975). Field planting of bulbils were done. Analysis made after the bulbs were harvested in late December showed that both number of saleable bulbs and individual bulb weights were greatest when 200 kg N, 400 kg $P_2O_5$ and 600 kg $K_2O$ per ha were applied at planting.

In another experiment, Mitra *et al.* (1979) observed that highest percentage of flowering plants, earliest flowering and highest number of flowers per spike were obtained from plants raised from large bulbs receiving 75 kg N per ha. In this trial, small (12-18 g) and large (19-25 g) bulbs were planted in late April. Phosphorus and potassium were given as basal and N applied in the form of ammonium sulphate in split doses at two to three leaf stage and before flowering.

Nanjan *et al.* (1980) revealed the effect of nitrogen, phosphorus and potassium on the yield of tuberose. They carried out trials with tuberose cv. Single cultivated in soil characterized by low N and low available P but high K. The highest flower production and economic returns were obtained with N, $P_2O_5$ and $K_2O$ at 200:60:0 kg $ha^{-1}$. In a comparison between different types of manuring for bulb enlargement, Cirrito and Vita (1981) conducted three year field trial on alkaline sandy soil near Palermo. Tuberose cv. La Perla was grown with or without chicken manure and mineral NPK. The highest production of new lateral bulbs measuring four to six cm and the bulbs ready for flowering (92%) were obtained in

the treatment with 500 kg $ha^{-1}$ of chicken manure incorporated before planting and 800 kg $(NH_4)SO_4$, 100 kg rock phosphate as well as 180 kg $K_2SO_4$ applied after planting.

In another experiment conducted by Cirrito and Zizzo (1981) in a three year trial on two sandy soils near Palermo, tuberose rhizomes enlarged best (i.e. 87% were saleable) when low mineral N and $P_2O_5$ and high $K_2O$ levels were supplied (25.6, 12.8 and 117.7 kg $ha^{-1}$, respectively).

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 several 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 the spike in the field was longest (22.8 days) with the highest N rate.

Another study conducted by Mukhopadhyay and Bankar (1985) revealed that the spike yield in tuberose improved with the application of 20 g N $m^{-2}$ in three split doses, out of which one application should be at the time of flower initiation.

Yadav *et al.* (1985) conducted trials with cv. Single in which the plants received N and $P_2O_5$, each at 0-300 kg $ha^{-1}$. Good plant growth and highest flower yield were obtained with N : $P_2O_5$ at 300:200 kg $ha^{-1}$ and N applied in two split doses, at planting and 40 days later.

Mukhopadhyay and Bankar (1986) studied the nutritional requirement of tuberose in a trial over two years, with tuberose (*Polianthes tuberosa*) cv. Single. The plants growing on 2 x 1 m plots received N:$P_2O_5$:$K_2O$ at 0-20:0-40:0-40 g $m^{-2}$ giving 45 treatment combinations. Of the three nutrients, only N, especially at the highest rate, improved plant growth, spike yield and flower quality. It was seen that N also enhanced the production of daughter rhizomes but not of main rhizomes.

In another experiment by Bankar (1988) in two year field trials, plants received N at 0, 5, 10, 15 or 20 g $m^{-2}$, and $P_2O_5$ and $K_2O$ each at 0, 20 or 40 g $m^{-2}$, giving 45 treatments altogether. Data were tabulated on plant height, number of leaves per plant, days to spike emergence, number of spikes per plant, spike length, rachis length, number of flowers per spike, duration of flowering, and number and weight of bulbs per plant. Nitrogen improved vegetative growth, flowering and bulb production in the first year. Phosphorus and K increased spike number, rachis length and duration of flowering only in the second year (the ratoon crop). The optimum fertilizer application rate was determined as 15 g N, 40 g $P_2O_5$ and 40 g $K_2O$ $m^{-2}$.

Bankar and Mukhopadhyay (1990) studied the effect of NPK on growth and flowering in tuberose cv. Double. In field trials, N was applied at 0, 5, 10, 15 or 20 g $m^{-2}$, $P_2O_5$ at 0, 20 or 40 g $m^{-2}$, and $K_2O$ at 0, 20 or 40 g $m^{-2}$. One half of the N and all of P and K were applied before planting; the remaining N was applied as top dressing at flower emergence. Data were tabulated on growth and flowering parameters, and on NPK contents of the leaves. Nitrogen application advanced flowering and improved growth. Leaf N content was positively correlated but leaf P and K contents were negatively correlated with number of flower spikes. The highest number of flower spikes per $m^2$ (20.09) was obtained with the highest N rate. Fertilization of tuberose with $N:P_2O_5:K_2O$ at 20:20:20 g $m^{-2}$ was recommended.

Gowda *et al.* (1991) compared three rates of N application (100, 150 and 200 kg), three of $P_2O_5$ (50, 75 and 100 kg) and three of $K_2O$ (100, 125 and 150 kg per hectare) for a cut flower crop of *Polianthes tuberosa* grown at a spacing of 30 x 30 cm. All the $P_2O_5$ and $K_2O$ and half the N were applied as basal dressing; the remaining N was applied as top dressing, 30 days after planting. It was observed that increasing N significantly increased plant height. Both N and $K_2O$ significantly influenced the number of days required for spike emergence. Increasing P and $K_2O$

rates resulted in a greater number of spikes and number of flowers per spike. The highest yield of flowers per spike (40.20), the longest spikes (81.28 cm) and the longest duration of flowering (29.75 days) were obtained with 200 kg N:75 kg $P_2O_5$ and 125 kg $K_2O$ $ha^{-1}$.

In an experiment aimed at determining the fertilizer requirement of *Polianthes tuberosa* cv. Single, N was applied at 50, 75, 100 or 125 kg, P at 25, 50 or 75 kg and K at 37.5, 62.5 or 87.5 kg $ha^{-1}$ (Parthiban and Khader, 1991). Full P and K and half of N were applied at planting. The remaining N was applied 45 days later. Application of 100 kg N, 75 kg P and 62.5 kg K $ha^{-1}$ resulted in the highest number of spikes per plant (1.72), highest number of flowers per spike (39.67) and the highest flower yield (3578.6 kg $ha^{-1}$).

In another experiment by Parthiban *et al.* (1992) *Polianthes tuberosa* cv. Single plants were supplied with 50, 75, 100 or 125 kg N $ha^{-1}$; 25, 50 or 75 kg P $ha^{-1}$ and 37.5, 62.5 or 87.5 kg K $ha^{-1}$. The greatest plant height (58.93 cm) was obtained with 125 kg N, 50 kg P and 62.5 kg K $ha^{-1}$. The highest mean number of leaves (41.34) and number of side suckers per clump were obtained with the 100 kg N, 75 kg P and 62.5 kg K $ha^{-1}$ treatment combination.

Belorkar *et al.* (1993) carried out a field experiment, during the kharif and rabi season of 1991, to study the effect of soaking the bulbs for 24 h in gibberellic acid (0, 10, 20 or 40 ppm) followed by N fertilizer treatment (0, 50, 60 or 70 kg $ha^{-1}$) in the field. Nitrogen at 70 kg $ha^{-1}$ produced the highest number of rachises per ha (132444), flowers per stalk (40.65) and flower yield (63.1 q $ha^{-1}$). They also postulated that soak in gibberellic acid 45 ppm along with application of 70 kg N $ha^{-1}$ was the best combination yielding 163555 rachises per ha, 50.6 flowers per stalk and 81.77 q flowers per ha. Distinct positive interaction was obtained between gibberellic acid and N for number of flowers per stalk and flower yield.

Wange and Patil (1994) have shown that application of 100 kg N $ha^{-1}$ alone or inoculating with Azotobacter and Azospirillum mixtures significantly increased the number of flowers per stalk, bulb (rhizome) yield and the number of flower stems produced by *Polianthes tuberosa* cv. Single in pot experiments.

Singh *et al.* (1995) gave N fertilizers at the rate of 0, 100, 200, 300 or 400 kg $ha^{-1}$ and P and K fertilizer each at 0, 100 or 200 kg $ha^{-1}$ to plots of *Polianthes tuberosa* cv. Single. On one hand the increasing rate of N, P and K, increased the number of leaves per plant and plant height significant and on the other, the increasing rates of N and P reduced the number of days for sprouting of bulbs but K had no significant effect.

In a trial at Akola in 1993-94, N was applied at 60, 90 or 120 kg, P at 30, 45 or 60 kg $P_2O_5$ and K at 0, or 30 kg $K_2O$ $ha^{-1}$ to tuberose grown for cut flowers (Gopalakrishnan *et al.*, 1995). Average number of flowers per spike and flower diameter were greatest with 120 kg N + 60 kg $P_2O_5$ + 30 kg $K_2O$ $ha^{-1}$.

Singh *et al.* (1996) studied the effect of NPK on flowering and flower quality of tuberose. A trial with five rates of N (0, 100, 200, 300 and 400 kg $ha^{-1}$) and three rates each of P and K (0, 100 and 200 kg $ha^{-1}$) was conducted with *Polianthes tuberosa* cv. Single in a sandy loam soil in 1991 and 1992. The results revealed that application of high rates of N, P and K delayed spike emergence and considerably prolonged the flowering period and shelf life of florets in both the years. Length of spike and rachis increased significantly in both the years, at both the developmental stages (opening of first and last florets) with increasing doses of N and P fertilizers. Increased K application increased rachis length at the opening of the last floret, but not the first floret.

Singh *et al.* (1996) in a trial at Hissar, Haryana in 1991 and 1992 applied N at 0, 10, 20, 30 or 40 g $m^{-1}$, P at 0, 10 or 20 g $P_2O_5$ $m^{-1}$ and K at 0, 10 or 20 g

$K_2O$ $m^{-1}$. Bulb yields increased as N rate increased up to 30 g per plant. P and K rates had little effect on bulb yield. A significant interaction was obtained between N and P.

Singh and Uma (1996) carried out field studies at Bangalore, during 1992-94 on a sandy loam soil. N, as urea, was applied at 100, 150, 200, 250, 300 or 350 kg $ha^{-1}$, in three equal splits at planting, and 60 and 90 days after planting of the bulbs. Phosphorus and K (as single super phosphate and muriate of potash, respectively) were applied at 200 kg $ha^{-1}$, at planting. Various growth and floral parameters were recorded up to one year after planting for two successive years, and the results were pooled. Nitrogen at 250 kg $ha^{-1}$ gave the highest number of leaves per clump, number of florets per spike and individual floret weight. Increasing the rate up to 350 kg $ha^{-1}$ increased the spike and rachis length, but delayed flowering.

Barman *et al.* (1997) analysed the efficacy of split application of nitrogen on growth and yield of tuberose var. Single during March to November in 1994 and 1995. The effect of split applications (of a total of 200 kg $ha^{-1}$) of N on the growth and yield of tuberose (*Polianthes tuberosa*) was investigated in Tripura. At planting 100, 75, 50 or 25 per cent of the N was applied and the remaining N applied 30, 60 or 90 days later. The tallest plants were obtained when 25 per cent of the N was applied at planting and 75 per cent was applied 60 days later. Split application of N neither affected the bulb production nor flowering.

Baruah *et al.* (1998) compared the response of tuberose to increasing doses of NPK. The experiment included seven treatments of N:P:K, viz., 40:20:0, 40:20:20, 40:20:40, 80:40:60, 80:40:80, 120:60:100 and 120:60:120 g $m^{-2}$. Out of these, 80:40:60 g NPK $m^{-2}$ recorded the highest mean performance for yield of spike (692.86 g $m^{-2}$) and vase life (17.47 days), size of floret (3.88 cm), number of pairs of florets per spike (17.47) and plant height (101.13 cm). In addition, the treatment also gave high performance for length of spike (104.89 cm) and rachis

(33.67 cm). Days to emergence of shoot (19.30 days), days to emergence of spike (97.60 days) and days to opening of flower (98.33 days) exhibited by the treatment clearly indicated that 60 g K along with moderate levels of N and P (80:40) not only increased the yield and quality of flower but also induced earliness.

## 2.2 Effect of bioregulators

Ramaswamy *et al.* (1977) indicated that when dormant tubers of *Polianthes tuberosa* were dipped for one hour in solutions of ethrel (ethephon) 500 to 5000 ppm, GA 50 to 400 ppm or cycocel (chlormequat) 500 to 5000 ppm and planted. GA at 100 ppm or cycocel at 500 ppm advanced flowering at the most by 17 and 15 days, respectively. Flower yield was greatest after treatment with cycocel at 1000 ppm.

Jana and Biswas (1979) in trials with the tuberose cv. Single, sprayed the plants with $GA_3$ (10-1000 ppm), B9 (daminozide) (10-1000 ppm), cycocel (chlormequat) (500 to 2000 ppm) or ethrel (ethephon) (10-1000 ppm) at the 4-5 leaf stage and 30 days later. Data were tabulated on plant height, number of leaves, bulbils, spikes and flowers per plant, days to flower bud appearance, length of flower spike and length of the flowering portion of the spike. Treatment with cycocel at 2000 ppm, B9 at 1000 ppm or $GA_3$ at 10 ppm produced the maximum number of flowers per plant.

Response of auxins on flower production in gladiolus was studied by Sharga (1979). He reported that IAA and IBA concentrations of more than 50 ppm had a negative effect. The best result with regard to time taken to flower (92.85 days), duration of flowering (16.21 days), spike length (59.95 cm) and number of flower per spike (14.6) were obtained with NAA at 50 ppm.

Tonecki (1979) studied the effect of growth and shoot apex differentiation in *Gladiolus hortorum* cv. Acca Laurantia. Gladiolus corms were soaked for 24

hours in IAA, NAA, $GA_3$ or kinetin each at 100, 500, 1000 and 2000 ppm prior to planting. All treatments inhibited early growth except $GA_3$, which stimulated corm sprouting. The final effect of $GA_3$, however was to decrease leaf length.

The pre-treatment of tuberose bulbs with $GA_3$ (300 ppm), kinetin (300 ppm) or ABA (10 or 50 ppm) showed that $GA_3$ had no effect while kinetin and ABA appreciably stimulated sprouting (Pathak *et al.*, 1980). Abcissic acid was especially effective in stimulating sprouting in small bulbs. $GA_3$ and kinetin inhibited flowering whereas ABA stimulated it, especially in large bulbs.

According to El-Meligy (1981) soaking the gladiolus corms in colchicine solution at 200 ppm for six hours were reported to increase plant height and the number of leaves. El-Meligy (1982) further studied the effect of soaking of gladiolus cormels in $GA_3$ at 500 ppm and irradiation at 1000 rad. He reported that the flower colour was deeper in the treated plants due to a higher anthocyanin content.

Auge (1982) reported that GA treated corms of gladiolus flowered ten days earlier than the untreated corms. The post emergent spray with GA advanced flowering.

Jana and Biswas (1982) found that when rhizomes of *Polianthes tuberosa* cv. Single were soaked for 24 h in solutions containing $GA_3$, B9 (daminozide), CCC (chlormequat) or ethrel (ethephon) at various concentrations, the minimum days to flower opening (97 days) occurred in plants treated with 10 ppm $GA_3$, and the maximum number of flower per spike (35.5) was on plants treated with 1000 ppm daminozide.

Biswas *et al.* (1983) reported that leaf emergence was quickest (11 days) in tuberose bulbs treated with IAA at 10 mg $l^{-1}$. The first flower spike emerged earliest (84 days) in bulbs soaked in CCC at 2.0 ml $l^{-1}$. The highest number of flower spikes (6 per clump) was obtained after foliar application of $GA_3$ at

1000 mg $l^{-1}$, CCC at 0.2 mg $l^{-1}$ and the highest number of flower per spike (46) was on plants sprayed with $GA_3$ at 100 mg $l^{-1}$.

Mukhopadhyay and Bankar (1983) sprayed the plants of tuberose cv. Single with $GA_3$ at 25 to 200 ppm or ethephon at 500 to 2000 ppm (40 days after planting and twice at fortnightly interval) and observed that increasing concentrations reduced the plant height. $GA_3$ increased spike length and flower number per spike. Ethephon at the highest concentration reduced both spike length and flower number. Duration of flowering in the field was improved with GA at 100 mg $l^{-1}$. Both $GA_3$ and ethephon at all concentrations inhibited bulb production.

In another trial, the effect of soil drench application of CCC (chlormequat) and B9 (daminozide), each at 1000, 2500 and 5000 ppm, ethrel (ethephon) at 500, 1000 and 2000 ppm and IAA, $GA_3$ and NAA, each at 10, 100 and 1000 ppm was studied on growth and flowering of gladiolus Cv. Friendship (Bhattacharjee, 1984). $GA_3$ at 10 and 100 ppm stimulated flower stalk and rachis length, accelerated floret size and number per spike and lengthened the life of the spike. Marked improvement in flowering was obtained with 100 ppm IAA. Application of CCC, B9 and ethrel generally increased flower size and IAA, $GA_3$ and NAA each at 10 and 100 ppm increased the number of flowers per spike.

Dua *et al.* (1984) reported that spraying $GA_3$ at 10 and 100 ppm stimulated flower stalk and rachis length, accelerated floret size and number per spike and lengthened the life of the spike in gladiolus. Marked improvement in flowering was obtained with 100 ppm IAA. Application of CCC, B9 and ethrel generally increased flower size and IAA, $GA_3$ and NAA at 10 and 100 ppm increased the number of flowers per spike. $GA_3$ at 10 and 100 ppm increased vegetative growth. Spraying three times with $GA_3$ 100 ppm increased plant height and the number of leaves in gladiolus. $GA_3$ at 50, 100 or 200 ppm improved spike quality in terms of number and size of flowers. In most cases a concentration of 100 ppm, applied three times,

was the most effective spray treatment. $GA_3$ at 10 and 100 ppm improved corm size and weight and induced cormel production. Marked improvement on flowering was obtained with 100 ppm IAA. Spraying with GA3 at 50, 100 or 200 ppm enhanced the number and quality of corms and cormels produced.

In a report of IIHR (1984), it was stated that $GA_3$ spray at 10 or 50 ppm concentration helped in accelerating flowering in gladiolus.

Corms treated with ethylene, camporan (ethephon) or heat, shortened dormancy and advanced flowering of the gladiolus Cv. Newmoon forced in artificial light. Ethephon, applied at 0.05 per cent for 30 minutes, was the most effective treatment (Mukhamed, 1985).

Mukhopadhyay and Sadhu (1985) conducted a trial on soaking of freshly harvested bulbs of tuberose cv. Single for 24 h in solution containing $GA_3$ at 10, 100, 250 and 500 ppm and then planted in 30 cm pots. They observed that the treatment delayed sprouting from 8.1 days in the control to 17.40 days (maximum) at 500 ppm and reduced final plant height from 42 to 34 cm (minimum) at 100 ppm, but increased rachis length, from 15.95 cm in the control to 20.80 cm (maximum) at 100 ppm.

Roychoudhuari *et al.* (1985) reported that, ethephon at 100 ppm increased flower size and length of flower stalk in gladiolus.

Hwang *et al.* (1986) studied the influence of paclobutrazol on growth and flowering of pot grown gladiolus (*Gladiolus gandarensis*). Paclobutrazol was applied at the two leaf or four leaf stage, either as a soil drench at the rate of 0 to 10 mg per 15 cm diameter plot or as a foliar spray at 0 to 100 ppm. They observed that plant height in Hunting Song was further reduced by treatments at the two leaf stage than at the four leaf stage, where as Spic and Span showed no difference in response. Soil application at the highest concentration produced the shortest plants, especially at the two leaf stage.

Suh and Kwack (1986) observed that NAA 20 ppm and ethychlozate 100 ppm induced sprouting of corms and increased the rate of stem growth in gladiolus.

Choudhary (1987) observed that in tuberose MH at all concentrations remarkably suppressed the plant height, while the treatment with $GA_3$ and CCC markedly promoted the height of plants and number of leaves per plant. The effect of ethrel reduced the period of flowering and increased the bulblet production per plant. All the treated plants increased the number of flowering spikes and flower number over control. The treatment with 500 ppm MH, 100 ppm ethrel, 1000 ppm and 50 ppm $GA_3$ produced maximum number of flowers per spike.

Dhua *et al.* (1987) reported that soaking of tuberose bulbs in $GA_3$, ethrel, kinetin and thiourea solutions before planting improved the growth and flowering of tuberose. Among the different chemicals used, $GA_3$ and thiourea proved more effective than others. Thiourea promoted plant height and leaf number while $GA_3$ improved flowering. Treatment with $GA_3$ at 2000 mg $l^{-1}$ caused earliest flowering and gave the maximum yield of spikes and flowers.

Mukhopadhyay and Bankar (1987), based on pot culture experiment with $GA_3$ on gladiolus Cv. Friendship, reported that $GA_3$ at all concentrations (10, 50, 100, 250 and 500 ppm) improved plant height. There was hardly any effect of ethrel on vegetative growth. $GA_3$ soaking at lower concentrations (10 or 50 ppm) accelerated the flowering date. There was hardly any effect of ethrel (10, 50, 100, 250, 500 and 1000 ppm) on flowering.

Roychoudhuri (1989) studied the effect of plant spacing and growth regulators on growth and flower yield of gladiolus grown under polythene tunnel. Corms were soaked for six hours in $GA_3$ (50 or 100 ppm), ethrel (100 or 200 ppm)

or kinetin (25 or 50 ppm), before planting. Treatment with kinetin increased the number of florets per spike and flower size, especially at the lower planting density. Soaking corms in ethrel (100 or 200 ppm) for six hours was reported to inhibit plant growth.

Ravidas (1990) reported the effect of GA on spike length. GA at 50 ppm were superior in increasing the spike length, number of florets per spike and the longevity of individual florets in gladiolus.

Parmar *et al.* (1993) conducted experiment on preplanting chemical dip of bulbs of tuberose Cv. Double and have reported that dipping of bulbs in BA and GA solutions delayed the sprouting. Earliest sprouting was reported and plants attained maximum height at flowering in water soaking treatment. The GA treated bulbs produced plants with greater height, fresh weight and number of sprouts per clump. Soaking of bulbs in GA and thiourea significantly increased the length of spike and rachis while more number of spikes were obtained with BA and GA treatments. Treatments of bulbs with BA, GA, tap water and thiourea significantly increased the fresh weight of the florets when compared to control. Significantly higher flower length was recorded in BA, GA and thiourea treated bulbs compared to others.

Preeti *et al.* (1997) studied the effects of preplanting treatment of bulbs of *P. tuberosa* Cv. Single with $GA_3$ (50, 100 or 200 ppm), ethrel (ethephon) 100, 200 or 400 ppm) and thiourea (1 and 2%) on growth of tuberose. Compared with the control, treatment of bulbs with $GA_3$, ethrel or thiourea promoted the early appearance of flower spikes and also the number of flower spikes, but reduced the number of bulbs produced per plant. Ethrel treated plants gave a mixed response. Flower production tended to decrease with increasing concentrations of ethrel. Treatment with $GA_3$ at 200 ppm produced the highest number of spikes with the longest length and the highest number of florets per spike.

# MATERIALS AND METHODS

# MATERIALS AND METHODS

Experiments on the regulation of growth and flowering in tuberose cv. Double type were carried out at the Department of Pomology and Floriculture, College of Horticulture, Vellanikkara, Thrissur during 1997-1999. The study was done to find out the effect of nutrients and bioregulators on growth parameters, spike qualities, yield and vase life of tuberose. Two separate experiments were conducted and the methods used for the conduct of the trial and analysis of data are presented in this chapter.

## 3.1 Experiment I

### 3.1.1 Planting materials

The experiment was laid out in the College of Horticulture, Vellanikkara using the 'Double' type tuberose bulbs of uniform size (1 cm to 1.5 cm diameter). Bulbs were treated with bavistin 0.1 per cent for half an hour and stored for three weeks before planting.

### 3.1.2 Season

Planting was done during two seasons viz., April-May and August-September (Plate 1).

### 3.1.3 Method of planting

The selected field was first ploughed and levelled. Weeds were then removed. Raised beds of size 7.5 m x 2.0 m and height 15 cm were taken, giving a spacing of 50 cm in between. Organic manure in the form of FYM @ 2 kg $m^{-2}$ was also applied uniformly in all treatments at the time of planting. Full dose of P and K and half dose of N was given as basal. Tubers were dipped in 0.1 per cent bavistin for half an hour just before planting and then planted on beds at a spacing of

**Plate 1. General view of the experimental field**

**Season I**


**Season II**

25 cm x 25 cm. The soil at the experiment site was of medium fertility with respect to nitrogen and potassium and low in phosphorus.

