EFFECT OF NUTRITION ON THE ESTABLISHMENT AND BUD TAKE IN BUDDED ROSES

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D E C L A R A T I O N

I hereby declare that this thesis entitled "EFFECT OF NUTRITION ON THE ESTABLISHMENT AND BUD TAKE IN BUDDED ROSES" 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 any degree, diploma, associateship, fellowship or other similar title of any other university or society.

Vellayani
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(S.USHA KUMARI)

C E R T I F I C A T E

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INTRODUCTION

INTRODUCTION

Some words instantaneously suggest beauty because they are associated with things that afford pleasure and delight. The word ROSE is one of them.

Flowers are among the loveliest objects on this earth. And among them the rose is the queen. In the beginning of its history, when the rose was a wild flower, rather simple in form and with a limited colour range, it must have been the fragrance that endeared it to man and made it the subject of legend and story. In modern times, however, the answer must be different. As a result of breeding work for several centuries, the rose has attained a wealth of form, ranging from the simple, five-petalled flower to the breathtakingly beautiful exhibition type of the show-bench, with a spectrum of colours in which only true blue and true black are missing. Although the delightful fragrance associated with the name is sometimes absent, or is faint and elusive, there still are many varieties which delight the senses (Pal, 1966).

A good supply of balanced plant nutrients is essential for a successful rose culture. Most Indian soils are deficient in nitrogen and organic matter. There are also

soils which are deficient in phosphorus, potassium and some of the secondary elements and trace elements too. A deficiency in any one will restrict the normal growth of the plant, and in extreme cases the plant may show signs of malnutrition.

Nitrogen is the all round growth element. It increases the green plant matter, stimulates growth of leaves and stems with consequent increase in plant size. Phosphorus works on the roots. Potassium stimulates flower blooming, improves flower colour and promotes disease and drought resistance.

Eventhough many studies have been conducted regarding the effect of nutrients on the growth and yield of rose plants the exact role of inorganic fertilization on the establishment and bud take of budded rose plants is not yet studied. Rose is commercially propagated by budding and the roses are gaining popularity because of their multifarous uses and therefore, there is a heavy demand for quality budded rose plants. The present study was therefore undertaken with the following objectives.

1. to study the effect of major nutrients and their interaction on the establishment and bud take of budded rose plants.

2. to find out the optimum dose of fertilizers for the better establishment and bud take of budded rose plants.

3. to study the effect of mineral nutrition on the flower bud initiation in young rose plants.

REVIEW OF LITERATURE

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 requirement of nutrients, especially their effect on bud take. The available literature on nutrition of rose and allied crops related to this study are reviewed here.

Effect of Nitrogen, Phosphorus and Potassium on growth

Nitrogen is an essential nutrient to promote vigorous growth and its ample supply ensure adequate size of plant, length of stem and size of leaf and bloom in chrysanthemum (Kyle, 1950). Lunt and Kofranek (1958) reported that nitrogen was very essential for the first 50 days of growth from planting. Potassium maintains the health and helps the plant to ward off diseases and assist the plant in converting sap sugar to plant tissue. Deficiency of potassium resulted in poor growth and brown foliage at the leaf edges (Kyle, 1958).

Smith and Golner (1961) reported that stem length was adversely affected by low potassium (50 ppm) and high nitrogen (400 ppm) treatments. Pal (1966) recommended application of N, P and K for better growth.

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/EM.106 was unaffected by fertilizer treatments (Cline, 1966). Increase in the plant height due to the higher dose of nitrogen was reported in rose varieties Christian Dior and Happiness (Young et al, 1973). Soukup and Stankova - Opolenska (1974) reported that one-year-old seedlings of Rosa canina pollumeriana cv. Pavur Cerveny Sipek, grew best with 1 N : 2.36 P_2O_5 : 2.47 K_2O : 1.43 CaO : 0.18 MgO applied at 5g/l 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 bushes cv. Rouge Meilland was found increased by spraying with 1 per cent urea (Hassan et al, 1976).

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 the low dose of nitrogen (25 g) (Nijjar and Rchalia, 1977). Goode et al. (1978) reported that higher rates of nitrogen increased growth in Cox's Orange Pippin apple trees.

With low nitrogen compared with a normal nitrogen level there was a reduction in the total growth and root weight as reported by Johansson (1978). Sampaio and Moraes (1980) reported that nitrogen application at 20, 40, or 60 g (per m of row) had no appreciable effect on scion shoot height in plants of citrus on Poncirus trifoliata.

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 root stocks. Phosphorus fertilizer resulted in an increase in trunk diameter. Increase in trunk diameter of peach trees variety Golden Jubilee due to the application of nitrogen, phosphorus and potassium in various combinations has reported by Degtyar (1979). Tree trunk girth increment was greatest in trees receiving the highest nitrogen, phosphorus and potassium rates. During the first two years of the rose variety Ekteal'za best growth was observed with nitrogen and potassium fertilizers given both before planting and as a top dressing (Nantrova, 1979).

Kerpe Gouda (1982) recommended the use of 8g nitrogen and 24 g potassium per plant for getting maximum stem girth in rose.

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

Three consecutive annual nitrogen applications to mature pear trees at 120 kg/ha increased shoot growth compared to no nitrogen (Lombard et al, 1982).

The application of nitrogen and potassium did not show the 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 to increase the trunk girth of the plants than the control and higher level of phosphorus (Divekar et al, 1984).

Effect of nutrients on Flowering

Growth of roses variety Hunter Value in high potassium and low nitrogen concentration resulted in less reddish and more bluish roses, while cultivation in a low nitrogen concentration, irrespective of the K/N ratio,

resulted in roses which were more highly coloured than those grown in high concentrations of Nitrogen and Potassium (Lindstrom and Markakis, 1963). Pal (1966) recommended application of nitrogen, phosphorus and potassium for better flowering. Watana (1968) found a significant increase in number of flower stems and flower stem length with the increased application of nitrogen and phosphorus. An emphasis on nitrogen application for improved flower production has been given by Mattson and Widmer (1971).

The flower bud initiation was found to accelerate in apple, pear, plum and sourcherry scions grafted on to root stocks by nitrogen and phosphorus nutrition but not by potassium application (Nesterov et al, 1972). Bik (1972) found that rising 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 flower fresh weight. At low potassium or nitrogen levels, increasing either potassium or nitrogen depressed flower fresh weights.

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. Increase in flower number, flower stem length and number of strong flowering shoots per plant with the increase in nitrogen level was also reported by Dakly (1974). Flower yields and quality were highest with an NPK mixture of 90 : 180 : 90 g/plant.

Nanjan and Muthuswamy (1974) showed that the foliar nutrient treatments 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 3.03 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'tsas and Chemarin (1974) stated that when phosphorus was increased from 60 to 100 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 only. Johnsen (1975) showed that in chrysanthemum equal amounts of nitrogen

and potassium in any factorial combinations between 110 - 330 kg per hectare had no effect in most cases on the number of blooms per square meter, bloom diameter, length of stem or earliness.

Jayaprasad (1976) reported that maximum number of shoot and total stem length were obtained in "Superstar" rose under the individual influence of 8 g nitrogen and 16 g of potassium per plant. Mharana and Pradhan (1976) found that flower numbers 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 Rchalia (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 results on flower production of the rose cultivar "Chrysler Imperial" were obtained with 300 kg of calcium nitrate, 400 kg calcium super phosphate and 150 kg potassium sulphate (El - Gamassy et al, 1977).

The best flower yields were obtained from roses variety Baccara on Rosa canina 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 an normal nitrogen level a reduction in the flower number and stem weight was reported by Johansson (1978). Low phosphorus also reduced flower number, flower weight and petal number.

Kosova *et al.* (1978) reported that oil bearing - kazanluk rose bushes receiving 70 kg per hectare each of nitrogen, phosphorus and potassium produced higher flower yields than unfertilized controls. Soil application of nitrogen (67 - 134 kg per hectare) delayed blooming in peach trees variety Red Globe (Reeder and Bowen, 1978).

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). Williams and Thompson (1979) obtained greatest number of flower clusters in apple trees as a result of application of 0.046 kg phosphorus per tree in combination with daminozide.

Malik (1980) reported that the number of flowers produced in the variety, Queen Elizabeth increased with the

increase in nitrogen level and largest number of blooms were obtained with 20 g nitrogen per hectare.

Hansen and Granslund (1980) reported that flower bud formation increased in apple trees grown without potassium compared with trees receiving potassium.

Woodson and Boodley (1982) found that low potassium limited flower production regardless of nitrogen form in green house roses.

In one-year-old Edward roses, 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 (Yadav 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).

Studies on bud take

Said and Inayatullah (1965) found that application of sulphate of zinc to the root stocks of sour orange before budding had a significant effect on the take. The

use of Ammonium sulphate resulted in the highest percentage of budding survival in apple as reported by Sabirov and Razzakov (1967).

Kudratov (1972) reported that application of nitrogen, phosphorus and potassium at 60 : 45: 30 kg per hectare 25 -30 cm deep into the soil fifteen days before budding resulted in better take and production of apple (82.3 per cent) and plum (79.3 per cent) transplants compared with the next best variant NK in apples (74.1 per cent) and NP in plums (72.8 per cent) and with the unfertilized control (52.4 per cent in apples and 49.8 per cent in plums).

No positive relationship between petiole drop and successful bud union was found in peach and pear until about 10 days after budding when both processes were almost complete (Iseki et al, 1973). Lundstad (1973) found that the bud take was better on Rosa multiflora than on Rosa canina. With Rosa canina there was a greater percentage of take on the largest (8-12 mm) root stocks than on the other sizes. Plant height increased with increasing collar diameter for both root stocks.

The bud take was lower in peach with thin seedling root stocks than with the other sizes, but no differences in response between root stock size were observed with plum or apricot (Pandey and Srivastava, 1974). The survival and the final height and diameter of all trees were considerably greater on the thickest root stocks.

Sampaio and Ibnaes (1980) found that the bud take was highest (90 per cent) in Pongiru tibfoliata root stocks when the root stocks were cut at 2/3 of their length.

The thinnest root stocks resulted in the highest percentage of discards in apple as reported by Oosten and Grocne (1982). They recommended a root stock diameter of 7 - 9 mm for budding.

Effect of fertilization on nutrient content of plants

Cline (1967) reported that leaf nitrogen and leaf potassium reflected fertilizer treatments in apple trees. However, levels of both nitrogen and potassium were adequate even without fertilizer applications. Magnesium uptake was depressed to deficient levels by potassium fertilization. Both scion variety and root stock had an important influence on leaf composition.

Knoblauch (1971) found that the optimal levels of nutrients in rose leaves were 3.9 to 4.6 per cent nitrogen, 0.55 to 0.65 per cent phosphorus and 1.85 to 2.6 per cent potassium. The leaf nitrate - N varied directly with applied N and varied inversely with applied P in citrus trees (Bar-Akiva, 1972). It was also affected by applied K.

Stoilov and Lokhova (1974) observed that the increasing N rates raised the leaf N concentration in apple trees on both root stocks (M. 7 and M. 4). A negative relationship was found between leaf N content and P or K. Leaf phosphorus levels of both Elberta peach seedlings and M.104 apple root stocks budded with Red Haven peach and Jonathan apple rose in the third year by orchard applications of super phosphate.

Placais (1976) found that the leaf N content continued to rise in citrus trees, eventhough at higher rates yields were sharply depressed. The soluble N fraction increased in young apple trees when they were supplied with ammonium nitrate (0.4 g in 100 ml water) into the soil at selected times during the annual growth cycle (Catlin and Priestley, 1976).

Nijjer and Rehalia (1977) found a direct relationship between the doses of N, P and K and their foliar contents in roses. Application of N had a favourable effect on P and K content in rose leaves. Application of P also had a favourable effect on N content in the leaves. Ammonium nutrition led to higher leaf N and P contents than nitrate nutrition in apple leaves (Manolakis and Ludders, 1977). Matsui et al. (1977) found that Delicious apple trees which were given no P grew poorly with a leaf P level of 0.1 per cent. Phosphorus level was negatively correlated with K. only the heaviest P treatment kept leaf P at an adequate level throughout the study.

Leaf N content in chrysanthemums declined from 5.3 to 4.4 per cent at the lower application rates (Sciaroni et al. 1977). They reported that leaf K content also showed a similar trend. Cassin et al. (1977) found that root stock had a pronounced effect on leaf mineral composition in citrus trees. Trees on Poncirus trifoliata and Troyer Citrange had higher leaf N and P than sour orange. Sadowski et al. (1978) reported that optimal foliar N level in apple trees was observed on plots receiving the lowest N rate. Foliar P level eventually decreased under the highest N rate.

Buds from peach trees that received high N was found to contain higher levels of N and lower levels of carbohydrates than buds from trees receiving no N (Reeder and Bowen, 1978). The data on leaf mineral element composition in Red Delicious apple plants indicated that there was a response to N at the highest level in the second year, to P_2O_5 at 20 g per tree in two years, and to K_2O at 25 g per tree in all three years.

Armitage and Tsuyitha (1979) reported that increasing the N level to 400 ppm in roses, resulted in higher foliar N content in lighted roses. The leaf nutrient content reported in green house roses after N, P and K treatment averaged 3.04 per cent N, 0.29 per cent P and 2.14 per cent K over the five main harvests (Johansson, 1979).

Kalvoznukho (1980) reported that in apple trees, generally, NPK nutrition increased leaf N but decreased P and K, especially in Renet Simirenko. The leaf content of nutrient elements were found to be 2.57 to 2.65 per cent N, 0.162 to 0.19 per cent P and 1.05 to 1.23 per cent K.

The leaf K concentration was found to reduce at the lowest K concentrations in green house roses (Woodson and Boodley, 1982). Mehta et al. (1983) found that NPK had a more beneficial effect on leaf K than K applied alone in

apple trees. Leaf K peaked in May, July and September. Raese and Jarvis (1983) reported that the highest N rate was associated with higher leaf N in trees. High urea rate in combination with soil - applied paclobutrazol was associated with increased leaf N.

Fallahi et al. (1984) found that leaf mineral composition of Golden Delicious apple trees on six root stocks was influenced by N and K fertilizers. Nitrogen application significantly increased leaf N and Mg but decreased P and K. Divakar et al. (1984) observed that the N concentration in the leaves of Royal Delicious apple trees was significantly increased with increasing N rates. No significant effect of N was found on P and K concentration of the leaves. K status increased in the leaves with increasing level of K application. The concentration of N increased initially, but later decreased with the increasing level of K.

The highest N level decreased the absorption of N and K in apple trees but had little effect on the uptake of P (Lebedev, 1984). The optimum ratio of N, P and K in the biomass was 3.1 : 1 : 3.8. The correlation coefficients between the rate of N and the rate of N, P and K absorption by the roots were 0.393, 0.755 and 0.335 respectively.

Mehta *et al.* (1984) reported that the initial P level generally decreased in leaves of Royal Delicious apple trees and then gradually rose when NPK fertilizers were applied in the soil. Increased leaf N was measured at the highest N rate in Golden Delicious apple trees for one year (Nielsen *et al.*, 1984).

MATERIALS AND METHODS

MATERIALS AND METHODS

The present investigation was carried out to study the effect of major nutrients such as nitrogen, phosphorus and potassium on the establishment and bud take 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 Department of Horticulture, College of Agriculture, Vellayani.

Pot mixture

A standard pot mixture consisting of 1:1:1 parts by volume river sand, red loam and dried powdered cowdung was used for growing the root stock.

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

Planting

Cuttings of *Rosa multiflora* with uniform age and thickness were planted in earthern pots of 8 inch size,

containing approximately 2 kg of pot mixture during September, 1984. Plants were irrigated daily.

Experimental design

The experiment was laid out in Completely Randomised Design with a factorial combination of one hundred and twenty five treatments and three replications. Each replication consisted of a group of 4 plants. The treatment consisted of the various combinations of 5 levels each of the NPK nutrients. Nitrogen was given in the form of urea, phosphorus as super phosphate and potassium as muriate of potash. The dosages of the nutrients tested in the experiment are as given below.

Treatments		Dosages g/plant grown in 8 inch diameter pots
Nitrogen (N)	N_0	0
	N_1	0.25
	N_2	0.5
	N_3	0.75
	N_4	1

Treatments		Dosages g/plant grown in 8 inch diameter pots
Phosphorus (P)	P_0	0
	P_1	0.25
	P_2	0.5
	P_3	0.75
	P_4	1
Potassium (K)	K_0	0
	K_1	0.25
	K_2	0.5
	K_3	0.75
	K_4	1

Application of nutrients

The nutrients in different combinations were applied fifteen days prior to budding.

Budding

The budding was carried out during the last week of June, 1985. The buds were collected from the variety 'Happiness' and budding was completed within a period of four days. The maximum and minimum temperature, relative humidity and rainfall during the days of budding is given

in Appendix 2. The method adopted was T - budding which is the most popular method for propagation of roses.

Irrigation

The pots were irrigated once daily in the morning and the quantity of water limited(½ lit per plant) so as to prevent loss of nutrients by leaching.

Plant protection

No serious incidence of pests or disease was noticed in the plants during the period of observation. However as a prohylatic measure Ekalux EC-25 was sprayed periodically.

Observations

Morphological characters

Observations on morphological characters were recorded at periodic intervals till first flower opening.

1. Thickness of the root stock

Thickness of the root stock at collar region was recorded at the time of budding.

2. Fall of Petiole

Number of days taken for the fall of petiole starting from the day of budding was recorded.

3. Initiation of buds

Number of days taken for the initiation of buds after budding was also recorded.

4. Appearance of first leaf

Number of days taken for the appearance of first leaf in each budded plant was recorded.

5. Appearance of subsequent leaves

After the first leaf emergence the emergence of subsequent leaves were noted at periodic intervals. Number of leaves at the time of flowering was also recorded.

6. Height of the scion

After initiation of buds the height of the scion was noted at 15 days interval till the completion of the experiment.

7. First flower bud

Number of days taken for the appearance of first flower bud in each budded plant was recorded.

