STUDIES ON THE EFFECT OF PRUNING AND NUTRIENTS ON GROWTH, FLOWERING AND VASE LIFE OF ROSE cv. SUPER STAR

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in

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Dedicated

To

My Beloved Parents,

DIVISION OF HORTICULTURE
UNIVERSITY OF AGRICULTURAL SCIENCES
BANGALORE

CERTIFICATE

This is to certify that the thesis entitled "STUDIES ON THE EFFECT OF PRUNING AND NUTRIENTS ON GROWTH, FLOWERING AND VASELIFE OF ROSE cv. SUPER STAR" submitted by S. Uma for the degree of MASTER OF SCIENCE (HORTICULTURE) in FLORICULTURE of the University of Agricultural Sciences, Bangalore is a record of bona-fide research work done by her during the period of her study in this University, under my guidance and supervision and the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar titles.

October 1st, 1985

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Bangalore,
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S. Uma

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INTRODUCTION

CHAPTER I

INTRODUCTION

No flower is more steeped in history than the rose in all its many lovely forms and no flower is held in greater esteem. Referred to as 'Tiruni Pushpa' in Sanskrit, the rose reigns supreme as the 'Queen of flowers'. The title bestowed on it by the Greek poetess Sappho, and none has since questioned its right to the title. Rose is the first flower to become domesticated and has been planted wherever civilization spread.

According to a survey, it is estimated that 100 million rose plants are sold every year in the world. The world flower consumption is estimated to be of value about 8750 million pounds (Rs.16,000 crores) and about 4 lakh people are engaged in the trade (Anon., 1983).

Rose cultivation is a highly remunerative enterprise and also has good export potentials. In European countries, since the roses have to be grown under glass especially during winter it limits the production and cuts down the supply to the market. During winter season in India we get good blooms and a few varieties even with 3 to 4 flushes. Commercial cut flower production in India is comparatively a recent development. Bangalore is agroclimatically suited for growing roses throughout the year, there is a vast scope for building up a flourishing commercial cut flower industry to meet the demands of both internal and international market. Considering even the cost of production, is much less in India. It comes to about 20 paise per bloom. In India where roses are regarded as a luxury, there is little local consumption and hence there is scope for exporting (Malik, 1968). Increased flower production, quality of flowers and perfection in the form of plants are the important objectives to be reckoned in commercial flower production.

Though the quality of cut flower is primarily a varietal trait, it is greatly influenced by climatic, nutritional and cultural practices. Though climatic and geographical factors affect the yield and the quality to some extent, nutrition and cultural practices play a major role (Hussein, 1955).

Rose cv. Super Star is adjudged as the finest hybrid tea rose after Peace because of its luminous, clear, vermilion-orange colouring of the blooms which is unique to hybrid teas. It grows tall and bushy, with plenty of glossy medium - green foliage and is most free flowering. Called 'Tropicana' in America where it received the All America Award for 1963. Blooms are with a sweet fragrance.

Chandrashekaraiah (1973) has reported that the cut flowers of this variety comprise of four different grades in equal proportions, a highly desirable attribute for meeting the flexible demands of different grades of flowers in the market.

The first step towards providing the roses, the care which they deserve, is apply them adequate fertilizers and do proper pruning. Roses, to a great extent are meant for cut flowers. An ideal cut flower should remain afresh with respect to its colour and fragrance without losing its grade for a reasonable length of time. It is estimated that two thirds of the life of cut flower will depend on the environment to which the flower is exposed after harvest with which the vase solution gains its importance. Considering the economic importance of this crop, the present study was taken up with the following objectives:

1. To study the effect of N, K pruning levels and their interactions on growth and flower production.

2. To study the effect of N, K pruning levels and their interactions on the keeping quality of cut flowers.

3. To study the interaction effect of nutrients and pruning with kinetin (vase solution) on the keeping quality of cut flowers.

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

Importance of cultural practices like pruning and fertilizing in plant growth regulation and production of flowers have been stressed by several workers. The various effects of pruning and fertilization of roses on growth, production, quality of bloom and on vase life are reviewed here under:

2.1 Effects of nitrogen and potassium

2.1.1 Effect of nitrogen

Of the many elements essential for commercial production of flowers, none of them had any pronounced effect nor required degree of attention in their fertilizer application as that of nitrogen which is the most mobile of all the mineral nutrients absorbed by plants (White, 1954 and 1958 and Raneja, 1966).

2.1.1.1 Yield of flowers: Major nutrients had a marked effect on the yield as revealed by many studies. The work by Heeney *et al.* (1960) has shown that yield of flowers was correlated to the N/K ratio and indicated that this ratio should be kept minimum for higher yields. Yields were highest when N/P ratio in leaves was 2 : 3 and that of N : K was 0.25 : 03 (Chan, 1961). The maximum production of flowers was shown when soil nitrate concentration ranged between 25 and 75 ppm, whereas 10 ppm resulted in lower production and injury occurred with 300 ppm (Seeley and Post, 1948).

Field experiments with two cultivars of rose conducted by Young et al. (1967) revealed that increased flower yield with increased levels of nitrogen. Bik (1972) assessed the effects of N and K, applied either separately or together at rates between 1.12 and 7.7 g N/pot and 0.56 and 14.7 g K_2O/pot in a two year trial with pot grown roses cv. Baccara, where he observed that an increased levels of N application increased the flower number and fresh weight per flower. With a factorial experiment Young et al. (1973) reported that 2310 to 2530 kg N/ha produced the greatest number of flowers. Similarly, a higher flower yield and better quality of cut flower was obtained with Happiness and Christian Dior roses with increasing level of N. An increase in the number of flowers with increased N dose from 6 g to 16 g/plant was observed by Jayaprasad (1976).

2.1.1.2 Stem length: Kamp and Pokorny (1958 and 1959) and Kamp and Shannon (1960) observed beneficial effects on stem length by increasing N and K levels. Highest was recorded with 80 ppm N and 16 ppm K. Keeping P_2O_5 and K_2O levels constant, varying N to three levels Durkin (1960) has shown that N at 50 ppm was inadequate for plant as measured by stem length. Penningsfeld (1968) reported the positive linear effect on growth with increased levels of N and suggested 168 kg N/ha. In an experiment with rose cv. Super Star Waters (1968) found an increased number of stem due to nitrogen application. Similarly, Young *et al*. (1973) obtained an increased number of stem due to nitrogen application. Jayaprasad (1976) obtained a maximum stem length with 8 g of N and 16 g of K/plant.

Maharana and Pradhan (1976) have found that the application of high nitrogen both for higher number and yield per plant. Armitage and Tsujita (1979) studied the effect of nitrogen resulted in better quality whereas 400 ppm resulted in higher foliar content, yield and quality. Reports by the same workers revealed that low N compared to normal N level resulted in a reduction in the flower number, flower weight, petal number and stem weight. Borrelli (1981) observed an increased stem length with increasing N, but beneficial effects were much greater when number of irrigation and nitrogen application levels increased.

2.1.2 Effect of potassium

2.1.2.1 Yield of flowers: In rose, Post and Fischer (1951) evaluated the need of potassium under green house roses and recommended 330 kg/ha for higher flower production. White (1958) pointed out that the flower production was effected by many factors, especially the age of the plant than by the potassium level of the soil. But Bik (1970) observed that K levels had no influence on flower production. Young _et al_. (1976) also reported that flower production declines with the increased levels of K.

In an experiment with glass house roses Bik (1972) observed differential effects of K levels on flower number, but flower weight markedly increased with increased levels. An enhanced fresh weight was obtained by maintaining a ratio of 1 : 1 of NK. Frenguelli and Romano (1977/78) observed that a maximum uptake at the time of pre flowering stage, an intermediate requirement during flower production. Forever Yours roses supplied with a low K of 0.25 m.eq/l had no antagonistic effect on Ca and Mg accumulation in leaves (Woodson and Boodley, 1982). In another experiment they observed that low K reduced growth and flower production, regardless of N form higher K reduced NH_4 toxicity symptoms.

2.1.2.2 _Stem length and quality_: Insufficient supply of K to greenhouse grown rose plants resulted in shorter flowering shoots and smaller flowers (Seeley, 1950). Kamp and Pokorny (1958) reported that stem length was greatly affected by K when plants were grown in boron rich soil. But flower having longer stem length were associated with K levels upto 1870 kg per ha (Young _et al_., 1973). Maharana and Pradhan (1976) in an experiment with pot grown roses observed an increase in the anthocyanin content due to an application of N and K. Jayaprasad (1976) obtained good quality blooms with 16 g of K/plant under Bangalore conditions. Johansson (1978) in sand culture studies with green house grown rose cv. Parel Van Aalsameer showed reduction in stem length and stem and root weight with lower levels of K.

2.2 Nutritional disorders in roses

In general, the development of flower bud is affected by nutritional factors and when nutrients are at deficient levels, the number of differentiated flower buds are drastically reduced, their development is retarded and sometime stopped. This is due to imbalance in plant chemical substance influencing flower formation.

Due to atrophy or death of terminal bud the vegetative shoots fail to develop into terminal buds, such a failure is referred to as 'blindness'. Post and Fischer (1951) summarised the role of potassium and found that a negative relation between the blind shoot production with low levels of potassium in plants. But Post (1952) obtained an increased number of blind shoots in plants with lower nitrate levels compared to at higher nitrate levels, further he obtained a high percentage of non colloidal nitrogen and insoluble carbohydrates in blind shoots over a high percentage of reducing sugars in flowering shoots, thereby concluded that lack of carbohydrates, lack of nitrogen and a low supply of water are involved and also any nutritional factor limiting carbohydrate production or movement necessary for growth probably can cause an increase in blind shoots, contrary to this Lindstrom and Kiplinger (1955) observed that in rose cv. Better Times, neither nitrate nitrogen nor potassium influence the production of blind shoots.

2.3 Leaf sampling and analyses

The fact that the effects of one nutrient element can be influenced by the presence of the other is well understood.

Nutritional studies carried out by Chan (1961) showed that for better growth and flower yield combined with increased flower size could be obtained by maintaining the N at 2.8 to 3.0 per cent, P at 0.28 to 0.3 per cent and K at 2.4 to 2.6 per cent. Carlson and Bergman (1966) reported that the upper leaves of flowering shoot are the most suitable plant parts for analysis. Bik (1970) reported the optimum leaf contents of N and K at 3.8 per cent and 2.1 per cent respectively for Baccara roses. Johansson (1979) recommended optimum concentrations of 3.04 per cent of N, 0.29 per cent of P and 2.14 per cent of K in leaf tissues for maximum yield of cut flowers.

2.4 Fertilizer recommendations for roses

General fertilizer recommendations have been made based on experience and judgement for rose varieties grown under different geographical and climatic situations. Judicious and balanced fertilizer applications are known to result in overall improvement in quality of flowers and total flower yield.

Lauricenko (1965) reported that the best nutrient combination for hybrid teas and perpetual flowering roses at 1.0 N : 0.21 P : 0.77 K. Pal (1966) recommended 100 g/plant of the following mixture to obtain good results. This mixture consists of:

	parts by weight
Nitrate of potassium	6
Sulphate of ammonia	2
Superphosphate of calcium	16
Sulphate of potassium	8
Sulphate of magnesium	2
Sulphate of iron	½

But Raghava (1969) reported that an application of superphosphate, potassium sulphate and ammonium sulphate in the ratio 8 : 3 : 2, fifteen days after pruning at 60 g per sq. m. is necessary to obtain the best results. Sinha and Motial (1967) recommended a combination of NPK for rose cv. Belcento in the ratio of 12 : 12 : 6 combined with trace elements like Mg, Mn, Fe and B.

Swarup (1971) suggested an application of a mixture of ammonium sulphate 2 parts, superphosphate 8 parts and potassium sulphate 3 parts at the rate of 30 g per bush a fortnight after pruning.

Bose and Mukherjee (1972) recommended a foliar spray of 10 g of ammonium sulphate, 30 g of superphosphate, 5 g of sulphate of potash and 2 g of ferrous sulphate in 5 litres of water. Jayaprasad (1976) concluded that in rose cv. Super Star N at 8 g P at 4 g and K at 16 g per plant, a combination of increased the flower yield and quality of blooms. Baccara roses on Rosa canina root stocks grown in a clay - peat soil recorded the best results with 40 mg of N and 85 mg of K per 100 g soil (Skalska, 1977).

2.5 Effect of pruning

2.5.1 Time of flowering

Though quality of cut flower is a varietal character it is also influenced by time and level of pruning.

Kohl and Post (1952), Moe (1970a, 1971 a and 1973) and Holley (1973a and 1973b) revealed that lighter pruning resulted in shorter time required for that shoot to flower. Holley (1973b) showed a varietal differences in flowering time among Forever Yours, Town Crier and Bridal Pink roses, when pruned and pinched at different dates. Eccher and Mignani (1977) reported an advanced flowering in all treatments like heavy, medium and light pruning. Gowda et al. (1984)

reported that the varietal differences in flowering and suggested that continuous production of the cut flower can be manipulated by simultaneous pruning of early flowering cv. American Home and late flowering cv. Fontain Bleau.

2.5.2 Stem length

In general, pruning resulted in an increased stem length as compared to no pruning (Lindermann, 1972). El-Gamassay *et al*. (1960) observed an increased flower stem length with an increase in the severity of pruning in Hoover roses and similar results were obtained by Moe (1970a and 1970b) in Baccara roses. But in another experiment with Baccara, Zorina and Carol roses, Moe (1971a and 1973) found that severe pruning to one dormant bud or light pruning to six to seven buds resulted in shorter stems as compared to less severe pruning to three dormant buds. A maximum total stem length was recorded with medium or heavy pruning in cvs. like Queen Elizabeth, Maria Callas, White Christmas, Fragrant Cloud, Peace and Confidence (Appanna, 1976). Eccher and Mignani (1977) reported that a regular removal of flower buds produced on small branches in the second year resulted in a considerable increase in the mean stem length of marketable flowers. Borrelli (1978) observed a reduction in stem length due to pruning above the fourth leaf over second leaf in Super Star. But Degeyter (1978) with his experiments in green house roses reported that severity of pruning made no difference with respect to length of flower stem.

2.5.3 Flower quality

As a whole, pruning results in good quality flowers over control (June, 1950, Marston, 1968, Lindermann, 1972). June (1950) and El-Gamassy *et al*. (1960) reported that severe pruning resulted in top quality blooms as compared to no pruning and light pruning. Light pruning is recommended for light soils for good quality rose production by National Rose Society of Great Britain (Anonymous, 1962). Heavy and medium pruning resulted in maximum bud length, bud diameter and petal length and breadth (Appanna, 1976). Nuzhdina (1977) reported that Queen Elizabeth and Rosa Gaujard pruned to 6 to 8 buds resulted in good crop of high quality flowers. Malik (1980) obtained a large number of first grade flowers with low levels of pruning in cultivars viz., Super Star, Happiness and Queen Elizabeth. Gowda *et al*. (1984) observed that flower quality is very much influenced by level and time of pruning in roses.

2.5.4 Yield of flowers

June (1950), Smeal (1958), Holley (1959) and Van Marsbergen *et al*. (1960) reported that light pruning resulted in more number of flowers as compared to severe pruning. Similar results are also obtained by El-Gamassy *et al*. (1960) in Hoover roses, in Baccara roses by Moe (1970b), in Zorina and Carol by Holley (1973b). Seasonal differences in flower yield with different pinching treatments in roses was observed by Durkin (1959). The cultivars like Forever Yours, Town Crier and Bridal Pink showed seasonal differences regarding flower yield when subjected to different levels of pruning.