### 3.1.4 General management

The plants were watered once daily with the help of hose during summer months. Need based application of plant protection chemicals was done. Attack of rats were noticed in a few plots for which some traditional control methods were used. Weeding was done manually every month and earthing up was also done along with the second dose of nitrogen fertilizer, i.e., 60 days after planting. When plants started flowering, spikes were given support with bamboo sticks.

## 3.2 Experiment II

The planting materials and the season of planting was similar to the first experiment. Field was prepared as in the first experiment, and beds of 4.5 m x 1.5 m were taken at a spacing of 50 cm from each other. Fertilizers were given according to the Package of Practices Recommendations of Kerala Agricultural University. Full dose of P and K and half dose of N along with 2 kg $m^{-2}$ of FYM was given as basal dose in all treatments. The tubers were soaked for one hour in the bioregulators before planting. The tubers were then planted on the beds at a spacing of 25 cm x 25 cm. Management practices were similar to those of the first experiment.

## 3.3 Layout of the experiment

### 3.3.1 Experiment I

A $3^3+1$ partially confounded factorial experiment in randomised complete block design with two replications was laid out to find out the effect of chemical fertilizers on growth and flowering of tuberose. There were 27 different treatments for nutrients along with a control. Each plot had 35 plants and each replication had

1050 plants. Three plants each at vegetative, flowering and post flowering stages were taken for nutrient analysis in the laboratory. Three spikes from each plot were taken to the laboratory when the first pair of flowers were fully opened for vase life studies.

The treatment combinations were as follows:

$T_1$ - 10:5:5 g $m^{-2}$ NPK

$T_2$ - 10:5:10 g $m^{-2}$ NPK

$T_3$ - 10:5:15 g $m^{-2}$ NPK

$T_4$ - 10:10:5 g $m^{-2}$ NPK

$T_5$ - 10:10:10 g $m^{-2}$ NPK

$T_6$ - 10:10:15 g $m^{-2}$ NPK

$T_7$ - 10:15:5 g $m^{-2}$ NPK

$T_8$ - 10:15:10 g $m^{-2}$ NPK

$T_9$ - 10:15:15 g $m^{-2}$ NPK

$T_{10}$ - 20:5:5 g $m^{-2}$ NPK

$T_{11}$ - 20:5:10 g $m^{-2}$ NPK

$T_{12}$ - 20:5:15 g $m^{-2}$ NPK

$T_{13}$ - 20:10:5 g $m^{-2}$ NPK

$T_{14}$ - 20:10:10 g $m^{-2}$ NPK

$T_{15}$ - 20:10:15 g $m^{-2}$ NPK

$T_{16}$ - 20:15:5 g $m^{-2}$ NPK

$T_{17}$ - 20:15:10 g $m^{-2}$ NPK

$T_{18}$ - 20:15:15 g $m^{-2}$ NPK

$T_{19}$ - 30:5:5 g $m^{-2}$ NPK

$T_{20}$ - 30:5:10 g $m^{-2}$ NPK

$T_{21}$ - 30:5:15 g $m^{-2}$ NPK

$T_{22}$ - 30:10:5 g $m^{-2}$ NPK

$T_{23}$ - 30:10:10 g $m^{-2}$ NPK

$T_{24}$ - 30:10:15 g $m^{-2}$ NPK

$T_{25}$ - 30:15:5 g $m^{-2}$ NPK

$T_{26}$ - 30:15:10 g $m^{-2}$ NPK

$T_{27}$ - 30:15:15 g $m^{-2}$ NPK

$T_{28}$ - Control (FYM @ 2 kg $m^{-2}$)

Full dose of P and K and half dose of N were applied as basal at the time of planting. The remaining N was applied after 60 days of planting. Organic manure in the form of FYM @ 2 kg $m^{-2}$ was given at the time of planting in all the treatments.

3.3.2 Experiment II

Lay out was done in a randomised complete block design with three replications. There were eight different treatments for bioregulators along with a control. Each plot had 25 plants and each replication had 225 plants. Observations were noted as in the above experiment.

The treatments were as follows:

$T_1$ - IAA 25 ppm

$T_2$ - IAA 50 ppm

$T_3$ - GA 50 ppm

$T_4$ - GA 100 ppm

$T_5$ - BA 50 ppm

$T_6$ - BA 100 ppm

$T_7$ - Ethrel 50 ppm

$T_8$ - Ethrel 100 ppm

$T_9$ - Control

The bulbs were soaked for one hour in these bioregulators before planting. Foliar sprays of these bioregulators were given twice, i.e., 30 days and 60 days after planting.

## 3.4 Observations

The following observations were recorded during the course of the experiment.

### 3.4.1 Preharvest studies

#### 3.4.1.1 Vegetative characters

The following vegetative characters of plants under each treatment were recorded.

##### 3.4.1.1.1 Percentage of sprouting

The number of tubers sprouted in each plot was recorded and the percentage of sprouting was worked out as

$$\frac{\text{Number of tubers sprouted} \times 100}{\text{Total number of tubers}}$$

##### 3.4.1.1.2 Plant height

The height of the plant was measured from the base to the top of the shoot at monthly interval and recorded in centimetres.

##### 3.4.1.1.3 Plant spread

The spread of the plant in East-West and North-South directions were measured and expressed in centimetres.

3.4.1.1.4 Number of leaves

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

3.4.1.1.5 Number of tillers per hill

The number of plants produced from the tuber were recorded at monthly interval.

3.4.1.2 Floral characters

3.4.1.2.1 Days to first spike emergence

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

3.4.1.2.2 Days to first floret opening

Time taken (days) for the opening of the first floret in each spike was noted and recorded.

3.4.1.2.3 Days to complete opening of the florets

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

3.4.1.2.4 Length and girth of spike

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

3.4.1.2.5 Length of rachis

Length of rachis of each spike was recorded in centimetres.

3.4.1.2.6 Number of florets

Total number of florets in each spike was observed.

3.4.1.2.7 Size of florets

The length and breadth of each floret in a spike was measured and recorded in centimetres.

3.4.1.2.8 Longevity of a floret

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

3.4.1.2.9 Longevity of a spike in the field

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

3.4.1.2.10 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.

3.4.1.2.11 Yield of spikes per hill

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

3.4.2 Post harvest studies

3.4.2.1 Yield of bulbs and bulblets

3.4.2.1.1 Size of bulb or bulblets

Size of each bulb and bulblets in a hill was recorded in centimetres.

3.4.2.1.2 Number of bulb or bulblets

Number of bulb or bulblets from each hill was counted and recorded.

3.4.2.1.3 Weight of bulbs or bulblets

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

3.4.2.2 Post harvest spike characters

Spikes were harvested when the first pair of flowers fully opened and were kept in water and the following observations taken.

3.4.2.2.1 Fresh weight of spike

Fresh weight of each spike was noted and expressed in grams.

3.4.2.2.2 Days taken for opening of each floret

Number of days taken by each spike for opening of florets were taken and recorded.

3.4.2.2.3 Number of florets opened at a time

Number of florets opened at a time in the vase were noted and recorded.

3.4.2.2.4 Total water uptake

The water uptake of each spike in vase was noted and expressed in millilitres.

3.4.2.2.5 Vase life

Vase life of each spike was noted and given as number of days.

3.4.2.2.6 Geotropic bending of the spike

Geotropic bending of the spike was observed visually and recorded.

## 3.5 Chemical analysis

### 3.5.1 Nutrient content of leaves

Representative samples were taken from each treatment at the different stages, viz., vegetative, flowering and post flowering stages and they were dried well in an oven. After proper drying, the leaves were ground in a grinder. One gram of the powdered sample was used for the analysis.

The total nitrogen in the plant sample was determined by microkjeldahl method (Jackson, 1973). Phosphorus content in the plant sample was determined colourimetricaly by Vanadomolybdo-phosphoric yellow colour method (Jackson, 1973). The potassium content in the plant sample was determined by flame photometry.

## 3.6 Analysis of data

The data generated from the study were subjected to analysis of variance using the methods suggested by Panse and Sukhatme (1985). Treatment means were compared using DMRT wherever necessary.

# RESULTS

# RESULTS

The effect of application of graded doses of nitrogen, phosphorus and potassium on the growth and flowering of *Polianthes tuberosa* (Linn.) were investigated upon, through a partially confounded $3^3$+1 factorial experiment with two replications. There were three levels each of N, $P_2O_5$ and $K_2O$, viz., 10, 20 and 30 g $m^{-2}$ for nitrogen, 5, 10 and 15 g $m^{-2}$ for each phosphorus and potassium. In addition, a control plot receiving no fertilizers was also tagged to each block for the purpose of comparison. The experiment was done in two seasons, viz., April-May and August-September. The results of the experiment are presented below:

## 4.1 Effect of chemical fertilizers

### 4.1.1 Morphological characters of the plant

The data relating to the various shoot characters of the plant as influenced by N, P and K fertilization are presented in Tables 1 and 2 and the analysis of variance in Appendices I and II. All the treated plants showed cent per cent germination during both the seasons.

#### 4.1.1.1 Plant height

The data revealed that there was a progressive improvement in the height of plants with increasing levels of applied nitrogen in all the four months [Fig.1(a)]. The mean height of plants receiving no fertilizers was 24.18 cm in the first month. The height increased from 20.70 cm at $N_1$, to 25.69 cm at $N_2$ and to a maximum of 26.38 cm at $N_3$ level, in the first month. The mean height of plants in the control plot was 36.40 cm in the second month. The height of plants increased from 33.72 cm at $N_1$, to 41.10 cm at $N_2$ and to a maximum of 44.24 cm at $N_3$ level. Similarly the mean height of the plants in control plots were 49.20 cm and 61.17 cm respectively in 3rd and 4th months. The height of the plants increased from 48.52 cm and 61.61 cm at $N_1$, to 52.40 cm and 65.51 cm at $N_2$ and to maximum of

Table 1. Effect of chemical fertilizers on morphological characters - Season I

| Treatments | Plant height (cm) | | | | No. of leaves | | | |
|---|---|---|---|---|---|---|---|---|
| | I | II | III | IV | I | II | III | IV |
| Control | 24.18 | 36.40 | 49.20 | 61.17 | 8.52 | 12.30 | 15.92 | 17.72 |
| $N_1$-10 g $m^{-2}$ | 20.70 | 33.72 | 48.52 | 61.61 | 9.74 | 14.04 | 18.51 | 21.34 |
| $N_2$-20 g $m^{-2}$ | 25.69 | 41.10 | 52.14 | 65.51 | 12.38 | 17.02 | 21.05 | 23.79 |
| $N_3$-30 g $m^{-2}$ | 26.38 | 44.24 | 58.62 | 74.98 | 10.86 | 15.21 | 18.86 | 22.30 |
| CD (0.05) | 6.11 | 5.05 | 5.15 | 4.89 | 1.81 | 2.27 | 2.09 | 1.87 |
| $P_1$-5 g $m^{-2}$ | 22.11 | 37.54 | 53.72 | 67.99 | 10.99 | 15.24 | 19.97 | 23.08 |
| $P_2$-10 g $m^{-2}$ | 25.96 | 40.99 | 53.90 | 68.27 | 11.31 | 15.70 | 19.61 | 22.74 |
| $P_3$-15 g $m^{-2}$ | 24.71 | 40.53 | 51.65 | 65.84 | 10.68 | 15.33 | 18.83 | 21.61 |
| CD (0.05) | 6.11 | NS | NS | NS | NS | 2.27 | NS | NS |
| $K_1$-5 g $m^{-2}$ | 25.63 | 40.81 | 55.87 | 69.54 | 12.03 | 16.12 | 20.29 | 23.50 |
| $K_2$-10 g $m^{-2}$ | 23.00 | 38.79 | 50.58 | 65.02 | 10.62 | 14.71 | 18.50 | 21.63 |
| $K_3$-15 g $m^{-2}$ | 24.14 | 39.46 | 52.82 | 67.54 | 10.32 | 15.45 | 19.62 | 22.30 |
| CD (0.05) | 6.11 | NS | NS | NS | NS | NS | NS | NS |

NS – Non significant

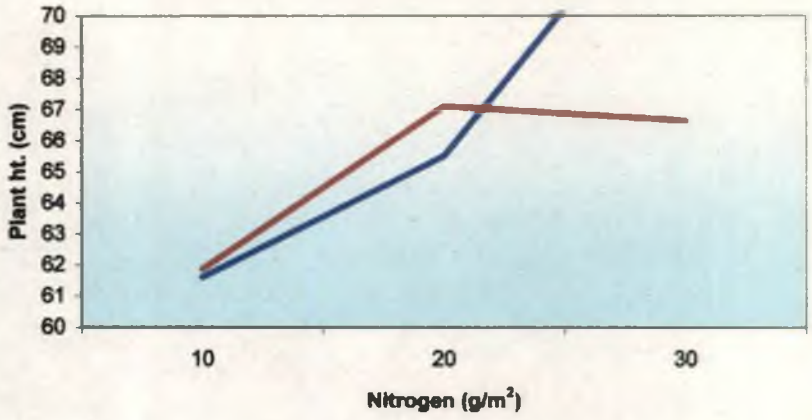
Table 2. Effect of chemical fertilizers on morphological characters - Season II

| Treatments | Plant height (cm) | | | | No. of leaves | | | |
|---|---|---|---|---|---|---|---|---|
| | I | II | III | IV | I | II | III | IV |
| Control | 19.28 | 28.27 | 45.85 | 57.59 | 8.90 | 12.40 | 15.73 | 18.87 |
| $N_1$-10 g $m^{-2}$ | 18.21 | 27.73 | 44.98 | 61.87 | 9.48 | 12.64 | 15.78 | 19.40 |
| $N_2$-20 g $m^{-2}$ | 21.61 | 33.41 | 50.53 | 67.11 | 10.82 | 14.76 | 18.14 | 22.53 |
| $N_3$-30 g $m^{-2}$ | 22.39 | 34.48 | 51.36 | 66.64 | 10.92 | 15.06 | 19.65 | 23.06 |
| CD (0.05) | 1.88 | 2.49 | 3.21 | NS | NS | 2.03 | 2.29 | 2.48 |
| $P_1$-5 g $m^{-2}$ | 21.31 | 33.22 | 49.49 | 66.90 | 10.00 | 13.96 | 17.52 | 21.43 |
| $P_2$-10 g $m^{-2}$ | 21.00 | 32.11 | 48.45 | 63.55 | 10.94 | 14.72 | 18.62 | 22.38 |
| $P_3$-15 g $m^{-2}$ | 19.90 | 30.30 | 48.93 | 65.17 | 10.27 | 13.77 | 17.45 | 21.18 |
| CD (0.05) | Ns | NS | NS | NS | NS | NS | NS | NS |
| $K_1$-5 g $m^{-2}$ | 20.75 | 31.73 | 49.58 | 66.04 | 10.68 | 14.13 | 18.34 | 21.93 |
| $K_2$-10 g $m^{-2}$ | 21.56 | 33.71 | 50.41 | 66.34 | 10.64 | 14.68 | 18.02 | 22.15 |
| $K_3$-15 g $m^{-2}$ | 19.90 | 30.19 | 46.88 | 63.24 | 9.89 | 13.64 | 17.20 | 20.92 |
| CD (0.05) | 1.88 | 2.49 | 3.21 | NS | NS | NS | NS | NS |

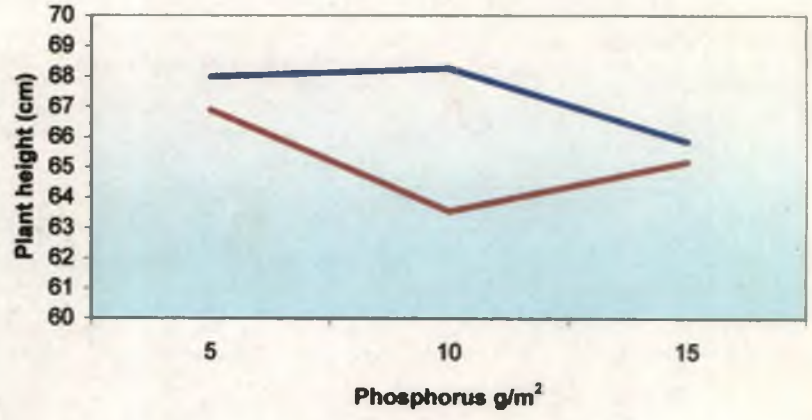
NS – Non significant

## Fig.1 Effect of Chemical Fertilizers on Plant Height

(a) Effect of nitrogen on plant height




(b) Effect of phosphorus on plant height




(c) Effect of potassium on plant height

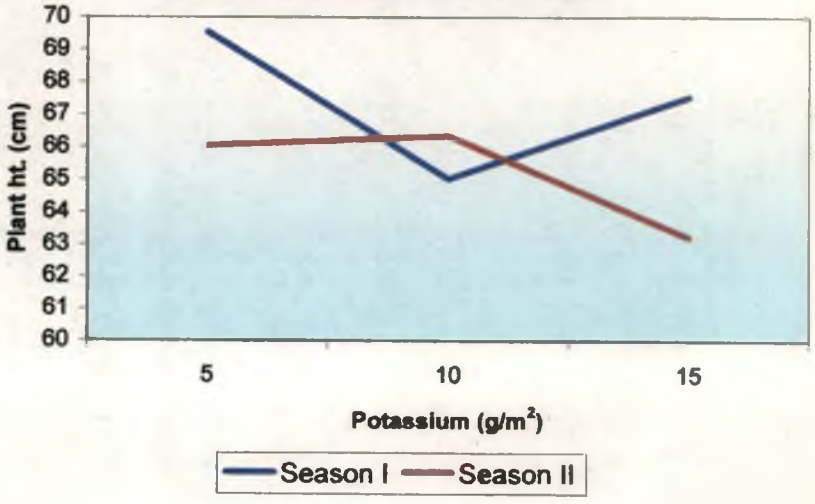


**Plate 2. Comparison of plants at 90 DAP**



58.62 cm and 74.98 cm respectively at 3rd and 4th months. However, the difference between $N_1$ and $N_2$ as well as between $N_2$ and $N_3$ were not significant. Significant difference could be observed between control and $N_3$ as well as $N_1$ and $N_3$ in all the months. The other two major nutrients, P and K showed a significant but non-progressive change in height in the first month of planting. The plant height increased from 22.11 cm at $P_1$ to 25.96 cm at $P_2$ but decreased to 24.71 cm at $P_3$ level [Fig.1(b)]. The plant height decreased from 25.63 cm at $K_1$ to 23.00 cm at $K_2$, but again increased to 24.14 cm at $K_3$ level [Fig.1(c)]. Among the K treatments $K_1$ recorded maximum plant height. Phosphorus and K did not seem to influence plant height in the rest of the months. NP and K interactions were found to be significant in first month only and other interactions were not significant.

During the second season (Table 2 and Appendix II) there was a significant and progressive improvement in the height of the plants with increasing levels of applied nitrogen except in the fourth month of planting [Fig.1(a)]. The mean height of the plants receiving no fertilizers was 19.28 cm, 28.27 cm, 45.85 cm and 57.59 cm respectively in the four months. The plant heights increased from 18.21 cm, 27.73 cm and 44.98 cm at $N_1$ to 21.61 cm, 33.41 cm and 50.53 cm at $N_2$ to a maximum of 22.39 cm, 34.48 cm and 51.36 cm at $N_3$ level in the first three months. During the fourth month, the plant height increased from 61.87 cm at $N_1$ to 67.11 cm at $N_2$, but decreased to 66.64 cm at $N_3$ level. The other major nutrient P did not seem to influence this character. But K showed a significant, but non-progressive change in the plant height in the first three months. However, the change in plant height was not significant in the fourth month.

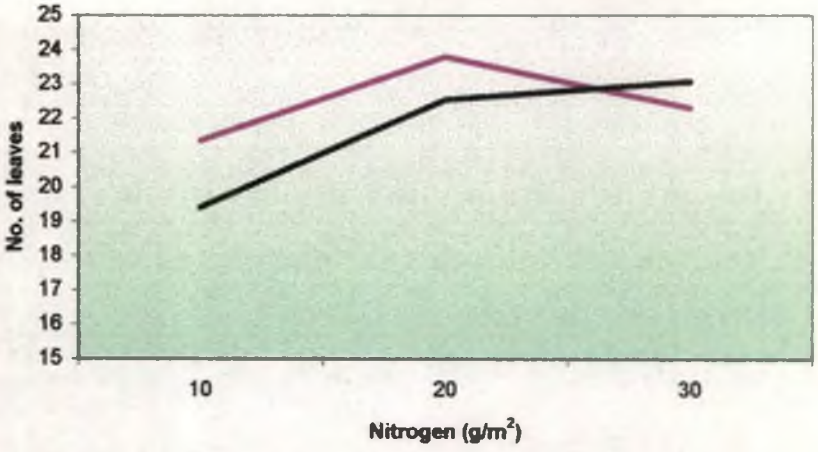
$NP^2K$ interaction was significant in first three months of planting. All other interactions were not significant.

4.1.1.2 Number of leaves

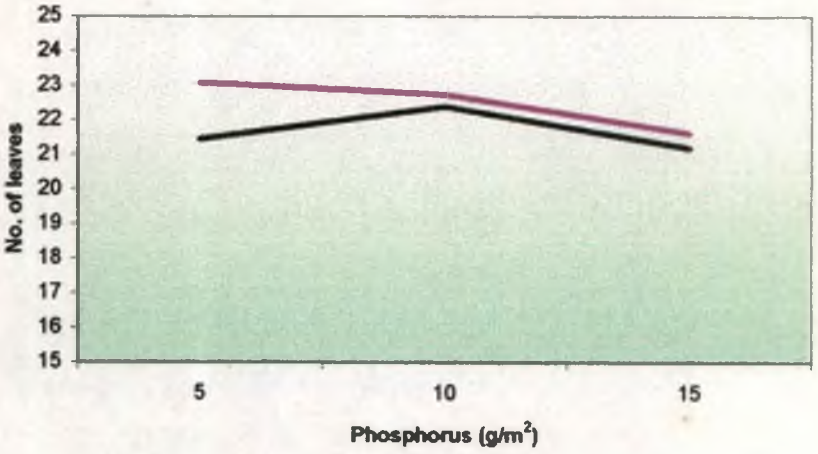
Significant differences were observed in the number of leaves per plant with changing levels of nitrogen in all the four months [Fig.2(a)]. The mean

**Fig.2 Effect of chemical fertilizers on number of leaves**

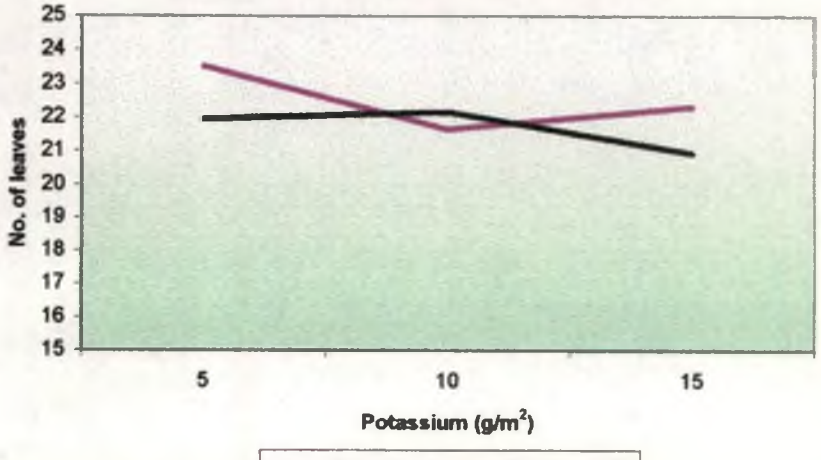
(a) Effect of nitrogen on no. of leaves




(b) Effect of phosphorus on no. of leaves




(c) Effect of potassium on no. of leaves



number of leaves of the plants receiving no fertilizers was 8.52, 12.30, 15.92 and 17.72 respectively in the four months. The leaf number increased to 9.74, 14.04, 18.51 and 21.34 at $N_1$, to 12.38, 17.02, 21.05 and 23.79 at $N_2$. However, the number of leaves decreased to 10.86, 15.21, 18.86 and 22.30 respectively in $N_3$. The highest number of leaves was observed in $N_2$. The other two major nutrients, P and K did not seem to influence the leaf number. NK and PK interaction in the first month and NK interaction in the fourth month were significant.

