INFLUENCE OF USING POLYEMBRYONIC ROOTSTOCKS IN THE GRAFTING OF MANGO IN THE ESTABLISHMENT OF GRAFTS

By

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THESIS

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DECLARATION

I hereby declare that the thesis entitled 'Influence of using polyembryonic rootstocks in the grafting of mango and in the establishment of grafts' is a bonafied record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree diploma associateship fellowship or other similar title of any other University or Society

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Introduction

INTRODUCTION

Mango is one of the most important fruit crops covering the largest area under its cultivation in the Country It occupies an area of 10 63 million hectares with an annual production of 9 34 million metric tonnes of fruits This accounts for 42 7 per cent of the area under fruits and 40 per cent of the total fruit production in the Country Mango is seen in every homestead of Kerala and the State has the distinction of producing the earliest mangoes in the Country besides its unparalleled wealth of pickle types The estimated area of mango in the State is 72418 ha with an annual production of 225934 tonnes

Traditionally mango trees have been raised from seedlings Mango is highly heterozygous and cross pollinated and asexual methods of propagation are to be resorted to for producing true to type progenies Different methods of vegetative propagation are in vogue in mango with varying degrees of success Approach grafting the commercial method of propagation owing to its time consuming and cumbersome nature is being replaced by epicotyl and soft wood graftings which are comparatively easier and less expensive The age of rootstock height of grafting, precuring of scion etc have been perfected for epicotyl and soft wood grafting of mango in the Department of Pomology and Floriculture College of Horticulture Vellanikkara

The influence of the rootstock on the growth and performance of scion has been well established in fruit crops like apple and citrus In mango also rootstocks are found to have strong influence on establishment of grafts growth and longevity of the grafted tree the yeld fruit quality time of ripening of fruits and mineral composition of leaves This important aspect is often neglected and assorted mango stones are used for raising rootstocks Seeds of polyembryonic races due to their uniformity can be used as rootstocks with advantage so as to minimize variability In this situation the need was felt to identify a rootstock among the local polyembryonic varieties which will ensure a better percentage of success and establishment of soft wood grafts Keeping this objective in view the present study was carried out with the following objectives

1 To study the varietal differences of polyembryonic rootstocks with respect to the percentage of success establishment and further growth of soft wood grafts of mango

2 To examine the anatomy of the graft union to find out the different stages of healing process and the possible reasons for graft failure

Review of Literature

REVIEW OF LITERATURE

In mango large scale propagation is still being done on seedling rootstocks which are highly heterogenous in nature Preliminary work on rootstocks of mango was done by Sen (1939) who reported Kalapady as a dwarfing rootstock Further Gunaratnam (1946) found that a wild variety Pulima when used as a rootstock caused profuse and regular bearing Oppenheimer (1956) found that there was wide variation in the performance of the grafted trees of the same variety growing in the same orchard of homogenous conditions and orchard management which showed the high degree of uncertainity being faced by orchardists who planted mango grafts prepared out of heterozygous seedling stock Many workers had suggested the use of polyembryonic rootstocks due to their uniformity to minimize variability among grafted mango trees (Gunaratnam 1946 Rangacharlu 1955 Oppenheimer 1958 Bakshi 1963 and Swamy et al 1972)

1 Polyembryony in mango

In India most of the commercial varieties of mango are monoembryonic Only a few varieties found in the Westcoast and South of India are polyembryonic but inferior in fruit quality Sen and Malik (1940) from a survey conducted in the Westcoast of India reported that out of 400 varieties examined only 10 were polyembryonic and even in those polyembryonic varieties there

was a fair percentage of monoembryonic seed Naik (1941) Hayes (1953) and Singh (1960) also reported that large number of mango varieties in India are monoembryonic

Monoembryonic varieties give rise to asexual seedling from seed On the other hand, polyembryonic races give many seedlings from a single stone The origin of multiple shoots from seeds of mango have been noted by Strasburger (1878) Oliver (1903) Cook (1907) and Arndt (1935) Arndt (1935) is of view that multiple shoots arising from seeds may originate through polyembryony the development of adventitious buds on the seedlings before or dur ng germination or a combination of two types Juliano (1934) opined that adventitious embryos originate from the epidermal cells of the nucellus situated close to the micropolar end of the side opposite to the funicle Maheswari et al (1955) also obtained similar results According to Sturrock (1969) polyembryonic condit ion in mango is a recessive factor and is probably controlled by a single pair of genes

