# EFFECT OF SEASON AND POSITION OF BUD IN BUDDING OF ROSE

BY

**ANITHA, I**

THESIS
submitted in partial fulfilment of the requirement
for the degree
**MASTER OF SCIENCE IN HORTICULTURE**
Faculty of Agriculture
Kerala Agricultural University

DEPARTMENT OF HORTICULTURE
COLLEGE OF AGRICULTURE
VELLAYANI, TRIVANDRUM

1989

## DECLARATION

I hereby declare that this thesis entitled "Effect of season and position of bud in budding of rose" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship, or other similar title, of any other University or Society.

Vellayani,
12-12-89

Anitha I.
ANITHA, I.

## CERTIFICATE

Certified that this thesis, entitled "Effect of season and position of bud in budding of rose" is a record of research work done independently by Kum. ANITHA, I under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

12/12

Dr. S. RAMACHANDRAN NAIR
(Chairman, Advisory Committee)
Professor and Head
Department of Horticulture

College of Agriculture,
Vellayani, 12. 12. 1989

APPROVED BY:

CHAIRMAN:

Dr. S. Ramachandran Nair,
Professor and Head,
Department of Horticulture,
College of Agriculture,
Vellayani.

28.4.90

MEMBERS:

Dr. N. Mohanakumaran,
Associate Director,
NARP (Southern Region),
Kerala Agricultural University,
College of Agriculture, Vellayani.

28/4/90

Dr. N. Krishnan Nair,
Professor and Head,
Department of Agricultural Botany,
College of Agriculture, Vellayani.

28/4/90

Dr. (Mrs.) P. Saraswathi,
Associate Professor,
Department of Agricultural Statistics,
College of Agriculture, Vellayani.

EXTERNAL EXAMINER .. 28/04/90
(J.V. NARAYANA GOWDA

## ACKNOWLEDGEMENT

I wish to express my heartfelt gratitude and indebtness to :-

- Dr. S. Ramachandran Nair, Professor and Head, Department of Horticulture and the Chairman of my Advisory Committee for suggesting the topic, valuable guidance and constant encouragement during the course of investigations as well as during the preparation of the thesis.
- Dr. N. Mohanakumaran, Associate Director, NARP (SR), for his healthy criticism and constructive suggestions in improving the quality of this thesis work.
- Dr. N. Krishnan Nair, Professor and Head, Department of Agricultural Botany, Dr. (Mrs.) P. Saraswathy, Associate Professor, Department of Agricultural Statistics, for their valuable guidance and encouragement at all stages of this study and in the preparation of the thesis.
- Dr. K. Vasanthakumar, Associate Professor, Department of Horticulture, Sri. R. Balakrishnan Asan, Assistant Professor (Stat.), NARP (SR) for their sincere help in the preparation of the thesis.
- All the staff members, Department of Horticulture, for their valuable co-operation and encouragement during the course of research work.

- Sri. P. Rajendran, Assistant Professor, Department of Soil Science and Agricultural Chemistry for his advice and help during the chemical assay.
- Sri. C.E. Ajithkumar, Junior Programmer, for his help in the statistical analysis of the data.
- Labourers in the field for their manual efforts.
- Friends for their understanding, love, help and encouragement showered on me.
- My parents, brothers and sister Usha, for their valuable help during the course of this study.
- Kerala Agricultural University for the fellowship made available to me.
- Sri. S. Raghavan who showed much patience and interest in typing this manuscript correctly and finally,
- Sri. C. Madhusoodanan Nair, Duplicator Operator for his sincere assistance.

Vellayani ANITHA, I.

CONTENTS

## LIST OF TABLES

## LIST OF FIGURES

# LIST OF APPENDICES

# INTRODUCTION

# INTRODUCTION

Rose, the 'Queen of flowers' is probably the most important flower crop in the world. Inspite of this, the research on roses lags behind that on other major flower crops such as chrysanthemum and carnations, probably because of the experimental difficulties encountered.

Down through the centuries long ago, the written word, the rose of legend has cast its spell, influencing man and history. Because, it was known to man from his first days, the rose quite naturally became a part of ceremonial life. No other flower has appeared more frequently in literature and few subjects have received as much attention.

The hybrid tea roses, especially the bicolour and those bearing bloom of orange and apricot shades may take considerably longer time to root from cuttings and are best budded on to rootstocks. Budding is more certain of success, though the use of modern hormone preparations now makes it easy to root cuttings (Genders, 1965). One great advantage of budding is that a strong flowering plant could be established in a period slightly exceeding a year, which is about half the period taken when propagated from cuttings.

Generally 'T' budding or shield budding is the method adopted for roses.

Although some research works have been conducted on propagation aspects of rose in India, the best season for propagation by budding, particularly the seasons specific to different locations have not been worked out. In commercial practice eventhough rose budding is done throughout the year by nursery men and others, there are certain specific periods of the year during which maximum percentage of success could be obtained. The success varies from locality to locality. The suitable season for budding should, therefore, be sorted out for each region. The time and the season are not the only factors controlling the success of budding. The position of bud has profound influence on the bud take. For the selection of the best bud, nursery men have their own choice. Although several studies were conducted on the "position effect" of buds in pruning, anatomical works and *in vitro* culture (Zieslin *et al*., 1976 and Zamski *et al*., 1985), the studies conducted on budding and successive growth characters of scion are rather meagre in spite of the importance, which are otherwise important as far as commercial multiplication of rose is concerned.

The correct stage of bud coupled with optimum environmental conditions and nutrient status of the plants will bring about higher percentage of success in budding.

The present study, undertaken to achieve these objectives, was conducted at the Department of Horticulture, College of Agriculture, Vellayani during 1987. Unlike in the case of fruit trees, very little is known about the specific beneficial effects of rose rootstocks. Research conducted till date has focused on the practical evaluation of various rootstocks. The rootstock recommended for South Indian conditions 'Briar' (*Rosa multiflora*), has been selected for the study. Three scion varieties and five bud positions of scion were selected for throwing light on position effect of varieties. Eventhough past work on the effect of nutrient status, or carbohydrate and nitrogen content of the scion buds and rootstocks on the success of budding has been limited an attempt has been made to unravel the information.

# REVIEW OF LITERATURE

# REVIEW OF LITERATURE

Rose is an important flower crop which is grown commercially in several parts of the Country. Much work has been done on improvement, propagation and management of the crop. But very little work has been done on this crop with regard to the suitability of season for budding in the different localities and on the position effect of the buds on the success. The available literature on propagation aspects of rose and allied crops related to this study, has been reviewed here.

## Rootstocks

The choice of rootstock is an important aspect in the propagation of roses. Swarup (1967) reported that in South and East India, *Rosa multiflora* is generally used as the rootstock for budding of rose varieties.

Singh (1972) found that, bud take was better on *Rosa bourboniana* and *Rosa multiflora* than on *Rosa moschata*. Bud mortality and bud break were both affected by rootstock, scion, time of budding and their interactions. Lundstad (1974) also reported similar results. The cultivars he experimented, flowered prolifically on *Rosa multiflora* cv Japonica rootstocks.

Pandey and Sharma (1976) found *Rosa multiflora* Thunb (a form of 'Briar') to be superior in respect of bud take, bud sprout, plant vigour and flower bud production to *R. bourboniana* Desp. (Edward, non flowering type) and *R. indica* Lour. var. *Odorata* Audr. rootstocks.

Mukhopadhyay and Banicar (1982) revealed that roses budded on *R. multiflora* rootstocks gave slightly better results than those on *Rosa indica* with regard to shoot length, flower number, plant spread and export quality flowers for June and November pruned plants. Lal and Seth (1984) confirmed that *Rosa multiflora*, is a good rootstock for budding, which recorded 96 per cent bud take, for cv. Superstar. On other species, the cultivar recorded 76 to 92 per cent take.

Studies on propagation

Methods

Generally, roses are propagated by 'T' budding or shield budding as established by Wells (1955), Mahlstede (1957), Miller and Synge (1971), Nanjan *et al*., (1971) and Pal (1972). Wild roses can be propagated by planting the cuttings. Rojas in 1972 recommended that for rapid propagation of rose bushes, easily rooting cuttings of *Rosa multiflora* japonica were T budded or shield budded with various rose cultivars and rooted in polythene bags either outside or inside the greenhouse. Moss and Dalgleish (1982) recommended propagation of *Rosa multiflora* rootstock cuttings in a medium consisting of 50:50 peat sand or perlite-peat moss mixture under mist. Rooted cuttings were potted individually, T-budded and grown in the greenhouse for producing saleable bushes within a period of five months.

Early and continuous removal of rootstock growth after budding (snagging) stimulated early scion growth in autumn and the following spring whereas later snagging induced more growth in early summer. Reduction of rootstock length produced good scion growth; but not so much as with its complete removal (Estcout, 1974). Fann *et al.*, (1983) found that the rootstock above the graft must be pruned to overcome the inhibition of scion apices. The axillary buds in the rootstocks are necessary for establishment of adequate initial root system; but they should be removed early in the growth cycle to maximise scion development and to reduce the time for production.

Effect of time on propagation

The success of bud take and sprouting of the bud are largely governed by the time of budding. Genders (1965) reported that the budding on the rootstocks commence by the middle of July and may continue almost till the end of September. The correct time of budding will depend mostly upon the weather conditions. If a period of dry weather is experienced, successful budding is difficult. Pal (1972) reported that the best time for budding in and around Delhi is from the end of October to early March. In places with a mild climate as in Bangalore, year-round budding can be practiced. In other areas it is better to follow the local practice.

Maiti (1974) reported 80 to 93 per cent success when budding was done at weekly intervals, during December-January. However, the percentage of success with floribunda scions decreased with later planting dates. An increase was noted with hybrid tea roses.

Nanjan and Kumar (1983) conducted a two-year trial at monthly intervals with 16 cultivars budded by two methods (T-budding and chip budding) between January and December at Yercaud. The mean percentage bud take was over 80 from January to June. Thereafter, the success declined to 52 to 55 per cent in August and September and then, the take rose again;

Several such studies have been reported in related crops.

Based on his studies with stone fruit trees (cherry, almond, cherry plum, apricot and peach) and pome fruit trees (apple), Syrbu (1975) recommended the optimal time for budding to be not later than early August and not later than mid-August, respectively. Galkina (1979) observed that in apples, bench grafting in November gave 51.8 per cent good quality grafts, but grafting in January and March gave only 41 and 21 per cent, respectively. For November grafts, the buds were in a dormant state which took longer time to unite (21-25 days).

Ugolik (1981) found that in sour cherry the success of budding was greatest (81.4 per cent) for plants budded on 11$^{th}$ July and it decreased to 65.5 and 41.2 per cent for trees budded on 24$^{th}$ July and 8$^{th}$ August respectively. Aswathi _et al._, (1982) reported highest success (66.6 to 83.3 per cent) for walnut on first June, the plant survival being 95 to 100 per cent. For peach, budding from late June to early August gave 69 to 82 per cent success whereas budding after August 10$^{th}$ gave only 48 to 53 per cent [Shcherbakova and Maslova, 1982]. The best results in pecan nuts were obtained (90 per cent), followed by side grafting (80 per cent) in August (Misra 1985).

The ideal months for veneer grafting of mango in Tarai was found to be June to August by Ram and Bist (1982) during which period 100 per cent take was observed. The highest mean success in soft wood grafting of cashew was obtained in August (83.66%) and April (83%) and the lowest (22.33%), in December (Sawke et al., 1985). Inverted T-budding of Kinnow mandarin on Citrus jambhiri seedling rootstocks during May gave the highest success of 90 per cent (Joolka, 1986).

Effect of environmental factors

Shippy (1930) conducted detailed studies on the influence of environment on callusing of apple cuttings and grafts. The complete range of temperature permitting the formation of callus from apple cuttings and grafts was found to lie between 0° and 40°C. At 3-5°C only a small amount of callus developed during a period of several months. Between 5°C and 32°C, the rate of callus formation increased and the time elapsing before attainment of final volume decreased with rise in temperature. At temperatures above 32°C, injury usually resulted and at 40°C death of the tissues, accompanied by mould formation, always occurred within the first few days. Callusing was accelerated or retarded according to the degree and duration of the temperature. Air moisture below saturation was generally found to be inhibiting in their effect on callus formation, since below this point desiccation of the tissues occurred. A film of water enclosing the cutting, appeared to provide the most favourable conditions for bringing about uniform callusing. Desiccation of callus tissue was accelerated by increase in temperature and decrease in humidity. Proper aeration was found to be important for callusing. He found that these are true for Rosa spp. also.

Lundstad (1972) studied the effect of different climatic conditions (in the open, in a Phytotron or in a growth room) on the budding of roses on Rosa multiflora and Rosa canina var. Schmids Ideal. He found that the use of plastic tunnels over the plants in the open for a week before and four weeks after the budding significantly increased the number of budded plants. In Phytotron, alterations in the temperature after budding resulted in reduced growth and bud take on both the rootstocks compared with the controls at a constant temperature. Two levels of relative humidity, 40 and 70 per cent, did not show any difference in plant height, neck diameter or shoot length; but bud take was less with *Rosa multiflora* at the lower relative humidity. In a growing room with additional illumination, growth was slight and almost no buds united at 6°C, whereas at 18°C, the percentage take was excellent.

Moe (1972) studied the interrelated effects of temperature, day length and light intensity on the growth and flowering in roses, and found that increasing the day length inhibited bud break while high temperature hastened it. Ahijer (1973) pointed out that for apple highest number of one year old trees was obtained with early budding (end of July, August) when the sum of active temperatures (above 10°C) during the 29-30 days after budding was 590-758°.

Korobov (1976) budded roses from 10th July to 3rd September at 10 days interval and the material was anatomically examined at interval during the autumn. He observed that temperature between 16°C and 25°C was optimum for union in garden roses.

Buds of the rose cv. Sugandha were budded on *Rosa indica* rootstocks in January and the plants were kept under redlight, clear white light, diffused sunlight or direct sunlight. The quickest take (8.3 days) and the highest take (100%) were obtained under direct sunlight. Bud losses under diffused sunlight, redlight and white light were 25, 50 and 70 per cent, respectively (Maharana and Singh, 1978).

Singh *et al.* (1979) reported significant positive correlation of methods, especially budding and inarching, with minimum temperature and rainfall and found that the success was retarded where there was departure of any of the four meteorological indices (maximum temperature, minimum temperature, relative humidity, rainfall) from the ideal combination. Savin (1980) conducted experiments in apple and sour cherries and showed that in apples, the union between the graft components took place both at low (5°C) and high (30°C) temperatures; but the best results were obtained by stratifying the grafts at 25°C to 30°C during the first 4-6 days followed by 8-10 days at 5° to 10°C. In sour cherries, union was best at 25°C to 30°C and no union occurred at temperatures lower than 20°C.

Khosh-Khui and Sink (1982) conducted micropropagation studies on the leaf and stem explants of *Rosa manetti* and *Rosa hybrida* cv. Tropicana on different medias like Murashige and Skoog (MS), Schenk and Hildebrandt (SH) or Gamberg and wetter (1-$B_5$C). The explants were then cultured in darkness or light at 26°C. Friable fast growing callus was evident after three weeks for both species. Callus initiation occurred faster in darkness than in light, but deteriorated when continuously subcultured in the dark.

Effect of position of bud

Genders (1965) found that the best buds were those at the middle of the stem, being in just the right condition. Those at the top of the stem were too advanced while those at the base were not sufficiently mature. Lundstad (1965) also reported, after studying the effect of source of budwood in roses, that mature buds appeared to give better success. Statons (1969) observed that the use of buds of different degrees of ripeness had no clear effect on the percentage of successful unions; but mature buds appeared to give the best results. Rupperecht (1971) reported that a careful selection of scion wood from mature vigorous mother plants and of buds themselves ensured better success in budding of roses.

Zieslin and Co-workers in 1976 studied the components of axillary bud inhibition in rose plants through a series of four different experiments. In the first experiment Zieslin and Hálevy (1976), various levels of pruning were applied to the rose cv. Baccara under glass and removal of uppermost bud was found to enhance sprouting of the buds immediately below.

In a second experiment (Zieslin et al. 1976) the effect of bud position on the degree of inhibition was studied. They found that the lateral buds at different positions along the shoots (2nd, 3rd, 4th, 6th or 8th bud from the bottom up) differed in their ability to sprout, those lowest on the branch being the most inhibited. The degree of inhibition differed between the three cultivars investigated (Baccara, Sonia and Belinda which produced long, medium-long and short flowering shoots, respectively.) The response was similar in the cultivars.

In the third experiment, Zieslin and Halevy (1978) studied the effect of stem orientation and bud position on the stem on the success rate, by budding in glasshouse rose cv. Baccara. Laying the stems horizontally resulted in the sprouting along the stem of all the upward oriented buds and inhibition of the downward oriented buds. Shoot growth was intermittent, a long shoot was succeeded by a short shoot. Upper buds (which were uninhibited *in situ*) were inhibited when budded on the basal part of the stem. On the other hand, basal buds retained part of their inhibition when they were budded on the upper part of the stem.

In the fourth experiment, Zieslin *et al.* (1978) studied the inhibitory activity of plant extracts. The stem extracts of the rose, cv. Baccara inhibited sprouting when applied to the uppermost buds of rose shoots and also prevented elongation of wheat coleoptiles in bioassay. The inhibitory activity was proportional to the amount of extracted tissue. The level of endogenous abscissic acid (ABA) was found to be higher in the basal than in the upper part of the rose stem.

VanStaden in 1982 studied the transport of zeatin from the mature leaves, after shoot decapitation. He found that after shoot decapitation, the cytokinins were transported from the subtending leaves towards their axillary buds in the upper part of the shoots. According to him, this transport augmented the cytokinins already present in the buds and apparently accelerated their growth.

Zamski *et al.* (1985) conducted detailed studies on the comparative morphology and anatomy of axillary buds on a rose shoot. The lateral buds of rose plants (of the greenhouse cv. Baccara) were separated into three groups according to their position in the axils of different leaves along the shoot. The first group of buds, in the axils of the uppermost leaves with one or three leaflets beneath the terminal flower, were sylleptic ie. they grew continuously from their initiation without periods of inhibition. The second group of buds in the axils of the lower leaves were proleptic in that they underwent a period of inhibition at a very early stage, thus developing fewer and smaller amounts of parenchyma cells in the pith. The buds located between groups, 1 and 2 in the axils of seven leaflet leaves and upper five leaflets were also proleptic; but leaf primordia continued to form during inhibition. Buds in the axils of the upper and the lower five-leaflet leaves had the same growth potential.. However, there was one week growth delay of the lower buds, indicating a stronger inhibition state of the bud. The leaves of the lower half of the shoot were present as primordia in the mother bud which produced the shoot. This section contained the inhibited proleptic buds, suggesting that the lower axillary buds were influenced, on formation, by the physiological conditions prevailing in the leaf primordia axils before the bud sprouted.

In the *in vitro* propagation studies of "Golden Times" roses, Mederos and Rodriguez (1987) found that nodes taken from the middle of a shoot gave better results than nodes from the apical or basal parts of the shoot.

In an allied crop apple, Dayton (1976) observed the importance of scion selection for grafting. According to him, the new growth from the uppermost bud on each of the distal graft sticks did not start growth until 13 days after grafting. Sevin (1976) found that in the red leaved rootstock cv. Paradise and the hybrids 57 to 490 and 57 to 146, take was always better when the grafting material was from the basal part of the shoot. The success was poor when the grafting material was obtained from the shoot tips and this was attributed to their lower starch and higher sugar and water content.

Biometrical characters of roses

Haenchen (1967) observed that the growth of the budded scions was affected by the variety, rootstock, the skill of the budder etc. With *Rosa multiflora* rootstocks, there was a correlation between the losses occurring during the period between budding and lifting of the bushes for sale and the root collar diameter of the rootstocks at planting. Pal (1972) pointed out that if the leafstalk or petiole drops off cleanly next to the bud, this is a good indication that bud has united, especially if the bark piece retains its green colour and the bud stays plump. Rojas (1972) studied the propagation of bush roses by budding several cultivars on *Rosa multiflora* rootstock. He found that the first flower could be expected within eight weeks of budding.

Maiti (1974) observed that the plant height and branch number increased with later budding dates when budding was carried out on briar rootstocks at weekly intervals during December and January.

Eccher and Mignani (1975) conducted a statistical study of various parameters measured on 320 plants cvs. Carla and Baccara. The studies showed that the cross sectional area of the main branches, 2.0 cm from the point of insertion, was directly correlated with the number of leaves and the total length of the main branches. According to them, this provided a good index of the vegetative development of the plant.

The relationship between growth and juvenile period (number of days from seed germination to appearance of a flower bud) was studied by de Vries (1976) for three years in several seedlings bred for glasshouse cut flowers. The average length of the juvenile period ranged from 32.9 to 24.8 days although some of the seedlings did not produce flower buds until 54 days after sowing. Compared to the plants with a long juvenile period, those with a short juvenile period had shorter shoots (both when the apical flower bud first appeared and at flowering) were earlier in flowering, taller at a given date and yielded about three times more cut flowers in six months than the former.

Cockshull and Horridge (1977) found that although a requirement for a minimum number of leaves with leaflet is needed before flowering total number of leaf primordia formed differed, and is simply the passage of time, while some metabolic change occurs within the shoot. de Vries and Smeets (1978) found that with increasing irradiance the juvenile period of the seedlings shortened, the plants were taller at bud formation, first flowering and flower bud abortion, and the leafarea and the number of petals greater. de Vries *et al.*, (1980) reported that significant differences occurred among 30 hybrid tea populations only in the number of days to first flower or shoot length at first flower. The two characteristics were not influenced by genotype temperature interactions. Several populations combined short number of days to first flower with long shoot.

Haenchen (1981) tabulated the average plant height and diameter of 53 hybrid tea rose cultivars. At the first flowering in June, the height of the hybrid tea roses ranged from 42 cm to 98 cm. Growth between the two flowering peaks ranged from 5 to 48 cm for hybrid tea plants the average being 19.2 cm. Plant diameter ranged between 30 and 63 cm. The height diameter ratio was 1.0:0.5 to 1.0:1.1.

de Vries and Dubois (1983) conducted studies in three successive years by bench grafting different batches of hybrid tea rose seedlings selected for cut rose purposes onto *Rosa canina* in greenhouse. The early sprouting clones produced both earlier and more basal bottom breaks (shoots emerging from the base of the main shoot than the late sprouting clones. Since lateral shoots from bottom breaks are marketable, this resulted in a higher number of shoots harvested in the early varieties. Basal bottom breaks emerged over a 22-week period, starting approximately 14 weeks after sprouting of the scion. The possible use of the time of sprouting of the scion as a parameter for assessing rootstock vigour has been advocated.

de Vries and Dubois (1983) in another study found that the number of bottom breaks was more in grafted seedlings than in ownrooted seedlings. In these studies, they confirmed the significant positive correlation between the time of sprouting of the scion in the nursery, the time of bottom break formation, the number of bottom breaks and the number of harvested shoots of clones.

de Vries and Dubois (1984) found that a highly significant correlation existed between the girth at the graft union and the root weight or the number of bottom breaks. Plant vigour in clones was mainly determined by the scion. Rootstock-scion relations in rose were similar to those in apples and cherries. From the studies, they pointed out the importance of equilibrium between aerial and underground parts in composite plants, and recommended breeding of rose rootstocks that promote scion vigour under various glass-house conditions.

Haenchen (1935) in a comparative study on the flowering behaviour of outdoor rose cultivars propagated by cuttings and grafting, found that grafted plants started to flower 0.48 days earlier. Plants from cuttings had a 1.91-week shorter flowering period and the flower production was only 74.05 per cent of that of the grafted plants.

Dayton (1976), who conducted scion selection studies in apple. He found that the subsequent growth of the buds on the distal graft sticks were more vigorous and by the end of the season their average length was 54 cm compared with 37 cm for those on proximal graft sticks.

Nutrient status with reference to carbohydrate and nitrogen

Tukey and Green (1935) studied the gradient composition of rose shoots from tip to base. They observed that shoots of Rosa multiflora thurnb, 100 cm in length, when cut into 10 cm sections, showed a gradient of increasing moisture, ash and total nitrogen content from base to tip, and a gradient of decreasing starch content. Sections of rose stem were reported with as much as 12.36 per cent starch and only 0.407 per cent nitrogen on the drybasis; on fresh weight basis, with as much as 2.4 per cent total nitrogen and only 4.71 per cent starch.

Bik (1970) reported that leaf analysis gave a better indication of the flower yield. The optimum leaf content of nitrogen appeared to be 3.8 per cent for good growth of roses.

In Edward rose, Akbar (1979) observed highest leaf nitrogen in April-May (1.86 - 3.36 per cent). The leaf nitrogen content started decreasing from June, with an increase from September. He recorded a carbohydrate content ranging from 6.68 to 8.17 per cent which showed the gradual increase from April-May (7.55%) to June-July (8.17%). In August-September the carbohydrate content dropped to 7.66 per cent. A rise to 7.75 per cent was observed in October. The lowest value (6.68%) was recorded in February-March. From these, he estimated the leaf C/N ratio which ranged from 3.03 to 3.86 per cent (February-March). The C/N ratio during February-March was superior to that during the other months. During April-May, there was a sudden decline of leaf C/N ratio (2.82) which began to increase in June-July (3.74) ie. at peak flowering period.

Johansson (1979) studied the effect of season on leaf composition of the flowering shoots in different greenhouse rose cultivars. For nitrogen, the quantity was lower in the middle of summer and higher in the spring and autumn.

Mor and Halevy (1979) examined the movement of $^{14}C$ assimilates from young and mature leaves to young rose shoots (Rosa hybrida cv. Marimba). After bud break the young shoot, especially its tip was found to depend for its supply of assimilates mainly on the mature foliage. At this stage, the young leaves were powerful sinks and retained 97 per cent of their own photosynthates.

Jacobs et al. (1980) conducted studies on the factors affecting $^{14}C$ sucrose uptake by single node explants of rose flower stems. They found that initially the uppermost buds contained significantly more $^{14}C$ per unit weight than the lower ones (this disappeared after 72 h); but in stems, $^{14}C$ concentration was higher in the lower region. Accumulation of $^{14}C$ metabolites was found to be directly related to the deviation from the direction of gravity. Three per cent of the assimilates was found to move mainly to roots. At a later stage, just after the appearance of the flower bud, most of the leaves on the shoot became a source. The upper leaves were found to supply assimilates to the flower bud and to the upper part of the stem. The $^{14}C$ assimilates from the lower leaves moved in two directions, the larger part being directed downwards.

In other crops several studies have been conducted on the nutrient content of the leaves. In guava, Chadha *et al.* (1973) reported that the leaf nitrogen content in the non fruiting shoots was more than in the fruiting shoots. Significant differences were observed between the leaf position with respect to nitrogen content which was influenced both by season and by fruitfulness. Pathak and Pandey (1978) showed that leaf nitrogen increased from the base to the tip of the shoots in mango cv. Dashehari.

Button (1978) in a study on citrus ovular callus, found that sucrose promoted callus growth to the greatest extent followed by glucose, fructose, lactose, galactose, starch, maltose and sorbose in the order. The callus showed a definite preference for sucrose over its constituent monosaccharides. Kaplankiran et al.(1985) found that in citrus, reducing sugar, sucrose and total sugar content in the scion and rootstock trunk cortices were higher in winter (January) than in summer (June).

Khera et al. (1981) analysed the basal, central and apical leaves from the current season non-bearing shoots of the peach cv. Sharbati at fortnightly intervals between early April and late September. The least variations in nutrient levels were observed in the central leaves, between early June and late August. Sandhu and Singh (1983) analysed the seasonal changes in the levels of metabolites during dormancy in sub-tropical peach cv. Sharbati. Total carbohydrates, total nitrogen and the C:N ratio were determined in the shoots during three dormancy phases.

# MATERIALS AND METHODS

# MATERIALS AND METHODS

The present investigation was carried out to study the effect of season and position of bud on the bud take in budding of rose. Three varieties, viz., Ambassador, Pink Panther and Princess were used as scion and briar rose (*Rosa multiflora*), as the rootstock. The experiment was conducted in the Department of Horticulture, College of Agriculture, Vellayani during 1987.

## Pot mixture

A standard pot mixture consisting of 1:1:1 parts by volume of riversand, redloam and dried powdered farm yard manure was used for growing the plants.

## Planting

Cuttings of *Rosa multiflora*, 15 cm long, of uniform age and thickness were planted in 20 cm earthern pots. Plants were irrigated daily. Three grams of urea was also applied at weekly intervals to make the plants grow vigorous.

Mother plants of the three scion varieties were maintained by regular watering, manuring, pesticide application, pruning etc. to obtain the required number of buds.

Experimental design

The experiment was laid out as a factorial experiment in Completely Randomised Design, with three varieties and five positions of bud (position of the bud starting from the flower downwards in each scion shoot). Thus there were a total of fifteen treatments, replicated thrice. The number of plants per plot per replication was one.

Treatments

1. Rootstock budded with first bud ($P_1$)
below a flower from Ambassador ($V_1$)
2. ,, ,, ,, second bud ($P_2$)
below a flower from Ambassador ($V_1$)
3. ,, ,, ,, third bud ($P_3$)
below a flower from Ambassador ($V_1$)
4. ,, ,, ,, fourth bud ($P_4$)
below a flower from Ambassador ($V_1$)
5. ,, ,, ,, fifth bud ($P_5$)
below a flower from Ambassador ($V_1$)
6. Rootstock budded with first bud ($P_1$)
below a flower from Pink Panther ($V_2$)
7. ,, ,, ,, second bud ($P_2$)
below a flower from Pink Panther ($V_2$)

8. Rootstock budded with third bud ($P_3$)
below a flower from Pink Panther ($V_2$)

9. ,, ,, ,, fourth bud ($P_4$)
below a flower from Pink Panther ($V_2$)

10. ,, ,, ,, fifth bud ($P_5$)
below a flower from Pink Panther ($V_2$)

11. Rootstock budded with first bud ($P_1$)
below a flower from Princess ($V_3$)

12. ,, ,, with second bud ($P_2$)
below a flower from Princess ($V_3$)

13. ,, ,, with third bud ($P_3$)
below a flower from Princess ($V_3$)

14. ,, ,, with fourth bud ($P_4$)
below a flower from Princess ($V_3$)

15. ,, ,, with fifth bud ($P_5$)
below a flower from Princess ($V_3$)

Budding

T-budding was done at fortnightly intervals over a period of one year starting from first January 1987 to 15$^{th}$ December 1987. Each time, 45 buddings were done and the budding operation was completed before forenoon of the first day of the fortnight, ie. every 1$^{st}$ and 15$^{th}$ of each month.

The combinations in which the buds were healthy, green and plump after two weeks of budding were reckoned as successful.

Aftercare

Suckers sprouting from the stock were removed regularly. The polythene strips covering the buds were removed three weeks after budding. The stock shoot above the bud union was removed leaving 2 cm above the union, after three weeks of budding.

Meteorological parameters

The data on meteorological parameters were collected daily from the meteorological observatory in the campus. From the daily mean data tabulated, fortnightly averages were computed for the parameters, viz., maximum temperature, minimum temperature (both day temperatures), rainfall, relative humidity and sunshine hours. These parameters were examined for their possible role in the success of budding. The data are given in Appendix I.

Observations

Morphological characters

Observations on the morphological characters were recorded from the date of budding till the second crop of flowering.

1. Vegetative characters before the appearance of first flower

a) Fall of petiole

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

b) Bud emergence

Number of days from budding to bud burst was recorded.

c) Appearance of first leaf

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

d) Leaves till the appearance of first flower bud

The number of leaves produced till the appearance of the first flower bud was noted.

e) Height of the scion

The height of the scion from the bud union to the first flower bud was recorded.

2. First flower characters

a) First flower bud

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

b) Size of the first flower

The diameter of the first flower across the middle was taken to indicate the size.

c) Petals in the first flower

The number of petals in the first flower of each budded plant was counted.

3. Subsequent growth and flowering characters

a) Subsequent shoots

The number of shoots produced after the first flowering was recorded.

b) Second crop flower bud production

The number of second crop of flower buds on the subsequent shoots was recorded.

c) Appearance of second crop flower buds

The number of days taken for the production of the second crop of flower buds from the date of budding was counted.

d) Petals in subsequent flowers

The number of petals in each flower of the second crop was counted and averaged.

e) Total height of the plant

The height of the plant from the soil level to the tip of the longest shoot after the second crop flowering was recorded.

Biochemical aspects

The study was also aimed at estimating the C/N ratio and its effect on the bud take. Leaf samples were analysed at the time of budding. From each variety, five leaf samples were collected at a time (i.e., for each position of bud). The leaf samples were also collected from the rootstock at the time of budding. They were analysed for N and CHO content and the C/N ratio computed.

1. Total nitrogen content

The method by Jackson (1973) was adopted. The plant samples were dried, powdered, 0.5 g quantities placed in a 100 ml conical flasks. Concentrated $H_2SO_4$ (10 ml) was added to each sample and digested. Heating was continued till the whole sample was digested and the content in each flask turned clear. After cooling, the digest was made upto 100 ml. 10 ml of this solution was then distilled, collecting the distillate in a conical flask containing 10 ml of 4 per cent boric acid. The boric acid was then back titrated with a standard 0.02. At NHCl the end point, the green colour changed to blue.