8. First flower opening

The number of days taken for the opening of the first flower bud was noted.

Chemical studies

To study the changes in the nutrient contents of leaves, leaf samples were analysed before the application of fertilizers and at the time of budding.

1. Nitrogen content (Microkjeldahl method)

Plant sample dried, powdered and accurately weighed to 0.5 g was placed in a 100 ml conical flask and 10 ml concentrated H_2SO_4 added to sample and digested. Heating was continued till the whole sample is digested and the content in the flask turned clear. After cooling the digest was made upto 100 ml. 10 ml of made up solution was then distilled collecting the distillate in a conical flask containing 10 ml of 4 per cent boric acid. It was then back titrated against acid.

2. Phosphorus content (vandomolybdo phosphoric yellow colour method)

A standard curve was prepared using 0, 1, 2, 4, 6, 8 and 10 ml of 50 ppm solution of potassium di phosphate.

The 0.5 g of the plant material was taken, digested and made upto 100 ml, 5 ml of this plant extract was then taken in a 50 ml volumetric flask and developed the colour. This colour was then read in a Klett summerson photoelectric colorimeter and concentration of phosphorus in ppm was found out from the standard curve. From this value concentration of phosphorus in percentage was calculated.

3. Potassium content (Flame photometer method)

A standard curve was prepared using 2, 4, 6, 8 and 10 ppm of potassium. Then 5 ml of the extract was taken in a volumetric flask and diluted with distilled water. This was then read in flame photometer (Jackson, 1967).

Character of the pot mixture

To know the content of nutrients in the pot-mixture samples were taken before applying the fertilizers and analysed for available nitrogen, phosphorus and potassium.

2. Available nitrogen (Modified microkjeldahl method)

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. Carefully started heating the flask. The free ammonia thus released was absorbed in 20 ml of N/50 H_2SO_4 and 2 or 3 drops of methyl red indicator at the outlet of the condenser. The excess H_2SO_4 was titrated against N/50 NaOH.

3. Available Phosphorus (Bray's method)

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 filter paper, collecting the filtrate 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 fed to photoelectric colorimeter. The ppm concentration of P was found out from the standard curve.

4. Available potassium (Ammonium acetate method)

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

Statistical analysis

The data on different characters were subjected to statistical analysis by using the analysis of variance technique for Factorical experiment in completely Randomised Design. The critical difference for compairing treatment means was found out by using the Tukey's Q method (Panse and Sukhatme, 1967).

RESULTS

RESULTS

The biometric data and the results of the chemical analysis obtained from the present investigation on the nutritional studies on roses were analysed statistically. The mean values of various experimental data and the critical differences pertaining to each of them are presented in Tables 1 to 30 and Appendices 3 to 7.

Effect of Nitrogen

Girth of the stock at the time of budding

The observations on the girth of the stock at the time of budding (Table 1) showed that the effect of nitrogen was not significant. However, the girth was found to increase at higher levels of nitrogen. The maximum girth was observed with the treatment N_3 (0.75 g N) and the minimum with the treatment N_1 (0.25 g N).

Days taken for the fall of petiole

Significant differences were observed among the different treatments with regard to the number of days taken for the fall of petiole (Table 1). Nitrogen application at the highest level resulted in a significant reduction in the number of days taken for the fall of petiole when compared to

all other treatments. The number of days for the retention of petiole was found to be more at medium levels (0.5 and 0.75 g per plant) of nitrogen.

Days taken for the initiation of buds

There was significant difference between treatments with regard to the number of days taken for the initiation of buds (Table 1). The earliest sprouting was found when nitrogen was given at the rate of 0.75 g per plant (11.39), but this was not significantly different from the application of nitrogen at 1 g per plant. However, all the nitrogen applications were found to be superior when compared to control.

Days taken for the emergence of leaves after bud initiation

The treatments differed significantly in their effect on leaf emergence. The earliest leaf emergence was observed when nitrogen was given at the rate of 0.75 g per plant. (Table 2). But application of nitrogen at the rate of 1 g per plant was not significantly superior from its preceding lower rate with regard to the days taken for leaf emergence. All the four levels of nitrogen significantly influenced the early emergence of the first leaf than the control. But with regard to the emergence of subsequent

leaves the two lower doses of nitrogen did not produce any significant response. The average number of days taken by plants treated with nitrogen at the rate of 0.25 g was found to be significantly higher than the control plants.

In general, application of nitrogen at the higher levels (0.75 and 1 g per plant) resulted in a significant reduction in the number of days taken for leaf emergence(Fig.1).

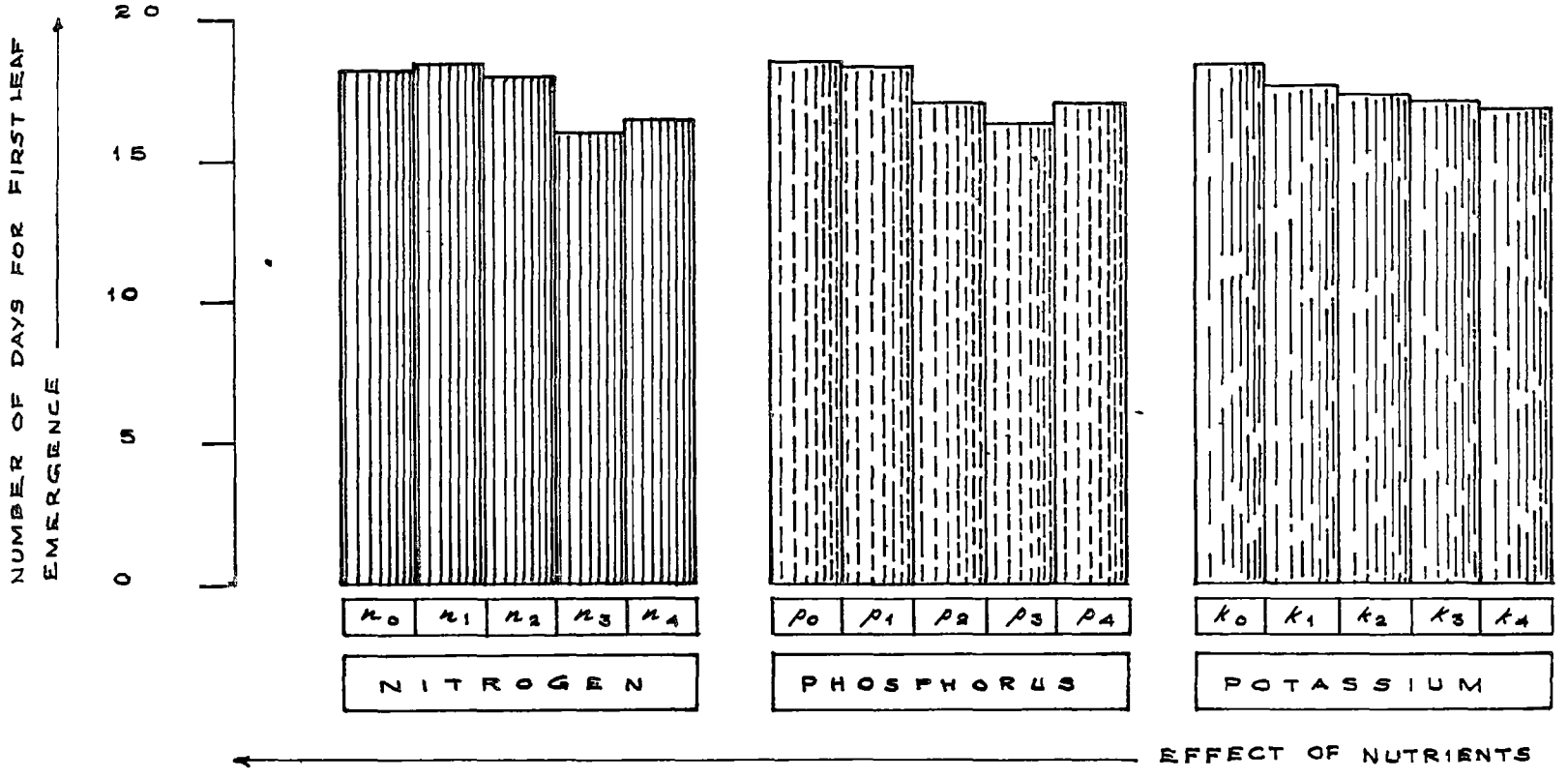
Height of the plants at periodic intervals after budding

At all stages of growth the plants which received 0.75 g nitrogen showed maximum height (Table 3). This was on par with the treatment of 1 g nitrogen per plant. The application of nitrogen at 0.75 g per plant showed the maximum plant height at 30th, 45th and 90th days after budding. However, all the treatments were found to be significantly superior to control.

Days taken for the initiation of first flower bud and flower opening

The data presented in Table 4 revealed significant variation among the treatments with respect to the number of days taken for the initiation of first flower bud.

FIG 1 DAYS TAKEN FOR FIRST LEAF EMERGENCE



$n_0/p_0/k_0$ – 0 g N/P/K / PLANT
$n_1/p_1/k_1$ – 0 25 g N/P/K/ PLANT
$n_2/p_2/k_2$ – 0 50 g N/P/K / PLANT
$n_3/p_3/k_3$ – 0 75 g N/P/K/PLANT
$n_4/p_4/k_4$ – 1 0 g N/P/K/PLANT

Nitrogen application at the level of 0.75 g per plant required less days for flower bud initiation (54.99) compared to control (56.67). All the other levels of nitrogen were also found effective in shortening the number of days taken for flower bud initiation.

However, there was no significant difference between treatments with regard to the number of days taken from flower bud initiation to flower opening. The range of variability was from 11.89 days for control to 13.41 days for 1 g nitrogen per plant. All the treated plants showed significant delay in flower opening when compared to control. As the levels of nitrogen increased a progressive delay in flower opening was observed.

The nutrient content of leaves

Data on NPK content of leaves (Table 5) showed that the effects due to different levels of nitrogen were significant. The nutrient contents exhibited an increasing trend with higher levels of nitrogen. The nutrient content was maximum when 0.75 g of nitrogen was applied (2.20 per cent N, 0.47 per cent P and 1.61 per cent K).

Table 1. Effect of nitrogen on girth of the stock, fall of petiole and initiation of buds

Levels of nitrogen (g/plant)	Girth of the stock at the time of budding	Days taken for the fall of petiole	Days taken for bud initiation
0	1.36	9.80	15.27
0.25	1.27	11.39	14.65
0.5	1.30	9.66	12.41
0.75	1.38	9.67	11.39
1.0	1.37	9.21	11.65
C.D. (5%)	-	0.21	0.16

Table 2. Effect of nitrogen on the number of days taken for the emergence of leaves after bud initiation

Levels of nitrogen (g/plant)	Position of leaves				
	First	Third	Fifth	Seventh	Nineth
0	18.28	20.70	24.31	28.84	34.38
0.25	18.47	21.24	25.38	30.80	36.84
0.5	17.88	20.00	24.07	29.06	35.22
0.75	15.87	18.29	22.67	27.73	33.74
1.0	16.56	18.70	22.63	27.61	33.48
C.D. (5%)	0.16	0.47	0.28	0.33	0.37

Table 3. Effect of Nitrogen on plant height at periodic intervals

Levels of Nitrogen (g/plant)	Days after budding				
	30	45	60	75	90
0	2.83	8.45	24.29	33.03	38.02
0.25	3.47	9.41	23.32	38.28	45.34
0.5	4.00	9.68	24.94	38.50	45.48
0.75	4.48	10.75	26.89	41.87	49.83
1.0	3.96	10.68	27.10	42.07	49.55
C.D. (5%)	0.52	0.22	0.39	1.26	0.39

Table 4. Effect of nitrogen on Flowering

Levels of nitrogen (g/plant)	Days taken for the initiation of first flower bud	Days taken for the flower opening after initiation
0	56.67	11.89
0.25	59.57	12.75
0.5	56.98	12.03
0.75	54.99	12.63
1.0	59.32	13.31
C.D. (5%)	0.73	-

Table 5. Effect of nitrogen on NPK content of leaves

Levels of nitrogen (g/plant)	N	P	K
0	1.22	0.37	1.47
0.25	1.23	0.39	1.58
0.5	1.75	0.44	1.48
0.75	2.20	0.47	1.61
1.0	2.11	0.47	1.22
C.D. (5%)	0.009	0.006	0.012

Effect of Phosphorus

Girth of the stock at the time of budding

Significant difference was observed between the different treatments with regard to the girth of the stock at the time of budding. The highest girth of 1.45 cm was recorded when phosphorus was given at the rate of 1 g per plant. The control plants showed a girth of 1.34 cm.

Days taken for the fall of petiole

A significant variation was observed between treatments in respect of the number of days taken for the fall of petiole (Table 6). Application of phosphorus at medium level of 0.5 g per plant was found to retain leaf petiole for a longer period compared to other treatments. But this was on par with the highest level of phosphorus (1 g per plant).

Days taken for the initiation of buds

All treatments were found to vary significantly (Table 6) with regard to the effect on the number of days taken for the initiation of vegetative buds. Application of phosphorus resulted in early bud emergence except when it

was applied at the rate of 0.5 g per plant. The treatment P_3 (0.75 g per plant) recorded the minimum number of days for the initiation of buds (11.93) compared to control (14.60).

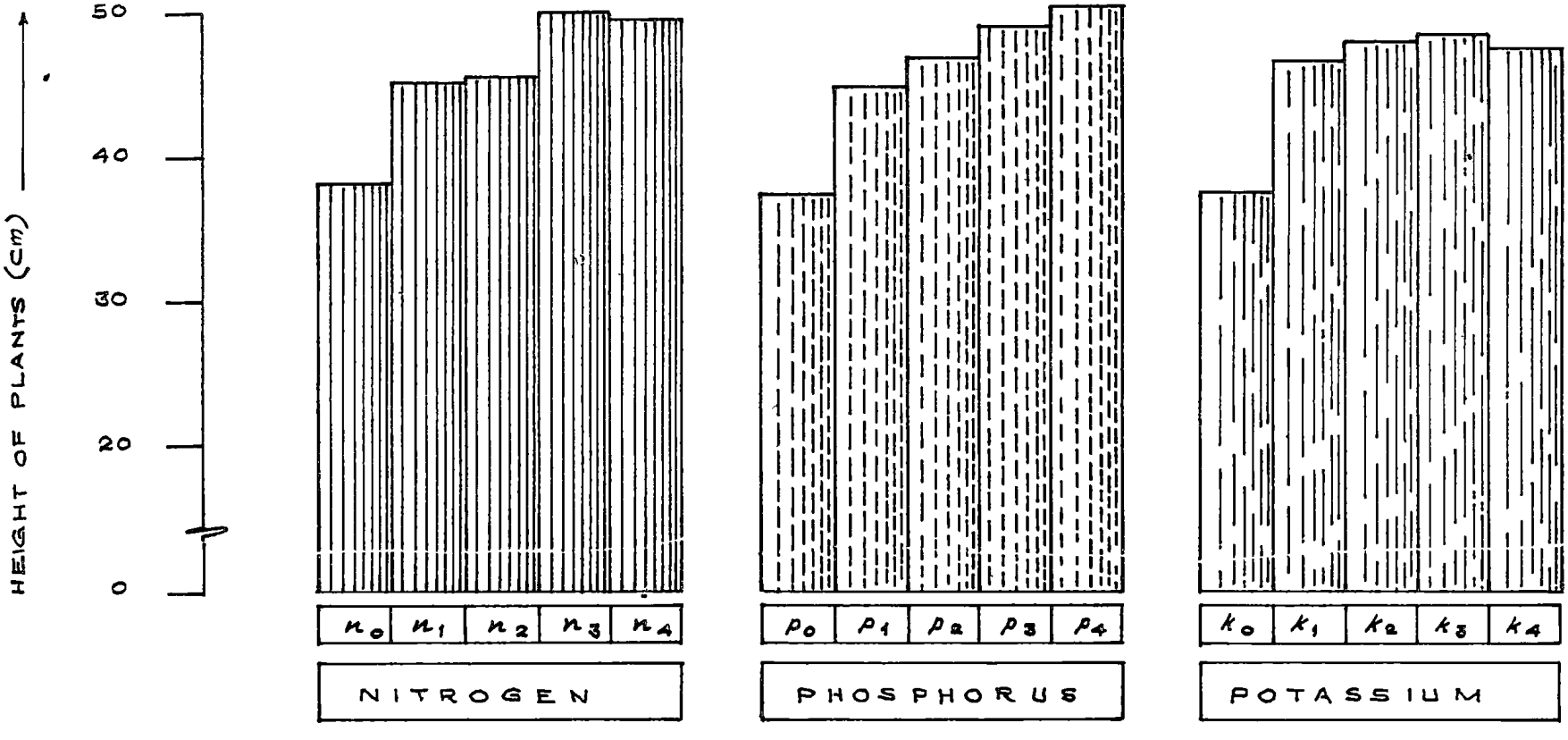
Days taken for the emergence of leaves after bud initiation

The earliest leaf emergence was observed when phosphorus was given at the rate of 0.75 g per plant (Table 7). The treatment P_1 (0.25 g per plant) was found on par with control. All other levels of phosphorus was found significantly superior to control.

Height of the plants at periodic intervals

Data on the mean height of plants (Table 8) showed that plants treated with phosphorus at the rate of 0.75 g per plant were on an average taller than other plants at 30th, 45th and 60th days of observation. But on the 75th day of observation the plant which received 0.75 g and 1 g phosphorus gave statistically identical results, while on the 90th day plants treated with 1 g of phosphorus were found to gave more height than all other plants.(Fig 2).

FIG 2 HEIGHT OF PLANTS (cm) AT 90th DAY



$n_0/p_0/k_0$ – 0 g N/P/K/ PLANT
$n_1/p_1/k_1$ – 0 25 g N/P/K/ PLANT
$n_2/p_2/k_2$ – 0 50 g N/P/K/ PLANT
$n_3/p_3/k_3$ – 0 75 g N/P/K/ PLANT
$n_4/p_4/k_4$ – 1 0 g N/P/K/ PLANT

Days taken for the initiation of first flower bud and flower opening

Data on the mean number of days taken from budding to initiation of first flower bud and the days from bud appearance to flower opening are presented in Table 9.