It is generally believed that in most polyembryonic types the sexual embryo degenerated early in development with the result that in some varieties all the seedlings are nucellar (Singh 1960 and Sturrock 1969) In Philippines Pico and Carabao are the principal commercial varieties and they retain their characters with remarkable consistency even when reproduced from seed (Valmayor 1972) The possibility of the survival of the zygotic

seedling however cannot entirely be ruled out The presence of numerous local trees showing distinct and different characteristics from the main polyembryonic types support this contention (Asadullah and Khan 1960 Singh 1960 Ahmed 1964) In the early stages of growth it is not possible to distinguish between the sexual and nucellar seedlings but is generally believed that sexual embryos are suppressed by nucellar embryos in the early stage of development and are relatively weak and stunted in growth (Ahmed 1960 Singh 1960)

The polyembryonic races breed true to the female parent from seed However with the exception of a few types in Indo China and the Philippines most polyembryonic mangoes are inferior in fruit characters (Asadullah and Khan 1960 Ahmed 1964 Rao 1967) The real value of polyembryony in mangoes lies in the production of nucellar seedlings to be used as rootstocks More than one seedling emerges from the seed three to eight seedlings from one seed are not uncommon In Philippines more than thirty have been recorded (Belling 1908 Juliano 1937 Asadullah and Khan 1960 Ahmed 1964) However Singh and Reddy (1990) observed that the mean range of seedling formation per stone was 2 33 to 2 75 for the polyembryonic varieties studied They also obtained higher germination percentage for polyembryonic varieties than most of the monoembryonic varieties

2 Varietal response of rootstock and scion

The differential response of varieties of rootstocks and scions to the success of grafting and further growth of grafts has been well established The salient results of relevant studies are briefly summarised below

Srivastava and Singh (1981) reported that when Dasheharı was veneer grafted on ten different rootstocks Kalapady stock resulted in 90 per cent success followed by Nakkare which recorded 85 per cent success Similar studies by inarching using Dasheharı scion on Nakkare and Langra rootstocks resulted in 97 per cent success where as maximum survival (100 per cent) was observed with Goa stock In rootstock and scion combinations studied Mallika/Kalapady Mallika/Muvandan Dasheharı/Kalapady and Langra/Muvandan resulted in appreciable success which was too low with Chausa on Nakkare rootstock In a similar study Hussain et al (1989) under Lahore conditions obtained maximum grafting success (55 5 per cent) with Anwar Rataul rootstock for Samar Bahist scions and with Malda for Langra scions (83 9 per cent) They also observed that Anwar Rataul rootstock induced greatest extension growth (8 40 cm) with Samar Bahist scion while the maximum girth was recorded by the Samar Bahist rootstock grafted with scion of the same variety In the Langra scion maximum length (27 1 cm) and girth (0 8 cm) were induced by the Langra rootstock itself

In softwood grafting of mango Kulwal and Tayde (1985) obtained nearly 100 per cent success for the varieties Pairi Kesar Pundur and Panchadarakalasa under Konkan conditions Other varieties like Neelum Local 1 Local 2 Totapuri and Banganappally showed an ultimate survival of 72 to 85 per cent In the studies conducted by Reddy and Melanta (1989) in in situ softwood grafting Dasheheri scion recorded the highest graft take of 100 per cent at 30 days 95 per cent at 45 days and 90 per cent at 60 days after grafting with Nakkare as rootstocks followed by Totapuri and Langra as scions on Nakkare

In a study to find out the response of selected varieties of mango to epicotyl grafting Dhakal (1979) obtained 86 85 70 66 65 64 and 61 per cent success respectively for varieties Kesar Totapuri Pairi Vanraj Fernandin Gomankur and Alphonso when used as scions Maiti and Biswas (1980) obtained high percentage of successful grafts with defoliated scion shoots of Fazli (96 per cent) Raneepasand (94 per cent) and Kohinoor (90 per cent) Chakrabarti and Sadhu (1984) observed the variety Langra as the best scion for grafting followed by the varieties Bombai and Himsagar regardless of time of grafting Reddy and Kohli (1985) reported that Totapuri as scion shoots gave better success than Alphonso as scion shoots on Alphonso rootstocks under Bangalore conditions

In an experiment conducted at Kerala Agricultural University Vellanikkara Trichur to find out the response of six scion varieties of mango viz Mulgoa Prior Banganapally Mundappa Bangalora and Alphonso to stone grafting Radhamony (1987) reported highest percentage of sprouting for Banganapally with scion shoots of length six and ten centimetres and for Prior with scions of eight centimetres length The variety Prior recorded maximum survival with scions of eight centimetres while variety Mulgoa with scions of six centimetre long scions recorded the least survival