During the second season (Table 2) however, a progressive increase in the number of leaves was observed with increasing levels of nitrogen. The mean leaf number of the control plot was 8.9, 12.64, 15.73 and 18.87 respectively. The leaf numbers increased to 9.48, 12.4, 15.78 and 19.4 at $N_1$, to 10.82, 14.76, 18.14 and 22.53 cm at $N_2$ and to a maximum of 10.92, 15.6, 19.65 and 23.06 at $N_3$ level. Phosphorus and K did not found to influence this character. None of the interactions were found to be significant.

4.1.1.3 Plant spread

Significant differences were not observed in plant spread (Table 3 and Appendix III) with increasing levels of either N, P or K except the east west spread in first month and north south spread in the second month. However, the data revealed that the treatment plants, in general, produced more leaves than the control plants. The interactions of the nutrients were also not significant.

In the second season (Table 4 and Appendix IV), nitrogen application had shown a significant difference in the plant spread during the third and fourth months after planting. Nitrogen at the highest level ($N_3$) gave the highest plant spread, viz., 53.23 cm (EW) and 53.20 cm (NS) in the third month and 68.26 cm (EW) and 69.82 cm (NS) in the fourth month. Potassium showed a significant change in plant spread in the east west side during the fourth month. Phosphorus

Table 3. Effect of chemical fertilizers on morphological characters - Season I

| Treatments | Plant spread (cm) | | | | | | | | Number of tillers | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | I | | II | | III | | IV | | I | II | II | IV |
| | EW | NS* | EW | NS* | EW | NS* | EW | NS* | | | | |
| Control | 18.15 | 16.28 | 32.97 | 30.17 | 44.37 | 46.23 | 58.73 | 58.73 | 1.25 | 1.95 | 2.37 | 3.20 |
| $N_1$-10 g $m^{-2}$ | 20.21 | 21.06 | 42.25 | 41.98 | 58.15 | 57.17 | 68.70 | 68.27 | 1.48 | 2.19 | 3.08 | 3.98 |
| $N_2$-20 g $m^{-2}$ | 24.39 | 22.88 | 39.20 | 37.89 | 54.24 | 53.72 | 64.41 | 66.27 | 1.51 | 2.70 | 4.52 | 5.35 |
| $N_3$-30 g $m^{-2}$ | 23.93 | 23.76 | 47.04 | 45.91 | 58.52 | 59.48 | 70.49 | 71.13 | 1.52 | 2.95 | 4.18 | 5.46 |
| CD(0.05) | 3.09 | NS | NS | 5.27 | NS | NS | NS | NS | Ns | 0.36 | 0.23 | 0.92 |
| $P_1$-5 g $m^{-2}$ | 21.88 | 22.42 | 43.48 | 44.51 | 56.67 | 59.02 | 67.65 | 68.47 | 1.57 | 2.53 | 3.76 | 4.93 |
| $P_2$-10 g $m^{-2}$ | 24.06 | 23.44 | 43.91 | 42.34 | 58.98 | 57.86 | 70.13 | 70.40 | 1.54 | 2.65 | 4.18 | 5.06 |
| $P_3$-15 g $m^{-2}$ | 22.59 | 21.84 | 41.11 | 38.94 | 55.26 | 53.49 | 66.81 | 66.80 | 1.40 | 2.66 | 3.84 | 4.80 |
| CD(0.05) | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| $K_1$-5 g $m^{-2}$ | 22.77 | 22.53 | 43.80 | 40.44 | 57.08 | 54.99 | 67.83 | 66.87 | 1.48 | 2.42 | 3.64 | 4.54 |
| $K_2$-10 g $m^{-2}$ | 22.93 | 21.63 | 41.76 | 40.90 | 56.80 | 57.02 | 68.47 | 68.41 | 1.45 | 2.36 | 3.86 | 4.80 |
| $K_3$-15 g $m^{-2}$ | 22.83 | 23.54 | 42.93 | 44.44 | 57.03 | 58.37 | 68.29 | 70.39 | 1.58 | 3.06 | 4.28 | 5.45 |
| CD(0.05) | Ns | NS | NS | NS | NS | NS | NS | NS | NS | 0.35 | NS | NS |

NS – Non significant
EW – East West, *NS – North South

Table 4. Effect of chemical fertilizers on morphological characters – Season II

| Treatments | Plant spread (cm) | | | | | | | | Number of tillers | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | I | | II | | III | | IV | | I | II | II | IV |
| | EW | NS* | EW | NS* | EW | NS* | EW | NS* | | | | |
| Control | 19.21 | 20.80 | 27.54 | 27.93 | 49.59 | 49.84 | 61.09 | 64.35 | 1.47 | 2.03 | 2.52 | 2.78 |
| $N_1$-10 g $m^{-2}$ | 19.68 | 21.41 | 29.46 | 30.72 | 50.62 | 51.89 | 62.19 | 64.10 | 1.41 | 1.92 | 2.35 | 2.75 |
| $N_2$-20 g $m^{-2}$ | 19.96 | 21.59 | 29.05 | 29.68 | 46.30 | 47.79 | 59.55 | 63.06 | 1.38 | 1.97 | 2.46 | 2.82 |
| $N_3$-30 g $m^{-2}$ | 21.39 | 22.33 | 30.49 | 31.10 | 53.23 | 53.20 | 68.26 | 69.82 | 1.92 | 2.50 | 3.05 | 3.46 |
| CD(0.05) | NS | NS | NS | NS | 2.91 | 2.77 | 2.39 | 3.21 | 0.17 | 0.19 | 0.27 | 0.30 |
| $P_1$-5 g $m^{-2}$ | 19.89 | 21.66 | 29.82 | 30.86 | 49.91 | 51.66 | 62.76 | 65.42 | 1.54 | 2.06 | 2.57 | 2.95 |
| $P_2$-10 g $m^{-2}$ | 20.73 | 22.24 | 30.18 | 30.90 | 50.59 | 52.01 | 63.69 | 67.00 | 1.56 | 2.11 | 2.63 | 3.04 |
| $P_3$-15 g $m^{-2}$ | 20.41 | 21.44 | 28.99 | 29.74 | 49.65 | 49.21 | 63.55 | 64.56 | 1.61 | 2.22 | 2.66 | 3.04 |
| CD(0.05) | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| $K_1$-5 g $m^{-2}$ | 19.89 | 21.62 | 29.44 | 30.02 | 51.20 | 51.31 | 64.92 | 66.74 | 1.53 | 2.03 | 2.43 | 2.82 |
| $K_2$-10 g $m^{-2}$ | 20.14 | 21.55 | 28.93 | 30.56 | 48.30 | 50.70 | 61.61 | 65.62 | 1.55 | 2.13 | 2.63 | 3.02 |
| $K_3$-15 g $m^{-2}$ | 21.01 | 22.17 | 30.63 | 29.92 | 50.65 | 50.87 | 63.47 | 64.62 | 1.63 | 2.23 | 2.79 | 3.19 |
| CD(0.05) | NS | NS | NS | NS | NS | NS | 2.39 | NS | NS | NS | 0.27 | 0.30 |

NS – Non significant
EW – East West, *NS – North South

did not seem to influence this character. Also all the interactions were found to be non-significant.

4.1.1.4 Number of tillers

Significant difference was observed in the number of tillers (Table 3 and Table 4) in second, third and fourth months of season I and in all months of season II with increasing levels of nitrogen. In general, nitrogen at the highest level produced maximum tillers per plant. Potassium also gave a significant increase in tiller number in 3rd and 4th months. Phosphorus did not influence this character significantly. None of the interactions was found to be significant.

4.1.2 Floral characters

The data on the floral characters as influenced by the NPK fertilization are presented in Table 5 (Season I) and in Table 6 (Season II). The analysis of variance for the character is given in Appendix V (Season I) and in Appendix VI (Season II).

4.1.2.1 Days to spike emergence

Application of N, P or K did not seem to have any effect on the days required for the first spike to emerge. However, as compared to the control, the fertilizer application generally tended to reduce the number of days required for the spike emergence. With increasing levels of nitrogen, the time required for spike emergence was reduced to the minimum (218.23 days). None of the interactions were significant.

During the second season (Table 6), application of higher doses of nitrogen, significantly reduced the days required for spike emergence [Fig. 3 ]. The days were reduced from 214.3 at $N_1$ to 209.96 at $N_2$ to a minimum of 200.67

Table 5. Effect of chemical fertilizers on floral characters - Season I

| Treatments | Days to first spike emergence | Days for first floret opening | Days for complete floret opening | Length of spike (cm) | Length of rachis (cm) | No. of florets | Size of florets (cm) | Longevity of a floret (days) | Longevity of a spike (days) | Duration of crop (days) | No. of spike per hill |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Control | 229.67 | 25.54 | 18.70 | 82.56 | 24.11 | 25.76 | 3.07 | 2.24 | 43.53 | 268.80 | 1.00 |
| $N_1$-10 g $m^{-2}$ | 226.40 | 23.91 | 18.55 | 81.34 | 25.09 | 26.59 | 3.87 | 2.07 | 42.62 | 268.31 | 1.02 |
| $N_2$-20 g $m^{-2}$ | 221.88 | 23.11 | 18.40 | 84.70 | 26.55 | 28.26 | 4.04 | 2.41 | 41.63 | 263.94 | 1.03 |
| $N_3$-30 g $m^{-2}$ | 218.23 | 22.58 | 17.63 | 85.60 | 28.69 | 29.91 | 3.99 | 5.20 | 54.06 | 244.47 | 1.03 |
| CD(0.05) | NS | NS | NS | 2.35 | 2.20 | NS | NS | 0.1 | NS | NS | NS |
| $P_1$-5 g $m^{-2}$ | 222.29 | 22.96 | 18.48 | 82.83 | 26.97 | 29.20 | 4.12 | 2.24 | 41.16 | 261.21 | 1.04 |
| $P_2$-10 g $m^{-2}$ | 221.16 | 23.02 | 17.76 | 85.06 | 26.61 | 28.10 | 4.02 | 2.66 | 41.76 | 263.68 | 1.03 |
| $P_3$-15 g $m^{-2}$ | 223.06 | 23.62 | 18.34 | 83.75 | 26.76 | 27.46 | 3.76 | 4.76 | 55.39 | 251.83 | 1.04 |
| CD(0.05) | NS | NS | NS | NS | NS | NS | NS | 0.1 | NS | NS | NS |
| $K_1$-5 g $m^{-2}$ | 222.33 | 23.09 | 18.22 | 83.56 | 26.57 | 28.37 | 4.02 | 2.57 | 42.27 | 266.79 | 1.04 |
| $K_2$-10 g $m^{-2}$ | 224.52 | 23.53 | 18.46 | 84.95 | 26.69 | 29.37 | 3.97 | 2.41 | 40.89 | 260.55 | 1.02 |
| $K_3$-15 g $m^{-2}$ | 219.66 | 22.98 | 17.90 | 83.13 | 27.08 | 27.02 | 3.92 | 4.69 | 55.16 | 249.38 | 1.03 |
| CD(0.05) | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |

NS – Non significant

Table 6. Effect of chemical fertilizers on floral characters - Season II

| Treat-ments | Days to first spike emergence | Days for first floret opening | Days for complete floret opening | Length of spike (cm) | Length of rachis (cm) | No. of florets | Size of florets (cm) | Longevity of a floret (days) | Longevity of a spike (days) | Duration of crop (days) | No. of spike per hill |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Control | 218.25 | 24.50 | 20.24 | 80.73 | 24.16 | 28.91 | 2.78 | 2.47 | 44.65 | 261.32 | 1.01 |
| $N_1$-10 g $m^{-2}$ | 214.30 | 23.57 | 19.35 | 85.08 | 25.16 | 27.24 | 4.08 | 2.65 | 43.03 | 258.39 | 1.31 |
| $N_2$-20 g $m^{-2}$ | 209.96 | 24.01 | 19.18 | 91.78 | 29.47 | 32.46 | 3.83 | 2.88 | 44.14 | 252.16 | 1.09 |
| $N_3$-30 g $m^{-2}$ | 200.67 | 23.06 | 23.21 | 89.40 | 29.00 | 31.74 | 3.98 | 5.74 | 56.57 | 231.00 | 1.06 |
| CD(0.05) | 7.11 | NS | NS | 5.23 | 1.78 | 3.26 | NS | 0.12 | NS | 21.07 | NS |
| $P_1$-5 g $m^{-2}$ | 209.82 | 24.02 | 19.29 | 91.83 | 28.19 | 31.77 | 3.95 | 2.98 | 43.49 | 252.63 | 1.11 |
| $P_2$-10 g $m^{-2}$ | 210.99 | 23.16 | 18.96 | 88.43 | 28.33 | 29.86 | 4.10 | 2.82 | 42.33 | 251.88 | 1.10 |
| $P_3$-15 g $m^{-2}$ | 204.12 | 23.46 | 23.48 | 86.10 | 27.11 | 29.80 | 3.83 | 5.47 | 57.91 | 237.05 | 1.09 |
| CD(0.05) | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| $K_1$-5 g $m^{-2}$ | 205.87 | 23.23 | 19.43 | 91.79 | 28.29 | 31.06 | 3.90 | 2.96 | 43.52 | 253.50 | 1.11 |
| $K_2$-10 g $m^{-2}$ | 209.87 | 23.99 | 19.85 | 87.06 | 27.43 | 30.56 | 4.05 | 2.94 | 44.11 | 253.53 | 1.31 |
| $K_3$-15 g $m^{-2}$ | 209.43 | 23.41 | 22.47 | 87.42 | 27.92 | 29.80 | 3.92 | 5.37 | 56.11 | 234.52 | 1.09 |
| CD(0.05) | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |

NS – Non significant

**Fig . 3 Effect of chemical fertilizers on days to spike emergence**

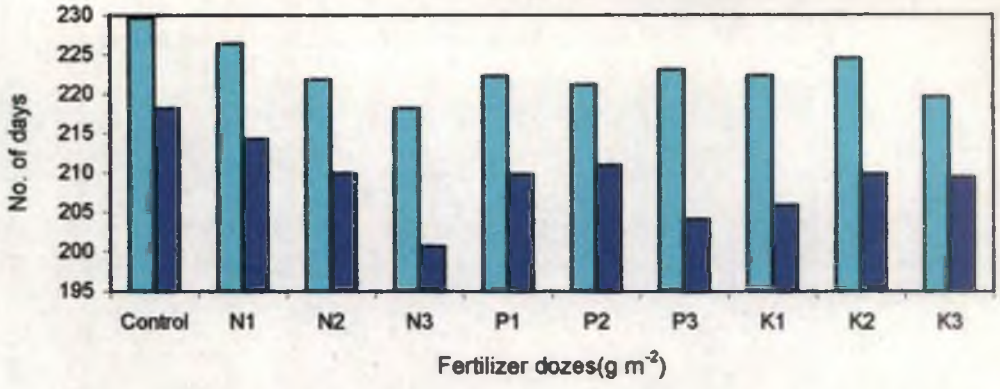



**Fig . 4 Effect of chemical fertilizers on length of spike**

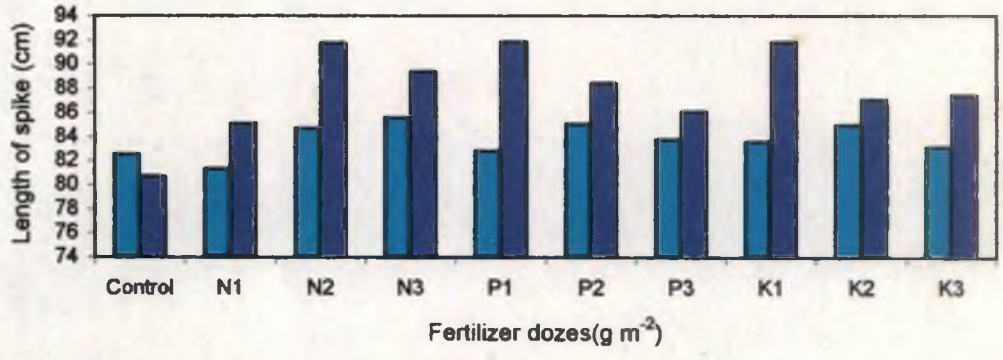
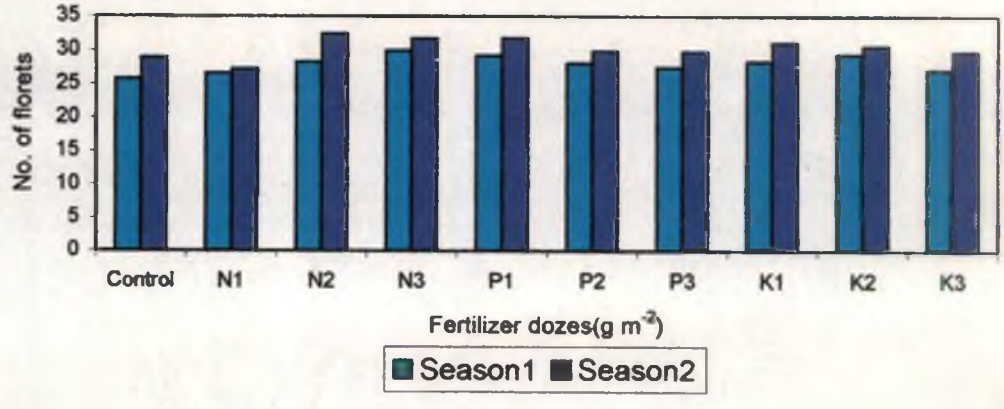



**Fig . 5 Effect of chemical fertilizers on number of florets per spike**



days at $N_3$ level. Phosphorus and K did not influence this character much. Also none of the interactions were found to be significant.

4.1.2.2 Days to first floret opening

Varying levels of applied nutrients did not bring about any significant difference in the days for the first floral opening in both the seasons. Compared to the control, the treatment plants showed a general decrease in days required for first floret opening. None of the interaction were found to be significant.

4.1.2.3 Days to complete opening of florets

Similarly the application of different doses of NPK did not significantly influence the days required for complete opening of florets in the two seasons. But with the increasing levels of nitrogen, a progressive decrease in days required for the complete floret opening was observed in the first season, but it was not observed so, in the second season.

4.1.2.4 Length of spike

Length of the spike showed significant difference due to nitrogen treatments [Fig. 4 ]. The length increased from 81.34 cm at $N_1$, to 84.7 cm at $N_2$, to a maximum of 85.60 cm at $N_3$ level. Whereas the mean spike length of the control plot was 82.56 cm. During the second season (Table 6) also, nitrogen application showed a significant difference in the spike length. Spike length increased from 85.08 cm at $N_1$, to 91.78 cm at $N_2$ level, but showed a slight reduction to 89.40 cm at $N_3$ level. P and K did not seem to influence this character significantly in both seasons. None of the interaction was significant.

4.1.2.5 Length of rachis

Significant difference was observed in the length of rachis of plants in both the seasons. The mean length of rachis of the plants receiving no fertilizers

was 24.11 cm in fist season. The length increased to 25.09 cm at $N_1$, 26.55 cm at $N_2$ and to 28.69 cm at $N_3$ level. However, the differences between $N_1$ and $N_2$ as well as between $N_2$ and $N_3$ were not significant. The other nutrients P and K did not seem to influence this character. During the next season also increasing nitrogen level produced significant change in rachis length. But the progressive increase in length was not noticed as in the first season. The rachis length increased from 25.16 cm at $N_1$, to 29.47 cm at $N_2$ and then decreased to 29.00 cm as against the control which was 24.16 cm. None of the interaction were found to be significant.

4.1.2.6 Number of florets per spike

Significant differences were not observed in the total number of florets per spike with NPK application in the first season. But as compared to the control (25.76), the floret number found to be increasing with increasing levels of nitrogen. The number of florets per spike decreased with increasing levels of applied P.

The number of florets per plant decreased from 29.20 cm at $P_1$ to 28.10 cm at $P_2$ and further to 27.46 cm at $P_3$ levels. The other nutrient, K had neither positive nor negative effect. During the second season, nitrogen application significantly influenced total floret number per spike [Fig. 5 ]. The floret number increased from 27.24 at $N_1$ to 32.46 at $N_2$, but decreased to 31.74 at $N_3$ level. The number of florets in the control plot was 28.91.

4.1.2.7 Size of florets

The size of the florets decreased with increasing levels of both P and K. The size of the floret decreased from 5.12 cm at $P_1$, to 5.02 cm at $P_2$, and to 4.76 cm at $P_3$ levels. And the decrease was from 5.02 cm at $K_1$ to 4.97 cm at $K_2$ and to 4.92 cm at $K_3$ levels in the first season. The mean size of florets of control plot was 3.07 cm. During the second season, the three nutrients, N, P and K had

neither positive nor negative effects individually. None of the interaction were found to be significant.

4.1.2.8 Longevity of a floret

Longevity of a floret in the spike showed a significant difference with increase in nitrogen and phosphorus in first season and with nitrogen only in the second season. The longevity of a floret showed a progressive increase from 2.07 days at $N_1$, to 2.41 days at $N_2$, and to a maximum of 5.20 days at $N_3$. The increase in longevity was from 2.24 days at $P_1$, to 2.66 days at $P_2$, and to 4.76 days at $P_3$ level. The mean longevity of plants receiving no fertilizers was 2.24 days. During the second season also, application of higher doses of nitrogen showed a significant increase in longevity from 2.64 days at $N_1$, to 2.88 days at $N_2$, to 5.74 days at $N_3$ level. Application of K did not bring about any significant difference in this character.

4.1.2.9 Longevity of a spike in field

Varying levels of applied nutrients did not significantly effect the longevity of a spike in the field in both the seasons. But nitrogen showed a progressive increase in longevity of spikes at higher doses of application in the second season. None of the interactions were found to be significant.

4.1.2.10 Crop duration

It is apparent from the data that nitrogen tended to reduce the crop duration from 268.31 days at $N_1$, to 263.94 days at $N_2$ and to a minimum of 244.47 days at $N_3$ levels in the first season [Fig. 6 ]. Application of K also showed a decrease in the crop duration with increasing doses. During the second season also a significant reduction in the crop duration was noticed with nitrogen application. The duration of plants in the control plot was 261.32 days. This was reduced to 258.39 days at $N_1$, to 252.16 days at $N_2$ and to a minimum of 231.00 days at $N_3$

Fig . 6 Effect of chemical fertilizers on crop duration

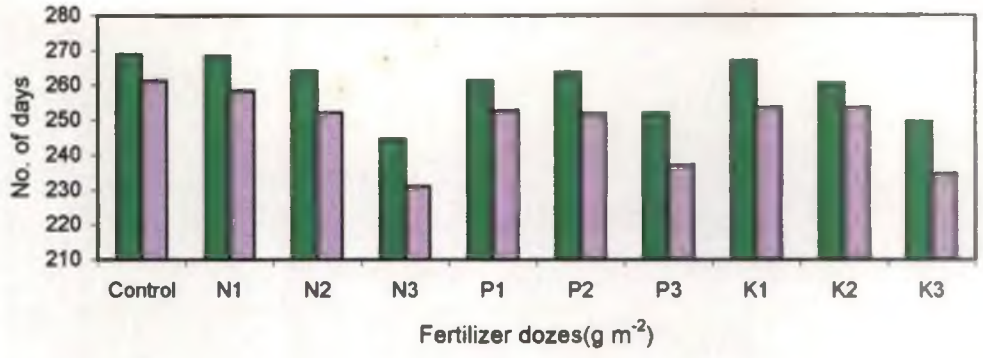



Fig . 7 Effect of chemical fertilizers on fresh weight of spike

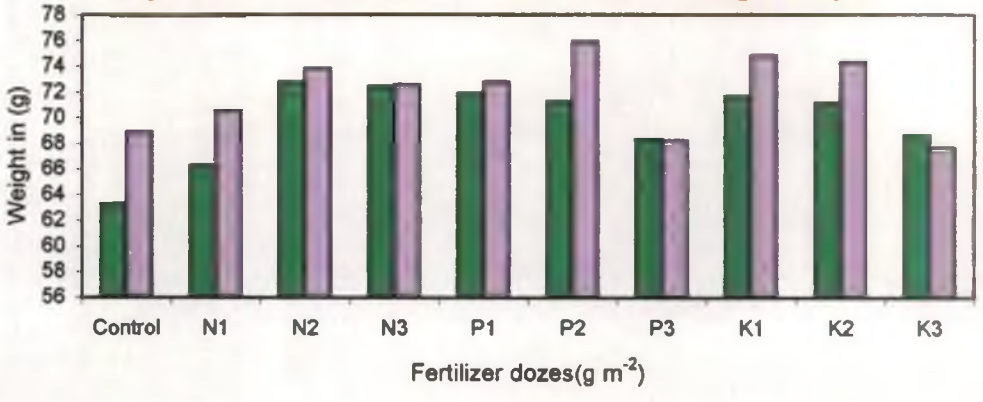
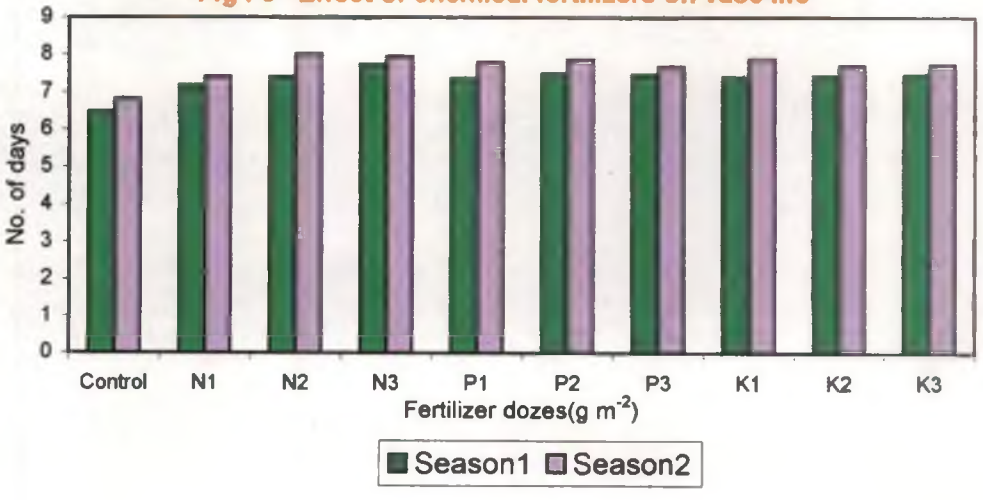



Fig . 8 Effect of chemical fertilizers on vase life



levels. Other two major nutrients, P and K did not influence this character significantly. None of the interaction were found to be significant.