The treatments were found to have no beneficial effects on the days taken for flower bud initiation. Control plants showed minimum number of days for flower bud initiation (53.66) when compared to the highest level of phosphorus (58.79) and also to the level of phosphorus at 0.25 g per plant (61.29). However, plants treated with phosphorus at the rate of 0.5 g plant produced statistically identical results with control.

As regards to flower opening the application of phosphorus did not produce any positive response. Higher levels of phosphorus produced significant delay in flower opening when compared to the lower levels of phosphorus and control.

The nutrient content of leaves

The data showed that the various levels of phosphorus affected the nutrient contents. The nutrient content of the leaves were maximum when phosphorus was applied at the rate

of 0.75 g per plant and the values of nitrogen, phosphorus and potassium were found to be 2.07, 0.47 and 1.77 per cent respectively. The corresponding values in the control plants were 1.45, 0.37 and 1.46 per cent respectively for nitrogen, phosphorus and potassium.

Effect of potassium

Girth of the stock at the time of budding

Data on girth of the stock at the time of budding (Table 11), showed that the various treatments were significant. Potassium application at the level of 0.5 g per plant resulted in a significant increase in the girth of root stocks when compared to all other treatments and control.

Days taken for the fall of petiole

The plants treated with potassium at the rate of 0.25 g per plant showed minimum number of days for the fall of petiole. All other levels of potassium produced statistically identical results with control. The lower levels of potassium promoted the early fall of petiole.

Table 5. Effect of phosphorus on girth of the stock, fall of petiole and initiation of buds.

Levels of phosphorus (g/plant)	Girth of the stock at the time of budding	Days taken for the fall of petiole	Days taken for bud initiation
0	1.35	10.16	14.60
0.25	1.27	9.89	13.40
0.5	1.37	10.49	15.50
0.75	1.39	8.90	11.93
1.0	1.45	10.30	12.91
C.D. (5%)	0.10	0.21	0.16

Table 7. Effect of phosphorus on the number of days taken for the emergence of leaves after bud initiation

Levels of phosphorus (g/plant)	Position of leaves				
	First	Third	Fifth	Seventh	Nineth
0	18.45	21.12	25.47	30.65	36.71
0.25	18.34	20.93	25.81	30.69	36.81
0.5	17.07	19.34	23.37	28.31	34.25
0.75	16.20	18.46	21.97	26.74	32.44
1.0	17.00	19.09	22.95	27.65	33.45
C.D. (5%)	0.16	0.47	0.28	0.33	0.37

Table 8. Effect of phosphorus on plant height at periodic intervals

Levels of phosphorus (g/plant)	Days after budding				
	30	45	60	75	90
0	3.20	8.16	23.05	33.12	37.16
0.25	3.14	8.81	23.03	38.18	44.95
0.5	3.01	9.72	25.08	39.55	46.90
0.75	5.27	11.64	28.31	41.81	48.92
1.0	4.15	10.65	27.06	41.89	50.27
C.D. (5%)	0.52	0.22	0.39	1.26	0.39

Table 9. Effect of phosphorus on flowering

Levels of phosphorus (g/plant)	Days taken for the initiation of first flower bud	Days taken for the flower opening after initiation
0	53.66	12.13
0.25	61.29	12.23
0.5	59.36	12.19
0.75	54.35	12.59
1.0	58.79	13.57
C.D. (5%)	0.73	-

Table 10. Effect of phosphorus on NPK content of leaves

Levels of phosphorus (g/plant)	N	P	K
0	1.45	0.37	1.46
0.25	1.67	0.41	1.37
0.5	1.82	0.45	1.37
0.75	2.07	0.47	1.77
1.0	1.52	0.44	1.40
C.D.(5%)	0.009	0.006	0.012

Days taken for the initiation of buds

Potassium applied at the rate of 0.25 g and 0.5 g per plant was found to initiate buds earlier than the control plants (Table 11). However, treatment with potassium at the rate of 0.25 g per plant was found superior to its application at the rate of 0.5 g per plant. The treatment K_3 (0.5 g per plant) was on par with the control. The highest level of potassium (1.0 g) was found to be rather ineffective in reducing the number of days for the initiation of buds.

Days taken for the emergence of leaves after bud initiation

Different levels of potassium significantly influenced the emergence of leaves. The highest level of potassium induced the emergence of leaves with the minimum number of days in all cases. The treatment of potassium at the rate of 0.25 g per plant proved to be not effective in the early emergence of 7th and 9th leaf when compared to control. The treatment K_3 (0.75 g per plant) was on par with K_4 (1 g per plant) in the emergence of 3rd leaf and 9th leaf. The mean values ranged from 18.32 (K_0) to 16.01 (K_4) in the case of first leaf emergence (Table 12).

Height of the plants at periodic intervals

The height of plants showed significant variation among treatments (Table 13) except on 30th and 60th day. During initial stages of growth, lowest dose of potassium (0.25 g per plant) was found to be more effective than the other treatments and control.

After 45th day of budding the effect of potassium in increasing the plant height was found to be almost identical at different levels and they were found to be on par. The same trend continued till the end of study.

Days taken for the initiation of first flower bud and flower opening

Significant variation was observed among treatments with regard to the days taken for the initiation of first flower bud (Table 14).

All the treatments were effective in the early induction of first flower bud except the treatment K_1 (0.25 g per plant). The lowest value was obtained with highest level of potassium (52.65) as against in control (60.86). The highest mean value was obtained when potassium was applied at the lowest rate of 0.25 g per plant (61.63).

Regarding flower opening also the higher level of potassium required less number of days. More number of days were required by the plants treated with potassium at the rate of 0.25 g per plant. The treatment K_2 (0.5 g per plant) was on par with K_1 (0.25 g per plant).

Nutrient content of leaves

A significant difference between treatments with regard to NPK content of leaves was observed (Table 15). The amount of potassium in the leaves showed an increasing trend with increasing levels of potassium application. The phosphorus content showed a decreasing trend. The maximum nitrogen content was obtained when potassium was applied at the rate of 0.25 g per plant (2.43 per cent). The mean values of potassium content ranged from 1.02 per cent (K_0) to 2.08 per cent (K_1).

Effect of NP interaction on different characters

Girth of the stock at the time of budding

Data on the mean girth of the stock showed that the effect due to NP interaction was significant (Table 16). The highest girth was recorded when both nitrogen and phosphorus were given at 0.5 g per plant (40 cm). The control plants showed a girth of 1.35 cm.

Table 11. Effect of potassium on girth of the stock, fall of petiole and initiation of buds

Levels of potassium (g/plant)	Girth of the stock at the time of budding	Days taken for the fall of petiole	Days taken for bud initiation
0	1.34	10.13	13.37
0.25	1.27	9.19	12.20
0.5	1.38	10.04	12.99
0.75	1.34	10.18	13.21
1.0	1.37	10.19	13.61
C.D. (5%)	0.10	0.21	0.16

Table 12. Effect of potassium on the number of days taken for the emergence of leaves after bud initiation

Levels of potassium (g/plant)	Position of leaves				
	First	Third	Fifth	Seventh	Nineth
0	18.32	20.52	24.20	28.88	34.52
0.25	17.55	20.01	24.09	29.41	35.47
0.5	17.31	19.75	23.99	29.08	35.27
0.75	17.07	19.35	23.60	28.53	34.44
1.0	16.81	19.29	23.17	28.16	33.96
C.D. (5%)	0.16	0.47	0.28	0.33	0.37

Table 13. Effect of potassium on plant height at periodic intervals

Levels of potassium (g/plant)	Days after budding				
	30	45	60	75	90
0	3.73	9.47	25.03	33.85	37.70
0.25	4.12	10.50	25.06	39.19	46.63
0.5	3.82	9.03	25.55	40.35	47.99
0.75	3.94	9.67	25.76	40.85	48.36
1.0	3.15	9.40	25.12	40.30	47.54
C.D. (5%)	0.52	0.22	0.39	1.26	0.30

Table 14. Effect of potassium on flowering

Levels of potassium (g/plant)	Days taken for the initiation of first flower bud	Days taken for the flower opening after initiation
0	60.86	12.61
0.25	61.63	12.89
0.5	56.01	12.88
0.75	54.30	12.02
1.0	52.65	12.32
C.D. (5%)	0.73	0.27

Table 15. Effect of potassium on NPK content of leaves

Levels of potassium (g/plant)	N	P	K
0	1.74	0.46	1.02
0.25	2.43	0.49	1.18
0.5	1.91	0.44	1.39
0.75	1.41	0.39	1.71
1.0	1.04	0.35	2.08
C.D. (5%)	0.009	0.006	0.012

Days taken for the fall of petiole

A significant difference was observed between the different combinations upon the days taken for the fall of petiole.

A treatment combination of N_4P_3 showed minimum number of days for the fall of petiole (7.77). The treatment N_1P_2 recorded maximum number of days for the fall of petiole (12.81).

At the lower levels of nitrogen, the number of days taken for the fall of petiole decreased with increasing levels of phosphorus upto 0.75 g per plant. But at higher levels of nitrogen, 0.25 g of phosphorus per plant was found to enhance the early fall of petiole.

Days taken for the initiation of buds.

A significant difference was observed between the various treatment combinations upon the number of days taken for the initiation of buds after budding (Table 16). The least mean value was shown by a treatment combination of nitrogen 1 g per plant and phosphorus 0.25 g per plant (9.70) and maximum value by a treatment combination of nitrogen 0 and phosphorus 0.25 g per plant (18.59).

Days taken for the emergence of leaves after bud initiation

There was significant difference between the various treatment combinations on the number of days taken for leaf emergence (Table 17).

The minimum number of days for the emergence of first leaf and third leaf was recorded for a treatment combination of nitrogen at 0.75 g per plant and phosphorus at 0.5 g per plant (N_3P_2). The same was on par with the treatment combination N_3P_3. The treatment combination N_4P_3 recorded minimum number of days for the third leaf emergence (20.71) and it was on par with the treatment combination N_3P_3.

In general the treatment combination N_0P_1 showed maximum number of days for the leaf emergence.

Height of the plant at periodic intervals

The observations recorded on the height of plants indicated that except on 30th day a significant difference was observed between the various treatment combinations with regard to the height of plants at periodic intervals (Table 18).

The maximum plant heights were recorded for a treatment combination of nitrogen at 0.5 g per plant and phosphorus at 0.75 g per plant (N_2P_3) upto 60th day. On 60th day the

maximum height was found to be 31.22 cm. Thereafter the maximum height was shown by a treatment combination of N_3P_2. The height on 90th day for the N_3P_2 combination was 55.34 cm and for control 32.71 cm. However, the same combination was on par with N_2P_3. All other treatments were found to be superior when compared to control.

Days taken for the initiation of first flower bud and flower opening.

The data on the number of days taken for the initiation of first flower bud and days taken for flower bud opening showed that the best combination for early induction of flower bud and flower bud opening was N_3P_0. The combination N_3P_4 was also found on par with N_3P_0 with regard to early flower bud induction. All the treatments differed significantly upon their effect on flower bud induction and flower bud opening (Table 19).

Nutrient content of leaves.

The observations on the nutrient(NPK)content of leaves showed significant variation between treatments. The treatment combination N_3P_3 recorded maximum nitrogen and phosphorus content in the leaves. The values for nitrogen and phosphorus were 2.86 and 0.52 per cent respectively

The least potassium content was observed in plants which received the N_4P_1 treatment combination (1.08 per cent).

Effect of PK interaction on growth characters

Girth of the stock at the time of budding

The observations on the girth of the stock at the time of budding showed that the PK interaction was not significant. However, the girth was found to increase due to certain treatment combinations than control. The maximum girth was observed with the treatment combination P_2K_3 (1.68 cm) and the minimum with the treatment combination P_3K_1 (1.23 cm), the corresponding value in control being 1.35 cm.

Days taken for the fall of petiole

A significant difference was observed between the various combinations upon the number of days taken for the fall of petiole (Table 21).

The fall of petiole was earliest when a treatment combination of phosphorus at 0.75 g per plant and potassium at 0.25 g per plant was given (7.54). The control plants showed maximum number of days for the retention of petiole which was on par with the treatment P_2K_2.

Table 16. Interaction effect of nitrogen and phosphorus on girth of the stock, fall of petiole and initiation of buds.

Levels of Nitrogen and phosphorus	Girth of the stock at the time of budding (cm)	Days taken for the fall of petiole	Days taken for bud initiation
N_0P_0	1.35	10.93	17.18
N_0P_1	1.27	9.38	18.59
N_0P_2	1.43	11.62	14.28
N_0P_3	1.41	8.41	13.95
N_0P_4	1.38	9.27	12.34
N_1P_0	1.21	10.45	16.80
N_1P_1	1.39	12.63	15.42
N_1P_2	1.44	12.81	14.98
N_1P_3	1.39	10.47	12.81
N_1P_4	1.53	10.59	13.22
N_2P_0	1.29	10.54	15.32
N_2P_1	1.37	9.41	11.90
N_2P_2	1.80	9.67	11.95
N_2P_3	1.25	8.37	10.79
N_2P_4	1.40	10.29	12.03
N_3P_0	1.35	9.41	11.51
N_3P_1	1.38	9.31	11.30
N_3P_2	1.40	9.32	10.47
N_3P_3	1.38	9.45	10.81
N_3P_4	1.41	10.89	12.84
N_4P_0	1.41	9.45	12.21
N_4P_1	1.35	8.73	9.70
N_4P_2	1.26	9.61	10.96
N_4P_3	1.25	7.77	11.29
N_4P_4	1.36	10.47	14.11
C.D. (5%)	0.045	0.47	0.35

Table 17. Interaction effect of nitrogen and phosphorus on the number of days taken for the leaf emergence after bud initiation

Levels of nitrogen and phosphorus	Position of leaves				
	First	Third	Fifth	Seventh	Ninth
N_0P_0	19.90	21.71	25.49	30.13	36.57
N_0P_1	20.07	21.10	27.15	31.78	36.37
N_0P_2	17.41	19.52	22.91	27.41	32.93
N_0P_3	17.87	20.28	23.99	28.32	33.95
N_0P_4	17.16	19.90	22.00	26.57	32.09
N_1P_0	19.89	23.68	27.47	33.01	38.27
N_1P_1	19.87	21.46	26.87	32.95	39.31
N_1P_2	18.39	21.79	26.16	31.78	37.73
N_1P_3	16.91	19.19	22.35	26.95	33.44
N_1P_4	17.29	20.08	24.05	29.52	36.45
N_2P_0	19.47	22.23	26.95	32.42	38.35
N_2P_1	18.66	20.68	24.35	28.89	36.33
N_2P_2	17.64	19.55	23.79	29.62	36.20
N_2P_3	16.22	18.55	22.08	26.71	31.47
N_2P_4	17.43	19.00	23.16	27.65	33.75
N_3P_0	17.67	19.81	24.66	29.85	36.26
N_3P_1	16.42	20.16	24.75	30.67	37.17
N_3P_2	14.94	16.71	21.05	25.29	31.65
N_3P_3	14.99	17.00	20.71	26.11	32.29
N_3P_4	15.35	17.75	22.19	26.77	31.35
N_4P_0	16.35	18.15	22.77	27.85	34.11
N_4P_1	16.67	19.25	23.41	29.19	35.09
N_4P_2	16.69	19.11	22.95	27.48	32.75
N_4P_3	15.03	17.27	20.71	25.63	31.05
N_4P_4	17.61	19.71	23.34	27.93	33.66
C.D. (5%)	0.36	1.05	0.62	0.73	0.84

Table 18. Interaction effect of nitrogen and phosphorus on plant height at periodic intervals

Levels of nitrogen and phosphorus	Day after budding				
	30th	45th	60th	75th	90th
N_0P_0	1.65	6.71	22.67	29.76	32.71
N_0P_1	1.88	7.05	23.03	30.76	34.33
N_0P_2	3.17	8.41	22.87	30.13	33.04
N_0P_3	3.46	9.25	26.15	38.57	41.93
N_0P_4	4.0	10.85	26.72	39.91	43.11
N_1P_0	3.03	8.26	21.64	31.19	34.78
N_1P_1	2.01	7.65	19.87	40.34	48.81
N_1P_2	2.25	9.83	23.60	40.71	50.29
N_1P_3	5.83	10.83	25.28	36.29	40.64
N_1P_4	4.22	10.36	26.18	42.87	52.17
N_2P_0	4.05	7.63	22.43	32.74	36.75
N_2P_1	3.08	8.33	20.99	33.49	40.03
N_2P_2	2.80	10.19	24.31	38.61	44.59
N_2P_3	6.26	13.13	31.22	45.15	54.76
N_2P_4	3.83	9.13	25.73	42.53	51.25
N_3P_0	4.04	8.93	22.68	35.52	40.57
N_3P_1	4.67	10.15	25.24	45.18	54.49
N_3P_2	3.81	10.86	27.69	45.35	55.34
N_3P_3	4.95	12.29	29.23	43.93	52.82
N_3P_4	4.93	11.53	29.59	39.38	54.91
N_4P_0	3.25	9.28	25.85	36.39	41.00
N_4P_1	4.05	10.85	26.00	41.11	47.10
N_4P_2	3.02	9.29	26.91	42.95	51.26
N_4P_3	5.83	12.60	29.65	45.11	54.44
N_4P_4	3.75	11.39	27.09	44.78	53.93
C.D. (5%)	1.16	0.51	0.88	2.82	0.88

Table 19. Interaction effect of nitrogen and phosphorus on flowering

Levels of nitrogen and phosphorus	Days taken for the initiation of first flower bud	Days taken for the flower opening after initiation
N_0P_0	56.99	12.94
N_0P_1	55.51	11.43
N_0P_2	57.61	12.14
N_0P_3	57.33	11.17
N_0P_4	55.89	11.74
N_1P_0	55.27	14.55
N_1P_1	64.42	12.09
N_1P_2	62.77	13.03
N_1P_3	51.97	11.75
N_1P_4	63.41	12.31
N_2P_0	52.35	10.77
N_2P_1	62.74	12.67
N_2P_2	57.15	11.03
N_2P_3	49.51	12.01
N_2P_4	62.66	13.73
N_3P_0	50.63	10.26
N_3P_1	63.35	11.82
N_3P_2	58.72	11.33
N_3P_3	51.29	13.57
N_3P_4	50.99	16.17
N_4P_0	53.07	12.10
N_4P_1	60.43	13.16
N_4P_2	60.53	13.41
N_4P_3	61.62	14.47
N_4P_4	60.97	13.92
C.D. (5%)	1.63	0.61

Table 20. Interaction effect of nitrogen and phosphorus on NPK content of leaves

Levels of nitrogen and phosphorus	N	P	K
N_0P_0	0.84	0.27	1.29
N_0P_1	1.31	0.35	1.72
N_0P_2	1.14	0.39	1.53
N_0P_3	1.48	0.41	1.51
N_0P_4	1.32	0.46	1.29
N_1P_0	0.80	0.30	1.87
N_1P_1	1.15	0.37	1.41
N_1P_2	1.68	0.43	1.49
N_1P_3	1.27	0.43	1.85
N_1P_4	1.25	0.43	1.30
N_2P_0	1.57	0.38	1.40
N_2P_1	1.63	0.42	1.18
N_2P_2	1.71	0.46	1.22
N_2P_3	2.27	0.52	2.42
N_2P_4	1.60	0.41	1.20
N_3P_0	2.27	0.47	1.35
N_3P_1	1.64	0.42	1.45
N_3P_2	2.45	0.49	1.41
N_3P_3	2.86	0.52	1.88
N_3P_4	1.81	0.43	1.97
N_4P_0	1.77	0.42	1.40
N_4P_1	2.61	0.52	1.08
N_4P_2	2.10	0.48	1.20
N_4P_3	2.47	0.49	1.21
N_4P_4	1.62	0.45	1.21
C.D. (5%)	0.02	0.001	0.026

Days taken for the initiation of buds

The data on the number of days taken for the initiation of buds are furnished in Table 21.