Madalageri et al (1989) observed that epicotyl grafting done in June success ranged from 64 6 per cent in the cultivar Dasheheri and 66 1 per cent in the hybrid Mallika and 34 per cent in the hybrid Amrapali

In veneer grafting Singh and Srivastava (1979) obta ned 85 80 and 35 percentage graft take using the scion varieties Ratna Mallika and Chausa respectively Bajpai et al (1985) tried two scion varieties Amprapali and Mallika and obtained better survival percentage of the grafts with vigorous scion growth using Amprapali as scion compared to Mallika Kashyap et al (1989) obtained higher success rates with Dasheheri and Langra varieties than with Taimuria and Fazli

3 Influence of rootstock on the success and survival of grafts

The age of rootstock height of grafting and thickness of rootstocks are found to influence the success of grafting

3 1 Age of rootstock

Amin (1978) obtained about 100 per cent success with one year old rootstocks in the *in situ* method of softwood grafting in mango From the trials conducted using variety Dashehari as scion shoot softwood grafting on one year old rootstock was found to give the highest grafting success of 90 per cent (Singh and Srivastava 1982) Later on in a study at Lucknow to evaluate the selected methods of mango propagation cleft grafting on the softwood apical portion of the seedling rootstock was found to give 75 to 80 per cent success (Gaur 1984) Singh *et al* (1984) reported about 100 per cent success with softwood grafting using one year old rootstock Kulwal and Tayde (1985) also stressed the superiority of using one year old roostock for softwood graft ing in mango Savithri (1990) obtained maximum success for Banga napally and Neelum scions when grafted with one and two month old seedling rootstocks respectively

In epicotyl grafting Majumder and Rathore (1970) recommended the use of young germinating mango stones as root stocks Seedlings of four to seven days of age were proved better which resulted in 73 3 per cent success (Chhate *et al* 1976)

But Singh and Srivastava (1981) observed that four to five days old seedling rootstocks were the most ideal for stone grafting in mango According to Gunjate et al (1982) seedling rootstocks of age less than two weeks were most suitable for epicotyl grafting However Chakrabarti and Sadhu (1984) obtained the highest graft ing success with the use of five days old seedling rootstock Desai and Patil (1984) grafted scion shoots of cv Alphonso on seven days old rootstock and obtained a success of 70 per cent under green house conditions A combination of four days old seed ling stocks and five days of defoliation was to be best by Patil et al (1984) In a trial to standardise the optimum age of root stock under Vellanikkara conditions, Dhungana (1984) obtained 58 per cent success when five days old seedling rootstocks were used The survival rate decreased from 50 to 32 per cent when the age of rootstock increased from five to 15 days

According to Patil and Patil (1985) in mango stone grafting initial sprouting was more in the grafts prepared six days old rootstocks but the final success was more with four days old rootstocks A high grafting success of 95 per cent was reported by Reddy and Kohli (1985) when grafting was done on eight days old stocks In a study on epicotyl grafting in mango Aravindakshan et al (1987) obtained maximum per cent of sprouting and survival using five to ten days old rootstocks

Ahmad (1964) obtained the maximum success with the use of nine month old seedling rootstocks for veneer grafting in mango However Jagirdar and Bhatti (1968) did not observe any difference between the rootstocks of different ages viz three months or nine months Bhambota et al (1971) successfully conducted a study on veneer grafting in mango with the use of one year old rootstock and could get an average success of 87 50 per cent But Prasad et al (1973) obtained best results with the use of two year old rootstocks According to Singh and Srivastava (1979) 12 months old rootstocks were the best for veneer grafting in mango Singh et al (1984) also suggested the use of one year old rootstocks for mango veneer grafting and they got 96 6 per cent success in mid June The beneficial effect of two year old rootstocks for the growth of grafts and for their survival was however stressed by Bajpai et al (1985)

As early as in 1921 Burns and Prayag obtained maximum success with three week old seedling rootstocks for inarching in mango in Phillippines But Naik (1941) suggested roostocks of four and a half months of age are the best for inarching in mango Later in 1948 Naik also revealed the suitability of older rootstocks of nine to fifteen months of age for inarching Use of older rootstocks was stressed by Singh (1960) Teaotia and