2. Total carbohydrate

The method described by Somogui (1953) was adopted. The dried and powdered material (100 mg) was hydrolysed with one ml of 2.5 N analar hydrochloric acid for two hours. The material was filtered, the filtrate neutrilised with a pinch of sodium carbonate and clarified with one ml of cadmium sulphate solution (26.2 g of cadmium sulphate in 132 ml of N sulphuric acid made up to 1000 ml) and one ml of 0.55 N sodium hydroxide solution. The volume was then made up to 100 ml and the same aliquot was used for estimation of total carbohydrate.

The neutralized and clarified digest (1.0 ml) was added to an equal volume of copper reagent and heated in a boiling waternath for 10 minutes. After cooling the mixture one ml of Nelson's arseno-molybdate reagent was added to dissolve completely the cuprous oxide formed. The solution was then made upto 50 ml and the intensity of the blue to bluish green colour was measured in Klett Summerson's photoelectric colorimeter using green filter No. 54 against a suitable blank. The data were arrived at by comparing with a standard curve drawn from various concentrations of glucose solution and expressed as percentage of carbohydrates.

Reagents

1. Copper reagents

(a) Sodium potassium tartarate (12.0 g) and anhydrous sodium carbonate (24.0 g) were dissolved in 250 ml of water — Solution (A)

(b) Copper sulphate (4.0 g) was dissolved in 40 ml of water — Solution (B)

(c) Solution (B) was added to solution (A). To this mixture, 16 g of sodium bicarbonate was added — Solution (C)

(d) Anhydrous sodium sulphate (180.0 g) was dissolved in 500 ml of hot water and boiled to expel the air — Solution (D)

(e) Solution (C) was added to solution (D) and made upto 1000 ml of stock solution

2. Nelson's arseno-molybdate reagent

Ammonium molybdate (25.0 g) was dissolved in 450 ml of distilled water followed by the addition of 21 ml of analar sulphuric acid. A solution of 3.0 g of sodium arsenate in 25 ml of water was added to this mixture and the reagent thus prepared was incubated at 37°C for 48 hours.

The C/N ratio was computed and the values are given in Appendix XV.

Statistical analysis

The data collected were subjected to analysis of variance for the particular design adopted (Panse and Sukhatme 1967).

I. Success in budding in different months

The data on budtake percentage with reference to the three varieties during the different fortnights of the year 1987 were analysed as follows.

Analysis of variation

| Source of variation | df |
|---|---|
| Between varieties | 2 |
| Between fortnights | 23 |
| Fortnights x varieties | 46 |
| Total | 71 |

The interaction of fortnights (period of budding) x varieties, was used as the experimental error for testing the effect of varieties and fortnights on bud take percentage.

II. Effect of environmental parameters on percentage budtake

The weather parameters were correlated with the mean budtake percentage of the three varieties from January 1987 to December 1987. The weather parameters in a fortnight were correlated with the data on mean bud take percentage during that fortnight (simultaneous or lag 0). In addition, the parameters during the succeeding fortnight (lag +1) and the preceding fortnight (lag -1) were correlated with the data on mean bud take percentage during a particular fortnight. Similarly, the factors during two fortnight before the budding and the data on mean bud take percentage during a particular fortnight were also correlated (lag -2).

Regression of bud take percentage on weather parameters was fitted to find out the dependence of the factors on bud take.

Path analysis (Wright, 1921) was also done with lag +1, lag 0, lag -1 and lag -2, to study the cause and effect relationship among a system of variables which will help to measure the direct influence along each separate path in such a system and to find the degree to which the variation of a given effect is determined by each particular cause.

III. Analysis of biometrical observations

The data collected for the whole period could not be analysed since some of the buds failed to take.

The complete data available for the fortnights starting from September 1st to October 15th were analysed in factorial CRD to find out the effect of period of budding varieties and positions of buds and their interactions on biometrical characters.

Analysis of variance

| Source | df |
|---|---|
| Between varieties | 2 |
| Between positions | 4 |
| Between fortnights | 2 |
| Variety x position | 8 |
| Variety x fortnights | 4 |
| Position x fortnights | 8 |
| Variety x position x fortnights | 16 |
| Total | 44 |

The second order interaction was used as the experimental error.

Correlations were also worked out to find the mutual relationship between the thirteen characters under study.

IV. C/N ratio

The estimated data on C/N ratio with reference to the three varieties during the different fortnights of the year 1987 were analysed as follows. The rootstock was common and had only one value for C/N ratio, as against five values for each scion, with respect to the bud positions. Hence, for easy comparison, the rootstock was considered as a variety and the C/N ratio of each scion variety taken as an average of the values for the five bud positions.

Analysis of variance

| Source of variation | df |
|---|---|
| Between varieties | 3 |
| Between fortnights | 23 |
| Fortnights x varieties | 69 |
| Total | 95 |

The effect of varieties and fortnights on C/N ratio was tested against their interaction.

To determine the effect of C/N ratio on bud take percentage, correlations were worked out between the C/N ratio of rootstock, C/N ratio of the three scion varieties and the bud take percentage of the three scion varieties.

The data on C/N ratio, percentage N and percentage CHO of the five bud positions, of the three scion varieties for the period September 1st to October 15th were analysed in factorial CRD to determine the effect of season, varieties, bud position and their interactions on C/N ratio, N percentage and CHO percentage.

Analysis of variance

| Source | df |
|---|---|
| Between varieties | 2 |
| Between positions | 4 |
| Between fortnights | 2 |
| Variety x position | 8 |
| Variety x fortnights | 4 |
| Position x fortnights | 8 |
| Variety x position x fortnights | 16 |
| Total | 44 |

# RESULTS

# RESULTS

The data on the success of budding of three scion varieties under study, namely, Ambassador ($V_1$), Pink Panther ($V_2$) and Princess ($V_3$) during different periods of budding starting from first fortnight of January to second fortnight of December 1987 were analysed statistically to find out the ideal season for budding.

## 4.1 Varietal influence on the success of budding

There was no significant difference among the three varieties $V_1$, $V_2$ and $V_3$ in respect of success in budding in the twentyfour fortnights of the year 1987 (Table 1).

## 4.2 Effect of time on the success of budding

The time of budding significantly influenced the percentage success in bud take. Maximum bud take percentage (97.67 per cent) was recorded when budding was done during September first fortnight, which was on par with the bud take during September second, October first, August second, December second and July first fortnights. The percentage bud take was minimum (26.43 per cent) when the plants were budded during February first fortnight, which was on par with that during August first, February second, March first

Table 1. Success in budding in different months during 1987

| Month | No. of plants budded for each variety in a fortnight | Success in different months (%) | | | Mean |
|---|---|---|---|---|---|
| | | Ambassador $V_1$ | Pink Panther $V_2$ | Princess $V_3$ | |
| 1st January | 15 | 60.00 | 60.00 | 33.30 | 51.10 |
| 15th January | 15 | 53.30 | 60.00 | 40.00 | 51.10 |
| 1st February | 15 | 20.00 | 33.30 | 26.00 | 26.43 |
| 15th February | 15 | 46.00 | 40.00 | 40.00 | 42.00 |
| 1st March | 15 | 46.00 | 40.00 | 46.00 | 44.00 |
| 15th March | 15 | 33.30 | 46.00 | 53.30 | 44.21 |
| 1st April | 15 | 60.00 | 53.30 | 33.30 | 48.87 |
| 15th April | 15 | 73.00 | 46.00 | 40.00 | 53.00 |
| 1st May | 15 | 66.00 | 53.30 | 53.30 | 57.53 |
| 15th May | 15 | 66.00 | 46.00 | 60.00 | 57.33 |
| 1st June | 15 | 66.00 | 60.00 | 73.00 | 66.33 |
| 15th June | 15 | 80.00 | 66.00 | 80.00 | 75.33 |
| 1st July | 15 | 86.00 | 73.00 | 73.00 | 77.33 |
| 15th July | 15 | 26.00 | 93.00 | 66.00 | 61.67 |
| 1st August | 15 | 20.00 | 40.00 | 46.00 | 35.33 |
| 15th August | 15 | 53.30 | 100.00 | 93.00 | 82.10 |
| 1st September | 15 | 100.00 | 93.00 | 100.00 | 97.67 |
| 15th September | 15 | 93.00 | 80.00 | 86.00 | 86.33 |
| 1st October | 15 | 86.00 | 86.00 | 80.00 | 84.00 |
| 15th October | 15 | 86.00 | 60.00 | 73.00 | 73.00 |
| 1st November | 15 | 60.00 | 66.00 | 60.00 | 62.00 |
| 15th November | 15 | 66.00 | 53.00 | 66.00 | 61.77 |
| 1st December | 15 | 60.00 | 66.00 | 60.00 | 62.00 |
| 15th December | 15 | 80.00 | 80.00 | 86.00 | 82.00 |
| Mean | | 61.91 | 62.25 | 61.13 | |

F for varieties 0.051$^{NS}$
F for fortnights 6.021$^{**}$
CD for fortnights 20.599

NS Not significant
** Significant at 1% level

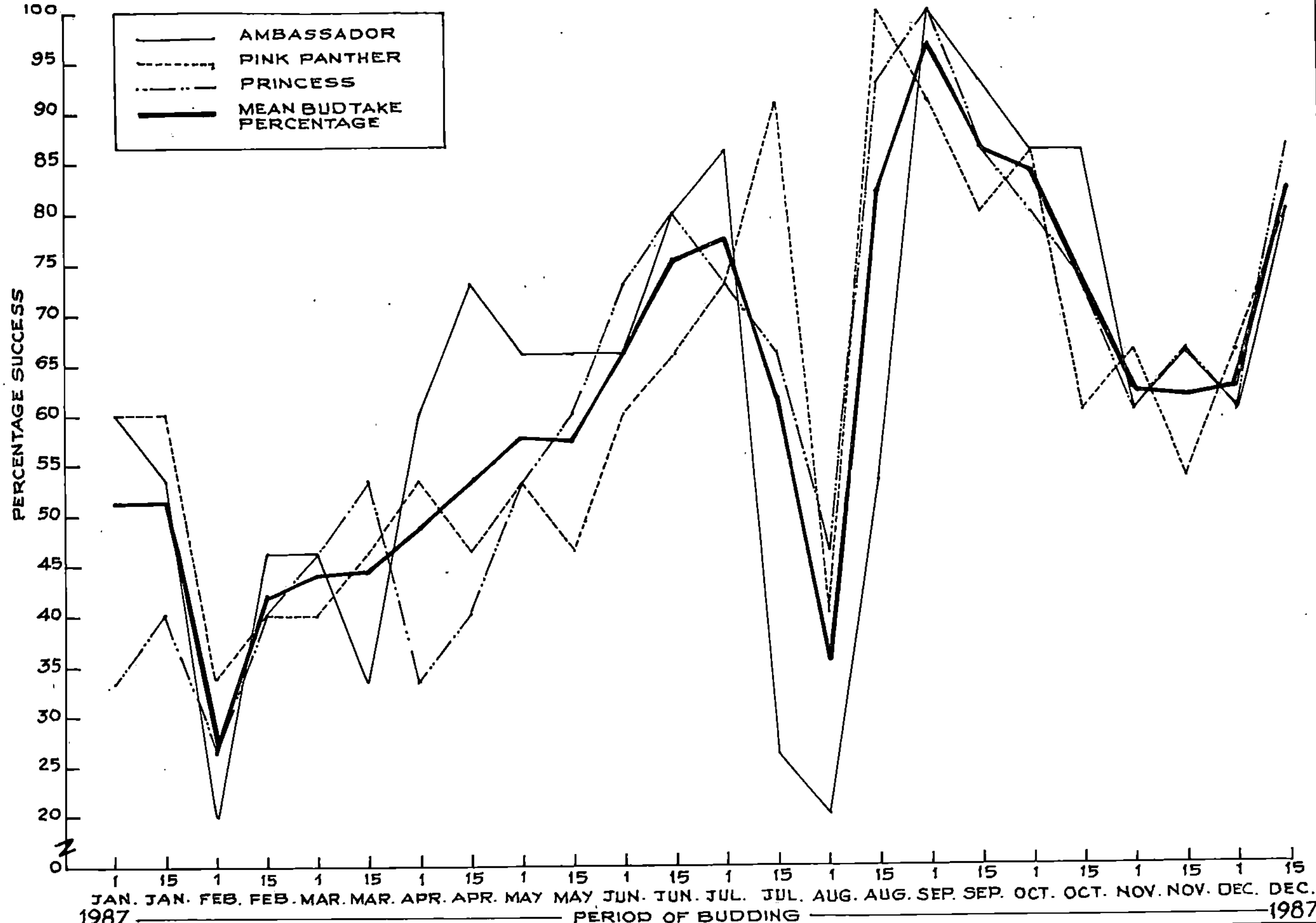
and March second fortnights. April first, January second, January first and April second fortnights also were found to be unsuitable for budding. In general the period from January to April second fortnight was found to be the most unsuitable period for budding (Fig. 1).

A clear picture of the results obtained, could be obtained from the classification given below.

The periods of budding with their degree of success were observed to be as follows

| Bud take | Periods |
|---|---|
| Above 75% | June second, July first, August second, September first, September second, October first and December second fortnights |
| 50 - 75% | January first, January second, April second, May first, May second, June first, July second, October second, November first, November second and December first fortnights |
| Below 50% | February first, February second, March first, March second and August first fortnights |

FIG. 1. SUCCESS IN BUDDING IN DIFFERENT MONTHS DURING 1987.



## 4.3 Influence of environmental parameters on bud take (Fig.2)

### 4.3.1 Correlation between environmental factors and percentage bud take

The maximum temperature during the succeeding fortnight of budding (lag +1) showed significant negative correlation with the bud take percentage (Table 2). Minimum temperature, rainfall, relative humidity and sunshine hours had no significant effect on bud take.

The maximum temperature during the fortnight of budding (lag 0) showed significant negative correlation with the bud take percentage. Minimum temperature had no significant effect on bud take. The rainfall and relative humidity showed significant positive correlation with the bud take percentage, the rainfall exhibiting maximum influence. Sunshine hours showed significant negative correlation with the bud take percentage of the varieties.

The weather parameters during the fortnight prior to the fortnight of budding (lag -1) exhibited results more or less similar to those of the current fortnight (lag 0). Maximum temperature showed significant negative correlation with bud take while minimum temperature exhibited no signi-

FIG. 2. BUD TAKE PERCENTAGE AND WEATHER PARAMETERS DURING 1987.

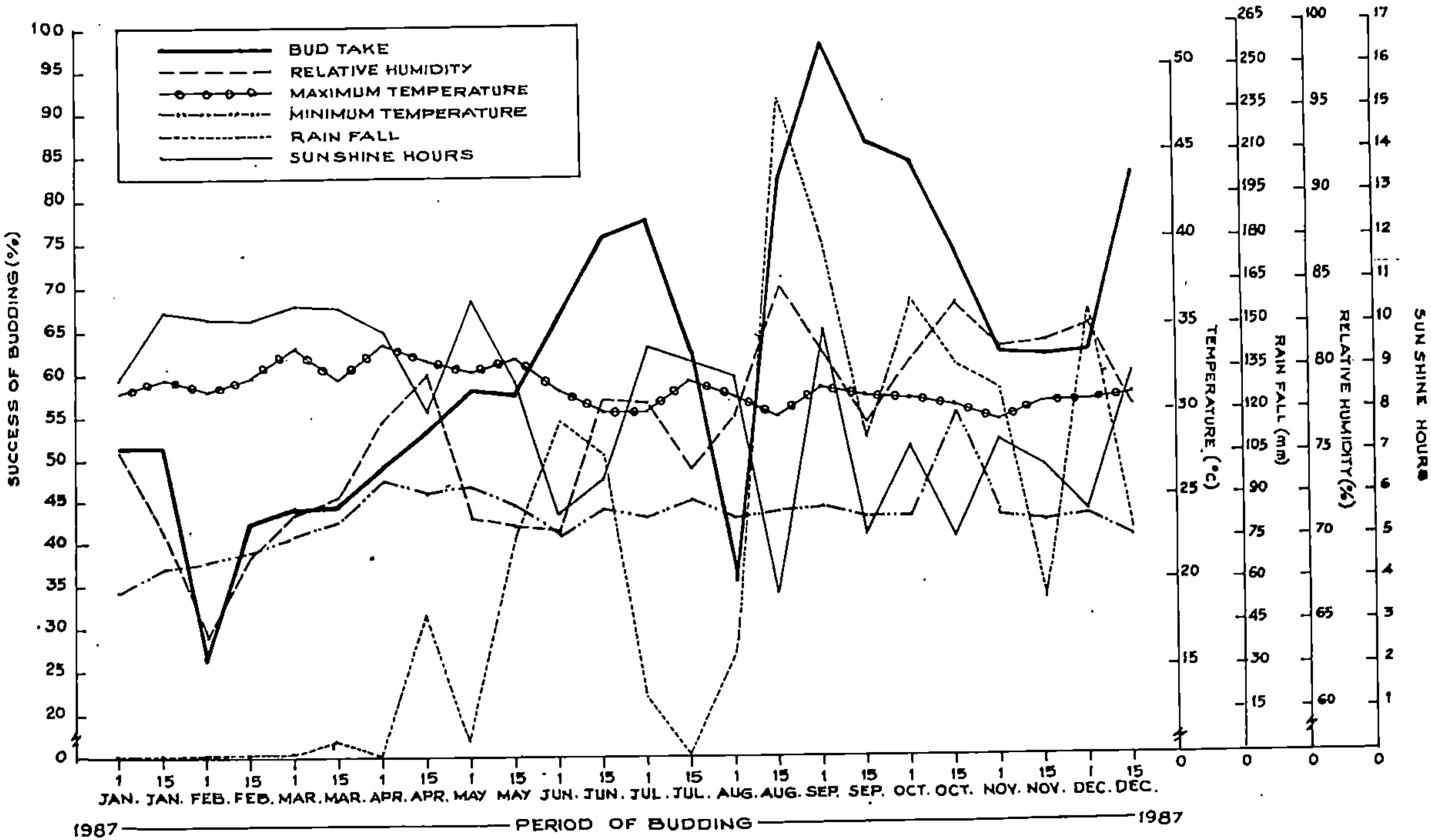


Table 2. Effect of weather parameters on bud take percentage

| Factors | Correlation coefficients | | | |
|---|---|---|---|---|
| | Succeeding fortnight (lag +1) | Current fortnight (lag 0) | Previous fortnight (lag -1) | 2 fortnights prior (lag -2) |
| Maximum Temperature | -0.4392* | -0.4513* | -0.4823* | -0.2095 |
| Minimum Temperature | 0.1733 | 0.0632 | 0.0358 | 0.1685 |
| Rainfall | 0.3246 | 0.7400** | 0.8298** | 0.5206* |
| Relative Humidity | 0.3866 | 0.6407** | 0.6341** | 0.3710 |
| Sunshine Hours | -0.3133 | -0.5126* | -0.6930** | -0.4307 |

* Significant at 5% level

** Significant at 1% level

ficant effect. Rainfall and relative humidity showed significant positive effect on bud take percentage.

Among the weather parameters during the two fortnights prior to budding (lag -2), only rainfall showed significant positive correlation with the bud take percentage.

4.3.2 Regression of bud take on weather parameters

The regression analysis of bud take percentage on the weather parameters, indicated that rainfall was the major factor influencing the bud take, among the five weather parameters studied (Table 3).

4.3.3 Path analysis (Fig. 3)

4.3.3.1 Path analysis of lag +1

The correlation between bud take and maximum temperature was negative and significant ($r = -0.4392^{*}$). Its direct effect was also negative. Indirect effect through other factors such as rainfall, relative humidity and sunshine hours was negligible. The direct effect accounted for about 79.02 per cent of the total correlation (Table 4).

The correlation between bud take and environmental parameters like rainfall, relative humidity and sunshine

Table 3. Regression of bud take percentage on weather parameters

| Factors | Regression coefficients | | | |
|---|---|---|---|---|
| | Succeeding fortnight (lag +1) | Current fortnight (lag 0) | Previous fortnight (lag -1) | 2 fortnights prior (lag -2) |
| Maximum Temperature ($b_1$) | $-6.0460^{NS}$ | $-0.1501^{NS}$ | $1.6449^{NS}$ | $1.9149^{NS}$ |
| Minimum Temperature ($b_2$) | $1.1014^{NS}$ | $-0.2253^{NS}$ | $-0.5777^{NS}$ | $0.4848^{NS}$ |
| Rainfall ($b_3$) | $-0.0037^{NS}$ | $0.1827^{**}$ | $0.1784^{**}$ | $0.1235^{NS}$ |
| Relative humidity ($b_4$) | $0.5706^{NS}$ | $1.0113^{NS}$ | $0.4587^{NS}$ | $0.0442^{NS}$ |
| Sunshine Hours ($b_5$) | $0.6180^{NS}$ | $2.2724^{NS}$ | $-0.8737^{NS}$ | $-0.0229^{NS}$ |
| Constant ($b_0$) | 177.74 | -36.76 | -15.83 | -12.48 |
| Coefficient of determination ($R^2$) | 0.488 | 0.604 | 0.703 | 0.295 |
| Test of significance of Regression (F) | $1.13^{NS}$ | $5.480^{**}$ | $8.057^{**}$ | $1.342^{NS}$ |

** Significant at 1% level

NS Not significant

Table 4. Direct and indirect effects of weather parameters on bud take percentage (lag +1)

| | Maximum Temperature $X_1$ | Rainfall $X_2$ | Relative Humidity $X_3$ | Sunshine Hours $X_4$ | Total correlation |
|---|---|---|---|---|---|
| Maximum Temperature ($X_1$) | <u>-0.3479</u> | 0.0089 | 0.1272 | 0.0269 | -0.4392* |
| Rainfall ($X_2$) | 0.2058 | <u>-0.0152</u> | 0.1685 | -0.0346 | 0.3246 |
| Relative humidity ($X_3$) | 0.1821 | -0.0105 | <u>0.2432</u> | -0.0281 | 0.3866 |
| Sunshine Hours ($X_4$) | -0.2137 | 0.0119 | -0.1555 | <u>0.0439</u> | -0.3133 |

Residue = 0.7718

Direct effects are underlined

* Significant at 5% level

hours was not significant and their direct effects were also negligible.

4.3.3.2 Path analysis of lag 0

The correlation between bud take and maximum temperature was negative and significant ($r = -0.4513^{*}$). But the direct effect was negligible. The maximum indirect effect was via rainfall (-0.4339). This indirect effect via rainfall of the current fortnight accounted for about 96.14 per cent of the correlation. The indirect effect via relative humidity was -0.1517 and via sunshine hours, r = 0.1674. The negative correlation was mainly due to negative indirect influence via rainfall (Table 5). Correlation between bud take and rainfall was positive and significant ($r = 0.7400^{**}$) and the direct effect also was positive and high (0.7335). This correlation was mainly the resultant of the direct effect of current rainfall. 99.12 per cent of this correlation is accounted for rainfall. The maximum indirect effect was via sunshine hours (-0.2145). The indirect effects via maximum temperature was 0.0195 and via relative humidity, 0.2145.

Correlation between bud take and relative humidity was positive and significant ($r = 0.6407^{**}$) and its direct

Table 5. Direct and indirect effects of weather parameters on bud take percentage (lag 0)

| | Maximum Temperature $X_1$ | Rainfall $X_2$ | Relative Humidity $X_3$ | Sunshine Hours $X_4$ | Total correlation |
|---|---|---|---|---|---|
| Maximum Temperature ($X_1$) | -0.0330 | -0.4339 | -0.1517 | 0.1674 | -0.4513* |
| Rainfall ($X_2$) | 0.0195 | 0.7335 | 0.2014 | -0.2145 | 0.7400** |
| Relative humidity ($X_3$) | 0.0174 | 0.5123 | 0.2884 | -0.1773 | 0.6407** |
| Sunshine Hours ($X_4$) | -0.0203 | -0.5772 | -0.1876 | 0.2725 | -0.5126* |

Residue = 0.6303

Direct effects are underlined

* Significant at 5% level

** Significant at 1% level

effect was also positive (0.2384). However only 45 per cent of this correlation was attributed by the direct effect. The maximum indirect effect was via rainfall (0.5123) which contributed to 79.96 per cent of the correlation. The indirect effect via maximum temperature was 0.0174 and via sunshine hours, -0.1773.

Correlation between bud take and sunshine hours was negative and significant (r = -0.5126*) whereas the direct effect was positive (0.2725). The maximum indirect effect was via rainfall (-0.5772) which was higher than the correlation. The indirect effect via maximum temperature was (-0.0203) and via relative humidity, -0.1876. The negative correlation may be attributed through the indirect effect through rainfall.

The weather parameters accounted about 37 per cent of the variation on bud take.

4.3.3.3 Path analysis of lag -1

The correlation between bud take and maximum temperature was negative and significant (r = -0.4823**). On the contrary the direct effect was positive and negligible. The maximum indirect effect was through rainfall (-0.4259). This

Table 6. Direct and indirect effects of weather parameters on bud take percentage (lag -1)

| | Maximum Temperature $X_1$ | Rainfall $X_2$ | Relative Humidity $X_3$ | Sunshine hours $X_4$ | Total corre-lation |
|---|---|---|---|---|---|
| Maximum Temperature ($X_1$) | 0.0527 | -0.4257 | -0.0518 | -0.0576 | -0.4823** |
| Rainfall ($X_2$) | -0.0312 | 0.7190 | 0.0691 | 0.0729 | 0.8298** |
| Relative Humidity ($X_3$) | -0.0276 | 0.5022 | 0.0989 | 0.0607 | 0.6341** |
| Sunshine Hours ($X_4$) | 0.0329 | -0.5687 | -0.0651 | -0.0923 | -0.6930** |

Residue = 0.5497

Direct effects are underlined

** Significant at 1% level

indirect effect via rainfall of the previous fortnight of budding accounted for about 88.26 per cent of the correlation. The indirect effect via relative humidity was -0.0518 and via sunshine hours, -0.0576. The negative correlation may be mainly due to the negative indirect influence via rainfall (Table 6).

Correlation between bud take and rainfall was positive and significant (r = 0.8298**) and the direct effect was also positive and high (0.7190). This correlation was mainly the resultant of the direct effect of previous rainfall. 86.65 per cent of this correlation is accounted for rainfall. The maximum indirect effect was through maximum temperature -0.0312 and via relative humidity, 0.0691.

Correlation between bud take and relative humidity was positive and significant (r = 0.6341**) and the direct effect was also positive but not significant. The maximum indirect effect was via rainfall (0.5022) which attributed to 79.2 per cent of the correlation. The indirect effect via maximum temperature was -0.0276 and via sunshine hours, 0.0607.

Correlation between bud take and sunshine hours was negative and significant (r = -0.6930**) and the indirect effect was also negative and non significant. The maximum indirect effect was via rainfall (-0.5687). The indirect effect of rainfall attributed to 82.06 per cent of the correlation. The indirect effect via maximum temperature was 0.0329 and via relative humidity, -0.0651.

The factors contributed about 45 per cent of the variation in the bud take.

4.3.3.4 Path analysis of lag -2

In this case (Table 7), only the correlation between bud take and rainfall was positive and significant ($r = 0.5206^{**}$) and the direct effect was also positive and high (0.4924). The direct effect of rainfall contributed to 94.58 per cent of this correlation. The maximum indirect effect was attributed by maximum temperature, (-0.1026). The indirect effect via relative humidity was 0.0315 and via sunshine hours, 0.0993.

## 4.4 Biometric characters

The data on biometrical characters obtained in the experiment on the effect of season and position of bud in budding of rose could not be statistically analysed for the whole period as per the design, since some of the buds failed

Table 7. Direct and indirect effects of weather parameters on bud take percentage (lag -2)

| | Maximum Temperature $X_1$ | Rainfall $X_2$ | Relative Humidity $X_3$ | Sunshine hours $X_4$ | Total correlation |
|---|---|---|---|---|---|
| Maximum Temperature ($X_1$) | 0.1773 | -0.2848 | -0.0236 | -0.0785 | -0.2095 |
| Rainfall ($X_2$) | -0.1026 | 0.4924 | 0.0315 | 0.0993 | 0.5206* |
| Relative Humidity ($X_3$) | -0.0899 | 0.3333 | 0.0465 | 0.0811 | 0.3710 |
| Sunshine Hours ($X_4$) | 0.1086 | -0.3818 | -0.0294 | -0.1281 | -0.4307 |

Residue = 0.8417

Direct effects are underlined

* Significant at 5% level

Fig. 3 Path diagram showing the direct effects and inter-relationships of bud take percentage with four meteorological parameters

$Y$ - Bud take percentage

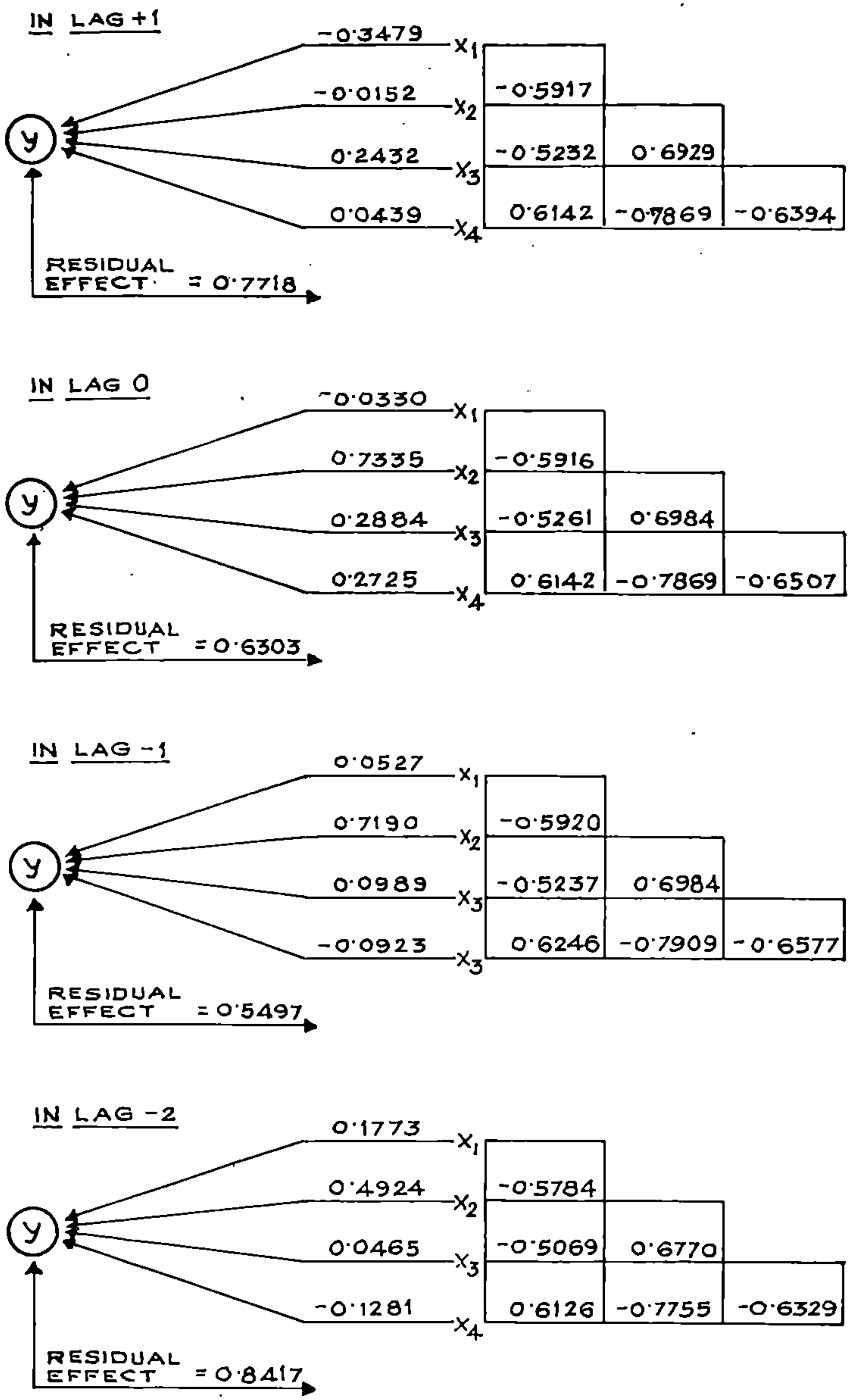
$X_1$ - Maximum Temperature

$X_2$ - Rainfall

$X_3$ - Relative Humidity

$X_4$ - Sunshine hours

FIG. 3. PATH DIAGRAM SHOWING THE DIRECT EFFECTS AND INTER-RELATIONSHIPS OF BUDTAKE PERCENTAGE WITH FOUR METEOROLOGICAL PARAMETERS.



to take. Hence the mean values for each character were worked out and are presented in Appendices II to XIV. In general, the first bud of all the three varieties failed to take in almost all periods of budding. The second bud also showed a trend almost similar to the first bud.

The complete data with respect to the varieties $V_1$, $V_2$ and $V_3$ were available only for the fortnights starting from first September to fifteenth October. The data were analysed separately splitting the sources of variation and the results are presented in tables 8 to 25.

4.4.1 Influence of period of budding

4.4.1.1 Vegetative characters before the appearance of first flower

Days taken for fall of petiole

Significant variation was observed in the number of days taken for the fall of petiole during the different fortnights (Table 8). September first fortnight was found to induce early fall of petiole (8.18 days). September second fortnight was found to delay the fall of petiole (19.38 days).