The various treatment combinations were found to be significant with regard to the days taken for the initiation of buds. The earliest bud initiation was found when a combination of phosphorus at 0.75 g per plant and potassium at 0.5 g per plant was applied (11.05) and the maximum mean value was for control (15.99).

Days taken for the emergence of leaves after bud initiation

The observations on the leaf emergence (Table 22) showed that there was significant variation between the different treatment combinations with regard to the days taken for the leaf emergence.

The treatment combination of phosphorus at 0.75 g per plant and potassium at 0.25 g per plant recorded the minimum number of days for the emergence of all the leaves. Except in the case of first leaf emergence, maximum number of days for the emergence of all other leaves were taken for a treatment combination of P_0K_1. Control plants showed maximum value for first leaf emergence.

Height of the Plants at periodic intervals

The data on the height of budded plants at periodic intervals showed that the PK interaction was significant (Table 23).

The maximum height of 6.42 cm was recorded on the 30th day by an interaction effect between 0.75 g each of Phosphorus and potassium (P_3K_3). But after 30th day the best combination for getting maximum height was found to be P_3K_1. Among the various treatments the P_0K_1 combination was found to give minimum plant height at all stages. The interaction was again found not significant on the 75th day.

Days taken for the initiation of first flower bud and flower opening

The mean values for the number of days taken for the initiation of first flower bud (Table 24) showed P_0K_4 as the best combination for earliest flower bud initiation (47.36). The control plants required more number of days (62.81). For early flower development and opening the best combination was P_0K_4. It was also found on par with a combination of P_0K_3.

Nutrient content of leaves

The observations on NPK content of leaves are presented in Table 25. The data showed significant variation among different treatment combination as regards to the nutrient content of the leaves. Maximum nitrogen content was recorded with a treatment combination of P_3K_1 (3.07 per cent) and minimum with a combination of P_0K_4 (0.87 per cent). The interaction was also found to be significant with regard to phosphorus and potassium content. Maximum phosphorus content was recorded with P_3K_1 combination (0.56 per cent) and potassium content with P_0K_4 combination (2.73 per cent), the corresponding values for control being 0.42 and 0.74 per cent respectively.

Effect of NK interaction on growth and development

Girth of the stock at the time of budding

Data on girth of the stock at the time of budding (Table 26) showed that the various treatment combinations were not significant. However, girth was found to be affected by some treatment combinations compared to control. Maximum stem girth was shown by N_3K_3 and N_2K_2 combinations.

Table 21. Interaction effect of phosphorus and potassium on girth of the stock, fall of petiole and initiation of bud

Levels of phosphorus and potassium	Girth of the stock at the time of budding (cm)	Days taken for the fall of petiole	Days taken for bud initiation
P_0K_0	1.35	11.97	15.90
P_0K_1	1.31	9.49	13.34
P_0K_2	1.27	9.79	14.35
P_0K_3	1.33	9.42	14.04
P_0K_4	1.33	10.11	15.30
P_1K_0	1.27	10.69	14.25
P_1K_1	1.38	9.13	13.34
P_1K_2	1.43	9.36	13.31
P_1K_3	1.40	10.17	13.06
P_1K_4	1.27	10.11	13.03
P_2K_0	1.39	10.32	13.02
P_2K_1	1.43	10.16	12.15
P_2K_2	1.50	11.70	12.65
P_2K_3	1.68	10.07	12.23
P_2K_4	1.33	10.19	12.59
P_3K_0	1.37	8.75	12.10
P_3K_1	1.23	7.54	9.90
P_3K_2	1.31	8.58	11.05
P_3K_3	1.41	9.77	12.79
P_3K_4	1.37	9.84	13.77
P_4K_0	1.45	8.93	11.48
P_4K_1	1.41	9.60	12.21
P_4K_2	1.40	10.77	13.57
P_4K_3	1.42	11.49	13.91
P_4K_4	1.41	10.70	13.38
C.D. (5%)		0.47	0.35

Table 22. Interaction effect of phosphorus and potassium on the number of days taken for the leaf emergence after bud initiation

Levels of phosphorus and potassium	Position of leaves				
	First	Third	Fifth	Seventh	Nineth
P_0K_0	20.08	22.11	25.37	29.85	35.29
P_0K_1	19.39	22.31	27.14	33.56	39.95
P_0K_2	18.25	21.15	26.03	31.21	37.88
P_0K_3	17.69	20.40	24.97	30.07	35.98
P_0K_4	16.87	19.60	23.83	28.55	34.46
P_1K_0	18.81	20.97	24.95	29.77	35.56
P_1K_1	18.93	21.83	26.05	31.67	37.92
P_1K_2	18.75	22.17	26.49	31.66	38.14
P_1K_3	17.84	19.67	25.13	30.42	36.77
P_1K_4	17.36	20.01	23.92	29.76	35.67
P_2K_0	18.14	20.51	24.65	29.49	35.32
P_2K_1	17.38	19.79	23.54	28.56	34.81
P_2K_2	16.62	18.34	22.79	27.81	33.86
P_2K_3	16.52	18.77	22.70	27.43	33.48
P_2K_4	16.68	19.27	23.18	28.29	33.77
P_3K_0	17.69	19.99	23.76	28.49	34.34
P_3K_1	14.97	17.06	20.31	24.62	29.64
P_3K_2	15.60	17.83	20.99	25.65	31.50
P_3K_3	16.15	18.46	21.91	27.05	32.46
P_3K_4	16.60	18.95	22.87	27.91	34.25
P_4K_0	16.90	19.03	22.29	26.58	32.09
P_4K_1	17.10	19.09	23.40	28.65	35.03
P_4K_2	17.34	19.26	23.67	29.06	34.97
P_4K_3	17.17	19.47	23.30	27.67	33.53
P_4K_4	16.51	18.60	22.07	26.29	31.65
C.D. (5%)	0.36	1.05	0.62	0.73	0.84

Table 23. Interaction effect of phosphorus and potassium on plant height at periodic intervals

Levels of phosphorus and potassium	Day after budding				
	30th	45th	60th	75th	90th
P_0K_0	3.61	8.17	21.58	32.03	36.82
P_0K_1	2.77	7.79	21.03	30.33	33.96
P_0K_2	3.03	8.16	23.01	32.67	35.89
P_0K_3	3.11	8.17	25.25	35.31	39.36
P_0K_4	3.51	8.51	24.41	35.25	39.78
P_1K_0	2.53	8.28	22.49	29.99	32.07
P_1K_1	3.44	9.37	22.75	38.87	45.67
P_1K_2	3.17	8.64	23.21	40.65	48.80
P_1K_3	3.76	9.06	23.82	40.90	49.29
P_1K_4	2.78	8.68	22.85	40.47	48.13
P_2K_0	3.20	9.21	24.53	32.77	35.86
P_2K_1	3.73	10.84	24.81	40.33	48.83
P_2K_2	2.80	9.65	25.63	41.99	50.75
P_2K_3	2.91	9.85	25.41	42.14	50.54
P_2K_4	2.41	9.02	25.01	40.51	48.55
P_3K_0	4.31	10.99	28.25	36.72	40.23
P_3K_1	6.11	13.35	30.02	43.80	52.30
P_3K_2	5.71	12.27	28.44	43.47	51.92
P_3K_3	6.42	11.09	28.35	42.84	50.35
P_3K_4	3.79	10.51	26.47	42.22	49.79
P_4K_0	4.99	10.71	28.31	37.75	42.77
P_4K_1	4.57	11.15	26.68	42.63	52.37
P_4K_2	4.38	10.91	27.47	42.97	52.57
P_4K_3	3.49	10.20	25.97	43.08	52.20
P_4K_4	3.29	10.28	26.89	43.05	51.45
C.D.(5%)	1.16	0.51	0.88	2.82	0.88

Table 24. Interaction effect of phosphorus and potassium on flowering

Levels of phosphorus and potassium	Days taken for the initiation of first flower bud	Days taken for the flower opening after initiation
P_0K_0	62.81	13.58
P_0K_1	55.67	13.01
P_0K_2	52.61	11.91
P_0K_3	49.86	11.23
P_0K_4	47.36	10.89
P_1K_0	60.25	12.79
P_1K_1	67.64	11.66
P_1K_2	62.85	12.30
P_1K_3	59.62	11.43
P_1K_4	56.09	12.99
P_2K_0	60.47	12.21
P_2K_1	64.23	12.54
P_2K_2	61.15	12.44
P_2K_3	56.59	11.79
P_2K_4	54.93	11.95
P_3K_0	60.78	12.45
P_3K_1	57.41	12.88
P_3K_2	53.75	13.39
P_3K_3	50.12	11.98
P_3K_4	49.67	12.27
P_4K_0	59.99	12.02
P_4K_1	63.19	14.34
P_4K_2	59.67	14.35
P_4K_3	55.29	13.67
P_4K_4	55.78	13.48
C.D. (5%)	1.63	0.61

Table 25. Interaction effect of phosphorus and potassium on NPK content of leaves

Levels of phosphorus and potassium	N	P	K
P_0K_0	1.57	0.42	0.74
P_0K_1	2.04	0.42	0.92
P_0K_2	1.52	0.36	1.23
P_0K_3	1.25	0.34	1.69
P_0K_4	0.87	0.30	2.73
P_1K_0	1.73	0.45	1.28
P_1K_1	2.32	0.47	1.21
P_1K_2	1.82	0.42	1.29
P_1K_3	1.46	0.38	1.46
P_1K_4	1.01	0.35	1.60
P_2K_0	1.74	0.44	1.19
P_2K_1	2.66	0.52	1.22
P_2K_2	2.05	0.49	1.33
P_2K_3	1.43	0.42	1.55
P_2K_4	1.20	0.39	1.55
P_3K_0	1.92	0.49	1.06
P_3K_1	3.07	0.56	1.50
P_3K_2	2.46	0.50	1.69
P_3K_3	1.67	0.44	2.19
P_3K_4	1.22	0.37	2.43
P_4K_0	1.73	0.50	0.85
P_4K_1	2.05	0.51	1.03
P_4K_2	1.69	0.44	1.39
P_4K_3	1.25	0.38	1.64
P_4K_4	0.89	0.34	2.07
C.D. (5%)	0.02	0.001	0.026

Days taken for the fall of petiole

There was significant interaction between nitrogen and potassium treatments. The interaction effect between treatments with 0.25 g N per plant and 0.25 g K per plant was significantly superior to the rest of treatments which were on par with control.

Days taken for the initiation of buds

Among the various treatment combinations N_3K_1 was found to be the best combination for the early initiation of buds. The maximum number of days was taken by control plants (17.07). However, the interaction between all the treatments were found to be significant.

Days taken for the emergence of leaves after bud initiation

The observations on the number of days taken for the leaf emergence are presented in Table 27.

All the treatment combinations were found to interact significantly. The first leaf emergence was earlier when a combination of nitrogen and potassium each at 0.75 g per plant was given (N_3K_3). However, the same was on par with N_3K_2 and N_3K_4 combinations. The subsequent leaf emergence

was found to be influenced more by N_4K_1 combination. This was also on par with N_3K_3 and N_3K_2 during third leaf emergence. Maximum number of days for leaf emergence was shown by the treatment combination N_0K_1.

Height of the plant at periodic intervals

A significant difference was observed between the various treatment combinations for the plant height. It was found that the maximum plant height observed on the 45th day was due to the effect of a combination of nitrogen and potassium at 0.75 and 0.25 g per plant respectively (N_3K_1). Later N_3K_2 combination was found to be the best for getting maximum height. But it was on par with N_3K_1 combination. Again on 90th day N_3K_1 treatment combination showed maximum height (53.33 cm). Minimum height was recorded with control except on 30th day.

Days taken for the initiation of first flower bud and flower opening

The data on the number of days taken for the initiation of first flower bud showed that the (Table 29) earliest flower bud initiation was for a treatment combination of N_3K_4 (49.0) which was on par with N_3K_3 (49.5).

It was also found that the same treatment combination of N_3K_4 showed an early opening of flowers. Both flower bud initiation and flower opening showed more or less a similar trend.

Nutrient content of leaves

A significant variation was observed between different treatment combination with regard to the nitrogen content of leaves (Table 30). Maximum nitrogen content was observed in a combination of nitrogen at 0.75 g per plant and potassium at 0.25 g per plant (3.66 per cent). The least nitrogen content was observed for N_0K_4 combination (0.85 per cent). The highest phosphorus content was recorded in a treatment combination N_4K_0 (0.58 per cent) which was on par with N_3K_1. Among the various treatment combinations N_1K_4 showed maximum potassium content (2.29 per cent) in the leaves compared to control (0.98 per cent).

Table 26. Interaction effect of nitrogen and potassium on girth of the stock, fall of petiole and initiation of buds.

Levels of nitrogen and potassium	Girth of the stock at the time of budding (cm)	Days taken for the fall of petiole	Days taken for bud initiation
N_0K_0	1.36	12.21	17.07
N_0K_1	1.33	8.91	14.89
N_0K_2	1.38	9.53	14.22
N_0K_3	1.34	9.06	13.68
N_0K_4	1.43	9.30	16.47
N_1K_0	1.43	10.76	14.38
N_1K_1	1.37	12.18	14.92
N_1K_2	1.44	11.54	15.49
N_1K_3	1.41	11.41	14.60
N_1K_4	1.31	11.07	13.84
N_2K_0	1.34	10.69	13.93
N_2K_1	1.40	8.90	11.65
N_2K_2	1.54	9.06	11.61
N_2K_3	1.53	9.62	12.37
N_2K_4	1.31	10.00	12.52
N_3K_0	1.37	9.41	11.69
N_3K_1	1.38	7.10	8.69
N_3K_2	1.31	10.43	11.68
N_3K_3	1.54	11.09	12.60
N_3K_4	1.32	10.35	12.27
N_4K_0	1.32	7.59	9.77
N_4K_1	1.29	8.84	10.82
N_4K_2	1.23	9.65	11.93
N_4K_3	1.43	9.72	12.79
N_4K_4	1.35	10.23	12.96
C.D. (5%)		0.47	0.35

Table 27. Interaction effect of nitrogen and potassium on the number of days taken for the leaf emergence after bud initiation

Levels of nitrogen and potassium	Position of leaves				
	First	Third	Fifth	Seventh	Ninth
N_0K_0	18.55	20.77	23.82	28.49	34.06
N_0K_1	19.12	21.36	25.22	29.71	35.23
N_0K_2	18.59	21.00	24.77	26.60	34.90
N_0K_3	17.95	20.80	24.47	28.76	33.96
N_0K_4	17.20	19.59	23.27	28.57	33.73
N_1K_0	19.98	22.76	26.99	32.35	38.27
N_1K_1	19.65	23.05	27.35	33.31	39.93
N_1K_2	18.41	21.65	25.64	31.59	37.52
N_1K_3	17.56	19.13	23.95	29.18	35.45
N_1K_4	16.75	19.61	22.96	27.58	33.01
N_2K_0	19.06	21.43	25.35	29.47	35.26
N_2K_1	17.97	20.23	24.81	30.03	37.11
N_2K_2	17.71	19.76	24.08	29.31	36.22
N_2K_3	17.54	19.52	23.38	28.47	34.47
N_2K_4	17.13	19.07	22.71	27.19	33.05
N_3K_0	17.79	19.72	23.13	27.66	33.12
N_3K_1	15.41	18.00	21.99	27.39	34.19
N_3K_2	15.85	17.66	22.91	28.19	34.26
N_3K_3	15.15	17.85	22.53	27.45	33.38
N_3K_4	15.44	18.20	22.79	27.79	33.77
N_4K_0	16.24	17.93	21.73	26.41	31.89
N_4K_1	15.62	17.43	21.06	25.81	30.89
N_4K_2	16.29	18.69	22.59	27.61	33.42
N_4K_3	17.16	19.47	23.66	28.77	34.96
N_4K_4	17.51	19.98	24.13	29.47	36.25
C.D.(5%)	0.36	1.05	0.62	0.73	0.84