An improved yield, fruit size and weight as well as shoot growth occurred when Rosa pomifera plants were severely cutback to 2 to 3 buds (Nitransky 1972). Rose varieties like Texas Centennial and Florex produced maximal flower yield with medium pruning above 4th to 5th bud . (Smirnov, 1977). But Akhmedova (1978) has reported an increase of flower yield by 1.5 to 2 times with the heavier bud loads of 50 to 75 per plant over the light load of 25 per cent plant without any deterioration in quality.

2.6 Effect of pruning on rose disorders

Moe (1970b and 1970c) obtained maximum number of blind shoots and bull heads upto 45 per cent in severely pruned (cut back to two dormant buds) plants as compared to moderate pruning (cut back to four dormant buds) which resulted in 16 per cent of blind shoots and bull heads. More blind shoots were obtained at low light intensity, low temperature and heavy pruning. Zieslin and Mor (1981) observed marked defoliation of plants before pruning and partial removal of leaves from the sprouting shoots promoted blind shoot formation.

2.7 Effect of pruning on pests and diseases

Mc-Clellan et al. (1958) studied the effect of pruning on growth, disease and pest incidence in five varieties of roses and observed that the reduction in the incidence of black spot (*Diplocarpon rosae*) by severe pruning (1 to 2 inches bud bud union) and spotted spider mites (*Tetranychus telarius*). Non parasitic leaf fall was also attributed to severe pruning (Tramier, 1968).

2.8 Vase life studies as affected by cytokinins

The termination of vase life of many cut flowers is characterized by wilting, even though they are constantly held in water (Kende and Baumgartner, 1974). Many studies have been carried out to evaluate the events leading to this phenomenon. The use of preservative solution to promote the quality and prolong the vase life of cut flowers has been known for many years.

The delay in senescence of carnation and chrysanthemum as a result of BA treatment was found to be accompanied by an inhibition of respiration rate and optimum concentration recommended is 0 to 10 ppm (Mclean and Dedolph, 1962). Treatment of anthurium flowers with N^6-BA was found to impart tolerance to chilling and extend the salable period (Takumi et al., 1964). Halevy *et al.* (1966) and Mayak and Halevy (1970) observed that the inhibition of senescence of BA and growth retardants was not always associated with a reduction in respiration. BA stimulated respiration and hastened senescence in Grand Rapids leaf lettuce. But the keeping quality and storage ability of cut carnation were significantly improved by post-harvest treatment with cytokinin, 6-benzylamino-purine. Immersion of flower stems increased the display life of the flowers by 3 to 5 days (Halevy <u>et al</u>., 1966 and Ola and Oydvin 1969). According to Mayak and Halevy (1970), the exogenous application of BA directly to the flower bud delayed the senescence of both aged and fresh flowers of the short lived variety Golden Wave. Chandrashekaraiah (1973) reported that a vase solution of BA (0.2 ppm) + sucrose (3.0 per cent) resulted in better effect on vase life of rose cultivar Super Star followed by only BA (0.2 ppm) where the vase life was 7.69 and 7.25 days respectively. Mayak and Halevy (1974) showed that kinetin delays the fading of cut rose (cv. Golden Wave) flower shoots exposed to stress condition. Willium Eisinger (1977) observed a delayed senescence of flowers with stem and leaf tissues of kinetin 5 to 10 $\mu g/ml$. BA together with auxin helped in opening of carnations and when applied to buds with sucrose prevented calyx splitting (Cywinska et al., 1978). Nakamura <u>et al</u>. (1980) observed a rapid accumulation of anthocyanin when a combination of kinetin, visible light and ultra-violet light were provided for rose cv. Ehigasa.

Kuc (1964) observed an enhanced vase life of Better Times roses with potash application but a reduced vase life with N content. Maharana and Pradhan (1976) also obtained the highest vase life either with K alone or along with phosphorus.

MATERIAL AND METHODS

CHAPTER III

MATERIAL AND METHODS

The present investigation was carried out to study the effects of different levels of nitrogen, potassium, different levels of pruning and their interactions on the growth, yield and vase life of rose cv. Super Star.

The experiment was conducted under irrigated conditions at Horticultural Research Station, Gandhi Krishi Vignana Kendra, University of Agricultural Sciences, Bangalore during the period from May 1984 to March 1985.

3.1 Geographical location and climate

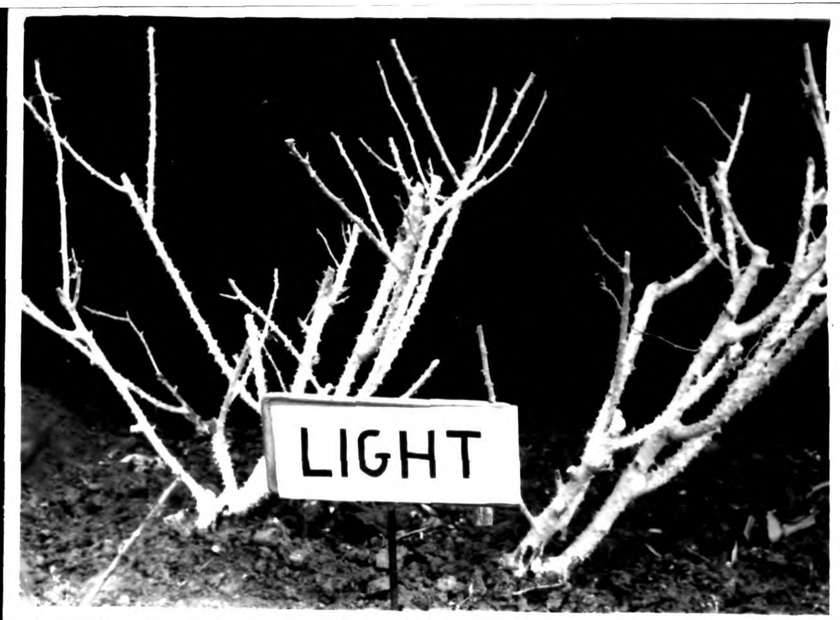
The experiment was laid out in reddish sandy loam with clay sub soil of Horticultural Research Station situated on latitude of 12°58' North and 77°35' East. The data relating to meteorological observations for the experiment period are presented in Appendix I.

3.2 Experimental details

3.2.1	Experimental design	:	Factorial Randomized Complete Block Design (RCBD).
3.2.2	No. of treatments	:	24
3.2.3	No. of replications	:	3
3.2.4	No. of plants per treatment	:	2
3.2.5	Total No. of plants	:	144

PLATE 1 : L : Light pruning : Leaving 6-7 buds

PLATE 2 : M : Medium pruning : Leaving 4-6 buds


LIGHT

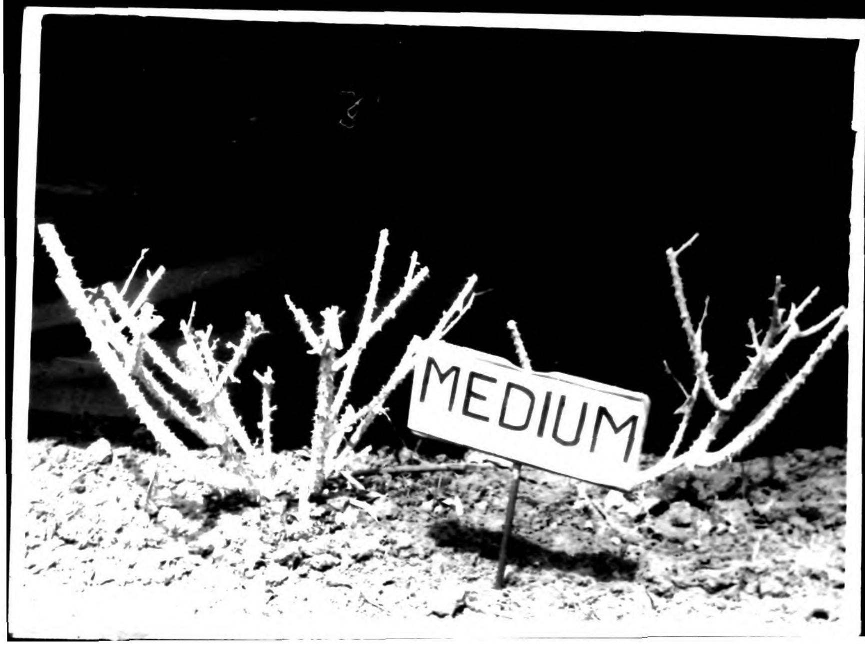

MEDIUM

PLATE 3 : H : Heavy pruning : Leaving
2 buds

PLATE 4 : C : Control : No pruning


HEAVY


CONTROL

DIFFERENT TREATMENT COMBINATIONS

Sl. No.	Treatment combination	Details		
		N g/plant	K g/plant	Pruning level
1	N_0K_0 L	0	0	Light
2	N_0K_0 M	0	0	Medium
3	N_0K_0 H	0	0	Heavy
4	N_0K_0 C	0	0	Control
5	N_0K_1 L	0	1	Light
6	N_0K_1 M	0	1	Medium
7	N_0K_1 H	0	1	Heavy
8	N_0K_1 C	0	1	Control
9	N_1K_0 L	1	0	Light
10	N_1K_0 M	1	0	Medium
11	N_1K_0 H	1	0	Heavy
12	N_1K_0 C	1	0	Control
13	N_1K_1 L	1	1	Light
14	N_1K_1 M	1	1	Medium
15	N_1K_1 H	1	1	Heavy
16	N_1K_1 C	1	1	Control
17	N_2K_0 L	2	0	Light
18	N_2K_0 M	2	0	Medium
19	N_2K_0 H	2	0	Heavy
20	N_2K_0 C	2	0	Control
21	N_2K_1 L	2	1	Light
22	N_2K_1 H	2	1	Medium
23	N_2K_1 H	2	1	Heavy
24	N_2K_1 C	2	1	Control

3.2.6 Treatments

(a) Two nutrient elements nitrogen and potassium in various combinations were tried. Phosphorus level was kept constant. The different levels of nutrients tried are as follows:

Nutrients	Level of nutrient (g/plant)		
	0	1	2
Nitrogen	0	8.0	16.0
Phosphorus (P_2O_5)	16.0	16.0	16.0
Potassium (K_2O)	0	16.0	-

(b) Pruning trials: Different pruning levels were tried in combination with fertilizer treatments.

L : Light - Leaving 6-7 buds
M : Medium - Leaving 4-6 buds
H : Heavy - Leaving 2 buds
C : Control - No pruning except for diseased and spent branches

(c) Vase life studies: Kinetin - 0.5 ppm and 1.0 ppm
Control - with distilled water
No. of replications : 3

3.3 Experimental procedure

Method of pruning: A sharp cut slanting inwards was given on the cane with the help of a secateur just above the bud facing outside. The cut was made 5 to 6 mm above the bud. All the leaves on the canes were removed. The cut ends were smeared with Blitox (copper oxychloride) paste to prevent fungal infection.

3.3.1 Pruning time

Pruning for the monsoon crop was done on 24th May, 1984 and for the winter season crop on 15th November, 1984.

3.3.2 Fertilizer treatments

The fertilizer treatments were allocated in accordance with the experimental design. The required quantities of nitrogen, phosphorus and potassium were applied according to treatments in the form of urea (46% N), single superphosphate (16% P_2O_5) and muriate of potash (60% K_2O) respectively.

The calculated quantities of fertilizers for different treatments are given below:

Fertilizers	Levels of fertilizers (g/plant) 0	1	2
Urea	0	17.5	35.0
Superphosphate	100.0	100.0	100.0
Muriate of potash	0	13.5	-

3.3.3 Fertilizer application

The entire dose of fertilizer was applied exactly ten days after pruning for both monsoon and winter crops.

3.3.4 Weeding and plant protection measures

The entire plot was kept weed-free by hand weeding at regular intervals.

Powdery mildew and black spot diseases were noticed in both the crops which were controlled by spraying wettable sulphur and blitox (0.2%) respectively. Rogor (0.2%) was sprayed to control the aphid attack.

3.3.5 Harvesting of flowers

First few flowers from each plant were selected for recording the observations. Flowers were cut when the calyx reflexed and the first petal started opening out, leaving four nodes from the base of the shoot.

3.4 Biometric data

Days taken for 1st flowering: The number of days taken for 1st flowering of the plant from the time of pruning.

Shoot length: The length (cm) of the shoot from the fourth node from base of the shoot to the first terminal node was taken as shoot length.

Blind shoots: The failure of vegetative shoots to develop into flowers due to flower bud atrophy is known as 'Blind shoots'. The number of such blind shoots per plant was recorded.

Fresh weight (g) of the flowering shoot: The fresh weight of the shoot with the flower immediately after cut from the plant was recorded.

Bud diameter: The maximum diameter of the buds was measured by means of vernier calipers.

Bud length: The length (cm) from the base of the bud to the tip was taken as bud length and was measured by means of vernier calipers.

Neck length: The length (cm) from the end of first terminal node to the base of the flower bud was taken as neck length.

Number of petals: The total number of well developed petals in a flower was recorded.

No. of marketable flowers: The total number of flowers with all good characteristics of a cut flower was recorded.

No. of unmarketable flowers: The total number of flowers which do not possess all the characteristics of good cut flower like those affected by pests, diseases, disorders etc., was recorded.

3.5 Vase life studies

The buds with the completely reflexed calyx and the outer petal beginning to unfold, were cut and the cut ends were immediately kept in water. Later these flowers were cut under water to have uniform stem length of 30 cm with top two leaves. After that such prepared flowers were held individually in flasks containing 35 ml of test solution. Test solution was added whenever necessary to maintain the same level. Flowers were observed daily till they were found unfit for continuing in the vase.

The observations were recorded as under:

3.5.1 Fresh weight (g) : Changes in flower weight were recorded by weighing each flower on alternate days.

3.5.2 Vase life: The vase life was expressed in terms of days from the date of harvest to the final observations.

3.6 Chemical analysis

3.6.1 Leaf analysis: The mature leaves of the flowering shoot were randomly collected from each experimental unit in butter paper bags. These were dried in hot air oven at 60°C. The dried leaf material was ground to a fine powder and stored for further analysis of N, P and K contents.

Nitrogen: The nitrogen content of the plant was determined by Microkjeldahl's method (Piper, 1950), distilling ammonia into boric acid and titrating it against standard sulphuric acid.

Phosphorus: The samples were digested separately using triacid method and phosphorus content of these was determined by Vanadomolybdate method (Jackson, 1967).

Potassium: The potassium content of the leaves which were digested using triacid method were determined using a flame photometer.

2.7 Statistical analysis

The data on various biometric observations collected during the period of this study was subjected to statistical analysis as per the procedure outlined by Sundararaj *et al.* (1972). The results have been presented and discussed at probability level of 5 per cent.

EXPERIMENTAL RESULTS

CHAPTER IV

EXPERIMENTAL RESULTS

The results of experiments carried out to study the influence of different levels of nitrogen, potassium and pruning on the plant growth, flowering and vase life of rose cv. Super Star are presented hereunder.

4.1 Growth attributes

4.1.1 Number of days taken for first flowering

Data on the effect of N, K pruning levels and NK interaction on the number of days taken for flowering are presented in Table 1 and fig.1.

