EFFECT OF SPLIT APPLICATION OF N, P & K ON THE GROWTH AND FLOWERING OF ROSE cv. HAPPINESS

By

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THESIS

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DECLARATION

I hereby declare that this thesis, entitled "Effect of split application of N, P & K on the growth and flowering of rose cv. Happiness" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship, or other similar title, of any other University or Society.

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CERTIFICATE

Certified that this thesis, entitled "Effect of split application of N, P & K on the growth and flowering of rose cv. Happiness" is a record of research work done independently by Miss. Nirmala George under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship, or associateship to her.

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INTRODUCTION

I. INTRODUCTION

The flower most admired, most loved, and most widely cultivated throughout the world today is surely the rose. No flower is more steeped in history than the rose in all its many lovely forms, and no flower is held in greater esteem. Today, the rose reigns supreme as the "Queen of Flowers", the title bestowed on it by the Greek poetess Sappho, and none has since questioned its right to the title.

Every year millions of roses are grown in open and under glass to provide cut blooms to decorate our homes and to bring happiness on special occasions. The rose is not a plant native to those countries lying on or south of the equator and has become known in the southern hemisphere only when introduced by man. The rose prefers cool conditions, and for this reason is to be seen in its full glory growing in the British Isles, where the flowering season is comparatively long. From the modern varieties at least some blooms may be expected from the first days of June until almost the year end, whilst some of the species come into bloom in May. No other plant enjoys so long a flowering season, nor gives so great a number of flowers during the period it is in bloom.

India has recently taken up large scale production of cutblooms for export purposes. Indian roses have elicited good demand in European countries; especially in winter months for cut flowers. In Kerala roses are now being cultivated only in home gardens. Field cultivation of roses will be difficult in Kerala due to unpredictable environmental conditions. Wherever the climatic conditions permit the cultivation of roses, it becomes an essential part of the garden. Especially the pot grown roses are more fascinating in places where the garden space is much limited. As rose is a perennial plant and exhausts more nutrients under pot conditions, application of a balanced fertilizer at regular intervals becomes essential to get better vegetative growth and continuous supply of more number of quality flowers.

For all its popularity, however, the rose remains a subject on which most people know very little. The fertilizer practices followed hitherto for roses are arbitrary schedules based on individual's experience. Optimum use of manures and fertilizers to rose plants will increase the yield and will help to reduce the expenditure. Regular and systematic feeding is necessary to get uniform flowering throughout the year and to obtain the desired petal colour, bloom shape, keeping quality, and stalk length. It is also necessary to make it strong enough for facing adverse weather condition and attack of pest and disease.

The present investigation was undertaken with the object of studying the effect of N, P and K at different levels and at different splits on the growth and flower yield of rose, cv. Happiness.

REVIEW OF LITERATURE

II. REVIEW OF LITERATURE

Rose is one of the important cut flower crop in the country. Only very little work has been done on this crop with regard to its nutrient requirements, especially split application of fertilizers on pot grown roses. The available literature on nutrition of rose and related crops are reviewed here. The review has been grouped into three classes.

1. Effect of N, P and K on growth
2. Effect of N, P and K on flowering
3. Effect of split application of N, P and K on growth and flowering

1. Effect of N, P and K on growth

Nitrogen is mainly concerned with the vegetative growth of the plants, with the formation of leaf and stem that are the necessary preliminaries to complete development. Smith (1941) reported that the hardy and vigorous growth of hybrid tea rose is due to the use of fertilizers low in nitrogen and high in phosphorus and potassium. Phosphorus plays an important role as a structural component of the cell constituents and metabolically active compounds. Narayanaswamy and Biswas (1957) found that application of soluble phosphatic fertilizers was found beneficial to the luxuriant growth of the rose plants, but the growth was at the expense of flowers.

According to Kamp and Pokorny (1958) increase in nitrogen level had no effect on the production of long, medium and short stemmed flowers. The longest average stem length was obtained at 80 ppm nitrate. Bordeianu et al. (1966) found that in apple, pears, plums and apricot, application of nitrogen prolonged the growing period of young shoots and promoted increase in girth, lengthening of shoots and increase in canopy. Pal (1966) recommended application of N, P and K for better growth of rose plants.

Hulle (1966) reported that increase in nitrogen application upto 300 kg per ha increased collar diameter in rose. The early growth of both ungrafted Robusta 5 and Mc Intosh/ Robusta 5 was depressed when potassium was applied with nitrogen, but the growth of Quinte/MM.106 was unaffected by fertilizer treatments (Cline, 1966).

Waters (1968) showed the linear rise in the total weight and number of stems with the increased rates of nitrogen fertilization from 16 to 48 lbs per acre for a 3 week period. Increasing the rate of potassium fertilizers from 16 to 32 lbs per acre for three weeks had no effect on growth but increased the K content of leaves.

Muniswamy (1969) reported that the rose plant that suffer from K deficiency develops brown colour around the margin of the leaf and shoot system have poor development. Overdosage of K causes hard and stocky growth. Sinha and Motial (1969) obtained highest shoot length in the rose variety 'Belcanto' by the N:P:K (9:6:3) applied as foliar spray. Increase in the levels of NPK caused substantial decrease in shoot length.

Increase in plant height due to higher dose of nitrogen was reported in rose varieties Christian Dior and Happiness (Young et al., 1973). Soukup and Stankova-Opoienska (1974) reported that one year old seedlings of Rosa canina pollumeriana cv. Pavur Cerveny Sipek, grew best with 1N: 2.36 P_2O_5 : 2.47 K_2O : 1.43 CaO : 0.18 MgO applied at 5 g per 1 substrate. In field trials very good results were obtained with 108 kg N + 180 kg P_2O_5 + 190 kg K_2O ha^{-1}. Increase in potassium supply was associated with better growth of shoots (Nanjan and Muthuswamy, 1974). The stem length of rose bushescv. Rouge Milland was found to increase by spraying with 1 per cent urea (Hassan et al., 1976).

Lekhova (1976) reported best growth of shoot, foliage and trunk diameter in apple cv. Golden Delicious by 12 g N per m^2. A further increase in the fertilizer rate gave poor results and application at 48 g per m^2 did not improve growth compared with control.

The stem diameter and stem length of rose bushes variety 'Superstar' were found to increase significantly with high dose of nitrogen (50 g) in combination with either level (25 g or 50 g) of phosphorus and potassium as compared with low dose (25 g) of nitrogen (Nijjar and Rehalia, 1977). Goode et al. (1978) reported that higher rates of nitrogen increased growth in Cox's Orange Pippin apple trees. A low dose of nitrogen showed a reduction in the total growth and root weight compared with a medium level as reported by Johansson (1978).

Saini et al. (1978) observed an increase in stem length of rose cv. 'Super Star' under high doses of nitrogen. But high doses of P and K reduced the flower stem length.

Williams and Thompson (1979) reported that nitrogen and phosphorus fertilization at planting increased plant height in the first growing season of Golden Delicious apple trees on M.26 rootstocks. Phosphorus fertilizer resulted in an increase in trunk diameter. Increase in trunk diameter of peach tree variety Golden Jubilee due to the application of nitrogen, phosphorus and potassium in various combinations has been reported by Degtyar (1979). Tree trunk girth increment was greatest in trees receiving the highest nitrogen, phosphorus and potassium rates.

Akbar (1979) found that increasing levels of N had no significant influence on the number of vegetative shoots and the total vegetative growth production. Length of internodes was highest in the treatment which received N alone (as urea) through foliar spray. Nanjan (1979) reported that in Edward Rose application of nitrogenous fertilizers profoundly influenced the production of leaves. N in combination with P and K also markedly increased leaf production. Both the levels of N and P and higher level of K promoted the production of bottom breaks and it was much influenced by the nitrogenous fertilizers in general.

During the first two years in rose variety Extsel'za, best growth was observed with nitrogen and potassium fertilizers given both before planting and as a top dressing (Mantrova, 1980).

Borrell (1981) observed that increasing nitrogen levels increased stem length in rose, cv. Baccara. Gowda (1982) recommended the use of 8 g nitrogen and 24 g potassium per plant for getting maximum stem girth in rose.

Woodson and Boodley (1982) reported reduced growth in green house roses due to low potassium supply (0.25 or 2.5 meq per l).

Three consecutive annual nitrogen applications to Bartlett pear trees at 120 kg per ha increased shoot growth compared to no nitrogen (Lombard et al., 1982). The application of nitrogen and potassium did not show significant difference on the per cent increase of the trunk girth and height of the plant while the lower level of phosphorus was found superior in increasing the trunk girth of the plants compared to higher level of phosphorus (Divakar et al., 1983).

Raese et al. (1984) found that a moderate rate of monoammonium phosphate (6 g per tree) resulted in trees with greater shoot extension and leaf number on Delicious apple trees in the green house. Yadav (1985) reported that in rose, plant height increased markedly with the increase in N levels and highest dose of nutrient produced the tallest plants. Shedeed et al. (1986) obtained best growth in cvs., Baccara and Eiffel Tower by applying 10.4 kg calcium nitrate + 14.3 kg superphosphate + 2.69 kg potassium sulphate per feddan (0.42 ha) + 4000 ppm urea as foliar spray.

2. Effect of N, P and K on flowering

Adequate amounts of readily available potassium in soils for roses are necessary to produce blooms of good size and weight with long, heavy stems. Inadequate amounts of potassium result in relatively shorter and lighter stems. Potassium apparently performs some important functions related to the elongation of flowering stems of roses. The roles of nitrogen and phosphorus in the nutrition of rose seem to be relatively more important in the initiation of flowering shoots than in the later elongation of those shoots (Culbert, 1948). Sealey (1950) obtained shorter flowering shoots and smaller flowers in rose plants grown with an insufficient supply of potassium. The plants showed chlorosis resembling that of a deficiency of iron.

In Italy, Puccini (1958) noticed that in beds containing 5 to 7 ppm of boron, production of 'Better Times' roses increased with each increase in N and P levels, the effect being greater with N than with P fertilization. The effect of K fertilization was not consistent but at the highest K levels, flower production was reduced. Kamp and Pokorny (1958) observed that in 'Better Times' roses, increase in soil N levels upto 80 ppm were accompanied by increases in the total production of saleable flowers. The greatest benefit was obtained by raising soil nitrate from 20 to 40 ppm.

Fahmy and El-Bakly (1959) studied the response of rose varieties, viz., Signora, Chryslar Imperial and Rough Mullard against response to applications of 30 tonnes of FYM per acre or FYM plus 3 applications each of 100 kg of NPK and Ca mixture. The order of yield in bloom per acre per annum was Signora, Chryslar Imperial and Rough Mullard in both treatments, but the actual yield showed two fold increase by the addition of chemical fertilizers. El-Gamassy et al. (1963) noted that flowering and rate of opening of flowers were delayed by higher fertilizer rates.

Pal (1966) recommended application of nitrogen, phosphorus and potassium for better flowering of rose plants.

Kolarova et al. (1967) conducted trials in rose, in soils containing low level of nutrient and found that application of phosphorus produced the highest response in terms of flower yield. Waters (1968) found a significant increase in number of flower stems and flower stem length with the increased application of nitrogen and phosphorus. Raghava (1969) recommended application of 10 kg FYM plus 10 g of mixture containing 8:8:3 of N, P_2O_5 and K_2O 15 days after pruning and during the fourth week of January for spring flush under Delhi condition.

Sinha and Motial (1969) observed that in the rose variety 'Belcanto' foliar spray of NPK in 12:12:6 ratio produced the largest size of buds and any increase in the levels of N and K caused reduction of size of buds. This treatment also produced the highest number of flowers while 12:6:6 treatment was the best with regard to the weight of flowers. NPK ratios of 12:12:6 and 9:6:3 were best suited for longevity of the flowers. Subina (1969) reported that application of N and P each at 90 kg per ha increased the flower yield by 23 per cent over unfertilized control and 17 per cent over P_{90} or a mixture of $N_{45} + P_{45} + K_{45}$.

In a two year study with Baccara plants under glass, the number of flowers produced increased with increasing N, more so in the first than in the second year, but raising the N above the 3rd level (equivalent to 33.1 and 43.48 kg per 100 sq.m in the first and second year, respectively) had no advantage with regard to flower number or weight (Bik, 1970). An emphasis on nitrogen application for improved flower production has been given by Mattson and Widmer (1971).

Gault and Synge (1971) recommended Tonks' formula for manuring of roses to get increased yield of flowers which consisted of superphosphate 12 parts, potassium nitrate 10 parts, magnesium sulphate 2 parts, iron sulphate and calcium sulphate 8 parts by weight, applied at 3 to 4 ounces per sq.yard.

Bik (1972) found that in rose cv. Carol raising nitrogen concentration had a favourable effect on flower yield and stem length but a detrimental effect on the intensity of flower colour. Increasing potassium had no significant effect on flower yield or keeping quality, but it improved the stem length and slightly reduced colour intensity and a N:K ratio of 1:1 is recommended. Bik (1972) also found a marked positive N x K interaction on fresh weight of flower. At low potassium or nitrogen levels, increasing either potassium or nitrogen depressed fresh weight of flowers. Minkov (1972) conducted a 6 year trial and found that application of N, P and K at 50:50:50 kg per ha to 15-19 year old rose cv. 'Krysnskaya Krasnaya' gave 21 per cent yield increase to control.

Young _et al_. (1973) recorded the highest yield of flowers in rose varieties Christian Dior and Happiness with the application of 2300 and 2100 lbs nitrogen per acre respectively. They however, failed to get any response with phosphorus and potassium on this character. Nanjan (1973) recorded high yield of flowers, both in number and weight in Edward Rose by foliar spray of 2.5 g of a mixture of urea and potassium hydrogen phosphate in equal proportion by weight.

Bakly (1974) reported increase in flower number, flower stem length and number of strong flowering shoots per plant with increase in nitrogen level in Chryslar Imperial rose plants. Flower yield and quality were highest with an NPK mixture of 90:180:30 g per plant. Nanjan and Muthuswamy (1974) showed that treatment of foliar nutrients increased the flowering shoot length, number of shoots per plant and flower yield of Edward roses. The treatment supplying 1.27 g N, 0.88 g P_2O_5 and 2.01 g K_2O per plant registered the highest flowering shoot length, while the treatment supplying 3.08 g N, 1.85 g P_2O_5 and 1.75 g K_2O produced the largest number of shoots per plant. The highest flower yield came from the treatment supplying 1.93 g N, 1.34 g P_2O_5 and 1.5 g K_2O. Zal'tsfas and Chemarin (1974) stated that when phosphorus was increased from 60 to 180 kg per hectare the yield of flowers increased by 11 per cent. The interaction of nitrogen and phosphorus showed significant effect on the flower yield.

Jayaprasad (1976) reported that maximum number of shoot and total stem length were obtained in "Super Star" rose under the individual influence of 8 g nitrogen and 16 g of potassium per plant. Maharana and Pradhan (1976) found that flower number and yields per plant were highest with nitrogen alone in rose variety 'Celebration'. Anthocyanin content was highest with a combination of nitrogen and potassium.

Nijjar and Rehalia (1977) obtained more number of flowers with the application of high dose of nitrogen (50 g per plant) in combination with either of the levels (25 g and 50 g per plant) of phosphorus. The best flower yields were obtained from rose variety Baccara on Rosa canina root stocks with NPK at various rates at different times (Skalska, 1977). Nitrogen at 40 mg + Potassium at 85 mg per 100 g soil was found to be the best combination. With low nitrogen compared with a normal nitrogen level, a reduction in the flower number was reported by Johansson (1978). Low phosphorus also reduced flower number, flower weight and petal number.

Koseva et al. (1978) reported that oil bearing Kazanluk rose plants receiving 70 kg per hectare each of nitrogen, phosphorus and potassium produced higher flower yields than unfertilized controls. Saini et al. (1978) observed that in rose, cv. 'Super Star' higher dose of P (75 g) exhibited a beneficial effect on the number of flowers per bush, but higher doses of N and K had an adverse effect. The biggest size of flowers were produced under high dose of N and low doses of P and K. The low doses of N and K improved the longevity of the flowers than the respective high doses.

The longevity of flowers was also improved with high dose of P.

Johansson (1979) obtained highest returns of cut flowers from green house rose in the $N_2P_0K_1$ treatment (60 g nitrogen as ammonium sulphate + 39 g potassium as potassium sulphate per m^2 annually). Nitrogen and potassium were found to influence flower yield of green house roses on *Rosa fortuniana* and *Rosa odorata* root stocks (Gammon and Mc.Fadden, 1979).