Srivastava (1961) suggested a new method of inarching in mango with the use of four to six week old seedling rootstocks A similar report was made by Majhail and Singh (1962) in which they recommended the use of two month old seedlings as rootstocks

3 2 Height of grafting

Singh and Srivastava (1982) suggested that the height of grafting had no appreciable effect on success of softwood grafts This was further proved by Savithri (1990) She found that there was no effect of length of rootstocks on sprouting and survival of softwood grafts in both Neelum and Banganapally varieties

According to Patel and Amin (1976) epicotyl grafting can be done best at a height of six centimetres on the rootstock in mango Later on Chakrabarti and Sadhu (1984) obtained better results by grafting at five centimetres height compared to other treatments Based on a study conducted under Vellanikkara condit ions Ratan (1985) reported a sprouting of 87 50 per cent and survival of 72 50 per cent when epicotyl grafting was done at a height of six to eight centimetres from the collar region of the rootstock

3 3 Thickness of rootstock

Studies have revealed that for a proper combination same thickness of stock and scion is a must For in situ softwood graft ing in mango Amin (1978) recommended the use of ~~scion shoots~~

of the same thickness as that of the terminal shoot of the root stock to get 100 per cent success Similarly for flush grafting in mango also scion shoots of the same thickness as that of the second flush of the rootstock were proved most ideal (Subramani 1988) Rajput and Haribabu (1971) reported that in mango the stock and scion of uniform thickness were most ideal for epicotyl grafting

Rootstock and scion of uniform thickness were found to be most suitable for veneer grafting in mango (Singh and Srivastava 1979) Dhungana (1984) recommended the use of stock and scion of diameter two centrimetres and one centimetre respectively for veneer grafting of mango

In a trial using rootstocks of three different girths viz 8 to 10 mm 11 to 14 mm and 15 to 17 mm for inarching there was no significant difference in success between rootstocks of various thickness (Majhail and Singh 1962) Later on, Giri (1966) reported that the percentage of success was high on seedling root stocks of 1 3 to 1 6 cm girth

4 Influence of rootstock on the growth of grafted trees

As early as in 1939 Sen reported Kalapady as a promising dwarfing rootstock for mango Naik (1947) working in Southern India found that polyembryonic rootstocks imparted better vigour to the scion as compared to monoembryonic rootstocks Openheimer

(1958) indicated that Sabre roostocks inspite of its dwarfing character imparted more vigour to the scion

Studies conducted by Teaotia et al (1967) showed that polyembryonic stocks reduced the tree vigour as compared with Dasheharı seedling However George and Nair (1969) after a period of six years study in Kerala revealed that the scion varieties Bennet Alphonso and Baneshan when inarched onto the polyembryonic rootstocks Chandrakaran and Bappakaı showed greater vigour than on monoembryonic rootstock Majumder et al (1972) have classified 31 rootstocks into very vigorous vigorous and dwarfing

Dasheharı seedlings proved to be vigorous compared to polyembryonic rootstocks Ambalavı Mylepalium Olour and Vellaı kolamban in a trial with Dasheharı scion by Jauharı et al (1972) In another study using scion varieties Baneshan and Neelum Swamy et al (1972) observed that in case of Neelum the plants grew larger on polyembryonic stock as compared to monoembryonic stock Goa and Olour rootstocks produced the largest Neelum trees With Baneshan the trees were bigger on Pahutan and Olour Pahutan the most vigorous for Baneshan was the least vigorous for Neelum In studying the performance of Neelum variety on poly embryonic rootstocks Gowder et al (1973) found trees on Olour are the smallest and those on Bappakaı the largest

According to Singh and Singh (1976) nucellar stocks of polyembryonic varieties used for Dasheharı scion consistently produced dwarf trees Vellaikolamban caused maximum reduction in height and it was significantly lesser than the nucellar stock of Mylepalium Olour and seedling Dasheharı Later on in a study Reddy and Singh (1988) also found that Vellaikolamban imparted dwarfness to Alphonso scion Rumanı rootstocks were observed to impart dwarfness to Dasheharı scion compared to Chandrakaran Sakarchina Latra and ST 9 rootstock by Sinha and Rajan (1989) Sammadar and Chakrabartı (1989) reported Olour as a dwarfing rootstock for Himsagar and Langra varieties under West Bengal conditions