4.1.2.11 Number of spikes per hill

It can also be seen from the Tables 5 and 6 that application of N, P or K individually or their interactions had no effect on the yield of spike per hill in both the seasons.

4.1.3 Post harvest spike characters

Data on the vase life characters as influenced by the graded levels of nitrogen, phosphorus and potassium are presented in Tables 7 and 8. The analysis of variance is presented in Appendices VII and VIII.

4.1.3.1 Fresh weight of spike

Application of nitrogen significantly increased the fresh weight of spikes in the first season [Fig. 7 ]. The mean fresh weight of the spikes of the control plot was 63.29 g. This has been increased to 66.27 g at $N_1$, to 72.80 g at $N_2$ and then decreased to 72.44 g at $N_3$ levels. However, significant effect was not noticed in the second season. Other nutrients, P and K did not seem to influence this character significantly. None of the interaction were found to be significant.

4.1.3.2 Days for opening of each floret

Nitrogen in both the seasons significantly influenced the days for opening of each floret. In the first season, the days for opening of each floret increased from 1.56 days at $N_1$, to 1.76 days at $N_2$, to a maximum of 2.02 days at $N_3$ levels as against 1.4 days in the control plot. During the next season, the change was from 1.78 days at $N_1$, to 1.49 at $N_2$ and then it increased to a maximum of 2.19 days at $N_3$ level. The effect of P and K in this character was not significant.

Table 7. Effect of chemical fertilizers on post harvest spike characters - Season I

| Treatments | Fresh weight of spike (g) | Days for opening of each floret | Days for complete opening of florets | No. of florets opened at a time | Total water uptake (ml) | Vase life (days) |
|---|---|---|---|---|---|---|
| Control | 63.29 | 1.40 | 13.11 | 1.27 | 39.12 | 6.48 |
| $N_1$-10 g $m^{-2}$ | 66.27 | 1.56 | 13.45 | 1.51 | 42.47 | 7.17 |
| $N_2$-20 g $m^{-2}$ | 72.80 | 1.76 | 13.34 | 1.74 | 44.42 | 7.39 |
| $N_3$-30 g $m^{-2}$ | 72.44 | 2.02 | 13.31 | 3.91 | 40.47 | 7.73 |
| CD (0.05) | 5.28 | 1.18 | NS | 0.05 | NS | 0.38 |
| $P_1$-5 g $m^{-2}$ | 71.90 | 1.55 | 13.56 | 1.78 | 42.56 | 7.36 |
| $P_2$-10 g $m^{-2}$ | 71.25 | 1.56 | 13.56 | 1.61 | 44.40 | 7.48 |
| $P_3$-15 g $m^{-2}$ | 68.36 | 2.22 | 12.99 | 3.77 | 40.41 | 7.45 |
| CD (0.05) | NS | NS | NS | NS | NS | NS |
| $K_1$-5 g $m^{-2}$ | 71.70 | 1.54 | 13.50 | 1.66 | 43.14 | 7.40 |
| $K_2$-10 g $m^{-2}$ | 71.14 | 1.51 | 13.68 | 1.66 | 42.61 | 7.43 |
| $K_3$-15 g $m^{-2}$ | 68.67 | 2.29 | 12.93 | 3.83 | 41.60 | 7.46 |
| CD (0.05) | NS | NS | NS | NS | NS | NS |

NS – Non significant

Table 8. Effect of chemical fertilizers on post harvest spike characters - Season II

| Treatments | Fresh weight of spike (g) | Days for opening of each floret | Days for complete opening of florets | No. of florets opened at a time | Total water uptake (ml) | Vase life (days) |
|---|---|---|---|---|---|---|
| Control | 68.92 | 1.46 | 14.60 | 1.58 | 39.62 | 6.81 |
| $N_1$-10 g $m^{-2}$ | 70.57 | 1.78 | 14.26 | 1.79 | 44.76 | 7.40 |
| $N_2$-20 g $m^{-2}$ | 73.84 | 1.49 | 13.51 | 2.19 | 43.14 | 8.01 |
| $N_3$-30 g $m^{-2}$ | 72.56 | 2.19 | 13.89 | 3.90 | 42.70 | 7.94 |
| CD (0.05) | NS | 0.10 | NS | 0.10 | NS | NS |
| $P_1$-5 g $m^{-2}$ | 72.80 | 1.53 | 14.05 | 1.87 | 42.01 | 7.79 |
| $P_2$-10 g $m^{-2}$ | 75.92 | 1.61 | 13.94 | 1.99 | 45.10 | 7.88 |
| $P_3$-15 g $m^{-2}$ | 68.25 | 2.32 | 13.68 | 4.02 | 43.49 | 7.68 |
| CD (0.05) | NS | NS | NS | NS | NS | NS |
| $K_1$-5 g $m^{-2}$ | 74.84 | 1.61 | 14.09 | 1.94 | 44.70 | 7.90 |
| $K_2$-10 g $m^{-2}$ | 74.40 | 1.61 | 14.42 | 1.97 | 41.90 | 7.70 |
| $K_3$-15 g $m^{-2}$ | 67.74 | 2.23 | 13.18 | 3.96 | 44.01 | 7.75 |
| CD (0.05) | 6.21 | NS | NS | NS | NS | NS |

NS – Non significant

4.1.3.3 Days to complete opening of florets

None of the nutrients showed significant effects on the days for complete opening of the florets in both the seasons. All the interactions were also not significant.

4.1.3.4 Number of florets open at a time

Application of nitrogen at higher levels significantly increased the number of flowers opened at a time in the vase. During the first season, the increase was from 1.51 at $N_1$, to 1.74 at $N_2$ and to a maximum of 3.91 at $N_3$ levels. The control plot mean was 1.27 flowers. In the next season also number of flowers opened, increased from 1.58 of control, to 1.79 at $N_1$, to 2.19 at $N_2$ to a maximum of 3.90 at $N_3$ levels. Both P and K did not show much significant effect on this character.

4.1.3.5 Total water uptake

It can also be seen from the table that, total water uptake by the spikes in vase was not influenced significantly by any of the applied fertilizers in both the seasons. But when compared to the control, all the spikes of the treated plants showed an increased water uptake.

4.1.3.6 Vase life

Vase life of the spikes was significantly influenced by the application of graded doses of nitrogen, in the first season [Fig. 8 ]. The mean vase life of the spikes of the plants receiving no fertilizers was 6.48 days. The vase life increased to 7.17 days at $N_1$, to 7.39 days at $N_2$ and to a maximum of 7.73 days at $N_3$ levels. However, the differences between $N_1$ and $N_2$ as well as between $N_2$ and $N_3$ were not significant. The other two major nutrients, P and K did not seem to influence the vase life significantly. But K, showed a slight increase in vase life from 7.40

days at $K_1$ to 7.43 days at $K_2$, and 7.46 days at $K_3$ level. During the second season, application of N, P or K had no significant effect on the vase life of spikes. But nitrogen at 20 g $m^{-2}$ gave the longest vase life of 8.01 days. None of the interactions were found to be significant.

4.1.3.7 Geotropic bending of spike

Geotropic bending was not observed in vase by any of the treated plants.

4.1.4 Yield of bulbs and bulblets

Data on the tuber characters as influenced by the graded levels of nitrogen, phosphorus and potassium are presented in Tables 9 and 10, and the analysis of variance is presented in Appendices IX and X.

4.1.4.1 Size of bulbs

Effects of nitrogen and potassium on the size of bulb were significant. Nitrogen increased the size of bulbs from 8.52 cm at $N_1$, to 11.12 cm at $N_2$, and then decreased to 10.75 at $N_3$ level. Potassium also showed a similar effect by increasing the size from 9.76 cm at $K_1$, to 10.72 cm at $K_2$, and then decreased to 9.90 cm at $K_3$ levels. The other nutrient P did not show a significant change in bulb size. None of the three fertilizers showed significant effect on bulb size in the second season.

4.1.4.2 Number of bulbs

Number of bulbs per hill was significantly influenced by nitrogen application in the second season. The mean number of bulbs of the control plot was 1.95. This has been increased to 2.37 at $N_1$, to 2.78 at $N_2$ and to a maximum of 2.87 at $N_3$ level. The other two major nutrients P and K did not seem to influence this character. None of the interactions were significant.

Table 9. Effect of chemical fertilizers on yield of bulbs and bulblets - Season I

| Treatments | Size of bulb (cm) | No. of bulbs per hill | Size of bulblets (cm) | No. of bulblets per hill | Weight of bulbs and bulblets per hill (g) |
|---|---|---|---|---|---|
| Control | 9.13 | 1.34 | 2.18 | 15.38 | 120.21 |
| $N_1$-10 g $m^{-2}$ | 8.52 | 1.67 | 2.72 | 16.52 | 123.30 |
| $N_2$-20 g $m^{-2}$ | 11.12 | 1.46 | 2.88 | 17.90 | 152.84 |
| $N_3$-30 g $m^{-2}$ | 10.75 | 1.48 | 2.51 | 19.93 | 144.97 |
| CD (0.05) | 0.75 | NS | NS | 1.47 | 11.82 |
| $P_1$-5 g $m^{-2}$ | 10.27 | 1.56 | 2.60 | 17.78 | 129.57 |
| $P_2$-10 g $m^{-2}$ | 10.45 | 1.60 | 2.89 | 17.77 | 141.33 |
| $P_3$-15 g $m^{-2}$ | 9.66 | 1.46 | 2.62 | 18.79 | 150.21 |
| CD (0.05) | NS | NS | NS | NS | 11.82 |
| $K_1$-5 g $m^{-2}$ | 9.76 | 1.55 | 2.91 | 17.93 | 141.93 |
| $K_2$-10 g $m^{-2}$ | 10.72 | 1.55 | 2.48 | 17.97 | 143.06 |
| $K_3$-15 g $m^{-2}$ | 9.90 | 1.52 | 2.72 | 18.45 | 136.11 |
| CD (0.05) | 0.75 | NS | NS | NS | NS |

NS – Non significant

Table 10. Effect of chemical fertilizers on yield of bulbs and bulblets - Season II

| Treatments | Size of bulb (cm) | No. of bulbs per hill | Size of bulblets (cm) | No. of bulblets per hill | Weight of bulbs and bulblets per hill (g) |
|---|---|---|---|---|---|
| Control | 8.73 | 1.95 | 2.52 | 16.73 | 140.54 |
| $N_1$-10 g $m^{-2}$ | 9.29 | 2.37 | 3.55 | 18.15 | 157.46 |
| $N_2$-20 g $m^{-2}$ | 10.04 | 2.78 | 3.65 | 19.69 | 174.14 |
| $N_3$-30 g $m^{-2}$ | 9.34 | 2.87 | 3.83 | 19.50 | 172.79 |
| CD (0.05) | NS | 0.35 | NS | NS | NS |
| $P_1$-5 g $m^{-2}$ | 9.44 | 2.63 | 3.37 | 20.05 | 169.50 |
| $P_2$-10 g $m^{-2}$ | 9.89 | 2.79 | 3.59 | 18.87 | 175.43 |
| $P_3$-15 g $m^{-2}$ | 9.34 | 2.61 | 4.07 | 18.40 | 159.47 |
| CD (0.05) | NS | NS | NS | NS | NS |
| $K_1$-5 g $m^{-2}$ | 9.73 | 2.71 | 3.48 | 18.75 | 185.18 |
| $K_2$-10 g $m^{-2}$ | 9.76 | 2.73 | 3.27 | 18.72 | 167.56 |
| $K_3$-15 g $m^{-2}$ | 9.19 | 2.59 | 4.20 | 19.86 | 151.65 |
| CD (0.05) | NS | NS | NS | NS | NS |

NS – Non significant

4.1.4.3 Size of bulblets

In both the seasons, the application of graded levels of nitrogen, phosphorus or potassium did not show any significant difference on the size of the bulblets. Also none of the interactions were significant.

4.1.4.4 Number of bulblets

Application of higher doses of nitrogen, significantly influenced the number of bulblets per hill, during the first season. The mean number of bulblets per plant receiving no fertilizer was 15.38. Nitrogen application increased the number of bulblets to 16.52 at $N_1$, to 17.90 at $N_2$ and to a maximum 19.93 cm at $N_3$ levels. Other two nutrients P and K did not show any significant effect on this character. All the three nutrients did not seem to influence the bulblet number in the second season.

4.1.4.5 Weight of bulbs and bulblets per hill

Nitrogen and phosphorus application significantly influenced the weight of bulbs and bulblets per hill. The mean tuber weight of the plants receiving no fertilizers was 120.21 g. The weight of the tubers increased to 123.30 g at $N_1$, to a maximum of 152.84 g at $N_2$ and then declined to 144.97 at $N_3$ level. By the application of phosphorus, tuber weight increased to 129.57 g at $P_1$, to 141.33 g at $P_2$ to a maximum of 150.21 g at $P_3$ level. Potassium did not show any significant difference in the weight of tuber. During the second season, N, P or K did not seem to influence this character. None of the interactions were found to be significant.

4.1.5 Major nutrient composition of the leaves

Tables 11 and 12 represent the mean values of nitrogen, phosphorus and potassium concentrations of the leaves at vegetative, flowering and post flowering

Table 11. Effect of chemical fertilizers on nutrient composition (%) of the leaves - Season I

| Treatments | Nitrogen (%) | | | Phosphorus (%) | | | Potassium (%) | | |
|---|---|---|---|---|---|---|---|---|---|
| | I | II | III | I | II | III | I | II | III |
| Control | 2.99 | 2.69 | 2.57 | 0.17(0.04) | 0.26(0.08) | 0.32(0.09) | 0.254 | 0.210 | 0.160 |
| $N_1$-10 g $m^{-2}$ | 2.85 | 3.13 | 3.15 | 0.35(0.16) | 0.27(0.08) | 0.39(0.12) | 0.243 | 0.239 | 0.215 |
| $N_2$-20 g $m^{-2}$ | 3.73 | 3.46 | 3.49 | 0.23(0.06) | 0.30(0.08) | 0.31(0.12) | 0.272 | 0.173 | 0.159 |
| $N_3$-30 g $m^{-2}$ | 3.91 | 3.60 | 3.24 | 0.26(0.08) | 0.29(0.07) | 0.33(0.11) | 0.244 | 0.209 | 0.204 |
| CD(0.05) | 0.21 | 0.15 | 0.14 | 0.06 | NS | NS | 0.014 | 0.030 | 0.030 |
| $P_1$-5 g $m^{-2}$ | 3.50 | 3.56 | 3.29 | 0.29(0.11) | 0.26(0.07) | 0.33(0.11) | 0.235 | 0.208 | 0.192 |
| $P_2$-10 g $m^{-2}$ | 3.57 | 3.46 | 3.31 | 0.27(0.10) | 0.28(0.08) | 0.34(0.12) | 0.280 | 0.234 | 0.191 |
| $P_3$-15 g $m^{-2}$ | 3.43 | 3.17 | 3.27 | 0.28(0.10) | 0.31(0.10) | 0.35(0.13) | 0.246 | 0.178 | 0.195 |
| CD(0.05) | 0.21 | 0.15 | NS | NS | NS | NS | 0.014 | 0.030 | NS |
| $K_1$-5 g $m^{-2}$ | 3.48 | 3.40 | 3.27 | 0.30(0.12) | 0.29(0.09) | 0.35(0.13) | 0.242 | 0.192 | 0.174 |
| $K_2$-10 g $m^{-2}$ | 3.60 | 3.37 | 3.25 | 0.26(0.08) | 0.28(0.08) | 0.32(0.11) | 0.242 | 0.225 | 0.200 |
| $K_3$-15 g $m^{-2}$ | 3.41 | 3.42 | 3.35 | 0.28(0.10) | 0.28(0.08) | 0.34(0.12) | 0.276 | 0.203 | 0.203 |
| CD(0.05) | 0.21 | NS | NS | NS | NS | NS | 0.014 | NS | NS |

NS – Non significant
Original value in paranthesis

Table 12. Effect of chemical fertilizers on nutrient composition (%) of the leaves - Season II

| Treatments | Nitrogen (%) | | | Phosphorus (%) | | | Potassium (%) | | |
|---|---|---|---|---|---|---|---|---|---|
| | I | II | III | I | II | III | I | II | III |
| Control | 3.27 | 2.53 | 2.56 | 0.180(0.03) | 0.270(0.07) | 0.330(0.11) | 0.260 | 0.190 | 0.150 |
| $N_1$-10 g $m^{-2}$ | 3.72 | 2.85 | 3.14 | 0.352(0.16) | 0.266(0.07) | 0.344(0.13) | 0.245 | 0.240 | 0.215 |
| $N_2$-20 g $m^{-2}$ | 3.86 | 2.78 | 2.91 | 0.224(0.05) | 0.296(0.09) | 0.340(0.12) | 0.264 | 0.169 | 0.159 |
| $N_3$-30 g $m^{-2}$ | 4.19 | 2.97 | 2.99 | 0.258(0.08) | 0.289(0.09) | 0.330(0.11) | 0.244 | 0.211 | 0.206 |
| CD(0.05) | NS | NS | NS | 0.06 | NS | NS | NS | 0.060 | 0.020 |
| $P_1$-5 g $m^{-2}$ | 3.93 | 3.02 | 3.18 | 0.290(0.11) | 0.262(0.07) | 0.328(0.11) | 0.228 | 0.203 | 0.191 |
| $P_2$-10 g $m^{-2}$ | 4.03 | 2.87 | 2.94 | 0.267(0.10) | 0.277(0.08) | 0.337(0.12) | 0.278 | 0.239 | 0.191 |
| $P_3$-15 g $m^{-2}$ | 3.81 | 2.71 | 2.93 | 0.277(0.10) | 0.313(0.11) | 0.352(0.13) | 0.246 | 0.178 | 0.199 |
| CD(0.05) | NS | NS | NS | NS | NS | NS | 0.020 | 0.060 | NS |
| $K_1$-5 g $m^{-2}$ | 3.91 | 2.76 | 2.95 | 0.299(0.12) | 0.291(0.09) | 0.353(0.13) | 0.234 | 0.183 | 0.175 |
| $K_2$-10 g $m^{-2}$ | 3.98 | 2.98 | 3.07 | 0.257(0.08) | 0.282(0.09) | 0.325(0.11) | 0.240 | 0.205 | 0.198 |
| $K_3$-15 g $m^{-2}$ | 3.89 | 2.86 | 3.03 | 0.278(0.11) | 0.279(0.08) | 0.338(0.12) | 0.278 | 0.232 | 0.207 |
| CD(0.05) | NS | NS | NS | NS | NS | NS | 0.020 | 0.060 | 0.020 |

NS – Non significant
Original value in paranthesis

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stages as influenced by nutrients. The analysis of variance is furnished in Appendices XI and XII.

4.1.5.1 Nitrogen content

The nitrogen content of the leaves vary significantly with varying levels of nitrogen, phosphorus and potassium during the vegetative stage of the first season (Table 11). The mean nitrogen content of the plants from control plot was 2.99 per cent. The nitrogen content increased from 2.85 per cent at $N_1$, to 3.73 per cent at $N_2$ to a maximum of 3.91 per cent at $N_3$ level. Nitrogen content increased to 3.57 per cent at $P_2$ from 3.50 per cent at $P_1$, which however declined to 3.43 per cent at $P_3$ level. Potassium also showed similar results. NP, NK and PK interactions were significant. The content of nitrogen at the flowering stage of the first season also showed a progressive increase with increasing levels of applied nitrogen. The nitrogen content was maximum at $N_3$ level (3.6%). The content was 3.13 per cent and 3.46 per cent respectively at $N_1$ and $N_2$ levels. At the same time phosphorus application showed a negative relation in the nitrogen content. The nitrogen content decreased from 3.56 per cent at $P_1$ to 3.45 per cent at $P_2$ to a minimum of 3.17 per cent at $P_3$ level. K did not seem to influence the nitrogen content. NP, NK, NPK and $NP^2K$ interactions were significant. During the post flowering stage, only nitrogen application significantly affected the leaf nitogen content. The content increased to 3.49 per cent at $N_2$ from 3.15 per cent at $N_1$, which, however declined to 3.24 per cent at $N_3$ level. NP, NK, PK, NPK and $NP^2K$ interactions were significant. All the treated plants showed significantly higher nitrogen content than control.

The leaf nitrogen content did not vary significantly with any of the applied fertilizers during the second season. However, the treated plants gave significant increase in the leaf nitrogen content than the control during vegetative and post flowering stages. None of the interactions were found to be significant.

4.1.5.2 Phosphorus content

Application of nitrogen at the vegetative stage of both seasons significantly influenced the leaf phosphorus content. During the first season, leaf phosphorus content decreased from 0.35 per cent at $N_1$ to 0.23 per cent at $N_2$ and again slightly increased to 0.26 per cent at $N_3$ level. A similar relation was obtained in the second season also. Leaf phosphorus content reduced from 0.35 per cent at $N_1$, to 0.22 per cent at $N_2$ and slightly increased to 0.26 per cent at $N_3$ level. NP, PK, NPK interactions were significant in both the seasons. P and K did not seem to influence the phosphorus content at the vegetative stage of both seasons.

The three nutrients or their interactions did not exhibit any influence on the leaf phosphorus content during flowering and post flowering periods of both seasons.

4.1.5.3 Potassium content

All the applied nutrients gave significant difference in leaf potassium content during the vegetative stage of first season. Potassium content increased from 0.24 per cent at $N_1$, to 0.27 per cent at $N_2$ and slightly declined to 0.24 per cent at $N_3$ level. Influence of nitrogen application on leaf potassium content of vegetative stage during second season was not significant.

Leaf potassium was increased to 0.28 per cent at $P_2$, from 0.24 per cent at $P_1$ and 0.25 per cent at $P_3$ during the first season. During the second season, potassium content increased from 0.23 per cent at $P_1$ to 0.28 per cent at $P_2$ and then decreased to 0.25 per cent at $P_3$ level.

Applied potassium significantly influenced the leaf potassium on both the seasons. During the first season the leaf potassium was constant (0.24%) at $K_1$ and $K_2$ levels, which increased to 0.28 per cent at $K_3$ level. During the second

season, leaf potassium increased from 0.23 per cent at $K_1$ to 0.24 per cent at $K_2$ to a maximum of 0.28 per cent at K3 level. NK and PK interactions were significant.