Armitage and Tsujita (1979) in a study with glass house rose cv. Caliente found that plants receiving the lowest level of N (200 ppm) produced the highest yield of cut roses under ambient light, while those receiving 3000 ppm N produced the highest yield under supplemental irradiation. In Edward Rose, N, P and K influenced the length of flowering shoot whereas N and K profoundly influenced the initiation of flower buds. In respect of yield, both N and K augmented the number and weight of flowers. P was found essential for increasing the size of flowers (Nanjan, 1979). Akbar (1979) reported that foliar application of N, P and K 6.9 g, 2 g and 7.5 g respectively per plant registered the highest yield of flowers in number and weight in Edward Rose. NPK 6:6:1.9 g respectively per plant registered the highest flower diameter.

Treatment which received the highest amount of nitrogen recorded a delay in flowering by 6 days.

Malik (1980) reported that the number of flowers produced in the variety, Queen Elizebeth increased with the increase in nitrogen level and largest number of blooms were obtained with 20 g nitrogen per hectare. In Edward rose optimal rates for flower production were 10 kg FYM per plant + NPK at 6:12:12 g per plant (Irulappan et al., 1980). Nambisan et al. (1981) obtained highest flower yield viz. 53.2 per cent over control (no N) in Edward roses receiving the 40 g N per plant.

In one year old Edward rose, bimonthly foliar application of nitrogen, phosphorus and potassium at 2.5:1.5:1.5 g per plant gave the highest flower yield of 4446.2 g per plant (Akbar and Rao, 1982).

The application of phosphorus improved the flowering, but its effect on the production of first and third grade blooms was not significant. The total yield and flower diameter increased among the treatments P_{100}, P_{50} and P_{200} were not significant (Yadav et al., 1985). Ushakumari (1986) found that in rose cv. Happiness nitrogen and potassium alone and in combination were found effective in the early induction of first flower bud. But phosphorus was effective only when combined with nitrogen and potassium. The best combination was found to be 0.75 g N : 0.75 g P_2O_5 : 0.75 g K_2O.

3. Effect of split application of N, P and K on growth and flowering

Henslow (1934) stated that roses are gross feeders and hence manuring should be repeated twice yearly with NPK mixture of 5:10:5. Hellyer (1957) recommended the use before planting of 10 ounces of sulphate of potash and 4 to 6 ounces of superphosphate per square yard, to be followed by top dressing at 4 ounces per square yard in April. He had also recommended the application of liquid manure once in 5 or 6 days made up of superphosphate, ammonium sulphate and sulphate of potash.

According to Hollis (1969) for feeding roses, 16 parts of superphosphate, 10 parts of potassium sulphate, 5 parts of ammonium sulphate, 2 parts of magnesium sulphate have to be mixed together and applied at one teaspoon full per plant at an interval of 3 to 4 weeks.

Fiedler and Schuricht (1974) applied N at 120 or 240 kg per ha at different times of the year on low stemmed apple trees. Total trunk growth over a 10 year period showed that a single dressing of 120 kg N per ha in May June promoted better growth than the other treatments. The higher rates or split dressing of 120 kg N per ha in May-June promoted better growth than the other treatment.

In trials with apple trees split applications of N, the first half in early spring and the second half after flowering or after fruitlet drop, produced higher yields on young trees than a single application in early spring. Split application did not increase markedly the yield of older trees compared with single application (Buciunas, 1977).

MATERIALS AND METHODS

III. MATERIALS AND METHODS

The present investigation was carried out to study the effect of split application of major nutrients such as nitrogen, phosphorus and potassium on the growth and flowering of rose plants. One of the popular export variety 'Happiness', was used as scion material and briar (*Rosa multiflora*) was used as the root-stock. The experiment was conducted in the garden attached to the Department of Horticulture, College of Agriculture, Vellayani, from January, 1987 to January, 1988.

Pot mixture

A standard pot mixture consisting of equal proportion by volume of river sand, red loam and cowdung was used for growing the plants.

The nutrient status of the pot mixture (NPK) at the time of treatment was estimated and presented in Appendix I.

Planting

Uniform size budded rose plants of one year old were planted in earthen pots of 30 cm diameter containing 6 kg standard pot mixture during December, 1986. Plants were irrigated daily.

Variety

The variety 'Happiness' is free flowering and vigorous, producing export quality cut blooms. It has large, full, well formed bright crimson red flowers with reflexing petals, but lacking fragrance.

Experimental design

The experiment was laid out in Completely Randomised Design with a Factorial Combination of eighty two treatments including one absolute control and two replications. Each replication consisted of one plant. The treatments consisted of different combinations of 3 levels each of NPK applied at three different time intervals. Nitrogen was given in the form of ammonium sulphate, phosphorus as superphosphate (single) and potassium as muriate of potash. The dosages of the nutrients tested in the experiment and the time intervals at which they were applied as splits are given below.

Treatments		Dosages
Nitrogen (N)		g per plant per year grown in 30 cm diameter pots
	n_1	10
	n_2	20
	n_3	30

Phosphorus (P)	
p_1	15
p_2	30
p_3	45
Potassium (K)	
k_1	5
k_2	10
k_3	15
Time interval (T)	
t_1	15 days
t_2	30 "
t_3	45 "

Application of nutrients

The nutrients were applied corresponding to all the possible treatment combinations at different time intervals for a period of one year commencing from January, 1987.

Irrigation

The pots were irrigated once daily in the morning and the quantity of water was limited to half litre per plant so as to prevent loss of nutrients by leaching.

Plant protection

No serious incidence of pests was noticed in the plants during the period of observation. But the frequent attack of dieback disease was kept under check by spraying Dithane-M45. As a prophylactic measure Ekalux EC-25 was also sprayed periodically.

Observations

Morphological characters

Observations on morphological characters were recorded at periodical intervals till the completion of the experiment.

1. Height of the plant

Height of the plant was recorded before and after the application of fertilizer at fortnightly intervals, till the experiment was over.

2. Number of sprouts

Appearance of new sprouts was noticed and their number was recorded.

3. Length of flower shoot

Mean length of the flowering shoot was recorded at the time of flowering.

4. Thickness of flower shoot

Thickness of the flower shoot at the basal region was also recorded.

5. Number of leaves

Number of leaves on each flowering shoot was recorded during the flowering phase.

6. Number of flowers

Number of flowers in each plant was recorded daily, till the completion of the experiment.

7. Opening of flower buds

Number of days taken for the opening of the flower buds in each plant was recorded.

8. Flower size

Diameter of the flower was noted, at full bloom.

9. Number of petals

Number of petals in each flower was recorded, when anthesis was completed.

10. Life span of a flower

Number days for which, each flower remained on the plant without withering or fading was recorded.

Chemical studies

Character of the pot mixture

The content of nutrients in the pot mixture was estimated by taking samples before applying the fertilizers and analysed for available nitrogen, phosphorus and potassium.

1. Available nitrogen (Modified microkjeldahl method) (Jackson, 1973)

20 g of the sample was placed in a distillation flask. Added 20 ml water and 100 ml of 0.32 per cent $KMnO_4$. Added 100 ml of 2.5 per cent NaOH and immediately connected the flask with the distillation apparatus. The flask was heated gradually and carefully. The free ammonia thus released was absorbed in 20 ml of 4% boric acid containing 2 or 3 drops of mixed indicator in a conical flask, at the outlet of the condenser. The boric acid was titrated with 0.02 N HCl.

2. Available phosphorus (Bray's method) (Jackson, 1973)

Weighed out 5 g soil into a 500 ml shaking bottle. Added 50 cc of bray solution and the mixture was shaken for 5 minutes in a mechanical shaker. Filtered the contents through a Whatman No. 42 filterpaper and the filtrate was collected in a beaker. 5 ml of the soil extract was then transferred to a 50 ml volumetric flask. Added 5 ml of molybdate reagent followed by 1 cc of $Sncl_2$. After the development of the colour, it was read in a photoelectric colorimeter. The concentration of P (ppm) was found out from the standard curve.

3. Available potassium (Ammonium acetate method) (Jackson, 1973)

Added 50 ml of 1N Ammonium acetate (pH 7.0) to 100 ml conical flask containing 10 g of soil. It was then shaken vigorously for five minutes and filtered. After that the filtrate was fed to Flame photometer and reading was noted.

Statistical analysis

The data on different characters were subjected to statistical analysis by using the analysis of variance technique for Factorial experiment in Completely Randomised Design. The critical difference for comparing treatment means was found out by using the Tuckey's Q method (Panse and Sukhatme, 1967). The plants which received the following treatments were dried up and hence the statistical analysis was done by excluding these treatments.

$n_2p_3k_1t_3$

$n_2p_3k_2t_3$

$n_2p_3k_3t_3$

$n_3p_2k_1t_3$

$n_3p_2k_2t_3$

$n_3p_2k_3t_3$

$n_3p_3k_1t_3$

$n_3p_3k_2t_3$

$n_3p_3k_3t_3$

So the main and interaction effects were compared with unequal precision.

Correlation was worked out for nitrogen, phosphorus, potassium and the intervals of fertilizer application with the different biometric characters. Correlation coefficients were also computed among the different biometric characters and tested for their significance.

RESULTS

IV. RESULTS

The biometric data recorded from the present study on roses were analysed statistically. The average effect of nitrogen, phosphorus, potassium and intervals of fertilizer application along with their interaction effects are presented in Tables 1 to 10. The mean values with respect to each character under each treatment are given in Appendix II and the analysis of variance is presented in Appendices III to XII. The correlation among characters are presented in Tables 11 and 12.

1. <u>Main effects of N, P, K and T</u> (vide Tables 1-4)

(i) Mean increase in plant height during a period of 15 days

No significant difference was observed in the increments of plant height due to the application of different levels of nitrogen, phosphorus or potassium. A negative trend was observed with increased levels of nitrogen and phosphorus. The intervals of fertilizer application affected the height of the plant. An increase in the interval of fertilizer application helped to increase the plant height. When the fertilizers were applied at 15 days interval the increase in mean plant height was 2.84 cm. The increase was 4.86 cm when

Table 1 Effect of nitrogen on growth, yield and flower characteristics

Levels of nitrogen (g per plant per year)	Mean increase in height of plant during a period of 15 days (cm)	Mean number of sprouts produced	Mean number of flowers produced	Mean length of flower shoot (cm)	Mean thickness of flower shoot (cm)	Mean number of leaves in the flower shoot	Mean diameter of flower (cm)	Mean number of petals in a flower	Mean number of days taken for opening of flower bud	Mean life of flower in days
n_1 10	4.25	25.52	12.70	17.60	1.38	6.61	5.74	16.84	3.65	3.30
n_2 20	4.18	22.81	10.90	17.85	1.39	6.82	5.91	16.92	3.68	3.12
n_3 30	4.03	20.86	7.14	19.53	1.44	6.95	6.07	17.48	3.65	2.98
C.D. (P = 0.05)										
n_1 vs n_2	-	-	2.323	0.8828	-	-	0.1468	-	-	0.101
n_1 vs n_3	-	-	2.409	0.9155	-	-	0.1520	-	-	0.105
n_2 vs n_3	-	-	2.474	0.9402	-	-	0.1560	-	-	0.108

Table 2 Effect of phosphorus on growth, yield and flower characteristics

Levels of phosphorus (g per plant per year	Mean increase in height of the plant during a period of 15 days (cm)	Mean number of sprouts produced	Mean number of flowers produced	Mean length of flower shoot (cm)	Mean thickness of flower shoot (cm)	Mean number of leaves in the flower shoot	Mean diameter of flower (cm)	Mean number of petals in a flower	Mean number of days taken for opening of flower bud	Mean life of flowers in days
p_1 15	4.39	24.65	10.80	18.29	1.40	6.79	5.87	16.92	3.57	2.68
p_2 30	4.09	21.44	10.46	18.08	1.36	6.75	5.86	16.88	3.67	3.19
p_3 45	3.95	23.55	10.09	18.38	1.44	6.79	5.96	17.40	3.78	3.69
C.D. (P = 0.05)										
p_1 vs p_2									0.1032	0.101
p_1 vs p_3									0.1070	0.105
p_2 vs p_3									0.1099	0.108

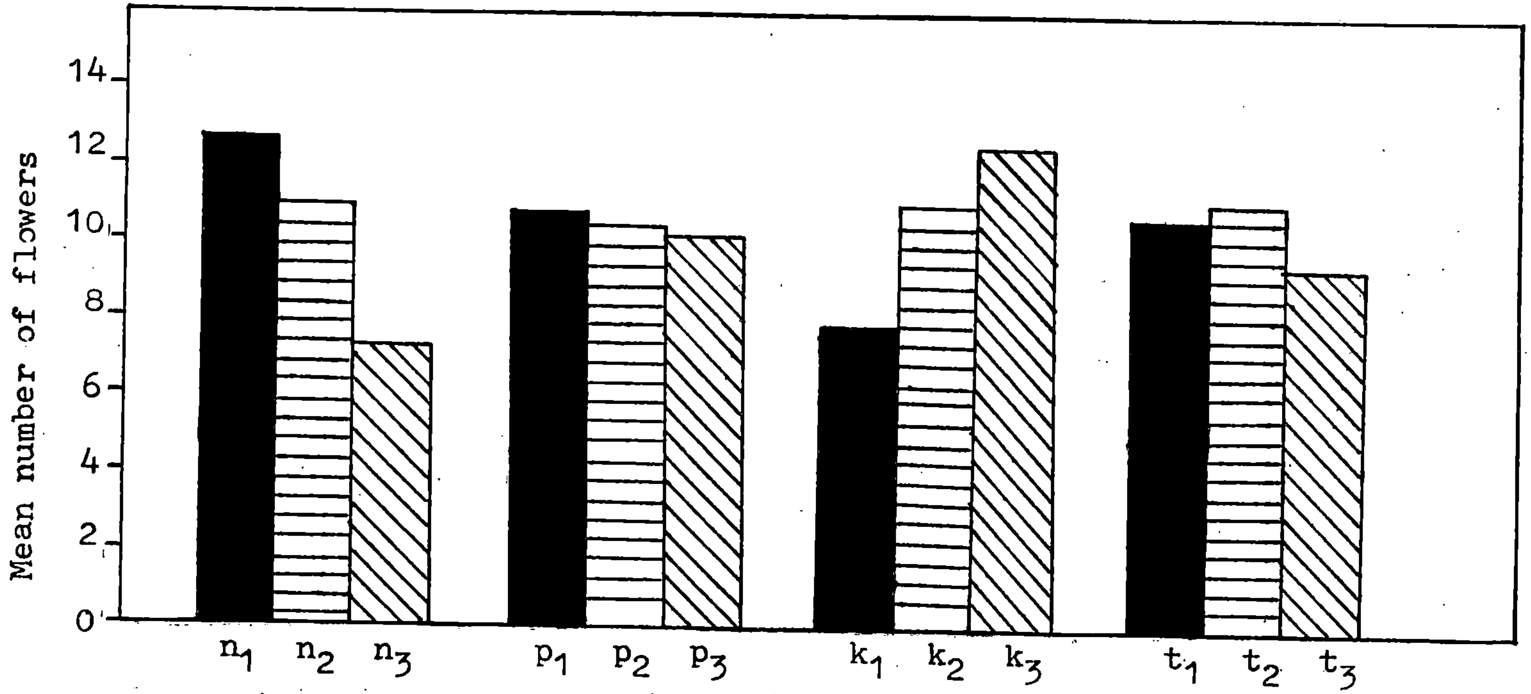
Table 3 Effect of potassium on growth, yield and flower characteristics

Levels of potassium g per plant per year)	Mean increase in height of the plant during a period of 15 days (cm)	Mean number of sprouts produced	Mean number of flowers produced	Mean length of flower shoot (cm)	Mean thickness of flower shoot (cm)	Mean number of leaves in the flower shoot	Mean diameter of flower (cm)	Mean number of petals in a flower	Mean number of days taken for opening of flower bud	Mean life of flower in days
k_1 5	4.14	19.40	7.94	18.81	1.40	6.61	5.85	16.79	3.63	3.20
k_2 10	3.95	26.58	11.0	17.44	1.39	6.75	5.86	17.23	3.73	3.15
k_3 15	4.40	23.79	12.5	18.49	1.41	6.98	5.97	17.13	3.62	3.09
C.D. ($P = 0.05$)	-	4.235	2.323	0.908	-	-	-	-	-	-

Table 4 Effect of time interval of fertilizer application on growth, yield and flower characteristics

Intervals of fertilizer application in days	Mean increase in height of the plant during a period of 15 days (cm)	Mean number of sprouts produced	Mean number of flowers produced	Mean length of flower shoot (cm)	Mean thickness of flower shoot (cm)	Mean number of leaves in the flower shoot	Mean diameter of flower (cm)	Mean number of petals in a flower	Mean number of days taken for openings of flower bud	Mean life of flower in days
t_1 15	2.84	23.35	10.61	18.97	1.38	6.97	5.94	16.71	3.57	2.94
t_2 30	4.86	25.07	11.06	17.52	1.42	6.74	5.93	17.05	3.63	3.16
t_3 45	5.12	20.39	9.42	18.26	1.40	6.54	5.76	17.55	3.84	3.42
C.D. ($P = 0.05$)										
t_1 vs t_2	0.6484	-	-	0.8564	-	-	-	0.539	0.100	0.098
t_1 vs t_3	0.7252	-	-	0.9575	-	-	-	0.603	0.112	0.1099
t_2 vs t_3	0.7252	-	-	0.9575	-	-	-	0.603	0.112	0.1099

FIG. 1 EFFECT OF NITROGEN, PHOSPHORUS, POTASSIUM AND INTERVAL OF FERTILIZER APPLICATION ON MEAN NUMBER OF FLOWERS PRODUCED



n_1 - 10 g per plant per year
n_2 - 20 "
n_3 - 30 "

p_1 - 15 "
p_2 - 30 "
p_3 - 45 "

k_1 - 5 g per plant per year
k_2 - 10 "
k_3 - 15 "

t_1 - 15 days
t_2 - 30 "
t_3 - 45 "

the fertilizer was applied at 30 days interval, and 5.12 cm with a fertilizer application at 45 days interval.