Table 28. Interaction effect of Nitrogen and potassium on plant height at periodic intervals

Levels of nitrogen and potassium	Day after budding				
	30th	45th	60th	75th	90th
N_0K_0	3.28	7.69	21.30	29.09	31.48
N_0K_1	2.81	7.93	23.13	31.34	35.67
N_0K_2	2.87	8.63	24.68	34.08	38.63
N_0K_3	2.71	8.67	25.54	36.27	40.74
N_0K_4	2.80	9.34	26.79	38.35	43.59
N_1K_0	3.91	9.66	23.84	32.11	35.77
N_1K_1	2.81	9.75	23.45	39.47	47.37
N_1K_2	3.05	9.62	23.99	40.51	48.85
N_1K_3	4.73	8.85	23.44	40.43	48.57
N_1K_4	2.80	9.15	21.85	38.87	46.14
N_2K_0	3.34	8.39	22.85	33.55	38.05
N_2K_1	4.07	10.10	24.55	38.51	46.05
N_2K_2	4.53	10.36	25.48	40.40	48.43
N_2K_3	4.15	9.97	26.08	40.23	47.62
N_2K_4	3.93	9.59	25.73	39.83	47.23
N_3K_0	3.70	10.12	26.13	34.67	38.79
N_3K_1	6.10	13.07	27.42	43.92	53.33
N_3K_2	4.75	10.53	27.46	44.05	53.11
N_3K_3	4.43	10.57	27.44	43.98	53.01
N_3K_4	3.41	9.47	25.98	42.74	50.90
N_4K_0	4.41	11.51	31.05	39.84	44.46
N_4K_1	4.83	11.67	26.74	42.73	50.73
N_4K_2	3.90	10.49	26.15	42.71	50.91
N_4K_3	3.67	10.31	26.29	43.36	51.81
N_4K_4	3.10	9.44	25.26	41.71	49.83
C.D.(5%)	1.16	0.51	0.88	2.82	0.08

Table 29. Interaction effect of nitrogen and potassium on flowering

Levels of nitrogen and potassium	Days taken for the initiation of first flower bud	Days taken for the flower opening after initiation
N_0K_0	61.85	12.81
N_0K_1	60.47	12.63
N_0K_2	55.91	12.55
N_0K_3	54.01	11.47
N_0K_4	51.10	9.98
N_1K_0	61.99	13.13
N_1K_1	62.53	13.06
N_1K_2	60.30	13.07
N_1K_3	57.90	12.07
N_1K_4	55.12	12.41
N_2K_0	59.51	13.61
N_2K_1	61.63	11.97
N_2K_2	56.87	12.34
N_2K_3	53.54	10.50
N_2K_4	52.87	11.77
N_3K_0	62.16	11.91
N_3K_1	59.07	13.21
N_3K_2	55.24	13.02
N_3K_3	49.50	12.17
N_3K_4	49.00	12.83
N_4K_0	58.79	11.59
N_4K_1	64.45	13.56
N_4K_2	61.72	13.41
N_4K_3	56.53	13.91
N_4K_4	55.14	14.60
C.D.(5%)	1.63	0.61

Table 30. Interaction effect of nitrogen and potassium on NPK content of leaves

Levels of nitrogen and potassium	N	P	K
N_0K_0	1.03	0.44	0.98
N_0K_1	1.73	0.43	1.10
N_0K_2	1.31	0.40	1.33
N_0K_3	1.18	0.31	1.74
N_0K_4	0.85	0.28	2.21
N_1K_0	1.07	0.35	1.57
N_1K_1	1.54	0.43	1.02
N_1K_2	1.26	0.42	1.35
N_1K_3	1.22	0.37	1.60
N_1K_4	1.05	0.35	2.29
N_2K_0	1.61	0.38	1.09
N_2K_1	2.38	0.51	1.33
N_2K_2	2.09	0.47	1.41
N_2K_3	1.53	0.42	1.69
N_2K_4	1.16	0.40	1.90
N_3K_0	2.05	0.52	0.78
N_3K_1	3.66	0.58	1.40
N_3K_2	2.63	0.47	1.54
N_3K_3	1.56	0.41	2.05
N_3K_4	1.13	0.35	2.28
N_4K_0	2.93	0.58	0.61
N_4K_1	2.85	0.51	1.03
N_4K_2	2.23	0.45	1.31
N_4K_3	1.57	0.44	1.44
N_4K_4	1.00	0.37	1.71
C.D.(5%)	0.020	0.001	0.026

Interaction effect of nitrogen, phosphorus and potassium

Girth of the stock at the time of budding

The data pertaining to the girth of the stock at the time of budding is given in Appendix 3. Girth of root stocks were influenced by the various treatments. The best treatment was found to be $N_2P_2K_3$ which gave a girth of 2.37 cm. The control plants showed a girth of 1.43 cm.

Days taken for the fall of petiole

There was significant difference between various treatments on the number of days taken for the fall of petiole. The earliest fall of petiole was found with the treatment $N_3P_3K_1$ (5.2 days). It was on par with the treatments $N_2P_3K_1$ and $N_3P_2K_1$. Maximum days for retention of the petiole was shown by the control plants.

Days taken for the initiation of buds

Among the various treatments $N_3P_3K_1$ was found to be the best treatment giving the earliest bud take, but the effect of $N_3P_3K_1$ was statistically on par with that of $N_3P_2K_1$. On an average the plants under $N_3P_3K_1$ treatment showed 6.63 days and control plants showed 23.13 days for initiation of buds.

Days taken for the emergence of leaves after bud initiation

The observations on the average number of days taken for leaf emergence are presented in Appendix 4.

The treatments exerted significant effect on the number of days taken for leaf emergence. The best treatment for the first leaf emergence was found to be $N_4P_3K_1$ which recorded only 11.17 days for leaf emergence. However, it was on par with $N_3P_3K_1$. A similar trend was observed for the emergence of subsequent leaves. The control plants required more number of days for leaf emergence.

Height of the plant at periodic intervals

A significant difference was observed between the various treatments for plant height (Appendix 5).

The best treatment was found to be $N_4P_3K_1$. In the final stage maximum height was shown by the Treatment $N_3P_2K_2$. The height recorded was 62.27 cm. It was also at par with the treatment $N_3P_2K_2$. The plant heights recorded by the treatment $N_0P_0K_1$ were minimum at all stages.

Days taken for the initiation of first flower bud and flower opening

The data on the mean number of days taken for the initiation of first flower bud showed that the earliest flower bud initiation was with the treatment $N_3P_3K_3$ which was on par with the treatments $N_3P_4K_3$, $N_2P_3K_3$ and $N_2P_3K_4$. The control plants showed maximum number of days for flower bud initiation.

It was also observed that the treatments $N_0P_3K_4$ and $N_3P_0K_3$ showed an early opening of the flower taking 8.97 days after bud initiation. However, it was on par with the treatment $N_2P_3K_3$. The flower opening was very late with the treatment $N_3P_4K_1$.

Nutrient content of leaves

A significant difference was observed between various treatments with regard to the NPK content of leaves. Maximum nitrogen content was observed for the treatment $N_3P_3K_1$ (4.66 per cent) and minimum for $N_1P_0K_4$ (0.42 per cent). The treatment $N_3P_2K_1$ showed maximum phosphorus content of 0.64 per cent in the leaves and the treatment $N_0P_0K_4$, the minimum value

(0.21 per cent). Potassium content was highest in plants which received the treatment $N_1P_0K_4$ (3.84 per cent) and lowest with the treatment $N_4P_0K_0$ (0.44 per cent). The control plants showed 0.77, 0.28 and 0.78 per cent of nitrogen, phosphorus and potassium respectively.

DISCUSSION

DISCUSSION

The present investigation was carried out to find out the effect of nitrogen, phosphorus and potassium individually and in combination on the establishment and bud take in rose plants. The results obtained from the study are discussed in this chapter.

Girth of the stock at the time of budding

The results indicate that a combination of medium levels of the nutrients (N_2P_2) had a significant influence on the girth of root stocks at the time of budding. Further increase in the levels of nitrogen and phosphorus had very little effect in enhancing the stem girth. Nijjar and Rehalia (1977) also found that the stem diameter of rose bushes, variety Superstar increased significantly with high dose of nitrogen in combination with either level of phosphorus and potassium.

The NK interaction was found not significant in this study. However, the medium levels of nitrogen and potassium (N_2K_2) had an effect in increasing the stem girth. This is

in conformity with the results obtained by Kempe Gowda (1982) who recommended the use of 8 g nitrogen and 24 g potassium per adult plant for getting maximum stem girth in rose.

The PK interaction was also found not significant. However, medium levels of phosphorus and potassium (P_2K_3) were found to increase the stem girth.

Medium levels of nitrogen, phosphorus and potassium was also found to have an effect in increasing the stem girth.

Lundstad (1973) found that the bud take was greater on root stocks having 8-12 mm thickness. A similar result was obtained in this study also.

Days taken for the fall of petiole

The results given in Table 1 revealed that the highest level of nitrogen had induced earliness in the fall of petiole. The effect of nitrogen in enhancing the vegetative growth and other growth attributes might have induced this earliness also. Maximum number of days for the retention of petiole in the colon material was found to be influenced by medium levels of nitrogen (0.5 and 0.75 g per plant).

The addition of phosphatic fertilizer at medium level also increased the number of days for the fall of petiole.

The effect of potassium on earliness in the fall of petiole was also found significant. Higher levels of potash delayed the fall of petiole. It may be due to the fact that higher levels of potash limited the uptake of nitrogen and hence fall of petiole was delayed.

The interaction effects were also found significant.

But no positive relationship between petiole drop and successful bud union was found in peach and pear until about ten days after budding (Izaki et al. 1973).

Days taken for the initiation of buds

It is found that nitrogen at the level of 0.75 g per plant had significant effect in the early initiation of buds. This may be due to the fact that nitrogen had a beneficial effect in increasing the general growth and vigour of the plant. This was in conformity with the results obtained by Said and Inayatullah (1965), who found that application of sulphate of ammonia to the root stocks of sour orange before budding had a significant effect on the bud take.

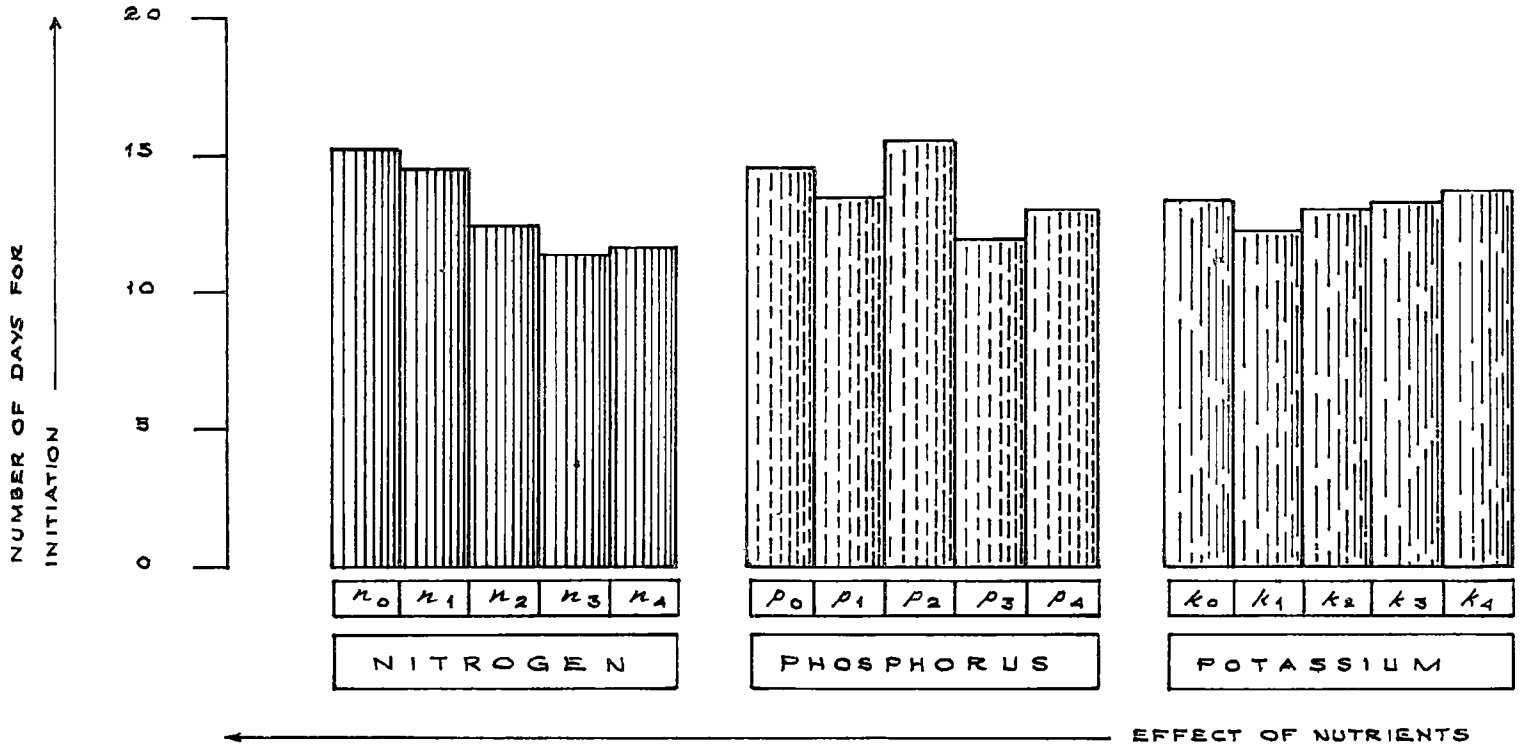
The effect of different levels of phosphorus and potassium was also significant in influencing the early initiation of buds. However, the general trend revealed that higher level of phosphorus (P_3) and lower level of potassium (K_1) induced earliness in bud initiation as compared to other levels and control (Fig.3).

Kudratov (1972) reported that application of nitrogen, phosphorus and potassium at 60 : 45 : 30 kg per hectare 25-30 cm deep into the soil 15 days before budding resulted in better bud take in apple and plum. The results of the present study also indicate a similar trend to the response of potassium in bud take.

The response obtained in the early initiation of buds for the higher levels of nitrogen and phosphorus and still a lower level of potassium in this study may be due to the fact that this crop may be requiring all the three major nutrients for a better bud take. However, the response of plants to applied potash is found to be less effective compared to the other two major elements.

The NP, PK and NK interactions were also found significant. The best treatment combination for the earliest initiation of buds was found to be $N_3P_3K_1$.

FIG 3 DAYS FOR INITIATION OF VEGETATIVE BUDS



$n_0/p_0/k_0$ – 0 g N/P/K / PLANT
$n_1/p_1/k_1$ – 0 25 g N/P/K/ PLANT
$n_2/p_2/k_2$ – 0 50 g N/P/K/ PLANT
$n_3/p_3/k_3$ – 0 75 g N/P/K/ PLANT
$n_4/p_4/k_4$ – 1 0 g N/P/K/ PLANT

Days taken for the emergence of leaves after bud initiation

It is seen that nitrogen at the level of 0.75 g per plant had significant effect in the early emergence of leaves. This may be due to the fact that nitrogen had a beneficial effect in increasingthe general growth and vigour of the plant including the number and size of leaves. The beneficial effect of nitrogen in promoting the growth of plants may be explained from the fact that nitrogen is the major constituent of plant proteins, amino acids and chlorophyll. With the application of higher dose of nitrogen, protein and chlorophyll synthesis markedly accelerated (Wadeigh, 1957).

Kyle (1958) also reported the beneficial effect of nitrogen in enhancing the size of leaves in annual flowering plants. All these results are in full agreement with the results of the present investigation.

Higher level of phosphorus (P_3) was also found to induce earliness in leaf emergence. This may be due to the role of phosphorus in enhancing the vegetative growth of plants.

Potassium was also found to enhance the early emergence of leaves at higher levels. A deficiency of potassium resulted in poor growth and brown foliage (Kyle, 1958).

The combinations of the nutrients ($N_4P_3K_1$ and $N_3P_3K_1$) also showed effect in early emergence of leaves. This is an indication that nitrogen, phosphorus and also potassium are equally important in regulating the vegetative growth of the scion part.

Height of plants at periodic intervals

It is evident from the results that higher levels of nitrogen had significant influence in increasing the height of plants. This was due to the role of nitrogen in enhancing the vegetative growth of plants. The significant increase in height attained by all levels of nitrogen in this investigation is in conformity with the results obtained by Young et al. (1973) in rose varieties Christian Dior and Happiness.

The results also indicated that the effect of Phosphorus was also marked as that of nitrogen. This may be due to the fact that phosphorus directly involve in enhancing the vegetative growth.

The observations on the height of plants with higher doses of phosphorus in the present study is in conformity with the results obtained by Young et al. (1973) who obtained a significant improvement in plant height by higher doses of phosphorus eventhough it was less pronounced as compared to nitrogen.

The height of plants was significantly influenced by the application of potassium. During all stages of growth the lower levels of potassium was sufficient to enhance the height. The effect was found to be more pronounced at the early stages of growth. Investigations conducted on leguminous crops to study the effect of potassium on vegetative growth have also shown only very slight increase in the height of plants (Sasidhar, 1989).