Table 8. Effect of period of budding on vegetative characters before the appearance of first flower

| Period of Budding | Days taken for fall of petiole | Days taken for bud emergence | Days taken for first leaf emergence | Leaves till first flower bud | Height of scion till first flower bud (cm) |
|---|---|---|---|---|---|
| September 1st fortnight | 8.189 | 15.822 | 25.089 | 10.011 | 18.068 |
| September 2nd fortnight | 19.389 | 34.533 | 47.078 | 12.167 | 18.689 |
| October 1st fortnight | 15.711 | 26.678 | 42.299 | 9.267 | 15.776 |
| F | 140.83** | 53.25** | 40.80** | 20.39** | 6.99** |
| C.D. (5%) | 1.442 | 3.860 | 5.428 | 0.999 | 1.739 |

** Significant at 1% level

Days taken for bud emergence

The number of days taken for bud burst was found to be influenced significantly by the period of budding (Table 8). The plants budded during September first fortnight took the minimum period for bud burst (15.82 days) which was significantly less than that of October first fortnight when the number of days was maximum (34.53 days).

Days taken for first leaf emergence

The period of budding significantly influenced the time taken for first leaf emergence (Table 8). Plants budded during September first fortnight took the minimum number of days for first leaf emergence (25.09 days) as compared to the plants budded during October first and September second fortnights which were on par 42.28 and 47.07 days respectively.

Leaves produced till the appearance of the first flower bud

The plants budded during October first fortnight had the minimum number of leaves (9.26) till the appearance of flower bud, which was on par with those of the plants budded during September first fortnight. The plants budded during September second fortnight recorded the maximum (12.16) number of leaves till the appearance of the first flower bud (Table 8).

Height of scion upto the first flower bud

The period of budding was found to influence the height of scion upto the first flower bud (Table 8). The plants budded during September first and second fortnights recorded significantly more plant height (18.68 cm) than that during October first fortnight (15.77 cm).

4.4.1.2 First flower characters

Days taken for first flower bud production

Period of budding significantly influenced the number of days taken for first flower bud production (Table 9). The plants budded during September first fortnight produced first flower bud significantly earlier (55.46 days) than those budded during September second fortnight, which took the maximum number of days (65.47 days).

Size of first flower

The period of budding significantly influenced the size of the first flower (Table 9). The plants budded during September second fortnight produced the biggest flower (7.02 cm)

Table 9. Effect of period of budding on first flower characters

| Period of Budding | Days taken for production of first flower | Size of first flower (cm) | Petals in first flower |
|---|---|---|---|
| September 1st fortnight | 55.467 | 6.113 | 23.433 |
| September 2nd fortnight | 72.256 | 7.024 | 24.178 |
| October 1st fortnight | 65.478 | 6.468 | 34.645 |
| F | 28.32** | 11.90** | 33.79** |
| C.D. (5%) | 4.759 | 0.399 | 3.234 |

** Significant at 1% level

than the flowers produced by the plants budded during September first and October first fortnights (6.11 cm).

Petals in first flower

Period of budding significantly influenced the number of petals in the first flower (Table 9). The plants budded during October first fortnight possessed maximum number of petals in the first flower (34.64) which was significantly more than that of September first fortnight (23.43) and September second fortnight (24.17).

4.4.1.3 Subsequent growth and flowering characters

Subsequent shoots

Period of budding significantly influenced the number of subsequent shoots produced after first flowering (Table 10). The plants budded during September first and second fortnights (3.76 and 3.8) produced significantly more number of subsequent shoots than that of the plants budded during October first fortnight (3.17).

Second crop flower buds

Significant influence on the production of second crop flower buds was exerted by the period of budding (Table 10). The plants budded during September first and second fortnights

Table 10. Effect of period of budding on subsequent growth and flowering characters

| Period of Budding | Subsequent shoots | $2^{nd}$ crop flower buds | Days taken for production of $2^{nd}$ crop | Petals in subsequent flowers | Total height of the plant after $2^{nd}$ crop (cm) |
|---|---|---|---|---|---|
| September $1^{st}$ fortnight | 3.767 | 2.178 | 93.344 | 22.211 | 23.236 |
| September $2^{nd}$ fortnight | 3.800 | 2.489 | 95.633 | 22.667 | 22.558 |
| October $1^{st}$ fortnight | 3.178 | 1.822 | 97.255 | 27.533 | 20.552 |
| F | 4.07* | 9.88** | 0.59$^{NS}$ | 12.64** | 6.04* |
| C.D. (5%) | 0.520 | 0.318 | — | 2.488 | 1.702 |

* Significant at 5 per cent level

** Significant at 1 per cent level

NS Not significant

produced significantly more number of second crop flower buds (2.17 to 2.48) than those budded during October first fortnight (1.82).

Days taken for production of second crop flower buds

Period of budding exhibited no significant effect on the number of days taken for the production of second crop flower buds (Table 10).

Petals in subsequent flowers

Significant variation was caused in the number of petals present in the subsequent flowers (second crop of flowers) by the period of budding (Table 10). The plants budded during October first fortnight possessed maximum number of petals (27.53) than that of the flowers produced by the plants budded during September first and second fortnights (22.21 and 22.66 respectively).

Total height of the plant after the second crop of flowering

The plants budded during September first and second fortnights recorded significantly more total height (23.23 and 22.55 cm) than the plants budded during October first fortnight (20.55 cm) (Table 10).

### 4.4.2 Influence of varieties

Varietal influence on various characters under study are given in tables 11 to 13.

#### 4.4.2.1 Vegetative characters before the appearance of first flower

Days taken for fall of petiole

The varieties had no influence on the number of days taken for the fall of petiole.

Days taken for bud emergence

Varietal influence on the number of days taken for bud burst was not significant.

Days taken for first leaf emergence

The number of days taken for first leaf emergence was not found to be influenced by the variety.

Leaves till the appearance of first flower bud

The variety $V_3$ possessed significantly more number of leaves (11.18) than $V_2$ (9.95) which possessed the minimum.

Height of scion till first flower bud

Varietal influence on height of scion till first flower-bud was not significant.

Table 11. Effect of variety on vegetative characters before the appearance of first flower

| Varieties | Days taken for fall of petiole | Days taken for bud emergence | Days taken for first leaf emergence | Leaves till first flower-bud | Height of scion till 1st flower bud (cm) |
|---|---|---|---|---|---|
| Ambassador | 13.722 | 25.322 | 36.211 | 10.300 | 17.922 |
| Pink Panther | 14.667 | 26.333 | 38.511 | 9.956 | 18.172 |
| Princess | 14.900 | 25.378 | 39.733 | 11.189 | 16.438 |
| F | 1.69 NS | 0.195 NS | 0.976 NS | 3.64* | 2.61 NS |
| C.D. (5%) | - | - | - | 0.999 | - |

* Significant at 5% level

NS Not significant

Table 12. Effect of variety on first flower characters

| Variety | Days taken for first flower production | Size of first flower (cm) | Petals in first flower |
|---|---|---|---|
| Ambassador | 63.789 | 6.915 | 25.589 |
| Pink Panther | 64.600 | 6.217 | 27.011 |
| Princess | 64.811 | 6.475 | 29.656 |
| F | 0.116 NS | 7.02** | 3.66* |
| C.D. (5%) | - | 0.399 | 3.234 |

** Significant at 1% level

NS Not significant

Table 13. Effect of variety on subsequent growth and flowering characters ($2^{nd}$ crop)

| Variety | Subsequent shoots | $2^{nd}$ crop flowerbuds | Days taken for production of $2^{nd}$ crop | Petals in subsequent flowers | Total height of the plant after $2^{nd}$ crop (cm) |
|---|---|---|---|---|---|
| Ambassador | 4.078 | 2.233 | 93.556 | 23.589 | 22.352 |
| Pink Panther | 3.611 | 2.233 | 98.500 | 23.856 | 21.973 |
| Princess | 3.056 | 1.922 | 94.178 | 24.967 | 22.021 |
| F | 8.69** | 4.08** | 1.113NS | 0.776NS | 0.133NS |
| C.D. (5%) | 0.520 | 0.318 | - | - | - |

** Significant at 1% level

NS Not significant

4.4.2.2 First flower characters

Days taken for the first flower bud production

The number of days taken for the first flower bud production was not significant among the different varieties.

Size of the first flower

Significant varietal effect was seen on first flower size. Variety $V_1$ had maximum flower diameter (6.91 cm) than $V_2$ and $V_3$ which possessed the minimum (6.21 and 6.47 respectively).

Petals in the first flower

The varietal influence on deciding the number of petals was significant. $V_3$ possessed maximum number of petals (29.65) which was significantly more than $V_1$ (25.58) which produced the minimum petals.

4.4.2.3 Subsequent growth and flowering characters

Subsequent shoots

The variety $V_2$ and $V_1$ produced significantly more number of subsequent shoots after first flowering (3.61 and 4.07) than $V_3$ which possessed the minimum (3.05).

Second crop flower buds

$V_1$ and $V_2$ produced significantly more number of flower buds in second crop (2.23) than $V_3$ (1.92).

Days taken for second crop flower bud production

Varietal influence on this character was not significant.

Petals in subsequent flowers

Varietal influence was not significant on the number of petals in subsequent flowers.

Total height of the plant after second crop of flowers

The varieties had no significant effect on total height of the plant after second crop of flowering.

4.4.3 Influence of bud position

Effect of bud position was examined and the results are given in tables 14 to 16.

4.4.3.1 Vegetative characters before the appearance of first flower bud

Days taken for fall of petiole

First bud ($P_1$) induced early fall of petiole (11.83 days) which was significantly less than that of $P_5$ which took maximum number of days for fall of petiole (17.77 days) and significantly superior to $P_2$, $P_3$ and $P_4$.

Days taken for bud emergence

The number of days taken for bud burst was found to be influenced significantly by the bud positions. Second bud took minimum number of days for burst (21.81 days) which was on par with $P_1$, $P_3$ and $P_4$ but significantly less than $P_5$ which was found to delay the bud burst (31.81 days).

Days taken for first leaf emergence

Second bud ($P_2$) produced the first leaf early (32.77 days) which was on par with $P_3$, $P_4$ and $P_1$ but significantly less than $P_5$ (46.81 days).

Leaves produced till the appearance of the first flower bud

The fifth bud ($P_5$) possessed maximum number of leaves (12.44) which was significantly more than $P_1$ (8.7) which possessed the minimum.

Height of scion upto the first flower bud

First bud possessed lowest height (15.72 cm) which was significantly lower than that obtained for fourth bud ($P_4$) (18.95 cm) which recorded the maximum. $P_1$ was on par with $P_5$ but showed significantly lower height than $P_2$ and $P_4$.

Table 14. Effect of bud position on vegetative characters before the appearance of first flowerbud

| Position | Days taken for fall of petiole | Days taken for bud emergence | Days taken for first leaf emergence | Leaves till first flower-bud | Height of scion till first flowerbud (cm) |
|---|---|---|---|---|---|
| First bud | 11.833 | 23.556 | 37.352 | 8.704 | 15.724 |
| Second bud | 12.833 | 21.815 | 32.778 | 9.408 | 18.300 |
| Third bud | 14.815 | 25.389 | 36.629 | 10.667 | 17.626 |
| Fourth bud | 14.889 | 25.815 | 37.185 | 11.185 | 18.952 |
| Fifth bud | 17.778 | 31.815 | 46.815 | 12.445 | 16.452 |
| F | 13.52** | 5.17* | 4.94* | 11.73** | 3.59* |
| C.D. (5%) | 1.862 | 4.984 | 7.007 | 1.291 | 2.245 |

* Significant at 5% level

** Significant at 1% level

Table 15. Effect of bud position on first flower characters

| Positions | Days taken for the production of first flower-bud | Size of first flower (cm) | Petals in first flower |
|---|---|---|---|
| First bud | 58.685 | 6.385 | 32.463 |
| Second bud | 54.611 | 6.367 | 26.315 |
| Third bud | 63.185 | 6.335 | 26.759 |
| Fourth bud | 65.037 | 6.722 | 28.889 |
| Fifth bud | 80.481 | 6.867 | 22.667 |
| F | 23.16** | 1.99NS | 6.68** |
| C.D. (5%) | 6.143 | - | 4.174 |

** Significant at 1% level

NS Not significant

Table 16. Effect of bud position on subsequent growth and flowering characters

| Positions | Subsequent shoots | $2^{nd}$ crop flower buds | Days taken for production of $2^{nd}$ crop | Petals in subsequent flowers | Total height of the plant after $2^{nd}$ crop (cm) |
|---|---|---|---|---|---|
| First bud | 5.204 | 2.185 | 88.982 | 19.611 | 21.102 |
| Second bud | 4.389 | 2.537 | 89.944 | 20.389 | 22.754 |
| Third bud | 3.611 | 2.129 | 92.241 | 23.389 | 22.522 |
| Fourth bud | 2.519 | 2.037 | 100.889 | 27.000 | 23.059 |
| Fifth bud | 2.185 | 1.925 | 105.000 | 30.296 | 21.141 |
| F | 31.68** | 2.84 NS | 4.68* | 17.69** | 1.60 NS |
| C.D. (5%) | 0.672 | - | 9.882 | 3.211 | - |

* Significant at 5% level

** Significant at 1% level

NS Not significant

4.4.3.2 First flower characters

Days taken for the production of first flower bud

$P_2$ showed early production of flower buds (54.61 days) which was significantly less than $P_4$ and $P_5$. $P_5$ took the maximum number of days for first flower bud production (80.48 days).

Size of first flower

Effect of position of buds in the scion was not significant for this character.

Petals in first flower

$P_1$ (first bud) possessed maximum number of petals in the first flower (32.46). $P_5$ and $P_2$ possessed more petals than $P_4$ and $P_1$. Fifth bud produced flowers with lowest number of petals (22.66).

4.4.3.3 Subsequent growth and flowering characters

Subsequent shoots

Significant variation was observed for different positions on the production of subsequent shoots. $P_1$ produced the highest number of subsequent shoots (5.2). $P_5$ produced the least number of subsequent shoots (2.18) which was on par with $P_4$ but significantly lower than $P_3$, $P_2$ and $P_1$.

Second crop flower buds

The position of buds exhibited no significant influence on the number of second crop flower buds produced.

Days taken for the production of second crop flower buds

$P_1$ produced second crop of flower buds early but, on par with $P_2$. (88.98 days) and significantly less than $P_4$ and $P_5$ which were on par. $P_3$ took longer period for the production of second crop flower buds (105 days).

Petals in subsequent flowers

$P_5$ possessed the maximum number of petals (30.29). $P_1$ possessed least number of petals in second crop of flowers (19.61) which was on par with $P_2$ but significantly lower than that of $P_3$, $P_4$ and $P_5$.

Total height of the plant after second crop flowering

The position of buds did not influenced the total height of the plant significantly.

4.4.4 Interaction effect of period of budding x varieties

4.4.4.1 Vegetative characters before the appearance of first flower

The interaction of varieties and period of budding on various characters were examined and the results are given in tables 17 to 19.

Days taken for fall of petiole

The interaction effect of period of budding and variety was not significant for this character.

Days taken for bud emergence

The interaction effect was not significant.

Days taken for first leaf emergence

The number of days taken for first leaf emergence was not significantly influenced by the interaction of period of budding and varieties.

Leaves till the appearance of first flower bud

The interaction of the period of budding and variety possessed significant influence in deciding the number of leaves till the appearance of flower bud. For $V_1$ and $V_2$ almost same number of leaves appeared on plants budded during September first and October first fortnights (8.36 to 10.23).

For $V_3$, there was no difference during the three fortnights. For $V_1$ maximum number of leaves were present on plants budded during September first fortnight (12.3) and minimum during October first fortnight (8.6) and for $V_2$ maximum leaves were present in plants budded during September second fortnight (12.53) than that of during September first fortnight (8.36).

Height of scion till first flower bud

The interaction between the period of budding and variety significantly influenced the height of scion till first flower bud. The plants budded during September first and second fortnights recorded more or less equal height (18.5 to 20.34 cm) in $V_1$ but significantly more than that of October first fortnight budded plants. The plants budded during September first and October first fortnights recorded same height (15.72 cm) but significantly less than September second fortnight budded plants (23.03 cm) in $V_2$. The plants budded during September second fortnight recorded minimum height (14.53 cm) which was on par with plants budded during October first fortnight which in turn on par with that of September first fortnight but recorded the maximum (18.10 cm).

4.4.4.2 First flower characters

Table 17. Interaction effect of period of budding and varieties on vegetative characters before the appearance of first flower

| Treatments | Days taken for fall of petiole | Days taken for bud emergence | Days taken for first leaf emergence | Leaves till flowerbud | Height of scion till first flower (cm) |
|---|---|---|---|---|---|
| $F_1V_1$ | 7.467 | 13.933 | 24.867 | 10.000 | 20.340 |
| $F_1V_2$ | 8.167 | 16.200 | 25.800 | 8.367 | 15.757 |
| $F_1V_3$ | 8.933 | 17.333 | 24.600 | 11.667 | 18.107 |
| $F_2V_1$ | 19.433 | 37.100 | 47.767 | 12.300 | 18.500 |
| $F_2V_2$ | 18.600 | 33.433 | 42.933 | 12.533 | 23.033 |
| $F_2V_3$ | 20.133 | 33.067 | 50.533 | 11.667 | 14.533 |
| $F_3V_1$ | 14.267 | 24.933 | 36.000 | 8.600 | 14.927 |
| $F_3V_2$ | 17.233 | 29.367 | 46.800 | 8.967 | 15.727 |
| $F_3V_3$ | 15.633 | 25.733 | 44.067 | 10.233 | 16.673 |
| F | $1.56^{NS}$ | $1.27^{NS}$ | $1.89^{NS}$ | $3.66^{*}$ | $10.63^{**}$ |
| C.D. | - | - | - | 1.732 | 3.012 |

* Significant at 5% level

** Significant at 1% level

NS Not significant

Table 18. Interaction effect of period of budding and variety on 1st flower characters

| Treatments | Days taken for the production of 1st flower-bud | Size of first flower (cm) | Petals in first flower |
|---|---|---|---|
| $F_1V_1$ | 57.000 | 6.467 | 30.333 |
| $F_1V_2$ | 57.533 | 5.613 | 19.750 |
| $F_1V_3$ | 51.867 | 6.260 | 20.267 |
| $F_2V_1$ | 69.633 | 7.377 | 20.167 |
| $F_2V_2$ | 71.533 | 6.643 | 22.100 |
| $F_2V_3$ | 75.600 | 7.053 | 30.267 |
| $F_3V_1$ | 64.733 | 6.900 | 26.267 |
| $F_3V_2$ | 64.733 | 6.393 | 39.233 |
| $F_3V_3$ | 66.967 | 6.110 | 38.433 |
| F | $1.31^{NS}$ | $1.13^{NS}$ | $14.98^{**}$ |
| C.D. (5%) | - | - | 5.061 |

** Significant at 1% level

NS Not significant

Table 19. Interaction effect of period of budding and variety on subsequent growth and flowering (2nd crop)

| Treatments | Subsequent shoots | 2nd crop flower buds | Days taken for production of 2nd crop | Petals in subsequent flowers | Total height of the plant after 2nd crop (cm) |
|---|---|---|---|---|---|
| $F_1V_1$ | 4.267 | 2.267 | 94.800 | 26.667 | 25.333 |
| $F_1V_2$ | 3.167 | 2.067 | 97.167 | 19.700 | 19.193 |
| $F_1V_3$ | 3.867 | 2.200 | 88.067 | 20.267 | 25.180 |
| $F_2V_1$ | 4.500 | 2.567 | 88.667 | 21.100 | 21.383 |
| $F_2V_2$ | 3.957 | 2.833 | 101.367 | 19.967 | 26.640 |
| $F_2V_3$ | 2.933 | 2.067 | 96.867 | 26.933 | 19.653 |
| $F_3V_1$ | 3.467 | 1.867 | 97.200 | 23.000 | 20.340 |
| $F_3V_2$ | 3.700 | 2.100 | 96.967 | 31.900 | 20.087 |
| $F_3V_3$ | 2.367 | 1.500 | 97.600 | 27.700 | 21.230 |
| F | 3.68* | 1.71NS | 1.08NS | 11.42** | 13.31** |
| C.D. (5%) | 0.901 | - | - | 4.309 | 2.948 |

* Significant at 5% level

** Significant at 1% level

NS Not significant

Days taken for the first flower bud production.

No significant interaction of period of budding x varieties was seen this character.

Size of the first flower

There was no interaction effect due to size of the flower.

Petals in the first flower.

The number of petals in first flower was influenced significantly by the interaction of period of budding and varieties. For $V_1$, the plants budded during September first fortnight produced flowers with significantly more number of petals (30.33) than that of September second fortnight budded plants (20.61). For $V_2$, the number of petals were almost same in flowers produced by the plants budded during September first and second fortnight but significantly less than that of October first fortnight (39.23) which was the maximum. Maximum number of petals were present in flowers, when plants were budded during October first fortnight (38.43) than that of plants budded during September first fortnight (20.26).

4.4.4.3 Subsequent growth and flowering.

Subsequent shoots

The interaction of period of budding and variety had profound influence on the production of subsequent shoots. For $V_1$, more or less equal number of subsequent shoots were produced in plants budded during September first and second fortnight (4.26 and 4.5) but, significantly higher than October first fortnight budded plants (3.46). Almost equal number of subsequent shoots were produced when budding was done during all the three fortnights for $V_2$. Significantly more number of subsequent shoots were produced in plants budded during September first fortnight (3.87) than plants budded during September second and October first fortnights.

Second crop flower buds

The interaction of period of budding and variety was not significant.

Days taken for the production of second crop flower buds

The interaction was not significant for this character.

Petals in subsequent flowers

The interaction of period of budding and variety had significant influence on deciding the number of petals in subsequent flowers. For $V_1$, maximum number of petals were present in flowers when plants were budded during September first fortnight (26.66). Maximum petals were produced in flowers of plants budded during October first fortnight (31.9) than plants budded during September first and second fortnights which were on par for $V_2$. For $V_3$, minimum number of petals were present in flowers of plants budded during September first fortnight (20.26) which was significantly less than that of plants budded during September second and October first fortnights (26.93 and 27.7).

Total height of the plant after second crop flowers

The interaction of period of budding and variety influenced the total height significantly. Maximum height was recorded when plants were budded during September first fortnight budded plants (25 cm) which was significantly higher than that of September second and October first fortnight budded plants for $V_1$ and $V_3$. For $V_2$, almost same height was recorded in plants budded during September first and October first fortnights but significantly lower than that of plants budded during September second fortnight which recorded the maximum (27 cm).

4.4.5 Interaction effect of varieties x position of bud

The interaction effect of varieties and position of bud were studied and the results are given in tables 20 to 22.

4.4.5.1 Vegetative characters before the appearance of first flower bud

Days taken for fall of petiole

The variety and position of bud did not interact significantly on the number of days taken for fall of petiole.

Days taken for bud emergence

No significant interaction effect was found between the variety and the position of bud in the number of days taken for bud burst.

Days taken for first leaf emergence

The interaction effect of variety and position of bud was not significant with respect to the number of days taken for first leaf emergence.

Leaves till the appearance of flower bud

Interaction was not significant for this character.

Height of scion till first flower bud

Interaction effect was not significant for this character.

4.4.5.2 First flower characters

Days taken for first flower bud production

The days taken for first flower bud production was found to have no significant interaction effect of variety and position of bud.

Size of the first flower

Interaction effect was not significant.

Petals in first flower

Interaction of variety and position of bud was not significant for this character.

4.4.5.3 Subsequent growth and flowering

Subsequent shoots

Interaction effect was not significant for this character.

Second crop flower buds

There was no significant interaction between varieties and bud position on the production of second crop flower buds.

Table 20. Interaction effect of variety and position on vegetative characters before the appearance of first flowerbud

| Treatments | Days taken for fall of petiole | Days taken for bud emergence | Days taken for the production of 1st leaf | Leaves till 1st flowerbud | Height of scion till 1st flowerbud (cm) |
|---|---|---|---|---|---|
| $V_1P_1$ | 11.833 | 26.277 | 34.722 | 7.167 | 16.878 |
| $V_1P_2$ | 12.111 | 23.444 | 34.333 | 8.778 | 19.722 |
| $V_1P_3$ | 14.222 | 23.333 | 31.111 | 11.000 | 18.767 |
| $V_1P_4$ | 14.222 | 23.111 | 35.667 | 12.667 | 19.033 |
| $V_1P_5$ | 16.222 | 30.444 | 45.222 | 11.889 | 15.211 |
| $V_2P_1$ | 12.333 | 21.833 | 35.667 | 8.500 | 15.650 |
| $V_2P_2$ | 12.444 | 21.111 | 30.667 | 9.167 | 17.322 |
| $V_2P_3$ | 15.000 | 28.056 | 39.444 | 10.111 | 19.355 |
| $V_2P_4$ | 14.889 | 27.222 | 38.222 | 9.778 | 21.067 |
| $V_2P_5$ | 18.667 | 33.444 | 48.556 | 12.222 | 17.467 |
| $V_3P_1$ | 11.333 | 22.556 | 41.667 | 10.444 | 14.644 |
| $V_3P_2$ | 13.944 | 20.889 | 33.333 | 10.278 | 19.356 |
| $V_3P_3$ | 15.222 | 24.778 | 39.333 | 10.889 | 14.756 |
| $V_3P_4$ | 15.556 | 27.111 | 37.667 | 11.111 | 16.756 |
| $V_3P_5$ | 18.444 | 31.556 | 46.667 | 13.222 | 16.678 |
| F | $0.39^{NS}$ | $0.59^{NS}$ | $0.45^{NS}$ | $1.85^{NS}$ | $1.59^{NS}$ |

NS Not significant

Table 21. Interaction effect of variety and bud position on first flower characters

| | Days taken for the production of 1st flower-bud | Size of first flower (cm) | Petals in first flower |
|---|---|---|---|
| $V_1P_1$ | 53.944 | 6.150 | 25.944 |
| $V_1P_2$ | 57.000 | 6.644 | 25.667 |
| $V_1P_3$ | 57.889 | 6.744 | 25.222 |
| $V_1P_4$ | 66.111 | 7.367 | 30.444 |
| $V_1P_5$ | 84.000 | 7.667 | 20.667 |
| $V_2P_1$ | 54.667 | 6.517 | 34.333 |
| $V_2P_2$ | 51.889 | 6.417 | 26.556 |
| $V_2P_3$ | 67.222 | 6.017 | 27.167 |
| $V_2P_4$ | 67.333 | 6.033 | 24.000 |
| $V_2P_5$ | 81.889 | 6.100 | 23.000 |
| $V_3P_1$ | 67.444 | 6.489 | 37.111 |
| $V_3P_2$ | 54.944 | 6.039 | 26.722 |
| $V_3P_3$ | 64.444 | 6.244 | 27.889 |
| $V_3P_4$ | 61.667 | 6.767 | 32.222 |
| $V_3P_5$ | 75.556 | 6.833 | 24.333 |
| F | $2.26^{NS}$ | $2.01^{NS}$ | $1.59^{NS}$ |

NS Not significant

Table 22. Interaction effect of variety and bud position on subsequent growth and flowering (2$^{nd}$ crop)

| Treatments | Subsequent shoots | 2$^{nd}$ crop flower buds | Days taken for production of 2$^{nd}$ crop flower-bud | Petals in subsequent flowers | Total height of the plant after 2$^{nd}$ crop |
|---|---|---|---|---|---|
| $V_1P_1$ | 5.611 | 1.944 | 81.556 | 19.944 | 21.094 |
| $V_1P_2$ | 5.333 | 3.111 | 85.333 | 21.111 | 23.889 |
| $V_1P_3$ | 4.444 | 2.111 | 95.556 | 22.889 | 23.322 |
| $V_1P_4$ | 2.667 | 2.000 | 95.778 | 25.111 | 22.144 |
| $V_1P_5$ | 2.333 | 2.000 | 109.556 | 28.889 | 21.311 |
| $V_2P_1$ | 5.000 | 2.500 | 96.833 | 22.000 | 20.900 |
| $V_2P_2$ | 4.330 | 2.444 | 92.167 | 18.222 | 20.733 |
| $V_2P_3$ | 3.611 | 2.500 | 93.833 | 22.389 | 21.733 |
| $V_2P_4$ | 2.778 | 2.222 | 105.111 | 26.778 | 25.367 |
| $V_2P_5$ | 2.333 | 2.000 | 104.556 | 29.889 | 21.133 |
| $V_3P_1$ | 5.000 | 2.111 | 88.556 | 16.889 | 21.311 |
| $V_3P_2$ | 3.500 | 2.056 | 92.333 | 21.833 | 23.6389 |
| $V_3P_3$ | 2.778 | 1.778 | 87.333 | 24.889 | 22.511 |
| $V_3P_4$ | 2.111 | 1.889 | 101.778 | 29.111 | 21.667 |
| $V_3P_5$ | 1.889 | 1.778 | 100.889 | 32.111 | 20.978 |
| F | 0.91$^{NS}$ | 1.39$^{NS}$ | 0.75$^{NS}$ | 1.17$^{NS}$ | 1.18$^{NS}$ |

NS Not significant

Days taken for the production of second crop flower buds

In the, number of days taken for the production of second crop flower buds, there was no significant interaction effect of variety and position of bud.

Petals in subsequent flowers

Interaction was not significant for this character.

Total height of the plant after second crop of flowering

Interaction was not significant.

4.4.6 Interaction effect of period of budding x bud position

The results are presented in tables 23 to 25.

4.4.6.1 Vegetative characters before the appearance of first flower bud

Days taken for fall of petiole

The period of budding and the position of buds interacted significantly for this character. Plants budded during September first fortnight took minimum number of days for the fall of petiole irrespective of the position of buds (7.22 to

9.77 days). The plants budded during September second fortnight and October first fortnight took more or less same number of days for petiole fall for third, fourth and fifth bud positions which was significantly more than September first fortnight budded plants. Maximum number of days were taken for $P_5$ (22.55 days) when budded during $F_3$ (October first fortnight). For first bud ($P_1$), when budding was done during September first and October first fortnight took more or less same number of days for petiole fall but significantly less than that of September second fortnight (18.83 days). For $P_2$, the time taken was significantly different when budding was done during the three fortnights in which maximum was taken during September second fortnight (18 days).

Days taken for bud emergence

Period of budding and position of buds were found to be jointly influencing the number of days taken for bud emergence. Early bud burst was found in plants budded during September first fortnight irrespective of the bud positions (14.11 to 18.44 days). For $P_3$, $P_4$ and $P_5$ it took more or less same number of days when budded during September second and October first fortnight which was significantly more than September first fortnight budded plants. For $P_1$ and $P_2$ when plants were budded during September first and October first fortnight, took more or less same time for bud burst but significantly less than that for September second fortnight budded plants (36.83 days).

Days taken for first leaf emergence

The period of budding and different positions of buds interacted significantly in the number of days taken for first leaf emergence. Irrespective of the position, September first fortnight budded plants took minimum number of days (21.77 to 32 days). For the first and second bud more or less same number of days were taken when budding was done during September first and October first fortnight, which was significantly less than that of September second fortnight. September second and October first fortnight budded plants took more or less same time which was significantly more for $P_3$ and $P_4$ than, when the budding was done during the September first fortnight. For $P_5$ (5th bud) maximum number of days were taken when budded during October first fortnight (60.88 days).

Leaves till the appearance of first flower bud

No significant interaction was found between the period of budding and the position of bud on this character.