(ii) Production of new sprouts

No significant difference was observed in the number of sprouts at various levels of nitrogen and phosphorus. Application of potassium at 10 g per plant was found to increase the number of sprouts. The number of sprouts increased from 19 to 27 when potassium level was raised from 5 g to 10 g and further increase in potassium to 15 g, reduced the number of sprouts to 24. The time of application of fertilizers did not influence this character.

(iii) Flower production

There was significant difference in flower production at different levels of nitrogen and potassium while the main effects of phosphorus and interval of fertilizer application were not significant (Fig. 1). Higher doses of N was not found to be beneficial; an increase in K helped to increase the flower production.

When N was applied at 10 g per plant, 13 flowers were produced. The flower number decreased to 11 with an application of 20 g N. This drop in flower number was not statistically significant. A further increase in N (30 g per plant) reduced the production of flowers to 7.

An increase in K from 5 to 15 g per plant increased the flower production from 8 to 13. Application of K at 10 g per plant gave 11 flowers which was not significantly different with the flower number (13) obtained at 15 g per plant.

(iv) Length of flower shoot

The length of flower shoot was significantly different at various levels of N and K and also at different intervals of fertilizer application. Application of nitrogen at 30 g per plant increased the length of flower shoot by 1.93 cm and 1.68 cm respectively at 10 and 20 g per plant of nitrogen application. An increase in P did not help to make and change in the length of flower shoot.

Differential response to K was observed for the length of flower shoot. Application of K at 5 g per plant gave maximum length of flower shoot (18.81 cm). Application of K at 10 g per plant significantly reduced the length (17.44 cm). A further increase in K (15 g per plant) showed a proportionate increase in length of flower shoot (18.49 cm).

A similar trend was noticed in the case of interval of fertilizer application. The length of shoots were more when the fertilizers were applied at 15 days interval (18.97 cm) which reduced when the interval was doubled (17.52 cm). The shoot length decreased at 45 days interval of application (18.26 cm). The difference in length was not significant at 30 and 45 days interval of application.

(v) Thickness of flower shoot

The treated plants had more thickness for flower shoot than the untreated (control) plants. The main effects of N, P, K or T were not significant with respect to this character.

(vi) Leaf production in flower shoots

There was an increase in the number of leaves with N-P-K application. But no significant difference in the number of leaves was noticed with respect to various levels of N, P, K or T.

(vii) Flower size (diameter)

A significant difference in the size (diameter) of flower was observed at various levels of N. The main effects of P, K and T were not significant. An increase in the nitrogen level was found to increase the diameter of the flower. The size of the flower increased from 5.74 cm to 5.91 cm and 6.07 cm respectively with an application of 20 and 30 g of N per plant. The differences in the size was not significant at 20 and 30 g of N application. The treated plants showed an increase in flower size compared to control plants.

(viii) Number of petals in a flower

This character was highly influenced by the interval of fertilizer application. The main effects of N, P and K were not significant. Fertilizer application at 45 days interval was found to be beneficial for petal number. There was a significant increase in the number of petals per flower at 45 days interval as compared to 15 days interval of fertilizer application.

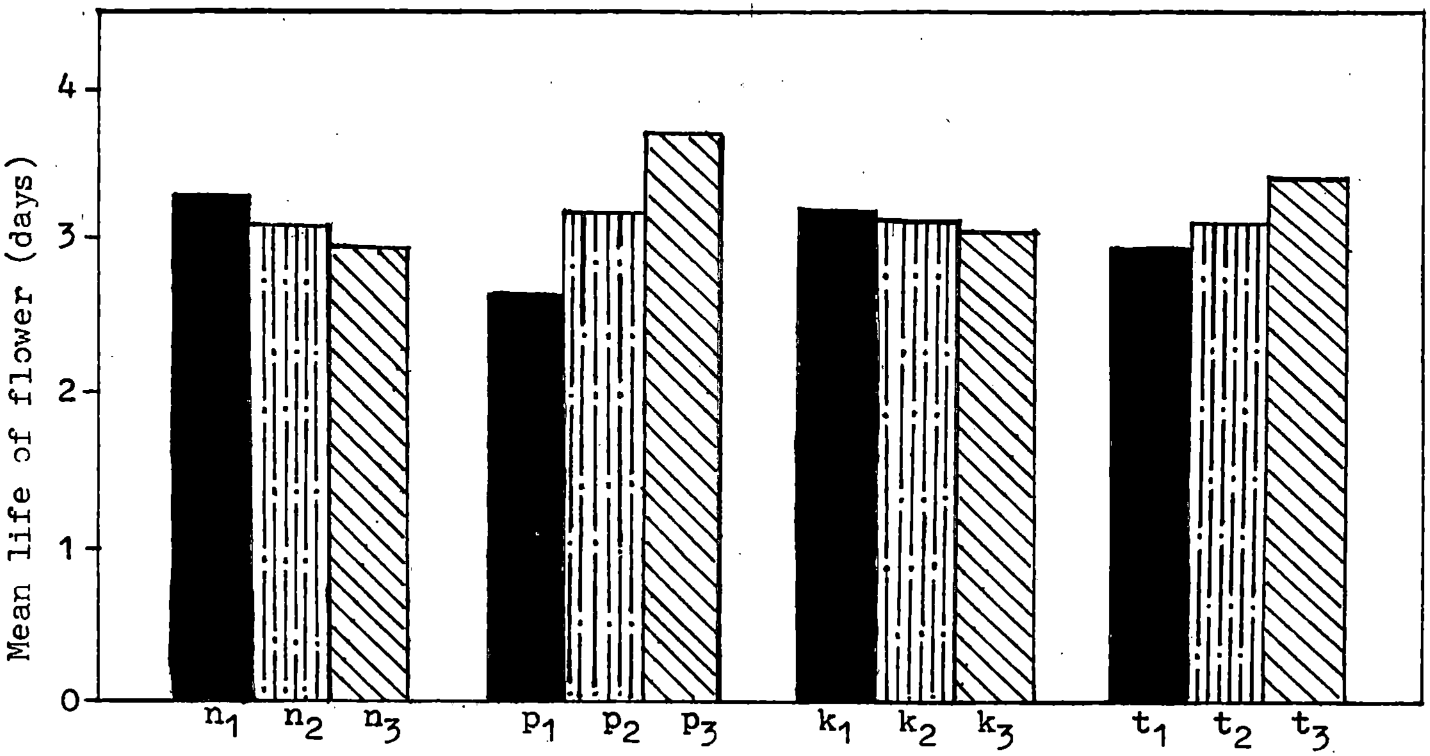
(ix) Number of days taken for opening of flower bud

The main effects of interval of fertilizer application and phosphorus were found to be significant. Number of days taken for opening of flower bud was significantly less in treated plants compared to control plants. Opening of the flower bud was delayed with an increase in the level of phosphorus. Application of phosphorus at 45 g per plant was found to delay the opening of flower bud. Application of fertilizer at long intervals was also found to delay the opening of flower bud.

(x) Life of flower

Significant difference in the mean life of flower was

FIG. 2 EFFECT OF NITROGEN, PHOSPHORUS, POTASSIUM AND INTERVAL OF FERTILIZER APPLICATION ON MEAN LIFE OF FLOWER



n_1 - 10 g per plant per year
n_2 - 20 "
n_3 - 30 "

p_1 - 15 "
p_2 - 30 "
p_3 - 45 "

k_1 - 5 g per plant per year
k_2 - 10 "
k_3 - 15 "

t_1 - 15 days
t_2 - 30 "
t_3 - 45 "

noticed at different levels of N, P and T (Fig. 2). Higher doses of nitrogen was found to reduce the life of the flower while higher doses of phosphorus increased the mean life of flower. Application of nitrogen at 10 g per plant gave a mean flower life of 3.3 days. This was reduced to 2.98 days at 30 g of nitrogen application. While the mean life of flower was 2.68 days at 15 g per plant of phosphorus application, it increased to 3.69 days at 45 g per plant of phosphorus application. Application of fertilizer at longer intervals was found to increase the mean life of flowers.

2. <u>Interaction effect of NP, NK, PK, NT, PT and KT</u> (vide Tables 5 to 10)

(i) Increase in plant height during a period of 15 days

None of the interactions were significant. So all the nutrients and intervals of fertilizer application behaved independently with respect to this character.

(ii) Number of sprouts produced

Though the NP and NT interaction effect were found to be significant, their main effects being not significant they are not important in producing variation in the mean number of sprouts produced.

(iii) Number of flowers produced

The interactions NP, NT and KT were significant with

Table 5 Interaction effect of nitrogen and phosphorus on growth, yield and flower characteristics

Levels of nitrogen and phosphorus	Mean increase in height of the plant during a period of 15 days (cm)	Mean number of sprouts produced	Mean number of flowers produced	Mean length of flower shoot (cm)	Mean thickness of flower shoot (cm)	Mean number of leaves in the flower shoot	Mean diameter of flower (cm)	Mean number of petals in a flower	Mean number of days taken for opening of flower bud	Mean life of flower in days
n_1p_1	4.50	27.89	14.56	17.42	1.34	6.55	5.66	16.54	3.47	2.72
n_1p_2	4.15	24.89	12.61	16.81	1.36	6.37	5.68	16.49	3.66	3.39
n_1p_3	4.11	23.78	10.94	18.59	1.43	6.92	5.87	17.46	3.83	3.79
n_2p_1	3.94	21.83	9.17	17.58	1.39	6.79	5.92	16.66	3.59	2.63
n_2p_2	4.27	18.56	9.94	18.51	1.40	6.85	5.96	17.14	3.77	3.33
n_2p_3	4.40	30.67	14.92	17.25	1.38	6.80	5.83	16.96	3.69	3.55
n_3p_1	4.75	24.22	8.67	19.88	1.49	7.04	6.03	17.57	3.64	2.70
n_3p_2	3.73	20.58	8.0	19.35	1.30	7.17	5.98	17.66	3.52	2.70
n_3p_3	3.26	16.08	4.0	19.18	1.52	6.59	6.21	17.76	3.79	3.68
	NS	S	S	NS	NS	NS	NS	NS	S	S

Table 6 Interaction effect of phosphorus and potassium on growth, yield and flower characteristics

Levels of phosphorus and potassium	Mean increase in height of the plant during a period of 15 days (cm)	Mean number of sprouts produced	Mean number of flowers produced	Mean length of flower shoot (cm)	Mean thickness of flower shoot (cm)	Mean number of leaves in the flower shoot	Mean diameter of flower (cm)	Mean number of petals in a flower	Mean number of days taken for opening of flower bud	Mean life of flower in days
p_1k_1	4.38	20.72	8.44	18.59	1.37	6.60	5.77	16.57	3.53	2.70
p_1k_2	4.08	26.78	10.56	17.68	1.38	6.90	5.85	17.06	3.61	2.74
p_1k_3	4.72	26.44	13.39	18.60	1.47	6.89	5.99	17.15	3.57	2.61
p_2k_1	4.12	17.25	7.38	18.94	1.36	6.50	5.79	16.34	3.64	3.31
p_2k_2	4.17	28.50	13.38	17.32	1.36	6.72	5.84	17.33	3.77	3.11
p_2k_3	3.98	18.56	10.63	17.98	1.36	7.03	5.97	16.96	3.59	3.15
p_3k_1	3.87	20.14	7.93	18.94	1.49	6.74	6.04	17.57	3.74	3.70
p_3k_2	3.50	24.14	8.86	17.26	1.43	6.60	5.90	17.34	3.85	3.70
p_3k_3	4.48	26.36	13.50	18.93	1.39	7.05	5.94	17.31	3.74	3.62
	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

NS - Not significant

Table 7 Interaction effect of nitrogen and potassium on growth, yield and flower characteristics

Levels of nitrogen and potassium	Mean increase in height of plant during a period of 15 days (cm)	Mean number of sprouts produced	Mean number of flowers produced	Mean length of flower shoot (cm)	Mean thickness of flower shoot (cm)	Mean number of leaves in the flower shoot	Mean diameter of flower (cm)	Mean number of petals in a flower	Mean number of days taken for opening of flower bud	Mean life of flower in days
n_1k_1	4.06	20.00	9.44	17.68	1.36	6.18	5.60	16.45	3.63	3.35
n_1k_2	4.01	29.72	13.78	16.35	1.36	6.52	5.55	17.08	3.68	3.31
n_1k_3	4.68	26.83	14.89	18.79	1.41	7.14	6.07	16.98	3.66	3.24
n_2k_1	4.46	19.13	7.63	18.01	1.40	6.70	5.83	16.81	3.70	3.23
n_2k_2	3.82	23.06	10.06	18.42	1.40	7.04	6.11	17.03	3.78	3.07
n_2k_3	4.27	26.25	15.00	17.12	1.38	6.71	5.80	16.90	3.57	3.07
n_3k_1	3.89	18.93	6.36	21.18	1.47	7.05	6.20	17.19	3.56	2.97
n_3k_2	4.00	26.57	8.50	17.72	1.42	6.71	5.97	17.66	3.75	3.06
n_3k_3	4.19	17.07	6.57	19.68	1.45	7.09	6.04	17.58	3.64	2.91
	NS	NS	NS	S	NS	NS	S	NS	NS	NS

S - Significant

NS - Not significant

Table 8 Interaction of nitrogen and interval of fertilizer application on growth, yield and flower characteristics

Levels of nitrogen and interval fertilizer application	Mean increase in height of plant during a period of 15 days (cm)	Mean number of sprouts produced	Mean number of flowers produced	Mean length of flower shoot (cm)	Mean thickness of flower shoot (cm)	Mean number of leaves in the flower shoot	Mean diameter of flower (cm)	Mean number of petals in a flower	Mean number of days taken for opening a flower bud	Mean life of flower in days
n_1t_1	2.96	27.22	14.22	16.92	1.33	6.41	5.71	16.58	3.58	2.94
n_1t_2	4.95	29.22	13.44	18.02	1.42	7.01	5.85	16.69	3.55	3.27
n_1t_3	4.85	20.11	10.44	17.88	1.38	6.41	5.65	17.23	3.85	3.69
n_2t_1	2.89	22.72	11.06	19.17	1.37	7.18	6.05	16.36	3.65	3.00
n_2t_2	4.79	26.28	12.95	16.32	1.42	6.68	5.84	16.73	3.60	3.12
n_2t_3	5.21	17.75	7.58	18.16	1.38	6.48	5.83	18.03	3.86	3.31
n_3t_1	2.67	20.11	6.56	20.82	1.43	7.33	6.07	17.20	3.47	2.89
n_3t_2	4.32	19.72	6.78	18.21	1.43	6.54	6.10	17.73	3.76	3.11
n_3t_3	5.74	26.50	10.00	19.62	1.53	7.04	5.98	17.56	3.84	2.86
	NS	S	S	S	NS	S	NS	NS	S	S