During the flowering and post flowering stages, significant differences were noticed on leaf potassium with the three applied fertilizers. At flowering of first season, leaf potassium was reduced to 0.17 per cent at $N_2$ from 0.24 per cent at $N_1$ and increased to 0.21 per cent at $N_3$ level. During the second season also, leaf potassium was reduced to 0.17 per cent at $N_2$ from 0.24 per cent at $N_1$ and slightly increased to 0.21 per cent at $N_3$ level.

The leaf potassium content was found to be increased from 0.21 per cent at $P_1$ to 0.23 per cent at $P_2$ then reduced to 0.18 per cent at $P_3$ level during the first season. A similar result was obtained in the next season also. Potassium content was 0.20, 0.24 and 0.18 per cent respectively at $P_1$, $P_2$ and $P_3$ levels.

Application of potassium influenced leaf potassium content during flowering in second season only. Here potassium content increased from 0.18 per cent at $K_1$ to 0.21 per cent at $K_2$ to a maximum of 0.23 per cent at $K_3$.

During the post flowering stage, a differential response on leaf potassium was found with the applied nutrients. Nitrogen on both season significantly influenced leaf potassium. During the first season, potassium content reduced from 0.22 per cent at $N_1$, to 0.16 per cent at $N_2$ and increased to 0.20 per cent at $N_3$ level. During the second season, potassium contents were 0.22 per cent, 0.16 per cent and 0.21 per cent respectively at $N_1$, $N_2$ and $N_3$ levels.

Application of phosphorus did not seem to influence the leaf potassium at this stage, in both the seasons.

Applied potassium, significantly influenced the leaf potassium during the second season only. Here a steady increase of leaf potassium with applied

potassium was seen. Leaf potassium content were 0.18 per cent, 0.20 per cent and 0.21 per cent respectively at $K_1$, $K_2$ and $K_3$ levels.

## 4.2 Effect of bioregulators

Studies were also conducted to examine the effect of different bioregulators on spike qualities of tuberose in two seasons. Four bioregulators, viz., IAA, GA, BA and ethrel each at two levels were used. The results of the experiment are presented below.

### 4.2.1 Morphological characters of the plant

#### 4.2.1.1 Plant height

During the first season, the influence of bioregulators on plant height was significant at four months (Table 13). $T_4$ (GA 100 ppm) was found to be the maximum in all the four months which was on par with $T_3$ (GA 50 ppm) in the first and fourth months. $T_5$ (BA 50 ppm) recorded the least height in all the four months. Fig. 9

During the second season, $T_2$ (IAA 50 ppm) was the best in third month which was on par with $T_3$ (GA 50 ppm) and $T_1$ (IAA 25 ppm). In the fourth month $T_1$ (IAA 25 ppm) gave the best height and was on par with $T_2$ (IAA 50 ppm). Here also BA at both levels gave the least plant height (Table 14).

#### 4.2.1.2 Number of leaves

Ethrel gave the best results in the number of leaves on both seasons. During the first season, $T_8$ (Ethrel 100 ppm) gave the highest number of leaves, in first month, whereas $T_4$ (GA 100 ppm) was the best in third and fourth months, which was on par with $T_8$ (Ethrel 100 ppm) and $T_7$ (Ethrel 50 ppm).

Table 13. Effect of bioregulators on morphological characters - Season I

| Treatments | Plant height (cm) | | | | Number of leaves | | | |
|---|---|---|---|---|---|---|---|---|
| | I | II | III | IV | I | II | III | IV |
| $T_1$ - IAA 25 ppm | 26.43 | 46.87 | 61.47 $^{b}$ | 72.13 $^{b}$ | 11.98 | 15.83 $^{bc}$ | 21.33 | 25.00 $^{bcd}$ |
| $T_2$ - IAA 50 ppm | 25.63 | 47.20 | 62.23 $^{b}$ | 70.67 $^{b}$ | 11.37 | 15.93 $^{bc}$ | 21.10 | 24.70 $^{cd}$ |
| $T_3$ - GA 50 ppm | 30.50 | 48.60 | 67.00 $^{ab}$ | 78.77 $^{a}$ | 13.77 | 18.87 $^{ab}$ | 23.43 | 26.63 $^{abc}$ |
| $T_4$ - GA 100 ppm | 32.63 | 49.20 | 69.80 $^{a}$ | 82.47 $^{a}$ | 13.86 | 20.83 $^{a}$ | 23.21 | 29.40 $^{a}$ |
| $T_5$ - BA 50 ppm | 27.97 | 35.60 | 42.47 $^{c}$ | 51.90 $^{c}$ | 13.43 | 17.53 $^{abc}$ | 21.90 | 25.63 $^{abcd}$ |
| $T_6$ - BA 100 ppm | 19.17 | 32.90 | 44.47 $^{c}$ | 55.23 $^{c}$ | 10.87 | 15.65 $^{c}$ | 18.97 | 21.90 $^{d}$ |
| $T_7$ - Ethrel 50 ppm | 20.83 | 33.60 | 46.13 $^{c}$ | 54.77 $^{c}$ | 15.40 | 19.93 $^{a}$ | 23.81 | 29.03 $^{a}$ |
| $T_8$ - Ethrel 100 ppm | 20.93 | 35.00 | 45.27 $^{c}$ | 55.63 $^{c}$ | 16.37 | 20.43 $^{a}$ | 24.21 | 28.70 $^{ab}$ |
| $T_9$ - Control | 21.13 | 34.43 | 43.17 $^{c}$ | 53.40 $^{c}$ | 14.40 | 17.43 $^{abc}$ | 22.23 | 24.63 $^{cd}$ |

Treatment means having similar alphabets in superscript do not differ significantly

Table 14. Effect of bioregulators on morphological characters - Season II

| Treatments | Plant height (cm) | | | | Number of leaves | | | |
|---|---|---|---|---|---|---|---|---|
| | I | II | III | IV | I | II | III | IV |
| $T_1$ - IAA 25 ppm | 34.40 | 58.70 | 66.55$^{a}$ | 83.75$^{a}$ | 14.80$^{d}$ | 18.45$^{d}$ | 24.03$^{d}$ | 28.77$^{c}$ |
| $T_2$ - IAA 50 ppm | 35.85 | 55.50 | 66.96$^{a}$ | 83.45$^{a}$ | 15.90$^{cd}$ | 19.95$^{cd}$ | 25.84$^{cd}$ | 29.90$^{c}$ |
| $T_3$ - GA 50 ppm | 31.98 | 54.30 | 65.50$^{a}$ | 81.85$^{ab}$ | 15.83$^{cd}$ | 22.47$^{abc}$ | 26.77$^{cd}$ | 30.10$^{c}$ |
| $T_4$ - GA 100 ppm | 33.35 | 44.85 | 61.85$^{ab}$ | 76.40$^{abc}$ | 19.47$^{ab}$ | 24.37$^{ab}$ | 30.65$^{ab}$ | 35.44$^{ab}$ |
| $T_5$ - BA 50 ppm | 24.63 | 35.85 | 52.75$^{bc}$ | 63.65$^{d}$ | 17.55$^{abcd}$ | 21.94$^{bc}$ | 25.30$^{cd}$ | 31.43$^{bc}$ |
| $T_6$ - BA 100 ppm | 31.70 | 35.00 | 45.40$^{c}$ | 69.05$^{cd}$ | 17.94$^{abc}$ | 22.53$^{abc}$ | 28.40$^{bc}$ | 32.37$^{abc}$ |
| $T_7$ - Ethrel 50 ppm | 27.22 | 42.41 | 55.40$^{abc}$ | 72.80$^{bc}$ | 20.20$^{a}$ | 25.55$^{a}$ | 32.12$^{a}$ | 36.13$^{a}$ |
| $T_8$ - Ethrel 100 ppm | 32.15 | 46.25 | 62.15$^{ab}$ | 79.80$^{ab}$ | 17.17$^{bcd}$ | 20.44$^{cd}$ | 25.22$^{cd}$ | 31.50$^{bc}$ |
| $T_9$ - Control | 29.15 | 44.25 | 58.20$^{ab}$ | 75.45$^{abc}$ | 16.03$^{cd}$ | 21.47$^{bcd}$ | 26.01$^{cd}$ | 29.87$^{c}$ |

Treatment means having similar alphabets in superscript do not differ significantly

Fig . 9 Effect of bioregulators on plant height

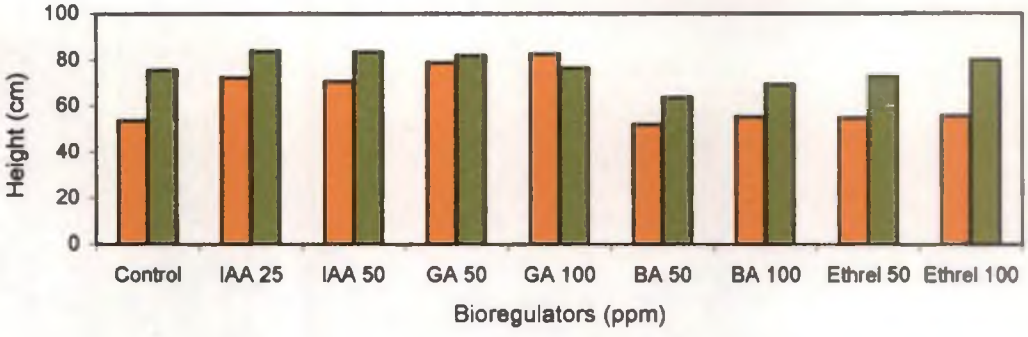



Fig . 10 Effect of bioregulators on days to spike emergence

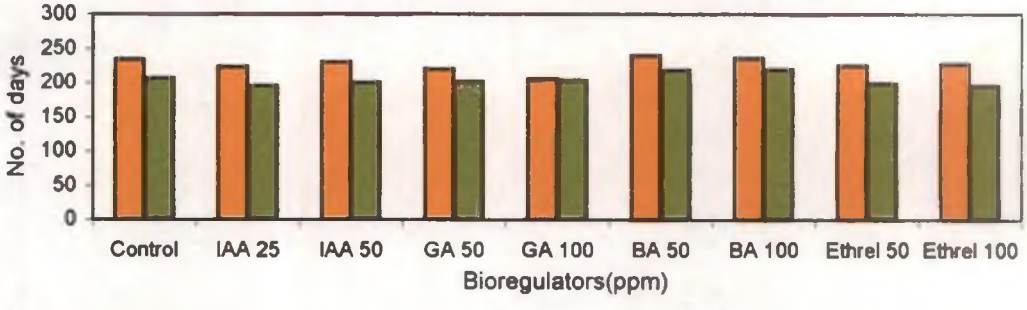
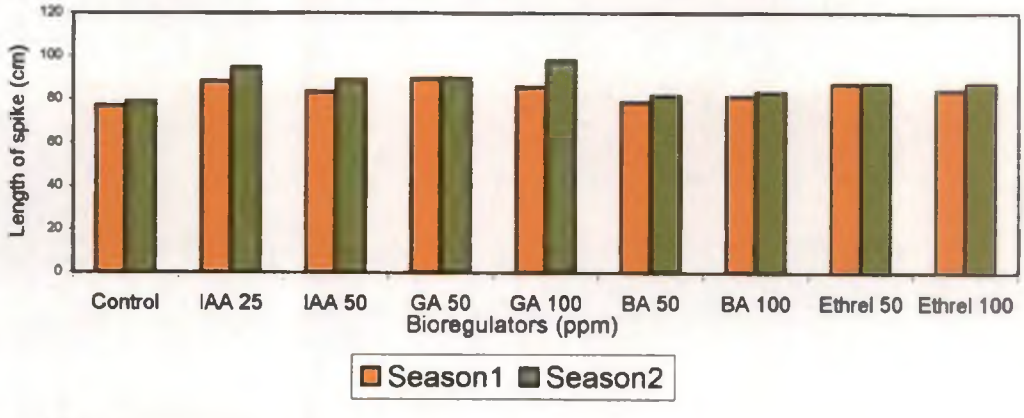



Fig. 11 Effect of bioregulators on length of spike



During the second season, $T_7$ (Ethrel 50 ppm) gave the best result in the number of leaves, and was closely followed by $T_4$ (GA 100 ppm) in all the four months. $T_1$ (IAA 25 ppm) gave the least number of leaves.

4.2.1.3 Plant spread

$T_3$ (GA 50 ppm) was found to give the widest plant spread in almost all months, which was on par with $T_7$ (Ethrel 50 ppm), $T_2$ (IAA 50 ppm) and $T_8$ (Ethrel 100 ppm) (Table 15). $T_5$ (BA 50 ppm) and $T_6$ (BA 100 ppm) gave the least plant spread during the first season.

The response to bioregulators were different during the second season, as $T_9$ (control) gave the best spread in the first month. $T_2$ (IAA 50 ppm) and $T_4$ (GA 100 ppm) gave the best results in rest of the months. $T_8$ (Ethrel 100 ppm) gave the least plant spread (Table 16).

4.2.1.4 Number of tillers

Number of tillers was significantly influenced by different bioregulators during the first season. But significant differences were not found in the second season. $T_3$ (GA 50 ppm) gave the maximum number of tillers in all the four months. Which was closely followed by $T_4$ (GA 100 ppm) and $T_8$ (Ethrel 100 ppm).

Different treatments did not significantly influence this character during the second season.

4.2.2 Floral characters

4.2.2.1 Days to spike emergence

$T_5$ (BA 50 ppm) and $T_6$ (BA 100 ppm) took the maximum days for first spike to emerge in both the seasons (Table 17). Whereas $T_4$ (GA 100 ppm) took

Table 15. Effect of bioregulators on morphological characters - Season I

| Treatments | Plant spread (cm) | | | | | | | | No. of tillers | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | I | | II | | III | | IV | | I | II | III | IV |
| | EW | NS | EW | NS | EW | NS | EW | NS | | | | |
| $T_1$ - IAA 25 ppm | 22.53 $^{abc}$ | 23.43 $^{abcde}$ | 45.00 $^{ab}$ | 46.77 $^{abc}$ | 60.00 $^{a}$ | 60.67 $^{abc}$ | 69.77 $^{a}$ | 70.70 $^{ab}$ | 1.70 $^{abc}$ | 2.40 $^{b}$ | 3.87 $^{ab}$ | 4.43 $^{b}$ |
| $T_2$ - IAA 50 ppm | 25.33 $^{a}$ | 22.23 $^{bcde}$ | 48.50 $^{a}$ | 44.20 $^{bc}$ | 55.63 $^{a}$ | 50.33 $^{bcd}$ | 61.00 $^{ab}$ | 57.30 $^{c}$ | 1.50 $^{c}$ | 2.23 $^{b}$ | 3.17 $^{b}$ | 3.83 $^{b}$ |
| $T_3$ - GA 50 ppm | 27.40 $^{a}$ | 27.70 $^{a}$ | 50.57 $^{a}$ | 51.77 $^{ab}$ | 61.90 $^{a}$ | 61.03 $^{abc}$ | 70.87 $^{a}$ | 72.00 $^{a}$ | 2.10 $^{a}$ | 3.67 $^{a}$ | 6.37 $^{a}$ | 6.90 $^{a}$ |
| $T_4$ - GA 100 ppm | 18.00 $^{c}$ | 26.20 $^{ab}$ | 35.97 $^{bc}$ | 39.97 $^{c}$ | 49.33 $^{ab}$ | 48.80 $^{cde}$ | 58.77 $^{ab}$ | 61.27 $^{bc}$ | 2.00 $^{ab}$ | 3.03 $^{ab}$ | 5.00 $^{ab}$ | 5.83 $^{ab}$ |
| $T_5$ - BA 50 ppm | 19.53 $^{bc}$ | 19.60 $^{de}$ | 29.80 $^{c}$ | 28.80 $^{d}$ | 37.43 $^{b}$ | 36.30 $^{e}$ | 46.70 $^{c}$ | 45.83 $^{d}$ | 1.63 $^{bc}$ | 2.30 $^{b}$ | 2.73 $^{b}$ | 3.37 $^{b}$ |
| $T_6$ - BA 100 ppm | 17.87 $^{c}$ | 18.57 $^{e}$ | 29.33 $^{c}$ | 29.19 $^{d}$ | 38.87 $^{b}$ | 40.83 $^{de}$ | 49.10 $^{bc}$ | 50.90 $^{cd}$ | 1.63 $^{bc}$ | 2.33 $^{b}$ | 3.27 $^{b}$ | 3.80 $^{b}$ |
| $T_7$ - Ethrel 50 ppm | 26.47 $^{a}$ | 23.73 $^{abcd}$ | 45.83 $^{ab}$ | 48.17 $^{abc}$ | 62.27 $^{a}$ | 63.07 $^{ab}$ | 67.07 $^{a}$ | 72.50 $^{a}$ | 1.83 $^{abc}$ | 2.33 $^{b}$ | 3.63 $^{b}$ | 4.20 $^{b}$ |
| $T_8$ - Ethrel 100 ppm | 24.40 $^{ab}$ | 24.97 $^{abc}$ | 50.93 $^{a}$ | 54.40 $^{a}$ | 59.70 $^{a}$ | 64.13 $^{a}$ | 68.37 $^{a}$ | 72.37 $^{a}$ | 2.03 $^{a}$ | 2.90 $^{ab}$ | 3.93 $^{b}$ | 5.07 $^{ab}$ |
| $T_9$ - Control | 18.47 $^{c}$ | 20.13 $^{cde}$ | 41.93 $^{ab}$ | 45.10 $^{abc}$ | 53.00 $^{a}$ | 52.00 $^{abcd}$ | 59.57 $^{ab}$ | 60.67 $^{bc}$ | 1.60 $^{bc}$ | 2.03 $^{b}$ | 2.93 $^{b}$ | 3.70 $^{b}$ |

Treatment means having similar alphabets in superscript do not differ significantly

EW – East West, NS –North South

Table 16. Effect of bioregulators on morphological characters - Season II

| Treatments | Plant spread (cm) | | | | | | | | No. of tillers | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | I | | II | | III | | IV | | I | II | III | IV |
| | EW | NS | EW | NS | EW | NS | EW | NS | | | | |
| $T_1$ - IAA 25 ppm | 33.45$^{a}$ | 28.38$^{abc}$ | 46.55$^{a}$ | 45.50 | 57.15$^{abc}$ | 62.05$^{ab}$ | 71.35$^{abc}$ | 76.90 | 2.07 | 2.50 | 3.90 | 4.70 |
| $T_2$ - IAA 50 ppm | 25.22$^{bc}$ | 29.30$^{abc}$ | 40.75$^{abc}$ | 44.45 | 63.47$^{a}$ | 67.50$^{a}$ | 78.25$^{ab}$ | 82.85 | 1.78 | 2.17 | 3.23 | 4.37 |
| $T_3$ - GA 50 ppm | 28.81$^{abc}$ | 27.85$^{abc}$ | 40.92$^{abc}$ | 40.55 | 58.95$^{abc}$ | 63.00$^{ab}$ | 74.38$^{abc}$ | 79.50 | 1.93 | 2.67 | 3.60 | 4.60 |
| $T_4$ - GA 100 ppm | 26.66$^{bc}$ | 29.00$^{abc}$ | 43.40$^{ab}$ | 45.45 | 61.10$^{ab}$ | 63.85$^{ab}$ | 80.50$^{a}$ | 85.08 | 1.97 | 2.73 | 2.33 | 4.73 |
| $T_5$ - BA 50 ppm | 18.04$^{d}$ | 21.42$^{d}$ | 35.50$^{bc}$ | 37.45 | 52.80$^{cd}$ | 50.25$^{c}$ | 65.65$^{c}$ | 67.55 | 1.57 | 2.83 | 3.57 | 4.33 |
| $T_6$ - BA 100 ppm | 23.52$^{cd}$ | 23.58$^{cd}$ | 39.50$^{abc}$ | 41.20 | 51.30$^{cd}$ | 54.90$^{bc}$ | 68.10$^{bc}$ | 77.20 | 1.63 | 2.50 | 3.40 | 3.97 |
| $T_7$ - Ethrel 50 ppm | 26.90$^{bc}$ | 29.75$^{ab}$ | 39.55$^{abc}$ | 45.95 | 53.90$^{bcd}$ | 62.25$^{ab}$ | 69.35$^{abc}$ | 84.85 | 1.87 | 2.63 | 3.37 | 4.13 |
| $T_8$ - Ethrel 100 ppm | 23.63$^{cd}$ | 25.25$^{bcd}$ | 34.75$^{c}$ | 37.40 | 49.05$^{d}$ | 51.05$^{c}$ | 63.77$^{c}$ | 72.55 | 1.67 | 2.40 | 3.43 | 4.10 |
| $T_9$. Control | 30.45$^{ab}$ | 32.50$^{a}$ | 43.20$^{abc}$ | 45.10 | 58.80$^{abc}$ | 56.85$^{abc}$ | 77.20$^{ab}$ | 79.85 | 1.37 | 2.30 | 2.76 | 3.53 |

Treatment means having similar alphabets in superscript do not differ significantly

EW – East West, NS –North South

Table 17. Effect of bioregulators on floral characters - Season I

| Treatments | Days to first spike emergence | Days to first floret opening | Days for complete opening of florets | Length of spike (cm) | Length of rachis (cm) | Number of florets per spike | Size of a floret (cm) | Longevity of a floret (days) | Longevity of a spike in field (days) | Duration of crop (days) | No. of spikes per hill |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $T_1$ - IAA 25 ppm | 223.97 $^{bc}$ | 26.44 | 24.48 | 88.65 $^{a}$ | 33.40 $^{a}$ | 37.23 $^{ab}$ | 3.76 $^{b}$ | 2.03 $^{c}$ | 50.90 | 274.87 $^{bc}$ | 1.07 |
| $T_2$ - IAA 50 ppm | 230.91 $^{abc}$ | 30.38 | 17.09 | 83.70 $^{bc}$ | 27.85 $^{b}$ | 38.64 $^{a}$ | 3.32 $^{c}$ | 2.42 $^{bc}$ | 47.47 | 281.71 $^{ab}$ | 1.07 |
| $T_3$ - GA 50 ppm | 220.22 $^{c}$ | 26.46 | 16.33 | 89.48 $^{a}$ | 33.40 $^{a}$ | 35.63 $^{ab}$ | 4.51 $^{a}$ | 3.07 $^{ab}$ | 42.78 | 263.00 $^{c}$ | 1.00 |
| $T_4$ - GA 100 ppm | 205.74 $^{d}$ | 34.49 | 21.02 | 85.70 $^{abc}$ | 26.16 $^{bc}$ | 40.41 $^{a}$ | 4.06 $^{b}$ | 3.55 $^{a}$ | 55.51 | 271.02 $^{bc}$ | 1.20 |
| $T_5$ - BA 50 ppm | 240.47 $^{a}$ | 24.98 | 21.75 | 78.85 $^{de}$ | 23.35 $^{bc}$ | 31.94 $^{bc}$ | 3.89 $^{b}$ | 2.64 $^{bc}$ | 46.73 | 283.96 $^{ab}$ | 1.13 |
| $T_6$ - BA 100 ppm | 236.17 $^{ab}$ | 33.02 | 23.92 | 81.70 $^{cd}$ | 25.35 $^{bc}$ | 34.41 $^{abc}$ | 3.00 $^{cd}$ | 2.12 $^{c}$ | 56.94 | 293.11 $^{a}$ | 1.00 |
| $T_7$ - Ethrel 50 ppm | 225.47 $^{bc}$ | 23.30 | 20.79 | 87.05 $^{ab}$ | 27.35 $^{bc}$ | 39.49 $^{a}$ | 3.20 $^{cd}$ | 3.12 $^{ab}$ | 44.09 | 269.55 $^{bc}$ | 1.02 |
| $T_8$ - Ethrel 100 ppm | 227.57 $^{abc}$ | 28.34 | 24.02 | 84.25 $^{bc}$ | 25.35 $^{bc}$ | 34.47 $^{abc}$ | 3.20 $^{cd}$ | 2.12 $^{c}$ | 52.33 | 279.90 $^{abc}$ | 1.10 |
| $T_9$ - Control | 234.53 $^{abc}$ | 34.15 | 23.35 | 77.20 $^{e}$ | 23.20 $^{c}$ | 29.57 $^{c}$ | 2.89 $^{d}$ | 2.64 $^{bc}$ | 57.50 | 295.36 $^{a}$ | 1.17 |

Treatment means having similar alphabets in superscript do not differ significantly

the minimum days (205.7 days) for first spike emergence in first season, and $T_1$ (IAA 25 ppm) was best in season II (195.7 days). Fig. 10

4.2.2.2 Days to first floret opening

Days for first floret opening was significantly influenced by bioregulators in the second season (Table 18). $T_4$ (GA 100 ppm) took the minimum days for the first floret opening (23.84 days). Where as the control plants took the maximum days (35.58 days).