5 **Influence of roostock on flowering, fruiting and yield**

Significantly high sex ratio was observed in grafts on poly embryonic stocks as compared with grafts on Dasheharı seedling by Teaotia et al (1967) Trees on Olour roostock produced the highest percentage (24 28) of hermaphrodite flowers and on Dasheharı seed lings the lowest (16 34) Also they found that Olour and Vellaiko lumban had the shortest panicle initiation period Panicle initiation span in Dasheharı seedling Ambalavı and Mylepalium stocks was 15 days higher than that in Olour and Vellaikolumban

In Indonesia Kusumo and Tjiptosuhardji (1971) observed that Madu and Garih roostocks of mango delayed fruiting compared to Gadung Kopjar Budidaja Nanas and Saigon rootstocks

Studies conducted by Teaotia et al (1967) revealed that Dasheharı seedling gave the highest yield (22 03 kg per tree) as compared with polyembryonic stocks Ambalavı (11 99 kg per tree) Mylepalium (10 50 kg per tree) Vellaikolumban (8 32 kg per tree) and Olour the least (8 28 kg per tree) In a trial at Israel Oppenheimer (1968) observed only little difference between the yield of trees on rootstocks Sabre 14 6 and 14 7 Whereas trees on 3 2 and 14 2 rootstocks produced markedly less

George and Nair (1969) stated that polyembryonic rootstocks are more productive than monoembryonic rootstocks In 1972 Jauharı et al observed that Dasheharı scion on its own rootstock yielded higher than on polyembryonic rootstocks According to Swamy et al (1972), Neelum variety on Pahutan rootstocks gave the maximum yield followed by those on Goa rootstocks Monoembryonic seedlings although less vigorous in the matter of yield proved better than the otherwise moderately vigorous rootstocks Olour and Salen Gowder et al (1973) observed that the best yields were consistently produced on Bappakai followed by the mono embryonic rootstock and the Olour when Neelum was used as scion

When Dasheharı variety was grafted on its own seedling maximum yield was obtained as compared with polyembryonic root stocks both in case of yield per tree and yield per square metre (Singh and Singh 1976) They also found that Olour rootstock was poorest in respect of yield however or Alphonso scion

Olour rootstock was found to give the maximum yield by Reddy et al (1989) They also observed that Vellaikolumban gave the lowest fruit yield

6 Influence of rootstock on fruit quality

As early as in 1958 Oppenheimer found that Pairee root stocks produced small fruits whereas Haden rootstocks produced larger fruits Teaotia et al (1967) found Dasheharı seedling to produce slightly bigger sized fruits as compared to other poly embryonic stocks Larger sized fruits were obtained from Olour rootstock for Dasheharı scion (Singh and Singh 1976) According to Teaotia et al (1967) Mylepalium rootstock recorded the highest total sugar and total soluble solids contents

A rootstock trial by Gowder and Irulappan (1971) showed that the fruits had the highest total soluble solids content and tasted best when Neelum variety was grafted onto Bappakai Olour and monoembryonic stock Neelum fruit harvested on Pahutan stocks was found to possess higher total soluble solids by Swamy et al (1972)

In 1972 Jauharı et al opined that total soluble solid contents were higher in the fruits harvested from trees on Mylepalium and Vellaikolumban roostocks grafted with Dasheharı scion Later, in 1976 Singh and Singh also observed that Dasheharı scions on Mylepalium stocks gave higher total soluble solids total sugars and reducing sugars

7 Influence of rootstock on leaf nutrient composition

In mango Reddy et al (1989) found that nutrient composit ion of scion (Alphonso) varied with rootstocks In general Vellai kolumban rootstock recorded the lowest nutrient content compared to other rootstocks Thakur et al (1989) also reported that leaf nutrient contents were significantly influenced by different stocks Rumani rootstock increased leaf nitrogen content while ST 9 rootstock increased Phosphorus and Potassium contents

8 Influence of the season of grafting on success and survival

In mango softwood grafting between third week of May and third week of August was found to be the best giving 95 to 100 per cent graft take (Patel and Amin 1981) Singh and Srivastava (1982) obtained highest grafting success of 90 per cent when grafted on 20th August compared to 67 per cent in July and 70 per cent in late September using cv Dashehari as scion Gaur (1984) reported that under Lucknow conditions the ideal time for softwood graft ing in mango was July August and also March In another trial (Singh et al 1984) periodic grafting revealed that grafting in June was the best giving about 100 per cent success On the other hand August and September were reported to be more suitable by Kulwal and Tayde (1985) Temperature and humidity were reported to be the major limiting factors for the success in soft wood grafting in mango At Saharanpur, a grafting success of 95 per cent was recorded during June when the mean temperature

was 33 5°C and humidity 88 per cent (Srivastava 1985) Flush grafting in mango was found successful during January February under Tamil Nadu conditions when the maximum and minimum temp eratures recorded were 32 0°C and 21 0°C respectively There was no rainfall during these periods (Subramani 1988) Srivastava (1989) obtained more than 95 per cent success in mango softwood grafting done between 27th of June and 27th of August He also observed that temperature and humidity were the main limiting factors for successful graft take