S - Significant

NS - Not significant

Table 9 Interaction of phosphorus and interval of fertilizer application on growth, yield and flower characteristics

Levels of phosphorus and interval of fertilizer application	Mean increase in height of plant during a period of 15 days (cm)	Mean number of sprouts produced	Mean number of flowers produced	Mean length of flower shoot (cm)	Mean thickness of flower shoot (cm)	Mean number of leaves in the flower shoot	Mean diameter of flower (cm)	Mean number of petals in a flower	Mean number of days taken for opening of flower bud	Mean life of flower in days
p_1t_1	2.90	24.22	10.39	19.55	1.37	6.98	5.98	16.87	3.62	2.45
p_1t_2	4.41	24.94	10.28	17.08	1.38	6.49	5.81	16.85	3.45	2.60
p_1t_3	5.87	24.78	11.72	18.26	1.47	6.91	5.82	17.06	3.64	3.01
p_2t_1	2.62	20.89	10.11	18.35	1.36	6.93	5.92	16.09	3.53	2.83
p_2t_2	5.46	26.56	13.11	17.84	1.37	6.88	5.94	16.96	3.62	3.23
p_2t_3	4.25	14.58	7.00	18.04	1.36	6.29	5.67	17.95	3.93	3.68
p_3t_1	3.00	24.94	11.33	19.01	1.49	7.02	5.92	17.19	3.56	3.54
p_3t_2	4.70	23.72	9.78	17.63	1.43	6.86	6.05	17.34	3.83	3.67
p_3t_3	4.59	18.83	7.33	18.72	1.39	5.93	5.79	18.25	4.30	4.16
	NS	NS	NS	NS	NS	NS	NS	NS	S	S

S - Significant

NS - Not significant

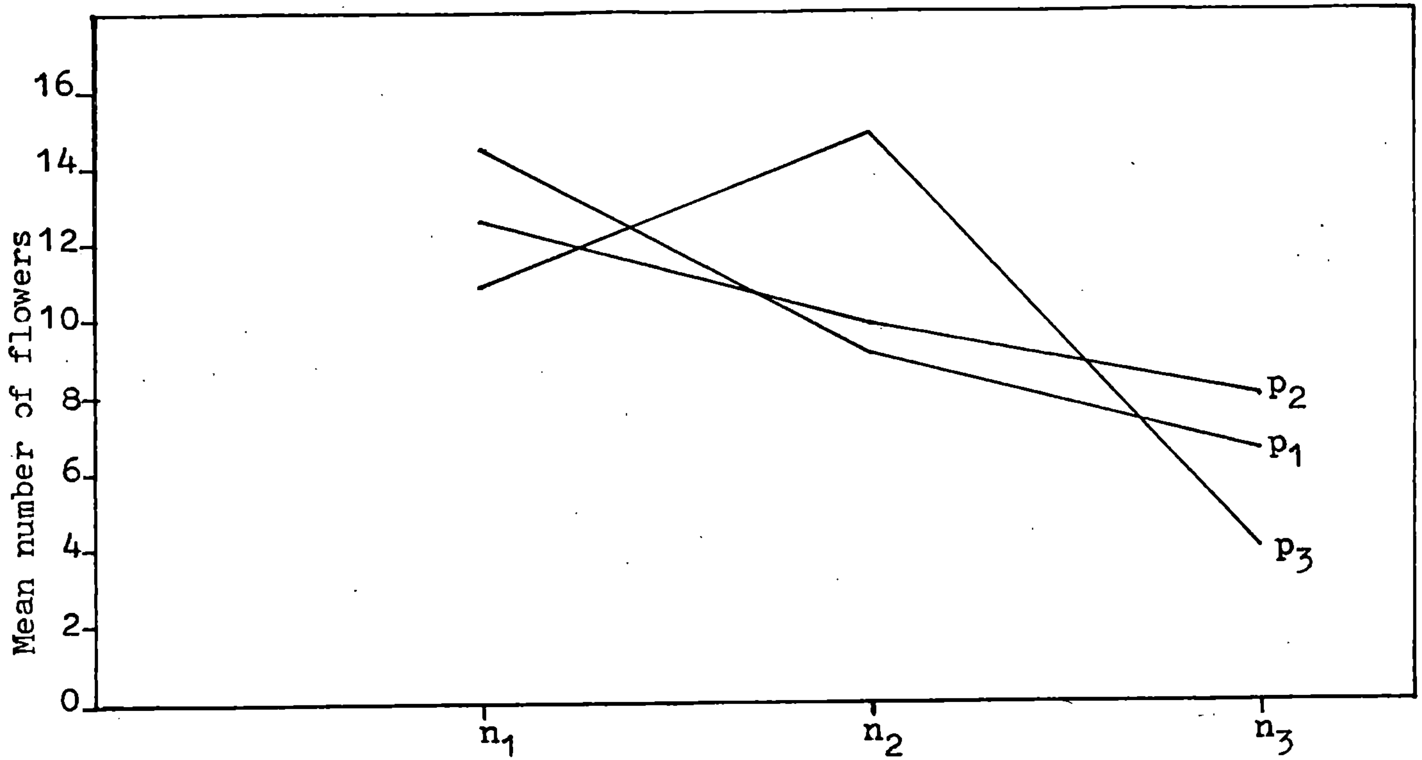
Table 10 Interaction of potassium and interval of fertilizer application on growth, yield and flower characteristics

Levels of potassium and interval of fertilizer application	Mean increase in height of plant during a period of 15 days (cm)	Mean number of sprouts produced	Mean number of flowers produced	Mean length of flower shoot (cm)	Mean thickness of flower shoot (cm)	Mean number of leaves in the flower shoot	Mean diameter of flower (cm)	Mean number of petals in a flower	Mean number of days taken for opening of flower bud	Mean life of flower in days
k_1t_1	2.95	20.61	8.50	19.24	1.36	6.74	5.95	16.15	3.56	2.96
k_1t_2	4.95	18.94	6.94	17.64	1.43	6.38	5.84	16.86	3.54	3.18
k_1t_3	4.74	18.25	8.58	19.93	1.42	6.75	5.72	17.63	3.88	3.57
k_2t_1	2.55	23.89	9.78	18.49	1.36	7.23	5.92	17.17	3.67	3.02
k_2t_2	4.58	29.22	11.50	16.56	1.44	6.52	5.88	17.26	3.73	3.22
k_2t_3	5.07	26.67	12.08	17.19	1.36	6.39	5.73	17.28	3.82	3.26
k_3t_1	3.02	25.56	13.56	19.18	1.41	6.96	5.95	16.81	3.48	2.84
k_3t_2	5.04	27.06	14.72	18.36	1.40	7.34	6.08	17.03	3.62	3.09
k_3t_3	5.54	16.25	7.58	17.66	1.43	6.48	5.84	17.76	3.83	3.44
	NS	NS	S	NS	NS	S	NS	NS	NS	S

S - Significant

NS - Not significant

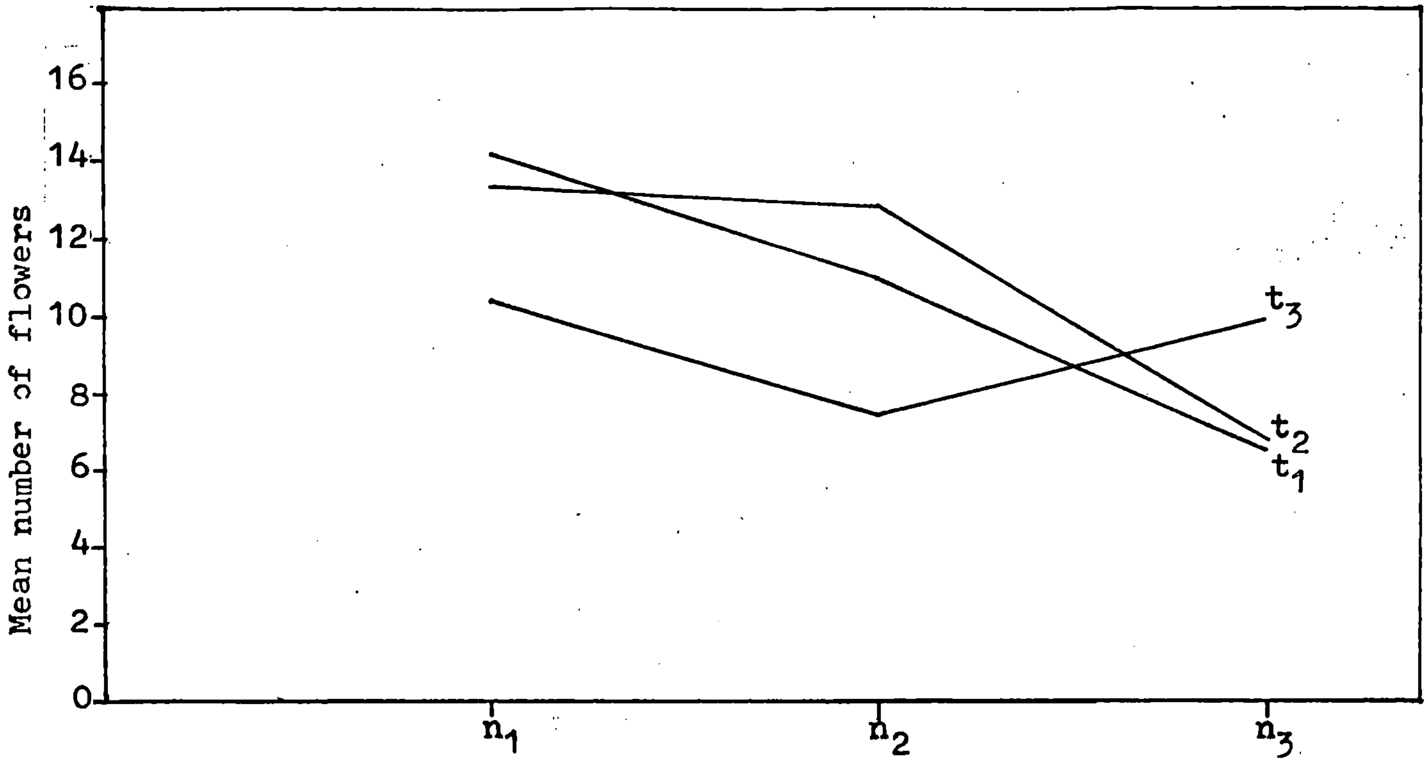
FIG. 3 INTERACTION EFFECT OF NITROGEN AND PHOSPHORUS ON MEAN NUMBER OF FLOWERS PRODUCED



n_1 - 10 g per plant per year
n_2 - 20 "
n_3 - 30 "

p_1 - 15 g per plant per year
p_2 - 30 "
p_3 - 45 "

FIG. 4 INTERACTION EFFECT OF NITROGEN AND INTERVAL OF FERTILIZER APPLICATION ON MEAN NUMBER OF FLOWERS PRODUCED



n_1 - 10 g per plant per year

n_2 - 20 "

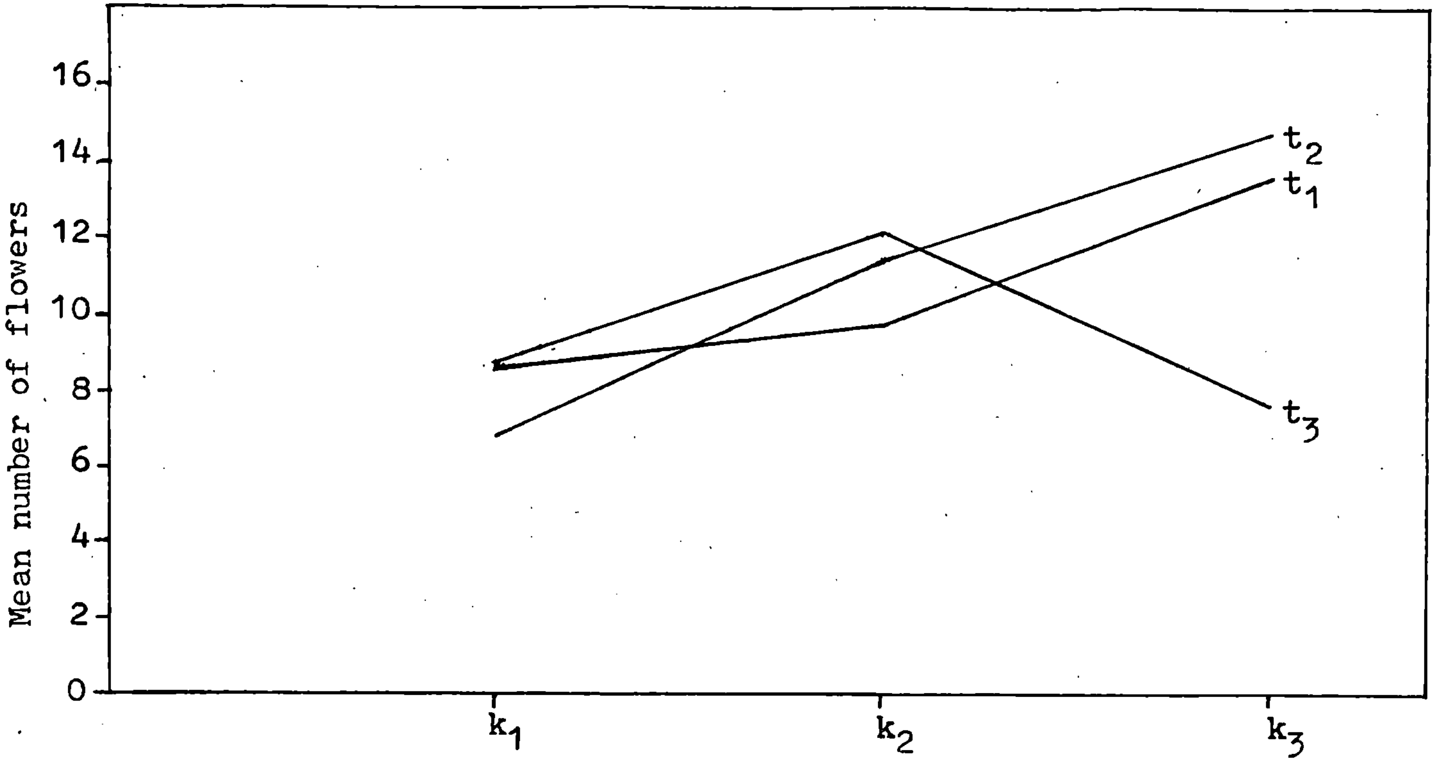
n_3 - 30 "

t_1 - 15 days

t_2 - 30 "

t_2 - 45 "

FIG. 5 INTERACTION EFFECT OF POTASSIUM AND INTERVAL OF FERTILIZER APPLICATION ON MEAN NUMBER OF FLOWERS PRODUCED



k_1 - 5 g per plant per year t_1 - 15 days

k_2 - 10 " t_2 - 30 "

k_3 - 15 " t_3 - 45 "

respect to this character.

When nitrogen was applied in combination with 15 g of P, there was a significant reduction in the number of flowers at higher doses of N (Fig. 3). A combination of N with 30 g of P showed no significant difference in the mean number of flowers at the first two levels of N, but the number of flowers was significantly less at n_3p_2 combination compared to n_1p_2. A combination of N with 45 g of P per plant gave a marked decrease in the mean number of flowers at n_3p_3 (4 flowers) compared to n_2p_3 (15 flowers) and n_1p_3 (11 flowers).

Application of N at longer interval of time (45 days) did not produce any significant variation in the mean number of flowers (Fig. 4). There were 8 to 10 flowers on an average at all the levels of N applied at 45 days interval of time. But when N was applied at 15 and 30 days interval of time, there was a significant reduction in the mean number of flowers at higher doses of N.

K application at 45 days interval also did not produce any variation in the mean number of flowers at different levels of K (Fig. 5); while K applied at 15 and 30 days interval produced more flowers at the highest dose of K, compared to the lowest dose of K.

(iv) Length of flower shoot

Only the NK and NT interactions were found to be significant on the mean length of flower shoot. When N was combined with 5 g per plant of K there was no significant difference in the mean length of flower shoot at first two levels of N (10 and 20 g per plant). But there was a significant effect on the elongation of flower shoot at n_3k_1 (21.18 cm) compared to n_1k_1 (17.68 cm) and n_2k_1 (18.01 cm). When nitrogen was applied with 10 g per plant of K, the length of flower shoot was significantly less at the lowest level of nitrogen (16.35 cm) compared to n_2k_2 combination (18.42 cm). But no significant difference was observed in the mean length of flower shoot at n_2k_2 (18.42 cm) and at n_3k_2 (17.72 cm). A combination of N with 15 g per plant of K showed no significant difference in the length of flower shoot at the lowest and highest levels of nitrogen, while along with medium level of nitrogen (20 g per plant) significant reduction in the length of flower shoot was noticed (17.12 cm) compared to n_1k_3 (18.79 cm) and n_3k_3 (19.68 cm) combinations.