The main effects of N, K and pruning levels had a varying influence on the number of days taken for flowering. Nitrogen at first level (N_0) was the quickest to initiate flowering(34.53 and 33.26 days) in both the seasons respectively N_2 delayed flowering with 38.24 days in monsoon and 36.73 days in winter season. K_0 showed delayed flowering with 38.62 and 36.42 days and K_1 recording the lowest number of days 36.26 and 34.37 in monsoon and winter seasons respectively. Among different pruning levels, heavy pruning delayed flowering which took 39.63 and 36.73 days in monsoon and winter season respectively which was closely followed by medium and light pruning. Unpruned plants took least number

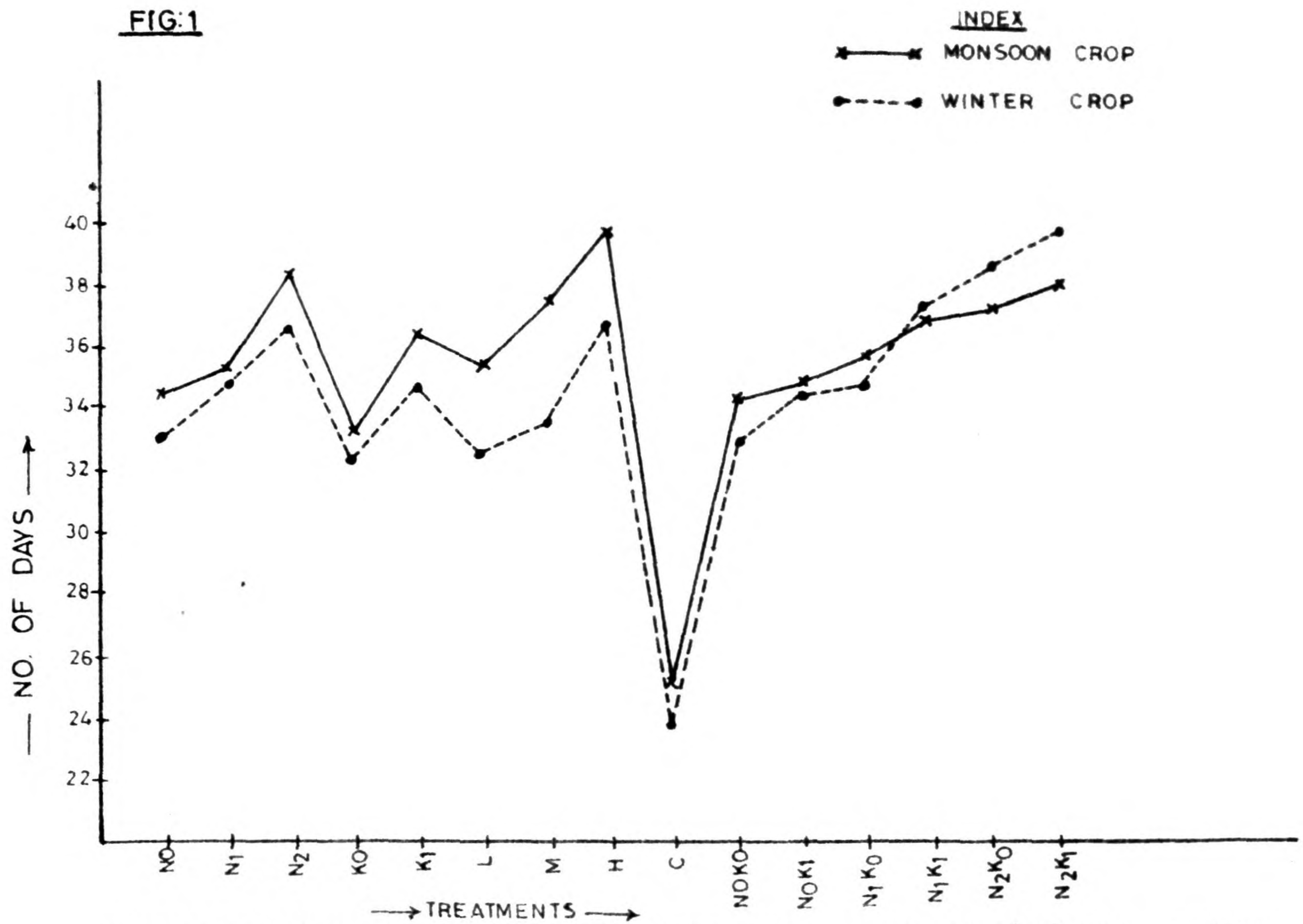
Table 1. Effect of N, K, pruning and NK interactions on the number of days taken for first flowering and number of blind shoots per plant of rose Cv. Super Star

Treatments	Monsoon crop		Winter crop	
	Days taken for 1st flowering	No. of blind shoots/ plant	Days taken for 1st flowering	No. of blind shoots/ plant
N levels				
N_0	34.53[a]	4.35	33.26[a]	4.43
N_1	33.76[a]	4.48	34.72[b]	4.23
N_2	38.24[b]	4.55	36.73[c]	3.91
C.D. at 5%	0.897*	NS	0.634*	NS
K levels				
K_0	38.62[a]	4.66[a]	36.42[a]	4.28[a]
K_1	36.26[b]	4.03[b]	34.37[b]	4.13[b]
C.D. at 5%	0.642*	0.012*	0.426*	0.016*
Pruning levels				
L	35.29[a]	3.04[a]	32.23[a]	3.21[a]
M	37.23[b]	3.05[a]	33.47[b]	3.65[a]
H	39.63[c]	4.41[b]	36.73[c]	4.27[b]
C	25.63[d]	6.24[c]	23.78[d]	5.35[c]
C.D. at 5%	0.422*	0.27*	0.276*	0.34*
NK levels				
N_0K_0	36.93[a]	5.65[b]	36.72[d]	5.55[d]
N_0K_1	36.89[a]	4.05[a]	36.03[e]	4.31[c]
N_1K_0	35.63[b]	4.69[b]	35.89[c]	4.28[b]
N_1K_1	34.42[c]	4.27[c]	35.73[c]	4.18[b]
N_2K_0	34.89[d]	4.64[b]	34.23[b]	4.04[b]
N_2K_1	33.62[c]	4.03[a]	33.87[a]	3.91[a]
C.D. at 5%	0.378*	0.32*	0.562*	0.27*

*Significant at P=0.05

Numbers followed by the same letter are not statistically significant

FIG:1



EFFECT OF N, K. PRUNING AND NK. INTERACTION ON THE (NO) DAYS TAKEN FOR 1st. FLOWERING OF ROSE CV. SUPER STAR.

of days to flower (25.63 and 23.78 days) in both the seasons.

Among interactions only NK combination recorded the significant influence on this parameter. N_2K_1 recorded early flowering with 33.62 and 33.87 days in the monsoon and winter respectively. In N_0K_0 levels flowering was advanced with 36.93 days in the monsoon and 36.72 days in winter crop. However NPr., KPr. and NKPr. had no significant influence on days taken for flowering in both the seasons.

4.1.2 Flowering shoot length

Data on the flowering shoot length as influenced by N, K, pruning and their significant treatment interactions are presented in Table 2 and 3.

The main effects of N, K and pruning significantly influenced the flowering shoot length in both the seasons.

Among different levels of nitrogen, N_2 recorded the highest shoot length of 22.43 cm and 24.59 cm in monsoon and winter season respectively. A minimum shoot length was recorded with N_0 in both monsoon and winter crops (20.47 cm and 22.89 cm). The difference observed in shoot length produced was found to be highly significant due to K levels.

Maximum shoot length was recorded in K_1 level in both monsoon and winter crops respectively (24.67 cm and

Table 2. Effect of N, K and pruning on flowering shoot length (cm), fresh weight (g) of flowering shoot of rose cv. Super Star

Treatments	Monsoon		Winter	
	Flowering shoot length (cm)	Fresh weight of flowering shoot (g)	Flowering shoot length (cm)	Fresh weight of flowering shoot (g)
N levels				
N_0	20.47[a]	14.91[a]	22.89[a]	14.85[a]
N_1	21.29[b]	16.50[b]	24.07[b]	16.62[b]
N_2	22.43[c]	16.82[c]	24.59[b]	16.94[b]
C.D. at 5%	0.43*	0.60*	0.57*	0.90*
K levels				
K_0	21.10[a]	15.61[a]	22.59[a]	16.38[a]
K_1	24.67[b]	16.54[b]	24.29[b]	16.49[a]
C.D. at 5%	0.49*	0.57*	0.52*	0.70*
Pruning levels				
L	23.67[a]	15.92[a]	25.15[a]	15.66[a]
M	25.23[b]	17.63[b]	27.77[b]	17.48[b]
H	27.22[c]	16.93[b]	31.72[c]	18.03[c]
C	10.44[d]	13.84[c]	13.14[d]	14.59[d]
C.D. at 5%	0.71*	0.82*	0.56*	0.410*

*Significant at P=0.05

Numbers followed by the same letter are not statistically significant

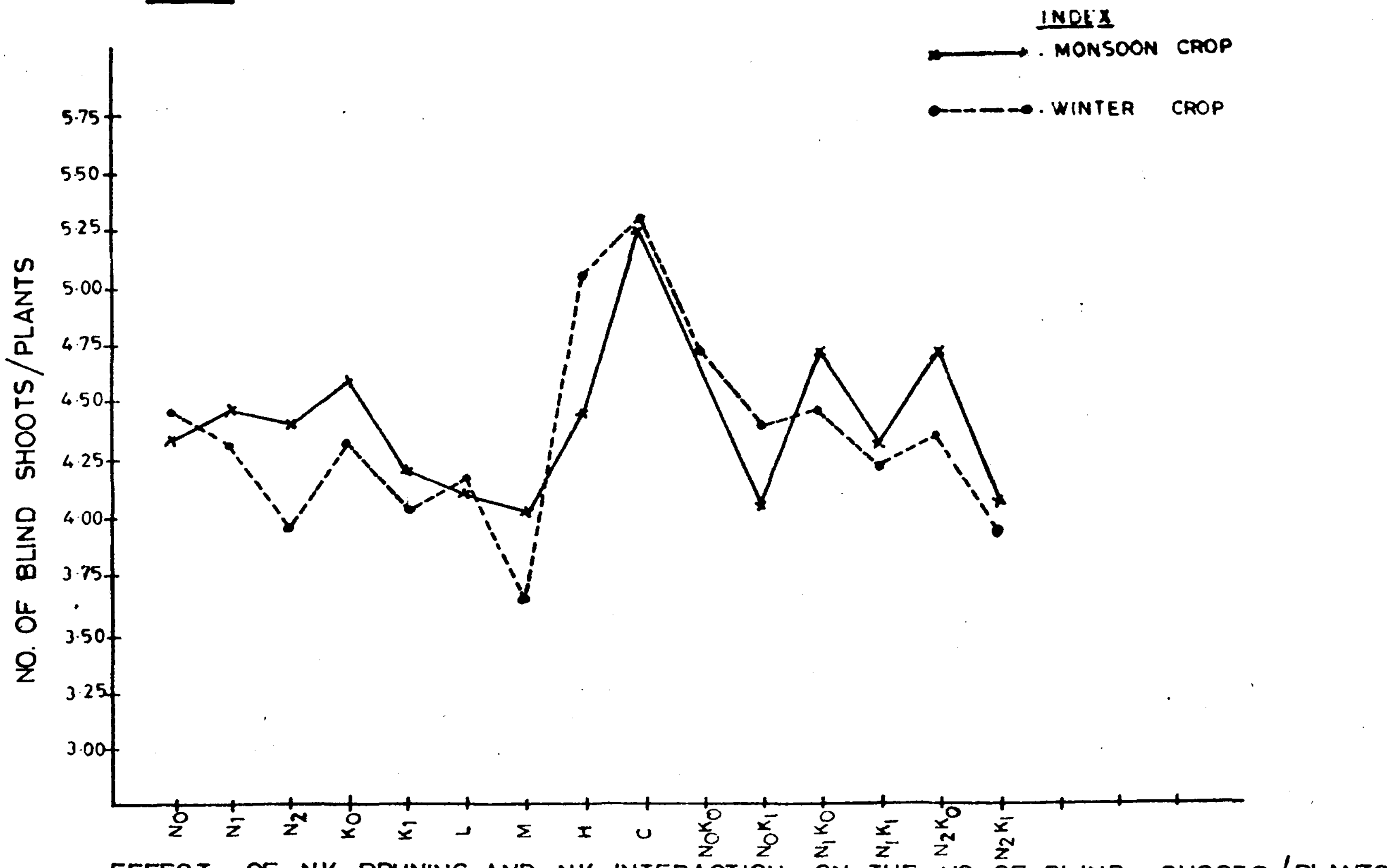
Table 3. Effect of NK and K Pr. interactions on flowering shoot length (cm), fresh weight of flowering shoot (g) of rose cv. Super Star

Treatments	Monsoon		Winter	
	Flowering shoot length (cm)	Fresh weight of flowering shoot (g)	Flowering shoot length (cm)	Fresh weight of flowering shoot (g)
NK levels				
N_0K_0	20.02^{a}	13.67^{a}	23.63^{a}	15.68^{a}
N_0K_0	20.91^{a}	14.92^{b}	23.89^{a}	16.04^{b}
N_1K_0	20.93^{a}	16.62^{b}	25.28^{c}	16.63^{c}
N_1K_1	21.66^{a}	16.38^{b}	24.77^{b}	16.62^{c}
N_2K_0	23.09^{b}	16.55^{b}	24.87^{b}	16.80^{d}
N_2K_1	23.43^{b}	17.09^{c}	25.22^{c}	16.84^{d}
C.D. at 5%	1.94*	1.01*	0.80*	0.13*
K Pr. levels				
K_0L	22.69^{a}	15.63^{a}	24.64^{a}	15.65^{b}
K_0M	24.53^{b}	17.44^{b}	28.07^{b}	17.33^{b}
K_0H	26.69^{c}	16.31^{a}	32.69^{c}	18.02^{c}
K_0C	10.12^{d}	13.06^{c}	12.97^{d}	14.56^{a}
K_1L	24.65^{b}	16.20^{a}	25.66^{a}	15.68^{b}
K_1M	24.93^{b}	17.52^{b}	27.47^{b}	17.63^{b}
K_1H	26.74^{c}	17.84^{b}	32.74^{c}	18.06^{c}
K_1C	10.36^{d}	14.61^{c}	13.30^{d}	14.63^{a}
C.D. at 5%	1.02*	1.43*	1.14*	1.82*

*Significant at $P=0.05$

Numbers followed by the same letter are not statistically significant

FIG: 2



EFFECT OF N,K, PRUNING AND N.K. INTERACTION ON THE NO. OF BLIND SHOOTS/PLANTS OF ROSE CV. SUPER STAR

24.29 cm) over K_0 recording 21.10 cm and 22.59 cm. Higher shoot length was recorded with heavy pruning in monsoon and winter (27.22 cm and 31.72 cm respectively) followed by medium and light pruning. Control resulted in lowest shoot length in both the seasons (10.44 cm and 13.14 cm).

Among different treatment interactions NK and NPr were found to influence the shoot length significantly. In both the seasons N_2K_1 combination recorded the highest shoot length of 23.43 cm in monsoon and 25.22 cm in winter, while N_0K_0 recorded the least in both the seasons. K_1 with heavy pruning gave the highest shoot length of 26.74 cm and 32.74 cm in monsoon and winter respectively. Whereas K_0C recorded the least in both the seasons (10.12 cm and 12.97 cm).

4.1.3 <u>Number of blind shoots per plant</u>

Data on the number of blind shoots per plant as influenced by N, K pruning and NK interaction are presented in Table 1 and fig.2.

Potassium and pruning levels significantly influenced the number of blind shoots per plants more markedly in the winter crop. K_1 recorded the least number of blind shoots 4.03 and 4.13 in monsoon and winter crop respectively. K_0 recorded the highest number of blind shoots (4.66 and 4.28) in monsoon and winter season respectively. Among different pruning levels, heavy pruning produced the highest number of blind shoots per plant (4.41 and 4.27) next to control which recorded 6.24 and 5.35 in monsoon and winter season respectively. But nitrogen levels had no significant influence on blind shoots in both seasons.