According to Patel and Amin (1976) success in stone grafting was found to have a direct relation with humidity and temperature Grafting during June to September was found to be most ideal giving a success of 55 to 65 per cent (Dhakal 1979) Mandal (1979) obtained 60 to 90 per cent success during July to October for mango stone grafting under Bihar conditions Maiti and Biswas (1980) successfully conducted epicotyl grafting under West Bengal conditions with varying success of 50 to 96 per cent during June and July Studies conducted at Central Mango Research Station Lucknow revealed the superiority of July and August months for stone grafting (Singh and Srivastava 1981) On the other hand Nagawekar (1981) could not observe any significant difference in the sprouting of mango grafts prepared during the months of June July or August Similarly, Chakrabarti and Sadhu (1983) reported that success is more or less uniform when epicotyl grafting was done in June July and August

Under Kerala conditions Dhungana (1984) suggested that stone grafting could be best done during the month of August with a maximum success of 69 33 per cent According to Gunjate (1985) the survival of stone grafts was the highest when grafted in June July under Konkan conditions High humidity and temperature were found to be associated with better success of stone grafting (Reddy and Kohli 1985) and they recorded a success of 96 per cent when grafted inside a mist chamber Singh et al (1989) observed that in epicotyl grafting success rate was higher in August than in July and September Some of the September grafted scions remained green and did not sprout until the following spring

Bambota e al (1971) obtained a success of 87 5 per cent in Punjab when veneer grafting was done during the month of August But according to Prasad et al (1973) the best season for veneer grafting was July giving maximum percentage of success Gunjate et al (1976) got a success of 76 to 84 per cent for mango veneer grafting during March to May Later on Singh et al (1979) recorded 75 to 92 per cent success for veneer graft ing in mango during the rainy season July and August Based on a study under Lucknow conditions Singh and Srivastava (1979) stated that grafting can be best done during August Ram and Bist (1982) observed 100 per cent success for veneer grafting in June July and August The significance of rainy season was also stressed by Singh et al (1983) They recorded 75 to 92 per cent success

for grafting during rainy season while the success was only 16 to 20 per cent during November December Singh et al (1984) suggested June as the best month of veneer grafting under the agroclimatic conditions of Varanasi when they got 96 6 per cent success They also suggested that June to August was the ideal time for veneer grafting in mango at Varanasi Ismail and Rao (1985) recorded a maximum success of 85 per cent for veneer graft ing during September and minimum success 0 to 5 per cent during April May

9 **Anatomy of the graft union**

As early as in 1941 Juliano studied the anatomy of the graft union in cleft grafting The first step in the process of graft union was reported to be the formation of callus cushion in the gap through the activity of parenchyma of both bark and pith Cambial bridge was developed from the newly formed callus joining the stock and scion He also observed that the callus tissue was initiated from the stock side but the total contribution of callus by stock and scion was almost equal Callus tissue was found to initiate from the bark portion at first Luthra and Sharma (1946) also observed excessive callus growth of parenchymatous tissue between stock and scion in mango variety Langra He also reported that the distorted xylem elements were responsible for blocking the conducting vessels and thus preventing the movement of water from stock to scion Singh (1960) conducted detailed

anatomical studies of mango stem and stated that mango stem consists of an outer cuticle an epidermis cortex endodermis pericycle, are shaped patches of fibres resin canals phloem cambium xylem uniseriate medullary rays biseriate medullary rays and pith region with granules

According to Wilson and Wilson (1961) when young stems were wounded or grafted the cambium was interrupted and new vascular cambia would regenerate from the callus proliferating from the wounded surfaces Auramov and Jokovic (1961) reported that the degree of callus formation varied considerably between varieties and was highly influenced by rootstock and weather conditions that prevailed during the previous growing season At the same time excessive undifferentiated callus or other irregular growths were observed at the union of incompatible stock and scion

Anatomical studies of graft union in pear showed that the injured parenchyma of the cambium produced callus tissue and met the callus developed on the other graft partner The combined callus tissue became intermingled and new cambial elements began to develop (Ihara 1966)