4.2.2.3 Days to complete opening of florets

None of the treatments significantly influenced days to complete opening of florets during both seasons.

4.2.2.4 Length of spike

$T_3$ (GA 50 ppm) and $T_4$ (GA 100 ppm) gave the longest spikes (89.48 cm and 97.93 cm respectively) in the first and second seasons. This was on par with $T_1$ (IAA 25 ppm). Fig. 11

4.2.2.5 Length of rachis

$T_1$ (IAA 25 ppm) gave the longest rachis during the first season (33.40 cm), which was on par with $T_3$ (GA 50 ppm).

4.2.2.6 Number of florets per spike

$T_4$ ($GA_3$ 100 ppm) gave the maximum floret number (40.41) which was on par with $T_7$ (ethrel 50 ppm) and $T_2$ (IAA 50 ppm) during the first season. In the second season, $T_1$ (IAA 25 ppm) gave the maximum number (39.33) which was on par with $T_8$ (ethrel 100 ppm) and $T_4$ (GA 100 ppm). Fig. 12

Table 18. Effect of bioregulators on floral characters - Season II

| Treatments | Days to first spike emergence | Days to first floret opening | Days for complete opening of florets | Length of spike (cm) | Length of rachis (cm) | Number of florets per spike | Size of a floret (cm) | Longevity of a floret (days) | Longevity of a spike in field (days) | Duration of crop (days) | No. of spikes per hill |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $T_1$ - IAA 25 ppm | 195.74 $^{c}$ | 26.54 $^{bc}$ | 19.90 | 94.78 $^{ab}$ | 29.19 | 39.33 $^{a}$ | 4.01 $^{a}$ | 2.11 $^{de}$ | 46.44 $^{bc}$ | 242.18 $^{c}$ | 1.23 |
| $T_2$ - IAA 50 ppm | 201.17 $^{bc}$ | 32.29 $^{ab}$ | 21.08 | 89.11 $^{abc}$ | 27.33 | 34.89 $^{ab}$ | 3.88 $^{a}$ | 2.17 $^{de}$ | 53.37 $^{abc}$ | 257.99 $^{ab}$ | 1.00 |
| $T_3$ - GA 50 ppm | 202.50 $^{bc}$ | 29.70 $^{abc}$ | 18.35 | 89.76 $^{abc}$ | 26.33 | 35.45 $^{ab}$ | 4.21 $^{a}$ | 3.00 $^{ab}$ | 48.05 $^{abc}$ | 250.55 $^{bc}$ | 1.67 |
| $T_4$ - GA 100 ppm | 203.88 $^{bc}$ | 23.87 $^{c}$ | 22.90 | 97.93 $^{a}$ | 28.01 | 38.31 $^{a}$ | 3.16 $^{b}$ | 3.44 $^{a}$ | 46.77 $^{bc}$ | 250.65 $^{bc}$ | 1.00 |
| $T_5$ - BA 50 ppm | 218.84 $^{a}$ | 26.56 $^{bc}$ | 15.52 | 81.91 $^{c}$ | 22.44 | 30.44 $^{ab}$ | 3.01 $^{b}$ | 1.94 $^{e}$ | 42.08 $^{c}$ | 260.93 $^{ab}$ | 1.00 |
| $T_6$ - BA 100 ppm | 219.37 $^{a}$ | 29.47 $^{abc}$ | 14.28 | 83.38 $^{bc}$ | 23.18 | 32.44 $^{ab}$ | 3.05 $^{b}$ | 2.52 $^{bcd}$ | 43.74 $^{c}$ | 265.65 $^{a}$ | 1.00 |
| $T_7$ - Ethrel 50 ppm | 199.58 $^{bc}$ | 31.72 $^{ab}$ | 26.24 | 87.65 $^{abc}$ | 27.83 | 34.22 $^{ab}$ | 3.73 $^{a}$ | 2.73 $^{bc}$ | 57.96 $^{ab}$ | 261.68 $^{ab}$ | 1.00 |
| $T_8$ - Ethrel 100 ppm | 196.38 $^{bc}$ | 34.25 $^{a}$ | 22.18 | 87.56 $^{abc}$ | 29.78 | 39.11 $^{a}$ | 3.73 $^{a}$ | 2.63 $^{bcd}$ | 56.44 $^{ab}$ | 256.08 $^{abc}$ | 1.00 |
| $T_9$ - Control | 207.05 $^{b}$ | 35.58 $^{a}$ | 23.77 | 79.01 $^{c}$ | 24.29 | 26.21 $^{b}$ | 2.77 $^{b}$ | 2.38 $^{cde}$ | 59.36 $^{a}$ | 267.51 $^{a}$ | 1.00 |

Treatment means having similar alphabets in superscript do not differ significantly

**Fig. 12 Effect of bioregulators on number of florets**

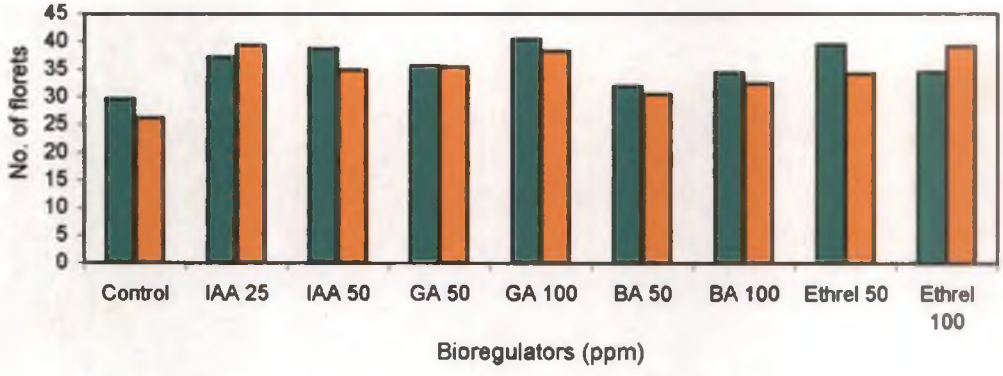



**Fig. 13 Effect of bioregulators on fresh weight of spike**

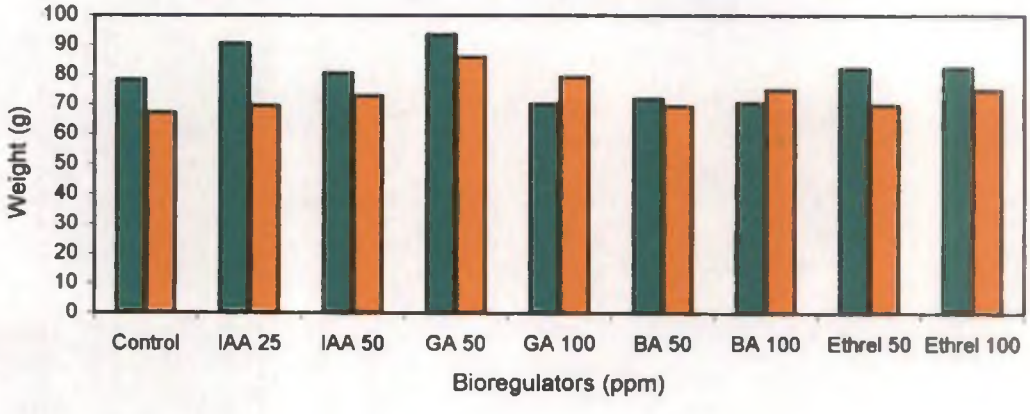
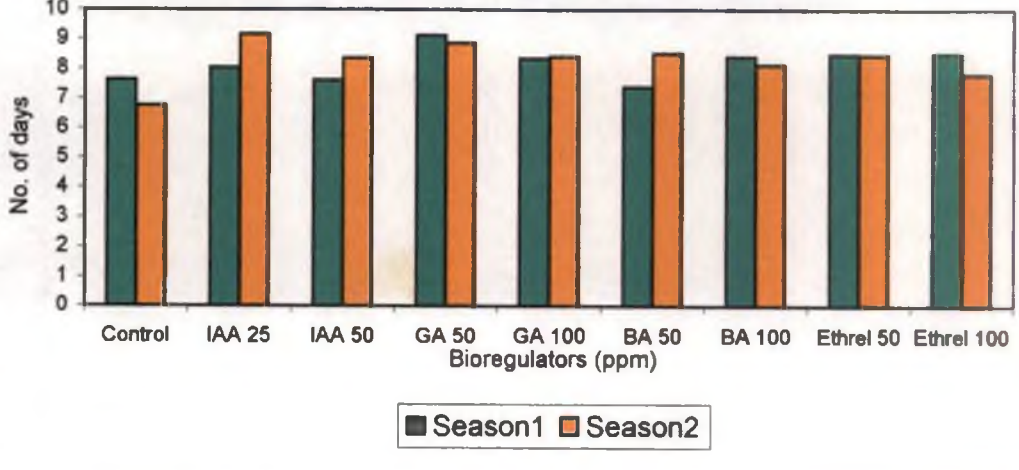



**Fig. 14 Effect of bioregulators on vase life**



4.2.2.7 Size of florets

Best results were obtained in terms of size of florets with $T_3$ (GA 50 ppm) in both the seasons (4.51 cm and 4.21 cm). This was on par with $T_1$ (IAA 25 ppm), $T_2$ (IAA 50 ppm), $T_7$ (ethrel 50 ppm) and $T_8$ (ethrel 100 ppm) during the second season.

4.2.2.8 Longevity of a floret

The maximum longevity of florets in both the seasons (3.55 days and 3.44 days respectively) were observed for $T_4$ (GA 100 ppm). This was on par with $T_3$ (GA 50 ppm).

4.2.2.9 Longevity of a spike in field

Control plants ($T_9$) gave the maximum longevity of spike in the field in both the seasons (57.50 days and 59.36 days respectively).

4.2.2.10 Crop duration

Similar results were observed with crop duration also. Control plants took maximum days (295.36 and 267.51 days respectively) from planting to flowering in both seasons.

4.2.2.11 Number of spikes per hill

The treatments did not significantly influence the yield of spikes per hill on both seasons. However, $T_3$ (GA 50 ppm) had shown an increase in spike yield, as compared to the other treatments.

4.2.3 Post harvest spike characters

4.2.3.1 Fresh weight of spike

Influence of the treatments on the fresh weight of spike was significant during both the seasons (Tables 19 and 20). $T_3$ (GA 50 ppm) was the best treatment in both the seasons (93.50 g and 86.06 g respectively). Fig. 13

4.2.3.2 Days for opening of each floret

The treatments significantly influenced the days for opening of each floret in vase (Table 19). In both the seasons, the control took maximum days for opening of florets (2.51 days and 2.50 days respectively). $T_3$ (Ga 50 ppm) and $T_4$ (GA 100 ppm) was on par with and took minimum days for opening of florets in both the seasons.

4.2.3.3 Days to complete opening of florets

Effect of treatments on the days for complete opening of florets was found to be significant during the first season (Table 19). $T_2$ (IAA 50 ppm) took maximum days for complete opening of florets in vase, where as $T_4$ (GA 100 ppm) took the minimum days. The treatments could not significantly influence these characters during the second season (Table 20).

4.2.3.4 Number of florets opened at a time

The number of florets opened at a time was significantly influenced by the bioregulators in both the seasons (Table 19 & 20). $T_3$ (GA 50 ppm) and $T_4$ (GA 100 ppm) were on par during the second season and with $T_5$ (BA 50 ppm) during the first season. $T_1$ (IAA 25 ppm) had the least number of florets opened at a time during the two seasons.

Table 19. Effect of bioregulators on post harvest spike characters - Season I

| Treatments | Fresh weight of spike (g) | Days for opening of each floret | Days for complete opening of florets | No. of florets opened at a time | Total water uptake (ml) | Vase life (days) |
|---|---|---|---|---|---|---|
| $T_1$ - IAA 25 ppm | 90.52 $^{ab}$ | 1.60 $^{cd}$ | 14.91 $^{bcd}$ | 1.95 $^{b}$ | 44.06 | 8.04 |
| $T_2$ - IAA 50 ppm | 80.56 $^{bcd}$ | 1.97 $^{bc}$ | 16.48 $^{a}$ | 2.39 $^{b}$ | 47.17 | 7.62 |
| $T_3$ - GA 50 ppm | 93.50 $^{a}$ | 1.41 $^{d}$ | 14.57 $^{cd}$ | 3.42 $^{a}$ | 45.28 | 9.12 |
| $T_4$ - GA 100 ppm | 70.15 $^{d}$ | 1.14 $^{d}$ | 13.87 $^{d}$ | 3.32 $^{a}$ | 49.18 | 8.35 |
| $T_5$ - BA 50 ppm | 72.08 $^{cd}$ | 2.20 $^{ab}$ | 14.57 $^{cd}$ | 3.27 $^{a}$ | 49.09 | 7.40 |
| $T_6$ - BA 100 ppm | 50.62 $^{d}$ | 2.17 $^{ab}$ | 15.02 $^{bcd}$ | 2.44 $^{b}$ | 50.34 | 8.42 |
| $T_7$ - Ethrel 50 ppm | 82.29 $^{bc}$ | 2.01 $^{abc}$ | 14.37 $^{d}$ | 2.19 $^{b}$ | 51.08 | 8.50 |
| $T_8$ - Ethrel 100 ppm | 82.48 $^{bc}$ | 2.50 $^{a}$ | 16.06 $^{ab}$ | 2.29 $^{b}$ | 49.84 | 8.52 |
| $T_9$. Control | 78.33 $^{cd}$ | 2.51 $^{a}$ | 15.78 $^{abc}$ | 2.17 $^{b}$ | 46.80 | 7.64 |

Treatment means having similar alphabets in superscript do not differ significantly

Table 20. Effect of bioregulators on post harvest spike characters - Season II

| Treatments | Fresh weight of spike (g) | Days for opening of each floret | Days for complete opening of florets | No. of florets opened at a time | Total water uptake (ml) | Vase life (days) |
|---|---|---|---|---|---|---|
| $T_1$ - IAA 25 ppm | 69.67 $^{c}$ | 1.99 $^{d}$ | 16.19 | 2.00 $^{e}$ | 46.30 | 9.17 $^{a}$ |
| $T_2$ - IAA 50 ppm | 73.04 $^{bc}$ | 2.22 $^{bcd}$ | 18.02 | 2.14 $^{de}$ | 45.62 | 8.36 $^{ab}$ |
| $T_3$ - GA 50 ppm | 86.06 $^{a}$ | 1.73 $^{e}$ | 15.75 | 3.60 $^{a}$ | 48.53 | 8.88 $^{ab}$ |
| $T_4$ - GA 100 ppm | 79.33 $^{ab}$ | 1.76 $^{e}$ | 14.74 | 4.04 $^{a}$ | 49.93 | 8.41 $^{ab}$ |
| $T_5$ - BA 50 ppm | 69.42 $^{c}$ | 2.26 $^{bc}$ | 14.83 | 2.57 $^{bcd}$ | 47.50 | 8.52 $^{ab}$ |
| $T_6$ - BA 100 ppm | 74.96 $^{bc}$ | 2.03 $^{cd}$ | 15.41 | 2.90 $^{b}$ | 45.90 | 8.14 $^{ab}$ |
| $T_7$ - Ethrel 50 ppm | 69.91 $^{c}$ | 2.38 $^{ab}$ | 14.56 | 2.82 $^{bc}$ | 42.21 | 8.48 $^{ab}$ |
| $T_8$ - Ethrel 100 ppm | 74.96 $^{bc}$ | 2.11 $^{cd}$ | 13.80 | 2.47 $^{bcde}$ | 44.29 | 7.83 $^{bc}$ |
| $T_9$. Control | 67.26 $^{c}$ | 2.50 $^{a}$ | 14.85 | 2.33 $^{cde}$ | 43.54 | 6.77 $^{c}$ |

Treatment means having similar alphabets in superscript do not differ significantly

4.2.3.5 Total water uptake

The influence of treatments on total water uptake by the spikes in vase was not significant on both the seasons.

4.2.3.6 Vase life

The treatments did not significantly influence the vase life during the first season (Table 19).

During the second season (Table 20). $T_1$ (IAA 25 ppm) showed maximum vase life (9.17 days) which was closely followed by $T_3$ (GA 50 ppm). $T_9$ (control) had the shortest vase life. Fig. 14

4.2.4 Yield of bulbs and bulblets

The size of the bulbs was also significantly influenced by the treatments during the second season only (Table 22). $T_5$ (BA 50 ppm) gave the maximum size of bulbs (8.76 cm) which was on par with all the other treatments except $T_9$ (control). The treatments influenced the number of bulbs significantly during the first season (Table 21). $T_4$ (GA 10 ppm) gave the maximum number of bulbs (2.82), whereas $T_7$ (ethrel 50 ppm) gave the least number of bulbs (1.09).

The treatments could not influence the number of bulbs during the second season (Table 22).

Other bulb characters viz. size of bulblets, number of bulblets and weight of bulbs per hill were not influenced significantly by the treatments in both the seasons.

Table 21. Effect of bioregulators on yield of bulbs and bulblets - Season I

| Treatments | Size of bulbs (cm) | No. of bulbs per hill | Size of bulblets (cm) | No. of bulblets per hill | Weight of bulbs and bulblets (g) |
|---|---|---|---|---|---|
| $T_1$ - IAA 25 ppm | 9.31 | 1.54 $^{bc}$ | 4.23 | 20.86 | 149.58 |
| $T_2$ - IAA 50 ppm | 8.77 | 1.52 $^{bc}$ | 3.21 | 18.90 | 142.84 |
| $T_3$ - GA 50 ppm | 8.55 | 2.04 $^{b}$ | 4.07 | 18.59 | 134.07 |
| $T_4$ - GA 100 ppm | 8.35 | 2.82 $^{a}$ | 3.62 | 21.42 | 136.26 |
| $T_5$ - BA 50 ppm | 8.32 | 1.77 $^{bc}$ | 4.19 | 18.14 | 123.24 |
| $T_6$ - BA 100 ppm | 8.42 | 1.44 $^{bc}$ | 3.63 | 18.31 | 130.63 |
| $T_7$ - Ethrel 50 ppm | 7.32 | 1.09 $^{c}$ | 3.37 | 16.62 | 131.78 |
| $T_8$ - Ethrel 100 ppm | 8.55 | 1.41 $^{bc}$ | 3.50 | 13.81 | 123.15 |
| $T_9$ - Control | 6.18 | 1.48 $^{bc}$ | 3.20 | 12.68 | 119.90 |

Treatment means having similar alphabets in superscript do not differ significantly

Table 22. Effect of bioregulators on yield of bulbs and bulblets - Season II

| Treatments | Size of bulbs (cm) | No. of bulbs per hill | Size of bulblets (cm) | No. of bulblets per hill | Weight of bulbs and bulblets per hill (g) |
|---|---|---|---|---|---|
| $T_1$ - IAA 25 ppm | 7.99 [a] | 2.32 | 4.59 | 16.11 | 163.89 |
| $T_2$ - IAA 50 ppm | 8.18 [a] | 2.50 | 4.56 | 20.56 | 172.22 |
| $T_3$ - GA 50 ppm | 8.25 [a] | 2.70 | 3.43 | 21.00 | 143.33 |
| $T_4$ - GA 100 ppm | 8.75 [a] | 2.60 | 4.22 | 15.58 | 133.94 |
| $T_5$ - BA 50 ppm | 8.76 [a] | 2.86 | 4.94 | 18.78 | 198.61 |
| $T_6$ - BA 100 ppm | 8.05 [a] | 2.90 | 4.04 | 19.43 | 157.22 |
| $T_7$ - Ethrel 50 ppm | 8.72 [a] | 2.63 | 3.93 | 18.37 | 125.00 |
| $T_8$ - Ethrel 100 ppm | 8.25 [a] | 2.88 | 3.52 | 19.34 | 180.00 |
| $T_9$ . Control | 6.35 [b] | 1.84 | 3.00 | 14.32 | 121.87 |

Treatment means having similar alphabets in superscript do not differ significantly

**Plate 3a. Effect of treatments on bulb size**







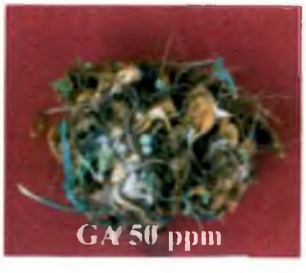
**Plate 3b. Effect of treatments on bulblet size**

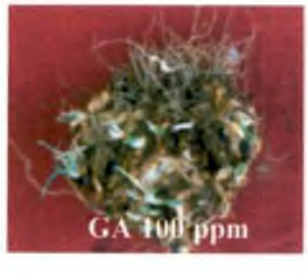






**Plate 3c. Effect of treatments on clump size**




# DISCUSSION

# DISCUSSION

Results generated from the studies conducted to examine the effect of nutrients and bioregulators on growth and flowering of tuberose are discussed hereunder.

Tuberose occupies a very special position among the ornamental bulbous plants because of its beauty, elegance and fragrance. It has good economic potential in cut flower trade and essential oil industry. The present experiment, was aimed at examining the effect of nutrients and bioregulators on spike qualities including the vase characters of tuberose. Major nutrients like nitrogen, phosphorus and potassium were emphasized and IAA, GA, BA and ethrel were the bioregulators tried.

The flowering and yield of any crop are attainment of its growth during the pre-flowering stage. In a crop like tuberose, where the cut flowers form the main consumable product, a healthy and vigorous pre-flowering period is an important contributing factor.

Though plant height need not have a direct correlation with the yield, its importance in a monocotyledonous plant lies in that the number of leaves produced by the plant is related to the stem length. But in tuberose, since the stem is beneath the soil, this does not manifest detectable difference. In fact, the height of the plant is a net result of the number of leaves produced and the length of the leaves in this crop.

From this experiment it was found that there was a general progressive increase in plant height with increasing levels of applied nitrogen in both the seasons. Nitrogen at higher level (30 g $m^{-2}$) gave the maximum plant height. All the treatments gave significant difference in plant height than control. Among the bioregulators tried, GA (100 mg $l^{-1}$) was found to be the best in increasing the plant

height, which was on par with GA 50 ppm during the first season. IAA 50 ppm gave maximum plant height during the second season which was on par with GA 50 ppm and IAA 25 ppm. BA at the two levels gave the least plant height in both the seasons. The role of GA in cell elongation is well known. Many findings have supported its role in improving growth and flowering in bulbous crops (Ramaswamy *et al.*, 1977; Bhattacharjee, 1984).

Of all the vegetative characters, the number of leaves forms the prominent factor that influence the growth and yield of a crop.

The results pertaining to the effect of different treatments on the number of leaves showed that the highest number of leaves was obtained when nitrogen was applied at 20 g $m^{-2}$. During the second month, phosphorus at 15 g $m^{-2}$ gave maximum number of leaves. However, during the second season, maximum number of leaves was obtained for nitrogen 30 g $m^{-2}$. Jana *et al.* (1974), Parthiban *et al.* (1992) and Singh (1996) also reported the role of nitrogen on the leaf number. Among the bioregulators tried, ethrel was found to be the best in improving the number of leaves, which was on par with GA 100 ppm. Choudhary (1987) also observed similar results with GA at 50-100 ppm.

The plant spread in general was not much influenced by the fertilizers applied except the east west spread in the first month and north south spread in the second month of first season. During the second season, nitrogen at 30 g $m^{-2}$ gave maximum plant spread in two months. GA at both levels gave best results with respect to the plant spread on both seasons. BA at both levels was found to give minimum spread. The number of tillers per clump was also found to be significantly influenced by the increase in nitrogen level. In general, nitrogen at the highest level (30 g $m^{-2}$) produced maximum tillers. Parthiban *et a l.* (1992) reported similar results in tuberose with higher rate of nitrogen. GA 50 ppm was found to be best in getting maximum number of tillers which was on par with GA 100 ppm and

ethrel 100 ppm. But the different treatments did not seem to influence the number of tillers during the second season.