A combination of K at different levels with 10 g per plant of N showed no significant difference in the mean length of flower shoot. But combinations involving n_1k_3 produced significantly longer flower shoot compared to those combinations involving n_1k_2. Application of K along with 20 g per plant of N showed no significant variation in the length of flower shoot at different levels of K. A combination of K with 30 g per plant of N caused a significant reduction in the length of flower shoot at n_3k_2 compared to n_3k_1 and n_3k_3; while no significant variation was noticed in the length of flower shoot at n_3k_1 and n_3k_3 combinations.

Application of different levels of nitrogen at an interval of 15 days showed a significant increase in the length of flower shoot; while at 45 days interval of application showed no significant difference in the length of flower shoot. When N was applied at 30 days interval a significant reduction in the length of flower shoot was noticed at n_2t_2 combination (16.32 cm) compared to n_1t_2 (18.02 cm) and n_3t_2 (18.21 cm) combination. No significant difference in the length of flower shoot was observed at n_1t_2 and n_3t_2 combinations.

When N at 10 g per plant was applied at different intervals of time like 15, 30 and 45 days and when 20 g of N was applied at 15 and 45 days interval of time, no significant difference was seen in the mean length of flower shoot, while N at 20 g per plant applied at 30 days interval significantly reduced the length of flower shoot compared to 15 and 45 days interval of application. Application of nitrogen at 30 g per plant at 30 days interval of time significantly reduced the length of flower shoot compared to 15 days interval of application. Nitrogen application at 45 days interval showed no significant difference in this character compared to 15 and 30 days interval of application.

(v) Thickness of flower shoot

None of the interactions were significant on the mean thickness of flower shoot. So all the nutrients with their interval of application behaved independently with respect to this character.

(vi) Number of leaves in the flower shoot

NT and KT interactions were found to be significant for this character. But their main effects being insignificant they are not important in producing variation in the mean number of leaves in the flower shoot.

(vii) Flower size

Only the NK interaction significantly affected this character.

A combination of nitrogen with 5 g per plant of K, significantly increased the diameter of flower at n_3k_1 combination (6.2 cm) compared to diameter at n_1k_1 (5.6 cm) and

n_2k_1 (5.83 cm). But no significant difference was seen at n_2k_1 and n_1k_1 with regard to this character. When 10 g per plant of K was applied along with nitrogen, no significant difference was obtained at medium and highest levels of nitrogen, while the n_1k_2 combination showed the least value compared to n_2k_2 and n_3k_2 combination. A combination of nitrogen with 15 g per plant of K, showed no significant difference at the highest level of nitrogen compared to low and medium level of N. But the n_1k_3 combination significantly increased the diameter of flower (6.07 cm) compared to n_2k_3 (5.8 cm).

(viii) Number of petals in a flower

None of the interactions were found to influence significantly the mean number of petals in a flower. Hence all the factors (N, P, K and T) behaved independently with respect to this character.

(ix) Number of days taken for opening of flower bud

A significant NP, NT and PT interactions were observed with regard to this character. When phosphorus was combined with 10 g nitrogen per plant, opening of the flower bud was earlier (3.47 days) at the lowest level of phosphorus compared to medium and highest level of phosphorus. But no significant variation was noticed between n_1p_2 and n_1p_3 combinations with respect to this character. A combination of phosphorus with 20 g per plant of N showed no significant difference in the mean number of days taken for opening of flower bud at 45 g per plant of P compared to 15 and 30 g per plant of P. While 15 g per plant of P combined with 20 g of N significantly reduced the time taken for opening of flower bud compared to 30 g of P combined with 20 g of N. When 30 g per plant of N was applied along with phosphorus, no significant difference was seen at the lowest level of P compared to medium and highest levels of P. The number of days for opening of the flower was significantly less in n_3p_3 combination compared to n_3p_2 combination.

Application of 10 g per plant of N at 15 and 30 days interval of time showed no significant difference in the number of days taken for opening of the flower bud. But 45 days interval of application significantly delayed the opening of the flower bud compared to 15 and 30 days interval of application. A similar trend was seen with 20 g of N also. Application of N at 30 g per plant showed no significant difference in the number of days taken for opening of flower bud, when applied at 30 and 45 days interval of time, while 15 days interval of application significantly delayed the opening of flower bud compared to the other two intervals.

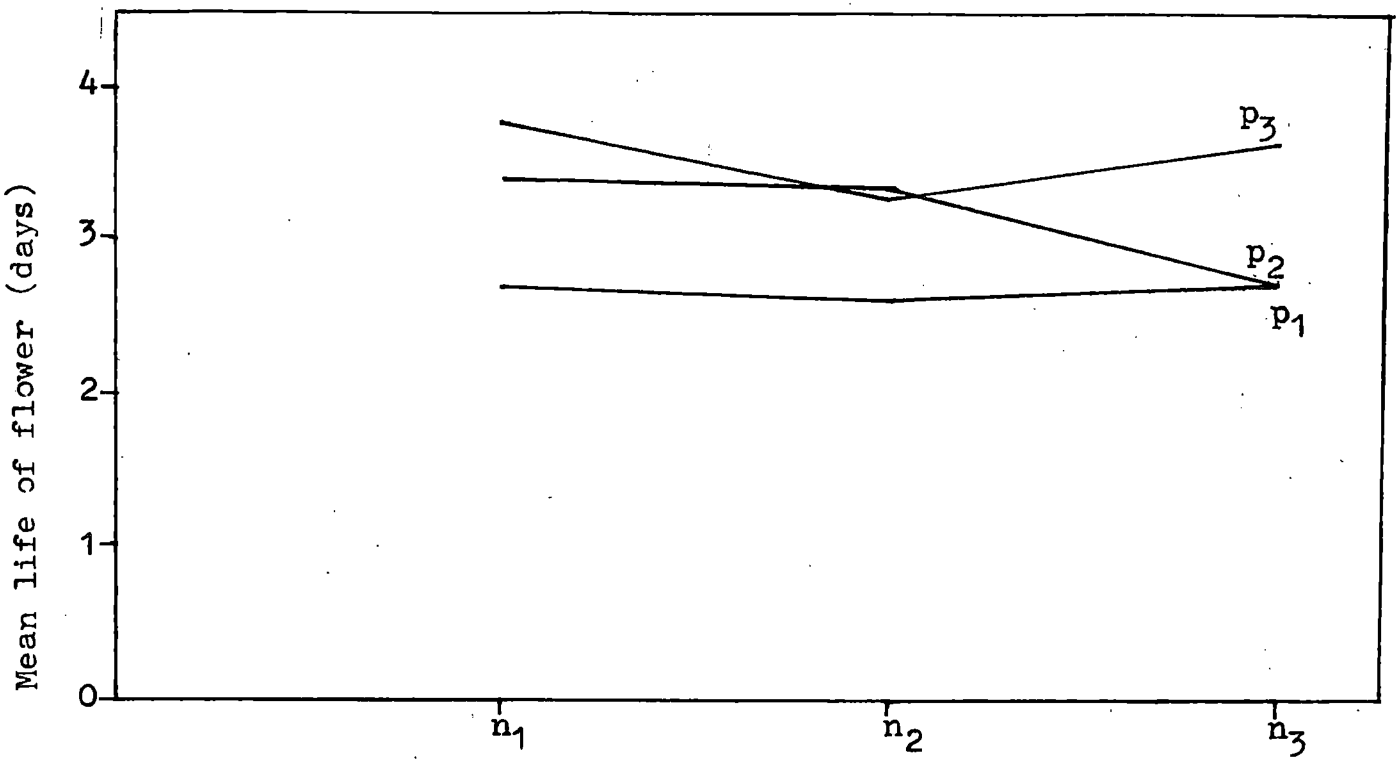
When P at 15 g per plant was applied at 15 days interval, no significant difference was noticed in the number of days taken for opening of flower bud compared to 30 and 45 days interval of application,while 45 days interval of application was found to delay the opening of flower bud compared to 30 days interval of application. When the quantity of P was doubled (30 g per plant), no significant difference was noticed among 15 and 30 days interval of application. Application at 45 days interval delayed the flower opening compared to the other two intervals of time. When 45 g per plant of P was applied at different intervals of time, there was a significant delay in the opening of flower bud, with increasing intervals of fertilizer application.

Application of phosphorus at 15 days interval of time showed no significant difference in the number of days taken for opening of flower bud at different levels of P. Application of P at 30 days interval significantly delayed flower opening at 45 g of P compared to 15 and 30 g per plant of P. But no significant difference was noticed between 15 and 30 g per plant of P. P applied at 45 days interval of time significantly increased the time taken for opening of flower bud with increasing levels of P.

(x) Life of flower

The NP, NT, PT and KT interactions significantly affected

FIG. 6 INTERACTION EFFECT OF NITROGEN AND PHOSPHORUS ON MEAN LIFE OF FLOWER



n_1 - 10 g per plant per year p_1 - 15 g per plant per year

n_1 - 20 " p_2 - 30 "

n_1 - 30 " p_3 - 45 "

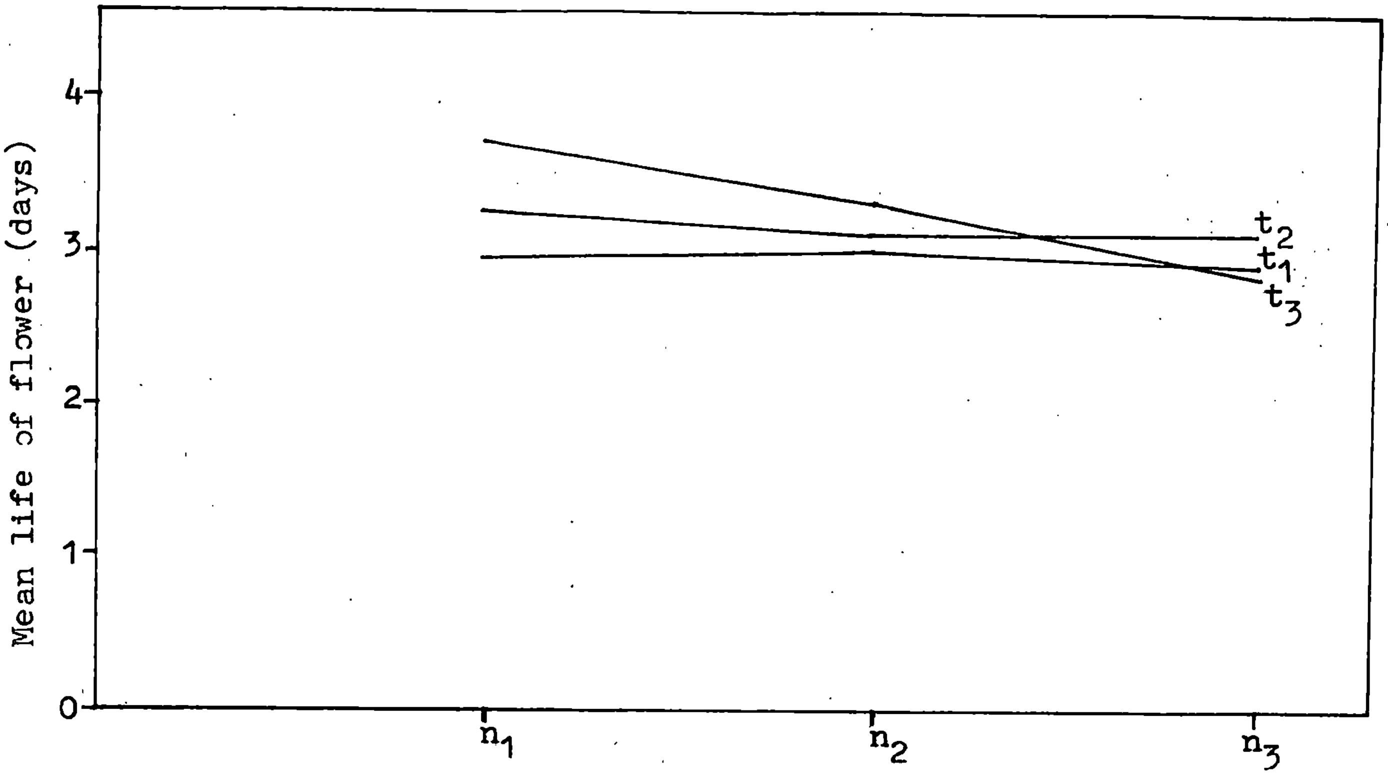
the mean life of flower.

A combination of N with 15 g per plant of P showed no significant difference in the mean life of flower at different levels of N (Fig. 6). But when P was doubled (30 g per plant), life of the flower was significantly reduced (2.7 days) at the highest level of N compared to lowest and medium levels of N. No significant difference in the life of the flower was seen at n_1p_2 (3.39 days) and n_2p_2 (3.33 days). Application of nitrogen along with 45 g per plant of P showed no significant difference at n_1p_3 and n_3p_3 combinations, while n_2p_3 combination significantly reduced the life of flower compared to n_1p_3 and n_3p_3 combinations.

When 10 g per plant of nitrogen was applied along with phosphorus, there was a significant increase in the life of flowers, with increasing levels of phosphorus. The same trend was noticed when 20 g N per plant was applied with phosphorus. When the level of nitrogen was increased to 30 g per plant, no significant difference was seen in the mean life of flower, at first two levels of P, while at the highest level of P life of the flower was significantly increased compared to lowest and medium levels of P.

When N was applied at 15 days interval, no significant

FIG. 7 INTERACTION EFFECT OF NITROGEN AND INTERVAL OF FERTILIZER APPLICATION ON MEAN LIFE OF FLOWER

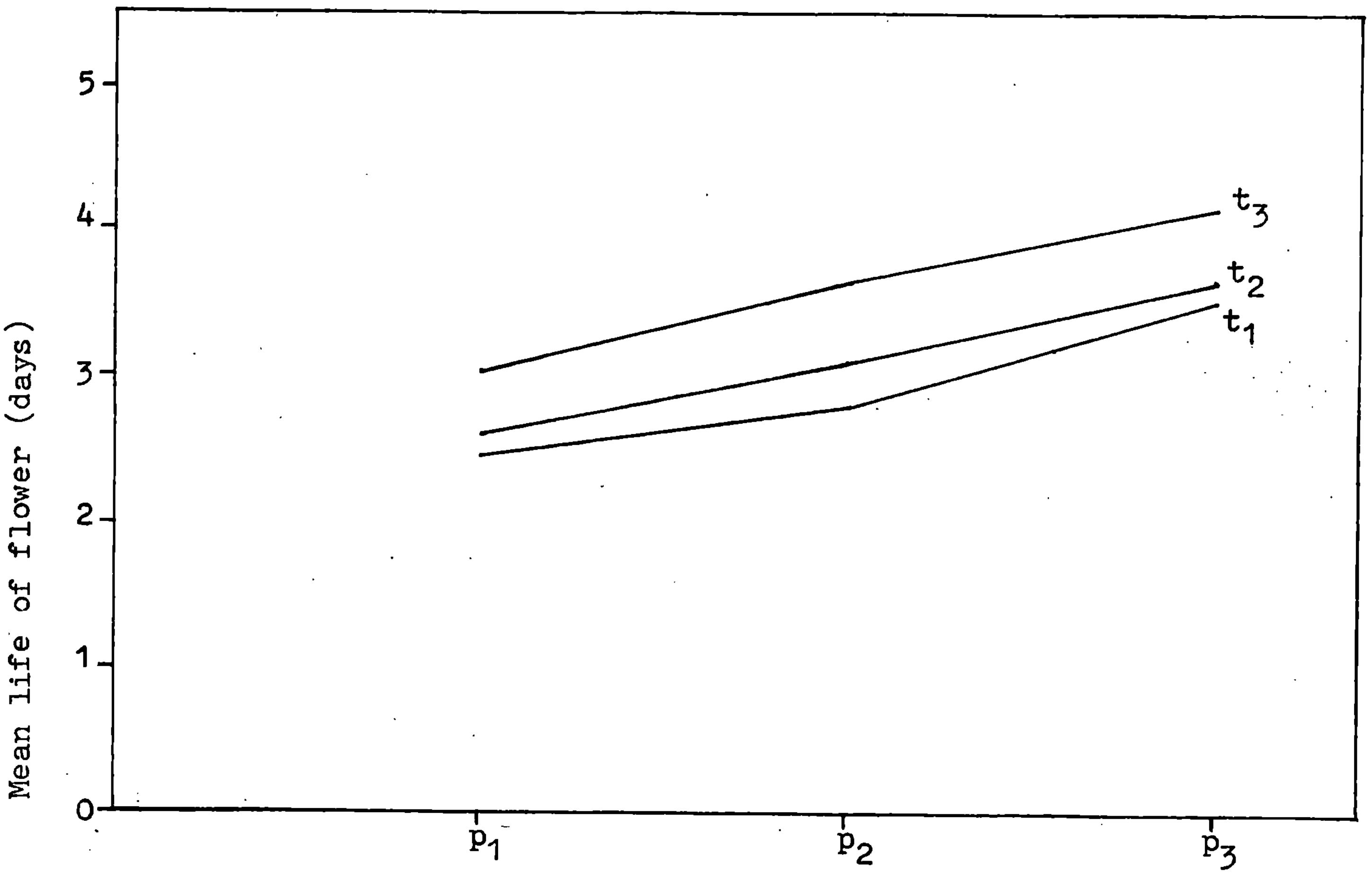


n_1 - 10 g per plant per year t_1 - 15 days

n_2 - 20 " t_2 - 30 "

n_3 - 30 " t_3 - 45 "