Among different interaction effects, only NK interaction was found to influence the number of blind shoots significantly in both the crops. N_2K_1 combination produced the least number of blind shoots per plant (4.03 and 3.91 in monsoon and winter season respectively). Maximum number of blind shoots was recorded with N_0K_0 5.65 during monsoon and 5.55 in winter. Other interactions NPr., KPr. and NKPr. did not influence the number of blind shoots significantly in both the seasons.

4.1.4 Fresh weight of flowering shoot

Data on the fresh weight of flowering shoot as influenced by N, K, Pr. and their significant treatment interactions are presented in Tables 2 and 3.

Nitrogen, potassium and pruning levels significantly influenced the fresh weight of flowering shoot in both seasons. Fresh weight was increased with increasing levels of N and K. N_2 recorded a maximum fresh weight of 16.82 g and 16.94 g in monsoon and winter respectively. N_0 level recorded a minimum fresh weight of 14.91 g and 14.85 g in monsoon and winter respectively. K_1 resulted in higher fresh weight over K_0 in both seasons (16.54 g and 16.49 g). Among different pruning levels heavy pruning recorded a maximum fresh weight of 16.93 g in monsoon and 18.03 g in winter closely followed by medium and light pruning. N_0 pruning resulted in minimum fresh weight in both seasons (15.92 g and 15.66 g).

NK and KPr significantly influenced the fresh weight. N_2K_1 recorded the highest fresh weight of 17.09 g and 16.84 g in monsoon and winter respectively. The lowest fresh weight of 13.67 g and 15.68 g was recorded with N_0K_0 in both seasons respectively. Among potassium and pruning interactions, K_1H recorded the maximum fresh weight of 17.84 g and 18.06 g in monsoon and winter respectively and K_0C recorded significantly less fresh weight of 13.06 g and 14.56 g in the monsoon and winter respectively.

4.1.5 Number of marketable flowers per plant

Data on the influence of N, K pruning, NK and KPr interactions on the number of marketable flowers per plant are presented in Table 4 and 4a and fig. 3 and 4.

Pruning significantly influenced the number of marketable flowers per plant in both the seasons. Light pruning recorded the maximum number of marketable flowers in monsoon (12.17) and winter (12.13). Number of marketable flowers increased with increasing levels of N and K. N_2 recorded the highest number of 10.05 flowers in monsoon and 9.21 in winter followed by N_1 and N_0 recorded a minimum

Table 4. Effect of N, K and Pruning on the number of marketable and unmarketable flowers/plant of rose cv. Super Star

Treatments	Monsoon		Winter	
	Marketable flower	Unmarketable flower	Marketable flower	Unmarketable flower
N levels				
N_0	9.08[a]	4.81[a]	9.12[a]	4.63[a]
N_1	9.35[b]	4.98[b]	9.12[a]	4.73[a]
N_2	10.05[c]	4.08[c]	9.21[b]	4.01[b]
C.D. at 5%	0.132*	0.15*	0.129*	0.161*
K levels				
K_0	9.44[a]	4.71[a]	9.05[a]	4.63[a]
K_1	9.55[a]	4.54[b]	9.25[b]	3.82[b]
C.D. at 5%	0.162*	0.141*	0.142*	0.0132*
Pruning levels				
L	12.17[a]	3.78[a]	12.13[a]	3.98[a]
M	11.66[b]	3.45[b]	10.33[b]	3.62[b]
H	11.78[b]	3.09[c]	9.24[c]	3.12[c]
C	3.27[c]	7.27[d]	4.89[d]	7.03[d]
C.D. at 5%	0.27*	0.23*	0.24*	0.213*

*Significant at P=0.05

Numbers followed by the same letter are not statistically significant

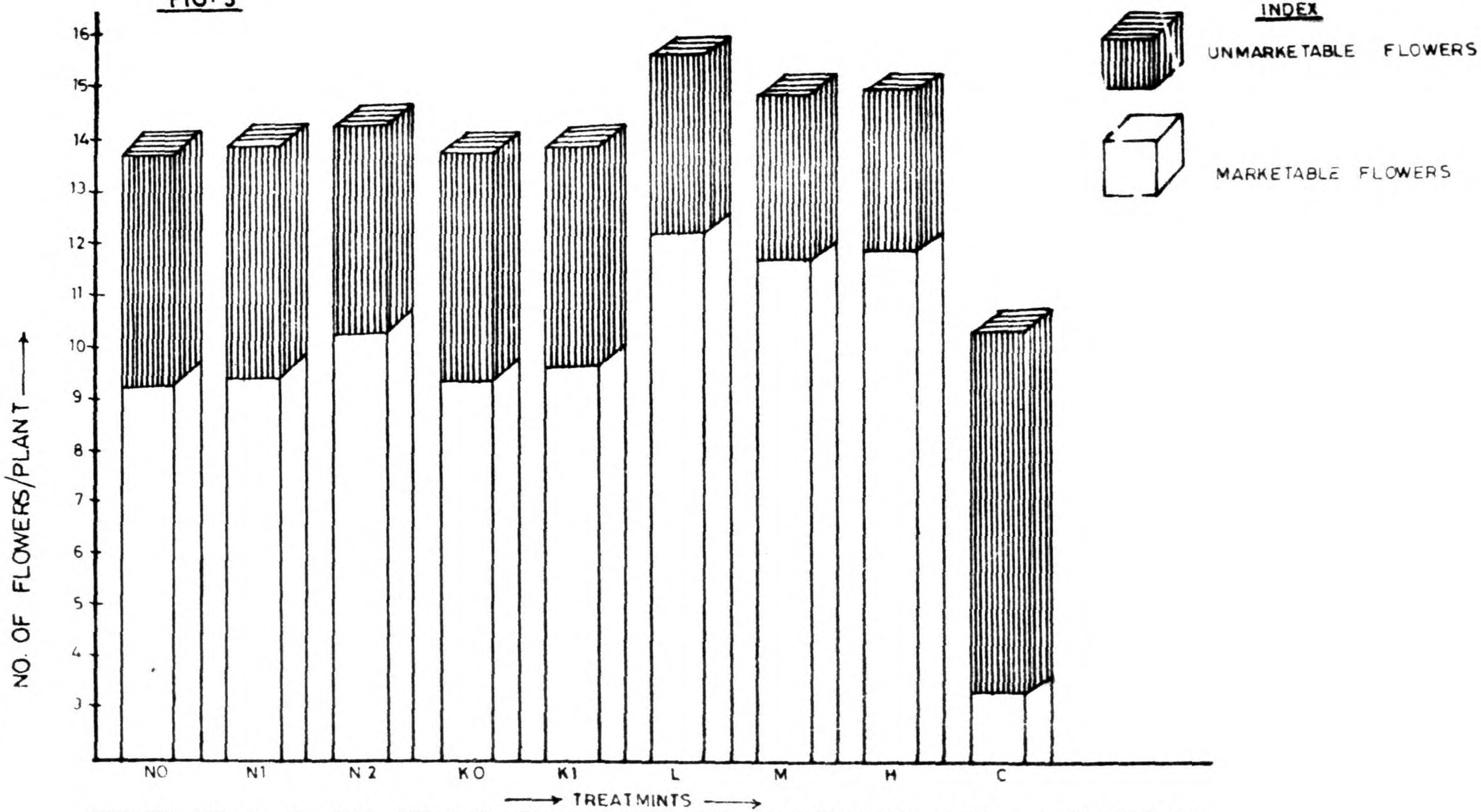
Table 4a. Effect of NK and K Pr. on the number of marketable and unmarketable flowers/plant of rose cv. Super Star

Treatments	Monsoon		Winter	
	Marketable flowers	Unmarketable flowers	Marketable flowers	Unmarketable flowers
NK levels				
N_0K_0	8.85[a]	5.38[f]	9.05[a]	5.02[e]
N_0K_1	9.08[a]	4.56[d]	9.18[a]	4.29[c]
N_1K_0	9.68[b]	4.88[e]	9.13[a]	4.63[d]
N_1K_1	9.03[a]	3.04[a]	9.12[a]	4.86[d]
N_2K_0	9.79[b]	4.19[c]	8.76[b]	4.02[b]
N_2K_1	10.31[b]	3.96[b]	10.44[c]	3.02[a]
C.D. at 5%	0.743*	0.243*	0.24*	0.223*
K Pr. levels				
K_0L	11.82[d]	3.80[a]	11.68[f]	3.60[a]
K_0M	11.61[d]	3.52[a]	10.51[de]	3.48[a]
K_0H	11.18[c]	4.63[b]	10.26[d]	3.78[ab]
K_0C	3.16[a]	6.86[c]	3.75[a]	6.93[c]
K_1L	12.52[e]	3.76[a]	13.59[g]	3.83[ab]
K_1M	11.70[d]	3.38[a]	10.74[e]	3.76[ab]
K_1H	10.58[b]	3.36[a]	8.24[c]	3.02[a]
K_1C	3.39[a]	6.68[c]	6.03[b]	3.89[ab]
C.D. at 5%	0.46*	0.55*	0.313*	0.481*

*Significant at P=0.05

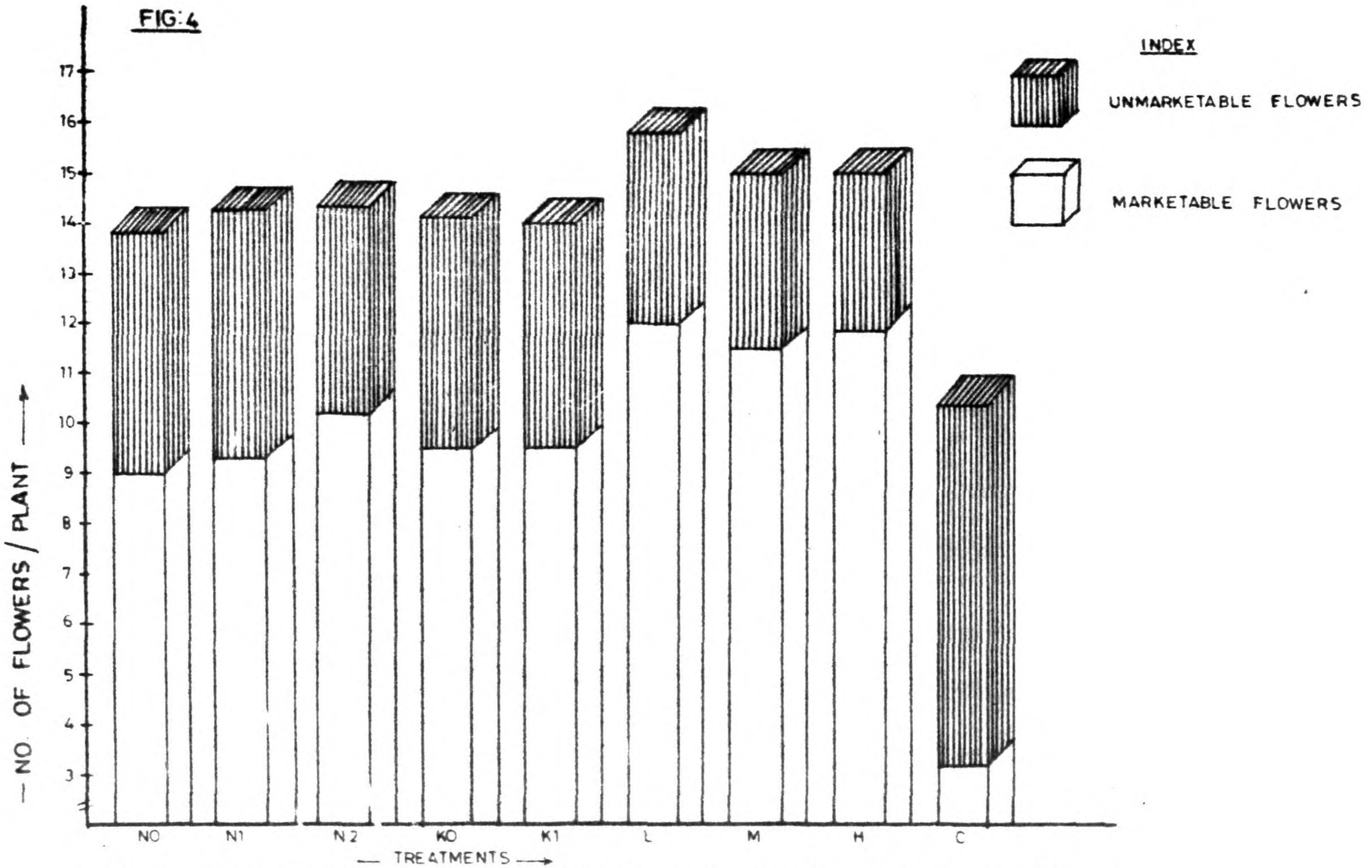
Numbers followed by the same letter are not statistically significant

FIG: 3



EFFECT OF N, K AND PRUNING ON NUMBER OF MARKETABLE AND UNMARKETABLE FLOWERS/ PLANT OF ROSE CV. SUPER STAR. (MONSOON CROP)

FIG: 4



EFFECT OF N,K. AND PRUNING ON NUMBER OF MARKETABLE AND UNMARKETABLE FLOWERS/ PLANT OF ROSE CV. SUPER STAR. (WINTER CROP) number of marketable flowers. K_1 recorded the highest of 9.55 and 9.25 flowers in monsoon and winter respectively.

The interaction effects of NK and NPr were found to be highly significant over other interactions. The maximum number of marketable flowers per plant was obtained with N_2K_1 in both the seasons (10.31 and 10.44) and a minimum was recorded with 8.85 flowers in the monsoon and 9.05 flowers in winter crop. Among different potassium and pruning interactions, K_1L recorded the highest of number of marketable flowers with 12.52 in monsoon and 13.59 in winter crop. The minimum number of flowers was recorded with K_0C which was significantly lower yielding 3.16 and 3.75 marketable flowers per plant in the monsoon and winter seasons respectively.

4.1.6 Number of unmarketable flowers per plant

Data on the number of unmarketable flowers per plant as influenced by N, K, Pr. and their interactions are presented in Table 4 and 4a and fig. 3 and 4.

K significantly influenced the number of unmarketable flowers per plant in both seasons. K_1 level produced less number of unmarketable flowers in both the seasons recording 4.54 in monsoon and 3.82 in winter. Marked differences were recorded in the number of unmarketable flowers per plant due to different levels of pruning. Heavy pruning produced least number of unmarketable flowers per plant recording 3.09 and

3.12 in the monsoon and winter respectively. Control recorded the maximum of 7.27 in monsoon and 7.03 in winter.

Interaction effects of NK and NPr. varied significantly the unmarketable flowers per plant, N_2K_1 treatment produced the least number of unmarketable flowers per plant recording 3.96 in monsoon and 3.02 in winter season. Maximum number of unmarketable flowers per plant was recorded with N_0K_0 treatment in both the seasons (5.38 and 5.02). Among different levels of potassium and pruning interaction K_1H recorded the least number of unmarketable flowers (3.36 in monsoon and 3.02 in winter). Whereas highest number of unmarketable flowers was recorded with K_0C with 6.86 in monsoon and 6.93 in winter. Other treatment interactions NPr. and NKPr. were not significant in both seasons.

4.2 Flower quality attributes

4.2.1 Bud length

The data on the bud length as influenced by N, K, Pr. and their interactions are presented in Table 5 and 6.