Duration from planting to spike emergence indicates the early or delayed flowering. In the study under report, earlier flowering (218.23 days) was observed with increased levels of nitrogen during the first season. During the second season, days for spike emergence was reduced from 214.3 days at 10 g $m^{-2}$ N, to a minimum of 200.67 days at 30 g $m^{-2}$ N. The role of nitrogen in flowering was reported by many scientists. A significant reduction in the number of days required for spike emergence with applied nitrogen was reported by Gowda *et al.* (1991). Advancement in flowering with N application was also reported by Bankar and Mukhopadhyay (1990) in tuberose. GA 100 ppm caused earlier flowering in tuberose during first season, and IAA at 50 ppm caused early flowering during the second season. GA is a well known flower inducing growth regulator. The stimulating effect of Gibberellins in flower development has also been described by Ramaswamy *et al.* (1977), Jana and Biswas (1982) and Dhua *et al.* (1987).

Differential response was observed with the treatments in the case of duration from spike emergence to opening. None of the treatments under nutrient study showed significant effect on this. But compared to control, the treatment plants showed a general decrease in the duration. Treatment with GA was found to decrease the duration in the second season and BA lengthened the duration.

Significant differences were not found in the duration of flower opening on the spikes with any of the treatments.

Inflorescence characters are the most significant factors, which determine the suitability of tuberose as a cut flower. Spike length, number of florets per spike and many other characters like length and size of the floret, decide the beauty and acceptability of the spike. Florets in a spike open one after another starting from the lower most pair of florets. Thus, one particular spike may last for

a week or upto a month, depending upon the environmental conditions. This in turn is determined by the number of florets per spike and the life of individual floret.

Generally long spikes hold more number of florets, they make a bold effect in vase when used as the height and centre of a design. But increase in length makes it more susceptible to breaking/bending of the spike when placed in the vase or susceptible to lodging in the field.

Both mineral nutrients and bioregulators significantly influenced the spike length in the study. Nitrogen at 30 g $m^{-2}$ was found to produce longer spikes during first season. During second season nitrogen at 20 g $m^{-2}$ produced maximum height. Sindhu and Arora (1989) observed increased height of spikes with 20 g $m^{-2}$ nitrogen in gladiolus. Singh and Uma (1996) got similar results in tuberose also which is in conformity with the present results.

Gibberellic acid at 50 ppm and 100 ppm were found to be the best treatments during the first and second season respectively, in increasing the spike length. Bhattacharjee (1984) and Mukhopadhyay and Bankar (1987) reported the effect of GA in increasing the spike length in gladiolus and Preeti *et al.* (1997) in tuberose.

Length of rachis reflects the number of florets as well as the spacing between the florets. The arrangement of the florets on the spike may sometimes be such that hardly any gap is left, thus enhancing the beauty of the spike. In the present study, when the length of rachis, as influenced by the different treatments, was considered, nitrogen at 30 g $m^{-2}$ gave maximum length in the first season and at 20 g $m^{-2}$ in second season.

In this case also GA treatment was found to be on par with the superior ones. When taken together, GA had an edge over the other treatments in increasing the length of rachis. The findings of Bhattacharjee (1984) in gladiolus are also on

similar lines. IAA at 25 ppm and ethrel at 100 ppm also gave best results regarding the spike length.

Of all the spike characteristics, number of florets per spike is the most important factor that directly influences the beauty of the spike. Tuberose being a cut flower and loose flower, this character is of utmost importance. Nitrogen at 20 g $m^{-2}$ gave maximum number of florets during second season. During the first season a progressive increase in the number of florets per spike was noted with increasing levels of nitrogen. Many findings have supported the role of nitrogen in increasing the floret number in tuberose (Jana *et al.*, 1974; Yadav *et al.*, 1985; Bankar and Mukhopadhyay, 1990 and Gopalakrishnan *et al.*, 1995). In general, regarding the number of florets, GA treatment was found to be superior. At 100 ppm, it produced the highest number of florets in the first season. During the second season, GA was on par with the superior ones. Jana and Biswas (1979); Biswas et al. (1983); Choudhary (1987) and Preeti et al. (1997) also reported the positive influence of GA in increasing the number of florets. IAA at 25 ppm and ethrel at 100 ppm also gave best results.

Length of the floret is an important character, in that, it contributes to the size of the floret. In this case also GA was found to be the best treatment in both the seasons. Various workers have reported the effect of nutrients and bioregulators on the size of the floret (Bhattacharjee, 1984 and Dua *et al.*, 1984). However, in the present study, the nutrients could not exert any significant influence on the length and size of the florets.

The longevity of an individual floret plays an important role in determining the vase life. Regarding the longevity of individual floret, significant influence by treatments were observed in the present experiments. Nitrogen at 30 g $m^{-2}$ and phosphorus at 15 g $m^{-2}$ gave maximum longevity during the first season and nitrogen alone in the second season. GA when applied at 100 ppm gave maximum floret longevity followed by GA at 50 ppm.

The longevity of a spike in the field was not significantly influenced by the different nutrients applied in both the seasons. In the second experiment a reduction in spike longevity was noticed when BA was applied at 50 ppm, followed by BA 100 ppm.

Days from planting to the end of blooming period give the total crop duration. It was apparent from the data that nitrogen tended to decrease the duration of the crop at higher levels. Application of potassium also showed a decrease in total duration. IAA at 25 ppm gave the minimum duration in the second experiment, followed by GA 50 ppm during the second season. GA 50 ppm gave the minimum duration in first season and maximum duration was of control plants.

Either nutrients or bioregulators did not influence yield of spikes per hill.

Fresh weight of the spike indicates its size and freshness. Fresh spikes weigh more because of its high water content. When the fresh weight of spike as influenced by the different treatments was considered, a differential response was observed. Nitrogen at higher level gave maximum fresh weight during the first season. But significant effect was not noticed in the second season. GA at 50 ppm produced maximum fresh weight on both seasons.

The numbers of days required for the opening of each floret was significantly influenced both by nutrients and bioregulators. The number of days increased with increase in nitrogen. The number of days required for opening of each floret in vase was minimum at both levels of BA during the second experiment.

Significant influence regarding the days for complete opening of florets was noticed only during the first season of the second experiment. GA at 100 ppm

took minimum days for complete opening of florets. Nutrients did not influence these character much.

One important feature of the spike that contributes to the attractiveness is the number of florets that open at a time. When the number of florets opened at a time increases, the appearance of the spike also increases. This is one of the factors, which determines the quality of tuberose.

In the studies reported, nitrogen at 30 g $m^{-2}$ gave maximum number of florets opened at a time in both the seasons. The maximum number of open florets at a time was recorded by the GA treatment during the second experiment.

The rate of water loss from the spikes must be equal to the rate of water uptake inorder to maintain a favourable water balance in the spike for a longer period. This in turn influences the vase life. In the present studies it was found that both nutrients and bioregulators did not significantly influence the water uptake by spikes. But it was noted that ethrel at 50 ppm and GA at 100 ppm were superior among other treatments during the second experiment.

The long keeping quality of flower spike makes tuberose one of the most important cut flower for interior decoration. The longevity of cut flowers is associated with maintenance of fresh weight. In the present study it was observed that the vase life was significantly influenced by increased nitrogen application at 30 g $m^{-2}$ during the first season. During the second season the effect was not significant. GA treatments at both the concentrations were found to produce maximum vase life during both the seasons. Bhattacharjee (1984) has also reported the superiority of GA (10 and 100 ppm) in increasing the vase life in gladiolus.

In tuberose, the size of bulb influences the growth, development, production and quality of spikes. A differential response was exhibited in the size of the bulbs. IAA at 25 ppm gave maximum bulb size during first season which was on par with GA 50 ppm and ethrel 100 ppm. During the second season GA at

100 ppm was the best which was on par with BA at 50 ppm in increasing the bulb size.

Among the nutrients nitrogen and potassium influenced the size of the bulbs at higher rate. Many other findings have also supported its function in increasing the size of bulbs (Cirrito, 1975; Cirrito and Zizzo, 1981 and Singh *et al.*, 1996).

Number of bulbs also has shown a differential response with the treatments applied. Nitrogen at 30 g $m^{-2}$ gave maximum number of bulbs per clump during the second season. Among the bioregulators tried, GA at 100 ppm gave the best result on number of bulbs during the first season. Bankar (1988) also reported similar results in tuberose with respect to nitrogen.

Tuberose can also be propagated through bulblets. The number of bulblets produced by the bulbs varies depending upon many factors like variety, season, cultural practices etc. Either nutrients or bioregulators in the present study did not significantly influence the size of bulblet produced in a bulb. However, application of nitrogen at 30 g $m^{-2}$ significantly influenced the number of bulblets per hill during the first season. Bioregulators did not show much influence on this character. Mukhopadhyay and Bankar (1986) also reported similar results.

Weight of tubers per hill was also seen affected by the nutrients as well as the bioregulators. Superiority of nitrogen and phosphorus fertilizers was seen in this character. Nitrogen at 30 g $m^{-2}$ and phosphorus at 15 g $m^{-2}$ gave maximum weight per hill of tubers during the first season. The effect of nitrogen on bulb weight in tuberose was also reported by many workers (Cirrito, 1975; Bankar, 1988 and Singh *et al.*, 1996). Growth regulators did not seem to influence the weight of tubers significantly in both the seasons.

Chemical analysis of the leaves at three stages, viz., vegetative, flowering and post flowering, revealed that the nitrogen concentration of the leaves gave a progressive increase with increasing nitrogen application. The data showed that from $N_1$ to $N_3$ there was a steep increase in N concentration during vegetative and flowering stages of first season. During post flowering period, the N concentration increased from $N_1$ to $N_2$ and then decreased at $N_3$. During the second season, N concentration of vegetative stage showed a constant increase with increase in nitrogen application. Other stages showed a differential response.

Nitrogen concentration of the leaves varied significantly at vegetative and flowering stages of first season with increase in phosphorus application. During vegetative stage, N concentration increased from $P_1$ to $P_2$ and then decreased at $P_3$. A steep decrease in N concentration was seen with increasing phosphorus from $P_1$ to $P_3$ at the flowering stage. Leaf nitrogen concentration first increased from $K_1$ to $K_2$ and then decreased to $K_3$ with increasing levels of potassium during the vegetative stage in the first season.

Increased levels of nitrogen fertilizers first decreased leaf phosphorus from $N_1$ to $N_2$ and then increased at $N_3$ on vegetative stage of both the seasons.

Potassium content of the leaves showed a differential response with applied fertilizers. With increasing levels of nitrogen fertilizers, leaf potassium first increased from $N_1$ to $N_2$ and then decreased at $N_3$ in both the seasons. Increased levels of phosphorus fertilizers showed similar trend also. With increasing levels of applied potassium fertilizer, an increase in leaf potassium was seen in the vegetative stage of both the seasons.

During the flowering stage, the potassium content first decreased and then slightly increased with increasing nitrogen fertilizers. This was accompanied by an almost reverse trend by phosphorus application. With increasing K fertilizer, leaf K content increased progressively during second season. At the post flowering

stage also, with increasing nitrogen fertilizer, leaf potassium first decreased and then increased. At the same time with increasing K fertilizer, leaf potassium increased from $K_1$ to $K_2$ and to a maximum at $K_3$ levels.

# SUMMARY

## SUMMARY

A study was conducted at the College of Horticulture, Vellanikkara during 1997-99 to examine the effects of different nutrients and bioregulators on the growth and flowering of tuberose. Three nutrients (nitrogen, phosphorus and potassium) each at three levels and four bioregulators (IAA, GA, BA and ethrel) each at two levels were tried. The nutrient study was done in a $3^3+1$ partially confounded factorial RBD comprising 28 treatments and two replications. The bioregulators were tried in a simple RBD with three replications comprising nine treatments. The results of the study are summarised below.

There was a progressive improvement in the height of the plants by the addition of nitrogen, while phosphorus and potassium did not exhibit any effect when applied alone or in combination. Nitrogen at the highest level, 30 g $m^{-2}$ gave maximum plant height. Among the bioregulators, GA in general gave maximum plant height which was on par with IAA 50 ppm.

Significant differences were obtained in the number of leaves with 20 g $m^{-2}$ nitrogen in the first season and 30 g $m^{-2}$ in the second season. In the second experiment, ethrel (both at 50 and 100 ppm) was found to be the best in improving the number of leaves, which were on par with GA 100 ppm.

All the three nutrients and their interactions were not found to significantly influence the plant spread in general. GA at both the levels were found to give maximum spread in the two seasons, and BA gave minimum spread.

Significant differences were not observed in the number of tillers per plant with increasing levels of N, P or K. Among the bioregulators, GA 50 ppm was found best in increasing the number of tillers, which was on par with GA 100 ppm and ethrel 100 ppm.

Nitrogen application brought about early flowering in this experiment. GA 100 ppm and IAA 50 ppm caused early flowering among the bioregulators.

Application of N, P or K had no effect on the duration from spike emergence to first floret opening. Treatment with GA was found to be decreasing the duration, where as BA increased the duration.

Nitrogen at higher rates produced maximum spike length on both the seasons. The spike length was found to be unaffected by different levels of P and K. Here also GA at both levels gave maximum spike length.

The length of rachis was unaffected by P and K levels, while nitrogen increased it. During the second experiment GA treatment was on par with the superior ones. Ethrel 100 ppm and IAA 25 ppm also gave best results.

Nitrogen application modified the number of florets per spike at higher rates. GA was among the superior ones with ethrel 100 ppm and IAA 25 ppm giving maximum florets per spike.

Application of N, P or K had no effect on the size of the florets. Whereas GA was found to give bigger sized florets than other treatments.

Nitrogen and phosphorus application increased the longevity of individual florets, at higher rates, while K exhibited no such effect when applied alone. Only GA was found to increase the floret longevity among the applied bioregulators.

Application of N, P, K or growth regulators did not significantly influence the longevity of the spike in the field during both the seasons.

As evident from the duration of spike emergence, the total duration of crop was also decreased with the application of nitrogen. Application of potassium

also decreased the total duration. GA and IAA were found superior in reducing the total duration of the crop.

Either nutrients or bioregulators did not influence the yield of spikes per hill.

The application of nitrogen during the first experiment and GA during the second experiment gave significant increase in the fresh weight of the spikes.

Nitrogen at the higher rate was found to be inhibiting the floret opening in vase. The number of days required for opening of each floret in vase was minimum at both levels of GA.

Nutrients did not influence the days for complete opening of florets in vase, whereas GA at 100 ppm took minimum days for complete floret opening among the bioregulators tried.

Nitrogen and GA was found to be influencing the number of florets opened at a time, in vase.

Either nutrients or bioregulators did not significantly affect the rate of water uptake by the spikes in the vase in both the seasons.

Both nutrients and growth regulators significantly influenced the vase life. Nitrogen at a higher rate gave maximum vase life. Among the bioregulators, GA at both levels recorded the longest vase life in the present study.

Nitrogen and potassium fertilizers significantly influenced the size of the bulbs at higher rates. GA at both levels were on par with IAA 25 ppm and ethrel 100 ppm in increasing the size of bulbs.

Nitrogen among the fertilizers and GA among the bioregulators also significantly influenced the number of bulbs. There were seasonal variations on these results.

Both nutrients and bioregulators were not able to make any significant difference on the size of bulblets.

Only the application of nitrogen at higher rate produced significant increase in the number of bulblets. The application of bioregulators had no effect on the number of bulblets.

Nitrogen and phosphorus at higher rates were superior to the other treatments on the weight of tubers per hill. Nitrogen at 30 g $m^{-2}$ and phosphorus at 15 g $m^{-2}$ gave maximum tuber weight per hill. Bioregulators did not seem to influence this character.

There was a general increase in the leaf nitrogen content during vegetative, flowering and post flowering stages with increasing levels of applied nitrogen.

The nitrogen content of the leaves showed a differential response with phosphorus fertilizers. During the vegetative stage nitrogen content first increased with increase in phosphorus fertilizer and then decreased. There was a steep decrease in N concentration with increasing phosphorus fertilizer. Nitrogen fertilizer at higher concentration increased the leaf phosphorus content.

With increasing levels of nitrogen fertilizer leaf potassium first increased and later showed a slight decrease during vegetative stage. Similar results were obtained with phosphorus fertilizers also.

During the flowering stage, the potassium content first decreased and then slightly increased with increasing nitrogen fertilizer. Phosphorus application

gave a reverse trend. With increasing K fertilizer, leaf potassium increased progressively. Similar results were obtained at post flowering stage also.

Based on the fertilizer combination which gave the best results, a tentative dose of nitrogen at 30 g $m^{-2}$ and phosphorus and potassium at 5 g $m^{-2}$ was fixed.

Best results were obtained when GA at 50 ppm and 100 ppm were used as bioregulators.

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# APPENDICES

APPENDIX-I

Analysis of variance for the effect of chemical fertilizers on morphological characters - Season I

| Source of variation | df | Mean squares | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Plant height | | | | Number of leaves | | | |
| | | I | II | III | IV | I | II | III | IV |
| Total | 59 | | | | | | | | |
| Blocks | 5 | 13.21 | 34.22 | 50.82 | 69.50 | 56.75 | 90.66 | 116.06 | 115.46 |
| N | 2 | 173.01 | 524.66 | 471.26 | 851.43 | 31.58 | 40.37 | 34.24 | 27.56 |
| P | 2 | 69.61 | 63.23 | 28.15 | 31.63 | 1.77 | 1.07 | 6.05 | 10.64 |
| NP | 4 | 33.30 | 76.98 | 134.54 | 115.41 | 10.29 | 19.09 | 18.80 | 14.65 |
| K | 2 | 31.24 | 19.10 | 126.57 | 92.21 | 15.09 | 8.97 | 14.78 | 16.11 |
| NK | 4 | 18.83 | 8.61 | 31.21 | 52.18 | 31.29 | 20.44 | 23.04 | 28.01 |
| PK | 4 | 12.37 | 20.31 | 34.34 | 41.04 | 26.84 | 22.64 | 26.48 | 23.37 |
| NPK | 2 | 41.15 | 75.87 | 7.74 | 32.39 | 29.20 | 8.22 | 12.24 | 8.20 |
| $NPK^2$ | 2 | 16.88 | 80.26 | 70.60 | 33.05 | 6.07 | 21.27 | 16.38 | 12.94 |
| $NP^2K$ | 2 | 14.40 | 49.30 | 7.26 | 5.13 | 40.35 | 39.07 | 41.08 | 33.89 |
| $NP^2K^2$ | 2 | 3.63 | 0.478 | 2.23 | 20.78 | 17.00 | 32.41 | 57.39 | 57.79 |
| Control vs Rest | 1 | 0.03 | 58.34 | 81.75 | 207.57 | 33.05 | 52.70 | 68.20 | 122.41 |
| Error | 27 | 8.97 | 54.89 | 57.11 | 51.43 | 7.04 | 11.09 | 9.43 | 7.56 |

Appendix – 1b

Effect of NP interaction on plant height of first month – Season I

| Nutrient levels | $N_1$ | $N_2$ | $N_3$ |
|---|---|---|---|
| $P_1$ | 17.58 | 20.82 | 23.70 |
| $P_2$ | 24.95 | 28.80 | 23.32 |
| $P_3$ | 23.78 | 28.27 | 27.10 |
| CD(0.05) | | 6.11 | |

Appendix – 1c

Effect of NK interaction on number of leaves of first month – Season I

| Nutrient levels | $N_1$ | $N_2$ | $N_3$ |
|---|---|---|---|
| $K_1$ | 12.55 | 10.03 | 6.63 |
| $K_2$ | 12.95 | 10.23 | 13.95 |
| $K_3$ | 10.60 | 11.60 | 10.37 |
| CD(0.05) | | 2.27 | |

Appendix – 1d

Effect of PK interaction on number of leaves of first month – Season I

| Nutrient levels | $P_1$ | $P_2$ | $P_3$ |
|---|---|---|---|
| $K_1$ | 13.85 | 8.25 | 10.87 |
| $K_2$ | 10.83 | 11.57 | 11.52 |
| $K_3$ | 11.42 | 12.05 | 8.57 |
| CD(0.05) | | 2.27 | |

Appendix – 1e

Effect of NK interaction on number of leaves of fourth month – Season I

| Nutrient levels | $N_1$ | $N_2$ | $N_3$ |
|---|---|---|---|
| $K_1$ | 24.30 | 20.52 | 19.17 |
| $K_2$ | 24.92 | 21.48 | 24.98 |
| $K_3$ | 21.25 | 22.90 | 22.75 |
| CD(0.05) | | 2.09 | |

APPENDIX-II

Analysis of variance for the effect of chemical fertilizers on morphological characters - Season II

| Source of variation | df | Mean squares | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Plant height | | | | Number of leaves | | | |
| | | I | II | III | IV | I | II | III | IV |
| Total | 59 | | | | | | | | |
| Blocks | 5 | 8.52 | 27.41 | 123.21 | 65.20 | 24.27 | 20.26 | 16.35 | 10.27 |
| N | 2 | 88.78 | 236.69 | 216.57 | 151.63 | 11.53 | 31.23 | 68.51 | 70.50 |
| P | 2 | 9.91 | 39.18 | 4.92 | 50.52 | 4.23 | 4.57 | 7.76 | 7.14 |
| NP | 4 | 4.27 | 22.98 | 19.91 | 6.86 | 3.82 | 6.69 | 7.61 | 4.04 |
| K | 2 | 12.47 | 55.93 | 61.18 | 52.41 | 3.53 | 4.81 | 6.05 | 7.78 |
| NK | 4 | 11.67 | 27.25 | 31.71 | 39.07 | 16.55 | 12.72 | 12.89 | 15.64 |
| PK | 4 | 2.01 | 8.45 | 11.89 | 67.66 | 5.34 | 8.19 | 11.26 | 14.17 |
| NPK | 2 | 1.91 | 17.53 | 7.02 | 38.52 | 3.57 | 6.86 | 8.49 | 6.93 |
| $NPK^2$ | 2 | 1.97 | 10.68 | 17.82 | 44.91 | 19.20 | 6.74 | 11.02 | 7.53 |
| $NP^2K$ | 2 | 32.79 | 48.31 | 79.74 | 148.54 | 4.39 | 4.48 | 15.32 | 14.41 |
| $NP^2K^2$ | 2 | 6.55 | 9.40 | 9.88 | 51.09 | 7.40 | 5.47 | 6.94 | 2.34 |
| Control vs Rest | 1 | 11.43 | 45.65 | 52.20 | 313.75 | 12.24 | 16.54 | 24.41 | 42.28 |
| Error | 27 | 7.61 | 13.40 | 22.26 | 54.45 | 5.24 | 8.84 | 11.35 | 13.26 |

APPENDIX-III

Analysis of variance for the effect of chemical fertilizers on morphological characters - Season I

| Source of variation | df | Mean square | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Plant spread | | | | | | | | Number of tillers | | | |
| | | I | | II | | III | | IV | | I | II | III | IV |
| | | EW | NS | EW | NS | EW | NS | EW | NS | | | | |
| Total | 59 | | | | | | | | | | | | |
| Blocks | 5 | 64.83 | 6.83 | 407.54 | 83.69 | 599.46 | 175.96 | 338.59 | 69.25 | 0.112 | 1.03 | 0.31 | 5.00 |
| N | 2 | 94.59 | 34.17 | 281.06 | 289.75 | 101.45 | 151.27 | 119.69 | 107.22 | 0.0057 | 2.71 | 0.61 | 12.19 |
| P | 2 | 22.08 | 11.82 | 40.96 | 141.42 | 63.55 | 153.25 | 53.72 | 58.59 | 0.15 | 0.086 | 0.04 | 0.31 |
| NP | 4 | 27.24 | 24.12 | 163.55 | 164.04 | 108.37 | 236.17 | 106.48 | 98.10 | 0.064 | 0.56 | 0.06 | 2.45 |
| K | 2 | 0.13 | 16.46 | 18.84 | 86.37 | 0.40 | 52.03 | 2.00 | 56.11 | 0.079 | 2.73 | 0.10 | 3.92 |
| NK | 4 | 24.85 | 12.21 | 49.98 | 36.19 | 12.69 | 42.32 | 3.76 | 22.94 | 0.089 | 1.08 | 0.12 | 1.11 |
| PK | 4 | 3.26 | 18.12 | 88.25 | 84.09 | 31.42 | 96.01 | 53.88 | 56.05 | 0.039 | 0.64 | 0.03 | 1.19 |
| NPK | 2 | 4.01 | 11.67 | 43.43 | 40.93 | 74.76 | 25.60 | 9.97 | 12.55 | 0.094 | 0.37 | 0.14 | 3.65 |
| $NPK^2$ | 2 | 2.56 | 9.17 | 55.92 | 28.21 | 4.36 | 4.38 | 16.54 | 22.63 | 0.049 | 0.68 | 0.02 | 2.89 |
| $NP^2K$ | 2 | 16.84 | 61.25 | 144.39 | 217.61 | 99.39 | 75.94 | 37.20 | 11.00 | 0.092 | 1.36 | 0.11 | 2.66 |
| $NP^2K^2$ | 2 | 14.46 | 1.65 | 6.86 | 32.81 | 27.15 | 25.97 | 34.58 | 39.09 | 0.191 | 1.69 | 0.08 | 0.86 |
| Control Vs Rest | 1 | 119.00 | 213.07 | 525.30 | 747.11 | 858.07 | 601.88 | 483.75 | 520.98 | 0.348 | 2.37 | 0.95 | 16.19 |
| Error | 27 | 20.55 | 16.23 | 94.21 | 59.92 | 85.92 | 62.82 | 62.44 | 39.44 | 0.107 | 0.28 | 0.11 | 1.81 |