Five important stages of bud union have been described in mango by Soule (1971) They are stage I (4 days) wound periderm development stage 2 (8 days) callus proliferation

and enlargement from the cambium resulting in firm attachment of both stock and scion stage 3 (12 days) completion of cambial bridge stage 4 (36 48 days) - differentiation of vascular tissue and complete healing of the union and stage 6 (6 8 months) formation of several cylinders of new tissues and lateral shifting of action to align with the stock

The secondary growth and cambial activity were also reported to be involved in proper graft union formation (Esau 1979) In the process of graft union the breakdown products of dead cells on the surface of stock and scion from a necrotic layer The cells next to this layer will enlarge divide and form callus tissue which fill the space left between the stock and scion Later on the callus tissue will develop into cambial cells and a continuous cambial bridge will be formed across the stock and the scion which later on gives rise to new vascular tissue The cambial cells undergo tangential divisions and give rise to vascular elements

The important function of cambium was found to be the formation of callus in the wounded portion In addition to the cambia the wood rays were also found to proliferate and take part in the graft union (Fahn 1982) According to Dave and Rao (1982) cambium is active all round the year in mango and hence the radial growth of the tree will be continuous From the studies conducted at the College of Horticulture Vellanikkara Kerala (1985)

also reported four stages of graft union for epicotyl grafting in Mango cv Neelum In successful grafts the callus proliferation was found to commence from 5th day onwards and the cambial bridge was completed within 15 days after grafting

According to Chakrabarti and Sadhu (1985) there were three main stages in the formation of graft union for splice grafting in mango They were callusing stage extending from 10 to 30 days after grafting when the live cells formed a mass of callus tissue cambial bridge stage from 30 to 60 days after grafting when cambial continuity between stock and scion was established healed union stage extending from 60 to 120 days after grafting when vascular tissues were differentiatd and complete union between rootstock and scion took place Callus proliferation was found to start initially from the rootstock but later on from both components The various changes in the union were found to be more rapid in splice method of grafting than in cleft method They also observed that graft take was faster for Langra than for Bombai and Himsagar due to more rapid formation of callus and vascular continuity

Savithri (1990) conducting studies on softwood grafts observed four distinct stages in the healing process of graft union viz formations of pre callus callus cambial bridge and healed union Cambial bridge was well established across the graft union after 45 days of grafting

Studies conducted by Kurien and Iyer (1992) with 24 mango cultivars of widely varying vigour indicated that low tree vigour was associated with a higher primary pholem to primary xylem ratio in young shoots Width of cortex or pith did not show any relationship to tree vigour There was no significant difference among the cultivars with respect to number of xylem vessels and the size of metaxylem vessels

Materials and Methods

MATERIALS AND METHODS

The present investigations were conducted in the Department of Pomology and Floriculture College of Horticulture, Vellanikkara Thrissur during the period from April 1990 to March 1991 Vellanikkara is located under warm humid tropical climate with high rainfall and less fluctuations in daily temperature The altitude of the place is 22 25 M above mean sea level at 10°32 N latitude and 76°16 E longitude Experiments were conducted to find the varietal differences of polyembryonic rootstocks with respect to the percentage of success survival and growth parameters of soft wood grafts of mango Anatomical studies were done to find out the different stages of graft union formation and the probable reasons for graft failure

The details of the experiment conducted and analysis done are presented in this chapter

Five polyembryonic varieties of mango (Puliyan Chandra karan Olour Tolikaipan and Muvandan) and one monoeybryonic variety (Bangalora) were selected as rootstocks Scions of two varieties (Neelum and Banganapally) were used for softwood graft ing One month old rootstocks of each of the above varieties were grafted at eight to ten centimetre height with scion shoots of length 10 cm defoliated ten days prior to grafting Grafting was done in June July and August The experiment was laid out in

completely randomised design with three replications Observations were recorded on initial success final success girth of stock girth of scion girth of sprout length of sprout number of primary branches and number of leaves The data were statistically analysed using the general method of analysis for a three factor experiment (6 x 2 x 3) in completely randomized design (Snedecor and Cochran 1967) The effect of rootstock scion and month on the various observations taken were analysed separately and in all possible combinations