The main effects N, K and Pr. had a varying influence on bud length. K and Pr. significantly influenced and bud length increased with increasing quantities of K, with K_1 level recording the highest bud length of 3.18 cm in monsoon and 3.29 cm in winter. Among different pruning levels, heavy pruning recorded flowers with the maximum bud length of 3.27 cm

Table 5. Effect of N, K and Pruning levels on the bud length (cm) and bud diameter (cm) of rose cv. Super Star

Treatments	Monsoon		Winter	
	Bud length (cm)	Bud diameter (cm)	Bud length (cm)	Bud diameter (cm)
N levels				
N_0	3.07	2.71	3.23	2.71
N_1	3.20	2.85	3.25	2.95
N_2	3.19	2.94	3.32	2.91
C.D. at 5%	NS	NS	NS	NS
K levels				
K_0	3.12^a	2.79^a	3.24^a	2.84^a
K_1	3.18^b	2.88^b	3.29^b	2.86^b
C.D. at 5%	0.004*	0.005*	0.003*	NS
Pruning levels				
L	3.20^a	2.86^a	3.28^a	2.93^a
M	3.23^b	3.02^b	3.36^b	3.12^b
H	3.27^c	3.26^c	3.39^c	3.17^c
C	2.09^d	2.20^d	3.22^d	2.17^d
C.D. at 5%	0.005*	0.007*	0.005*	0.006*

*Significant at P = 0.05

NS = Non significant

Numbers followed by the same letter are not statistically significant

Table 6. Effect of NK and N Pr interactions on the bud length (cm) and bud diameter (cm) of rose cv. Super Star

Treatment	Monsoon		Winter	
	Bud length (cm)	Bud diameter (cm)	Bud length (cm)	Bud diameter (cm)
NK levels				
N_0K_0	3.01[a]	2.63[a]	3.20[a]	2.67[a]
N_0K_1	3.13[b]	2.79[b]	3.25[b]	2.75[b]
N_1K_0	3.21[c]	2.84[c]	3.24[c]	2.96[c]
N_1K_1	3.19[d]	2.88[d]	3.25[d]	2.90[d]
N_2K_0	3.15[e]	2.91[e]	3.29[e]	2.90[e]
N_2K_1	3.23[f]	2.98[f]	3.34[f]	2.99[f]
C.D. at 5%	0.006*	0.0009*	0.0053*	0.006*
N Pr. levels				
N_0L	3.07	2.60	3.16[b]	2.48[a]
N_0M	3.11	2.91	3.23[c]	3.08[b]
N_0H	3.21	3.18	3.41[f]	3.15[c]
N_0C	2.87	2.14	2.12[d]	2.12[d]
N_1L	3.23	2.94	3.34[e]	3.21[e]
N_1M	3.32	3.08	3.41[g]	3.14[f]
N_1H	3.28	3.26	3.07[h]	3.18[g]
N_1C	2.97	2.16	3.18[i]	2.19[h]
N_2L	3.30	3.03	3.34[e]	3.39[i]
N_2M	3.25	3.07	3.35[j]	3.15[j]
N_2H	3.33	3.34	3.37[h]	3.69[k]
N_2C	2.89	2.29	3.11[a]	2.19[l]
C.D. at 5%	NS	NS	0.0076*	0.008*

*Significant at P = 0.05

NS = Non significant

Numbers followed by the same letter are not statistically significant

and 3.39 cm in monsoon and winter respectively, followed by medium pruning. Unpruned plants recorded the least bud length of 2.09 cm and 3.22 cm in monsoon and winter respectively. There was no significant influence on bud length due to nitrogen levels in both the seasons.

Bud length was influenced by NK and NPr. combinations significantly. N_2K_1 recorded the highest bud length of 3.23 cm and 3.34 cm in monsoon and winter respectively whereas N_0K_0 recorded the flowers with minimum bud length in both the seasons (3.01 cm and 3.20 cm). Among different NPr. combinations, N_2 level of nitrogen with heavy pruning (N_2H) recorded the maximum bud length of 3.33 cm and 3.37 cm in monsoon and winter seasons respectively. Whereas minimum bud length was obtained with N_0C in both the seasons (2.87 cm and 2.12 cm respectively). But bud length was not influenced by combinations of KPr. and NKPr. in both the seasons.

4.2.2 Bud diameter

The data on the bud diameter as influenced by N, K, Pr. and their interactions are presented in Table 5 and 6.

N, K and Pr. had varying influence on the bud diameter. Bud diameter was not influenced by nitrogen in both the seasons. Potassium significantly influenced the bud diameter, it increased with increasing levels of potassium. The highest bud diameter was with K_1 in both the seasons (2.88 cm and 2.86 cm respectively) over K_0 level recording the least bud length of 2.79 cm in monsoon and 2.84 in the winter. The maximum diameter of 3.26 cm and 3.17 cm in monsoon and winter respectively was recorded with heavy pruning followed by medium and low pruning. Unpruned plants recorded the least bud length of 2.20 cm and 2.17 cm in monsoon and winter respectively.

Bud diameter was significantly influenced by NK and NPr. combinations. N_2K_1 recorded the maximum bud diameter of 2.98 cm in monsoon and 2.99 cm in winter. Minimum diameter was produced with N_0K_0 in both the crops (2.63 cm and 2.67 cm respectively). N_2H recorded the maximum bud diameter of 3.34 cm and 3.69 cm in monsoon and winter respectively. Other treatment combinations NPr. and NKPr. were insignificantly influenced the bud diameter in both the seasons.

4.2.3 <u>Neck length</u>

Data with respect to neck length as influenced by N, K, Pr. NK and KPr. interactions are presented in Table 7 and 8.

Neck length was significantly influenced by potassium and pruning levels in both the seasons. The maximum neck length was 4.62 cm and 5.01 cm recorded with K_1 level in monsoon and winter respectively, whereas K_0 recorded the minimum neck length of 4.46 cm in monsoon and 4.97 cm in winter. Among different pruning levels, heavy pruning produced flowers

Table 7. Effect of N, K and pruning on neck length (cm) and number of petals per flower of rose cv. Super Star

Treatments	Monsoon		Winter	
	Neck length (cm)	No. of petals per flower	Neck length (cm)	No. of petals per flower
N levels				
N_0	4.35	25.13	4.87	26.79
N_1	4.56	26.19	5.03	27.21
N_2	4.71	27.09	5.06	28.08
C.D. at 5%	NS	NS	NS	NS
K levels				
K_0	4.46[a]	25.88[a]	4.97[a]	27.06[a]
K_1	4.62[b]	26.40[b]	5.01[b]	27.67[b]
C.D. at 5%	0.005*	0.02*	0.003*	0.41*
Pruning levels				
L	4.68[a]	26.13[a]	4.93[a]	26.88[a]
M	4.72[b]	26.82[b]	5.11[b]	28.76[b]
H	4.86[c]	27.68[c]	5.33[c]	30.71[c]
C	3.91[d]	23.93[d]	4.58[d]	24.02[d]
C.D. at 5%	0.007*	0.24*	0.056*	0.59*

*Significant at P = 0.05

NS = Non significant

Numbers followed by the same letter are not statistically significant

Table 8. Effect of NK and K Pr. interactions on neck length (cm) and number of petals per flower of rose cv. Super Star

Treatments	Monsoon		Winter	
	Neck length (cm)	No.of petals per flower	Neck length (cm)	No.of petals per flower
NK levels				
N_0K_0	4.11	24.98[a]	4.14	26.34[a]
N_0K_1	4.31	25.29[b]	4.29	27.24[b]
N_1K_0	4.55	25.71[b]	4.46	27.23[b]
N_1K_1	4.65	26.68[c]	4.67	27.36[b]
N_2K_0	4.80	26.96[cd]	4.81	27.59[b]
N_2K_1	4.83	27.23[d]	4.73	28.56[c]
C.D. at 5%	NS	0.58*	NS	0.73*
K Pr. levels				
K_0L	4.25	25.79[b]	4.34	26.93[c]
K_0M	4.19	26.35[c]	4.21	26.42[b]
K_0H	4.25	26.78[c]	4.27	28.72[e]
K_0C	3.90	24.63[a]	3.92	25.61[a]
K_1L	4.53	26.56[c]	4.47	26.19[b]
K_1M	4.69	27.42[d]	4.72	27.85[d]
K_1H	4.62	27.93[d]	4.74	28.91[e]
K_1C	3.92	25.04[a]	3.99	26.83[c]
C.D. at 5%	NS	0.43*	NS	0.5*

*Significant at P = 0.05

NS = Non significant

Numbers followed by the same letter are not statistically significant

with highest neck length of 4.86 cm and 5.33 cm in monsoon and winter respectively followed by medium and low pruning. In control plants recorded the minimum neck length of 3.91 cm in monsoon and 4.58 cm in winter. Nitrogen levels did not have any significant influence on the neck length in both the seasons.

The interactions of NK, KPr., NPr. and NKPr. did not have any significant influence on the neck length in both the seasons.

4.2.4 Number of petals per flower

Data on the number of petals per flower as influenced by N, K, Pr. and NK interactions are presented in Tables 7 and 8.

The main effects of N, K and pruning levels produced a varying influence on the shoot length. Potassium and pruning were found to influence the number of petals per flower in both the seasons. Higher number of petals per flower was recorded due to K_1 level in monsoon (26.40) and winter (27.67) and a least number of petals per flower was recorded with K_0 in both the seasons (25.88 and 27.06). Among different pruning levels, heavy pruning produced flowers with more number of petals of 27.68 and 30.71 in monsoon and winter crop respectively followed by medium and low pruning. Least number of petals per flower was recorded in control with 23.93 in monsoon and 24.02 in winter.

Significant differences were obtained in the number of petals per flower with the interaction of NK and NPr. in both the seasons. Maximum number of petals of 27.23 and 28.56 was recorded owing to N_2K_1 level in monsoon and winter respectively. N_0K_0 recorded the minimum number of petals of 24.98 and 26.34 in both the seasons. In pruning and potassium interaction levels K_1H recorded a maximum in both seasons (27.93 and 28.91 respectively). Similarly the minimum number of petals per flower was 24.63 in monsoon and 25.61 in winter with K_0C. However, other treatment combinations NPr. and NKPr. did not influence the petal number significantly in both the seasons.

4.2.5 <u>Foliar N, P and K contents</u>

Data on the effect of N, K, pruning levels NK and NPr. interactions on the foliar N, P and K contents are presented in Tables 9 and 10 and fig. 5 and 6.

a) <u>N content:</u> Nitrogen content was significantly influenced by N, K and pruning levels. Nitrogen content increased with increasing levels of K, highest nitrogen content was recorded with K_1 (2.57 and 2.44 per cent) in both the seasons over K_0 recording the lowest nitrogen of 2.28 per cent and 2.37 per cent in the two seasons. Among different pruning levels, heavy pruning resulted in maximum content of N recording 2.57 and 2.69 per cent in both the seasons followed by medium and then low pruning levels. Controlled plants recorded the minimum

Table 9. Effect of N, K and pruning on foliar nitrogen (%), phosphorus (%) and potassium content (%) of rose cv. Super Star

Treatment	Monsoon			Winter		
	N Content (%)	P content (%)	K content (%)	N content (%)	P content (%)	K content (%)
N levels						
N_0	2.173	0.223	1.92	2.25	0.222	1.94
N_1	2.53	0.238	2.15	2.38	0.234	2.07
N_2	2.71	0.247	2.17	2.59	0.246	2.17
C.D. at 5%	NS	NS	NS	NS	NS	NS
K levels						
K_0	2.28^a	0.233^a	2.06^a	2.37^a	0.229^a	2.01^a
K_1	2.57^b	0.239^b	2.11^b	2.44^b	0.238^b	2.12^b
C.D. at 5%	0.0032*	0.0003*	0.002*	0.003*	0.0002*	0.007*
Pruning levels						
L	2.48^a	0.235^a	2.09^a	2.37^a	0.233^a	2.09^a
M	2.53^b	0.236^b	2.09^b	2.52^b	0.235^b	2.10^b
H	2.57^c	0.244^c	2.11^c	2.69^c	0.241^c	2.12^c
C	2.32^d	0.228^d	2.05^d	2.02^d	0.227^d	2.06^a
C.D. at 5%	0.005*	0.0004*	0.0003*	0.004*	0.0001*	0.11*

*Significant at P = 0.05

NS = Non significant

Numbers followed by the same letter are not statistically significant

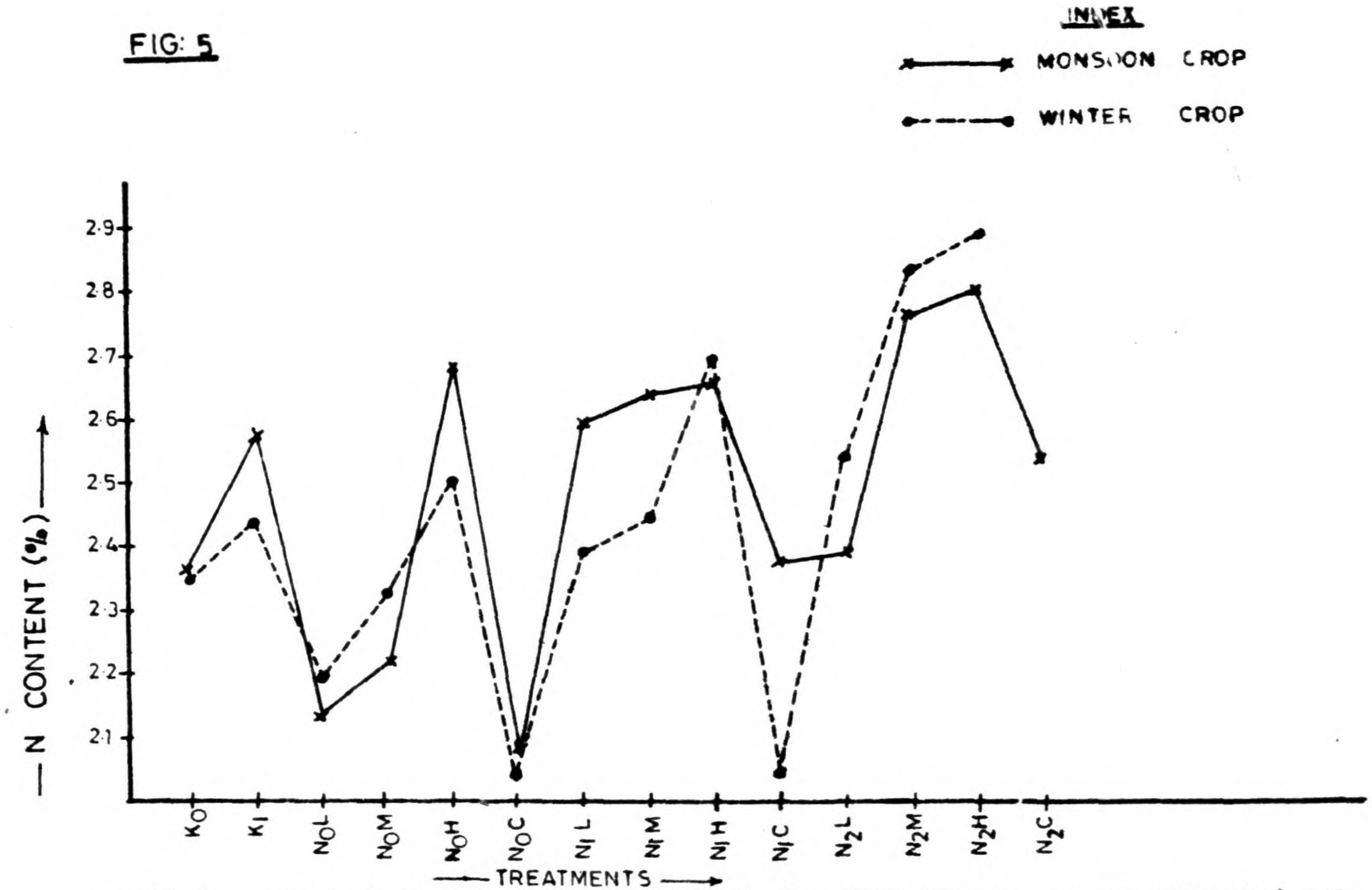
Table 10. Effect of NK and N Pr. interactions on foliar nitrogen (%), phosphorus (%) and potassium (%) content of rose cv. Super Star