Table 23. Interaction effect of period of budding and bud position on vegetative characters before the appearance of first flowerbud

| Treatments | Days taken for fall of petiole | Days taken for bud emergence | Days taken for the production of 1st leaf | Leaves till 1st flower bud | Height of scion till 1st flowerbud (cm) |
|---|---|---|---|---|---|
| $F_1P_1$ | 8.500 | 16.667 | 24.556 | 8.611 | 17.706 |
| $F_1P_2$ | 7.444 | 15.222 | 24.778 | 8.667 | 18.378 |
| $F_1P_3$ | 7.222 | 14.111 | 21.778 | 10.222 | 16.678 |
| $F_1P_4$ | 8.000 | 14.667 | 22.333 | 9.389 | 20.878 |
| $F_1P_5$ | 9.778 | 18.444 | 32.000 | 12.667 | 16.700 |
| $F_2P_1$ | 18.833 | 36.833 | 56.167 | 10.167 | 16.500 |
| $F_2P_2$ | 18.000 | 31.333 | 43.444 | 9.667 | 18.633 |
| $F_2P_3$ | 19.667 | 36.722 | 46.333 | 13.111 | 19.744 |
| $F_2P_4$ | 19.444 | 32.444 | 41.889 | 13.667 | 17.644 |
| $F_2P_5$ | 21.000 | 35.333 | 47.556 | 14.222 | 20.922 |
| $F_3P_1$ | 8.167 | 17.167 | 31.333 | 7.333 | 12.967 |
| $F_3P_2$ | 13.056 | 18.889 | 30.111 | 9.889 | 19.389 |
| $F_3P_3$ | 17.556 | 25.333 | 41.778 | 8.667 | 16.456 |
| $F_3P_4$ | 17.222 | 30.333 | 47.333 | 10.000 | 18.333 |
| $F_3P_5$ | 22.556 | 41.667 | 60.889 | 10.444 | 11.733 |
| F | 6.80** | 3.87* | 3.87* | 1.98NS | 3.27* |
| C.D. (5%) | 3.225 | 8.632 | 12.136 | - | 3.889 |

* Significant at 5% level
** Significant at 1% level
NS Not significant

Table 24. Interaction effect of period of budding and bud position on 1st flower characters

| Treatments | Days taken for the production of 1st flower | Size of first flower (cm) | Petals in 1st flower |
|---|---|---|---|
| $F_1P_1$ | 48.889 | 5.489 | 26.056 |
| $F_1P_2$ | 46.778 | 5.911 | 23.000 |
| $F_1P_3$ | 53.889 | 6.367 | 23.667 |
| $F_1P_4$ | 55.111 | 6.411 | 25.111 |
| $F_1P_5$ | 72.667 | 6.389 | 19.333 |
| $F_2P_1$ | 71.833 | 6.783 | 25.500 |
| $F_2P_2$ | 64.000 | 6.878 | 24.556 |
| $F_2P_3$ | 68.889 | 6.783 | 24.389 |
| $F_2P_4$ | 74.111 | 7.167 | 26.444 |
| $F_2P_5$ | 82.444 | 7.511 | 20.000 |
| $F_3P_1$ | 55.333 | 6.883 | 45.833 |
| $F_3P_2$ | 53.056 | 6.311 | 31.389 |
| $F_3P_3$ | 66.778 | 5.856 | 32.222 |
| $F_3P_4$ | 65.889 | 6.589 | 35.111 |
| $F_3P_5$ | 86.333 | 6.700 | 28.667 |
| F | 1.302$^{NS}$ | 1.39$^{NS}$ | 1.58$^{NS}$ |

NS Not significant

Table 25. Interaction effect of period of budding and bud position on subsequent growth and flowering (2nd crop)

| Treatments | Subsequent shoots | 2nd crop flower-buds | Days taken for the production of 2nd crop | Petals in subsequent flowers | Total height of the plant after 2nd crop (cm) |
|---|---|---|---|---|---|
| $F_1P_1$ | 5.278 | 2.222 | 87.278 | 19.167 | 23.289 |
| $F_1P_2$ | 5.333 | 2.889 | 90.445 | 18.889 | 24.478 |
| $F_1P_3$ | 3.556 | 2.000 | 91.000 | 21.778 | 22.811 |
| $F_1P_4$ | 2.444 | 1.889 | 96.667 | 25.889 | 24.200 |
| $F_1P_5$ | 2.222 | 1.889 | 101.333 | 25.333 | 21.400 |
| $F_2P_1$ | 5.500 | 2.500 | 92.667 | 18.167 | 20.850 |
| $F_2P_2$ | 4.333 | 2.667 | 93.111 | 19.333 | 21.133 |
| $F_2P_3$ | 3.944 | 2.500 | 87.167 | 20.944 | 23.811 |
| $F_2P_4$ | 2.889 | 2.444 | 105.111 | 23.778 | 22.711 |
| $F_2P_5$ | 2.333 | 2.333 | 100.111 | 31.111 | 24.289 |
| $F_3P_1$ | 4.833 | 1.833 | 87.000 | 21.500 | 19.167 |
| $F_3P_2$ | 3.500 | 2.056 | 86.278 | 22.944 | 22.650 |
| $F_3P_3$ | 3.333 | 1.889 | 98.556 | 27.444 | 20.944 |
| $F_3P_4$ | 2.222 | 1.778 | 100.889 | 31.333 | 22.267 |
| $F_3P_5$ | 2.000 | 1.556 | 113.556 | 34.444 | 17.733 |
| F | $0.97^{NS}$ | $0.57^{NS}$ | $0.84^{NS}$ | $0.97^{NS}$ | $1.75^{NS}$ |

NS Not significant

Height of scion till first flower bud

The interaction of period of budding and position exerted significant influence on the height of scion till first flower bud. First, second, third and fourth bud recorded more or less same height when budding was done during all the three fortnights. But fifth bud recorded minimum height when budded during October first fortnight (11.73 cm) and maximum during September second fortnight (20.92 cm).

4.4.6.2 First flower characters

Days taken for the production of first flower bud

The period of budding and position of bud did not jointly influence the time taken for first flower bud production.

Size of the first flower

The interaction effect of period of budding and position of buds was found to have no significant influence on the size of the first flower.

Petals in the first flower

Interaction of period of budding and position of buds was not significant for this character.

4.4.6.3 Subsequent growth and flowering

Subsequent shoots

There was no interaction effect between period of budding and position of buds in the production of subsequent shoots.

Second crop flower buds

There was no significant interaction effect between period of budding and position of buds in the number of second crop of flower buds produced.

Days taken for the production of second crop of flower buds

No significant interaction was found between period of budding and position of buds in the time taken for second crop of flower bud production.

Petals in subsequent flowers

No significant interaction was found between period of budding and position of buds in the number of petals present in subsequent flowers.

Total height of the plant after second crop flowering

There was no significant interaction between the period of budding and position of buds on total height of the plant after second crop of flowering.

4.5 Correlation studies

Correlations were worked out among the thirteen characters under study and the results are presented in Table 26 and Fig. 4.

4.5.1 Days taken for fall of petiole

This character showed significant positive correlation with days taken for bud emergence, days taken for first leaf emergence, number of leaves till first flower bud, days taken for first flower bud production size of first flower, days taken for the production of second crop flower buds, and petal number in subsequent flowers.

A negative correlation with height of scion till first flower bud, number of petals in first flower, number of subsequent shoots and total height of the plant after second crop flowers were also observed.

The character also showed a positive non significant correlation with number of second crop flower buds.

Table 26. Correlation coefficients between the thirteen biometric characters

| | N.D for fall of petiole | N.D for bud emergence | N.D for 1st leaf emergence | No. of leaves till 1st flower bud | Ht. of scion till 1st flower bud | N.D for 1st flower bud | Size of 1st flower | No. of petals in 1st flower | No. of subsequent shoots | No. of 2nd crop flower buds | N.D for 2nd crop flower buds | No. of petals in sub. flowers | Total ht. of the plant |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. N.D for fall of petiole | - | | | | | | | | | | | | |
| 2. N.D for bud emergence | 0.9009** | - | | | | | | | | | | | |
| 3. N.D for 1st leaf emergence | 0.8823** | 0.8968** | - | | | | | | | | | | |
| 4. No. of leaves till 1st flower bud | 0.3825** | 0.3524* | 0.2563 | - | | | | | | | | | |
| 5. Ht. of scion till 1st flower bud | -0.0393 | -0.0516 | -0.1925 | 0.3295* | - | | | | | | | | |
| 6. N.D for 1st flower bud | 0.7308** | 0.7429** | 0.8012** | 0.4760** | -0.1743 | - | | | | | | | |
| 7. Size of 1st flower | 0.3747* | 0.3628* | 0.3301* | 0.3778* | -0.1139 | 0.4084** | - | | | | | | |
| 8. No. of petals in 1st flower | -0.0274 | -0.1133 | 0.1041 | -0.2806 | -0.2570 | -0.1031 | 0.0566 | - | | | | | |
| 9. No. of subsequent shoots | -0.2841 | 0.1017 | -0.1837 | -0.3449* | 0.0882 | 0.4598** | -0.0917 | 0.0182 | - | | | | |
| 10. No. of 2nd croo flower buds | 0.0240 | 0.1555 | -0.0218 | 0.0868 | 0.3356* | -0.0676 | 0.1661 | -0.2657 | 0.5967** | - | | | |
| 11. N.D for production of 2nd crop | 0.3527* | 0.3458* | 0.3333* | 0.1378 | -0.1140 | 0.5628** | 0.1357 | -0.0642 | -0.4139** | -0.0450 | - | | |
| 12. No. of petals in sub. flowers | 0.3911** | 0.2784 | 0.3655* | 0.1277 | -0.1178 | 0.4149* | 0.1131 | 0.3135* | -0.5723** | -0.3688* | 0.4619** | - | |
| 13. Total ht. of the plant | -0.1544 | -0.1417 | -0.2557 | 0.3135** | 0.3470** | -0.2022 | -0.0833 | -0.2257 | 0.1849 | 0.3571* | -0.0419 | -0.1211 | - |

* Significant at 5 per cent level

** Significant at 1 per cent level

4.5.2 Days taken for bud emergence

This character showed significant positive correlation with days taken for first leaf emergence, number of leaves till first flower bud, days taken for first flower bud, size of first flower and days taken for the production of second crop flower buds.

A positive non significant correlation, with number of subsequent shoots produced after first flower, number of second crop flower buds and number of petals in subsequent flowers, was also observed.

This character showed negative correlation with height of scion till first flower bud, number of petals in first flower and total height of the plant after second crop flowering.

4.5.3 Days taken for first leaf emergence

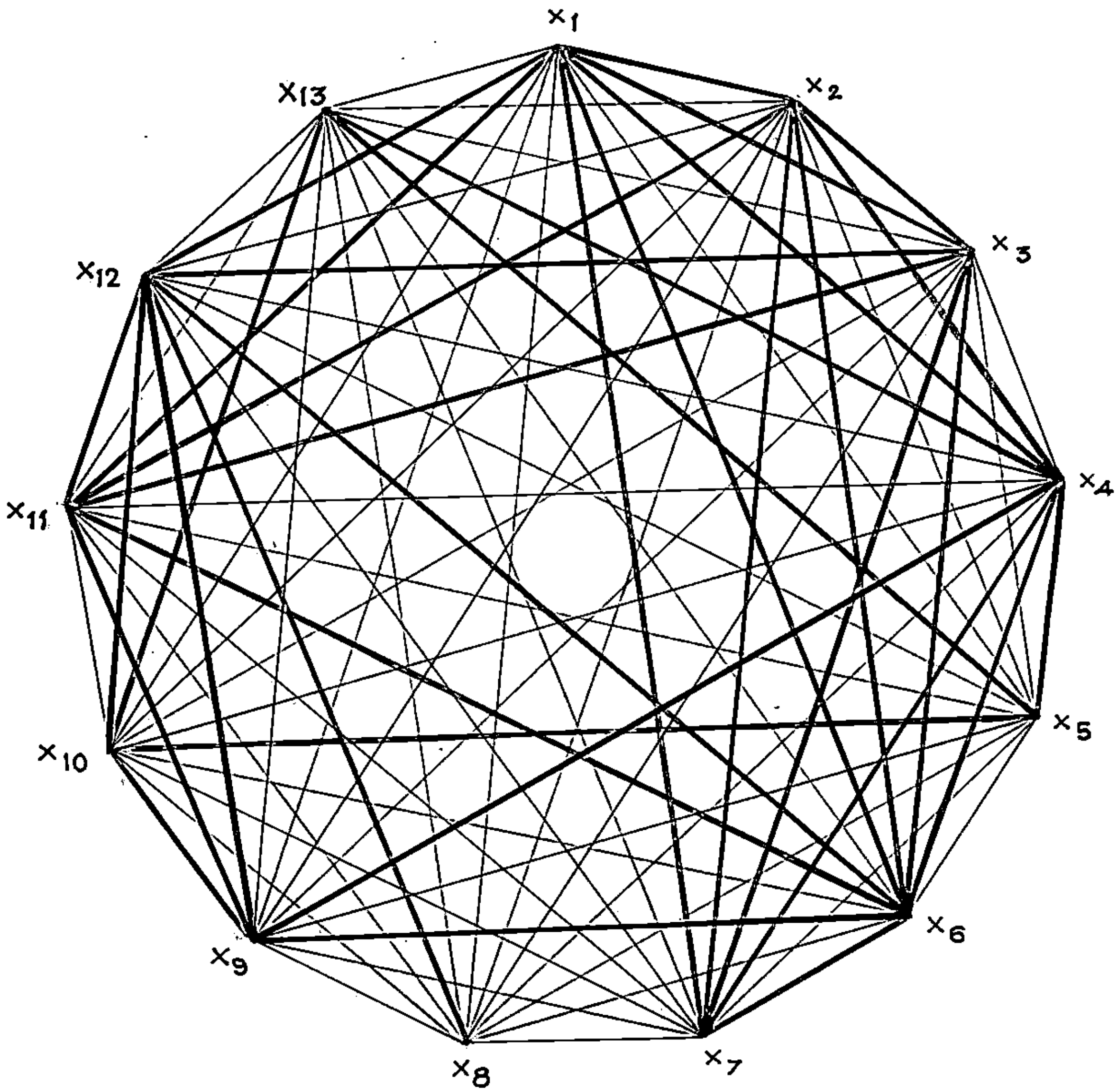
This character showed positive significant correlation with days taken for first flower bud, size of first flower, days taken for the production of second crop flower buds and number of petals in subsequent flowers.

A non significant positive correlation with number of leaves till first flower bud and number of petals in first flower was also observed.

FIG. 4. Correlation diagram

| | | |
|---|---|---|
| $X_1$ | - | Number of days for fall of petiole |
| $X_2$ | - | Number of days for bud emergence |
| $X_3$ | - | Number of days for first leaf emergence |
| $X_4$ | - | Number of leaves till first flower bud |
| $X_5$ | - | Height of scion till first flower bud |
| $X_6$ | - | Number of days for first flower bud |
| $X_7$ | - | Size of first flower |
| $X_8$ | - | Number of petals in first flower |
| $X_9$ | - | Number of subsequent shoots |
| $X_{10}$ | - | Number of second crop flower buds |
| $X_{11}$ | - | Number of days for second crop flower buds |
| $X_{12}$ | - | Number of petals in subsequent flowers |
| $X$ | - | Total height of the plant after second crop flowering |

FIG. 4. CORRELATION DIAGRAM.




POSITIVE SIGNIFICANT CORRELATION
POSITIVE NON SIGNIFICANT CORRELATION
NEGATIVE SIGNIFICANT CORRELATION
NEGATIVE NON SIGNIFICANT CORRELATION

Days taken for first leaf emergence showed negative correlation with height of scion till first flower bud, number of subsequent shoots, number of second crop flower buds and total height of the plant after second crop flowering.

4.5.4 Leaves produced till first flower bud

Leaves produced till first flower bud showed significant positive correlation with height of scion till first flower bud, days taken for first flower bud and size of first flower.

A positive non significant correlation with number of second crop flower buds, days taken for the production of second crop flower buds, number of petals in subsequent flowers and total height of the plant after the second crop flowers, was also observed.

This character showed significant negative correlation with number of subsequent shoots produced after first flower and negative non significant correlation with number of petals in first flower.

4.5.5 Height of scion till first flower bud

Height showed significant positive correlation with number of second crop flower buds and total plant height after the production of second crop flowers and showed non significant positive correlation with number of subsequent shoots.

This character showed negative correlation with number of days taken for first flower bud production, size of first flower, number of petals in first flower, days taken for the production of second crop flowers and number of petals in subsequent flowers.

4.5.6 Days taken for first flower bud production

This character showed significant positive correlation with size of first flower, days taken for the production of second crop flower buds and number of petals in subsequent flowers.

A significant negative correlation with number of subsequent shoots and non significant negative correlation with number of petals in first flower, number of second crop flower buds and total height of the plant after second crop flower bud production was also observed.

4.5.7 Size of first flower

This character showed non significant positive correlation with number of petals in first flower, number of second crop flower buds, days taken for the production of second crop flower buds and number of petals in subsequent flowers.

Size of first flower also showed a negative correlation with number of subsequent shoots and total height of the plant after second crop flower buds.

4.5.8 Number of petals in first flower

This character showed significant positive correlation with number of petals in subsequent flowers and non significant positive correlation with number of subsequent shoots.

Number of petals in first flower showed negative correlation with number of second crop flower buds, days taken for production of second crop flower buds and total height of the plant after second crop flowers.

4.5.9 Number of subsequent shoots

Number of subsequent shoots showed significant positive correlation with number of second crop flower buds and non significant positive correlation with total height of the plant after second crop flowering.

A significant negative correlation with days taken for the production of second crop flowers and number of petals in second crop flower buds was also observed.

4.5.10 Number of second crop flower buds

This character showed significant positive correlation with total height of the plant after second crop flowering.

Number of second crop flower buds also showed significant negative correlation with number of petals in subsequent flowers and non significant negative correlation with days taken for the production of second crop flowers.

4.5.11 Days taken for the production of second crop flower bud

A significant positive correlation with number of petals in subsequent flowers was observed. This character also showed a negative correlation with total height of the plant after second crop flowering.

4.6 Nutrient status or carbohydrate - nitrogen ratio

The C/N, is the ratio of estimated values of carbohydrate content and nitrogen content of buds. With the help

Table 27. Seasonal and varietal distribution of C/N ratio

| Treatments | | C/N ratio | | | | Mean |
|---|---|---|---|---|---|---|
| | | Rootstock | Ambassador | Pink Panther | Princess | |
| $T_1$ | 1st January | 1.932 | 2.097 | 2.064 | 2.260 | 2.086 |
| $T_2$ | 15th January | 1.613 | 1.935 | 1.800 | 1.754 | 1.776 |
| $T_3$ | 1st February | 2.630 | 3.010 | 3.291 | 2.722 | 2.931 |
| $T_4$ | 15th February | 2.740 | 2.887 | 3.183 | 3.155 | 2.991 |
| $T_5$ | 1st March | 2.780 | 2.980 | 3.317 | 3.145 | 3.056 |
| $T_6$ | 15th March | 2.750 | 3.018 | 3.298 | 2.858 | 2.981 |
| $T_7$ | 1st April | 2.656 | 3.122 | 2.635 | 3.007 | 2.855 |
| $T_8$ | 15th April | 2.093 | 2.096 | 2.458 | 2.126 | 2.195 |
| $T_9$ | 1st May | 2.000 | 2.111 | 2.268 | 1.971 | 2.088 |
| $T_{10}$ | 15th May | 2.052 | 2.064 | 2.127 | 1.959 | 2.051 |
| $T_{11}$ | 1st June | 2.486 | 3.377 | 3.869 | 3.965 | 3.424 |
| $T_{12}$ | 15th June | 2.395 | 3.413 | 3.428 | 3.657 | 3.223 |
| $T_{13}$ | 1st July | 2.710 | 3.672 | 3.698 | 3.935 | 3.504 |
| $T_{14}$ | 15th July | 2.820 | 4.464 | 4.176 | 4.569 | 4.007 |
| $T_{15}$ | 1st August | 2.835 | 3.270 | 2.922 | 2.957 | 2.996 |
| $T_{16}$ | 15th August | 2.603 | 3.208 | 2.716 | 2.837 | 2.841 |
| $T_{17}$ | 1st September | 2.702 | 3.198 | 3.165 | 2.880 | 2.986 |
| $T_{18}$ | 15th September | 2.814 | 3.305 | 3.475 | 3.098 | 3.173 |
| $T_{19}$ | 1st October | 2.623 | 2.787 | 3.182 | 2.799 | 2.848 |
| $T_{20}$ | 15th October | 2.826 | 2.905 | 3.301 | 3.129 | 3.040 |
| $T_{21}$ | 1st November | 2.740 | 2.838 | 3.442 | 2.946 | 3.004 |
| $T_{22}$ | 15th November | 2.440 | 2.866 | 3.227 | 2.871 | 2.851 |
| $T_{23}$ | 1st December | 2.260 | 2.478 | 2.734 | 2.559 | 2.508 |
| $T_{24}$ | 15th December | 2.180 | 2.317 | 2.305 | 2.553 | 2.339 |
| | Mean | 2.487 | 2.895 | 3.003 | 2.908 | |

F for varieties 19.98** F for fortnights 17.27**

CD for varieties 0.1451 CD for fortnights 0.356

** Significant at 1% level

of the data presented in Appendix XV and Fig. 5, the seasonal changes of carbohydrate content, nitrogen content and their ratio (C/N) have been examined.

The data on C/N ratio for rootstock and three scion varieties (Ambassador, Pink Panther and Princess) for the period from January first, 1987 to December $15^{th}$, 1987 at fortnightly intervals were analysed in randomised block design.

The Table 27 and Fig. 5 indicates that the three scion varieties $V_1$, $V_2$ and $V_3$ were on par with each other in carbohydrate content, nitrogen content and C/N ratio; but their C/N ratio was found to be significantly higher in comparison with that of the rootstock.

The carbohydrate level was maximum during June - July and minimum during February-March. Carbohydrate content showed a gradual increase from April-May to June-July, a sudden drop in August-September and an increase till October. The highest nitrogen content was registered during April-May and the lowest during February-March (Table 27). Nitrogen content started decreasing from June. An increase was noted from September upto January. The C/N ratio was maximum (4.007) for the treatment $T_{14}$ ($15^{th}$ July) and minimum (1.78)

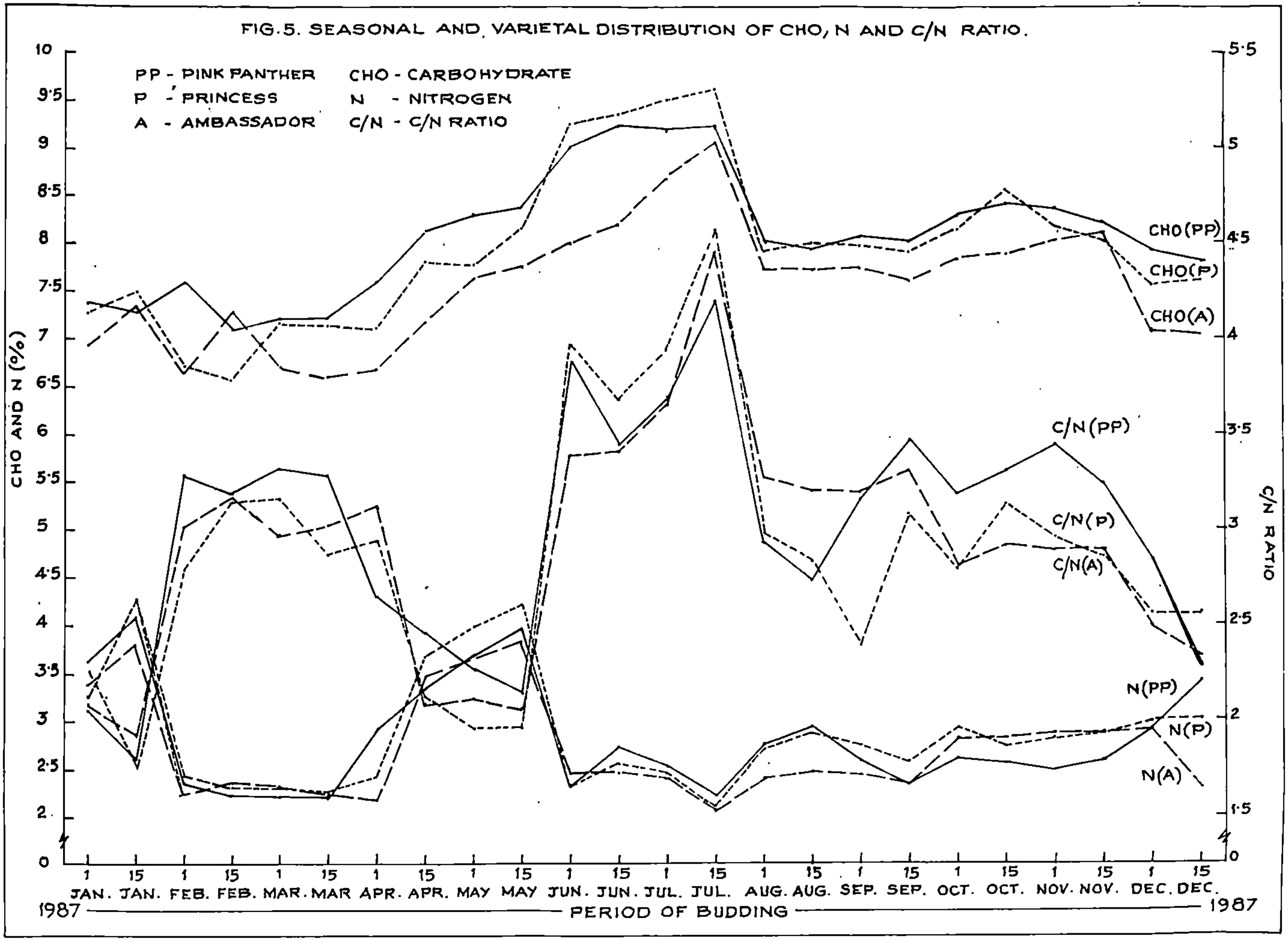


FIG. 5. SEASONAL AND VARIETAL DISTRIBUTION OF CHO, N AND C/N RATIO.
PP - PINK PANTHER
P - PRINCESS
A - AMBASSADOR
CHO - CARBOHYDRATE
N - NITROGEN
C/N - C/N RATIO
CHO AND N (%)
C/N RATIO
CHO(PP)
CHO(P)
CHO(A)
C/N(PP)
C/N(P)
C/N(A)
N(PP)
N(P)
N(A)
1 JAN. 15 JAN. 1 FEB. 15 FEB. 1 MAR. 15 MAR 1 APR. 15 APR. 1 MAY 15 MAY 1 JUN. 15 JUN. 1 JUL. 15 JUL. 1 AUG. 15 AUG. 1 SEP. 15 SEP. 1 OCT. 15 OCT. 1 NOV. 15 NOV. 1 DEC. 15 DEC.
1987 — PERIOD OF BUDDING — 1987

for $T_2$ (15th Jan.). June-July period recorded the maximum C/N ratio. From February-March, gradual increase was noted followed by a sudden decline in April-May and then a rise to a maximum in June-July.

4.6.1 Effect of C/N ratio on percentage of bud take

To determine the incluence of C/N ratio on bud take, correlations were worked out between the C/N ratio of the rootstock on the one hand and the position-wise bud take percentage of $V_1$, $V_2$ and $V_3$ individually and combined on the other. Similar correlations were worked out between the C/N ratios of the three scions $V_1$, $V_2$ and $V_3$ individually and combined, with the position-wise bud take percentage.

The rootstock C/N did not significantly influence the bud take on each variety individually and the three varieties together. The C/N ratio of $V_1$ did not significantly influence the bud take percentage of $V_1$. For $V_2$ and $V_3$, the C/N ratio significantly influenced the bud take percentage ($r = 0.3536^{**}$ and $r = 0.4446^{**}$, respectively). When the combined correlations were worked out, the C/N ratio of the scion varieties $V_1$, $V_2$ and $V_3$ as a whole significantly influenced the bud take percentage ($r = 0.3229^{**}$).

Table 28. Correlation of C/N ratio and bud take

| | $V_1$ | $V_2$ | $V_3$ | All varieties |
|---|---|---|---|---|
| Rootstock | -0.0744 | 0.0586 | 0.1474 | 0.0428 |
| Scion | 0.1725 | 0.3556** | 0.4446** | 0.3229** |

** Significant at 1% level

4.6.2 Effect of season, varieties and bud position on nutrient status

The data on C/N ratio, N percentage and CHO percentage during the season of best bud take only were analysed in CRD factorial design and the results are as follows.

4.6.2.1 Effect of season

The results are presented in Table 29.

C/N ratio

Significant variation was observed in the three fortnights which were analysed. October first fortnight recorded significantly least. C/N ratio (2.923). September second fortnight recorded maximum (3.293).

Table 29. Effect of season on C/N ratio, N% and CHO%

| Season | C/N ratio | N% | CHO% |
|---|---|---|---|
| Sep. 1st fort. | 3.082 | 2.600 | 7.834 |
| Sep. 2nd fort. | 3.293 | 2.419 | 7.835 |
| Oct. 1st fort. | 2.923 | 2.803 | 8.090 |
| F | 32.16** | 308.40** | 9.156** |
| C.D. | 0.098 | 0.033 | 0.147 |

** Significant at 1% level

Table 30. Effect of variety on C/N ratio, N% and CHO%

| Variety | C/N ratio | N% | CHO% |
|---|---|---|---|
| Ambassador | 3.098 | 2.547 | 7.739 |
| Pink Panther | 3.274 | 2.515 | 8.095 |
| Princess | 2.926 | 2.761 | 7.926 |
| F | 28.18** | 149.84** | 13.33** |
| C.D. | 0.098 | 0.033 | 0.147 |

** Significant at 1% level

Percentage of N

N content in the three fortnights showed significant variation. September second fortnight recorded minimum (2.419) and October first fortnight recorded maximum (2.803).

Percentage of carbohydrate

Carbohydrate percentage showed significant variation in the three fortnights. September first fortnight recorded minimum (7.834) and October first fortnight recorded maximum (8.090).

4.6.2.2 Effect of varieties

Varietal effect on C/N ratio, N% and CHO% are given in Table 30.

C/N ratio

Significant variation was observed in C/N ratio between the three varieties. $V_3$ recorded minimum C/N ratio (2.93) which was significantly less than $V_2$ and $V_1$. $V_2$ recorded maximum of 3.27.

Percentage of N

$V_2$ recorded minimum N percentage of 2.52 which was on par with $V_1$. $V_3$ recorded maximum of 2.76 which was significantly more than $V_1$ and $V_2$.

Carbohydrate percentage

$V_1$ had significantly less CHO percentage (7.74) than $V_2$ and $V_3$. $V_2$ recorded a maximum of 8.09 per cent.

4.6.2.3 Effect of position

The results are presented in Table 31.

C/N ratio

Significant variation was observed on the C/N ratio between the five bud positions of scion. Second bud recorded lowest C/N ratio of 2.58 which was on par with first bud, but significantly less than third bud (3.04), fourth bud (3.45) and fifth bud (3.75) which recorded maximum.

Percentage of N

Nitrogen content varied significantly in the five bud positions of the scion. Fifth bud recorded the lowest (2.32) which was significantly less than fourth (2.44), third (2.59), first (2.74) and second bud (2.93) which recorded the maximum.

Carbohydrate content

CHO varied significantly in the five bud positions of the scion. First bud recorded the lowest (7.32) which

Table 31. Effect of position on C/N ratio, N% and CHO%

| Position | C/N ratio | N% | CHO% |
|---|---|---|---|
| $1^{st}$ bud | 2.682 | 2.745 | 7.318 |
| $2^{nd}$ bud | 2.592 | 2.931 | 7.529 |
| $3^{rd}$ bud | 3.038 | 2.594 | 7.852 |
| $4^{th}$ bud | 3.449 | 2.443 | 8.332 |
| $5^{th}$ bud | 3.745 | 2.326 | 7.318 |
| F | 137.41** | 288.44** | 69.82** |
| C.D. | 0.127 | 0.042 | 0.189 |

** Significant at 1% level

was significantly less than second (7.53), third (7.85), fourth (8.33) and fifth bud (8.57) which recorded the maximum.

4.6.2.4 Interaction effect of season x variety

The results are given in Table 32.

C/N ratio

For $V_1$, the C/N ratio varied significantly in the three fortnights analysed. October first fortnight recorded minimum of 2.79 and September second fortnight recorded maximum of 3.31. For $V_2$ and $V_3$, the C/N ratio recorded in the September first and October first fortnight were on par but significantly less than that of September second fortnight.

Nitrogen content

For $V_1$ and $V_3$, N per cent varied significantly in the three fortnights analysed. September second fortnight recorded lowest and October first fortnight recorded maximum (2.85 to 2.94). For $V_2$, the N per cent recorded on September first and October first fortnight were on par but significantly less than that recorded in September second fortnight (2.32).

Table 32. Interaction effect of season and variety on C/N, N% and CHO% ratio

| Treatments | C/N ratio | N% | CHO% |
|---|---|---|---|
| $F_1V_1$ | 3.199 | 2.434 | 7.732 |
| $F_1V_2$ | 3.165 | 2.606 | 8.052 |
| $F_1V_3$ | 2.890 | 2.762 | 7.718 |
| $F_2V_1$ | 3.306 | 2.354 | 7.628 |
| $F_2V_2$ | 3.475 | 2.322 | 7.966 |
| $F_2V_3$ | 3.098 | 2.582 | 7.912 |
| $F_3V_1$ | 2.787 | 2.852 | 7.856 |
| $F_3V_2$ | 3.182 | 2.618 | 8.268 |
| $F_3V_3$ | 2.799 | 2.940 | 8.148 |
| F | 4.019* | 29.152** | 1.259$^{NS}$ |
| C.D. | 0.170 | 0.057 | - |

* Significant at 5% level
** Significant at 1% level
NS Not significant

Carbohydrate content

The interaction of season and variety on Carbohydrate content was not significant.

4.6.2.5 Interaction effect of variety x position

The Table 33 gives the result of variety x position interaction.

C/N ratio

The interaction effect of variety and bud positions on C/N ratio was not significant.

Nitrogen content

Nitrogen percentage was not influenced significantly by the interaction of varieties and position of buds.

Carbohydrate content

For first and third bud, the carbohydrate content recorded for the three scion varieties differed significantly. But for second, fourth and fifth buds, the carbohydrate content recorded were on par for $V_1$ and $V_3$. For second bud this was significantly less than $V_2$. For fourth and fifth bud $V_1$ and $V_2$ were also on par, but $V_2$ recorded significantly lower carbohydrate content than $V_3$.