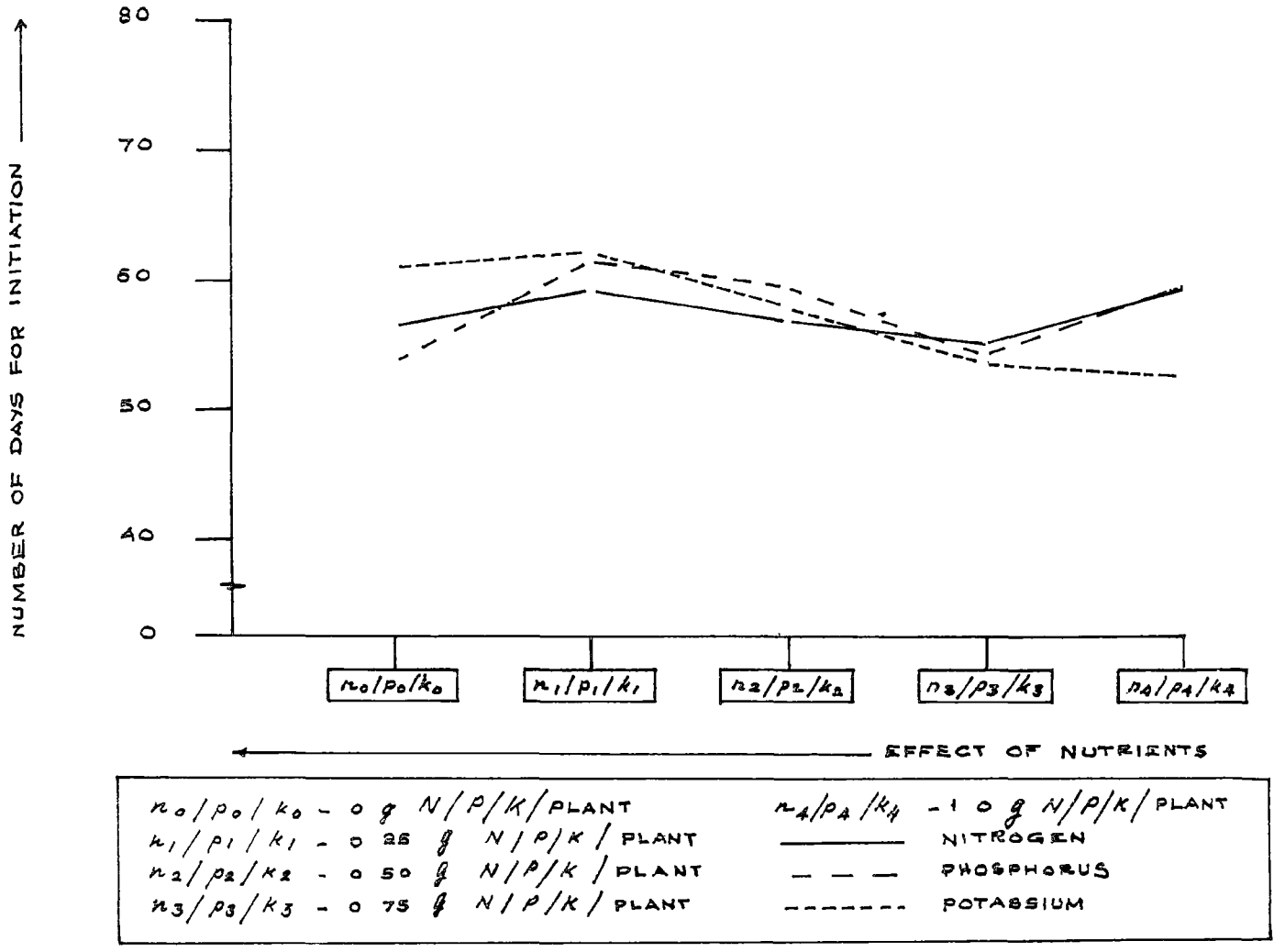
All the three interactions were also found significantly influencing the height of plants. But Divakar et al. (1984) found that the application of nitrogen and potassium did not show any significant difference on the per cent increase of the height of the plant. However, Williams and Thompson (1979) reported that nitrogen and phosphorus fertilization at planting increased plant height of Golden Delicious apple trees on M.26 root stocks. The results of the present investigation also agree with the results obtained in apple.

All the treatments were found enhancing the height of plants. The best treatment was found to be $N_4P_3K_1$.

Flowering

The results given in Table 4 revealed that the added nitrogen had induced earliness in flowering by 1.68 days (Fig. 4). The increased vegetative growth and other growth attributes contributed by the addition of nitrogen might have induced earliness in flowering also. An emphasis on nitrogen application for improved flower production has been given by various workers (Bik, 1970; Mattson and Widner, 1971; Nijjar and Rohalia, 1977 and Johnson, 1978). Malik (1980) reported that the number of flowers produced in the variety Queen Elizebath increased with the increase in nitrogen level. The results obtained in the present study also reveal the importance of nitrogen in flowering. The increase in flower number, flower stem length and number of strong flowering shoots per plant with the increase in nitrogen level was also reported by Bakly (1974). Maharana and Pradhan (1976) found that flower numbers and yield per plant were highest with nitrogen alone in rose variety Celebration.

FIG 4 DAYS FOR INITIATION OF FIRST FLOWERING BUD



The addition of phosphatic fertilizers also reduced the number of days taken for flowering eventhough it was not significant. Phosphates (Phosphorus) help the roots to grow well and speed up flower production (Gibson, 1980). Not enough of them may mean a reluctance of the flower buds to open. Malik (1980) reported that the application of phosphorus improved the flowering significantly but the differences among the treatments were insignificant.

The effect of potassium on earliness in flowering was significant. Potash (Potassium) gives resistance to drought and disease, good growth and fine quality blooms (Gibson, 1980). This study also is in conformity with the results obtained by Woodson and Boodley (1982) who found that low potassium limited flower production in green house roses.

All the three interactions were found significantly influencing the early initiation of flower bud. Waters (1968) found a significant increase in number of flower stems and flower stem length with the increased application of nitrogen and phosphorus. Nijjar and Rehalia (1977) also 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.

Mantrova (1980) showed that during the first two years in roses the best floral quality was obtained with nitrogen and potassium fertilizers. Young et al. (1973) recorded the highest yield of flowers in rose varieties Christian Dior and Happiness with the application of nitrogen. They, however, failed to get any response with phosphorus and potassium on this character.

The treatments were also found to induce early flowering in this study. This is in agreement with the results obtained by Pal (1966). Similar results were also obtained by Irulappan et al. (1980) in Edward rose.

The effect of nitrogen on delaying the flower opening was also positive. This indicates the favourable effect of nitrogen in influencing the productive character in addition to its influence on growth characteristics.

Eventhough the effect of phosphorus was insignificant beneficial effect on delaying flower opening with higher levels of phosphorus was found in this study. This indicates that plants need phosphorus also in addition to nitrogen for better flowering.

An early flower opening was observed due to the higher levels of potassium. This is contradicting the results obtained by Hanson and Granslund (1980) who reported that flower bud formation increased in apple trees grown without potassium compared with trees receiving potassium.

The application of nutrients in various combinations had significant influence in the flower opening of rose. Higher levels of nutrients in various combinations had marked influence in flower opening.

Nutrient content of leaves

The results revealed that with increased level of nitrogen up to 0.75 g per plant supplied to the crop, the nitrogen content of leaves was also correspondingly increased significantly. Thus the higher amount of nitrogen absorbed by the plant had its influence in growth and flowering. Stoilov and Lekhova (1974) also observed that the increasing nitrogen rates raised the leaf nitrogen concentration in apple trees on both root stocks (M.7 and M.4).

Phosphorus application at the rate of 0.75 g per plant resulted in the maximum content of nitrogen. It can be

inferred that the effect of phosphorus in increasing the root growth and development might have resulted in higher uptake of nutrients by the plant from a wide spectrum of the soil. This study was in conformity with the results obtained by Nijjar and Rohalia (1977) who found that application of phosphorus had a favourable effect on nitrogen content in the leaves.

The higher levels of potassium was found to decrease the nitrogen content in the leaves. Stoilov and Lekhova (1974) also found a negative relationship between leaf nitrogen content and potassium content.

The NP interaction was also significant and a combination of N_3P_3 resulted in the maximum content of nitrogen. The higher root growth at higher levels of phosphorus coupled with the beneficial influence of potassium as a carrier nutrient might have resulted in early leaf production, production of assimilates and finally the uptake of nitrogen.

The PK interaction was also found significant. Maximum nitrogen content was obtained under a combination of P_3K_1 and minimum under a combination of P_0K_4. A least value of nitrogen was also noticed under a combination of N_0K_4.

The effect of treatment combinations was also significant. Maximum nitrogen content was observed for the treatment $N_3P_3K_1$ and minimum for $N_1P_0K_4$. This may be the reason for the better vegetative growth of plants when the treatment $N_3P_3K_1$ was given.

Phosphorus

From the table it is clear that application of nitrogen at higher levels had resulted in a significant increase in the phosphorus content. The direct effect of nitrogen in enhancing the vegetative growth of plants might have resulted in a corresponding higher uptake of phosphorus. Nijjar and Rehalia (1977) also found a direct relationship between the doses of nitrogen, phosphorus and potassium and their foliar contents in roses. The same results were obtained in this study also with higher levels of phosphorus. The significant effect of phosphorus in the uptake of phosphorus might be due to the significant influence of this nutrient in the growth attributes of the crop.

The significant influence of potassium in increasing the phosphorus content shows that potassium had negative influence on the uptake of phosphorus.

The interactions were found significant. The best combinations for maximum phosphorus content of leaves was found to be N_3P_3, P_3K_1 and N_4K_0.

The treatments were also found to influence significantly the phosphorus content of leaves. The treatment $N_3P_2K_1$ showed maximum phosphorus content in the leaves. Mehta et al. (1984) reported that the initial phosphorus level generally decreased in leaves of Royal Delicious apple trees and then gradually rose when NPK fertilizers were applied in the soil.

Potassium

From the table it is evident that nitrogen had significantly increased the uptake of potassium in rose upto a level of 0.75 g per plant. Asif and Greig (1972) also found that higher levels of nitrogen had resulted in higher uptake of potassium in snap beans.

Raheja (1966) reported that potassium uptake of plants is normally independent of the concentration of available or total phosphorus in the soil. The significant effect of phosphorus on potassium uptake observed in this study is contradictory to the above finding.

The potassium content of leaves increased significantly with the higher levels of potassium. The leaf potassium concentration was found to reduce at the lowest potassium concentrations in green house roses (Woodson and Boodley, 1952). Divakar *et al.* (1984) also found that potassium status increased in the leaves with increasing level of potassium application.

The luxury consumption of potassium is a well known phenomenon noticed in crop plants under higher levels of potassium. Further, the higher content of potassium in leaves with higher doses of potassium might have contributed to higher uptake of the element. These factors together might have resulted in the higher content of this nutrient in the leaves.

The various combinations of nutrients were also found significantly influencing the potassium content of leaves. The combination P_0K_4 and N_1K_4 showed maximum potassium content and N_4P_1 the minimum content.

The various treatment combinations were also proved to be affecting the potassium content of leaves.

SUMMARY

S U M M A R Y

An investigation was undertaken in the Department of Horticulture, College of Agriculture, Vellayani, Trivandrum during the period from June to December 1985 to find out the effect of nutrition on the establishment and sun take of budded rose plants. A 5^3 factorial experiment was laid out with three replications. The results of the study are summarised below.

1. The various treatments were proved effective in influencing the girth of the stock at the time of budding eventhough the NK and PK interactions were found insignificant. The best treatment was found to be N_2 P_2 K_3 for getting maximum stem girth.

2. The optimum girth of the stock for an easy bud take was found to be 1.13 cm which was obtained under the treatment $N_3P_3K_1$.

3. The different treatments varied significantly in their effect on the days taken for the fall of petiole. Nitrogen and phosphorus at medium levels and potassium at a higher level were found most effective in retaining the petiole for longer periods.

4. A significant difference was observed between the various treatments with regard to their effect on the number of days taken for the initiation of vegetative buds. An early bud take was observed when nitrogen and phosphorus were given at the rate of 0.75 g per plant and potassium at the rate of 0.25 g per plant. The N_4P_1, P_3K_2 and N_3K_1 interactions were also found superior in the early initiation of vegetative buds. The best treatment combination for an early bud take was found to be $N_3P_3K_1$.

5. The emergence of leaves was found to be influenced by various treatments significantly. Eventhough all the levels of nutrients were found better than control, a superior effect was shown by the treatments N_3 (0.75 g per plant), P_3 (0.75 g per plant) and K_4 (1 g per plant) individually. The interactions N_3P_2, P_3K_1 and N_3K_3 were also found superior. The best treatment combination was found to be $N_4P_3K_1$ which was also found on par with the treatment combination $N_3P_3K_1$.

6. The treatments differed significantly in their effect on heights of budded plants. All treatments were proved effective in increasing the heights when compared to control.

Individually, nitrogen and phosphorus at the rate of 0.75 g per plant showed maximum height. During initial stages a lower dose of potassium was sufficient to enhance height of plants. But from 60th day onwards a higher dose of 0.75 g per plant of potassium was needed to produce significant variations in the heights of plants. The N_2P_3, P_3K_1 and N_3K_1 interactions were also found significantly contributing to the difference in the heights of plants. The treatment combination for getting maximum height of the plant was observed to be $N_4P_3K_1$.

7. The number of days taken for the initiation of first flower bud was found to be influenced by various treatments significantly. An early initiation of first flower bud was observed under the treatments N_3 (0.75 g per plant), K_2 (1 g per plant), N_3P_0, P_0K_2, N_3K_4 and $N_3P_3K_3$. No positive effect was found due to the application of phosphorus alone.

8. Regarding flower opening, the nutrients were not found to play a great role. In general a high dose of nitrogen was found to delay flower opening.

9. A significant difference was observed between various treatments with regard to their effect on nutrient content in the leaf samples. Generally, a high dose of nutrients applied to the soil was found to increase the nutrient content in the leaves.

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* Originals not seen

APPENDICES

APPENDIX 1

Chemical analysis of soil and leaf before the experiment

Constituents	Content (per cent)
Available nitrogen	0.090
Available phosphorus	0.005
Available potassium	0.038
Leaf nitrogen	1.74
Leaf phosphorus	0.36
Leaf potassium	1.44

APPENDIX 2

Weather data during the period of June and July, 1985

Parameters	June	July
Relative Humidity (per cent)	83.45	80.38
Rainfall (mm)	7.94	9.97
Average temperature(°C)	24.99	26.39

APPENDIX 3

Effect of NPK interaction on growth and flowering

Treatments	Girth of the stock at the time of budding (cm)	Days taken for the fall of petiole	Days taken for the initiation of buds	Days taken for the initiation of first flower bud	Days taken for the flower opening after initiation
1	2	3	4	5	6
$N_0P_0K_0$	1.43	16.30	23.13	75.27	12.50
$N_0P_0K_1$	1.27	11.43	15.17	57.43	15.53
$N_0P_0K_2$	1.30	10.10	14.07	51.63	13.00
$N_0P_0K_3$	1.37	9.43	13.20	53.97	12.67
$N_0P_0K_4$	1.37	7.40	12.33	46.67	11.00
$N_0P_1K_0$	1.27	13.10	21.00	56.73	15.00
$N_0P_1K_1$	1.33	7.33	19.70	59.93	11.03
$N_0P_1K_2$	1.23	8.03	18.73	56.60	11.53
$N_0P_1K_3$	1.23	8.33	17.13	52.33	10.10
$N_0P_1K_4$	1.27	10.10	16.37	51.97	9.80
$N_0P_2K_0$	1.47	12.47	15.10	56.93	11.00
$N_0P_2K_1$	1.30	10.07	14.47	63.43	13.03
$N_0P_2K_2$	1.53	14.17	14.00	59.77	14.07
$N_0P_2K_3$	1.37	9.00	13.83	54.93	12.47
$N_0P_2K_4$	1.50	9.40	14.00	52.03	10.13
$N_0P_3K_0$	1.30	9.00	13.70	58.17	13.00
$N_0P_3K_1$	1.27	7.33	12.27	60.43	12.20
$N_0P_3K_2$	1.53	8.03	11.47	55.93	11.67
$N_0P_3K_3$	1.43	8.37	12.77	57.13	10.03
$N_0P_3K_4$	1.53	9.33	19.53	55.00	8.97

Contd...

1	2	3	4	5	6
$N_0P_4K_0$	1.33	10.20	12.43	62.17	12.53
$N_0P_4K_1$	1.47	8.37	12.83	55.60	12.47
$N_0P_4K_2$	1.30	7.33	12.83	61.17	11.33
$N_0P_4K_3$	1.30	10.17	11.47	50.70	12.07
$N_0P_4K_4$	1.50	10.27	12.13	49.83	1.30
$N_1P_0K_0$	1.27	13.47	16.07	61.93	16.00
$N_1P_0K_1$	1.10	10.17	15.67	55.60	15.03
$N_1P_0K_2$	1.50	9.70	18.83	55.20	15.70
$N_1P_0K_3$	1.10	9.13	18.00	52.13	14.00
$N_1P_0K_4$	1.10	10.33	15.43	51.50	12.03,
$N_1P_1K_0$	1.37	11.37	15.00	61.33	11.07
$N_1P_1K_1$	1.40	13.20	16.60	69.63	12.57
$N_1P_1K_2$	1.33	11.90	15.73	66.60	11.67
$N_1P_1K_3$	1.43	14.67	15.03	66.13	10.33
$N_1P_1K_4$	1.40	12.03	14.73	58.40	14.83
$N_1P_2K_0$	1.30	10.33	13.93	62.90	13.07
$N_1P_2K_1$	1.37	15.07	16.67	67.83	12.03
$N_1P_2K_2$	1.47	14.20	16.10	63.03	14.00
$N_1P_2K_3$	1.77	12.10	14.20	60.43	13.37
$N_1P_2K_4$	1.30	12.27	14.00	59.63	12.67
$N_1P_3K_0$	1.63	9.30	13.67	62.53	12.83
$N_1P_3K_1$	1.40	12.33	13.77	54.03	12.23
$N_1P_3K_2$	1.20	10.07	12.57	50.97	11.73
$N_1P_3K_3$	1.33	10.00	12.00	47.63	10.80
$N_1P_3K_4$	1.40	10.57	12.07	44.70	11.17

Contd...