Treatment	Monsoon			Winter		
	N content (%)	P content (%)	K content (%)	N content (%)	P content (%)	K content (%)
NK levels						
N_0K_0	1.97^{a}	0.218^{a}	1.872^{a}	2.22^{a}	0.216^{a}	1.877^{a}
N_0K_1	2.38^{b}	0.228^{b}	2.00^{b}	2.25^{b}	0.226^{b}	2.008^{b}
N_1K_0	2.50^{c}	0.237^{c}	2.142^{c}	2.39^{c}	0.231^{c}	1.969^{c}
N_1K_1	2.61^{d}	0.238^{d}	2.153^{d}	2.36^{d}	0.237^{d}	2.158^{d}
N_2K_0	2.68^{e}	0.244^{e}	2.167^{e}	2.49^{e}	0.241^{e}	2.165^{e}
N_2K_1	2.73^{f}	0.251^{f}	2.183^{f}	2.69^{f}	0.251^{f}	2.184^{f}
C.D. at 5%	0.005*	0.0005*	0.003*	0.011*	0.0002*	0.004*
N Pr. levels						
N_0L	2.14^{b}	0.223^{b}	1.945^{b}	2.20^{a}	0.221^{b}	1.923^{a}
N_0M	2.21^{c}	0.222^{b}	1.938^{a}	2.31^{b}	0.220^{b}	1.938^{b}
N_0H	2.67^{g}	0.229^{c}	1.957^{c}	2.50^{c}	0.229^{c}	1.965^{d}
N_0C	2.07^{a}	0.218^{a}	1.937^{a}	2.03^{d}	0.216^{a}	1.943^{c}
N_1L	2.57^{f}	0.233^{c}	2.160^{f}	2.38^{c}	0.234^{d}	2.172^{g}
N_1M	2.63^{e}	0.238^{d}	2.170^{g}	2.44^{f}	0.235^{d}	1.838^{e}
N_1H	2.64^{e}	0.249^{e}	2.163^{f}	2.69^{g}	0.248^{f}	1.975^{f}
N_1C	2.37^{d}	0.230^{c}	2.097^{d}	2.02^{h}	0.227^{c}	2.110^{h}
N_2L	2.74^{h}	0.247^{e}	2.173^{g}	2.54^{i}	0.244^{c}	2.175^{gh}
N_2M	2.75^{h}	0.248^{e}	2.187^{h}	2.81^{i}	0.249^{f}	2.178^{h}
N_2H	2.80^{i}	0.254^{f}	2.192^{i}	2.89^{k}	0.254^{g}	2.195^{i}
N_2C	2.53^{j}	0.239^{d}	2.146^{e}	2.12^{l}	0.239^{h}	2.150^{j}
C.D. at 5%	0.015*	0.004*	0.005*	0.007*	0.003*	0.004*

*Significant at P=0.05

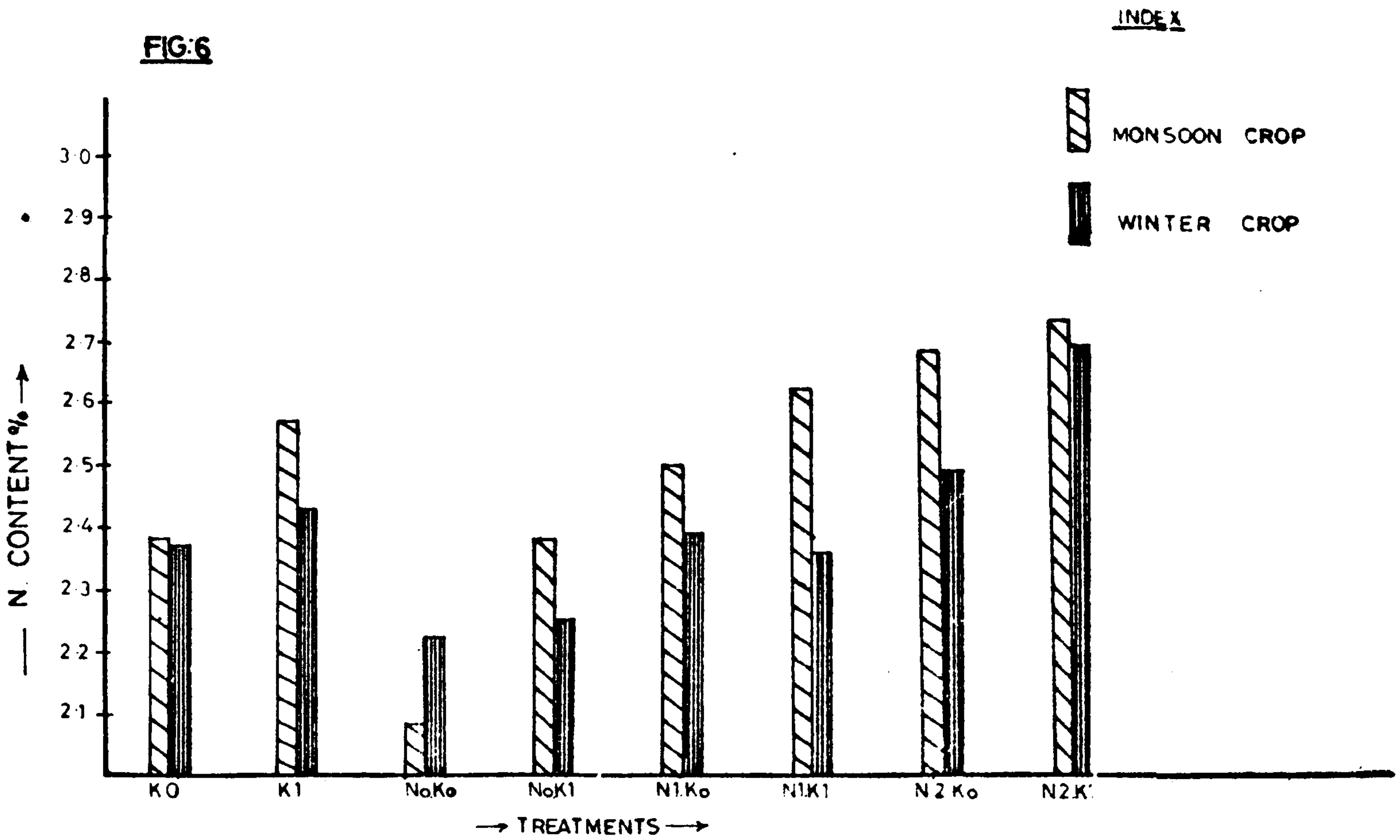
Numbers followed by the same letter are not statistically significant

FIG: 5



EFFECT OF K AND NX PR. INTERACTION ON THE FOLIAR N. CONTENT (%) OF ROSE CV. SUPER STAR.

FIG:6



EFFECT OF K. AND INTERATION EFFECT OF N.K. ON THE FOLIAR N. CONTENTS OF ROSE CV. SUPER STAR.

nitrogen content with 2.32 per cent in monsoon and 2.02 per cent in winter crop.

Nitrogen content was significantly influenced by NK and NPr. interactions. N_2H recorded the maximum N content of 2.73 per cent in monsoon and 2.69 per cent in winter. In both the seasons N_0K_0 recorded the minimum nitrogen content of 1.97 and 2.22 per cent in monsoon and winter respectively. Among different NPr. levels, N_2H recorded the maximum N content in the seasons (2.80 and 2.89 per cent respectively) while N_0C recorded the lowest nitrogen content of 2.07 and 2.03 per cent in monsoon and winter respectively. However, other treatment combinations KPr. and NKPr. had no significant influence on the foliar N content in both the seasons.

b) <u>P content:</u> The main effects N, K and pruning levels influenced significantly the foliar content of P in both the seasons. P contents increased with increasing levels of K, it was maximum with K_1 level recording 0.239 and 0.238 per cent in monsoon and winter respectively. Among different pruning levels, heavy pruning recorded the highest P content of 0.244 per cent in monsoon and 0.241 per cent in winter. The lowest percentage of P content was recorded in control plants (0.228 and 0.227 per cent in monsoon and winter respectively). But N levels had no significant influence in the foliar P content in both the seasons tried.

Among different interactions NK and NPr. were found to have influenced the phosphorus content significantly. Among different NK combinations, N_2K_1 recorded the maximum P content of 0.251 per cent in both the seasons followed by N_2K_0. The lowest percentage of phosphorus was recorded with N_0K_0 with 0.218 and 0.216 per cent in monsoon and winter respectively. Among different NPr. combinations, N_2H recorded the maximum P content of 0.254 per cent in both the seasons, closely followed by N_1H recording 0.249 and 0.248 per cent in monsoon and winter respectively. However other interactions KPr. and NKPr. had no significant influence on the phosphorus content in both the seasons.

c) <u>K content</u>: N, K and Pr. showed varying influence on the foliar K content in both the seasons. Even though the nitrogen levels had no significant influence on this parameter in both the seasons, K content increased with increasing levels of N. N_2 level recorded the maximum of 2.17 in both the seasons. Similarly K_1 recorded the highest K content of 2.11 and 2.12 per cent in monsoon and winter respectively over K_0 which recorded 2.06 and 2.01 per cent in the two seasons. Among different pruning levels heavy levels of pruning recorded the maximum of 2.11 and 2.12 per cent in monsoon and winter respectively followed by medium and low pruning. Untreated plants recorded the lowest potassium content of 2.05 in monsoon and 2.06 per cent in winter.

There was significant differences among treatment combinations, NK and NPr. with respect to foliar K content.

N_2K_1 recorded the highest K content of 2.183 and 2.184 per cent in the monsoon and winter respectively, closely followed by N_2K_0 recording 2.167 and 2.165 per cent in both the seasons respectively. Plants receiving N_0K_0 levels of fertilizers recorded the lowest potassium content of 1.872 per cent during monsoon and 1.877 per cent during winter. Among different NPr. treatment interactions N_2H recorded the maximum K content of 2.192 and 2.195 per cent in both the seasons followed by N_2M with 2.187 and 2.178 per cent respectively. The lowest percentage of potassium was recorded with N_0C in both the seasons (1.937 and 1.943 per cent respectively). Other treatment interactions KPr. and NKPr. did not have any significant influence the potassium content in both the seasons.

4.3 Vase life studies

4.3.1 Vase life of cut flowers

The data on the effect of potassium, pruning levels and NK interactions on the vase life of cut flowers (in days) of rose cv. Super Star are presented in Table 11 and Fig. 7.

There were significant differences in vase life (days) among the treatments with 0.5 ppm kinetin. Vase life was influenced by potassium and pruning levels. Longest vase life of 6.68 and 7.24 days was recorded due to application of K_1 level. Different pruning levels influenced the vase life of cut roses, the longest vase life of 5.99 and 6.29 days was recorded with the treatment 0.5 ppm of kinetin.

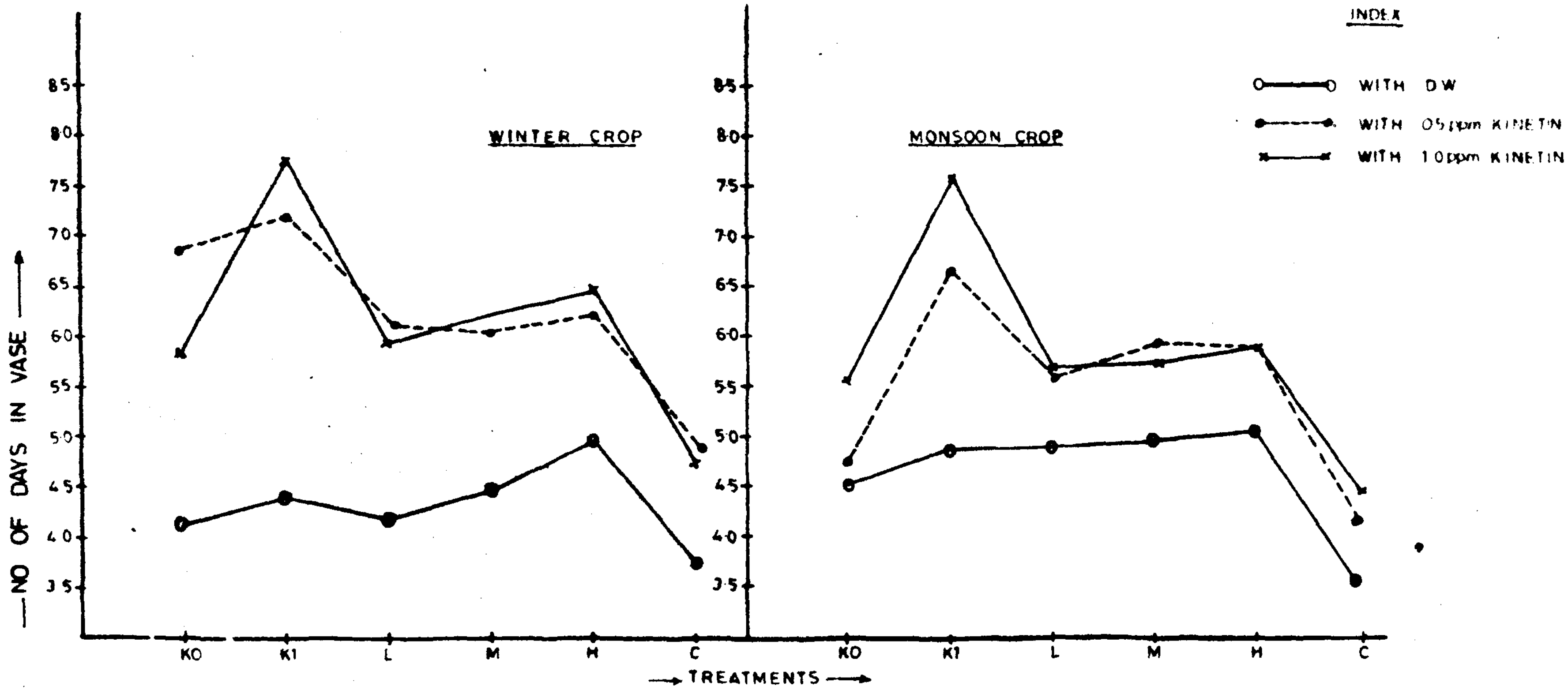
Table 11. Effect of K, Pruning and NK interactions on the vase life of cut flowers (days) of rose, cv. Super Star with 0.5 ppm, 1.0 ppm kinetin and distilled water

Treatments	Monsoon			Winter		
	Kinetin			Kinetin		
	0.5 ppm	1.0 ppm	D.W.	0.5 ppm	1.0 ppm	D.W.
K levels						
K_0	5.25[a]	7.51[a]	4.54[a]	6.69[a]	7.61[a]	4.18[a]
K_1	6.68[b]	7.53[b]	4.86[b]	7.24[b]	7.79[b]	4.33[b]
C.D. at 5%	0.24*	0.012*	0.01*	0.27*	0.04*	0.047*
Pruning levels						
L	5.53[b]	5.74[b]	4.95[b]	6.66[b]	5.86[b]	4.28[b]
M	5.98[b]	5.76[b]	4.98[c]	6.09[b]	6.03[c]	4.41[c]
H	5.99[b]	5.98[c]	5.29[d]	6.29[b]	6.12[d]	4.58[d]
C	4.37[a]	4.68[a]	3.59[a]	4.81[a]	4.80[a]	3.76[a]
C.D. at 5%	0.62*	0.049*	0.015*	0.73*	0.057*	0.066*
NK levels						
N_0K_0	4.77[a]	5.32[a]	3.87[a]	5.52[a]	5.02[a]	3.98[a]
N_0K_1	5.34[b]	5.48[a]	4.23[b]	6.70[c]	5.18[b]	4.08[a]
N_1K_0	5.13[b]	5.43[a]	4.63[c]	5.73[a]	5.78[c]	4.53[a]
N_1K_1	5.72[c]	5.60[b]	5.13[d]	5.93[a]	5.92[d]	4.75[b]
N_2K_0	5.87[c]	5.69[bc]	4.93[e]	5.81[a]	6.05[e]	4.84[b]
N_2K_1	6.01[c]	6.90[c]	5.40[f]	6.08[b]	6.35[f]	4.86[b]
C.D. at 5%	0.39*	0.21*	0.017*	0.47*	0.069*	1.08*

*Significant at P = 0.05

Numbers followed by the same letter are not statistically significant

FIG: 7



EFFECT OF K AND PRUNING ON THE VASELIFE (IN DAYS) OF ROSE CV. FLOWERS WITH 0·5 ppm, 1·0 ppm KINETIN AND DISTILLED WATER

However there was no significant differences with respect to different nitrogen levels in both the seasons.