Table 33. Interaction effect of variety and position on C/N ratio, N% and CHO%

| Treatments | C/N ratio | N% | CHO% |
|---|---|---|---|
| $V_1P_1$ | 2.658 | 2.673 | 7.073 |
| $V_1P_2$ | 2.494 | 2.920 | 7.243 |
| $V_1P_3$ | 2.967 | 2.523 | 7.467 |
| $V_1P_4$ | 3.512 | 2.367 | 8.317 |
| $V_1P_5$ | 3.856 | 2.250 | 8.593 |
| $V_2P_1$ | 2.980 | 2.660 | 7.917 |
| $V_2P_2$ | 2.853 | 2.813 | 8.020 |
| $V_2P_3$ | 3.236 | 2.507 | 8.093 |
| $V_2P_4$ | 3.498 | 2.343 | 8.150 |
| $V_2P_5$ | 3.803 | 2.253 | 8.297 |
| $V_3P_1$ | 2.407 | 2.900 | 6.963 |
| $V_3P_2$ | 2.398 | 3.060 | 7.323 |
| $V_3P_3$ | 2.911 | 2.753 | 7.997 |
| $V_3P_4$ | 3.337 | 2.620 | 8.530 |
| $V_3P_5$ | 3.576 | 2.473 | 8.817 |
| F | $2.33^{NS}$ | $1.16^{NS}$ | $10.76^{**}$ |
| C.D. | - | - | 0.328 |

** Significant at 1% level

NS Not significant

Table 34. Interaction effect of season and position on C/N, N% and CHO% ratio

| Treatments | C/N ratio | N% | CHO% |
|---|---|---|---|
| $F_1P_1$ | 2.658 | 2.733 | 7.153 |
| $F_1P_2$ | 2.494 | 2.886 | 7.307 |
| $F_1P_3$ | 2.967 | 2.583 | 7.690 |
| $F_1P_4$ | 3.512 | 2.440 | 8.380 |
| $F_1P_5$ | 3.856 | 2.360 | 8.640 |
| $F_2P_1$ | 2.980 | 2.580 | 7.333 |
| $F_2P_2$ | 2.853 | 2.760 | 7.510 |
| $F_2P_3$ | 3.236 | 2.420 | 7.707 |
| $F_2P_4$ | 3.498 | 2.223 | 8.170 |
| $F_2P_5$ | 3.803 | 2.113 | 8.457 |
| $F_3P_1$ | 2.407 | 2.920 | 7.467 |
| $F_3P_2$ | 2.398 | 3.147 | 7.770 |
| $F_3P_3$ | 2.911 | 2.780 | 8.160 |
| $F_3P_4$ | 3.337 | 2.667 | 8.447 |
| $F_3P_5$ | 3.576 | 2.503 | 8.610 |
| F | $1.438^{NS}$ | $1.628^{NS}$ | $1.490^{NS}$ |
| C.D. | - | - | - |

NS Not significant

### 4.6.2.6 Interaction effect of season x bud positions

The results are given in Table 34.

C/N ratio

The interaction of season and position on C/N ratio was not significant.

Nitrogen content

Nitrogen content was not influenced significantly by the interaction of season and bud positions.

Carbohydrate content

The interaction of season and bud positions had no significant influence on carbohydrate content.

# DISCUSSION

# DISCUSSION

The season plays an important role in the propagation of plants, especially under outdoor conditions. It is, therefore, essential to find out the most favourable season for propagation of the selected crop in different localities. The present investigations were carried out to find out the effect of the season and position of bud on the success of budding and further development of the scion. The results obtained from the studies are discussed in this chapter.

## 5.1 Varietal influence on the success of budding.

Since no significant difference was found among the three varieties, it may be presumed that season is more of concern for propagation i.e., for any variety of rose, budding can be performed in the suitable season.

## 5.2 Environmental parameters on the bud take

There was a marked difference in the percentage success in budding, during the different months. Better success (82 to 98 per cent) was recorded during the rainy season, from August second fortnight to October first fortnight. This result is in agreement with the reports made by Genders,(1965).

Rao (1967) found that, the suitable conditions in South India for propagation in mango prevails during August-September. Mukherjee (1964) as well as Singh and Srivastava (1962) found that in Lucknow, July was the best month for budding in mango.

During the present investigation, February first fortnight to March second fortnight was found to be the least favourable season for budding, having recorded only 26 to 44 per cent take. Ahmed (1960) also found this period to be unfavourable. Singh and Jawanda (1962) found that during the hot dry summer, the mango trees do not show much sap flow and hence the percentage of success was greatly reduced. Jauhari and Singh (1970) obtained increased success for mango budding in July than in March, due to increased relative humidity in July (93 per cent RH in July as against 60 per cent in March).

The coefficients of correlation indicate the intensity and direction of character associations. From the correlation of bud take with different meteorological observations, it can be seen that the maximum temperature of succeeding current and previous fortnights affected the bud take. However, the maximum temperature beyond two fortnights prior to budding did not exhibitsignificant association. The minimum day temperature was found to have no significant influence on the bud take. Rainfall and relative humidity of the current and previous two fortnights, proved highly favourable for good success in budding. The sunshine hours of the current and just previous fortnight showed significant negative correlation with the bud take.

When a number of characters are included in the correlation study, the direct association between the characters becomes more complex. In such a situation, the path analysis devised by Wright (1921) provides an effective measure to find out the direct and indirect effects, permitting a critical examination of the specific factors that produce a given correlation. It is an efficient tool throwing light on the contribution (direct effect of a character to the main character) and also its influence (indirect effect) through the other characters.

From the path analysis of weather parameters on the bud take, it was found that in the fortnight succeeding the fortnight of budding, the direct contribution of maximum temperature on the bud take was negative and high. The indirect effects were negligible. The other parameters were not influential. Hartmann and Kester (1986) had observed that at higher temperature, callus production is retarded, with cell injury becoming more apparent until death of the cells occurs. It is likely that in the present case also, this happens. This shows the importance of the maximum temperature on the success of budding.

In the current fortnight the direct contribution of maximum temperature on the bud take was negative; but negligible. Its positive indirect influence was through sunshine hours. The direct contribution of rainfall was positive, and maximum, the next being that of relative humidity followed by sunshine hours. The maximum direct contribution of rainfall was due to the high positive and significant correlation of rainfall and relative humidity. Though the correlation of sunshine hours with the bud take was negative and significant, it exhibited positive direct contribution. The negative value was due to the high negative indirect influence through rainfall. Eventhough maximum temperature had no direct contribution on the bud take, it indirectly influenced the bud take through the sunshine hours.

Rainfall and relative humidity have been found to have the two important factors for better success. Eventhough sunshine hours exhibited some beneficial effects on the success of budding, to better success, it was found that, in general, as the sunshine hours increased bud take was affected. As rainfall increases, relative humidity also increases while maximum temperature and sunshine hours decrease. Kuster (1903) and Ricker and Keit (1926) pointed out the influence of temperature and even more particularly, of moisture to be of great importance in determining the extent of callus development in the case of apple root grafts. They found that within certain limits, callus development increased with higher temperature and moisture and decreased with lower temperature and moisture. The results of the present studies are also in agreement with those of Shippy (1930) and Lundstad (1972) who found that alterations in temperature after budding resulted in reduced growth as well as bud take and bud take was less with Rosa multiflora at lower relative humidity. Korobov (1976) observed that for union of garden roses, optimum temperature should be between 16°C - 25°C. Highly turgid cells were found to give enhanced proliferation of callus than those in a wilted condition. Doley and Leyton (1970) also proved this by observing callus development of ash (Fraxinus excelsior) that callus production was markedly reduced as the water potential decreased. The results are also in accordance with those of Singh et al. (1979).

According to Hartmann and Kester (1986), temperature plays an important role in high cell activity. In the spring and monsoon, the plant tissues especially the cambium, are in naturally active state. The new callus arising from the cambial region will be composed of thin walled turgid cells which can easily become desiccated and die. It is important for the production of these parenchyma cells that the humidity in the vicinity of the cambial region of the graft union be kept at a high level. Regarding the sunshine hours, Burbidge (1977) found that dull moist weather is preferable for budding. Maharana and Singh (1978) also pointed out that the quickest and the highest take was obtained under direct sunlight and the losses were only minimum at diffused sunlight than in white light. Caponetti et al. (1971) and Khosh-Khui and Sink (1982) also observed that callus initiation and development occurred faster in darkness than in light. The opined that continuous darkness is detrimental to callus development. The adverse effect of sunshine hours on bud take obtained in the present studies may be due to the fact that as sunshine hours in a day increased, the temperature also increased. The high temperature was detrimental to callus formation. For initiation of callus, the sunshine hours in a day should decrease and, that is effected through rainfall and thus suitable dull moist weather for better take was maintained. This condition was only needed in the current fortnight of budding. It is important, too, that the region of the graft union be kept as free as possible from pathogenic organisms. The thin walled parenchymatous cells, under comparatively high relative humidity and temperature conditions provide a favourable medium for growth of fungi and bacteria, which are exceedingly detrimental to the successful healing of the union (Hartman and Kester, 1986).

Similar trend of influence was observed from the path analysis of meteorological parameters of the previous and two fortnights before budding. But in the previous fortnight of budding, only rainfall exhibited high positive direct contribution to bud take,and maximum temperature and relative humidity having positive contribution. Among the climatic factors during two fortnights before budding, only rainfall possessed high positive direct contribution on budding. From these, the importance of rainfall and relative humidity on budding has been clearly brought out.

The climatic factors of the succeeding fortnight and current fortnight directly contributed to and indirectly influenced the bud take by 23 per cent and 37 per cent respectively. Those of the previous fortnight and two fortnights before budding exhibited 45 per cent and 15.83 per cent influence respectively. This may be explained on the basis of one of the important internal factors influencing the formation of graft union, that is, the growth activity of the scion and rootstock at the time of budding Bose et al. (1986). For T-budding, it is essential that the bark of the rootstock and scion should slip freely so that the bark can easily be separated from the wood. At this stage, the cells of the cambium divide freely and union takes place readily (Hartmann and Kester, 1986). The rainfall during the previous fortnight and two fortnights before budding causes vigorous active growth of the rootstock and scion, thereby making the budding operation easy and budding success more.

Perusal of the meteorological data in relation to the percentage of success obtained in budding during the different months indicates that high atmospheric humidity consequent on high rainfall, neither too high nor too low maximum but high minimum temperatures and sunshine hours in a day were very congenial for the union of the rootstock and scion. The success was retarded when there was departure of any of the five meteorological parameters from the above combination. The aforesaid favourable conditions coupled even distribution of rainfall prevailed during August second fortnight to October middle, causing efficient flow of cell sap and thus enabling maximum success in budding. A gradual increase in bud take was observed upto August first fortnight and a sudden decline in take was obtained during August first fortnight accordingly with a decline in rainfall. The decrease in bud take might have been due to the wilting or reduced sap flow of the plants which were otherwise succulent by the receipt of increasing rainfall till then. It was also understood that as far as rose budding is concerned climate during the preceding, current and succeeding fortnights are critical for successful bud union.

Shippy (1930) confirmed that air moisture level below the starvation point inhibited callus formation. The rates of desiccation of the cell increased as the humidity dropped.

Parenchymatous cells making up the important callus tissue are thin-walled and tender with no provision for resisting desiccation. It is obvious that if they are exposed to dry air very long, they will be killed. The failure observed in the drier months might have been due to the above fact. The climatic factors, thus play an important role in budding of rose and this is the reason why the preferred time of budding differs at different places.

## 5.3 Biometric characters

The results of the effects of season, varieties, position of buds and their interaction on different biometric characters are discussed in the following section.

### 5.3.1 Period of budding or season

Mukherjee (1964) observed that scion growth differs between grafts prepared and different months in the case of mango. The vegetative characters before the appearance of the first flower bud like petiole fall, bud emergence, first leaf emergence, number of leaves till first flower bud and height of the scion till first flower bud appearance are seen influenced by the period of budding. Singh (1980) had pointed out that the time of budding had great influence on bud break. Plants budded during September first fortnight showed earliness in petiole fall (8.18 days) as well took minimum days for bud burst (15.82 days) and first leaf emergence (25.09 days). On the other hand the plants budded during September first and Odtober first fortnights produced minimum number of leaves (9.26) and recorded significantly lower height (15.77 cm) before the first flower appearance. Maximum leaves (12.16) and plant height (18.68) was observed in plants budded during September second fortnight (Table 8).

Period of budding influenced the first flower characters like days taken for flower bud production, flower size and petals in the flower. Plants budded during September first fortnight produced the first flower bud early (55.46 days) than those budded during September second fortnight. However, the flower size was small (6.11 cm) and the number of petals was minimum (23.43) in the former. de Vries (1976) found that plants with shorter shoots produced the first flower bud early because of their shorter juvenile period. Similar results were also obtained from this study. The plants budded during September first fortnight produced shorter stem and flowered early within eight weeks of budding. Rojas (1972) also found that the first flower could be expected within eight weeks of budding.

Maiti (1974) observed the plant height and branch number to vary with the budding dates. In the present studies also, the period of budding exhibited profound influence on subsequent growth and flowering of rose plants. Plants budded during September first and second fortnights produced more subsequent shoots (3.76 and 3.8) and flower buds (2.17 and 2.48); but the petals were significantly less. Maximum total height also was attained by the plants budded during this period. The number of flowers produced by long cane was considerably greater than that by short cane, as has been reported previously (Hughes and Cockshull 1970). The benefits of longer stems in flower production varied with season (Zieslin, 1981). In the present studies also, plants budded during the first fortnight of September possessed maximum plant height and produced more number of flowers as second crop.

### 5.3.2 Variety

During the present investigations it has been found that varietal influence was evident only in certain characters of growth after budding. Variety had no influence on petiole fall, bud emergence, first leaf emergence and plant height. The number of leaves produced before the first flower appearance was found to be a variety dependent character. Haenchen (1967) observed the growth of the budded scions was dependent on the variety. Pink Panther produced the lowest number of leaves (9.95) and Princess the highest (11.18). Cockshull and Horridge (1977) pointed out that a minimum number of leaves is required to be produced before flower initiation takes place. In their studies, the cultivar Sweet Promise produced flowers only after the production of the minimum number of leaves. They could observe seasonal differences in this minimum requirement. In the present studies, varietal differences in this minimum requirement have been observed.

- The time taken for the first flower bud production was not a variety-dependent character. Among the three varieties, flowersize was maximum (6.91 cm) for Ambassador and minimum (6.21 cm) for Pink Panther. However they possessed more or less equal number of petals (25.58), which was significantly lower than that of Princess (29.65).

Considering the growth and flowering after first flower production, days taken for the appearance of second crop flower buds, petal number and total height were not influenced by variety. The number of subsequent shoots produced was influenced by the variety. Ambassador and Pink Panther produced the maximum number of subsequent shoots (3.61 and 4.07) and flowers (2.23). Princess produced minimum shoots and flowers. This may be due to the difference in the genetic characters of the different varieties and their growth pattern.

5.3.3 Bud position

The existence of a growth potential gradient along the axis of a shoot has been known for a long time. Various hypotheses have been suggested to explain the mechanism of apical inhibition of lateral buds (Phillips, 1975). Differences in the ability of buds to sprout and grow as related to the distance of the bud from the apex was termed the "distance effect" by Snow (1925). Gregory and Veal (1957) noted a similar phenomenon in flax and pea plants which they called "the gradient of growth potential in the stem". Powell (1973) made similar observations in apple. This difference in growth ability of different buds is found both in the intact plants and in the excised nodes.

In the present investigations, buds at different positions from the flower were detached and budded. The growth parameters upto the second crop of flowers were studied. Regarding the vegetative characters before the appearance of the first flowers, first bud (from the top) showed earliness in petiole fall, bud emergence and first leaf production; but recorded minimum number of leaves and lowest height. The time taken for these characters from the first bud to the fourth bud was more or less same, being statistically not significant. Fifth bud took maximum number of days for petiole fall, bud emergence, first leaf production and also recorded the maximum leaf number. The fourth bud recorded the maximum height. Zieslin et al., (1976) and Zamski et al., (1985) also have shown that there is a "gradient of readiness to sprout" along the stem, upper buds being less inhibited. The observed differences in sprouting ability may have been due to the difference in the age of the buds (buds which are situated lower on the branch are "older"). These differences between the buds from different locations on the stem may be a result of developmental differences related to the location of the bud on the stem (Zieslin et al., 1976) and may also be due to the accumulation of an inhibitory factor being higher in the extracts of the lower stem part (Zieslin et al., 1978).

The first, second and third buds produced the flower-buds early (54.61 days); but the fourth and fifth buds took more days (80.48 days). The flower size and petal number were not found to be a position dependent character.

Number of flower buds and total plant height were seen not influenced by the position. The first, second and third buds produced more subsequent shoots and showed earliness in flowerbud production. However the petals were few. The fourth and fifth buds produced fewer shoots and delayed the flower appearance. The number of petals was, however, more.

From these results, it is seen that the upper buds on the shoots were at a similar stage of development (age), although they were of different positions on the branch as described earlier by Zieslin et al. (1976). The greater inhibition of lower buds may be due to anatomical differences in the vascular system at the time of bud differentiation or as a result of bud aging at later stages. According to Phillips, (1975) some irregularity in the vascular system may be the reason for differences in the degree of bud inhibition. Eventhough this point was not examined in the present investigations, the gradient observed in the buds of similar age (Table 14 to 16) seem to indicate that the opinion expressed does not hold good here. This gradient in characters may be due to the gradient inhibition present in the intact mother plant eventhough the upper buds were at a similar stage of development.

The differences found in the sprouting ability of different buds and of the buds of similar age situated at different positions on the branch, were similar to the gradients found in the flowering ability (Rylski and Halevy, 1972) and other morphogenetic characters of buds along the plant axis (Nozeran *et al.*, 1971). This may indicate that these differences are developmental rather than correlative. The control for this phenomenon would, then, lie within the differentiating apex.

The initial effect on sprouting may be different from the subsequent effect on the growth of the sprouted shoot. Zieslin and Halevy (1976), Gender (1965); Pal (1972) and Fairbrother (1970) explained that the best buds are those near the middle of the stem. According to them, those at the top just below the flower, are often too advanced and those near the base less advanced. Pal (1987) was also of the opinion that the buds selected should not yet have started to elongate. From the analysed data of the most favourable season for budding, it was seen that the upper buds were faster in growth than the lower ones. The year round studies made on the biometrical characters (Appendices II to XIV); indicate that the first bud of $V_3$ failed to produce subsequent shoots (Appendix X). Appendix XI indicates that almost all the first buds of $V_1$, $V_2$ and $V_3$ failed to produce second crop of flower buds in the subsequent vegetative shoots. The fourth and fifth buds of $V_1$, $V_2$ and $V_3$ produced the second set flower buds in most subsequent shoots, eventhough the number of subsequent shoots produced was less than that of the first and second buds. But the first, second and third buds, produced second crop of flower buds, only in some of the subsequent shoots. Most of the plants produced from the first and second buds of $V_1$, $V_2$ and $V_3$ were comparatively weak and died after the first flowering was over. However, some of them died after production of subsequent shoots. The plants produced from the third, fourth and fifth buds, lasted long in a better condition and showed good flowering. The earliness in growth of the first, second and third buds in the favourable season may be due to the anatomical differences.

According to Tomlinson, (1978) and Zamski *et al.* (1985), the upper buds are sylleptic i.e., their growth continues without interruption immediately on formation, and the lower buds are proleptic, i.e., they undergo a period of inhibition prior to sprouting. The vigour of the plants developed from the upper buds was reduced after their early growth. But with reference to the lower buds, eventhough the early growth was very slow, the vigour of the plants were maintained. According to de Vries and Smeets (1979), growth control in roses should mean the highest possible vigour, the ability to stand continuous harvesting (pruning) of the scion and the ability to perform well under different environmental conditions. In the present investigations, among the five buds, the fourth and the fifth were found to be better for budding, when plant vigour was considered.

5.3.4 Interactions

Period of budding x variety interaction did not influence some of the vegetative characters before first flower appearance like petiole fall, bud emergence and first leaf production eventhough period of budding alone greatly influenced them. However, with respect to the number of leaves and height of the scion, the interaction exhibited profound influences. Ambassador and Pink Panther produced minimum leaves when budded during September first and October first fortnights; Princess was found to produce significantly more number of leaves on all the three fortnights. For Ambassador and Pink Panther, budding during September second fortnight was favourable for greater plant height. For Princess, September second and October first fortnights were favourable for greater plant height.

Days taken for first flower bud production and flower size were not influenced by the interaction. Petal number was influenced. Princess and Pink Panther recording minimum petals when budded during September first fortnight and maximum when budded during October first fortnight. Ambassador produced flowers with significantly more petals when budded during September first fortnight than during September second fortnight.

The interaction did not influence the time taken for production of second crop flower bud and their number. But significantly more number of shoots and maximum total height were recorded for Ambassador and Princess when budded during September first fortnight. Pink Panther showed lesser height and less number of shoots than the other two varieties during all the three fortnights. Ambassador produced more petals when budded during September first fortnight. For Pink Panther and Princess, more petals were found when budded during October first fortnight. The influence of the period of budding x variety interaction revealed that, these characters exhibit fluctuation for different varieties budded during different periods or seasons.

The growth characters, the characters of the first flower and the characters of the second crop flowers were not seen influenced by the variety x position interaction.

From the data on period of budding x bud position interaction it was found that irrespective of the bud position, budding during September first fortnight was favourable for early petiole fall, bud emergence and first leaf emergence. In this period itself, the first and second buds showed earliness than the third, fourth and fifth buds. For first leaf production, fifth bud took more days when budded during October first fortnight. In the case of plant height, the first, second, third and fourth buds recorded more or less the same height in all the three fortnights;

but the fifth bud showed maximum height when budded during October first fortnight. Considering the first flower characters and growth characters after the first crop of flower buds, period of budding x position interaction was not influential, eventhough period of budding alone influenced all of them, and position of buds, some of them.

5.4 Correlations of biometric characters

Strong positive inter correlation was seen between fall of petiole, bud emergence, first leaf production, number of leaves till first flower bud, time taken for first flower bud production, first flower size and time taken for the production of second crop flower buds. When petiole fall occurred early, bud emergence, first leaf production, production of first crop of flower buds and production of second crop of flower buds occurred early, the characters being significantly and positively correlated. On the otherhand, with early fall of petiole there were lesser number of leaves till the production of first flower bud, besides the flowers of the first crop being small.

Another strong positive correlation exists between fall of petiole, first leaf production, days taken for first flower bud production, days taken for second crop flower bud production and petals in second crop of flowers. Early the petiole fall, first leaf production, first flower bud production second crop flower bud production, all occurred early and the flowers of the second crop being with less number of petals. Petals present in first flower also found to have positive significant correlation with petals in second crop flowers. This means if the petals were more in first flower, second crop of flowers also possessed more.

Leaves present upto the formation of first flower showed positive significant correlation with plant height till first flower bud which in turn showed significant correlation with number of second crop flower buds produced and total height of plant after the production of second crop flowers. This may be explained as, if the leaves were more the plant possessed more height till the production of first flower bud and if the height was more second crop of flower buds produced and total height of plant after second crop of flowers were more. Hughes and Cockshull, (1970) also reported similar results.

The number of vegetative shoots produced after first flower showed positive significant correlation with number of second crop flower buds i.e., if the axillary shoots produced after first flower were more, more the number of second crop of flower buds.

It was found that leaves till first bud was negatively correlated with number of subsequent shoots i.e., if the leaves were more till first bud subsequent shoots produced will be few. This may be due to the inhibition gradient existing in every shoot of a plant from top downwards. The bottom buds were more inhibited that they do not show bud outgrowth.

It was also seen that the time taken for the production of first flower bud and the number of subsequent shoots produced were negatively correlated i.e., if more days were taken for the production of first flower bud, the less the subsequent shoots produced. Another negative significant correlation was observed between the number of subsequent shoots produced and the time taken for second crop flower bud production and petals present in second crop of flowers i.e., if the subsequent shoots were more, early the production of second crop buds and the flowers in the second crop with less number of petals.

The number of second crop flower buds and petals present in flowers of second crop were negatively correlated. i.e., the more the flower buds the less the petals.

5.5. Nutrient status or carbohydrate - nitrogen ratio

In February-March, carbohydrate and nitrogen content was low; but nitrogen content gradually increased from February-March upto April-May. During the period carbohydrate content was low, indicating the production of more vegetative growth leading to lowering of C/N ratio. Akbar, (1979) in his studies found that the carbohydrate and nitrogen content varied with season and the growth pattern of the plant, the Edward rose. Subsequent reduction in nitrogen content indicated the termination of vegetative phase and commencement of flowering. From April-May, carbohydrate content showed gradual increase upto June-July during which the nitrogen content was decreasing. Carbohydrate started accumulating in the later months, probably because it was not utilized either for vegetative growth or for the production of flowers, as the flower production was low in April. C/N ratio was high in June-July due to accumulation of carbohydrate. From August, carbohydrate content synchronised with the drop in the rate of flower yield. Eventhough the

C/N ratio of three scion varieties were similar, it was highly fluctuating compared to rootstock C/N. The C/N ratio of rootstock was more or less constant during the experimental period because briar the rootstock was not allowed to put-forth vegetative growth beyond the required level.

### 5.5.1 C/N ratio on bud take

According to Hartmann and Kester (1986), in the case of the healing process in T-budding of rose, about three days after budding, the terminal cells of the broken xylem rays and adjacent cambial derivatives on the exposed surface of the stock begin to enlarge and divide, leading to the production of callus strands. Simultaneously callus strands develop from terminal cells of broken phloem rays and adjacent young secondary phloem cells on the cut surface of the inner-side of the bud piece. In the present investigations, it was found that, the scion C/N ratio significantly influenced the bud take while the rootstock C/N did not significantly influence the take. The carbohydrate reserves (nutrient status) of the scion may have accelerated the formation of callus tissue from the bud piece thus, enabling the healing process to be completed earlier. From Fig. 5, it can be seen that in August to October, during which, maximum bud take was obtained, carbohydrate and nitrogen content was comparatively at a steady level than during the other seasons, when the fluctuation was more.

5.5.2 Season, varieties and bud position on nutrient status

From the analysis of the data of the carbohydrate, nitrogen and C/N ratio of each bud positions of the three scion varieties, in the three fortnights during which maximum bud take was obtained, it was understood that season plays an important role in the fluctuation of carbohydrate percentage, nitrogen percentage and C/N ratio.

In this precised analysis, the varieties significantly influenced the carbohydrate, nitrogen and C/N ratio since the varietal characters and growth habit differs in each variety. But when all the year round data were analysed varietal effect was not significant.

Influence of, bud position from the flower downwards in the scion, on carbohydrate, nitrogen and C/N ratio is an important factor to be considered since each bud showed different stages of anatomical development and different bud take. The nitrogen percentage was lowest in the buds in the order of fourth, third, first etc. However second bud possessed highest nitrogen content. This was in conformity with the results of Chadha et al. (1973), Pathak and Pandey, (1978) and Singh and Rajput, (1978). First bud recorded lowest carbohydrate content and it increased in the order of second, third, fourth and fifth, of which, the fifth bud recorded the highest. Tucky and Green, (1935) also proved that starch content decreased as a gradient from base to tip and nitrogen content increased from base to tip as a gradient. As fas as the C/N ratio was considered, second bud possessed lowest C/N ratio since second bud had highest nitrogen content which was on par with the first bud. From second bud onwards upto fifth bud, gradual increase was noted. Fifth bud recorded maximum C/N ratio. The increasing carbohydrate content from tip to base revealed that the reserve foods were more in lower buds and the reverse condition of nitrogen, that growth starts, early in upperbuds, as obtained from present investigations also.

### 5.5.3 Interactions

Season x variety interaction alone influenced the nitrogen content and C/N ratio since season and variety possessed individual significant influence on C/N ratio

N content. i.e., the C/N ratio and N content vary with each variety in different seasons. But when carbohydrate content was considered only variety x position interaction was influential. The three varieties differed significantly for each position because of developmental variations and varietal characters.

# SUMMARY

## SUMMARY

An Investigation was carried out at the Department of Horticulture, College of Agriculture, Vellayani during a period of one year starting from January 1987 to December 1987 to find out the effect of season and position of bud on the success of budding in rose plants. The experiment was laid out in factorial Completely Randomised Design with three replications. The treatments consisted of combinations of three varieties 'Ambassador', 'Pink Panther' and 'Princess' with five scion bud positions, starting immediately below the flower. Budding was done at fortnightly intervals and each time, 45 buddings were done. The daily meteorological data collected were examined for their possible role in the success of budding. Thirteen growth characters were also recorded and analysed. The nutrient status of the scions and rootstock were estimated to determine their role in the success of budding. The results of the study are summarised below:

1. There was no significant difference among the three varieties 'Ambassador', 'Pink Panther' and 'Princess' in respect of success in budding. It was thus revealed that as far as propagation is concerned variety is of not much concern; but the season is the most important factor.

2. The time of budding significantly influenced the success in bud take. Better success (82-98%) was recorded during the rainy season, August second fortnight to October first fortnight, during which period, the environmental factors were balanced and quite favourable for bud take. February first fortnight to March second fortnight was found to be the least favourable season for budding (with only 26 to 44 per cent take) presumably due to the desiccation of the new parenchymatous cells in the callus, due to the high temperatures that prevailed.

3. Maximum temperature in the succeeding, current and previous fortnights of budding showed significant negative correlation with the percentage bud take. Desiccation of parenchymatous cells would have caused the failure of bud union.

4. Minimum day temperature exhibited no significant effect on bud take in the succeeding (lag +1), current (lag 0), previous (lag -1) and two fortnights before (lag -2) budding.

5. Rainfall showed significant positive correlation with bud take in lag 0, lag -1 and lag -2 periods and among the five weather parameters studied, rainfall was found to be the major factor influencing the bud take.

6. Relative humidity exhibited significant positive correlation, and the sunshine hours, negative correlation with bud take during lag 0 and lag -1 periods.

7. Path analysis revealed that the direct effect of maximum temperature was negative during the lag +1 period.

During lag 0 period, maximum direct effect on success in budding was exerted through rainfall. Relative humidity and sunshine hours also had positive direct effect. But the maximum temperature showed negative direct effect.

During lag -1 and lag -2 periods, the maximum direct effect on budding was shown by rainfall. Relative humidity and maximum temperature also showed positive direct effect. Sunshine hours possessed negative direct effect on budding.

Path analysis thus indicated that high atmospheric humidity caused by high rainfall, medium level of temperature and medium level of sunshine hours in a day are very congenial to the union of rootstock and scion.

8. The climatic factors during the fortnight succeeding budding directly contributed and indirectly influenced the bud take by 23 per cent and those of the current and previous fortnights and two fortnights before, 37 per cent, 45 per cent and 15.83 per cent, respectively. The preceding, current and

succeeding fortnights were found to be critical, as far as success in rose budding was concerned.

9. The period of budding significantly influenced the vegetative and the flower characters except the number of days taken for the production of second crop flower buds.

10. Number of leaves produced before the first flower appearance, first flower size and petals in first flower, number of subsequent shoots produced and number of second crop of flower buds were found to be variety-dependent characters.

11. All the vegetative characters before the appearance of the first flower, the first flower characters (like days taken for the production of first flower bud, number of petals in first flowers) as well as subsequent growth and flowering characters (like number of subsequent shoots, days taken for the production of second crop of flower buds, petals in subsequent flowers) were influenced by the scion bud position.

12. Period of budding x variety interaction significantly influenced the number of leaves produced, height of scion till first flower, petals in first flower, number of subsequent shoots produced, petals in subsequent flowers and total height of the plant after second crop flowering.

13. The period of budding x bud position interaction significantly influenced the fall of petiole, bud emergence, first leaf production and height of scion till first flower bud.

14. The first and second buds were early to sprout and flower till the production of first flower bud, but the plants were comparatively weak. In the present investigations, the fourth and the fifth buds were found to be better for budding as far as plant vigour was considered.

15. A strong positive inter correlation was found to exist between fall of petiole, bud emergence, first leaf production, leaves till first flower bud, time taken for first flower bud production, first flower size and time taken for second crop flower bud production.

16. Significant negative correlation was observed between leaves produced till first flower bud and number of subsequent shoots produced after first flower; days taken for first flower bud production and number of subsequent shoots produced. Subsequent shoot number was inturn negatively correlated with days taken for second crop flower bud production and petals present in subsequent flowers. Number of second crop flower buds and petals in subsequent flowers were negatively correlated.

17. The carbohydrate and nitrogen content of the scion varied significantly throughout the year, according to the flowering phase and vegetative phase of the plant.

18. In the present investigations, it was found that, the scion C/N ratio significantly influenced the bud take while the rootstock C/N did not significantly influence the take. The carbohydrate reserves of the scion may have accelerated the formation of callus tissue from the bud piece thus, enabling the healing process to be completed earlier.

19. The carbohydrate and nitrogen content varied significantly with scion bud position and with variety.

REFERENCE

## REFERENCES


*Ahijer, M.A. (1973). The effect of the mean diurnal temperature after budding on the production of apple planting material. Azerbaijan. No.5: 16-19.

Ahmed, S. (1960). Propagation of mangoes. Punjab Fruit J., 23: 49-53.

Akbar, S.M. (1979). Studies on the effect of nutrients and their mode of application of Edward rose. (Rosa bourboniana Desp.) M.Sc. Thesis. Faculty of Hort. T.N.A.U., Coimbatore.