1	2	3	4	5	6
$N_1P_4K_0$	1.60	9.33	13.23	61.27	12.67
$N_1P_4K_1$	1.60	10.13	11.90	65.57	13.43
$N_1P_4K_2$	1.70	12.27	14.23	65.70	12.27
$N_1P_4K_3$	1.40	11.07	13.77	63.17	11.83
$N_1P_4K_4$	1.37	10.13	12.97	61.37	11.33
$N_2P_0K_0$	1.40	14.50	15.87	59.83	14.40
$N_2P_0K_1$	1.47	9.23	15.47	52.63	10.97
$N_2P_0K_2$	1.20	9.30	15.20	52.23	9.57
$N_2P_0K_3$	1.23	9.27	15.03	50.10	9.73
$N_2P_0K_4$	1.13	10.40	15.03	46.93	9.20
$N_2P_1K_0$	1.40	12.33	14.33	62.47	14.03
$N_2P_1K_1$	1.27	8.97	11.50	71.33	10.03
$N_2P_1K_2$	1.57	8.87	11.60	65.40	13.40
$N_2P_1K_3$	1.33	8.5	11.50	58.20	12.17
$N_2P_1K_4$	1.30	8.40	11.00	56.30	13.67
$N_2P_2K_0$	1.40	10.03	14.13	58.27	13.20
$N_2P_2K_1$	1.70	10.30	11.73	61.70	12.37
$N_2P_2K_2$	2.07	10.10	11.00	58.50	9.90
$N_2P_2K_3$	2.37	9.07	10.90	54.90	9.03
$N_2P_2K_4$	1.47	8.83	11.97	52.37	10.63
$N_2P_3K_0$	1.20	7.97	12.97	58.63	13.37
$N_2P_3K_1$	1.17	5.90	8.17	55.07	12.10
$N_2P_3K_2$	1.37	6.80	9.23	45.17	15.07
$N_2P_3K_3$	1.20	10.10	11.57	44.47	9.17
$N_2P_3K_4$	1.33	11.10	12.00	44.23	10.33
$N_2P_4K_0$	1.30	8.63	12.33	58.33	13.07
$N_2P_4K_1$	1.40	10.10	11.40	67.40	14.40
$N_2P_4K_2$	1.50	10.23	11.00	63.07	13.77

Contd...

1	2	3	4	5	6
$N_2P_4K_3$	1.50	11.20	12.83	60.00	12.40
$N_2P_4K_4$	1.30	11.27	12.60	64.50	15.00
$N_3P_0K_0$	1.30	8.47	12.83	59.47	12.00
$N_3P_0K_1$	1.43	5.90	7.87	53.47	11.47
$N_3P_0K_2$	1.10	10.07	11.10	51.57	9.77
$N_3P_0K_3$	1.40	10.10	12.00	43.47	6.97
$N_3P_0K_4$	1.50	12.53	13.77	45.17	9.10
$N_3P_1K_0$	1.10	8.33	12.03	61.30	11.43
$N_3P_1K_1$	1.50	9.10	11.67	69.60	11.53
$N_3P_1K_2$	1.60	8.97	10.20	65.50	12.47
$N_3P_1K_3$	1.50	10.07	11.60	65.07	11.27
$N_3P_1K_4$	1.20	10.07	12.00	55.27	12.40
$N_3P_2K_0$	1.47	10.10	11.83	64.17	12.00
$N_3P_2K_1$	1.47	6.03	7.50	61.83	11.70
$N_3P_2K_2$	1.33	10.03	11.17	59.60	11.30
$N_3P_2K_3$	1.57	10.20	10.87	53.33	9.83
$N_3P_2K_4$	1.27	10.23	11.00	54.67	11.80
$N_3P_3K_0$	1.30	10.83	11.17	63.47	12.53
$N_3P_3K_1$	1.13	5.20	6.63	55.03	13.03
$N_3P_3K_2$	1.20	10.03	11.40	49.77	13.97
$N_3P_3K_3$	1.83	12.10	13.30	42.77	13.93
$N_3P_3K_4$	1.23	9.07	11.57	45.40	14.37
$N_3P_4K_0$	1.47	9.30	10.60	62.40	11.60
$N_3P_4K_1$	1.47	9.27	10.80	55.43	18.33
$N_3P_4K_2$	1.33	13.03	14.53	49.77	17.60
$N_3P_4K_3$	1.40	13.00	15.23	42.87	16.83
$N_3P_4K_4$	1.40	9.83	13.03	44.50	16.47

Contd...

1	2	3	4	5	6
$N_4P_0K_0$	1.37	7.13	12.07	57.53	13.00
$N_4P_0K_1$	1.30	10.73	12.53	59.23	12.07
$N_4P_0K_2$	1.27	10.33	12.53	52.43	11.53
$N_4P_0K_3$	1.37	9.17	11.97	49.60	10.80
$N_4P_0K_4$	1.57	9.90	11.93	46.53	13.10
$N_4P_1K_0$	1.23	8.33	8.87	59.43	12.43
$N_4P_1K_1$	1.40	7.07	8.23	67.70	13.13
$N_4P_1K_2$	1.10	9.03	10.30	60.17	12.43
$N_4P_1K_3$	1.50	9.27	10.03	56.37	13.27
$N_4P_1K_4$	1.20	9.93	11.07	58.50	14.53
$N_4P_2K_0$	1.30	8.67	10.10	60.10	11.77
$N_4P_2K_1$	1.43	9.33	10.37	66.40	13.57
$N_4P_2K_2$	1.10	9.00	11.00	64.87	12.93
$N_4P_2K_3$	1.33	9.97	11.37	58.33	14.27
$N_4P_2K_4$	1.13	10.20	11.97	52.97	14.53
$N_4P_3K_0$	1.20	6.67	9.00	61.10	10.50
$N_4P_3K_1$	1.20	6.93	8.83	62.50	14.83
$N_4P_3K_2$	1.23	7.97	10.60	66.90	14.50
$N_4P_3K_3$	1.23	8.17	14.33	58.60	15.97
$N_4P_3K_4$	1.37	9.13	13.67	59.00	16.53
$N_4P_4K_0$	1.53	7.17	8.00	55.80	10.23
$N_4P_4K_1$	1.10	10.13	14.13	66.40	14.20
$N_4P_4K_2$	1.17	11.00	15.23	64.23	15.63
$N_4P_4K_3$	1.50	12.03	16.23	59.73	15.23
$N_4P_4K_4$	1.50	12.00	16.17	58.50	14.30
C.D.(5%)	0.22	1.04	0.78	3.63	1.38
S.E.m	0.08	0.38	0.28	1.31	0.49

APPENDIX 4

Effect of NPK interaction on the days taken for the emergence of leaves after bud initiation

Treatments	Position of leaves				
	First	Third	Fifth	Seventh	Nineth
1	2	3	4	5	6
$N_0P_0K_0$	20.90	24.00	27.70	34.07	41.27
$N_0P_0K_1$	18.97	21.00	24.23	28.20	34.57
$N_0P_0K_2$	18.07	21.23	24.73	27.93	35.13
$N_0P_0K_3$	19.03	21.97	26.00	30.63	35.60
$N_0P_0K_4$	17.53	20.37	24.80	29.80	36.27
$N_0P_1K_0$	18.83	20.20	23.53	27.73	31.53
$N_0P_1K_1$	21.87	24.70	28.93	33.50	38.07
$N_0P_1K_2$	21.20	25.23	29.30	32.67	37.37
$N_0P_1K_3$	19.83	24.50	28.83	33.20	38.23
$N_0P_1K_4$	18.60	20.87	25.17	31.80	36.63
$N_0P_2K_0$	17.90	19.67	23.20	26.93	32.17
$N_0P_2K_1$	18.10	20.23	23.57	28.10	32.83
$N_0P_2K_2$	17.70	19.67	22.13	26.70	33.73
$N_0P_2K_3$	16.83	18.90	22.40	27.10	32.90
$N_0P_2K_4$	16.53	19.13	23.23	28.20	33.03
$N_0P_3K_0$	17.97	20.13	22.47	27.13	32.43
$N_0P_3K_1$	19.07	21.77	25.63	29.87	35.73
$N_0P_3K_2$	18.20	19.83	23.77	27.23	33.80
$N_0P_3K_3$	17.13	20.10	24.20	28.10	33.17
$N_0P_3K_4$	16.97	19.57	23.90	29.27	34.63
$N_0P_4K_0$	17.13	19.83	22.20	26.57	32.90
$N_0P_4K_1$	17.60	19.10	23.73	28.87	34.93
$N_0P_4K_2$	17.80	19.03	23.90	28.87	34.63

Contd..

1	2	3	4	5	6
$N_0P_4K_3$	16.90	18.53	20.93	24.77	29.90
$N_0P_4K_4$	16.37	18.00	19.32	23.80	28.10
$N_1P_0K_0$	21.47	22.90	25.00	31.43	37.63
$N_1P_0K_1$	21.00	24.73	29.23	34.90	40.23
$N_1P_0K_2$	19.50	24.13	28.80	34.73	38.93
$N_1P_0K_3$	19.10	23.53	27.33	33.20	38.37
$N_1P_0K_4$	18.37	23.10	26.97	30.80	36.20
$N_1P_1K_0$	20.47	23.43	27.87	33.80	39.13
$N_1P_1K_1$	20.80	24.57	29.43	35.90	42.83
$N_1P_1K_2$	19.73	23.13	27.80	33.80	39.13
$N_1P_1K_3$	19.53	15.40	25.33	31.43	36.80
$N_1P_1K_4$	18.83	20.77	23.93	29.83	33.67
$N_1P_2K_0$	19.93	22.90	28.1	33.40	38.90
$N_1P_2K_1$	19.03	23.37	28.67	34.10	40.77
$N_1P_2K_2$	18.13	22.13	26.10	32.17	38.93
$N_1P_2K_3$	17.63	20.37	24.33	30.43	36.13
$N_1P_2K_4$	17.20	20.17	23.60	28.80	33.93
$N_1P_3K_0$	19.80	23.13	27.83	32.80	39.03
$N_1P_3K_1$	18.57	20.87	23.83	28.93	35.43
$N_1P_3K_2$	16.87	18.77	21.13	26.43	30.27
$N_1P_3K_3$	15.17	17.17	19.80	23.73	30.37
$N_1P_3K_4$	14.13	16.03	19.13	22.83	29.10
$N_1P_4K_0$	18.23	21.43	26.17	30.33	36.67
$N_1P_4K_1$	18.83	21.73	25.60	32.73	40.40
$N_1P_4K_2$	17.80	20.07	24.37	30.80	37.33
$N_1P_4K_3$	16.37	19.20	22.97	27.10	35.57
$N_1P_4K_4$	15.23	17.97	21.17	25.63	32.17

Contd....

1	2	3	4	5	6
$N_2P_0K_0$	20.63	23.23	26.67	29.67	34.27
$N_2P_0K_1$	20.23	23.77	28.77	35.83	42.83
$N_2P_0K_2$	19.27	22.37	28.13	34.13	40.67
$N_2P_0K_3$	19.03	21.33	26.27	32.33	38.87
$N_2P_0K_4$	18.17	20.43	24.90	30.13	35.13
$N_2P_1K_0$	19.47	22.07	26.03	30.43	36.97
$N_2P_1K_1$	19.53	21.50	25.37	31.67	38.90
$N_2P_1K_2$	19.20	20.80	24.83	29.37	37.83
$N_2P_1K_3$	17.92	19.77	23.43	27.23	34.90
$N_2P_1K_4$	17.17	19.27	22.10	25.73	33.07
$N_2P_2K_0$	19.13	21.97	26.30	31.73	37.43
$N_2P_2K_1$	18.77	20.67	25.40	32.73	39.13
$N_2P_2K_2$	17.93	19.53	24.13	30.13	37.87
$N_2P_2K_3$	16.93	18.23	21.97	27.63	35.17
$N_2P_2K_4$	15.93	17.33	21.17	25.87	31.43
$N_2P_3K_0$	18.13	20.43	24.90	29.17	35.83
$N_2P_3K_1$	14.13	16.10	19.80	23.77	27.57
$N_2P_3K_2$	15.13	17.43	20.10	24.00	29.00
$N_2P_3K_3$	16.47	18.97	22.10	27.63	30.17
$N_2P_3K_4$	17.23	19.83	23.50	28.97	34.17
$N_2P_4K_0$	17.93	19.43	22.83	26.37	31.83
$N_2P_4K_1$	17.20	19.13	24.73	30.17	37.10
$N_2P_4K_2$	17.03	18.67	23.20	28.93	35.73
$N_2P_4K_3$	17.83	19.30	23.13	27.53	33.23
$N_2P_4K_4$	17.13	18.47	21.90	25.27	30.83
$N_3P_0K_0$	19.53	21.20	24.77	28.40	34.17
$N_3P_0K_1$	18.97	22.17	27.73	36.03	42.20
$N_3P_0K_2$	17.87	19.83	25.40	30.13	38.23

Contd.....

1	2	3	4	5	6
$N_3P_0K_3$	16.13	18.07	23.37	27.47	33.93
$N_3P_0K_4$	15.87	17.80	22.03	27.13	32.77
$N_3P_1K_0$	18.10	19.90	23.43	28.83	34.57
$N_3P_1K_1$	17.93	22.13	27.20	33.10	40.17
$N_3P_1K_2$	16.47	21.43	26.30	32.30	38.90
$N_3P_1K_3$	15.13	19.20	24.07	30.37	37.13
$N_3P_1K_4$	14.47	18.13	22.73	28.77	35.10
$N_3P_2K_0$	17.50	2 .13	23.50	27.97	34.07
$N_3P_2K_1$	14.17	16.10	18.83	22.47	31.47
$N_3P_2K_2$	13.97	13.00	20.77	24.83	30.17
$N_3P_2K_3$	13.87	16.23	19.90	23.23	28.77
$N_3P_2K_4$	15.20	18.10	22.27	27.93	33.77
$N_3P_3K_0$	17.43	19.10	22.77	27.20	32.63
$N_3P_3K_1$	11.93	13.68	16.10	20.23	25.27
$N_3P_3K_2$	13.73	15.80	19.17	25.10	30.67
$N_3P_3K_3$	15.07	17.30	21.73	28.80	35.83
$N_3P_3K_4$	16.80	19.13	23.77	29.23	37.08
$N_3P_4K_0$	16.40	18.27	21.17	25.90	30.17
$N_3P_4K_1$	14.07	15.90	20.10	25.10	31.83
$N_3P_4K_2$	15.73	18.23	22.90	28.60	33.33
$N_3P_4K_3$	15.57	18.47	23.60	27.37	31.23
$N_3P_4K_4$	14.87	17.83	23.17	26.87	30.17
$N_4P_0K_0$	17.87	19.23	22.73	25.70	29.13
$N_4P_0K_1$	17.77	19.90	25.73	32.83	39.90
$N_4P_0K_2$	16.53	18.20	23.07	29.10	36.43
$N_4P_0K_3$	15.13	17.10	21.87	26.73	33.13
$N_4P_0K_4$	14.43	16.30	20.43	24.87	31.93

Contd...

1	2	3	4	5	6
$N_4P_1K_0$	17.17	19.23	23.87	29.07	35.60
$N_4P_1K_1$	17.53	16.23	19.33	24.17	29.63
$N_4P_1K_2$	17.13	20.27	24.23	30.17	37.47
$N_4P_1K_3$	16.77	19.50	23.97	29.67	36.77
$N_4P_1K_4$	17.73	21.03	25.67	32.67	39.90
$N_4P_2K_0$	16.23	17.87	22.13	27.40	34.07
$N_4P_2K_1$	16.83	18.57	21.23	25.40	29.83
$N_4P_2K_2$	15.37	17.37	20.83	25.20	28.60
$N_4P_2K_3$	17.83	20.13	24.90	28.73	34.03
$N_4P_2K_4$	18.53	21.63	25.63	30.67	46.70
$N_4P_3K_0$	15.13	17.17	20.83	26.13	31.77
$N_4P_3K_1$	11.17	12.90	16.17	20.30	24.20
$N_4P_3K_2$	14.07	17.33	20.80	25.50	30.77
$N_4P_3K_3$	16.90	18.77	21.70	26.97	32.77
$N_4P_3K_4$	17.87	20.20	24.03	29.23	35.73
$N_4P_4K_0$	14.80	16.17	19.10	23.73	28.90
$N_4P_4K_1$	17.80	19.53	22.83	26.37	30.87
$N_4P_4K_2$	18.33	20.30	24.00	28.10	33.83
$N_4P_4K_3$	19.17	21.83	25.87	31.57	37.70
$N_4P_4K_4$	18.97	20.73	24.90	29.90	37.00
C.D.(5%)	0.80	2.32	1.37	1.62	1.86
$S.E._m$	0.29	0.84	0.49	0.59	0.67

APPENDIX 5

Effect of NPK interaction on height of the plant at periodic intervals

Treatments	Days after budding				
	30	45	60	75	90
1	2	3	4	5	6
$N_0P_0K_0$	1.20	6.53	20.63	28.33	31.37
$N_0P_0K_1$	1.30	5.30	18.90	25.33	28.30
$N_0P_0K_2$	1.77	5.93	23.03	27.70	29.07
$N_0P_0K_3$	1.53	7.13	24.57	32.30	35.57
$N_0P_0K_4$	2.43	8.63	26.20	35.13	39.27
$N_0P_1K_0$	2.13	6.43	19.23	24.80	26.63
$N_0P_1K_1$	1.90	6.97	20.80	27.80	30.70
$N_0P_1K_2$	1.87	7.43	22.93	32.00	36.13
$N_0P_1K_3$	1.80	7.47	25.53	33.57	37.50
$N_0P_1K_4$	1.70	6.93	26.63	35.63	40.67
$N_0P_2K_0$	3.43	7.87	20.13	26.70	28.50
$N_0P_2K_1$	3.87	8.57	22.40	28.23	31.30
$N_0P_2K_2$	3.40	8.87	23.13	30.07	32.27
$N_0P_2K_3$	2.93	8.47	24.70	31.17	33.73
$N_0P_2K_4$	2.23	8.27	24.00	3 4.47	39.40
$N_0P_3K_0$	3.93	8.20	22.33	31.23	33.27
$N_0P_3K_1$	2.43	8.83	26.70	36.40	41.53
$N_0P_3K_2$	2.53	9.53	27.13	39.37	45.53
$N_0P_3K_3$	4.63	9.87	26.60	42.60	44.53
$N_0P_3K_4$	3.77	9.80	28.00	43.27	44.77

Cont....