Among different interaction effects, NK influenced the vase life of cut rose significantly. N_2K_1 combination gave a maximum vase life of 6.01 and 6.08 days was recorded with N_2K_1 while the minimum vase life (4.77 and 5.52 days) was recorded with N_0K_0 in monsoon and winter respectively. Interactions viz., NPr., KPr. and NKPr. did not influence significantly the vase life in both the seasons.

There was significant difference in vase life (days) with 1.0 ppm kinetin. Potassium and pruning levels significantly influenced the vase life where there was no significant influence due to N levels. Vase life was longest at an increased level of K, with K_1 recording 7.53 and 7.79 days in monsoon and winter respectively. Heavy pruning recording the maximum vase life in both the seasons. (5.98 and 6.12 days) whereas minimum vase life of 4.68 and 4.80 days was recorded with no pruning.

Among different interactions, N_2K_1 level recorded the maximum vase life of 6.90 and 6.35 days in monsoon and winter respectively, while the minimum was recorded with N_0K_0 (5.32 and 5.02 days respectively) in both the seasons. However NPr., KPr. and NKPr. did not influence the vase life in both the seasons.

The vase life of cut flowers in distilled water was influenced by K and pruning levels. Compared to other two concentrations of kinetin, vase life in distilled water recorded minimum in both the seasons. The highest vase life of 4.86 and 4.33 days was observed with K_1 level in monsoon and winter respectively. Different pruning levels influenced the vase life of cut roses under water, heavy pruning recorded the maximum vase life in both the seasons (5.29 and 4.58 days) with control recording the minimum of 3.29 and 3.76 days of vase life respectively. Nitrogen levels did not influence the vaselife during both the seasons.

Similarly, there was significant difference in vase life among the treatment combinations. NK level significantly influenced the vase life. N_2K_1 recorded the highest vase life of 5.40 and 4.86 days in monsoon and winter respectively followed by N_1K_1 in both the seasons, while N_0K_0 recorded the minimum with 3.87 in monsoon and 3.98 in winter. NPr., KPr. and NKPr. did not influence the vase life in both the seasons.

4.3.2 Changes in fresh weight of flowers during the vase life held with 0.5 ppm kinetin

Data on the effect of N, K and pruning levels on the fresh weight of flowers (g) during the vase life held with 0.5 ppm kinetin are presented in Table 12.

Table 12. Effect of N, K and pruning on the fresh weight (%) of flowers held in 0.5 ppm kinetin on 1st, 3rd and 5th day of rose cv. Super Star

Treatments	Monsoon			Winter		
	1st day	3rd day	5th day	1st day	3rd day	5th day
N levels						
N_0	10.14	9.66[a]	8.09[a]	13.02	11.89[a]	8.94[a]
N_1	12.39	10.61[b]	8.68[b]	13.99	12.32[b]	10.06[b]
N_2	11.27	10.29[c]	8.43[c]	13.68	12.24[c]	9.69[c]
C.D.at 5%	NS	0.052*	0.063*	NS	0.069*	0.074*
K levels						
K_0	11.55	9.89[a]	8.16[a]	13.49	12.09[a]	9.45[a]
K_1	10.98	9.97[b]	8.33[b]	14.02	12.18[b]	9.69[b]
C.D. at 5%	NS	0.02*	0.22*	NS	0.056*	0.061*
Pruning levels						
L	10.85	10.00[a]	8.53[a]	13.83	12.37[a]	10.02[a]
M	11.17	10.44[b]	8.91[b]	13.64	12.42[a]	9.74[b]
H	13.24	10.74[c]	8.95[c]	14.10	13.03[b]	10.54[c]
C	9.79	8.92[d]	6.24[d]	11.63	10.09[c]	10.08[d]
C.D. at 5%	NS	0.27*	0.076*	NS	0.079*	0.085

*Significant at P = 0.05

NS = Non significant

Numbers followed by the same letter are not statistically significant

Only the main effects, N, K and pruning levels had significant influence on the fresh weight during the vase life. Among N levels, N_1 maintained higher fresh weight on 3rd and 5th day in both the seasons (10.61 g and 8.68 g in monsoon and 12.32 g and 10.64 g in winter season). K_1 levels maintained higher fresh weight at all stages, its stay in vase with 9.97 g on 3rd and 8.33 g on 5th day in monsoon and 12.18 g on 3rd and 9.69 g on 5th day in winter was recorded. Among different pruning levels, heavy pruning maintained higher fresh weight in both the seasons and recorded 10.74 g on 3rd and 8.95 g on 5th day in monsoon and 13.03 g on 3rd and 10.54 g on 5th day in the winter season crop followed by medium and low pruning.

The treatment interactions did not have any significant influence on the maintenance of fresh weight throughout its vase life in both the seasons.

4.3.3 Changes in fresh weight of flowers (g) during the vase life held with 1.0 ppm kinetin

The data with respect to fresh weight of flowers during the vase life held with 1.0 ppm kinetin as affected by N, K and pruning levels is presented in Table 13.

Main effects of N, K and pruning levels significantly influenced the fresh weight in both the seasons. Among N levels, N_2 effect was found insignificant in both the seasons on 1st day and was significant on 3rd and 5th day only in

Table 13. Effect of N, K and pruning the fresh weight (g) of flowers held in 1.0 ppm kinetin on 1st, 3rd and 5th day of rose Cv. Super Star

Treatments	Monsoon			Winter		
	1st day	3rd day	5th day	1st day	3rd day	5th day
N levels						
N_0	9.89	12.68	16.26	10.94	9.55[a]	6.93[a]
N_1	11.05	13.19	10.03	11.55	10.08[b]	8.14[b]
N_2	11.06	13.67	10.83	11.72	10.56[c]	8.55[c]
C.D. at 5%	NS	NS	NS	NS	0.058*	0.055*
K levels						
K_0	10.78	13.09[a]	10.19[a]	10.78[a]	9.51[a]	7.65[a]
K_1	11.23	13.31[b]	10.71[b]	11.23[b]	9.94[b]	8.0[illegible][b]
C.D. at 5%	NS	0.052*	0.012*	0.034*	0.048*	0.045*
Pruning levels						
L	11.29	13.42[a]	10.51[a]	11.29[a]	10.02[a]	8.08[a]
M	11.39	13.51[a]	11.07[b]	11.38[b]	10.13[b]	8.29[b]
H	11.57	13.88[b]	11.89[c]	11.57[c]	10.29[c]	8.45[c]
C	9.76	7.91[c]	6.36[d]	9.76[d]	8.48[d]	6.6[illegible][d]
C.D. at 5%	NS	0.22*	0.17*	0.049*	0.068*	0.051*

*Significant at P = 0.05

NS = Non significant

Numbers followed by the same letter are not statistically significant

winter with 10.56 g on 3rd and 8.55 g on 5th day. Over K_0, K_1 level was superior in maintaining the fresh weight on 3rd and 5th day in both the seasons with 13.31 g and 3rd day and 10.71 g on 5th day in the winter crop. Among different pruning levels, heavy pruning significantly influenced the maintenance of fresh weight on 3rd and 5th day in both the crops. It recorded 13.88 g on 3rd and 11.89 g on 5th day in monsoon and 10.29 g on 3rd and 8.45 g on 5th day in winter crop followed by medium pruning. Untreated recorded the minimum fresh weight of 7.91 g on 3rd and 6.36 g on 5th day in monsoon crop and 8.48 g on 3rd and 6.68 g on 5th day in winter crop.

Interactions did not influence significantly the fresh weight of cut flowers in both the seasons.

4.3.5 <u>Changes in fresh weight of flowers (g) during the vase life held with distilled water</u>

The data with regard to the fresh weight of flowers during the vase life held with distilled water as affected by N, K and pruning levels are presented in Table 14.

There was significant differences in fresh weight of flowers due to N, K and pruning levels in both the seasons. Among N levels, N_2 was found to influence significantly with maximum fresh weight in both the seasons (11.05 g on 1st and 8.36 g on 3rd day in monsoon and 10.87 g and 8.04 g on 1st

Table 14. Effect of N, K and pruning on the fresh weight of flowers (g) on 1st and 3rd day in vase with rose cv. Super Star held in distilled water

Treatments	Monsoon		Winter	
	Fresh wt.(g) on 1st day	Fresh wt.(g) on 3rd day	Fresh wt.(g) on 1st day	Fresh wt.(g) on 3rd day
N levels				
N_0	10.06[a]	7.096[a]	9.62[a]	7.49[a]
N_1	10.45[b]	7.58[b]	9.73[b]	7.71[b]
N_2	11.05[c]	8.36[c]	10.87[c]	8.04[c]
C.D. at 5%	0.071*	0.06*	0.063*	0.0172*
K levels				
K_0	10.44[a]	7.64[a]	10.32[a]	7.55[a]
K_1	10.59[b]	7.72[b]	10.62[b]	7.94[b]
C.D. at 5%	0.058*	0.049*	0.061*	0.0141*
Pruning levels				
L	10.46[a]	7.53[a]	10.47[a]	7.91[a]
M	10.69[b]	7.97[b]	9.92[b]	7.93[b]
H	11.09[c]	8.19[c]	10.53[c]	8.18[b]
C	9.83[d]	7.02[d]	8.79[d]	6.980[c]
C.D. at 5%	0.082*	0.069*	0.079*	0.244*

*Significant at P = 0.05

Numbers followed by the same letter are not statistically significant

and 3rd day respectively in winter). The minimum fresh weight was recorded with N_0 treatment. Over K_0, K_1 recorded the maximum fresh weight on both the days in both the seasons. Highest fresh weight of 10.59 g on 1st and 7.72 g on 3rd day was recorded in the monsoon crop and in winter 10.62 g on 1st and 7.94 g on 3rd day was recorded. Among different pruning levels tried, heavy pruning recorded the maximum fresh weight of 11.09 g and 8.19 g in the monsoon crop and 10.53 g and 8.18 g in the winter crop on first and third day respectively which was followed by medium and low pruning. Unpruned recorded a minimum in both the seasons.

There was no significant differences due to treatment interactions on fresh weight of flowers held in distilled water in both the seasons.

DISCUSSION

CHAPTER V

DISCUSSION

Judicious and balanced use of nutrients are known to result in overall improvement in growth parameters, flower yield and flower quality in many flowering plants. An interruption in plant nutrition even for a short period has a negative effect on yield and quality. Therefore, in roses balanced supply of major nutrients combined with appropriate cultural practices is important for obtaining higher yield and quality flowers. The results of present investigation on the effect of different levels of nitrogen, potassium, pruning and their interaction on growth, flowering and vase life of rose cv. 'Super Star' during 1984-85 are discussed below:

Importance of proper and balanced mineral nutrition for food growth, development, flower production, quality and vase life have been recognised by several workers. Fertilizer recommendations have also been made for rose varieties grown under different geographical and climatic conditions (Pal, 1966; Raghava, 1969; Vishnu Swarup, 1971). Importance of pruning has been demonstrated by several other workers (June, 1950; Pal, 1966; Appanna, 1976; Zieslin and Mor, 1981 and Borrelli, 1982). Floral preservatives are under the use to increase the vase life of cut flowers from so many decades. Among many preservatives the use of cytokinins has been recognised by Mclean and Dedolph (1962), Halevy et al. (1966), Mayak and Halevy (1974), Cywinska et al. (1978) and Nakamura et al. (1980).

Studies conducted on the nutrition of roses have indicated notable influence of nitrogen and potassium on vegetative growth, flower production and on their vase life. (Seeley, 1950; Young et al., 1967 and 1973; Bik, 1972; Jayaprasad, 1976; Maharana and Pradhan, 1976; Johansson, 1978 and Woodson and Boodley, 1982).

5.1 Days taken for first flowering

The number of days taken for first flowering is an important parameter to be studied for commercial flower production. This remains the same with a small range for a particular variety for a given agro-climatic situation. In the present study, days taken for first flowering was much influenced by nutrients and pruning levels. The number of days taken for first flowering increased with the increasing levels of nitrogen, it was highest (38.24 days) with 16 g N/plant. Earlier flowering due to combination of nitrogen and pruning is in agreement with the results of Post (1952), Hussein (1955), Durkin (1960) and Bik (1972). Potassium also had a significant influence on number of days taken for first flowering. Potassium at 8 g/plant took 33.62 days over the plants not supplied with potassium similar results were obtained by Kamp and Shannon (1960), Raghava (1969) and Young *et al.* (1973).

In the present study, there was a remarkable influence of pruning on flowering. Flowering was delayed due to heavy pruning (39.63 and 36.73 days) by 4 to 5 days compared to lower levels of pruning. This may be due to the lower auxin content of flowering shoot which were severely pruned which in turn resulted in delayed flowering (Zieslin and Halevy, 1976; and Appanna, 1976). Light pruning resulted in early flowering. Similar results were reported by Kohl and Post (1952), Moe (1970a, 1971a and 1973), Holley (1973b) and Appanna (1976). The number of days required for flowering was influenced by NK levels among different combinations tried. Combinations such as N_2K_1 (16 g of N and 8 g of K/plant) delayed flowering flowering and flowering was hastened by N_1K_1 (8 g of N and 8 g of K/plant) which may be due to the higher dose of nitrogen effect on the uptake of potassium which resulted in delayed flowering.

5.2 Flowering shoot length

Shoot length plays an important role in determining its suitability of a cut flower for export (Post, 1952, Buck, 1964 and Malik, 1968). In the present study, shoot length was very much influenced by N, K and their interactions. Maximum shoot length was recorded with the highest dose of nitrogen (16 g/plant) and K at 8 g/plant. Interaction of these two (16 g/plant N and 8 g/plant K) recorded best results which are in accordance with the findings of Kamp and Shannon (1960); Young et al. (1973); Jayaprasad (1976); Degeyter (1978) and Woodson and Boodley (1982).