FIG. 8 INTERACTION EFFECT OF PHOSPHORUS AND INTERVAL OF FERTILIZER APPLICATION ON MEAN LIFE OF FLOWER



p_1 - 15 g per plant per year t_1 - 15 days

p_2 - 30 " t_2 - 30 "

p_3 - 45 " t_2 - 45 "

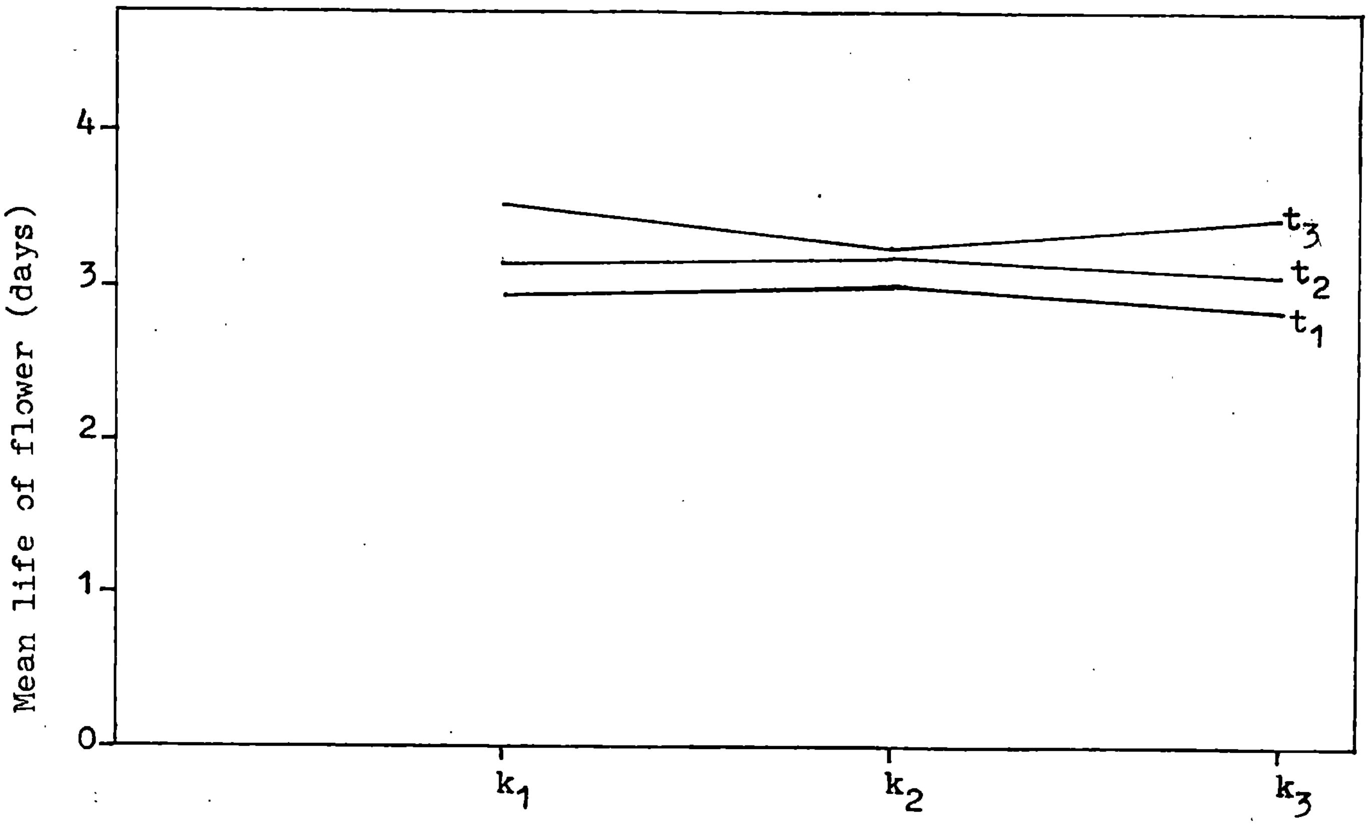
difference was seen in the mean life of flower at different levels of N (Fig. 7). N application at 30 days interval also showed no significant variation at different levels of N. But 45 days interval of N application, significantly reduced the mean life of flower, with increasing levels of nitrogen.

As the interval of N application increased there was a significant increase in the life of the flowers at 10 g per plant of N. When 20 g per plant of N was applied, maximum life of flower was noted at 45 days interval of application compared to 15 and 30 days intervals; while no significant difference was seen when N was applied at 15 and 30 days intervals. When the level of nitrogen was increased to 30 g per plant, 30 days interval of application significantly increased the life of flower compared to 15 and 45 days intervals. No significant difference was seen among 15 and 45 days interval of N application.

Application of P at 15 days interval of time showed a significant increase in the life of flower with increasing levels of P (Fig. 8). The same trend was noticed when P was applied at 30 and 45 days intervals, at different levels of P.

When 10 g per plant of P was applied at 15 and 30 days interval of time no significant difference was seen in the

FIG. 9 INTERACTION EFFECT OF POTASSIUM AND INTERVAL OF FERTILIZER APPLICATION ON MEAN LIFE OF FLOWER



k_1 - 5 g per plant per year t_1 - 15 days
k_2 - 10 " t_2 - 30 "
k_3 - 15 " t_3 - 45 "

life of flower, while P application at 45 days interval significantly increased the life of flowers compared to 15 and 30 days interval of application. This trend was again observed, when P at 45 g per plant was applied at different time intervals. Application of P at 30 g per plant significantly increased the life of flowers with increasing intervals of application.

Application of potassium at 5 and 15 g per plant at different intervals of time, significantly increased the life of flower, with increasing intervals of application. But application of K at 10 g per plant, significantly reduced the life of flower at 15 days interval, compared to 30 and 45 days interval of application. There was no significant difference in the mean life of flower when 10 g K was applied at 30 and 45 days intervals.

When potassium was applied at 15 days interval no significant difference was observed in the mean life of flower at first two levels (5 and 10 g) of K (Fig. 9). But 15 g of K applied at 15 days significantly reduced the life of the flower compared to 10 g of K. K application at 30 days interval showed no significant variation at different levels of K. But 45 days interval of application showed a significant reduction in the mean life of the flower at k_2 level compared to k_1 and k_3.

Table 11 Correlation of nitrogen, phosphorus, potassium and interval of fertilizer application with biometric characters

Characters	Nitrogen	Phosphorus	Potassium	Time interval of fertilizer application
Mean increase in height of the plant during a period of 15 days	0.1638	0.1121	0.3567**	0.3964**
Total number of sprouts produced	0.0806	0.0909	0.3506**	0.2736**
Total number of flowers produced	-0.0144	0.0597	0.3726**	0.2427**
Mean length of flower shoot	0.1875*	0.1821*	0.3619**	0.4544**
Mean thickness of flower shoot	0.1969*	0.2016*	0.3741**	0.4390**
Mean number of leaves in the flower shoot	0.1709*	0.1696*	0.4103**	0.4268**
Mean diameter of flower	0.2063**	0.1939*	0.4024**	0.4396**
Mean number of petals in a flower	0.2008*	0.1981*	0.3903**	0.4619**
Mean number of days taken for opening of flower bud	0.1908*	0.2330**	0.3889**	0.4717**
Mean life of flower	0.1094*	0.3236**	0.3571**	0.4663**

* Significant at 5 per cent level

** Significant at 1 per cent level

3. Correlation of N, P, K and T with biometric characters

Table 11 provides the results on the correlation of N, P, K and T with ten biometric characters. Nitrogen showed positive non significant correlation with mean increase in height of the plant and total number of sprouts produced. It's association with total number of flowers produced was negative and negligible (-0.0144). Significant positive correlation was existing between nitrogen and mean length of flower shoot, mean thickness of flower shoot, mean number of leaves in the flower shoot, mean diameter of flower, mean number of petals in a flower, mean number of days taken for opening of the flower bud and mean life of flower.

Phosphorus showed positive non significant correlation with mean increase in plant height, number of sprouts produced and number of flowers opened. Positive significant correlation was seen between phosphorus and other characters like mean length of flower shoot, mean thickness of flower shoot, mean diameter of flower, mean number of petals in a flower, number of days taken for opening of the flower and mean life of flower. From the different characters studied, the association of P with mean life of flower was the highest (0.3236).

Potassium exhibited highly significant positive correlation with all the characters studied.

Time interval of fertilizer application also showed high positive significant correlation with all the character under the study. Among these, highest correlation was seen with mean number of days taken for opening of flower bud (0.4717).

4. Inter correlation of biometric characters

Inter correlation of biometric characters from the study are presented in Table 12.

Mean increase in height of the plant showed highly significant and positive correlation with total number of sprouts produced, total number of flowers produced, mean length of flower shoot, mean thickness of flower shoot, mean number of leaves in the flower shoot, mean diameter of flower, mean number of petals in a flower, mean number of days taken for opening of flower bud, and mean life of flower. It's association with mean length of the flower shoot was the highest (0.8442).

Total number of sprouts produced also showed highly significant positive correlation with total number of flowers produced, mean length of flower shoot, mean thickness of flower shoot, mean number of leaves in the flower shoot, mean diameter of flower, mean number of petals in a flower, mean

Table 12 Inter correlation of biometric characters

Characters	Mean increase in height of the plant during a period of 15 days	Total number of sprouts produced	Total number of flowers produced	Mean length of the flower shoot	Mean thickness of the flower shoot	Mean number of leaves in the flower shoot	Mean diameter of flower	Mean number of petals in a flower	Mean number of days taken for opening of flower bud	Mean life of flower
Total number of sprouts produced	0.7103**									
Total number of flowers produced	0.6485**	0.8408**								
Mean length of flower shoot	0.8442**	0.6962**	0.5755**							
Mean thickness of flower shoot	0.8075**	0.6947**	0.5808**	0.9574**						
Mean number of leaves in the flower shoot	0.8395**	0.7238**	0.6181**	0.9722**	0.9523**					
Mean diameter of flower	0.8389**	0.7243**	0.6078**	0.9777**	0.9771**	0.9721**				
Mean number of petals in a flower	0.8214**	0.7069**	0.5936**	0.9590**	0.9708**	0.9514**	0.9846**			
Mean number of days taken for opening of flower bud	0.8093**	0.6828**	0.5731**	0.9570**	0.9706**	0.9443**	0.9815**	0.9856**		
Mean life of flower	0.7692**	0.6397**	0.5332**	0.9304**	0.9430**	0.9203**	0.9534**	0.9584**	0.9699**	

** Significant at 1 per cent level

number of days taken for opening of flower bud and mean life of flowers. Among these aspects highest correlation was seen with total number of flowers produced (0.8408).

Total number of flowers produced exhibited highly significant positive correlation with mean length of flower shoot, mean thickness of flower shoot, mean number of leaves in the flower shoot, mean diameter of flower, mean number of petals in a flower, mean number of days taken for opening of flower bud and the life of flowers.

Mean length of flower shoot showed positive and highly significant correlation with mean thickness of flower shoot, mean number of leaves in the flower shoot, mean diameter of flower, mean number of petals in a flower, mean number of days taken for opening of flower bud and the life of flower. It's association with size of the flower was the highest (0.9777).

Mean thickness of the flower shoot also showed high positive significant correlation with mean number of leaves in the flower shoot, mean diameter of flower, mean number of petals in a flower, mean number of days taken for opening of the flower bud and the life of flowers. Highest correlation was seen with size (diameter) of flower (0.9771).

Highly significant and positive correlation was observed between mean number of leaves in the flower shoot and other characters like mean diameter of flower, mean number of petals in a flower, mean number of days taken for opening of flower bud and mean life of flowers. Of these also, highest correlation was seen with mean diameter of flower (0.9721).

Mean diameter of flower exhibited highest positive significant correlation with mean number of petals in a flower (0.9846). It's association with mean number of days taken for opening of flower bud and mean life of flower were also positive and highly significant.

Mean number of petals in a flower showed highly significant positive correlation with mean number of days taken for opening of flower bud and mean life of flower.

Highly significant and positive correlation also existed between mean number of days taken for opening of flower bud and mean life of flowers.

DISCUSSION

V. DISCUSSION

Rose plants react differently to the application of major nutrients at different levels and at different splits. The present investigation was carried out to find out the effect of split application of nitrogen, phosphorus and potassium on the growth and flowering of rose cv. Happiness. The results obtained from the study are discussed under the following titles.

(i) Increase in height of the plant

The results given in Tables 1 to 4 indicated that no significant difference could be noticed in plant height increase, due to the application of different levels of nitrogen, phosphorus or potassium. So it is evident that minimal quantity of nutrients will be sufficient to meet the requirement of the crop in terms of plant height. Smith (1941) obtained hardy and vigorous rose plant at lower levels of N. Pal *et al*. (1985) reported that in *Jasminum sambac* phosphorus had no effect on plant height. The present results find support from this observation. But Young *et al*. (1973) obtained significant improvement in plant height of rose plants by higher dose of N. They further observed that the effect of P in increasing the plant height was less pronounced as compared to N. Yadav et al. (1985) also obtained an increase in height of rose plants with the increase in N level. Woodson and Boodley (1982) reported reduced growth in green house rose due to low K supply.

As the interval of fertilizer application increased the height of the plants also increased. This indicate the necessity of applying the correct quantity of nutrients at the correct time to rose plants. When the interval of fertilizer application was increased, the quantity of nutrients applied at a time also increased and the plant will get sufficient time for vegetative growth and flower production.

None of the interactions were found to affect significantly the height of the plants (Table 5 to 10). Yadav et al. (1985) observed that in rose, var. Montezeuma, NP interaction was not found significant on plant height. The result also agrees with the findings of Divakar (1983) in apple. He found that application of N and P did not show any significant difference on increase in plant height. But Williams and Thompson (1979) reported that N and P fertilization at planting time increased plant height in the first growing season of Golden Delicious apple trees on M-26 root stocks.

The data given in Appendix II reveals that in general the mean increase in height of plants were not influenced by various treatments compared to control. The treatment $n_1p_1k_3t_3$ showed the highest mean value (8.21 cm) for increase in plant height.

(ii) Production of new sprouts

N and P were not found to affect significantly the number of sprouts. The result agrees with the findings of Akbar (1979) in Edward rose, who reported that increasing levels of N had no significant influence on the number of vegetative shoots. So the lower doses of N will be sufficient for the production of shoots in rose plants.

The present study revealed that medium dose of potassium (10 g per plant) significantly increased the number of sprouts produced. Bhattacharjee (1985) observed that in *Jasminum grandiflorum* K_2O application increased the number of branches per plant.

Interval of fertilizer application did not influence the number of sprouts produced. This indicate that fertilizer application at longer intervals or reduced number of applications is sufficient for the crop with regard to production of new sprouts.

The interactions NP and NT were found to affect significantly the number of sprouts produced. But their main effects being insignificant, they are not important in producing variation in the number of sprouts. Chezhiyan et al. (1986) also observed significant interaction of nitrogen x phosphorus in respect of number of branches per plant in *Chrysanthemum indicum*.