Aswathi, D.N., Singh, M.M., Srivastava, R.P. and Misra, R.S. (1982). Evaluation of epicotyl grafting in walnut in relation to success and survival. Prog. Hortic., 14 (2/3): 178-179.

*Bik, R.A. (1970). Manuring trials with Baccara roses. Vakbl. Bloemist. 25: 478-479.

Bose, T.K., Mitra, S.K. and Sadhu, M.K. (1986). Propagation of Tropical and subtropical Horticultural crops. Naya Prakash, Calcutta, India.

Burbidge, F.W. (1977). Cultivated plants their propagation and improvement. Prakash publishers, Jaipur.

*Button, J. (1978). The effects of some carbohydrates on the growth and organization of Citrus ovular callus. Zeitschrift fuer Pflanzenphysiologie. 88 (1): 61-68.

Caponetti, J.D., G.C. Hall, and R.E. Farmar, Jr. (1971). Invitro growth of black cherry callus. Effects of medium, environment, and Clone. Bot. Gaz. 132 (4): 313-18.

Chadha, K.L., Arora, J.S., Ravel, P. and Shikhamany, S.D. (1973). Variation in the mineral composition of the leaves of guava. (Psidium guajava. L) as affected by leaf position, season and sample size. Indian J. Agric. Sci., 43 (6): 555-561.

Cockshull, K.E. and J.S. Horridge. (1977). Apical dominance and flower initiation in the rose. J. Hort. Sci., 52: 421-427.

Dayton, D.F. (1976). Scion selection for greenwood grafting in apple. Fruit. Var. J., 30 (2): 69-70.

de Vries, D.P. (1976). Juvenility in hybrid tea roses. Euphytica. 25 (2): 321-328.

de Vries, D.P. and Smeets, L. (1978). Hybrid tea roses under controlled light conditions. 1. The effect of the level of irradiance on the growth and development of seedlings. Neth. J. Agric. Sci., 26 (1): 119-127.

de Vries, D.P. and Dubois, L.A.M. (1983). Relations between time of sprouting of the scion in the nursery, the time of formation and number of basal bottom-breaks and the number of harvested shoots of glasshouse rose-clones on R. canina Inermis., Sci. Hortic., 21 (4): 375-379.

de Vries, D.P. and Dubois, L.A.M. (1983). Relations between basal bottom-breaks and harvested shoots in own rooted hybrid tea rose seedlings and their clones. Institute for Horticultural Plant Breeding, Wageningen, Netherlands.

de Vries, D.P. and Dubois, L.A.M. (1984). Scion-rootstock relationships in hybrid tea cut roses on Rosa canina 'Inermis'. Neth. J. Agric. Sci., 32 (1): 3-7.

de Vries, D.P., Smeets, L., and Dubois, L.A.M. (1980). Genetic variation for the time of first flower and shoot length in hybrid tea rose seedling populations under a range of temperatures. Sci. Hortic. 13 (1): 61-66.

Doley, D. and Leyton, L. (1970). Effects of growth regulating substances and water potential on the development of wound callus in Fraxinus. New Phytol. 69: 87-102.

*Eccher, J. and Mignani, I. (1975). Biometrical observations on characteristics of the vegetative development of roses. Rivista della Ortoflorofrutticoltura Italiana 59 (1): 41-47.

*Estcout, (1974). Ann. J. Roy. New Zealand Inst. Hort. No. 2: 12-15.

Fairbrother, F. (1970). Roses. Penguin books Ltd. England.

Fann, Y., Davies, F.T., JR and Paterson, D.R. (1983). The influence of rootstock lateral buds in bench chip-budded 'Mirandy' field roses. Sci. Hortic., 20 (1): 101-106.

*Galkina, I.F. (1979). Factors determining the extent of take in bench grafting of apples. Sadovodstvo, Vinogradarstvo i Vinodelie Moldavii. No. 11: 59-60.

Genders, R. (1965). The Rose. The Bobb Merrit Company, Inc. Indianapolis, Kansas City, New York.

Gregory, F.G. and Veal, J.A. (1957). A reassessment of the problem of apical dominance. Symp. Soc. Exp. Biol. 11: 1-20.

*Haenchen, E. (1967). The effect of several factors on the success of raising bush roses. Arch. Gartenb., 15: 453-75.

*Haenchen, E. (1981). Investigations into rose varieties grown in the GDR. 5. Plant height and diameter of hybrid tea and floribunda roses. Archiv Fur Gartenbau. 29 (6): 293-306.

*Haenchen, E. (1985). Results of 3 year comparative studies on the flowering behaviour of outdoor rose cultivars propagated by cuttings and grafting. Archiv Fur Gartenbau. 33 (5): 259-273.

Hartmann, T.H. and Kester, E.D. (1986). Plant propagation - principles and practices, 4th Ed. Prentice - Hall of India. Pvt. Ltd. New Delhi.

Hughes, A.P. and Cockshull, R.E. (1970). Commercial bloom production in the greenhouse rose, Pink Sensation. Exp. Hortic., 20: 1-9.

Jackson, M.L. (1973). Soil Chemical Analysis. Prentice Hall of India (P) Ltd. New Delhi.

Jacobs, G., Zieslin, N. and Halevy, A.H. (1980). Factors affecting $^{14}C$ - sucrose uptake by single node explants of rose flower stems. Physiol. Plant., 50 (3): 251-254.

Jauhari, O.S. and R.D. Singh. (1970). Effect of bud activation lopping and wrapping material of budding in mango (Mangifera indica L) var. Langra, Punjab Hort. J., 10: 198-202.

*Johansson, J. (1979). Leaf composition of flowering shoots from different greenhouse rose cultivars as influenced by rootstock and season. Acta. Agric. Scad., 29 (1): 85-92.

Joolka, N.K. (1986). A note on the effect of method and time of budding on budtake in kinnow mandarin. Haryana J. Hort. Sci., 15 (1/2): 54-56.

*Kaplankiran, M; Ozsan, M. and Tuzcu, O. (1985). Effects of the relationship between the rootstock and the scion on the content of carbohydrates in various citrus rootstocks. Doga Bilim Dergisi, Dz (Tarim ve - Ormanilik) 9 (3): 261-268.

Khera, A.P., Makhija, M., Chitkara, S.D. and Chauhan, K.S. (1981). Development of leaf nutrient concentration standards for sub-tropical peach (Prunus persica). Haryana Agric. Univ. J. Res., 11 (2): 181-184.

Khosh-Khui, M. and Sink, K.C., (1982). Callus induction and culture of Rosa. Sci. Hortic., 17 (4): 361-370.

*Korobov, V.I. (1976). Certain characteristics of rootstock/scion union in garden roses budded at different times. In Okharana Sredy i Ratsional'n Ispol'z. Rastitel'n. Resursov. Nauka: 243-245.

*Kuster, E. (1903). Pathologische Pflanzenanatomie. First ed. (Transl. by Frances Dorrance, 1913).

Lal, S.D. and Seth, J.N. (1984). Rosa multiflora - a good rootstock for rose budding. Prog. Hortic. 16(1/2): 158.

*Lundstad (1965). Meld Norg - Landbettoqsk; 44: 1-7.

*Lundstad, A. (1972). The effect of climate on the budding of roses. Meldenger frv Norges Landnukshoqskole. 51 (29): 16.

*Lundstad, A. (1974). Plant losses, plant size and flowering in garden roses on different rootstocks. Meld. Nor. Landbrukshoqsk., 53 (16): 34.

Maharana, T. and Singh, S.B. (1978). Effect of different light conditions on the bud union and subsequent growth of rose. Orissa J. Hortic. 6 (1/2): 74-76.

Mahlstede John, P. (1957). Plant propagation. John Wiley and sons. Inc.

Maiti, R.G. (1974). Effect of time and method on budding tea and floribunda roses. South Indian Hort., 22 (3/4): 125-126.

Mederos, S. and Rodriguez Enriquez, M.J. (1987). In vitro propagation of "Golden Times" roses. Factors affecting shoot tips and axillary bud growth and morphogenesis. Acta. Hortic., II (212): 619-624.

Millar Gault, S. and Synge (1971). The Dictionary of roses. Rain bird Reference Book Limited, London.

Misra, R.S. (1985). A note on soft wood grafting in pecan nut. Prog. Hortic., 17 (1): 80-82.

Moe, R. (1972). Effect of day length, light intensity and temperature on growth and flowering in roses. J. Ame. Soc. Hort. Sci., 97 (6): 796-800.

Mor. Y. and Halevy, A.H. (1979). Translocation of $^{14}C$ assimilates in roses. 1. The effect of the age of the shoot and location of the source leaf. Physiol. Plant 45: 177-182.

Moss, G.I. and Dalgleish, R. (1982). Container-grown roses, five months from cutting to flowering. Combined Proceedings, International Plant Propagator's Society. 32: 155-162.

Mukherjee, S.K. and P.K. Majumder. (1964). Effect of different factors on the success of veneer grafting. Indian J. Hort., 21: 46-50.

Mukhopadhyay, A., Banicar, G.J. (1982). A preliminary report on rootstock trial in roses. South Indian Horticulture. 30 (1): 61-63.

Nanjan, K. and Kumar, S. (1983). Comparative efficasy of patch budding versus shield budding in rose. South Indian Hort. 31 (2/3): 125-126.

Nanjan, K., Hiriyan, M.A. and Ravindran, R. (1971). A new technique in propagation of roses. Madras Agric. J. 59: 526-28.

Nozeran, R., Bancilhon, L. and Neville, P. (1971). Intervention of internal correlation in the morphogenesis of higher plants. Advance. Morphogenesis 9: 1-66.

Pal, B.P. (1972). The Rose in India. 2nd Ed. I.C.A.R., New Delhi.

Pal, B.P. (1987). All about roses. Tarang paperbacks Vikas Publishing House Pvt. Ltd. New Delhi. 10th Edn.

Pandey, D.S. and Sharma, R.K. (1976). Studies on the performance of rose varieties on different rootstocks in Allahabad. Plant Sci., 8: 88-92.

Panse, B.G. and Sukhatme, P.V. (1967). Statistical methods for agricultural workers. Indian Council of Agricultural Research. New Delhi.

Pathak, R.A. and Pandey, R.M. (1978). Studies on the chemical composition of leaves as associated with position on the shoot in mango (Magnifera indica. L.) cv. Dashehari. Prog. Hortic., 9 (4): 17-23.

Phillips, I.D.J. (1975). Apical dominance, Annu. Rev. Plant Physiol. 26: 341-367.

Powell, L.E. (1973). Naturally occurring plant growth regulators and their physiological roles in fruit trees. Acta Hort. 34: 33-40.

Ram, S. and Bist, L.D. (1982). Studies on veneer grafting of Mango in Tarai. Punjab Hort. J., 22 (1/2): 64-71.

Rao, V.N.M. (1967). Propagation practices. The mango handbook, ICAR, 32-69.

Riker, A.J. and G.W. Keitt. (1926). Studies of crowngall and would overgrowth on apple nursery stock. Phytopathol. 16: 765-808.

*Rojas, M. (1972). A new method of grafting for the rapid propagation of rose bushes (Rosa multiflora Japonica). Revista ICA. 7 (2): 111-119.

*Rupperecht (1971); Dlsche Gartenb. 18: 160-161.

Rylski, I. and Halevy, A.H. (1972). Factors controlling the readiness to flower of buds along the main axis of pepper (Capsicum annum. L.) J. Amer. Soc. Hort. Sci. 97: 309-312.

Sandhu, A.S. and Zora Singh. (1983). Seasonal changes in the levels of metabolites during dormancy in sub-tropical Peach (Prunus persica Batsch) cv. Sharbati. Indian J. Plant. Physiol., 26 (1): 39-14.

*Savin, E.Z. (1976). Take and growth of apple bench grafts in relation to the position of the grafting material on the shoot. Sadovodstvo. Vinogradarstvo i Vinodelie Moldavii No. 11.

*Savin, E.Z. (1980). Temperature regime during the stratification of bench-grafted apples and sour cherries. In Selektsiya i Agrotekhn. Vyrashchivaniya Plodov i Yagodn. Kul'tur v Sredn Povolzh'e Kuibyshev. USSR: 67-75.

Sawke, D.P., Salvi, M.J. and Patil, M.M. (1985). Prospects of clonal propagation in Cashewnut by softwood grafting. Indian Cashew Journal. 17 (4): 15-17.

*Shcherbakova, S.P. and Maslova, A.E. (1982). Optimal dates for peach budding in the Crimean Steppe zone. Byulletin Gosudarstvennogo. Nikitskogo Botanicheskogo Sada No. 49: 63-67.

Shippy, W.B. (1930). Influence of environment on the callusing of apple cuttings and grafts. Amer. Jour. Bot. 17: 290-327.

Singh, J.R. and R.P. Srivastava (1962). Studies in Mango. Indian J. Hort., 19: 130-34.

Singh, K.K. and J.S. Jawanda. (1962). Some promising seedling mango trees of Punjab. Punjab Hort. J., 2: 133-38.

Singh, S.N. (1972). Studies on rootstocks and budding in rose. Hort. Adv., 9: 39-42.

Singh, N.P. and Rajput, C.B.S. (1978). Effect of leaf age and position and fruiting status on guava leaf mineral composition. J. Hortic. Sci., 53 (1): 73-74.

Singh, N.P., Srivastava, R.P., Singh, H. and Rajput, M.S. (1979). Seasonal effect on success in different methods of mango propagation. Ind. J. Hort. 36 (2): 134-139.

Snow, R. (1925). The correlative inhibition of the growth of axillary buds. Ann. Bot. 39: 841-859.

Somogui, M. (1952). Notes on sugar determination. J. Biol. Chem., 200: 145-54.

*Statens Forsogsvirksomhed. (1969). Cultural trials with roses. Gartner Tidende. 85: 369-71.

Swarup, V. (1967). Garden flowers. National Book Trust I. New Delhi.

*Syrbu, I.G. (1975). Time of budding in relation to the growth characteristics of the graft components. Sadavodstvo, Vinogradarstvo, Vinodelic Moldavii No. 11: 31-35.

Tomlinson, P.B. (1978). Tropical trees as living systems., Branching and axis differentiation. Cambridge University Press. Cambridge. 187-207.

Tukey, H.B. and Green, E.L. (1935). Gradient composition of rose shoots from tip to base. Plant. Physiol., 9: 157-163.

*Ugolik, M. (1981). Effect of budding date and the type of tie used on budding success in the sour cherry cultivar, Lutowka. Akadamia, Rolnicza: 16-17.

Van Staden, J. (1982). Transport of ($8^{14}C$) - Zeatin from mature rose leaves after shoot decapitation. Bot. Gaz. 143 (2): 201-205.

Wells James, S. (1955). Plant propagation practices. The Macmillan Company. 153.

Wright, S. (1921). Correlation and causation. J. Agri. Res., 20: 557-587.

Zamski, E; Oshri, S. and Zieslin, N. (1985). Comparative morphology and anatomy of axillary buds along a rose shoot. Bot. Gaz. 146 (2): 208-212.

Zieslin, N. and Halevy, A.H. (1976). Components of axillary bud inhibition in rose plants. 1. The effect of different plant parts (correlative inhibition). Bot. Gaz. 137(4): 291-296.

Zieslin, N., Haaze, H. and Halevy, A.H. (1976). Components of axillary bud inhibition in rose plants. ll. The effect of bud position on degree of inhibition. Bot. Gaz., 137 (4): 297-300.

Zieslin, N. and Halevy, A.H. (1978). Components of axillary bud inhibition in rose plants. lll. Effect of stem orientation and changes of bud position on the stem by budding. Bot. Gaz. 139 (1): 60-63.

Zieslin, N., Spegelstein, H. and Halevy, A.H. (1978). Components of axillary bud inhibition in rose plants. iv. Inhibitory activity of plant extracts. Bot. Gaz. 139 (1): 64-68.

Zieslin, N. and Byrne, T. (1981). Plant management of greenhouse roses: flower cutting proceedure. Sci. Hortic., 15: 179-186.

*Originals not seen

# APPENDICES

**Appendix I** Weather parameters for 1987

| | | Maximum Temperature (°C) | Minimum Temperature (°C) | Rainfall (mm) | Relative Humidity (%) | Sunshine Hours |
|---|---|---|---|---|---|---|
| Jan. | 1-14 | 31.49 | 19.65 | 0 | 75.46 | 8.67 |
| | 15-31 | 32.09 | 20.81 | 0 | 70.38 | 10.46 |
| Feb. | 1-14 | 31.27 | 21.20 | 0 | 64.39 | 10.25 |
| | 15-28 | 32.10 | 21.90 | 0 | 69.25 | 10.22 |
| Mar. | 1-14 | 33.81 | 22.91 | 0 | 71.60 | 10.52 |
| | 15-31 | 32.09 | 23.68 | 4.80 | 72.52 | 10.50 |
| April | 1-14 | 34.20 | 26.23 | 0 | 77.07 | 9.97 |
| | 15-30 | 33.11 | 25.44 | 48.00 | 79.91 | 8.06 |
| May | 1-14 | 32.51 | 25.71 | 5.80 | 71.28 | 10.68 |
| | 15-31 | 33.20 | 24.70 | 77.20 | 70.85 | 8.74 |
| June | 1-14 | 31.49 | 22.95 | 117.70 | 70.71 | 5.68 |
| | 15-30 | 30.54 | 24.27 | 105.40 | 78.40 | 6.48 |
| July | 1-14 | 30.60 | 23.90 | 20.00 | 78.14 | 9.58 |
| | 15-31 | 31.80 | 24.80 | 0.40 | 74.05 | 9.28 |
| Aug. | 1-14 | 31.00 | 23.80 | 35.20 | 77.36 | 8.82 |
| | 15-31 | 29.80 | 24.20 | 238.20 | 84.94 | 3.73 |
| Sep. | 1-14 | 31.50 | 24.40 | 180.00 | 81.10 | 9.94 |
| | 15-30 | 31.00 | 23.80 | 126.00 | 76.84 | 5.10 |
| Oct. | 1-14 | 30.87 | 23.83 | 160.00 | 80.71 | 7.20 |
| | 15-31 | 30.37 | 30.11 | 136.90 | 84.00 | 5.02 |
| Nov. | 1-14 | 29.52 | 23.78 | 128.00 | 81.39 | 7.36 |
| | 15-30 | 30.66 | 23.56 | 55.00 | 81.59 | 6.76 |
| Dec. | 1-14 | 30.69 | 23.81 | 156.00 | 82.71 | 5.61 |
| | 15-31 | 31.03 | 22.66 | 77.70 | 77.88 | 8.94 |

Appendix II Average No. of days for fall of petiole

| Treatments | Jan $F_1$ | Jan $F_2$ | Feb $F_1$ | Feb $F_2$ | Mar $F_1$ | Mar $F_2$ | April $F_1$ | April $F_2$ | May $F_1$ | May $F_2$ | June $F_1$ | June $F_2$ | July $F_1$ | July $F_2$ | Aug $F_1$ | Aug $F_2$ | Sep $F_1$ | Sep $F_2$ | Oct. $F_1$ | Oct. $F_2$ | Nov. $F_1$ | Nov. $F_2$ | Dec. $F_1$ | Dec. $F_2$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $V_1P_1$ | 14.00 | xxx | xxx | 13.50 | xxx | xxx | 17.50 | 22.00 | 6.50 | 6.00 | xxx | xxx | 14.50 | 5.00 | xxx | xxx | 10.00 | 17.50 | 8.00 | 16.00 | xxx | 14.00 | xxx | 11.00 |
| $V_1P_2$ | 15.00 | 17.50 | xxx | xxx | xxx | xxx | 12.00 | 15.00 | 8.00 | 15.00 | 26.00 | 8.00 | 10.50 | 6.00 | 10.00 | 9.00 | 7.00 | 17.67 | 11.67 | 18.00 | 11.00 | 16.00 | 7.00 | 12.50 |
| $V_1P_3$ | 16.33 | 21.50 | xxx | 12.33 | 8.33 | 8.00 | 10.00 | 19.00 | 8.50 | 23.00 | 18.50 | 11.00 | 10.00 | xxx | 6.00 | 11.00 | 8.00 | 19.00 | 15.67 | 14.00 | 9.50 | 18.50 | 8.50 | 16.33 |
| $V_1P_4$ | 21.50 | 27.50 | 18.00 | xxx | 9.00 | 7.50 | 8.00 | 20.50 | 14.50 | 7.60 | 27.67 | 13.50 | 8.67 | xxx | xxx | 8.50 | 6.67 | 21.00 | 15.33 | 15.67 | 12.00 | 17.33 | 9.00 | 16.33 |
| $V_1P_5$ | 17.50 | 29.50 | 11.00 | 19.00 | 11.00 | 8.50 | 10.50 | 15.33 | 13.00 | 16.33 | 16.33 | 8.00 | 15.33 | 4.00 | 12.00 | 12.00 | 6.00 | 22.00 | 20.67 | 25.00 | 18.00 | 23.67 | 11.67 | 19.33 |
| $V_2P_1$ | 24.00 | 8.00 | xxx | xxx | xxx | 7.00 | 21.00 | 22.50 | xxx | xxx | xxx | xxx | 11.33 | 8.33 | xxx | 7.67 | 7.50 | 19.00 | 10.50 | 26.00 | xxx | xxx | xxx | 9.50 |
| $V_2P_2$ | 23.00 | 8.00 | xxx | 9.00 | 14.00 | 8.00 | 13.00 | 9.00 | 15.00 | 11.00 | 24.00 | 7.00 | 14.00 | 9.00 | xxx | 10.00 | 8.33 | 17.00 | 12.00 | xxx | 18.50 | 26.00 | 15.50 | 10.50 |
| $V_2P_3$ | 29.50 | 10.50 | 19.00 | 11.50 | 13.00 | 9.00 | 13.00 | 11.00 | 14.00 | 16.50 | 20.50 | 8.50 | 17.50 | 6.33 | 10.00 | 6.67 | 6.33 | 20.00 | 18.67 | 23.00 | 17.50 | 22.00 | 13.50 | 11.67 |
| $V_2P_4$ | xxx | 12.50 | 17.50 | 13.00 | 15.50 | 9.00 | 17.00 | 8.00 | 22.50 | 18.50 | 22.67 | 11.00 | 11.50 | 8.00 | 9.50 | 10.00 | 7.67 | 17.00 | 20.00 | 16.50 | 26.67 | 20.00 | 17.67 | 15.50 |
| $V_2P_5$ | 32.00 | 14.33 | 15.00 | 17.00 | 18.00 | 10.50 | 19.50 | 19.00 | 15.00 | 22.00 | 17.67 | 9.00 | 17.50 | 7.67 | 13.00 | 12.67 | 11.00 | 20.00 | 25.00 | 23.00 | 27.00 | 28.00 | 15.67 | 17.67 |
| $V_3P_1$ | 12.00 | xxx | xxx | 7.00 | xxx | xxx | xxx | 21.00 | 23.00 | 7.00 | 16.00 | xxx | xxx | 12.00 | xxx | 15.00 | 8.00 | 20.00 | 6.00 | 18.00 | 12.00 | 19.00 | 12.00 | 14.00 |
| $V_3P_2$ | 14.00 | 11.50 | 23.00 | 11.00 | xxx | xxx | 17.00 | xxx | 26.00 | 9.00 | 21.00 | 8.00 | 13.50 | 15.00 | 10.00 | 12.33 | 7.00 | 19.33 | 15.50 | 14.00 | 16.00 | 17.00 | 12.00 | 13.00 |
| $V_3P_3$ | 16.00 | 14.00 | 21.00 | 10.50 | 9.50 | 9.00 | xxx | 16.00 | 18.50 | 12.50 | 31.00 | 9.67 | 20.67 | 10.50 | 13.00 | 10.00 | 7.33 | 20.00 | 18.33 | 17.50 | 15.00 | 14.00 | 14.50 | 15.33 |
| $V_3P_4$ | 19.00 | 14.00 | 17.00 | xxx | 8.33 | 10.00 | 21.00 | 18.50 | 19.00 | 10.00 | 25.00 | 15.67 | 15.00 | 7.33 | 8.55 | 14.67 | 10.00 | 20.33 | 16.33 | 19.33 | 18.00 | 18.00 | 12.50 | 17.33 |
| $V_3P_5$ | xxx | 15.00 | 12.00 | 15.33 | 9.00 | 11.00 | 22.50 | 2.40 | 17.50 | 18.00 | 31.33 | 16.00 | 19.33 | 13.67 | 15.33 | 17.33 | 12.33 | 21.00 | 22.00 | 23.00 | 20.67 | 24.00 | 11.00 | 19.00 |

xxx Bud take nil in all replications

$F_1$ First fortnight

$F_2$ Second fortnight

Appendix III Average No. of days for bud emergence

| Treatments | Jan. F1 | Jan. F2 | Feb. F1 | Feb. F2 | March F1 | March F2 | April F1 | April F2 | May F1 | May F2 | June F1 | June F2 | July F1 | July F2 | August F1 | August F2 | Sept. F1 | Sept. F2 | Oct. F1 | Oct. F2 | Nov. F1 | Nov. F2 | Dec. F1 | Dec. F2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $V_1P_1$ | 30.00 | xxx | xxx | 22.00 | xxx | xxx | 59.50 | 36.67 | 17.50 | 18.00 | xxx | xxx | 20.00 | 17.00 | xxx | xxx | 18.33 | 48.50 | 12.00 | 27.00 | xxx | 26.00 | xxx | 28.00 |
| $V_1P_2$ | 30.00 | 32.00 | xxx | xxx | xxx | xxx | 27.50 | 24.00 | 19.00 | 24.00 | 37.50 | 23.30 | 14.50 | 18.00 | 17.00 | 23.50 | 18.67 | 33.00 | 18.67 | 29.33 | 21.00 | 34.00 | 14.00 | 32.50 |
| $V_1P_3$ | 35.00 | 29.50 | xxx | 22.67 | 16.67 | 13.00 | 21.00 | 30.00 | 18.50 | 34.50 | 30.00 | 27.30 | 14.33 | xxx | 9.00 | 18.00 | 11.67 | 36.67 | 21.67 | 24.33 | 18.50 | 34.50 | 15.00 | 32.33 |
| $V_1P_4$ | 30.00 | 37.50 | 36.00 | xxx | 17.00 | 16.00 | 11.00 | 44.00 | 23.00 | 13.67 | 36.67 | 33.67 | 15.33 | xxx | xxx | 19.50 | 11.00 | 32.00 | 26.33 | 30.33 | 33.67 | 37.00 | 16.50 | 35.00 |
| $V_1P_5$ | 26.00 | 39.50 | 19.50 | 28.00 | 19.67 | 12.00 | 21.00 | 25.33 | 22.00 | 28.00 | 25.33 | 23.67 | 29.67 | 15.00 | 23.00 | 22.33 | 10.00 | 35.33 | 46.00 | 51.00 | 36.67 | 43.00 | 20.67 | 41.67 |
| $V_2P_1$ | 34.00 | 17.00 | xxx | xxx | xxx | 18.00 | 49.00 | 45.00 | xxx | xxx | xxx | xxx | 19.00 | 17.33 | xxx | 16.33 | 16.00 | 28.00 | 21.50 | 39.00 | xxx | xxx | xxx | 30.50 |
| $V_2P_2$ | 35.00 | 16.00 | xxx | 17.00 | 21.00 | 17.00 | 32.00 | 19.00 | 25.00 | 21.00 | 32.00 | 15.50 | 21.15 | 16.00 | xxx | 24.67 | 14.00 | 32.33 | 17.00 | xxx | 28.50 | 31.00 | 21.50 | 35.00 |
| $V_2P_3$ | 39.50 | 24.00 | 31.00 | 18.50 | 21.00 | 17.00 | 35.00 | 21.00 | 27.50 | 27.50 | 28.50 | 19.50 | 30.00 | 17.33 | 21.00 | 14.00 | 16.00 | 40.50 | 27.67 | 42.00 | 31.00 | 29.50 | 19.50 | 36.67 |
| $V_2P_4$ | xxx | 41.00 | 29.50 | 22.00 | 24.00 | 18.50 | 37.50 | 16.00 | 32.00 | 27.50 | 28.00 | 19.67 | 18.00 | 16.67 | 20.50 | 23.30 | 13.33 | 32.00 | 36.33 | 37.50 | 41.00 | 26.50 | 24.33 | 32.00 |
| $V_2P_5$ | 40.66 | 24.60 | 26.50 | 23.50 | 27.50 | 22.00 | 49.00 | 35.50 | 31.50 | 34.50 | 25.00 | 21.00 | 31.00 | 16.00 | 28.50 | 31.33 | 21.67 | 34.33 | 44.33 | 49.00 | 43.67 | 36.67 | 25.33 | 43.33 |
| $V_3P_1$ | 18.00 | xxx | xxx | 16.00 | xxx | xxx | xxx | 32.00 | 30.00 | 16.00 | 28.00 | xxx | xxx | 19.00 | xxx | 32.50 | 15.67 | 34.00 | 18.00 | 32.00 | 21.00 | 25.00 | 28.00 | 33.00 |
| $V_3P_2$ | 22.00 | 26.00 | 37.00 | 21.00 | xxx | xxx | 37.00 | xxx | 41.00 | 19.00 | 31.30 | 16.67 | 20.00 | 20.00 | 14.00 | 30.00 | 13.00 | 28.67 | 21.00 | 19.50 | 31.00 | 26.50 | 28.00 | 30.00 |
| $V_3P_3$ | 30.00 | 22.00 | 29.00 | 17.00 | 19.50 | 18.50 | xxx | 28.00 | 28.00 | 19.00 | 46.00 | 17.67 | 26.33 | 18.50 | 25.00 | 20.67 | 14.67 | 33.00 | 26.67 | 28.00 | 31.00 | 22.50 | 28.00 | 35.67 |
| $V_3P_4$ | 45.00 | 29.00 | 25.00 | xxx | 16.33 | 19.67 | 31.00 | 37.50 | 30.00 | 17.00 | 34.67 | 27.00 | 20.00 | 12.67 | 18.50 | 30.33 | 19.67 | 33.33 | 28.33 | 32.67 | 35.67 | 31.50 | 21.00 | 33.00 |
| $V_3P_5$ | xxx | 30.50 | 21.00 | 26.67 | 18.00 | 21.67 | 35.5 | 40.00 | 29.50 | 25.33 | 39.00 | 27.67 | 28.33 | 20.00 | 31.67 | 31.33 | 23.67 | 36.33 | 34.67 | 30.33 | 41.67 | 38.67 | 27.67 | 44.67 |

xxx Bud take nil in all replications

$F_1$ First fortnight

$F_2$ Second fortnight

Appendix IV Average no. of days for first leaf emergence

| Treatments | Jan | | Feb | | March | | April | | May | | June | | July | | Aug. | | Sep. | | Oct. | | Nov. | | Dec. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ |
| $V_1P_1$ | 41.00 | xxx | xxx | 32.00 | xxx | xxx | 53.50 | 53.30 | 37.00 | 38.00 | xxx | xxx | 29.50 | 26.00 | xxx | xxx | 27.67 | 53.50 | 23.00 | 39.00 | xxx | 39.00 | xxx | 46.00 |
| $V_1P_2$ | 40.00 | 40.00 | xxx | xxx | xxx | xxx | 39.00 | 33.00 | 28.00 | 41.00 | 58.50 | 34.67 | 25.50 | 31.00 | 32.00 | 39.50 | 34.33 | 43.33 | 25.33 | 36.67 | 36.00 | 48.00 | 21.50 | 43.50 |
| $V_1P_3$ | 45.33 | 40.50 | xxx | 33.00 | 26.67 | 22.00 | 32.50 | 40.00 | 42.50 | 50.00 | 38.50 | 34.33 | 27.33 | xxx | 18.00 | 29.00 | 19.33 | 44.67 | 29.33 | 44.33 | 33.50 | 48.00 | 27.50 | 44.00 |
| $V_1P_4$ | 38.50 | 50.50 | 51.00 | xxx | 36.00 | 25.00 | 19.00 | 54.00 | 43.50 | 38.67 | 47.00 | 44.67 | 22.33 | xxx | xxx | 30.50 | 21.00 | 45.67 | 40.33 | 48.67 | 48.67 | 48.33 | 28.50 | 42.00 |
| $V_1P_5$ | 45.00 | 54.00 | 29.50 | 53.00 | 43.00 | 24.50 | 32.50 | 36.00 | 40.33 | 37.33 | 32.67 | 35.33 | 37.83 | 27.50 | 40.00 | 40.00 | 22.00 | 51.67 | 62.00 | 68.33 | 52.00 | 51.67 | 36.33 | 53.00 |
| $V_2P_1$ | 45.00 | 28.00 | xxx | xxx | xxx | 51.00 | 69.00 | 53.00 | xxx | xxx | xxx | xxx | 29.00 | 23.67 | xxx | 33.00 | 24.00 | 44.00 | 39.00 | 50.50 | xxx | xxx | xxx | 47.00 |
| $V_2P_2$ | 53.00 | 29.00 | xxx | 24.00 | 39.00 | 31.00 | 68.00 | 39.00 | 53.50 | 28.00 | 41.00 | 32.50 | 35.00 | 21.50 | xxx | 28.67 | 22.33 | 39.67 | 30.00 | xxx | 45.50 | 39.00 | 30.00 | 52.50 |
| $V_2P_3$ | 56.00 | 33.00 | 38.00 | 26.50 | 38.00 | 27.00 | 69.50 | 44.00 | 52.50 | 31.50 | 35.50 | 28.50 | 37.00 | 28.33 | 28.00 | 27.00 | 23.00 | 50.00 | 45.33 | 52.00 | 54.00 | 39.00 | 28.50 | 49.33 |
| $V_2P_4$ | xxx | 57.00 | 37.50 | 31.00 | 44.00 | 31.00 | 75.50 | 38.00 | 59.00 | 37.50 | 37.67 | 34.33 | 28.00 | 25.00 | 32.00 | 36.67 | 21.00 | 36.33 | 57.33 | 50.00 | 56.33 | 38.50 | 36.33 | 48.50 |
| $V_2P_5$ | 59.66 | 39.67 | 36.00 | 36.00 | 55.50 | 30.00 | 87.50 | 51.50 | 57.50 | 44.50 | 35.33 | 36.67 | 39.50 | 27.67 | 39.50 | 41.00 | 38.67 | 47.33 | 62.33 | 59.33 | 59.00 | 49.67 | 47.00 | 58.00 |
| $V_3P_1$ | 29.00 | xxx | xxx | 21.00 | xxx | xxx | xxx | 43.00 | 68.00 | 28.00 | 32.00 | xxx | xxx | 25.00 | xxx | 37.00 | 22.00 | 71.00 | 32.00 | 41.00 | 40.00 | 40.00 | 51.00 | 51.00 |
| $V_3P_2$ | 27.50 | 31.00 | 44.00 | 26.00 | xxx | xxx | 62.50 | xxx | 52.00 | 33.00 | 40.67 | 23.33 | 29.50 | 28.00 | 26.00 | 38.33 | 17.67 | 47.33 | 35.00 | 36.50 | 41.00 | 40.50 | 46.00 | 41.33 |
| $V_3P_3$ | 41.00 | 31.00 | 38.00 | 30.00 | 25.50 | 26.50 | xxx | 41.00 | 52.00 | 35.00 | 55.00 | 23.67 | 34.67 | 24.00 | 38.00 | 31.67 | 23.00 | 44.33 | 50.67 | 51.00 | 38.00 | 39.50 | 48.50 | 48.67 |
| $V_3P_4$ | 59.00 | 38.00 | 39.00 | xxx | 27.00 | 28.00 | 58.00 | 53.50 | 58.50 | 33.50 | 40.67 | 31.33 | 36.33 | 28.33 | 37.50 | 38.33 | 25.00 | 43.67 | 44.33 | 49.00 | 45.33 | 42.50 | 44.50 | 51.67 |
| $V_3P_5$ | xxx | 43.50 | 35.00 | 34.33 | 29.50 | 31.33 | 53.50 | 55.50 | 51.40 | 41.00 | 63.00 | 35.67 | 44.00 | 29.00 | 45.67 | 41.00 | 35.33 | 46.33 | 58.33 | 52.67 | 56.67 | 50.00 | 57.30 | 58.33 |