APPENDIX-IV

Analysis of variance for the effect of chemical fertilizers on morphological characters - Season II

| Source of variation | df | Mean square | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Plant spread | | | | | | | | Number of tillers | | | |
| | | I | | II | | III | | IV | | I | II | III | IV |
| | | EW | NS | EW | NS | EW | NS | EW | NS | | | | |
| Total | 59 | | | | | | | | | | | | |
| Blocks | 5 | 6.71 | 2.80 | 27.42 | 12.98 | 50.18 | 30.16 | 117.33 | 82.77 | 0.15 | 0.20 | 0.38 | 0.38 |
| N | 2 | 15.04 | 4.30 | 9.88 | 9.71 | 220.39 | 143.15 | 359.08 | 238.42 | 1.62 | 1.87 | 2.56 | 2.71 |
| P | 2 | 3.26 | 3.04 | 6.62 | 7.87 | 4.19 | 42.03 | 4.53 | 27.68 | 0.02 | 0.11 | 0.03 | 0.05 |
| NP | 4 | 7.58 | 10.49 | 11.04 | 6.93 | 145.36 | 95.04 | 253.35 | 165.60 | 0.16 | 0.13 | 0.24 | 0.41 |
| K | 2 | 6.25 | 2.06 | 13.78 | 5.42 | 42.61 | 1.79 | 49.43 | 20.20 | 0.05 | 0.19 | 0.57 | 0.64 |
| NK | 4 | 1.11 | 2.17 | 1.17 | 1.16 | 22.59 | 9.28 | 30.09 | 7.98 | 0.29 | 0.24 | 0.24 | 0.21 |
| PK | 4 | 2.04 | 5.61 | 8.34 | 5.29 | 11.41 | 18.33 | 4.83 | 16.14 | 0.02 | 0.14 | 0.20 | 0.29 |
| NPK | 2 | 10.07 | 3.39 | 39.53 | 11.15 | 69.37 | 68.02 | 228.11 | 221.29 | 0.03 | 0.12 | 0.10 | 0.09 |
| $NPK^2$ | 2 | 14.73 | 1.39 | 19.86 | 6.90 | 39.89 | 32.05 | 144.97 | 6.50 | 0.09 | 0.28 | 0.34 | 0.41 |
| $NP^2K$ | 2 | 2.59 | 32.35 | 6.18 | 37.80 | 7.18 | 59.33 | 28.31 | 99.99 | 0.16 | 0.35 | 0.59 | 0.49 |
| $NP^2K^2$ | 2 | 3.42 | 8.18 | 44.81 | 29.18 | 70.10 | 41.95 | 103.52 | 112.93 | 0.04 | 0.01 | 0.03 | 0.02 |
| Control Vs Rest | 1 | 7.02 | 5.15 | 24.36 | 35.80 | 1.13 | 6.78 | 27.13 | 9.22 | 0.06 | 0.05 | 0.06 | 0.28 |
| Error | 27 | 6.02 | 2.26 | 4.40 | 6.51 | 18.28 | 16.58 | 12.26 | 22.27 | 0.06 | 0.08 | 0.16 | 0.19 |

## APPENDIX-V

Analysis of variance for the effect of chemical fertilizers on floral characters - Season I

| Source of variation | df | Mean squares | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Days for first spike emergence | Days for first floret opening | Days for complete floret opening | Length of spike | Length of rachis | No. of florets | Size of florets | Longevity of a floret | Longevity of a spike | Duration of crop | No. of spikes per hill |
| Total | 59 | | | | | | | | | | | |
| Blocks | 5 | 121.63 | 41.12 | 1.77 | 3.80 | 7.99 | 35.79 | 0.14 | 0.04 | 0.31 | 1019.91 | 0.001 |
| N | 2 | 302.14 | 8.13 | 4.46 | 90.38 | 59.16 | 49.50 | 0.13 | 0.51 | 0.18 | 2900.81 | 0.0002 |
| P | 2 | 16.36 | 2.36 | 2.63 | 22.62 | 0.60 | 14.06 | 0.61 | 0.18 | 0.06 | 704.36 | 0.0007 |
| NP | 4 | 109.58 | 5.46 | 1.42 | 22.24 | 14.65 | 38.47 | 0.74 | 0.06 | 0.01 | 645.79 | 0.0006 |
| K | 2 | 107.03 | 1.51 | 1.40 | 16.27 | 1.29 | 24.99 | 0.04 | 0.02 | 0.05 | 1399.92 | 0.0003 |
| NK | 2 | 90.42 | 0.44 | 1.22 | 5.38 | 17.04 | 45.54 | 0.32 | 0.006 | 0.005 | 999.76 | 0.0008 |
| PK | 2 | 46.72 | 1.87 | 3.75 | 43.70 | 13.69 | 25.78 | 0.03 | 0.02 | 0.03 | 1126.57 | 0.0007 |
| NPK | 2 | 172.81 | 6.16 | 0.59 | 9.10 | 10.64 | 29.18 | 0.01 | 0.006 | 0.04 | 2377.81 | 0.0004 |
| $NPK^2$ | 2 | 57.99 | 0.92 | 0.35 | 3.43 | 8.96 | 68.35 | 0.18 | 0.03 | 0.002 | 2123.27 | 0.0005 |
| $NP^2K$ | 2 | 45.14 | 0.64 | 1.75 | 3.23 | 10.29 | 54.09 | 0.20 | 0.005 | 0.01 | 1593.58 | 0.0010 |
| $NP^2K^2$ | 2 | 306.80 | 0.21 | 3.58 | 8.92 | 4.43 | 11.69 | 0.09 | 0.004 | 0.04 | 87.41 | 0.002 |
| Control Vs Rest | 1 | 303.57 | 29.64 | 1.39 | 9.36 | 38.38 | 33.67 | 4.39 | 0.02 | 0.25 | 528.27 | 0.001 |
| Error | 27 | 146.14 | 4.20 | 2.86 | 11.83 | 10.40 | 23.73 | 0.19 | 0.02 | 0.06 | 1405.63 | 0.001 |

## APPENDIX-VI

Analysis of variance for the effect of chemical fertilizers on floral characters - Season II

| Source of variation | df | Mean squares | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Days for first spike emergence | Days for first floret opening | Days for complete floret opening | Length of spike | Length of rachis | No. of florets | Size of florets | Longevity of a floret | Longevity of a spike | Duration of crop | No. of spikes per hill |
| Total | 59 | | | | | | | | | | | |
| Blocks | 5 | 408.40 | 43.87 | 0.03 | 172.35 | 21.89 | 112.58 | 0.59 | 0.09 | 0.4 | 2143.14 | 0.005 |
| N | 2 | 872.89 | 4.14 | 0.006 | 208.01 | 100.94 | 143.93 | 0.27 | 0.36 | 0.004 | 3711.29 | 0.003 |
| P | 2 | 243.00 | 3.36 | 0.08 | 154.61 | 7.95 | 22.64 | 0.32 | 0.06 | 0.20 | 1390.29 | 0.002 |
| NP | 4 | 79.97 | 10.48 | 0.02 | 173.98 | 20.51 | 14.48 | 0.27 | 0.08 | 0.16 | 1346.44 | 0.0004 |
| K | 2 | 96.89 | 2.85 | 0.04 | 124.97 | 3.35 | 7.21 | 0.11 | 0.008 | 0.01 | 2165.96 | 0.004 |
| NK | 4 | 154.70 | 6.57 | 0.06 | 209.50 | 8.27 | 57.54 | 0.53 | 0.03 | 0.04 | 681.19 | 0.01 |
| PK | 4 | 22.26 | 2.27 | 0.05 | 72.28 | 12.64 | 52.42 | 0.11 | 0.03 | 0.05 | 710.94 | 0.01 |
| NPK | 2 | 151.89 | 14.82 | 0.03 | 218.04 | 25.31 | 78.77 | 0.11 | 0.0001 | 0.06 | 1476.18 | 0.004 |
| $NPK^2$ | 2 | 2.68 | 3.75 | 0.01 | 419.29 | 18.68 | 143.67 | 1.00 | 0.01 | 0.006 | 2252.10 | 0.004 |
| $NP^2K$ | 2 | 123.33 | 0.50 | 0.04 | 122.13 | 15.04 | 41.46 | 0.32 | 0.02 | 0.07 | 1014.29 | 0.007 |
| $NP^2K^2$ | 2 | 189.49 | 14.89 | 0.07 | 4.12 | 8.36 | 12.32 | 0.04 | 0.03 | 0.32 | 23.35 | 0.004 |
| Control Vs Rest | 1 | 545.38 | 4.91 | 0.01 | 347.91 | 74.59 | 13.27 | 1.25 | 0.03 | 0.04 | 1079.23 | 0.01 |
| Error | 27 | 108.99 | 11.60 | 0.05 | 58.94 | 6.84 | 22.84 | 0.25 | 0.03 | 0.08 | 956.36 | 0.003 |

## APPENDIX-VII

Analysis of variance for the effect of chemical fertilizers on post harvest spike characters - Season I

| Source of variation | df | Mean squares | | | | | |
|---|---|---|---|---|---|---|---|
| | | Fresh weight of spike | Days for opening of each floret | Days for complete opening of florets | No. of flowers opened at a time | Total water uptake | Vase life |
| Total | 59 | | | | | | |
| Blocks | 5 | 195.63 | 0.01 | 4.04 | 0.004 | 91.02 | 0.40 |
| N | 2 | 242.81 | 0.21 | 0.10 | 0.09 | 70.18 | 1.44 |
| P | 2 | 63.70 | 0.02 | 1.99 | 0.0008 | 71.79 | 0.07 |
| NP | 4 | 361.36 | 0.04 | 5.53 | 0.005 | 69.02 | 0.85 |
| K | 2 | 46.70 | 0.0004 | 2.70 | 0.001 | 10.95 | 0.02 |
| NK | 4 | 139.31 | 0.008 | 2.44 | 0.003 | 9.19 | 0.27 |
| PK | 4 | 177.98 | 0.004 | 1.62 | 0.03 | 41.37 | 0.06 |
| NPK | 2 | 196.19 | 0.005 | 3.49 | 0.0003 | 9.55 | 1.00 |
| $NPK^2$ | 2 | 287.11 | 0.004 | 4.88 | 0.005 | 55.25 | 0.34 |
| $NP^2K$ | 2 | 190.87 | 0.001 | 4.08 | 0.007 | 16.54 | 0.01 |
| $NP^2K^2$ | 2 | 3.05 | 0.005 | 0.79 | 0.004 | 11.29 | 0.98 |
| Control Vs Rest | 1 | 280.70 | 0.003 | 0.36 | 0.16 | 60.26 | 4.89 |
| Error | 27 | 60.01 | 0.010 | 3.35 | 0.006 | 50.21 | 0.31 |

APPENDIX-VIII

Analysis of variance for the effect of chemical fertilizers on post harvest spike characters - Season II

| Source of variation | df | Mean squares | | | | | |
|---|---|---|---|---|---|---|---|
| | | Fresh weight of spike | Days for opening of each floret | Days for complete opening of florets | No. of flowers opened at a time | Total water uptake | Vase life |
| Total | 59 | | | | | | |
| Blocks | 5 | 343.62 | 0.02 | 6.10 | 0.12 | 138.20 | 0.08 |
| N | 2 | 48.82 | 0.06 | 2.54 | 0.14 | 21.29 | 1.98 |
| P | 2 | 268.09 | 0.01 | 0.67 | 0.02 | 43.07 | 0.18 |
| NP | 4 | 161.38 | 0.05 | 6.20 | 0.06 | 173.68 | 2.42 |
| K | 2 | 285.23 | 0.001 | 7.37 | 0.02 | 38.31 | 0.21 |
| NK | 4 | 106.61 | 0.004 | 3.50 | 0.03 | 49.02 | 0.73 |
| PK | 4 | 190.51 | 0.03 | 2.49 | 0.02 | 30.49 | 1.15 |
| NPK | 2 | 232.28 | 0.004 | 0.76 | 0.002 | 30.26 | 1.40 |
| $NPK^2$ | 2 | 155.76 | 0.004 | 8.16 | 0.01 | 168.33 | 0.13 |
| $NP^2K$ | 2 | 183.86 | 0.01 | 6.43 | 0.02 | 79.68 | 0.68 |
| $NP^2K^2$ | 2 | 57.77 | 0.003 | 0.58 | 0.005 | 23.52 | 0.03 |
| Control Vs Rest | 1 | 62.76 | 0.00002 | 2.73 | 0.10 | 82.71 | 5.11 |
| Error | 27 | 83.14 | 0.02 | 5.11 | 0.02 | 57.35 | 0.71 |

APPENDIX-IX

Analysis of variance for the effect of chemical fertilizers on yield of bulbs and bulblets - Season I

| Source of variation | df | Mean squares | | | | |
|---|---|---|---|---|---|---|
| | | Size of bulb | No. of bulbs per hill | Size of bulblets | No. of bulblets per hill | Weight of bulbs and bulblets per hill |
| Total | 59 | | | | | |
| Blocks | 5 | 13.06 | 0.10 | 1.40 | 3.74 | 592.41 |
| N | 2 | 35.55 | 0.25 | 0.62 | 53.20 | 4212.98 |
| P | 2 | 3.12 | 0.09 | 0.47 | 6.22 | 1930.37 |
| NP | 4 | 8.07 | 0.10 | 0.34 | 19.82 | 474.23 |
| K | 2 | 4.92 | 0.04 | 0.84 | 1.48 | 250.42 |
| NK | 4 | 3.16 | 0.11 | 0.94 | 3.29 | 300.12 |
| PK | 4 | 7.57 | 0.05 | 0.18 | 6.91 | 401.11 |
| NPK | 2 | 8.77 | 0.06 | 0.46 | 0.13 | 826.81 |
| $NPK^2$ | 2 | 20.50 | 0.11 | 0.09 | 1.02 | 821.61 |
| $NP^2K$ | 2 | 1.73 | 0.36 | 1.45 | 0.62 | 368.87 |
| $NP^2K^2$ | 2 | 10.62 | 0.09 | 1.00 | 0.69 | 65.97 |
| Control Vs Rest | 1 | 5.39 | 0.21 | 1.45 | 40.51 | 2195.62 |
| Error | 27 | 1.20 | 0.17 | 0.64 | 4.68 | 301.07 |

APPENDIX-X

Analysis of variance for the effect of chemical fertilizers on yield of bulbs and bulblets - Season II

| Source of variation | df | Mean squares | | | | |
|---|---|---|---|---|---|---|
| | | Size of bulb | No. of bulbs per hill | Size of bulblets | No. of bulblets per hill | Weight of bulbs and bulblets per hill |
| Total | 59 | | | | | |
| Blocks | 5 | 0.78 | 0.56 | 0.24 | 3.49 | 3969.39 |
| N | 2 | 3.21 | 1.28 | 0.17 | 12.68 | 1546.21 |
| P | 2 | 1.52 | 0.17 | 0.26 | 13.01 | 1171.60 |
| NP | 4 | 3.47 | 0.17 | 1.00 | 11.09 | 827.62 |
| K | 2 | 1.83 | 0.10 | 0.06 | 7.58 | 5065.49 |
| NK | 4 | 3.22 | 0.72 | 0.11 | 14.12 | 2597.38 |
| PK | 4 | 4.18 | 0.10 | 0.55 | 15.85 | 1628.52 |
| NPK | 2 | 1.18 | 0.02 | 0.52 | 7.60 | 1869.38 |
| $NPK^2$ | 2 | 0.61 | 0.59 | 0.38 | 0.19 | 3854.90 |
| $NP^2K$ | 2 | 1.69 | 0.54 | 0.08 | 2.85 | 1728.65 |
| $NP^2K^2$ | 2 | 0.72 | 0.40 | 0.21 | 9.34 | 1731.86 |
| Control Vs Rest | 1 | 3.67 | 2.87 | 0.55 | 30.58 | 4112.18 |
| Error | 27 | 2.22 | 0.27 | 0.21 | 26.40 | 2125.67 |

APPENDIX-XI

Analysis of variance for the effect of chemical fertilizers on nutrient composition of leaves - Season I

| Source of variation | df | Mean squares | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Potassium | | | Phosphorus | | | Potassium | | |
| | | I | II | III | I | II | III | I | II | III |
| Total | 59 | | | | | | | | | |
| Blocks | 5 | 0.147 | 0.02 | 0.07 | 0.02 | 0.007 | 0.005 | 0.001 | 0.001 | 0.0008 |
| N | 2 | 5.91 | 1.04 | 0.55 | 0.08 | 0.005 | 0.0005 | 0.005 | 0.02 | 0.02 |
| P | 2 | 0.08 | 0.76 | 0.007 | 0.002 | 0.01 | 0.003 | 0.009 | 0.01 | 0.00009 |
| NP | 4 | 0.43 | 0.58 | 0.36 | 0.09 | 0.007 | 0.005 | 0.0003 | 0.006 | 0.009 |
| K | 2 | 0.16 | 0.009 | 0.06 | 0.007 | 0.0006 | 0.004 | 0.007 | 0.005 | 0.004 |
| NK | 4 | 0.28 | 0.56 | 0.43 | 0.01 | 0.008 | 0.007 | 0.005 | 0.001 | 0.001 |
| PK | 4 | 0.18 | 0.06 | 0.18 | 0.04 | 0.0005 | 0.007 | 0.004 | 0.002 | 0.004 |
| NPK | 2 | 0.24 | 0.20 | 0.13 | 0.07 | 0.01 | 0.008 | 0.008 | 0.0004 | 0.02 |
| $NPK^2$ | 2 | 0.33 | 0.009 | 0.08 | 0.005 | 0.01 | 0.006 | 0.0005 | 0.002 | 0.001 |
| $NP^2K$ | 2 | 0.11 | 0.84 | 0.55 | 0.02 | 0.006 | 0.003 | 0.001 | 0.001 | 0.003 |
| $NP^2K^2$ | 2 | 0.40 | 0.009 | 0.09 | 0.05 | 0.007 | 0.001 | 0.003 | 0.001 | 0.005 |
| Control vs Rest | 1 | 1.42 | 2.70 | 2.83 | 0.06 | 0.21 | 0.0009 | 0.000003 | 0.00007 | 0.007 |
| Error | 27 | 0.09 | 0.05 | 0.04 | 0.007 | 0.11 | 0.003 | 0.0004 | 0.002 | 0.002 |

## APPENDIX-XII

Analysis of variance for the effect of chemical fertilizers on nutrient composition of leaves - Season II

| Source of variation | df | Mean squares | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Potassium | | | Phosphorus | | | Potassium | | |
| | | I | II | III | I | II | III | I | II | III |
| Total | 59 | | | | | | | | | |
| Blocks | 5 | 1.75 | 0.24 | 0.15 | 0.02 | 0.007 | 0.006 | 0.001 | 0.0004 | 0.001 |
| N | 2 | 1.08 | 0.17 | 0.25 | 0.08 | 0.004 | 0.0006 | 0.002 | 0.02 | 0.02 |
| P | 2 | 0.22 | 0.42 | 0.35 | 0.002 | 0.01 | 0.003 | 0.01 | 0.02 | 0.0004 |
| NP | 4 | 0.32 | 0.54 | 0.29 | 0.093 | 0.006 | 0.005 | 0.001 | 0.06 | 0.01 |
| K | 2 | 0.04 | 0.22 | 0.06 | 0.008 | 0.0007 | 0.004 | 0.009 | 0.01 | 0.005 |
| NK | 4 | 0.40 | 0.21 | 0.16 | 0.01 | 0.009 | 0.006 | 0.005 | 0.0008 | 0.003 |
| PK | 4 | 0.41 | 0.09 | 0.19 | 0.04 | 0.0005 | 0.006 | 0.003 | 0.0004 | 0.003 |
| NPK | 2 | 0.14 | 0.73 | 0.21 | 0.06 | 0.01 | 0.009 | 0.007 | 0.00008 | 0.02 |
| $NPK^2$ | 2 | 0.08 | 0.25 | 0.29 | 0.009 | 0.01 | 0.006 | 0.00009 | 0.0009 | 0.003 |
| $NP^2K$ | 2 | 0.18 | 0.18 | 0.18 | 0.02 | 0.006 | 0.004 | 0.02 | 0.007 | 0.002 |
| $NP^2K^2$ | 2 | 0.13 | 0.28 | 0.23 | 0.05 | 0.002 | 0.001 | 0.003 | 0.001 | 0.005 |
| Control vs Rest | 1 | 2.29 | 0.61 | 1.12 | 0.05 | 0.002 | 0.001 | 0.0006 | 0.008 | 0.009 |
| Error | 27 | 0.36 | 0.32 | 0.19 | 0.007 | 0.002 | 0.003 | 0.001 | 0.0008 | 0.001 |

# REGULATION OF GROWTH AND FLOWERING IN TUBEROSE *Polianthes tuberosa* Linn.

By

M. MURALEE MANOHAR

## ABSTRACT OF A THESIS

**Submitted in partial fulfilment of the requirement for the degree of**

## Master of Science in Horticulture

**Faculty of Agriculture**

**Kerala Agricultural University**

Department of Pomology and Floriculture

**COLLEGE OF HORTICULTURE**

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**2000**

## ABSTRACT

A study was undertaken at the College of Horticulture, Kerala Agricultural University, Vellanikkara, Thrissur to determine the effect of nutrients and bioregulators on the growth and flowering of tuberose.

The treatments in general, significantly influenced all the vegetative characters, duration, most of the spike characters and yield of bulbs and bulblets in one season or the other.

Both nitrogen at 30 g $m^{-2}$ as well as $GA_3$ at 50 and 100 ppm gave maximum plant height in both the seasons. Nitrogen 20 g $m^{-2}$ and $GA_3$ 100 ppm produced maximum number of leaves, followed by ethrel 50 ppm. In number of tillers, nitrogen 30 g $m^{-2}$ caused a significant increase.

Increasing rate of applied nitrogen and $GA_3$ at 100 ppm reduced the days required for the emergence of spike. The effect of $GA_3$ 50 ppm and IAA 25 ppm were also found to be significantly superior.

Nitrogen 20 and 30 g $m^{-2}$ as well as $GA_3$ 50 and 100 ppm were superior in increasing the spike length. The longest rachis was obtained with nitrogen at 30 g $m^{-2}$ and $GA_3$ 50 ppm.

Among the nutrients, nitrogen and among bioregulators $GA_3$ 100 ppm increased the number of florets per spike and the longevity of individual floret on a spike. However, the longevity of the spike in the field was not affected significantly by the treatments.

The total crop duration was found to be reduced by nitrogen application, $GA_3$ 50 ppm and IAA 25 ppm.

Among the bioregulators $GA_3$ 50 ppm and among nutrients nitrogen at 20 and 30 g $m^{-2}$ recorded the maximum fresh weight of spike.

Control plot plants took maximum days in vase for opening of each floret, while $GA_3$ 100 ppm took minimum days. Higher doses of nitrogen were found to increase the number of days for floret opening. Days for complete opening of florets in vase were shortest and the number of florets opening at a time was the maximum with $GA_3$ 100 ppm.

Higher doses of nitrogen as well as IAA 25 ppm were able to enhance the vase life, followed by $GA_3$ 50 and $GA_3$ 100 ppm.

Nitrogen and phosphorus at 20 g $m^{-2}$ and 15 g $m^{-2}$ respectively were responsible for increased weight of bulbs and bulblets per hill. Bioregulators did not influence this character significantly.

Nitrogen and potassium content of the leaves increased with increasing levels of respective fertilizers, but application of phosphorus did not influence the leaf phosphorus content.