The treatment combination $n_1p_2k_2t_2$ recorded the maximum number of sprouts. The study revealed that by manipulating the nutrient levels it may be possible to increase the production of sprouts. Increased production of shoots might help to produce more flowers and thus increasing the yield.

(iii) Number of flowers produced

The results given in Tables 1 to 4 revealed that there is significant difference in the number of flowers produced at different levels of N and K used.

In this study lower dose of N was sufficient for producing maximum number of flowers. Saini et al. (1978) observed that higher dose of N had an adverse effect on the number of flowers per bush in rose. The present study find support from this observation. Higher dose of N causes excess vegetative growth. The increased vegetative growth is at the expense of flowers. But according to many other workers increasing levels of N was found to increase flower production in rose (Nijjar and Rehalia, 1977; Young et al., 1973; Maharana and Pradhan, 1976; Yadav et al., 1985 and Nanjan, 1979).

Addition of phosphatic fertilizers did not affect significantly the production of flowers in the present study. Similar effect was observed in rose by Young et al. (1973) and Maharana and Pradhan (1976) and also in *Jasminum auriculatum* by Pal et al. (1984) and Muthuswamy and Pappiah (1963). The result of the present study showed that the lowest dose of P is sufficient for producing maximum number of flowers. But Williams and Thompson (1979) found that in apple with greater amount of P fertilizer, the number of flower clusters increased.

The effect of K on flower production was significant. The results showed that medium level of K is sufficient for maximum flower production. Saini et al. (1978) and Kamp and Pokorny (1958) observed that medium levels of K was beneficial for flower production in rose. However Bik (1970) in rose, cv. Baccara showed that K individually did not record any significant response on flower production. Interval of fertilizer application did not affect significantly the yield of flowers. But at shorter intervals of fertilizer application, a slight beneficial effect was noticed in the flower yield. Muthuswamy and Pappiah (1977) obtained similar results in Jasminum grandiflorum.

In this study NP, NT and KT interactions were found to affect significantly the production of flowers. Zal'tsfas and Chemarin (1974) and Yadav et al. (1985) also observed that NP interaction had a significant effect on rose flower yield.

The treatment combination which recorded the maximum number of flowers was $n_1p_2k_2t_2$. Bakly (1974) in Chryslar Imperial variety of rose plants observed that higher level of N and K combined with medium level of P produced highest return of cut flowers. In Rosa bourboniana Irulappan et al. (1980) found that a combination of medium levels of N, P and K was better for flower production.

(iv) Length of flower shoot

Increase in N levels significantly increased the length of flowering shoot. This may be due to the fact that N had a beneficial effect in increasing the general growth and vigour of the plant and N is a major constituent of plant protein, aminoacid and chlorophyll. The present result was in confirmity with the findings of several workers in rose (Bik, 1972; Young et al., 1973; Nanjan, 1973; Nijjar and Rehalia, 1977; Akbar, 1979 and Saini et al., 1978).

Phosphorus application showed no significant effect on length of flower shoot. So the lower level of P may be sufficient for producing enough length for the flower shoot. Saini et al. (1978) reported that high dose of P reduced the flower shoot length. The results of the present study find support from this observation.

With regard to K application, the lower level of K (5 g per plant) produced the longest flower shoot. Increasing K above this level significantly reduced the length of flower shoot. Sealey (1950) and Culbert (1948) observed that potassium apparently perform some important function in the elongation of flower shoot of roses. In the present study also K seems to be associated with the length of flower shoot, but above the optimum level it is detrimental to growth. However Bik (1972) reported that increasing K levels improved stem length in rose.

As the interval of fertilizer application decreased, or when the fertilizers were applied in more splits, the length of flower shoot increased. This may be due to the fact that frequent dressing with fertilizer will help in better uptake of nutrients and thus increase the general growth and vigour of the plant. But Kim et al. (1969) in apple found that there was no significant difference in shoot growth by the application of N in different splits.

The NK and NT interactions were found significant on the length of flower shoot. Longest flower shoot was produced by the treatment combination $n_2p_2k_1t_3$. But Akbar (1979) reported that in Rosa bourboniana, the treatment which had a high potash content relative to N and P registered the highest value for the length of flower shoot. All the treatment combinations increased the length of flower shoot compared to control.

(v) Thickness of flower shoot

N, P or K did not affect significantly the mean thickness of flower shoot. Hence it seems that the lower levels of these nutrients were sufficient with regard to the thickness of the shoot. But Hulle (1966) reported that in rose an increase in the rate of N application resulted in a larger collar diameter but K had little effect. Nijjar and Rehalia observed that the higher level of N was effective in increasing the stem diameter of rose, cv. Superstar. Interval of fertilizer application also did not influence the thickness of the shoot.

None of the interactions were found significant on the mean thickness of flower shoot. Ushakumari (1986) also found that the NK and PK interactions did not affect significantly the girth of the root stock at the time of budding.

In general thickness of the flower shoot was affected by all the treatments compared to control. The treatment which produced the maximum stem girth was $n_3p_1k_3t_3$. Bose and Jana (1978) observed that in Bougainvillea increased amount of N, P and K promoted maximum diameter of shoot. In the present study the treatment which had a high N (30 g) content than P (15 g) and K (15 g) registered the highest value for the thickness of the shoot. This shows the role of N in the vegetative growth and vigour of the plant.

(vi) Number of leaves in flower shoot

An increase in the number of leaves was observed by N, P and K application. But significant difference was not observed among different levels. Nanjan (1979) observed that application of nitrogenous fertilizers profoundly influenced the production of leaves in Edward rose. Increased production of leaves might help to synthesize more photosynthates and to augment the stimulus for flowering, thus increasing the yield of flowers. In this study, interval of fertilizer application also did not influence the production of leaves. Hence 45 days interval of application is sufficient for maximum leaf production.

NT and KT interactions were found to affect significantly the production of leaves. But their main effects being insignificant, they are not important in producing variation in the number of leaves. The treatment $n_2p_2k_2t_1$ showed the maximum number of leaves in the flower shoot. Raese <u>et al</u>. (1984) found that in apple a moderate rate of monoammonium phosphate (6 g per tree) resulted in trees with greater leaf number. In the present study all the treatment combinations were found to be beneficial compared to control.

(vii) <u>Flower size</u>

Application of N showed a significant increase in flower size. Increasing levels of N might increase the length of flower shoot which might have produced a flower with larger diameter. The result agree with the findings of Nijjar and Rehalia (1977); Saini <u>et al</u>. (1978) and Yadav <u>et al</u>. (1985) who observed that higher level of N was highly effective in increasing the diameter of flower.

Application of P and K did not show any significant effect on flower size. This is supported by the findings of Maharana and Pradhan (1976) in rose. Hence the present study reveals that lower levels of P and K is enough for producing flowers with good size.

Interval of fertilizer application also did not affect significantly the flower size. So it seems that 45 days of application is sufficient for the crop compared to 15 or 30 days interval of application. Natarajan and Rao (1983) stated that in *Jasminum grandiflorum*, split application of fertilizers did not affect the floral characters as compared with a single annual application.

The NK interaction significantly influenced the flower size. The treatment combination which showed the maximum value for the flower size is $n_2p_1k_2t_1$. All the treatment combinations were found to be effective compared to control. According to Maharana and Pradhan (1976) complete application of NPK considerably increased the size of flower. This statement also lends support to the present study.

(viii) Number of petals in a flower

Application of N, P or K did not affect significantly the number of petals in a flower. This shows that nutrients have no definite role in determining the number of petals in a flower. Akbar (1979) reported that in *Rosa bourboniana* number of petals in a flower were not significantly influenced by the nutrients. This statement provide support to the result obtained in the present study. None of the interactions were found to affect significantly the number of petals in a flower. In general no significant difference was observed between the treatment combinations and control.

(ix) Number of days taken for opening of flower bud

Application of N and K were not significant with regard to the number of days taken for opening of flower bud. But as the level of P increased there was a significant delay in the opening of flower bud. This shows that among the major nutrients only P has a role in the opening of the flower bud. Ushakumari (1986) also reported that higher levels of P delayed the flower opening of rose. Fertilizer application at longer intervals also delayed the opening of flower bud. So fertilizer application in more number of splits will help in the early opening of the flower bud.

NP, NT and PT interactions significantly affected this character. The treatment combination which recorded the least number of days for flower opening was $n_3p_2k_3t_1$. Bakly (1979) also reported that higher fertilization levels delayed flower opening of rose. All the treatments were found effective compared to control.

(x) Life of flower

Nitrogen application at higher levels significantly reduced the life of flower. This may be due to the fact that N application at higher levels will make the plant succulent and weakens the plant which will reduce the life of flower. Higher levels of P increased the mean life of flower. This can be supported by the fact that P strengthens the plant and keeps in a vigorous healthy condition. Saini (1977) also reported that longevity of rose flowers was improved by high dose of phosphorus and low dose of nitrogen. Application of K showed no significant effect on the life of flower. Bik (1972) found that increasing levels of potassium had no significant effect on the keeping quality of rose flower.

The interactions NP, NT, PT and KT significantly affected the life of flower. The treatment $n_1p_3k_3t_3$ recorded the maximum life of the flower. All the treatment combinations were found effective compared to control.

(xi) Correlation studies

Correlation of nitrogen, phosphorus, potassium and interval of fertilizer application with the biometric characters were studied. N and P showed positive significant correlation with characters like length of flower shoot, thickness of flower shoot, number of leaves in the flower shoot, diameter of flower, number of petals in a flower, number of days taken for opening of flower bud and life of flower. Of these, diameter of the flower was seen to be highly correlated with N application. But P was seen to be highly correlated with the life of flower. P application will strengthens the plant and will retain the flowers for more days. Application of K showed positive significant correlation with all the characters studied. So K is required for the overall growth and flowering of rose plants. Interval of fertilizer application also showed positive significant correlation with all the characters.

All the biometric characters under the study showed highly significant positive correlations among themselves. Their correlations ranged from 53.3 per cent to 98.6 per cent.

SUMMARY

VI. SUMMARY

An investigation was undertaken in the Department of Horticulture, College of Agriculture, Vellayani, for a period of one year starting from January, 1987 to find out the effect of graded and split application of N, P and K on the growth and flowering of one export variety of rose, Happiness. The experiment was designed in factorial CRD with two replications. The treatments consisted of the various combinations of three levels each of N, P and K applied in three different time intervals and one absolute control. The results of the study are summarised below.

1. In general the mean increase in height of the plants were not influenced by different levels of N, P and K. So it is evident that minimal quantity of nutrients will be sufficient to meet the requirement of the crop in terms of plant height. The treatment $n_1p_1k_3t_3$ showed the highest mean value (8.21 cm) with reference to increase in plant height. An increase in the interval of fertilizer application was found to increase the plant height.

2. Medium level of K (10 g) was found to produce maximum number of sprouts. Application of N, P or altering the interval of fertilizer application did not influence this character.

Only the NP and NT interactions were found to be significant. The various treatment combinations were not found to play a significant role compared to control.

3. Higher levels of K was found to increase the number of flowers produced. But lower levels of N and P were sufficient for maximum flower yield. The interactions NP, NT and KT were significant with respect to this character. The treatment $n_1p_2k_2t_2$ recorded the maximum number of flowers.

4. N application (30 g per plant) significantly increased the length of flower shoot. With regard to P and K the lower levels were found to be effective. When the fertilizers were applied in more splits, the length of flower shoot increased. The longest flower shoot was produced by the treatment $n_2p_2k_1t_3$ and the interactions n_3k_1 and n_3t_1.

5. None of the main effects or their interactions were found to affect significantly the thickness of the flower shoot. So the lower levels of N, P and K were sufficient with regard to the thickness of the shoot. But all the treatments proved to be effective in increasing the thickness as compared to control. The best treatment was $n_3p_1k_3t_3$.

6. The NT and KT interactions had significantly affected the number of leaves in the flower shoot. In general all the

treatments were found to be beneficial compared to control. The treatment $n_2p_2k_2t_1$ recorded the maximum value.

7. An increase in the level of N was found to increase the diameter of the flower significantly. Lower levels of P and K were sufficient for producing flowers with good size. The best treatment was $n_2p_1k_2t_1$ which recorded the maximum value (7.03 cm). Only the NK interaction was found significantly contributing to the difference in diameter of the flower.

8. Fertilizer application at 45 days interval was found to be beneficial for petal number. The main effects of N, P, K and none of their interactions were found to influence significantly the number of petals in a flower. The treatment $n_2p_2k_3t_3$ recorded the maximum number of petals.

9. Opening of the flower bud was delayed with an increase in the level of phosphorus. Fertilizer application at longer intervals was also found to delay the opening of flower bud. An early opening of the flower bud was found to be associated with the treatment $n_3p_2k_3t_1$ and interactions n_1p_1, n_3k_1 and p_1t_2.

10. Higher dose of N (30 g) was found to reduce the life of the flower significantly, while higher doses of P (45 g) increased

the flower life. Fertilizer application at longer intervals (45 days) was also found to prolong the life of the flower. The treatment $n_1p_3k_3t_3$ and the interactions n_1p_3, n_1t_3, p_3t_3 and k_1t_3 recorded the maximum value with respect to the longevity of the flower.

11. Nitrogen and phosphorus showed positive significant correlation with length of flower shoot, thickness of flower shoot, number of leaves in the flower shoot, diameter of flower, number of petals in a flower, number of days taken for opening of flower bud and life of flower. Among these, the diameter of the flower was found to be highly correlated with nitrogen application. But phosphorus showed highest correlation with mean life of flower. Potassium and interval of fertilizer application showed highly significant positive correlation with all the characters studied. All the biometric characters under the study showed highly significant positive correlation among themselves.

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*Originals not seen

APPENDICES

APPENDIX - I

CHEMICAL ANALYSIS OF SOIL

Constituents	Content (per cent)
Available N	0.085
" P	0.013
" K	0.042

APPENDIX - II

Effect of treatments on growth, yield and flower characteristics

Treatments	Mean increase in height of the plant during a period of 15 days (cm)	Mean number of sprouts produced	Mean number of flowers produced	Mean length of flower shoot (cm)	Mean thickness of flower shoot (cm)	Mean number of leaves in the flower shoot	Mean diameter of flower (cm)	Mean number of petals in a flower	Mean number of days taken for opening of flower bud	Mean life of flower in days
1	2	3	4	5	6	7	8	9	10	11
$n_1p_1k_1t_1$	3.82	20.0	9.0	16.08	1.14	5.92	5.25	15.13	3.43	2.35
$n_1p_1k_1t_2$	5.85	20.0	9.5	18.86	1.28	5.92	5.90	16.41	3.42	2.56
$n_1p_1k_1t_3$	6.13	22.0	12.0	19.03	1.30	6.56	5.71	17.72	3.33	3.61
$n_1p_1k_2t_1$	1.97	24.0	9.5	14.49	1.28	6.47	5.25	16.91	3.65	2.32
$n_1p_1k_2t_2$	3.90	28.5	12.5	15.68	1.37	6.20	5.18	15.28	3.49	2.69
$n_1p_1k_2t_3$	3.84	17.5	9.5	17.35	1.38	6.88	5.54	17.20	3.46	3.47
$n_1p_1k_3t_1$	3.08	46.0	25.0	18.97	1.42	7.02	6.05	18.17	3.75	2.31
$n_1p_1k_3t_2$	3.69	45.0	23.5	17.06	1.47	6.67	5.99	15.98	3.18	2.49
$n_1p_1k_3t_3$	8.21	28.0	20.5	19.28	1.45	7.31	6.06	16.18	3.55	2.71
$n_1p_2k_1t_1$	3.20	33.0	18.5	18.10	1.38	6.72	6.00	14.2	3.36	3.32
$n_1p_2k_1t_2$	4.75	13.5	4.5	16.29	1.37	5.09	5.25	16.17	3.54	3.84
$n_1p_2k_1t_3$	1.92	9.0	5.5	12.27	1.37	4.56	4.55	17.15	3.98	3.71

Appendix - II contd.