xxx = Bud take nil in all replications

$F_1$ = First fortnight

$F_2$ = Second fortnight

Appendix V Average no. of leaves till first flower bud

| Treatments | Jan | | Feb | | March | | April | | May | | June | | July | | Aug | | Sep | | Oct | | Nov | | Dec | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ |
| $V_1P_1$ | 7.00 | xxx | xxx | 9.50 | xxx | xxx | 11.00 | 9.33 | 6.50 | 7.00 | xxx | xxx | 13.00 | 6.00 | xxx | xxx | 7.00 | 9.50 | 5.00 | 6.00 | xxx | 8.00 | xxx | 7.00 |
| $V_1P_2$ | 6.00 | 5.00 | xxx | xxx | xxx | xxx | 8.00 | 10.00 | 10.00 | 9.00 | 11.50 | 9.33 | 10.50 | 9.00 | 6.00 | 5.00 | 9.00 | 9.67 | 7.67 | 6.67 | 7.00 | 9.00 | 12.00 | 8.50 |
| $V_1P_3$ | 7.66 | 9.00 | xxx | 9.33 | 7.00 | 9.00 | 8.00 | 7.50 | 7.00 | 8.50 | 9.00 | 8.33 | 12.00 | xxx | 4.00 | 5.00 | 9.67 | 14.00 | 9.33 | 8.67 | 9.00 | 9.50 | 13.00 | 10.00 |
| $V_1P_4$ | 6.50 | 7.50 | 14.00 | xxx | 5.00 | 8.50 | 7.00 | 9.50 | 7.50 | 13.00 | 14.00 | 9.33 | 12.67 | xxx | xxx | 7.50 | 11.67 | 14.33 | 12.00 | 9.00 | 9.67 | 11.00 | 13.00 | 10.33 |
| $V_1P_5$ | 9.00 | 12.00 | 15.50 | 13.00 | 11.00 | 10.50 | 10.50 | 10.00 | 11.00 | 12.00 | 12.67 | 10.67 | 15.00 | 9.50 | 4.00 | 7.00 | 12.67 | 14.00 | 9.00 | 12.67 | 11.00 | 12.67 | 11.00 | 11.67 |
| $V_2P_1$ | 11.00 | 12.00 | xxx | xxx | xxx | 4.00 | 12.00 | 8.50 | xxx | xxx | xxx | xxx | 9.67 | 6.33 | xxx | 7.67 | 8.50 | 9.00 | 8.00 | 6.00 | xxx | xxx | xxx | 11.00 |
| $V_2P_2$ | 9.33 | 16.00 | xxx | 7.00 | 8.00 | 6.00 | 11.00 | 12.00 | 7.50 | 8.00 | 8.00 | 8.50 | 12.00 | 8.50 | xxx | 7.33 | 7.00 | 10.00 | 10.50 | xxx | 7.50 | 4.00 | 9.00 | 8.50 |
| $V_2P_3$ | 14.50 | 15.50 | 8.00 | 7.50 | 7.00 | 6.00 | 9.50 | 8.00 | 6.50 | 6.50 | 7.50 | 9.50 | 10.50 | 7.67 | 6.00 | 7.00 | 9.00 | 13.00 | 8.33 | 8.50 | 7.50 | 7.00 | 10.00 | 10.00 |
| $V_2P_4$ | xxx | 15.50 | 8.50 | 12.00 | 9.00 | 8.50 | 7.50 | 9.00 | 8.50 | 12.00 | 10.00 | 13.67 | 8.50 | 8.33 | 5.00 | 11.00 | 7.00 | 15.00 | 7.33 | 10.50 | 10.00 | 8.50 | 13.50 | 12.50 |
| $V_2P_5$ | 17.67 | 15.00 | 11.50 | 12.50 | 8.50 | 9.50 | 9.50 | 8.50 | 11.00 | 11.50 | 10.33 | 11.33 | 9.50 | 7.67 | 7.00 | 12.67 | 10.33 | 15.67 | 10.67 | 12.67 | 9.33 | 10.67 | 12.50 | 13.00 |
| $V_3P_1$ | 4.00 | xxx | xxx | 12.00 | xxx | xxx | xxx | 6.00 | 6.00 | 6.00 | 6.00 | xxx | xxx | 5.00 | xxx | 6.50 | 10.33 | 12.00 | 9.00 | 8.00 | 8.00 | 8.00 | 8.00 | 4.00 |
| $V_3P_2$ | 4.50 | 5.50 | 8.00 | 10.00 | xxx | xxx | 5.50 | xxx | 8.00 | 8.00 | 7.67 | 9.67 | 7.00 | 6.00 | 5.00 | 9.33 | 10.00 | 9.33 | 11.50 | 8.00 | 11.00 | 8.00 | 7.00 | 5.67 |
| $V_3P_3$ | 6.00 | 7.00 | 8.00 | 8.50 | 4.50 | 5.00 | xxx | 6.00 | 8.00 | 10.50 | 10.00 | 6.33 | 6.33 | 7.50 | 6.00 | 6.67 | 12.00 | 12.33 | 8.33 | 8.50 | 10.00 | 9.00 | 7.50 | 6.33 |
| $V_3P_4$ | 8.00 | 8.00 | 8.00 | xxx | 6.67 | 5.33 | 6.00 | 8.50 | 9.00 | 7.50 | 10.33 | 13.67 | 9.67 | 6.67 | 5.50 | 10.33 | 11.00 | 11.67 | 10.67 | 7.67 | 9.00 | 7.50 | 10.00 | 8.00 |
| $V_3P_5$ | xxx | 9.00 | 11.00 | 8.33 | 7.50 | 7.33 | 7.50 | 7.50 | 11.50 | 10.67 | 10.30 | 11.33 | 10.00 | 6.67 | 5.00 | 11.00 | 15.00 | 13.00 | 11.67 | 8.00 | 9.33 | 7.67 | 9.67 | 8.67 |

xxx = Bud take nil in all replications

$F_1$ = First fortnight

$F_2$ = Second fortnight

Appendix VI Average height of scion till first flower bud

| Treat-ments | Jan | | Feb | | March | | April | | May | | June | | July | | Aug | | Sep. | | Oct. | | Nov. | | Dec. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ |
| $V_1P_1$ | 8.00 | xxx | xxx | 12.90 | xxx | xxx | 17.50 | 11.13 | 11.85 | 12.80 | xxx | xxx | 14.40 | 8.10 | xxx | xxx | 20.33 | 18.50 | 11.80 | 10.80 | xxx | 11.20 | xxx | 14.00 |
| $V_1P_2$ | 10.00 | 12.90 | xxx | xxx | xxx | xxx | 12.60 | 14.70 | 8.00 | 11.80 | 18.55 | 22.13 | 15.95 | 10.30 | 12.30 | 8.20 | 22.33 | 16.67 | 21.70 | 10.07 | 8.30 | 10.30 | 18.75 | 15.00 |
| $V_1P_3$ | 15.00 | 18.50 | xxx | 13.00 | 6.10 | 8.00 | 12.75 | 10.00 | 13.20 | 19.10 | 19.10 | 19.43 | 17.37 | xxx | 15.70 | 6.40 | 21.37 | 20.33 | 14.60 | 14.10 | 8.85 | 10.30 | 22.65 | 14.87 |
| $V_1P_4$ | 14.50 | 19.55 | 34.00 | xxx | 4.80 | 10.85 | 12.00 | 9.00 | 15.15 | 21.03 | 21.63 | 23.67 | 27.57 | xxx | xxx | 11.75 | 21.39 | 16.67 | 19.10 | 13.60 | 12.17 | 15.10 | 21.55 | 18.13 |
| $V_1P_5$ | 16.75 | 22.60 | 33.00 | 17.00 | 11.10 | 11.65 | 15.65 | 14.13 | 16.73 | 14.03 | 15.93 | 22.67 | 29.17 | 13.35 | 6.00 | 9.40 | 16.33 | 20.33 | 8.97 | 21.57 | 14.53 | 15.13 | 18.67 | 21.77 |
| $V_2P_1$ | 21.00 | 23.00 | xxx | xxx | xxx | 2.80 | 10.30 | 14.60 | xxx | xxx | xxx | xxx | 22.20 | 13.27 | xxx | 8.17 | 13.65 | 18.00 | 15.30 | 13.90 | xxx | xxx | xxx | 18.65 |
| $V_2P_2$ | 21.33 | 30.00 | xxx | 11.80 | 14.00 | 6.90 | 10.80 | 21.00 | 8.55 | 10.10 | 10.20 | 8.70 | 22.15 | 15.00 | xxx | 9.43 | 13.80 | 21.77 | 16.40 | xxx | 7.05 | 8.50 | 14.25 | 15.00 |
| $V_2P_3$ | 28.00 | 27.50 | 12.00 | 13.00 | 13.00 | 10.00 | 11.65 | 14.00 | 6.85 | 17.20 | 12.80 | 12.60 | 21.20 | 15.17 | 12.10 | 14.00 | 14.00 | 24.70 | 19.37 | 17.10 | 10.05 | 10.90 | 14.40 | 15.77 |
| $V_2P_4$ | xxx | 23.50 | 13.50 | 15.20 | 12.85 | 9.50 | 13.70 | 13.10 | 14.20 | 23.25 | 16.20 | 19.53 | 17.40 | 22.00 | 10.65 | 16.73 | 21.27 | 25.03 | 16.90 | 20.15 | 12.93 | 10.25 | 17.33 | 19.40 |
| $V_2P_5$ | 40.67 | 33.00 | 15.75 | 16.30 | 10.70 | 9.50 | 15.55 | 8.90 | 14.15 | 19.10 | 14.67 | 21.77 | 17.75 | 17.37 | 7.45 | 13.93 | 16.07 | 25.67 | 10.67 | 19.03 | 13.27 | 12.40 | 17.83 | 18.77 |
| $V_3P_1$ | 8.00 | xxx | xxx | 22.00 | xxx | xxx | xxx | 5.00 | 8.80 | 6.80 | 10.40 | xxx | xxx | 14.30 | xxx | 14.50 | 19.13 | 13.00 | 11.80 | 13.40 | 11.30 | 16.00 | 11.30 | 10.00 |
| $V_3P_2$ | 11.10 | 7.95 | 12.10 | 20.80 | xxx | xxx | 9.50 | xxx | 9.10 | 10.20 | 21.00 | 11.73 | 11.80 | 18.00 | 10.30 | 20.33 | 19.00 | 17.47 | 21.60 | 17.15 | 13.00 | 14.60 | 12.00 | 12.30 |
| $V_3P_3$ | 20.00 | 8.00 | 12.80 | 13.90 | 8.40 | 4.20 | xxx | 8.00 | 10.85 | 13.20 | 22.00 | 10.80 | 11.00 | 18.30 | 8.80 | 13.77 | 14.67 | 14.20 | 15.40 | 16.10 | 15.00 | 12.10 | 13.80 | 14.03 |
| $V_3P_4$ | 21.50 | 11.00 | 14.00 | xxx | 9.53 | 7.06 | 11.80 | 13.40 | 13.50 | 13.80 | 16.00 | 16.33 | 14.33 | 18.97 | 10.30 | 18.73 | 20.03 | 11.23 | 19.00 | 18.10 | 15.00 | 10.85 | 14.15 | 16.80 |
| $V_3P_5$ | xxx | 12.25 | 18.00 | 13.53 | 12.00 | 9.20 | 12.65 | 11.15 | 14.50 | 12.33 | 18.70 | 14.10 | 16.00 | 14.00 | 10.07 | 12.90 | 17.70 | 16.77 | 15.57 | 22.33 | 18.80 | 15.83 | 16.87 | 20.83 |

xxx Bud take nil in all replications

$F_1$ First fortnight

$F_2$ Second fortnight

Appendix VII Average number of days for first flower bud production

| Treatments | Jan $F_1$ | Jan $F_2$ | Feb $F_1$ | Feb $F_2$ | March $F_1$ | March $F_2$ | April $F_1$ | April $F_2$ | May $F_1$ | May $F_2$ | June $F_1$ | June $F_2$ | July $F_1$ | July $F_2$ | Aug $F_1$ | Aug $F_2$ | Sep $F_1$ | Sep $F_2$ | Oct $F_1$ | Oct $F_2$ | Nov $F_1$ | Nov $F_2$ | Dec $F_1$ | Dec $F_2$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $V_1P_1$ | 51.00 | xxx | xxx | 62.50 | xxx | xxx | 90.00 | 67.33 | 53.50 | 63.00 | xxx | xxx | 54.50 | 51.00 | xxx | xxx | 47.33 | 65.50 | 49.00 | 48.00 | xxx | 58.00 | xxx | 61.00 |
| $V_1P_2$ | 54.00 | 54.50 | xxx | xxx | xxx | xxx | 86.50 | 60.00 | 39.00 | 84.00 | 80.00 | 54.67 | 53.00 | 58.00 | 54.00 | 46.50 | 54.33 | 63.00 | 53.67 | 49.33 | 54.00 | 71.00 | 50.00 | 53.50 |
| $V_1P_3$ | 62.00 | 57.50 | xxx | 67.66 | 57.33 | 42.00 | 64.50 | 59.50 | 46.50 | 61.50 | 65.50 | 50.33 | 60.67 | xxx | 44.00 | 47.00 | 48.33 | 62.00 | 63.33 | 58.67 | 48.50 | 71.50 | 59.50 | 65.33 |
| $V_1P_4$ | 54.00 | 63.50 | 53.00 | xxx | 64.00 | 57.50 | 56.00 | 74.50 | 55.00 | 62.00 | 71.33 | 60.67 | 53.67 | xxx | xxx | 59.50 | 62.33 | 75.00 | 61.00 | 68.67 | 57.33 | 71.67 | 62.50 | 69.33 |
| $V_1P_5$ | 56.50 | 70.00 | 55.00 | 77.00 | 72.33 | 60.50 | 64.50 | 62.33 | 54.67 | 67.67 | 62.33 | 66.67 | 68.33 | 64.50 | 67.00 | 58.67 | 72.67 | 82.67 | 96.67 | 84.00 | 68.33 | 78.33 | 71.00 | 83.00 |
| $V_2P_1$ | 79.00 | 75.00 | xxx | xxx | xxx | 76.00 | 81.00 | 85.00 | xxx | xxx | xxx | xxx | 53.67 | 66.67 | xxx | 55.67 | 48.00 | 62.00 | 54.00 | 64.50 | xxx | xxx | xxx | 68.50 |
| $V_2P_2$ | 75.33 | 70.00 | xxx | 58.00 | 67.00 | 68.00 | 88.00 | 76.00 | 71.00 | 44.00 | 81.00 | 43.00 | 50.50 | 73.00 | xxx | 61.00 | 48.67 | 61.00 | 46.00 | xxx | 65.50 | 61.00 | 53.50 | 70.50 |
| $V_2P_3$ | 79.50 | 68.00 | 71.00 | 62.00 | 63.00 | 68.00 | 80.00 | 82.00 | 69.50 | 44.50 | 65.00 | 42.50 | 53.00 | 62.67 | 41.00 | 50.00 | 62.00 | 76.00 | 63.67 | 67.50 | 62.50 | 61.50 | 50.00 | 67.67 |
| $V_2P_4$ | xxx | 96.50 | 70.00 | 71.00 | 69.50 | 69.50 | 86.50 | 78.00 | 75.00 | 52.00 | 64.67 | 56.00 | 57.00 | 57.67 | 47.50 | 69.00 | 51.33 | 76.67 | 74.00 | 67.50 | 69.33 | 73.00 | 59.00 | 68.00 |
| $V_2P_5$ | 85.33 | 80.33 | 62.50 | 76.50 | 75.00 | 74.50 | 99.50 | 89.00 | 76.50 | 70.50 | 57.67 | 65.00 | 63.50 | 61.33 | 54.50 | 79.30 | 77.67 | 82.00 | 86.00 | 71.00 | 75.33 | 76.00 | 71.67 | 82.33 |
| $V_3P_1$ | 40.00 | xxx | xxx | 67.00 | xxx | xxx | xxx | 56.00 | 79.00 | 56.00 | 67.00 | xxx | xxx | 41.00 | xxx | 46.50 | 51.33 | 88.00 | 63.00 | 64.00 | 58.00 | 62.00 | 71.00 | 73.00 |
| $V_3P_2$ | 44.00 | 47.00 | 81.00 | 71.00 | xxx | xxx | 81.50 | xxx | 71.00 | 62.00 | 61.33 | 38.33 | 59.50 | 51.00 | 71.00 | 50.00 | 37.33 | 68.00 | 59.50 | 61.50 | 60.00 | 62.50 | 59.00 | 62.67 |
| $V_3P_3$ | 52.00 | 51.00 | 82.00 | 81.00 | 42.00 | 51.00 | xxx | 58.00 | 67.00 | 65.50 | 70.00 | 38.00 | 55.33 | 50.50 | 64.00 | 49.33 | 51.33 | 68.67 | 73.33 | 71.00 | 59.00 | 62.00 | 70.00 | 68.33 |
| $V_3P_4$ | 71.00 | 54.00 | 78.00 | xxx | 49.33 | 58.67 | 69.00 | 67.50 | 69.00 | 64.50 | 62.00 | 49.00 | 53.00 | 50.67 | 53.50 | 49.00 | 51.67 | 70.67 | 62.67 | 65.67 | 65.33 | 61.00 | 64.50 | 73.67 |
| $V_3P_5$ | xxx | 66.50 | 65.00 | 81.33 | 55.00 | 59.67 | 71.00 | 73.50 | 66.00 | 71.67 | 70.00 | 48.33 | 59.67 | 62.67 | 74.67 | 60.33 | 67.67 | 82.67 | 76.33 | 74.33 | 73.67 | 76.00 | 79.33 | 82.33 |

xxx Bud take nil in all replications

$F_1$ First fortnight

$F_2$ Second fortnight

## Appendix VIII Average size of first flower

| Treatments | Jan | | Feb | | March | | April | | May | | June | | July | | Aug | | Sep | | Oct | | Nov | | Dec | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ |
| $V_1P_1$ | 5.00 | xxx | xxx | 6.35 | xxx | xxx | 6.55 | 6.63 | 6.50 | 8.00 | xxx | xxx | 7.70 | 7.10 | xxx | xxx | 5.60 | 6.35 | 6.50 | 7.30 | xxx | 5.80 | xxx | 5.30 |
| $V_1P_2$ | 6.10 | 6.10 | xxx | xxx | xxx | xxx | 6.40 | 5.60 | 5.60 | 7.90 | 6.45 | 8.23 | 8.35 | 6.80 | 5.80 | 5.45 | 5.80 | 7.40 | 6.73 | 6.70 | 7.30 | 6.70 | 7.05 | 6.35 |
| $V_1P_3$ | 6.46 | 6.20 | xxx | 6.53 | 5.53 | 6.20 | 6.65 | 6.55 | 6.20 | 7.40 | 6.55 | 7.20 | 7.97 | xxx | 6.70 | 6.10 | 7.07 | 7.07 | 6.10 | 6.70 | 6.80 | 7.00 | 5.95 | 6.56 |
| $V_1P_4$ | 6.95 | 6.70 | 7.00 | xxx | 4.30 | 6.00 | 5.80 | 6.00 | 5.40 | 7.23 | 7.23 | 7.90 | 8.70 | xxx | xxx | 5.95 | 7.07 | 7.77 | 7.27 | 7.83 | 7.97 | 7.90 | 8.15 | 7.27 |
| $V_1P_5$ | 9.00 | 6.95 | 7.30 | 6.30 | 4.87 | 5.90 | 6.35 | 7.04 | 5.60 | 8.30 | 7.50 | 7.23 | 8.87 | 7.95 | 7.20 | 5.43 | 6.80 | 8.30 | 7.70 | 8.23 | 7.67 | 7.80 | 7.63 | 8.27 |
| $V_2P_1$ | 6.00 | 6.00 | xxx | xxx | xxx | 4.80 | 6.10 | 6.00 | xxx | xxx | xxx | xxx | 7.23 | 6.03 | xxx | 5.63 | 5.30 | 7.20 | 7.05 | 6.20 | xxx | xxx | xxx | 6.35 |
| $V_2P_2$ | 6.20 | 6.50 | xxx | 6.30 | 6.20 | 5.00 | 6.20 | 7.80 | 5.35 | 6.20 | 7.10 | 4.95 | 8.05 | 5.25 | xxx | 5.60 | 6.50 | 6.07 | 6.65 | xxx | 5.20 | 6.70 | 6.55 | 6.50 |
| $V_2P_3$ | 7.25 | 5.90 | 6.10 | 6.10 | 6.50 | 5.60 | 6.00 | 6.80 | 6.45 | 6.30 | 5.35 | 5.80 | 7.95 | 6.57 | 7.10 | 4.83 | 5.40 | 6.95 | 5.70 | 7.05 | 5.55 | 7.20 | 5.95 | 6.57 |
| $V_2P_4$ | xxx | 5.35 | 5.95 | 6.00 | 6.00 | 5.25 | 5.75 | 6.20 | 8.05 | 6.50 | 5.80 | 6.43 | 8.15 | 6.03 | 7.00 | 7.03 | 5.27 | 6.37 | 6.47 | 6.90 | 5.25 | 7.05 | 6.17 | 7.15 |
| $V_2P_5$ | 7.97 | 5.77 | 5.95 | 5.95 | 5.70 | 5.05 | 6.00 | 5.45 | 8.15 | 6.60 | 5.80 | 5.87 | 8.40 | 6.47 | 5.90 | 6.37 | 5.57 | 6.63 | 6.10 | 7.20 | 5.20 | 7.40 | 5.70 | 6.67 |
| $V_3P_1$ | 4.80 | xxx | xxx | 6.80 | xxx | xxx | xxx | 6.30 | 6.30 | 5.10 | 5.80 | xxx | xxx | 5.30 | xxx | 6.70 | 5.57 | 6.80 | 7.10 | 5.90 | 4.80 | 5.20 | 4.20 | 6.80 |
| $V_3P_2$ | 6.25 | 4.95 | 5.60 | 6.30 | xxx | xxx | 5.45 | xxx | 6.10 | 5.80 | 6.87 | 5.40 | 7.00 | 6.30 | 5.10 | 6.43 | 5.40 | 7.17 | 5.55 | 7.05 | 5.40 | 5.35 | 6.10 | 5.10 |
| $V_3P_3$ | 6.00 | 5.70 | 5.80 | 6.15 | 5.20 | 5.80 | xxx | 6.40 | 6.40 | 5.25 | 7.10 | 5.70 | 6.17 | 6.15 | 4.80 | 6.20 | 6.63 | 6.33 | 5.77 | 5.10 | 6.10 | 5.75 | 5.55 | 4.97 |
| $V_3P_4$ | 8.10 | 6.40 | 6.20 | xxx | 5.43 | 5.63 | 5.90 | 5.95 | 5.10 | 5.35 | 6.03 | 6.30 | 6.47 | 5.93 | 4.60 | 6.43 | 6.90 | 7.37 | 6.03 | 6.93 | 6.73 | 5.25 | 5.95 | 6.03 |
| $V_3P_5$ | xxx | 6.40 | 6.80 | 5.13 | 4.95 | 5.60 | 6.20 | 5.65 | 6.90 | 5.47 | 6.03 | 6.23 | 7.03 | 4.93 | 4.47 | 7.43 | 6.80 | 7.60 | 6.10 | 6.17 | 5.77 | 5.40 | 6.10 | 6.33 |

xxx Bud take nil.in all replications

$F_1$ First fortnight

$F_2$ Second fortnight

## Appendix IX Average no. of petals in first flower

| Treatments | Jan | | Feb | | March | | April | | May | | June | | July | | Aug | | Sep | | Oct | | Nov | | Dec | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ |
| $V_1P_1$ | 11.00 | xxx | xxx | 22.50 | xxx | xxx | 24.50 | 22.00 | 24.50 | 22.00 | xxx | xxx | 21.00 | 15.00 | xxx | xxx | 27.33 | 18.50 | 32.00 | 23.00 | xxx | 19.00 | xxx | 18.00 |
| $V_1P_2$ | 12.00 | 17.50 | xxx | xxx | xxx | xxx | 28.50 | 15.00 | 26.00 | 18.00 | 21.00 | 33.67 | 27.00 | 18.00 | 26.00 | 26.50 | 32.67 | 21.67 | 22.67 | 25.33 | 24.00 | 22.00 | 15.50 | 20.00 |
| $V_1P_3$ | 14.00 | 24.00 | xxx | 37.33 | 17.00 | 17.00 | 24.00 | 22.00 | 18.50 | 22.50 | 16.50 | 28.00 | 28.00 | xxx | 37.00 | 19.00 | 32.67 | 18.00 | 25.00 | 28.00 | 22.00 | 18.50 | 22.50 | 25.67 |
| $V_1P_4$ | 21.50 | 34.00 | 26.00 | xxx | 21.00 | 20.00 | 22.00 | 20.50 | 19.00 | 29.67 | 30.67 | 21.67 | 32.00 | xxx | xxx | 22.50 | 35.67 | 24.00 | 31.67 | 31.00 | 30.67 | 22.00 | 30.00 | 22.67 |
| $V_1P_5$ | 24.00 | 24.50 | 25.50 | 41.00 | 22.67 | 23.00 | 23.50 | 15.33 | 17.33 | 38.33 | 22.00 | 17.33 | 34.00 | 14.50 | 24.00 | 21.00 | 23.33 | 18.67 | 20.00 | 22.00 | 27.33 | 15.67 | 23.00 | 20.67 |
| $V_2P_1$ | 26.00 | 18.00 | xxx | xxx | xxx | 21.00 | 31.00 | 43.50 | xxx | xxx | xxx | xxx | 33.33 | 28.33 | xxx | 20.67 | 24.50 | 29.00 | 49.50 | 26.50 | xxx | xxx | xxx | 22.50 |
| $V_2P_2$ | 32.00 | 14.00 | xxx | 21.00 | 31.00 | 23.00 | 23.00 | 34.00 | 37.50 | 31.00 | 16.00 | 22.50 | 37.50 | 31.00 | xxx | 20.67 | 20.33 | 20.33 | 39.00 | xxx | 17.50 | 14.00 | 17.50 | 28.50 |
| $V_2P_3$ | 37.00 | 19.50 | 18.00 | 22.00 | 28.00 | 20.00 | 23.00 | 31.00 | 23.50 | 30.00 | 18.00 | 20.50 | 19.50 | 28.33 | 20.00 | 18.67 | 18.00 | 23.50 | 40.00 | 22.00 | 22.00 | 18.00 | 24.00 | 28.33 |
| $V_2P_4$ | xxx | 23.00 | 23.50 | 25.00 | 24.50 | 18.50 | 27.00 | 26.00 | 26.50 | 31.00 | 20.00 | 25.33 | 17.00 | 39.00 | 22.50 | 24.67 | 21.00 | 17.00 | 34.00 | 27.00 | 18.67 | 18.50 | 17.67 | 23.50 |
| $V_2P_5$ | 38.00 | 32.33 | 27.50 | 29.50 | 22.50 | 15.00 | 19.50 | 22.00 | 26.50 | 32.50 | 17.00 | 23.00 | 18.50 | 39.33 | 15.00 | 25.33 | 14.67 | 20.67 | 33.67 | 21.33 | 17.33 | 15.33 | 20.33 | 20.00 |
| $V_3P_1$ | 24.00 | xxx | xxx | 18.00 | xxx | xxx | xxx | 22.00 | 16.00 | 18.00 | 34.00 | xxx | xxx | 48.00 | xxx | 21.50 | 26.33 | 29.00 | 56.00 | 31.00 | 36.00 | 34.00 | 36.00 | 32.00 |
| $V_3P_2$ | 31.00 | 24.00 | 26.00 | 19.00 | xxx | xxx | 42.00 | xxx | 15.00 | 21.00 | 38.33 | 18.00 | 15.50 | 36.00 | 29.00 | 20.33 | 16.00 | 31.67 | 32.50 | 44.00 | 41.00 | 27.50 | 21.00 | 28.33 |
| $V_3P_3$ | 46.00 | 27.00 | 24.00 | 21.00 | 27.50 | 34.50 | xxx | 17.00 | 13.00 | 29.50 | 36.00 | 29.67 | 21.67 | 44.50 | 22.00 | 16.00 | 20.33 | 31.67 | 31.67 | 46.50 | 40.00 | 34.50 | 34.50 | 39.67 |
| $V_3P_4$ | 52.00 | 31.00 | 36.00 | xxx | 30.67 | 37.33 | 48.00 | 17.00 | 15.50 | 34.50 | 50.33 | 49.33 | 19.00 | 33.00 | 27.00 | 24.33 | 18.67 | 38.33 | 39.67 | 39.00 | 32.67 | 37.50 | 24.00 | 29.33 |
| $V_3P_5$ | xxx | 37.00 | 29.00 | 22.00 | 39.50 | 29.67 | 46.00 | 17.50 | 15.50 | 40.33 | 41.00 | 39.00 | 16.33 | 21.67 | 18.67 | 24.00 | 20.00 | 20.67 | 32.33 | 31.67 | 26.33 | 31.67 | 27.67 | 25.67 |