1	2	3	4	5	6
$N_0P_4K_0$	5.70	9.40	24.17	34.37	37.63
$N_0P_4K_1$	4.53	10.00	26.83	38.93	46.50
$N_0P_4K_2$	4.77	11.37	27.17	41.27	50.17
$N_0P_4K_3$	2.63	10.40	26.30	41.73	52.37
$N_0P_4K_4$	2.37	13.07	29.13	43.27	53.87
$N_1P_0K_0$	2.70	7.40	19.40	29.27	23.43
$N_1P_0K_1$	3.20	8.80	20.10	28.87	31.80
$N_1P_0K_2$	3.13	8.90	22.67	32.27	35.20
$N_1P_0K_3$	2.93	7.67	22.50	31.50	34.17
$N_1P_0K_4$	3.17	8.53	23.53	34.03	39.30
$N_1P_1K_0$	3.30	8.47	20.87	28.57	31.90
$N_1P_1K_1$	1.30	7.27	19.83	41.87	50.53
$N_1P_1K_2$	2.03	7.47	21.00	45.20	56.43
$N_1P_1K_3$	1.83	7.27	20.90	46.30	57.47
$N_1P_1K_4$	1.57	7.77	16.77	39.77	47.73
$N_1P_2K_0$	3.53	10.27	23.63	31.53	34.50
$N_1P_2K_1$	1.33	10.47	24.00	45.73	55.70
$N_1P_2K_2$	1.70	9.57	24.03	43.83	56.13
$N_1P_2K_3$	1.93	9.33	23.51	45.43	54.50
$N_1P_2K_4$	2.77	9.53	22.83	41.00	50.60
$N_1P_3K_0$	4.87	10.77	28.17	36.50	39.67
$N_1P_3K_1$	3.43	10.80	26.20	36.80	40.80
$N_1P_3K_2$	4.07	12.03	25.47	37.53	42.37
$N_1P_3K_3$	3.13	10.47	25.23	36.37	41.30
$N_1P_3K_4$	3.67	10.60	21.33	34.23	39.07
$N_1P_4K_0$	5.17	11.40	27.13	34.67	39.37
$N_1P_4K_1$	4.80	11.40	27.13	46.07	58.00
$N_1P_4K_2$	4.30	10.13	26.80	43.70	54.10

Contd....

1	2	3	4	5	6
$N_1P_4K_3$	3.83	9.53	25.03	44.57	55.40
$N_1P_4K_4$	3.00	9.33	24.80	45.33	54.00
$N_2P_0K_0$	3.70	7.40	20.63	30.47	34.30
$N_2P_0K_1$	2.23	7.17	20.43	30.07	34.47
$N_2P_0K_2$	3.60	7.83	21.77	31.50	34.30
$N_2P_0K_3$	4.97	8.33	25.43	34.50	38.03
$N_2P_0K_4$	4.77	7.43	23.90	37.17	42.68
$N_2P_1K_0$	2.00	8.50	21.20	30.27	34.33
$N_2P_1K_1$	2.80	7.67	19.63	34.77	41.67
$N_2P_1K_2$	3.20	8.10	21.60	36.03	44.30
$N_2P_1K_3$	3.97	8.17	21.57	33.07	40.80
$N_2P_1K_4$	3.43	9.23	20.93	33.33	39.07
$N_2P_2K_0$	2.37	8.13	20.07	33.27	37.50
$N_2P_2K_1$	3.40	10.63	23.53	38.20	43.90
$N_2P_2K_2$	3.07	11.63	25.67	40.37	47.37
$N_2P_2K_3$	2.90	11.10	24.20	41.40	48.53
$N_2P_2K_4$	2.27	9.43	25.10	39.80	45.67
$N_2P_3K_0$	3.87	10.50	25.43	36.57	41.47
$N_2P_3K_1$	8.97	16.37	34.40	47.27	58.90
$N_2P_3K_2$	8.40	14.17	32.33	49.53	61.37
$N_2P_3K_3$	5.17	12.40	32.07	48.63	58.43
$N_2P_3K_4$	4.90	12.23	31.87	43.73	53.63
$N_2P_4K_0$	4.77	7.43	23.90	37.20	42.63
$N_2P_4K_1$	1.93	8.67	24.73	42.27	91.30
$N_2P_4K_2$	4.40	10.67	26.03	44.57	54.80
$N_2P_4K_3$	3.77	9.87	27.13	43.53	52.30
$N_2P_4K_4$	4.27	9.63	26.87	45.10	95.17

Contd...

1	2	3	4	5	6
$N_3P_0K_0$	4.60	8.70	22.80	34.77	40.20
$N_3P_0K_1$	4.20	9.80	22.47	33.47	37.50
$N_3P_0K_2$	4.03	8.77	23.00	36.40	41.03
$N_3P_0K_3$	3.77	8.53	24.23	38.63	44.90
$N_3P_0K_4$	3.60	8.83	20.90	34.33	39.23
$N_3P_1K_0$	1.67	8.20	24.60	34.20	34.27
$N_3P_1K_1$	6.30	12.33	25.87	49.40	60.77
$N_3P_1K_2$	5.90	10.03	24.23	47.80	57.60
$N_3P_1K_3$	5.40	10.37	26.73	48.23	59.27
$N_3P_1K_4$	4.10	9.83	24.77	49.27	60.37
$N_3P_2K_0$	2.83	9.43	26.07	33.87	35.87
$N_3P_2K_1$	5.13	12.40	27.70	46.93	58.50
$N_3P_2K_2$	3.33	10.37	28.20	49.23	61.60
$N_3P_2K_3$	4.73	12.43	29.10	50.00	62.27
$N_3P_2K_4$	3.00	9.67	27.37	46.70	58.47
$N_3P_3K_0$	4.60	12.17	27.20	36.37	40.03
$N_3P_3K_1$	7.60	16.00	33.03	49.37	59.47
$N_3P_3K_2$	5.47	12.07	30.20	44.70	54.80
$N_3P_3K_3$	4.27	11.40	29.17	43.41	53.93
$N_3P_3K_4$	2.80	9.83	26.53	45.77	55.87
$N_3P_4K_0$	4.80	12.10	29.97	37.13	43.6
$N_3P_4K_1$	7.27	14.80	28.03	40.43	50.40
$N_3P_4K_2$	5.03	11.43	31.67	42.13	50.33
$N_3P_4K_3$	4.00	10.10	27.97	39.57	44.67
$N_3P_4K_4$	3.53	9.20	30.33	37.63	40.57
$N_4P_0K_0$	5.83	10.83	20.43	37.33	44.80
$N_4P_0K_1$	1.90	7.90	23.23	33.90	37.73
$N_4P_0K_2$	2.63	9.37	24.60	35.50	39.67
$N_4P_0K_3$	2.33	9.17	29.50	39.63	44.13
$N_4P_0K_4$	3.57	9.13	27.50	35.60	38.47
$N_4P_1K_0$	3.57	9.80	26.57	35.10	37.23
$N_4P_1K_1$	4.90	12.63	27.60	40.53	44.70

Conde

1	2	3	4	5	6
$N_4P_1K_2$	2.87	10.17	26.30	42.23	49.33
$N_4P_1K_3$	5.80	12.03	24.37	43.33	51.43
$N_4P_1K_4$	3.10	9.63	25.17	44.37	52.80
$N_4P_2K_0$	3.83	10.37	29.73	38.47	42.93
$N_4P_2K_1$	4.93	12.13	26.43	46.47	56.37
$N_4P_2K_2$	2.50	7.83	27.10	46.47	56.37
$N_4P_2K_3$	2.07	7.93	25.53	44.90	53.67
$N_4P_2K_4$	1.77	8.20	25.73	40.57	45.60
$N_4P_3K_0$	4.27	13.33	38.13	42.93	46.70
$N_4P_3K_1$	8.10	14.77	29.77	49.17	60.80
$N_4P_3K_2$	8.10	13.53	27.07	46.20	55.53
$N_4P_3K_3$	4.90	11.30	28.67	43.13	53.57
$N_4P_3K_4$	3.80	10.07	24.60	44.10	55.60
$N_4P_4K_0$	4.53	13.23	36.40	45.37	50.63
$N_4P_4K_1$	4.33	10.93	26.67	45.47	55.67
$N_4P_4K_2$	3.40	11.57	25.67	43.17	53.43
$N_4P_4K_3$	3.23	11.10	23.40	46.00	56.27
$N_4P_4K_4$	3.27	10.17	23.30	43.90	53.67
C.D.(5%)	2.57	1.12	1.95	6.27	1.96
S.E.m	0.93	0.40	0.70	2.26	0.71

APPENDIX 6

Effect of NPK interaction on NPK content of leaves

Treatments	N	P	K
1	2	3	4
$N_0P_0K_0$	0.77	0.26	0.78
$N_0P_0K_1$	0.84	0.30	0.61
$N_0P_0K_2$	1.05	0.28	1.25
$N_0P_0K_3$	1.00	0.24	1.67
$N_0P_0K_4$	0.56	0.21	2.15
$N_0P_1K_0$	1.23	0.47	1.21
$N_0P_1K_1$	1.56	0.38	1.78
$N_0P_1K_2$	1.51	0.33	1.92
$N_0P_1K_3$	1.29	0.25	1.81
$N_0P_1K_4$	0.97	0.31	1.88
$N_0P_2K_0$	1.30	0.49	1.15
$N_0P_2K_1$	1.46	0.37	1.42
$N_0P_2K_2$	1.23	0.47	1.36
$N_0P_2K_3$	1.08	0.29	1.82
$N_0P_2K_4$	0.64	0.34	1.92
$N_0P_3K_0$	0.90	0.48	0.98
$N_0P_3K_1$	2.41	0.53	1.07
$N_0P_3K_2$	1.58	0.45	1.12
$N_0P_3K_3$	1.41	0.37	2.16
$N_0P_3K_4$	1.02	0.22	2.22
$N_0P_4K_0$	0.85	0.50	0.75
$N_0P_4K_1$	2.39	0.56	0.62
$N_0P_4K_2$	1.19	0.47	0.78

Contd...

1	2	3	4
$N_0P_4K_3$	1.12	0.42	1.24
$N_0P_4K_4$	1.07	0.34	2.88
$N_1P_0K_0$	0.69	0.38	1.14
$N_1P_0K_1$	0.98	0.31	1.14
$N_1P_0K_2$	0.88	0.38	1.40
$N_1P_0K_3$	0.78	0.27	1.84
$N_1P_0K_4$	0.42	0.23	3.84
$N_1P_1K_0$	0.86	0.33	2.07
$N_1P_1K_1$	1.58	0.41	0.98
$N_1P_1K_2$	1.23	0.38	1.13
$N_1P_1K_3$	1.12	0.35	1.24
$N_1P_1K_4$	0.94	0.36	1.64
$N_1P_2K_0$	0.98	0.30	1.93
$N_1P_2K_1$	1.81	0.40	1.15
$N_1P_2K_2$	1.79	0.47	1.29
$N_1P_2K_3$	1.96	0.43	1.44
$N_1P_2K_4$	1.85	0.40	1.68
$N_1P_3K_0$	1.23	0.40	1.80
$N_1P_3K_1$	1.85	0.41	1.20
$N_1P_3K_2$	1.05	0.52	1.46
$N_1P_3K_3$	1.13	0.44	1.98
$N_1P_3K_4$	1.07	0.39	2.71
$N_1P_4K_0$	1.31	0.42	1.40
$N_1P_4K_1$	1.48	0.56	0.57
$N_1P_4K_2$	1.36	0.45	1.46
$N_1P_4K_3$	1.12	0.36	1.50
$N_1P_4K_4$	0.97	0.36	1.57

Contd....

1	2	3	4
$N_2P_0K_0$	1.79	0.44	0.88
$N_2P_0K_1$	1.69	0.42	0.96
$N_2P_0K_2$	1.62	0.38	1.04
$N_2P_0K_3$	1.48	0.35	1.67
$N_2P_0K_4$	1.29	0.31	2.45
$N_2P_1K_0$	1 .87	0.32	1.30
$N_2P_1K_1$	2.18	0.48	1.13
$N_2P_1K_2$	1.78	0.45	0.89
$N_2P_1K_3$	1.67	0.43	1.25
$N_2P_1K_4$	0.95	0.40	1.32
$N_2P_2K_0$	1.59	0.35	1.25
$N_2P_2K_1$	2.64	0.52	0.90
$N_2P_2K_2$	1.84	0.49	1.25
$N_2P_2K_3$	1.32	0.47	1.33
$N_2P_2K_4$	1.14	0.48	1.35
$N_2P_3K_0$	1.61	0.40	1.15
$N_2P_3K_1$	3.36	0.62	2.52
$N_2P_3K_2$	3.26	0.59	2.61
$N_2P_3K_3$	1.75	0.50	2.91
$N_2P_3K_4$	1.34	0.47	2.93
$N_2P_4K_0$	1.49	0.41	0.88
$N_2P_4K_1$	2.04	0.50	1.12
$N_2P_4K_2$	1.96	0.44	1.24
$N_2P_4K_3$	1.45	0.34	1.31
$N_2P_4K_4$	1.06	0.35	1.45
$N_3P_0K_0$	1.08	0.52	0.46
$N_3P_0K_1$	4.17	0.63	0.91

Contd....

1	2	3	4
$N_3P_0K_2$	2.13	0.47	1.13
$N_3P_0K_3$	1.68	0.38	1.64
$N_3P_0K_4$	1.25	0.34	2.59
$N_3P_1K_0$	1.87	0.44	1.18
$N_3P_1K_1$	2.43	0.49	1.28
$N_3P_1K_2$	1.74	0.46	1.36
$N_3P_1K_3$	1.31	0.41	1.71
$N_3P_1K_4$	0.84	0.30	1.74
$N_3P_2K_0$	1.79	0.47	0.88
$N_3P_2K_1$	4.45	0.64	1.56
$N_3P_2K_2$	3.41	0.52	1.50
$N_3P_2K_3$	1.46	0.44	1.75
$N_3P_2K_4$	1.12	0.38	1.36
$N_3P_3K_0$	2.69	0.59	0.76
$N_3P_3K_1$	4.66	0.66	1.57
$N_3P_3K_2$	3.42	0.47	1.80
$N_3P_3K_3$	1.93	0.47	2.41
$N_3P_3K_4$	1.60	0.43	2.76
$N_3P_4K_0$	1.82	0.56	0.64
$N_3P_4K_1$	2.58	0.46	1.70
$N_3P_4K_2$	2.46	0.43	1.89
$N_3P_4K_3$	1.40	0.38	2.69
$N_3P_4K_4$	0.78	0.33	2.94
$N_4P_0K_0$	2.24	0.47	0.44
$N_4P_0K_1$	2.53	0.41	0.98
$N_4P_0K_2$	1.91	0.37	1.34

Contd...

1	2	3	4
$N_4P_0K_3$	1.32	0.45	1.60
$N_4P_0K_4$	0.79	0.38	2.62
$N_4P_1K_0$	3.13	0.70	0.64
$N_4P_1K_1$	3.84	0.58	0.89
$N_4P_1K_2$	2.84	0.49	1.15
$N_4P_1K_3$	1.90	0.45	1.29
$N_4P_1K_4$	1.34	0.41	1.42
$N_4P_2K_0$	3.03	0.52	0.76
$N_4P_2K_1$	2.95	0.56	1.07
$N_4P_2K_2$	1.97	0.48	1.28
$N_4P_2K_3$	1.34	0.47	1.43
$N_4P_2K_4$	1.23	0.36	1.45
$N_4P_3K_0$	3.07	0.58	0.60
$N_4P_3K_1$	3.08	0.57	1.07
$N_4P_3K_2$	2.98	0.49	1.42
$N_4P_3K_3$	2.14	0.46	1.42
$N_4P_3K_4$	1.08	0.35	1.51
$N_4P_4K_0$	3.17	0.62	0.59
$N_4P_4K_1$	1.78	0.45	1.12
$N_4P_4K_2$	1.46	0.43	1.37
$N_4P_4K_3$	1.47	0.40	1.46
$N_4P_4K_4$	0.57	0.34	1.52
C.D.(5%)	0.04	0.03	0.06
$S.E._m$	1.590	0.011	0.021

A B S T R A C T

An experiment was conducted to study the effect of nutrition on the establishment and bud take of budded rose plants. The experiment was laid out in S^3 factorial design with three replications.

The effect of three major nutrients (nitrogen, phosphorus and potassium) on the bud take and further vegetative growth and flowering has been proved by the results of the present study. All treatments caused an increase in the girth of the root stock at the time of budding. Application of nutrients greatly prolonged the retention of petiole. A treatment combination of 0.75 g N : 0.75 g P_2O_5 : 0.25 g K_2O ($N_3P_3K_1$) was found to be effective in promoting early bud take. The emergence of leaves was found to be influenced by various treatments significantly. A treatment combination of 1.0 g N : 0.75 g P_2O_5 : 0.25 g K_2O ($N_4P_3K_1$) was proved effective in the early emergence of leaves. The treatment with $N_3P_3K_1$ was also on par with $N_4P_3K_1$. The maximum height of the plants were observed under a treatment with 1.0 g N : 0.75 g P_2O_5 : 0.25 g K_2O.

During initial stages a lower dose of potassium was found sufficient to enhance the height of plants. But afterwards a higher dose was needed to increase the height significantly.

The flower bud initiation was observed to be affected by various treatments. Nitrogen and potassium, alone and in combination were found effective in the early induction of first flower bud. But phosphorus was found 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 ($N_3P_3K_3$). The various nutrients were not found to play a major role in flower opening. However, a higher dose of nitrogen delayed flower opening.

The study also proved the effect of various treatments on the nutrient content of leaves.