1	2	3	4	5	6	7	8	9	10	11
$n_1p_2k_2t_1$	2.84	25.5	8.0	15.45	1.37	5.65	5.46	17.50	3.60	3.05
$n_1p_2k_2t_2$	7.02	58.0	32.0	17.00	1.46	6.53	5.65	17.67	3.63	3.07
$n_1p_2k_2t_3$	5.03	33.5	18.5	16.27	1.23	6.65	5.57	16.37	3.73	3.46
$n_1p_2k_3t_1$	2.54	19.0	14.0	15.47	1.33	5.81	5.95	16.93	3.52	2.86
$n_1p_2k_3t_2$	5.30	18.0	6.5	19.91	1.30	8.35	6.62	16.67	4.03	3.96
$n_1p_2k_3t_3$	4.80	14.5	6.0	20.54	1.45	7.97	6.12	15.79	3.59	3.73
$n_1p_3k_1t_1$	3.23	20.0	7.0	15.88	1.33	6.28	5.60	16.00	3.55	3.31
$n_1p_3k_1t_2$	4.59	32.0	11.5	20.53	1.44	8.01	6.07	17.39	3.54	3.51
$n_1p_3k_1t_3$	3.09	10.5	7.5	22.09	1.63	6.55	6.08	17.88	4.50	3.96
$n_1p_3k_2t_1$	3.51	25.0	16.0	18.74	1.40	7.29	5.86	17.42	3.64	3.48
$n_1p_3k_2t_2$	4.21	19.5	6.0	15.83	1.43	7.89	5.70	17.72	3.62	4.11
$n_1p_3k_2t_3$	3.80	36.0	12.0	16.34	1.35	5.17	5.73	17.62	4.30	4.12
$n_1p_3k_3t_1$	2.45	32.5	21.0	19.12	1.36	6.59	5.95	17.01	3.75	3.50
$n_1p_3k_3t_2$	5.27	28.5	15.0	21.01	1.64	8.46	6.33	16.91	3.49	3.68
$n_1p_3k_3t_3$	6.88	10.0	2.5	17.75	1.26	6.09	5.56	19.25	4.09	4.42
$n_2p_1k_1t_1$	2.40	13.0	7.0	19.93	1.38	6.50	6.03	16.25	3.99	2.36
$n_2p_1k_1t_2$	3.21	17.0	2.5	13.75	1.64	5.70	5.62	15.75	3.42	2.42
$n_2p_1k_1t_3$	5.40	28.0	13.0	16.97	1.26	6.79	5.62	16.15	3.60	3.53
$n_2p_1k_2t_1$	1.98	22.0	10.5	20.91	1.47	7.57	7.03	16.64	3.49	2.42
$n_2p_1k_2t_2$	3.12	22.0	8.0	14.51	1.23	6.52	5.74	17.57	3.78	2.72

Appendix - II contd.

1	2	3	4	5	6	7	8	9	10	11
$n_2p_1k_2t_3$	6.00	26.0	10.0	19.03	1.29	7.28	5.79	16.05	3.61	2.62
$n_2p_1k_3t_1$	3.33	16.5	7.0	22.50	1.54	7.16	5.87	16.58	3.47	2.38
$n_2p_1k_3t_2$	4.00	30.0	14.0	16.86	1.43	7.35	5.85	17.35	3.36	2.72
$n_2p_1k_3t_3$	6.08	22.0	10.5	13.78	1.27	6.27	5.75	17.62	3.65	2.55
$n_2p_2k_1t_1$	2.65	20.0	9.5	15.94	1.38	6.98	5.65	16.84	3.64	2.55
$n_2p_2k_1t_2$	6.64	14.5	4.0	15.07	1.20	6.38	5.19	14.13	3.50	3.50
$n_2p_2k_1t_3$	7.00	9.5	2.0	27.88	1.60	8.00	6.63	19.00	4.25	4.00
$n_2p_2k_2t_1$	2.94	17.5	9.0	21.38	1.35	8.63	6.42	16.36	4.05	3.36
$n_2p_2k_2t_2$	3.98	34.5	15.5	20.62	1.56	7.69	6.42	17.38	3.79	3.58
$n_2p_2k_2t_3$	4.50	11.0	7.0	17.17	1.49	5.67	5.86	19.62	3.93	3.07
$n_2p_2k_3t_1$	3.31	28.5	16.5	17.73	1.29	6.71	6.03	13.89	3.32	2.69
$n_2p_2k_3t_2$	5.21	21.5	23.0	16.69	1.41	6.77	6.17	17.32	3.31	3.09
$n_2p_2k_3t_3$	2.25	10.0	3.0	14.13	1.37	4.88	5.32	19.75	4.13	4.13
$n_2p_3k_1t_1$	3.42	22.0	11.0	17.92	1.32	6.94	6.08	17.15	3.56	4.01
$n_2p_3k_1t_2$	4.95	29.0	12.0	16.61	1.41	6.36	5.84	19.24	3.65	3.45
$n_2p_3k_2t_1$	2.65	27.5	11.0	19.42	1.26	7.18	5.91	16.55	3.78	3.62
$n_2p_3k_2t_2$	5.40	24.0	9.5	14.32	1.60	5.81	5.76	16.09	3.80	3.18
$n_2p_3k_3t_1$	3.35	37.5	18.0	16.79	1.37	6.99	5.42	16.96	3.56	3.60
$n_2p_3k_3t_2$	6.65	44.0	28.0	18.46	1.35	7.54	5.99	15.77	3.76	3.42
$n_3p_1k_1t_1$	2.75	16.5	4.0	21.59	1.44	7.25	6.17	16.09	3.75	2.59
$n_3p_1k_1t_2$	4.92	19.5	7.5	19.80	1.49	6.70	5.85	17.75	3.25	2.30

Appendix - II contd.

1	2	3	4	5	6	7	8	9	10	11
$n_3p_1k_1t_3$	4.94	30.5	11.5	21.35	1.39	8.04	5.76	17.89	3.61	2.64
$n_3p_1k_2t_1$	2.91	41.0	13.0	22.51	1.64	8.46	6.09	18.78	3.46	2.60
$n_3p_1k_2t_2$	5.75	24.0	6.5	17.68	1.38	6.02	6.14	18.31	3.60	3.00
$n_3p_1k_2t_3$	7.29	36.0	15.5	17.02	1.44	6.70	5.92	16.81	3.92	2.83
$n_3p_1k_3t_1$	3.39	19.0	8.5	18.99	1.50	6.47	6.10	17.27	3.57	2.75
$n_3p_1k_3t_2$	5.25	18.5	8.5	19.51	1.36	7.34	6.03	17.22	3.59	2.47
$n_3p_1k_3t_3$	5.00	13.0	3.0	20.50	1.77	6.38	6.25	18.00	4.00	3.13
$n_3p_2k_1t_1$	2.47	20.5	5.5	26.62	1.20	7.02	6.70	16.44	3.39	2.55
$n_3p_2k_1t_2$	4.37	18.0	9.5	19.37	1.40	7.30	6.34	16.83	3.49	3.05
$n_3p_2k_2t_1$	1.17	13.0	5.5	13.22	1.11	6.47	5.32	16.45	3.75	2.72
$n_3p_2k_2t_2$	5.92	35.0	11.5	17.50	1.38	6.49	6.00	17.30	3.66	2.61
$n_3p_2k_3t_1$	2.47	11.0	4.5	21.25	1.43	8.40	5.75	16.17	3.17	2.42
$n_3p_2k_3t_2$	5.99	26.0	11.5	18.16	1.32	7.38	5.80	19.19	3.66	2.88
$n_3p_3k_1t_1$	2.59	20.5	5.0	21.13	1.72	7.03	6.11	17.29	3.34	3.63
$n_3p_3k_1t_2$	5.25	7.0	1.5	18.45	1.66	6.00	6.51	18.05	4.08	4.03
$n_3p_3k_2t_1$	3.02	19.5	5.5	20.27	1.38	7.36	5.94	17.96	3.59	3.65
$n_3p_3k_2t_2$	1.95	17.5	2.0	15.88	1.60	5.50	6.38	18.00	4.25	4.00
$n_3p_3k_3t_1$	2.77	20.0	7.5	21.79	1.47	7.50	6.42	18.33	3.25	3.09
$n_3p_3k_3t_2$	4.00	12.0	2.5	17.59	1.31	6.17	5.92	16.92	4.25	3.67
$n_0p_0k_0t_0$	1.80	31.5	13.5	12.78	1.12	4.53	5.20	16.18	3.28	2.42

APPENDIX - III

Table of Analysis of Variance on the mean increase in height of plant during a period of 15 days

Source	DF	MSS	F
Treatment	71	4.296	1.497
N	2	0.595	0.207
P	2	2.509	0.875
K	2	2.546	0.887
T	2	76.724	26.743**
N x P	4	3.918	1.366
P x K	4	1.416	0.494
N x K	4	1.020	0.356
N x T	4	0.894	0.312
P x T	4	7.045	2.456
K x T	4	0.754	0.263
Remaining interactions	39	3.044	1.062
Trt vs Ctr	1	11.032	3.845
Error	73	2.868	

SE = 1.1976

** Significant at 1 per cent level

APPENDIX - IV

Table of Analysis of Variance on mean number of sprouts produced

Source	DF	MSS	F
Treatments	71	175.625	1.615
N	2	263.777	2.426
P	2	133.481	1.228
K	2	630.215	5.796**
T	2	237.461	2.184
N x P	4	364.439	3.351*
P x K	4	161.337	1.484
N x K	4	188.606	1.734
N x T	4	274.664	2.526*
P x T	4	184.979	1.701
K x T	4	189.369	1.741
Remaining interactions	39	155.552	1.431
Trt vs Ctr	1	134.039	1.233
Error	73	108.739	

SE = 7.3736

* Significant at 5 per cent level

** Significant at 1 per cent level

APPENDIX - V

Table of Analysis of Variance on mean number of flowers produced

Source	DF	MSS	F
Treatments	71	72.093	2.083
N	2	371.528	10.732**
P	2	5.821	0.168
K	2	259.563	7.498**
T	2	29.760	0.859
N x P	4	134.802	3.894**
P x K	4	60.152	1.737
N x K	4	67.398	1.947
N x T	4	87.249	2.520*
P x T	4	77.819	2.248
K x T	4	103.358	2.985*
Remaining interactions	39	59.256	1.712
Trt vs Ctr	1	18.001	0.520
Error	73	34.616	

SE = 4.1603

* Significant at 5 per cent level

** Significant at 1 per cent level

APPENDIX - VI

Table of Analysis of Variance on mean length of flower shoot

Source	DF	MSS	F
Treatment	71	14.572	2.908
N	2	49.586	9.897**
P	2	1.064	0.212
K	2	24.705	4.931**
T	2	28.429	5.675**
N x P	4	11.181	2.232
P x K	4	2.008	0.400
N x K	4	25.691	5.128**
N x T	4	22.848	4.560**
P x T	4	4.596	0.917
K x T	4	9.459	1.888
Remaining interactions	39	16.796	3.353
Trt vs Ctr	1	59.063	11.789**
Error	73	5.009	

SE = 1.5827

** Significant at 1 per cent level

APPENDIX - VII

Table of Analysis of Variance on mean thickness of flower shoot

Source	DF	MSS	F
Treatment	71	0.031	0.928
N	2	0.058	1.747
P	2	0.069	2.081
K	2	0.003	0.113
T	2	0.028	0.843
N x P	4	0.069	2.060
P x K	4	0.043	1.295
N x K	4	0.011	0.331
N x T	4	0.021	0.645
P x T	4	0.028	0.855
K x T	4	0.013	0.543
Remaining interactions	39	0.035	1.071
Trt vs Ctr	1	0.155	4.641
Error	73	0.033	

SE = 0.1295

* Significant at 5 per cent level

APPENDIX - VIII

Table of Analysis of Variance on mean number of leaves in the flower shoot

Source	DF	MSS	F
Treatment	71	1.350	1.648
N	2	1.391	1.697
P	2	0.028	0.033
K	2	1.712	2.089
T	2	2.090	2.553
N x P	4	1.290	1.576
P x K	4	0.333	0.407
N x K	4	1.878	2.292
N x T	4	2.441	2.981*
P x T	4	1.796	2.191
K x T	4	2.297	2.804*
Remaining interactions	39	1.472	1.797
Trt vs Ctr	1	9.977	12.177**
Error	73	0.819	

SE = 0.640

* Significant at 5 per cent level

** Significant at 1 per cent level

APPENDIX - IX

Table of Analysis of Variance on mean diameter of flower

Source	DF	MSS	F
Treatment	71	0.291	2.109
N	2	1.313	9.511**
P	2	0.125	0.905
K	2	0.205	1.485
T	2	0.393	2.851
N x P	4	0.183	1.332
P x K	4	0.122	0.889
N x K	4	0.980	7.100**
N x T	4	0.044	0.324
P x T	4	0.125	0.904
K x T	4	0.068	0.496
Remaining interactions	39	0.337	2.442
Trt vs Ctr	1	0.946	6.851*
Error	73	0.138	

SE = 0.2628

* Significant at 5 per cent level

** Significant at 1 per cent level

APPENDIX - X

Table of Analysis of Variance on mean number of petals in a flower

Source	DF	MSS	F
Treatment	71	2.464	1.242
N	2	5.512	2.779
P	2	3.756	1.894
K	2	2.617	1.320
T	2	7.643	3.853*
N x P	4	2.130	1.074
P x K	4	1.704	0.859
N x K	4	0.265	0.133
N x T	4	3.214	1.620
P x T	4	3.890	1.961
K x T	4	1.837	0.926
Remaining interactions	39	2.715	1.369
Trt vs Ctr	1	1.488	0.750
Error	73	1.983	

SE = 0.9958

* Significant at 5 per cent level

APPENDIX - XI

Table of Analysis of Variance on mean number of days taken for opening of flower bud

Source	DF	MSS	F
Treatment	71	0.142	2.080
N	2	0.016	0.234
P	2	0.515	7.534**
K	2	0.174	2.552
T	2	0.863	12.617**
N x P	4	0.210	3.078*
P x K	4	0.021	0.312
N x K	4	0.072	1.053
N x T	4	0.176	2.581*
P x T	4	0.593	8.678*
K x T	4	0.078	1.153
Remaining interactions	39	0.093	1.363
Trt vs Ctr	1	0.287	4.200*
Error	73	0.068	

SE = 0.1849

* Significant at 5 per cent level

** Significant at 1 per cent level

APPENDIX - XII

Table of Analysis of Variance on mean life of flower in days

Source	DF	MSS	F
Treatment	71	0.580	8.795
N	2	1.225	18.560**
P	2	11.923	180.679**
K	2	0.150	2.278
T	2	2.530	38.346**
N x P	4	0.486	7.376**
P x K	4	0.077	1.180
N x K	4	0.056	0.859
N x T	4	0.300	4.551**
P x T	4	1.224	18.560**
K x T	4	0.186	2.825*
Remaining interactions	39	0.139	2.115
Trt vs Ctr	1	1.054	15.977**
Error	73	0.066	

SE = 0.1816

* Significant at 5 per cent level

** Significant at 1 per cent level

EFFECT OF SPLIT APPLICATION OF N, P & K ON THE GROWTH AND FLOWERING OF ROSE cv. HAPPINESS

By
NIRMALA GEORGE

ABSTRACT OF THE THESIS
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ABSTRACT

An experiment was conducted to study the effect of split application of N, P and K on the growth and flowering of rose plants. The experiment was laid out in factorial CRD with two replications. Three levels each of N, P and K applied at three different intervals were compared with one absolute control.

The effect of split application of nutrients has been proved by the results of the present study. In general, the mean increase in plant height was not affected by various treatments. The treatment combinations did not influence the production of sprouts also. Higher levels of K application increased the number of flowers produced, whereas higher levels of N reduced the flower yield. Maximum number of flowers were recorded by treatment with 10 g N: 30 g P: 10 g K applied at 30 days interval ($n_1p_2k_2t_2$). The longest flower shoot was produced by the treatment combination of 20 g N: 30 g P: 5 g K applied at 45 days interval ($n_2p_2k_1t_3$). All the treatments resulted in an increase in thickness of the flower shoot, and also the number of leaves in the flower shoot.

Diameter of the flower was found to increase significantly with increase in N level. The treatment with 20 g N:

15 g P: 10 g K applied at 15 days intervals ($n_2p_1k_2t_1$) recorded the maximum diameter for the flower. The treatments were not found to be effective for increasing the petal number compared to control. Opening of the flower bud was delayed by an increase in the level of phosphorus and also by the application of fertilizer at longer intervals. All the treatments were found effective in increasing the flower life. The treatment combination of 10 g N: 45 g P: 15 g K applied at 45 days interval ($n_1p_3k_3t_3$) recorded the maximum value for the flower life.

Diameter of the flower was seen to be highly correlated with nitrogen application. Phosphorus application showed highest correlation with the mean life of flower. All the biometric characters under the study showed highly significant positive correlation among themselves and also with the application of potassium.