xxx Budtake nil in all replications

$F_1$ First fortnight

$F_2$ Second fortnight

**Appendix X** Average number of subsequent shoots

| Treatments | Jan | | Feb | | March | | April | | May | | June | | July | | Aug | | Sep | | Oct | | Nov | | Dec | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ |
| $V_1P_1$ | 1.00 | xxx | xxx | 3.00 | xxx | xxx | 6.50 | 4.00 | 5.50 | 3.00 | xxx | xxx | 3.00 | 4.00 | xxx | xxx | 6.33 | 6.50 | 4.00 | 4.00 | xxx | 4.00 | xxx | 5.00 |
| $V_1P_2$ | 1.00 | 1.00 | xxx | xxx | xxx | xxx | 3.50 | 4.00 | 4.00 | 3.00 | 1.50 | 4.67 | 2.50 | 3.00 | 3.00 | 4.50 | 6.00 | 6.00 | 4.00 | 2.00 | 5.00 | 5.00 | 4.00 | 4.00 |
| $V_1P_3$ | 2.33 | 1.60 | xxx | 5.00 | 2.67 | 4.00 | 4.50 | 5.00 | 2.50 | 4.50 | 4.00 | 4.00 | 4.33 | xxx | 2.00 | 3.00 | 4.33 | 4.67 | 4.33 | 2.00 | 4.00 | 3.50 | 3.50 | 3.33 |
| $V_1P_4$ | 5.50 | 2.50 | 6.00 | xxx | 2.00 | 3.00 | 3.00 | 4.00 | 2.00 | 7.00 | 3.00 | 2.33 | 2.33 | xxx | xxx | 2.00 | 2.67 | 3.00 | 2.33 | 2.33 | 3.00 | 2.67 | 2.50 | 2.67 |
| $V_1P_5$ | 5.00 | 2.00 | 6.00 | 2.00 | 4.67 | 3.50 | 7.00 | 2.00 | 1.67 | 6.67 | 3.00 | 2.00 | 2.33 | 2.00 | 2.00 | 1.67 | 2.00 | 2.33 | 2.67 | 2.00 | 2.00 | 2.33 | 3.00 | 2.00 |
| $V_2P_1$ | 8.00 | 5.00 | xxx | xxx | xxx | 1.00 | 4.00 | 2.00 | xxx | xxx | xxx | xxx | 4.00 | 5.00 | xxx | 4.00 | 4.50 | 5.00 | 5.50 | 4.00 | xxx | xxx | xxx | 4.00 |
| $V_2P_2$ | 7.33 | 4.00 | xxx | 1.00 | 4.00 | 1.00 | 5.00 | 3.00 | 2.5 | 6.00 | 4.00 | 5.00 | 3.00 | 3.50 | xxx | 4.67 | 4.30 | 4.67 | 4.00 | xxx | 3.50 | 3.00 | 3.00 | 2.50 |
| $V_2P_3$ | 4.00 | 3.50 | 1.00 | 2.00 | 5.00 | 2.00 | 2.50 | 6.00 | 3.50 | 4.50 | 3.50 | 3.50 | 2.50 | 3.67 | 3.00 | 2.67 | 2.67 | 4.50 | 3.67 | 4.00 | 3.00 | 1.50 | 3.50 | 2.33 |
| $V_2P_4$ | xxx | 6.50 | 3.50 | 4.00 | 2.00 | 1.00 | 3.50 | 3.00 | 3.00 | 4.00 | 2.67 | 3.00 | 2.00 | 2.33 | 2.00 | 2.67 | 2.00 | 3.33 | 3.00 | 2.50 | 2.67 | 2.50 | 2.33 | 2.55 |
| $V_2P_5$ | 5.33 | 5.67 | 3.00 | 2.50 | 3.00 | 1.50 | 2.50 | 2.50 | 2.50 | 2.50 | 2.33 | 2.00 | 2.50 | 2.00 | 2.00 | 2.67 | 2.33 | 2.33 | 2.33 | 2.00 | 1.67 | 2.33 | 2.67 | 1.67 |
| $V_3P_1$ | 1.00 | xxx | xxx | 7.00 | xxx | xxx | xxx | 3.00 | 2.00 | 2.00 | 3.00 | xxx | xxx | 3.00 | xxx | 4.50 | 5.00 | 5.00 | - | 4.00 | 4.00 | 4.00 | 3.00 | 3.00 |
| $V_3P_2$ | 2.00 | 1.00 | 2.00 | 4.00 | xxx | xxx | 2.50 | xxx | 5.00 | 5.00 | 3.00 | 4.67 | 3.00 | 3.00 | 3.00 | 4.67 | 5.67 | 2.33 | 2.50 | 4.00 | 3.00 | 3.00 | 2.00 | 1.67 |
| $V_3P_3$ | 1.00 | 1.00 | 3.00 | 2.50 | 2.00 | 1.50 | xxx | 2.00 | 4.00 | 4.50 | 3.00 | 3.67 | 3.33 | 1.50 | 2.00 | 3.67 | 4.33 | 2.67 | 2.00 | 3.00 | 3.00 | 2.00 | 2.50 | 2.00 |
| $V_3P_4$ | 2.00 | 1.00 | 1.00 | xxx | 1.67 | 3.00 | 4.00 | 1.50 | 4.00 | 2.50 | 2.00 | 2.00 | 2.33 | 2.33 | 1.00 | 2.67 | 2.67 | 2.33 | 1.33 | 2.00 | 2.33 | 2.50 | 2.00 | 2.00 |
| $V_3P_5$ | xxx | 3.50 | 1.00 | 6.50 | 3.50 | 2.33 | 5.50 | 1.50 | 2.00 | 2.33 | 2.67 | 2.33 | 2.00 | 1.67 | 1.33 | 1.67 | 2.33 | 2.33 | 1.00 | 1.00 | 2.33 | 2.00 | 1.67 | 2.00 |

xxx Bud take nil in all replications

$F_1$ First fortnight

$F_2$ Second fortnight

Appendix XI  Average number of second crop flower buds

| Treatments | Jan | | Feb | | March | | April | | May | | June | | July | | Aug | | Sep | | Oct | | Nov | | Dec | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ |
| $V_1P_1$ | 0 | xxx | xxx | 1.00 | xxx | xxx | 2.00 | 2.00 | 1.50 | 2.00 | xxx | xxx | 1.00 | 1.00 | xxx | xxx | 2.33 | 2.50 | 1.00 | 0 | xxx | 0 | xxx | 0 |
| $V_1P_2$ | 1.00 | 1.00 | xxx | xxx | xxx | xxx | 1.50 | 3.00 | 1.00 | 2.00 | 1.00 | 1.33 | 1.50 | 2.00 | 1.00 | 1.00 | 3.33 | 3.33 | 2.67 | 1.33 | 1.00 | 3.00 | 1.50 | 2.00 |
| $V_1P_3$ | 1.66 | 1.50 | xxx | 1.30 | 1.67 | 1.00 | 1.50 | 3.50 | 1.50 | 1.50 | 1.50 | 1.67 | 2.00 | xxx | 2.00 | 2.00 | 1.67 | 2.33 | 2.33 | 1.67 | 2.50 | 2.50 | 2.50 | 2.67 |
| $V_1P_4$ | 2.50 | 1.50 | 3.00 | xxx | 1.00 | 1.50 | 3.00 | 2.50 | 2.00 | 2.33 | 1.67 | 2.00 | 1.67 | xxx | xxx | 1.50 | 2.00 | 2.33 | 1.67 | 2.00 | 2.00 | 2.33 | 2.00 | 2.00 |
| $V_1P_5$ | 4.50 | 1.50 | 2.00 | 2.00 | 2.67 | 1.50 | 2.00 | 2.00 | 1.67 | 2.67 | 2.33 | 2.00 | 2.33 | 2.00 | 2.00 | 1.67 | 2.00 | 2.33 | 1.67 | 2.00 | 2.00 | 2.33 | 2.33 | 2.00 |
| $V_2P_1$ | 0 | 3.00 | xxx | xxx | xxx | 0 | 2.00 | 1.50 | xxx | xxx | xxx | xxx | 0 | 1.00 | xxx | 1.67 | 2.00 | 3.00 | 2.50 | 2.00 | xxx | xxx | xxx | 1.00 |
| $V_2P_2$ | 0 | 1.00 | xxx | 0 | 1.00 | 0 | 1.00 | 2.00 | 1.00 | 2.00 | 1.00 | 1.00 | 1.50 | 1.50 | xxx | 2.00 | 2.67 | 2.67 | 2.00 | xxx | 1.50 | 1.00 | 1.50 | 1.50 |
| $V_2P_3$ | 1.50 | 1.50 | 0 | 1.00 | 2.00 | 1.00 | 1.50 | 3.00 | 1.50 | 2.00 | 1.50 | 1.50 | 1.50 | 1.67 | 1.00 | 1.67 | 2.33 | 3.50 | 1.67 | 2.50 | 2.50 | 1.50 | 2.00 | 2.00 |
| $V_2P_4$ | xxx | 2.50 | 1.50 | 1.00 | 1.50 | 1.00 | 1.50 | 3.00 | 2.00 | 3.00 | 1.67 | 1.67 | 1.50 | 1.33 | 2.00 | 1.67 | 1.67 | 2.67 | 2.33 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| $V_2P_5$ | 1.33 | 2.60 | 1.50 | 1.50 | 1.50 | 1.00 | 2.00 | 1.50 | 2.50 | 2.50 | 2.33 | 2.00 | 2.50 | 2.00 | 2.00 | 1.67 | 1.67 | 2.33 | 2.00 | 2.00 | 1.67 | 2.33 | 2.33 | 1.67 |
| $V_3P_1$ | 0 | xxx | xxx | 3.00 | xxx | xxx | xxx | 2.00 | 1.00 | 1.00 | 1.00 | xxx | xxx | 1.00 | xxx | 1.50 | 2.33 | 2.00 | 0 | 0 | 0 | 0 | 0 | 0 |
| $V_3P_2$ | 1.50 | 1.00 | 0 | 2.00 | xxx | xxx | 1.50 | xxx | 2.00 | 3.00 | 1.33 | 1.33 | 1.00 | 1.00 | 1.00 | 1.33 | 2.67 | 2.00 | 1.50 | 1.50 | 2.00 | 2.50 | 1.00 | 1.33 |
| $V_3P_3$ | 1.00 | 0 | 1.00 | 2.00 | 1.00 | 1.00 | xxx | 1.00 | 1.00 | 2.50 | 2.00 | 1.67 | 1.67 | 1.00 | 1.00 | 1.67 | 2.00 | 1.67 | 1.67 | 1.50 | 2.00 | 1.50 | 2.00 | 1.67 |
| $V_3P_4$ | 2.00 | 1.00 | 1.00 | xxx | 1.33 | 1.33 | 2.00 | 1.00 | 2.50 | 1.50 | 1.83 | 1.83 | 1.67 | 1.67 | 1.00 | 2.33 | 2.00 | 2.33 | 1.33 | 1.33 | 2.00 | 2.00 | 1.50 | 1.67 |
| $V_3P_5$ | xxx | 2.50 | 1.00 | 1.30 | 1.50 | 1.33 | 2.50 | 1.50 | 2.00 | 2.33 | 1.67 | 2.33 | 1.33 | 1.33 | 1.33 | 1.67 | 2.00 | 2.33 | 1.00 | 1.00 | 2.33 | 1.67 | 1.67 | 1.67 |

xxx  Bud take nil in all replications

$F_1$  First fortnight

$F_2$  Second fortnight

Appendix XII Average no. of days taken for second crop flower bud production

| Treat-ments | Jan $F_1$ | Jan $F_2$ | Feb $F_1$ | Feb $F_2$ | March $F_1$ | March $F_2$ | April $F_1$ | April $F_2$ | May $F_1$ | May $F_2$ | June $F_1$ | June $F_2$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $V_1P_1$ | - | xxx | xxx | 112.00 | xxx | xxx | 104.50 | 82.67 | 75.00 | 79.00 | xxx | xxx |
| $V_1P_2$ | 98.00 | 68.00 | xxx | xxx | xxx | xxx | 102.00 | 113.00 | - | 102.00 | 130.00 | 73.33 |
| $V_1P_3$ | 90.00 | 73.50 | xxx | 113.30 | 95.67 | 84.00 | 91.50 | 106.00 | 70.00 | 89.50 | 110.00 | 76.67 |
| $V_1P_4$ | 98.00 | 79.00 | 132.00 | xxx | 98.00 | 79.00 | 92.00 | 110.00 | 79.50 | 80.33 | 91.00 | 110.33 |
| $V_1P_5$ | 99.00 | 78.50 | 124.50 | 98.00 | 90.00 | 76.00 | 99.50 | 83.67 | 81.00 | 84.67 | 80.50 | 88.33 |
| $V_2P_1$ | - | 124.00 | xxx | xxx | xxx | - | 152.00 | 130.50 | xxx | xxx | xxx | xxx |
| $V_2P_2$ | - | 148.00 | xxx | - | 104.00 | - | 144.00 | 109.00 | 129.50 | 68.00 | 102.00 | 87.50 |
| $V_2P_3$ | 98.00 | 115.50 | - | 126.00 | 113.00 | 108.00 | 147.00 | 134.00 | 126.00 | 62.00 | 92.00 | 68.00 |
| $V_2P_4$ | xxx | 132.50 | 146.00 | 121.00 | 126.00 | 97.00 | 145.00 | 126.00 | 115.50 | 67.00 | 89.00 | 84.67 |
| $V_2P_5$ | 106.00 | 154.00 | 134.50 | 114.50 | 129.50 | 90.00 | 130.00 | 109.50 | 96.00 | 90.00 | 77.00 | 84.33 |
| $V_3P_1$ | - | xxx | xxx | 90.00 | xxx | xxx | xxx | 116.00 | 118.00 | 68.00 | 78.00 | xxx |
| $V_3P_2$ | 94.00 | 122.00 | - | 112.00 | xxx | xxx | 110.50 | xxx | 121.00 | 71.00 | 110.33 | 74.00 |
| $V_3P_3$ | 91.00 | - | 148.00 | 121.50 | 122.00 | 114.50 | xxx | 112.00 | 117.00 | 89.50 | 91.00 | 71.33 |
| $V_3P_4$ | 112.00 | 130.00 | 154.00 | xxx | 105.67 | 103.67 | 98.00 | 108.50 | 110.00 | 78.00 | 82.33 | 90.33 |
| $V_3P_5$ | xxx | 135.00 | 108.00 | 97.00 | 90.00 | 94.67 | 92.50 | 92.50 | 99.00 | 81.00 | 95.00 | 80.33 |

| Treat-ments | July $F_1$ | July $F_2$ | August $F_1$ | August $F_2$ | Sep $F_1$ | Sep $F_2$ | Oct $F_1$ | Oct $F_2$ | Nov $F_1$ | Nov $F_2$ | Dec $F_1$ | Dec $F_2$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $V_1P_1$ | 88.00 | 82.00 | xxx | xxx | 95.67 | 82.00 | 67.00 | - | xxx | - | xxx | - |
| $V_1P_2$ | 80.50 | 78.00 | 68.00 | 76.00 | 83.00 | 82.67 | 90.33 | 72.00 | 78.00 | 99.00 | 91.00 | 76.00 |
| $V_1P_3$ | 103.00 | xxx | 73.00 | 71.00 | 94.33 | 87.00 | 105.33 | 83.00 | 58.50 | 87.50 | 99.50 | 90.67 |
| $V_1P_4$ | 95.00 | xxx | xxx | 85.50 | 98.67 | 94.33 | 94.33 | 92.33 | 36.33 | 93.33 | 106.50 | 118.33 |
| $V_1P_5$ | 96.00 | 96.00 | 84.00 | 80.67 | 102.30 | 97.33 | 129.00 | 103.00 | 96.00 | 108.67 | 113.00 | 124.00 |
| $V_2P_1$ | - | 96.00 | xxx | 75.00 | 84.50 | 104.00 | 102.00 | 81.00 | xxx | xxx | xxx | 89.00 |
| $V_2P_2$ | 78.00 | 93.00 | xxx | 86.00 | 96.33 | 106.67 | 73.00 | xxx | 90.50 | 86.00 | 92.00 | 94.50 |
| $V_2P_3$ | 78.50 | 90.33 | 64.00 | 73.67 | 98.33 | 88.50 | 94.67 | 81.00 | 92.00 | 91.50 | 96.50 | 89.67 |
| $V_2P_4$ | 88.50 | 94.00 | 99.00 | 102.00 | 101.67 | 111.67 | 102.00 | 90.00 | 105.67 | 95.50 | 93.30 | 83.50 |
| $V_2P_5$ | 104.50 | 86.67 | 78.00 | 95.00 | 105.00 | 96.00 | 112.67 | 93.67 | 102.33 | 104.67 | 100.33 | 98.67 |
| $V_3P_1$ | xxx | 71.00 | xxx | 67.50 | 81.67 | 92.00 | - | - | - | - | - | - |
| $V_3P_2$ | 81.00 | 84.00 | 91.00 | 77.00 | 92.00 | 90.00 | 95.00 | 91.00 | 88.00 | 104.00 | 78.00 | 87.33 |
| $V_3P_3$ | 93.00 | 72.00 | 86.00 | 74.67 | 80.33 | 86.00 | 95.67 | 83.50 | 79.00 | 92.50 | 100.00 | 89.33 |
| $V_3P_4$ | 98.00 | 87.33 | 76.50 | 90.00 | 89.67 | 109.33 | 106.33 | 107.00 | 87.33 | 123.50 | 121.00 | 103.00 |
| $V_3P_5$ | 81.67 | 84.00 | 85.00 | 89.33 | 96.67 | 107.00 | 99.00 | 105.00 | 102.33 | 109.67 | 116.33 | 106.00 |

' - ' Plants lost after first flowering
xxx Bud take nil in all replications
$F_1$ First fortnight
$F_2$ Second fortnight

Appendix XIII Average number of petals in second crop flowers

| Treat-ments | Jan | | Feb | | March | | April | | May | | June | | July | | Aug | | Sep | | Oct | | Nov | | Dec | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ |
| $V_1P_1$ | - | xxx | xxx | 21.00 | xxx | xxx | 29.50 | 26.00 | 14.50 | 24.00 | xxx | xxx | 16.00 | 14.00 | xxx | xxx | 22.33 | 18.50 | 19.00 | - | xxx | - | xxx | - |
| $V_1P_2$ | 8.00 | 12.00 | xxx | xxx | xxx | xxx | 22.50 | 19.00 | 28.00 | 22.00 | 19.50 | 21.67 | 15.00 | 19.00 | 16.00 | 16.50 | 23.67 | 18.33 | 21.33 | 18.00 | 21.00 | 16.00 | 16.00 | 18.00 |
| $V_1P_3$ | 15.30 | 17.50 | xxx | 28.00 | 19.67 | 21.00 | 29.00 | 17.00 | 18.00 | 19.00 | 17.50 | 19.00 | 21.67 | xxx | 28.00 | 15.00 | 26.00 | 19.67 | 23.00 | 25.33 | 19.50 | 16.00 | 20.50 | 20.00 |
| $V_1P_4$ | 16.00 | 16.50 | 34.00 | xxx | 19.00 | 23.50 | 41.00 | 21.00 | 21.00 | 27.67 | 23.33 | 15.33 | 19.67 | xxx | xxx | 21.50 | 30.67 | 19.33 | 25.33 | 21.33 | 20.33 | 18.67 | 26.50 | 23.67 |
| $V_1P_5$ | 21.50 | 18.00 | 38.50 | 44.00 | 24.33 | 29.50 | 28.50 | 27.67 | 26.00 | 36.67 | 29.33 | 24.00 | 27.33 | 24.00 | 38.00 | 23.33 | 27.33 | 29.67 | 26.33 | 25.67 | 28.00 | 19.33 | 26.00 | 25.33 |
| $V_2P_1$ | - | 20.00 | xxx | xxx | xxx | - | 18.00 | 19.50 | xxx | xxx | xxx | xxx | - | 17.00 | xxx | 14.67 | 20.50 | 18.00 | 27.50 | 12.00 | xxx | xxx | xxx | 16.00 |
| $V_2P_2$ | - | 28.00 | xxx | - | 18.00 | - | 21.00 | 38.00 | 29.50 | 28.00 | 18.00 | 17.00 | 27.50 | 21.00 | xxx | 20.33 | 15.00 | 18.67 | 21.00 | xxx | 16.00 | 16.00 | 14.50 | 21.00 |
| $V_2P_3$ | 24.00 | 28.50 | - | 18.00 | 21.00 | 16.00 | 24.50 | 26.00 | 21.00 | 26.00 | 17.00 | 16.50 | 17.00 | 19.33 | 18.00 | 15.33 | 15.67 | 18.50 | 33.00 | 20.00 | 19.50 | 19.00 | 18.00 | 24.00 |
| $V_2P_4$ | xxx | 23.50 | 17.50 | 21.00 | 25.50 | 22.50 | 28.50 | 24.00 | 18.50 | 30.50 | 19.67 | 16.00 | 21.00 | 33.00 | 22.00 | 24.33 | 24.67 | 19.67 | 36.00 | 19.50 | 21.67 | 19.00 | 22.67 | 18.00 |
| $V_2P_5$ | 26.33 | 36.33 | 22.00 | 27.50 | 28.00 | 23.00 | 31.50 | 27.00 | 28.00 | 30.50 | 26.33 | 18.33 | 34.00 | 37.33 | 23.50 | 29.67 | 22.67 | 25.00 | 42.00 | 25.00 | 23.00 | 20.33 | 28.67 | 25.33 |
| $V_3P_1$ | - | xxx | xxx | 21.00 | xxx | xxx | xxx | 16.00 | 18.00 | 23.00 | 31.00 | xxx | xxx | 24.00 | xxx | 18.50 | 14.67 | 18.00 | - | - | - | - | - | - |
| $V_3P_2$ | 42.50 | 25.00 | - | 22.00 | xxx | xxx | 29.50 | xxx | 13.00 | 17.00 | 23.67 | 15.33 | 14.00 | 16.00 | 18.00 | 23.00 | 18.00 | 21.00 | 26.50 | 26.00 | 28.00 | 19.50 | 24.00 | 21.00 |
| $V_3P_3$ | 49.00 | - | 21.00 | 19.50 | 21.00 | 16.50 | xxx | 16.00 | 13.00 | 24.50 | 26.00 | 22.33 | 20.33 | 20.50 | 21.00 | 18.00 | 23.67 | 24.67 | 26.33 | 26.50 | 34.00 | 28.50 | 23.00 | 28.33 |
| $V_3P_4$ | 47.00 | 36.00 | 21.00 | xxx | 28.00 | 27.00 | 32.00 | 15.00 | 19.50 | 27.00 | 41.33 | 31.33 | 21.67 | 29.33 | 21.50 | 20.00 | 22.33 | 32.33 | 32.67 | 23.67 | 31.33 | 32.00 | 24.50 | 17.33 |
| $V_3P_5$ | xxx | 41.50 | 31.00 | 28.00 | 37.50 | 38.33 | 43.50 | 24.50 | 21.00 | 36.33 | 41.33 | 34.67 | 32.00 | 35.33 | 24.00 | 26.00 | 22.67 | 38.67 | 35.00 | 40.33 | 37.67 | 39.00 | 33.67 | 35.67 |

'-' Plants lost after first flowering
xxx Bud take nil in all replications
$F_1$ First fortnight
$F_2$ Second fortnight

Appendix XIV Average plant height after second crop flowering

| Treatments | Jan | | Feb | | March | | April | | May | | June | | July | | Aug | | Sep | | Oct | | Nov | | Dec | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ |
| $V_1P_1$ | - | xxx | xxx | 18.30 | xxx | xxx | 23.00 | 21.80 | 25.50 | 22:20 | xxx | xxx | 17.00 | 10.30 | xxx | xxx | 26.43 | 19.85 | 17.00 | - | xxx | - | xxx | - |
| $V_1P_2$ | 18.00 | 19.50 | xxx | xxx | xxx | xxx | 16.25 | 18.80 | 12.00 | 17.10 | 22.00 | 24.50 | 17.70 | 15.80 | 16.40 | 12.10 | 29.00 | 18.67 | 24.00 | 13.87 | 9.80 | 13.00 | 21.60 | 20.00 |
| $V_1P_3$ | 26.66 | 23.00 | xxx | 27.30 | 12.03 | 51.00 | 19.67 | 18.75 | 23.30 | 20.50 | 24.70 | 22.80 | 24.20 | xxx | 22.00 | 8.50 | 25.67 | 23.63 | 20.57 | 17.57 | 11.90 | 13.65 | 23.70 | 18.20 |
| $V_1P_4$ | 32.00 | 26.70 | 48.00 | xxx | 16.30 | 42.00 | 18.00 | 11.80 | 22.75 | 23.53 | 27.23 | 25.80 | 29.13 | xxx | xxx | 14.35 | 24.73 | 19.90 | 21.80 | 19.67 | 19.53 | 19.37 | 23.60 | 23.67 |
| $V_1P_5$ | 39.50 | 28.30 | 48.50 | 22.00 | 19.70 | 32.00 | 21.40 | 20.67 | 21.43 | 22.33 | 28.73 | 34.60 | 31.03 | 18.45 | 11.80 | 14.80 | 20.83 | 24.87 | 18.23 | 24.73 | 20.73 | 17.43 | 20.43 | 23.40 |
| $V_2P_1$ | - | 42.00 | xxx | xxx | xxx | - | 15.10 | 18.85 | xxx | xxx | xxx | xxx | - | 18.00 | xxx | 19.67 | 35.00 | 23.70 | 21.50 | 12.40 | xxx | xxx | xxx | 21.00 |
| $V_2P_2$ | - | 53.00 | xxx | - | 19.00 | - | 13.00 | 23.00 | 32.45 | 21.20 | 13.40 | 16.70 | 26.15 | 17.00 | xxx | 17.67 | 18.67 | 24.73 | 18.80 | xxx | 9.85 | 9.70 | 16.05 | 17.00 |
| $V_2P_3$ | 26.50 | 40.50 | - | 18.80 | 18.00 | 21.00 | 15.00 | 25.10 | 16.40 | 20.35 | 17.05 | 23.25 | 25.55 | 19.67 | 16.00 | 20.07 | 16.43 | 27.10 | 21.67 | 21.55 | 14.40 | 13.90 | 17.00 | 18.60 |
| $V_2P_4$ | xxx | 32.00 | 17.50 | 16.80 | 18.65 | 19.20 | 16.05 | 31.00 | 29.00 | 26.80 | 21.00 | 29.03 | 23.05 | 24.83 | 17.00 | 30.33 | 23.10 | 30.67 | 22.33 | 24.40 | 22.27 | 14.50 | 21.67 | 23.75 |
| $V_2P_5$ | 28.00 | 39.00 | 19.50 | 18.55 | 15.25 | 18.70 | 20.10 | 18.80 | 30.25 | 24.55 | 22.23 | 27.23 | 20.15 | 19.50 | 11.65 | 21.80 | 20.27 | 27.00 | 16.13 | 22.50 | 21.50 | 14.43 | 20.43 | 21.30 |
| $V_3P_1$ | - | xxx | xxx | 28.00 | xxx | xxx | xxx | 10.80 | 17.90 | 17.10 | 16.10 | xxx | xxx | 19.00 | xxx | 16.50 | 25.93 | 19.00 | - | - | - | - | - | - |
| $V_3P_2$ | 25.90 | 13.05 | - | 27.90 | xxx | xxx | 18.95 | xxx | 19.20 | 18.40 | 23.33 | 19.00 | 16.60 | 21.00 | 18.30 | 23.70 | 25.77 | 20.00 | 25.15 | 21.45 | 16.30 | 18.50 | 16.00 | 15.27 |
| $V_3P_3$ | 29.00 | 9.00 | 27.00 | 25.40 | 10.50 | 11.35 | xxx | 19.80 | 14.95 | 27.85 | 28.00 | 18.97 | 14.33 | 21.00 | 21.00 | 17.53 | 26.33 | 20.70 | 20.50 | 18.90 | 16.10 | 20.60 | 18.50 | 19.63 |
| $V_3P_4$ | 32.00 | 21.00 | 29.10 | xxx | 14.10 | 17.27 | 17.10 | 19.15 | 20.25 | 31.90 | 21.93 | 23.13 | 16.23 | 20.93 | 16.60 | 21.43 | 24.77 | 17.57 | 22.57 | 27.20 | 20.47 | 26.20 | 20.50 | 22.67 |
| $V_3P_5$ | xxx | 26.55 | 26.00 | 23.00 | 20.30 | 21.40 | 16.85 | 17.15 | 16.50 | 24.97 | 23.27 | 29.53 | 19.17 | 18.10 | 15.77 | 17.33 | 23.07 | 21.00 | 18.83 | 25.07 | 22.07 | 23.37 | 20.57 | 23.77 |

'-' Plants lost after first flowering

xxx Bud take nil in all replications

$F_1$ First fortnight

$F_2$ Second fortnight

Appendix XV Seasonal and varietal distribution of CHO, N, and C/N ratio

| Treatments | Ambassador | | | Pink Panther | | | Princess | | |
|---|---|---|---|---|---|---|---|---|---|
| | CHO% | N% | C/N ratio | CHO% | N% | C/N ratio | CHO% | N% | C/N ratio |
| 1st January | 6.98 | 3.36 | 2.09 | 7.38 | 3.60 | 2.06 | 7.30 | 3.24 | 2.26 |
| 15th January | 7.35 | 3.81 | 1.94 | 7.32 | 4.08 | 1.80 | 7.49 | 4.28 | 1.76 |
| 1st February | 6.66 | 2.24 | 3.01 | 7.59 | 2.34 | 3.29 | 6.70 | 2.42 | 2.79 |
| 15th February | 7.29 | 2.33 | 3.16 | 7.07 | 2.24 | 3.18 | 6.59 | 2.31 | 3.16 |
| 1st March | 6.72 | 2.29 | 2.98 | 7.19 | 2.19 | 3.32 | 7.17 | 2.30 | 3.15 |
| 15th March | 6.63 | 2.22 | 3.02 | 7.22 | 2.20 | 3.29 | 6.49 | 2.28 | 2.86 |
| 1st April | 6.68 | 2.16 | 3.12 | 7.59 | 2.92 | 2.64 | 7.12 | 2.41 | 2.95 |
| 15th April | 7.18 | 3.48 | 2.09 | 8.13 | 3.36 | 2.46 | 7.81 | 3.69 | 2.13 |
| 1st May | 7.65 | 3.69 | 2.11 | 8.28 | 3.67 | 2.27 | 7.78 | 3.98 | 1.97 |
| 15th May | 7.75 | 3.82 | 2.06 | 8.35 | 3.95 | 2.13 | 8.16 | 4.19 | 1.96 |
| 1st June | 7.98 | 2.42 | 3.33 | 9.02 | 2.35 | 3.87 | 9.24 | 2.35 | 3.97 |
| 15th June | 8.19 | 2.46 | 3.41 | 9.22 | 2.72 | 3.43 | 9.34 | 2.58 | 3.66 |
| 1st July | 8.65 | 2.41 | 3.67 | 9.16 | 2.51 | 3.69 | 9.49 | 2.46 | 3.94 |
| 15th July | 9.04 | 2.07 | 4.47 | 9.22 | 2.22 | 4.18 | 9.61 | 2.12 | 4.57 |
| 1st August | 7.73 | 2.41 | 3.27 | 8.03 | 2.76 | 2.92 | 7.92 | 2.71 | 2.96 |
| 15th August | 7.71 | 2.46 | 3.21 | 7.94 | 2.94 | 2.72 | 7.96 | 2.84 | 2.84 |
| 1st September | 7.73 | 2.45 | 3.19 | 8.05 | 2.57 | 3.17 | 7.96 | 2.76 | 2.38 |
| 15th September | 7.63 | 2.33 | 3.31 | 7.97 | 2.32 | 3.48 | 7.91 | 2.58 | 3.09 |
| 1st October | 7.36 | 2.35 | 2.79 | 8.27 | 2.62 | 3.18 | 8.15 | 2.94 | 2.79 |
| 15th October | 7.91 | 2.76 | 2.91 | 8.42 | 2.57 | 3.30 | 8.56 | 2.76 | 3.13 |
| 1st November | 8.02 | 2.82 | 2.89 | 8.38 | 2.47 | 3.44 | 8.16 | 2.81 | 2.95 |
| 15th November | 8.12 | 2.86 | 2.87 | 8.22 | 2.57 | 3.23 | 8.05 | 2.84 | 2.87 |
| 1st December | 7.12 | 2.91 | 2.48 | 7.92 | 2.92 | 2.73 | 7.57 | 2.98 | 2.56 |
| 15th December | 7.04 | 2.31 | 2.32 | 7.82 | 3.41 | 2.31 | 7.60 | 3.02 | 2.55 |

# EFFECT OF SEASON AND POSITION OF BUD IN BUDDING OF ROSE

BY

**ANITHA, I**

**ABSTRACT OF THE THESIS**
submitted in partial fulfilment of the requirement
for the degree
**MASTER OF SCIENCE IN HORTICULTURE**
Faculty of Agriculture
Kerala Agricultural University

DEPARTMENT OF HORTICULTURE
COLLEGE OF AGRICULTURE
VELLAYANI, TRIVANDRUM

1989

ABSTRACT

A research programme was carried out for a period of one year from January 1987 to December 1987, to study the effect of season and position of bud in budding of rose. The experiment was laid out in factorial CRD with three replications. The treatments consisted of combinations of three varieties, 'Ambassador', 'Pink Panther' and 'Princess', with scion buds from five positions, starting immediately below the flower. Budding was done at fortnightly intervals.

The effect of environmental parameters on success of budding; influence of period of budding, varieties and scion bud position on further vegetative growth and flower; influence of C/N ratio on bud take have been proved by the results of the present study. There was no significant difference among the three varieties, 'Ambassador', 'Pink Panther' and 'Princess' in respect of success in budding. A high rate of 82-98 per cent success was recorded during the rainy season of second fortnight of August to first fortnight of October. The period from first fortnight of February to second fortnight of March was the least favourable season. Higher temperature was found to be detrimental for the success in budding. Rainfall and relative humidity favoured the bud take. More sunshine hours

was detrimental. The preceding, current and succeeding fortnights of budding, were found to be critical, as far as success in rose budding is concerned.

The period of budding significantly influenced the biometric characters under study. The variety and bud position was found to exert significant influence on some of the biometric characters. The first and second buds were early to sprout and flower till the production of first flower bud, but the plants were comparatively weak. The fourth and the fifth buds were found to be better for budding when plant vigour was considered. Correlations were worked out between the thirteen biometric characters under study. The scion C/N ratio significantly influenced the bud take while the rootstock C/N did not significantly influence the take. The carbohydrate and nitrogen content varied significantly throughout the year and with scion bud position and variety.