Heavy pruning significantly influenced the shoot length in both the season with a maximum of 26.22 cm and 31.72 cm followed by medium pruning, whereas light and no pruning produced shorter flowering shoots. Similar observations were recorded by El-Gamassy et al. (1960), Moe (1970a, 1970b, 1971a and 1973). The severity of pruning increased the shoot length was also observed by June (1950), Appanna (1976), Smirnov (1977) and Borrelli (1978 and 1981) that when a few buds were left they threw out stronger growth and longer shoot length, when too many buds were left in the plant due to lack of judicious supply of nutrients and hormones, shorter shoots were produced.

Heavy pruning in combination with higher K levels gave higher shoot length was clearly evident to any other combinations. It is quite apparent that a few buds on the cane provided with nutrients resulted in vigorous and long shoots because of reduced competition for the nutrients.

5.3 Fresh weight of flowering shoot

The role of potassium in enhancing the translocation of metabolites and that of nitrogen in increasing the fresh weight of flowering shoot is well established.

Fresh weight of the flowering shoot was influenced by nutrients to a great extent. The results of this study are in accordance with the findings of Young *et al.* (1967, 1973 and 1978). Bik (1970 and 1972), Jayaprasad (1976), Johansson (1978), Armitage and Tsujita (1979) and Woodson and Boodley (1982). Fresh weight of flowering shoot was significantly influenced by higher levels of nitrogen and maximum fresh weight of flowering shoot was with N at 16 g/plant and K at 8 g/plant in both the seasons. Among different pruning levels heavy pruning followed by medium pruning recorded highest fresh weight. The earlier results in roses, Appanna (1976); Degeyter (1978), Johansson (1979) and Borrelli (1981) agree with the present findings. Interactions between N and K and K and pruning levels was favourable in increasing the fresh weight. Maximum fresh weight was obtained with higher doses of N and K (N_2K_1) and with K_1H.

With all this, it is apparent that with heavy pruning very few shoots were left on the cane, those plants provided with better nutrient amounts to results in the channelling up of the nutrients and carbohydrates to those fewer shoots to produce shoots with higher fresh weights.

5.4 Number of blind shoots per plant

The importance of blind shoots is realised when the potential flower production is reduced because of too many blind shoots. The reasons for blind shoot production is still not fully understood. Hubbel (1934a) was of the opinion that blind shoot is not an inherited character.

In the present study, number of blind shoots production was not influenced by nitrogen levels in both the seasons which is in accordance with the findings of Lindstrom and Kiplinger (1955) with Better Times roses, whereas potassium levels had a better influence with higher levels of potassium resulting in lower number of blind shoots production. Similar results were obtained by Post and Fischer (1951) who summarised that number of blind shoot and potassium levels are negatively correlated. Whereas interaction effect between N and K significantly influenced the blind shoot production. In the present study, higher levels of nitrogen and potassium recorded (N_2K_1) the least number of blind shoots.

The number of blind shoots increased with the severity of pruning. Heavy pruning followed by medium resulted in reduced number of blind shoots per plant, these results are in accordance with the findings of Moe (1970a, 1970b and 1970c); Zeislin and Halevy (1976) and Appanna (1976) who observed lower content of auxin in highly pruned which eventually resulted in higher number of blind shoots.

5.5 Marketable and unmarketable flowers per plant

Flower yield is one of the most important criterion for commercial flower production. As compared to control all the nutrients brought about a marked increase in the marketable flowers per plant and hence in yield. In the present study, increase in the levels of N and K, increased the number of marketable flowers and reduced the unmarketable flowers, similar desirable influence of nitrogen and potassium were obtained by Kamp and Pokorny (1958), White (1954 and 1958), Kamp and Shannon (1960), Heeney *et al.* (1960), Bik (1972), Jayaprasad (1976), Johansson (1978), Borrelli (1981) and Woodson (1982). The number of marketable flowers was significantly influenced by pruning levels. Unpruned and light pruned plants recorded more number of flowers per plant but were of poor quality compared with that of medium and heavy pruned plants. These results are in accordance with the findings of June (1950); Appanna (1976); Degeyter (1977), Smirnov (1978) and Borrelli (1978 and 1981). Evidently plants which were not pruned or lightly pruned had a greater capacity for flower production than medium or heavily pruned plants owing to larger reserved carbohydrates and nutrients. Plants with no or light pruning experienced the depressive effect of flowering alone to a larger extent, whereas heavy and medium pruned plants experienced combined depressive effects of flowering and pruning.

Nitrogen and potassium interacted favourably in influencing the number of marketable and unmarketable flowers along with potassium and pruning levels. N at

16 g/plant and K at 8 g/plant recorded the highest number of marketable flowers (10.4) whereas K at 8 g/plant with light pruning recorded the highest number of flowers in both seasons. Eventually N_0K_0 and N_0C recorded the maximum number of unmarketable flowers.

5.6 Quality attributes

Bud length, bud diameter, neck length, number of petals per flower and keeping quality etc., constitute important attributes of quality of a cut flower.

Neck length: Neck length is an important quality attribute of a cut flower for holding them errect on their stems which otherwise results in bent neck (Balasubramanian, 1963 and Malik, 1968). In the present study, there was no response to any combination of levels of nutrients on neck length, however in both crops the potassium and pruning significantly influenced the neck length of the flower. Contrary to this, Appanna (1976) observed that neck length was a varietal character and was not influenced by any pruning levels. Jayaprasad (1976) also obtained similar results with different fertilizer levels. The results obtained in this study may be because of the agroclimatic conditions of the area. Whereas NK interaction seemed to be significantly influencing the necklength in both the seasons. So this parameter may not be a varietal trait completely but may be manipulated to some extent with judicious fertilizer application. Similar results were also obtained by Maharana and Pradhan (1976) and Malik (1980).

5.6.1 Bud length and bud diameter

Bud length and diameter are the important cut flower quality attributes of rose. In the present study, quality flowers obtained with good bud length and diameter with increasing levels of N and K. This is in accordance with almost all nutrient trials (Frenguelli and Romano, 1977; Young *et al.*, 1978; Johansson, 1978; Armitage and Tsujita, 1979; Borrelli, 1981 and Woodson and Boodley, 1982a and 1982). Maximum bud length and bud diameter was obtained with N and 6 g/plant and K at 8 g/plant. Bud length and bud diameter was influenced by heavy pruning followed by medium pruning. Similar results were recorded by Tune (1950), Appanna (1976), Degeyter (1977), Smirnov (1977), Eccher and Migriani (1977) and Borrelli (1981). With medium and heavy pruning fewer buds were left on the cane. The amount of photosynthates hormones and others distributed to each bud was fairly high eventually resulting in quality blooms with greater bud length and diameter.

Even though N alone did not have any significant influence, it interacted favourably with K and pruning levels. Higher doses of N and K (N_2K_1) among different NK combinations and higher dose of N with heavy pruning (N_2H) resulted in greater bud length and bud diameter. Because the bud length and bud diameter were influenced by N_2 and K_1

both at their highest levels, indicating that further increases either in N or K level would enhance these parameters further. This may be due to fewer shoots competing for the nutrients and also adequate supply favouring better development of buds.

5.6.2 Number of petals per flower

Number of petals per flower is also a quality attribute of a flower. Too many petals per flower is reported to be an undesirable character (Malik, 1968). In the present study, number of petals per flower was not influenced by nitrogen levels, but were influenced by potassium and pruning levels in both the seasons. Petal number increased with an increase in potassium levels, which is in accordance with the findings of Johansson (1978) with Parel Van Aalsameer roses. Among pruning levels, heavy pruning produced the maximum number of flower petals in both the seasons, similar results were recorded by Appanna (1976).

Number of petals per flower was significantly influenced by NK interactions. The maximum number of petals was recorded with higher levels of N and K (16 g and 8 g of N and K/plant). Similar results were obtained by Johansson (1978). But number of petals per flower also seems to be variety specific with a small range. All these treatment combinations increased the petal number within that specific range.

5.7 Foliar N, P and K contents

The plant analysis is one of the methods by which nutritional requirement of crops may be determined. It is sensitive and convenient method for understanding the nutritional requirements. Significant increase in N, P and K were observed during both the seasons. In the present study composition of N, P and K increased with increasing levels of N and K. Similar results were reported by Jayaprasad (1976), Young *et al*. (1978), Armitage and Tsujita (1979), Woodson and Boodley (1982a and 1982). Heavy pruning recorded the maximum N and K contents followed by medium pruning which is in accordance with the findings of Appanna (1976). Among different interactions NK and N Pr. interacted favourably in influencing the foliar N and P content. Nitrogen alone did not have any significant influence on foliar nutrient contents. Addition of K or pruning levels might have triggered the N uptake and its foliar N accumulation. Among the various combinations, N and K at 16 and 8 g/plant promoted N P and K content. The maximum N and K contents recorded were 2.80 and 2.192 per cent respectively. But Bik (1970 and 1972) and Jayaprasad (1976) have suggested that a foliar N and K contents of 3.12 to 3.5 per cent and 2.05 to 2.30 per cent is optimum for better shoot length and other flower quality attributes. Perhaps, further increase in N might result in increased foliar N content and thus in better shoot length and fresh weight.

5.8 Vase life studies

5.8.1 Vase life of cut flowers (in days)

The use of preservative solution to promote the quality and prolong the life of cut flower has been known. The use of substances such as bactericide, sugars, mineral salts, respiratory inhibitors and antibiotics was met with varying degrees of success. The importance of kinetin in enhancing the vase life of cut flowers has been reported by so many workers (Mc Lean and Dedolph, 1962; Cywinska, 1978; Wang and Baker, 1979; and Nakamura et al., 1980).

Flowers from different levels of nutrients and different pruning levels of plants maintained in distilled water were used as control. Potassium significantly influenced the vase life of cut flowers especially when maintained in 1.0 ppm kinetin. This is in accordance with the findings of Kuo (1964) who observed an enhanced vase life after the harvest with potash application and with that of Maharana and Pradhan (1976) who also observed that vase life was longest with K alone or K in addition with P. Flowers from heavily pruned plants lasted long with both 0.5 ppm and 1.0 ppm kinetin over control flowers. In general, different pruning and nutrient levels and their combinations with kinetin gave very good vase life in both the seasons. Better water balance, higher fresh weight of cut flowers were maintained by kinetin. Kinetin 1.0 ppm was found to be more effective in increasing the vase life of cut roses without any detrimental effects. The vase life was increased from 3.62 to 7.53 days due to kinetin.

Kinetin seems to extend the life span of rose flowers because it is replacing the natural cytokinins which are normally supplied to the flower from the parent plant and shows that kinetin, a synthetic compound increases the life span of cut flowers. The delay in senescence as a result of BA treatment was found to be accompanied by an inhibition of respiration rate (MccLean and Dedolph, 1962). The increased longevity of cytokinin treated flowers might be the result of many different physiological effects of kinetin on the flower tissues and possible change in ABA contents and its implications in cut rose senescence cannot be over-ruled. They operate by maintaining membrane permeabilities, water balance, protein and nucleic acid metabolism. The presence of optimum concentrations of cytokinin may also enhance longevity of flowers by reducing their ethylene production and responsiveness. Research with rose flowers suggest that cytokinin play a role in natural senescence (Mayak and Halevy, 1970 and Kende and Baumgartner, 1974). Excision of flowers may also be reduced by 'antisenescence' factors such as kinetin (Kende, 1965). Kinetin also prevented fading of petals, thereby further extending the vase life and asthetic value of cut roses.

These investigations show that by manipulating the levels of N, K and pruning levels flowering shoot length and weight can be increased. The number of days required for flowering and the number of blind shoots by manipulating N, K and pruning levels. The total number of flowers and of marketable quality can also be altered by nutrients and pruning. Flowers thus obtained with longer shoot length, higher fresh weight and of good quality had a longer vase life when held in kinetin.

SUMMARY

CHAPTER VI

SUMMARY

Experiments were carried out to study the influence of different levels of nitrogen, potassium, pruning and their interactions on growth, flowering and vase life of rose cv. Super Star during 1984-85 at the Horticultural Research Station, Gandhi Krishi Vignana Kendra, University of Agricultural Sciences, Bangalore. The salient findings of the investigations are summarised below:

All the growth attributes studied were influenced by nitrogen potassium and pruning levels. Higher dose of nitrogen 16 g/plant delayed flowering and potassium at higher dose (8 g/plant) advanced flowering. Light pruning resulted in advanced flowering whereas heavy pruning delayed the time taken for first flowering. Nitrogen (16 g/plant) in combination with potassium (8 g/plant) recorded minimum number of days taken for flowering compared to other interactions.

Flowering shoot length and fresh weight of flowering shoots were enhanced due to nutrients and pruning levels. Flowering shoot length and fresh weight of flowering shoots increased with nitrogen, potassium levels as well as due to combination involving 16 g of N, 8 g of K and with heavy pruning.

Number of blind shoots per plant was positively influenced by potassium and pruning levels. Least number of blind shoots was recorded with the individual effects of K at 8 g/plant and with light pruning. Interaction effect of N at 16 g/plant and K at 8 g/plant recorded the maximum number of blind shoots per plant in both the seasons.

Number of marketable and unmarketable flowers per plant were influenced by nitrogen, potassium and pruning levels. Flower yield per plant was highest with the individual effects of 16 g N/plant, K at 8 g/plant and with light pruning. Controls that did not receive any nitrogen and potassium and left unpruned recorded the maximum number of unmarketable flowers per plant.

Foliar N, P and K contents increased with the increasing levels of soil application of nitrogen and potassium. Maximum shoot length, fresh weight of flowering shoot and flower yield were obtained with leaf N and K contents of 2.80 and 2.192 per cent respectively.

Flower quality attributes such as bud diameter, bud length, neck length and number of petals per plant were increased with increasing levels of nitrogen and potassium. Maximum flower quality was recorded with N at 16 g, K at 8 g/plant with heavy pruning. Interaction effects of higher nitrogen and potassium recorded the maximum flower quality attributes during both the seasons.

Vase life of cut rose flowers was improved due to all levels of potassium and pruning. In the studies to improve the vase life with nutrition and pruning levels, the vase life of cut rose increased with potassium at 8 g/ plant and heavy pruning when held with 1.0 ppm kinetin. Interaction of higher dose N at 16 g and K at 8 g/plant recorded the maximum vase life (days) with 1.0 ppm kinetin in both the seasons.

Based on the results obtained from the present study, application of 16 g of nitrogen and 16 g of phosphorus and 8 g of potassium per plant with light pruning for higher yield and good quality flower in rose may be recommended.

Application of 16 g of N and 8 g of K per plant with heavy pruning improves the quality parameters such as bud length, bud diameter, neck length and number of petals per flower.

Vase life of cut roses was improved with the application of nutrients and by pruning but can be further increased by 4 to 5 days by keeping the cut flowers in kinetin 0.5 and 1.0 ppm.

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CHAPTER VII

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*Originals not seen

APPENDIX

APPENDIX-I

METEOROLOGICAL DATA

Monthly means of temperature, sunshine hours and relative humidity from 5/84 to 5/85 during the crop period

Month/Year	Temperature (°C)	Sunshine hours	Relative humidity
5/84	27.80	9.4	55.00
6/84	24.00	5.9	68.00
7/84	23.00	4.4	72.00
8/84	22.95	6.9	71.00
9/84	22.95	6.5	71.00
10/84	22.45	6.5	71.00
11/84	21.05	7.3	61.00
12/84	19.75	8.9	57.00
1/85	20.95	8.5	63.00
2/85	21.35	9.7	47.00
3/85	25.40	10.0	47.50
4/85	27.40	9.5	55.50
5/85	27.20	9.5	54.00