1 Raising of rootstocks for grafting

Healthy well developed plump and uniform mango stones of five polyembryonic varieties viz Puliyan Chandrakaran Olour Tholikaipan Muvandan and the monoembryonic variety Bangalora, were collected during different months and sown in the nursery The seeds were sown in raised seed beds of 2 m x 1 m size in flat position A thin layer of sand was spread evenly on the surface of the nursery bed A layer of dried grass mulch was also provided on the surface of the beds In order to protect stones and seedlings from termite attack 10 per cent B H C dust was applied around the beds Seeds were sown during May June and July 1990 so as to get one month old seedlings ready for grafting during June July and August The beds were always kept moist Observation were recorded on germination percentage and number of seedlings produced per stone

Uniform healthy vigorous seedlings with straight stout epicotyl were uprooted one week after germination without injuring the root system They were transplanted in polyembryonic bags of size 20 cm x 15 cm filled with a mixture of farm yard manure sand and soil in 1 1 1 ratio After transplanting all the seedlings were kept under partial shade and irrigated daily

2 Selection and preparation of scion shoots

Healthy disease free uniform mother trees of two varieties Neelum and Banganapally, were selected from the mango orchard of the Instructional Farm Vellanikkara for taking scion shoots for grafting Three to four month old 10 cm long terminal shoots were selected as scions Scion shoots were defoliated 10 to 15 days prior to grafting by clipping the leaf lamina and keeping the petiole intact using a sharp knife The scions were cut back to required length at the time of grafting

3 Method of grafting

The wedge method of grafting was adopted The seedling rootstock was grafted within 15 to 20 days after transplanting in the polythene bag The rootstock was decapitated at 10 cm height from the collar region Two slanting cuts of two to three centimetre deep running from the periphery towards the centre of the stock was made to form a V shaped notch using a sharp

The precured scion was detached from the mother tree and made into a wedge giving two to three centimetre long slanting cut on both sides of the basal end with a sharp knife The wedge shaped scion of 10 cm length was then inserted carefully into the cleft already made on the rootstock so as to achieve a tight fitting of the scion into the rootstock The graft joint was tied firmly with transparent polythene tape of one to one and a half centimetre width and 30 cm length

The prepared grafts were kept in a temporary mist champer using thick polythene sheet over a wooden frame of the dimension 2 m x 2 m x 2 m Mist was created by spraying water to the polythene film at an interval of 60 minutes throughout the day The temperature was maintained at 32°C and humidity 90 per cent by this intermittant spray of water

4 Observations

4 1 Germination percentage and extent of polyembryony

The number of seedlings germinated were taken at weekly intervals When the germination was completed number of seedlings produced per stone was also recorded

4 2 Percentage of sprouting and survival

The scions that remained green whether sprouted or unsprouted 15 days after grafting were coun*ed o calcula e the

initial success The scions that actually sprouted and survived after three months of grafting were counted for calculating the final success (Aravindakshan et al 1988)

The following growth parameters were recorded at fortnightly intervals for a period of five months after grafting Five plants were selected from each treatment at random for taking observat ions

4 3 Girth of rootstock scion and new growth

The girth of the rootstock and scion were recorded at one centimetre above and below the graft joint at fortnightly intervals The girth of the new growth was measured at a height of one centimetre from the point where the scion put forth new growth

4 4 Length of sprout

The extension growth of scion was measured in centimetre from the point where the scion put forth new growth and expressed as length of scion

4 5 Number of leaves

The number of leaves produced by the scion was recorded at fortnightly intervals

4 6 Number of primaries

The number of primaries produced by the new growth was recorded at fortnightly intervals

5 Anatomical studies of the graft union

Representative samples of graft union were taken from all the rootstock scion combinations for anatomical studies Two samples each were collected from all treatments at four different intervals viz 15 days 45 days 60 days and 90 days after grafting Samples were also collected from the grafts showing signs of shrinking and the grafts remaining green without sprouting eve after 60 to 90 days of grafting Immediately after collection the samples were processed and preserved as detailed below

The samples were killed and fixed using F A A solution (850 ml of 70 per cent alcohol and 100 ml 40 per cent formaldehyde + 50 ml glacial acetic acid) The specimens were kept in F A A solution for 72 hours and then transferred to 70 per cent alcohol The samples were removed using sterilized forceps and washe in running water for 30 minutes and finally with distilled water Uniform sections of 40 µ (micron) thickness were taken usin Reichart sliding microtome as per standard microtomy suggeste for hard woods (Cutler 1978) The method suggestd by Johanso (1940) was followed for cleaning and staining the sections Th sections were treated in chemicals as follows

1% alcoholic safranin	(5 10 minutes)
30% alcohol	(2 minutes)
50% alcohol	(2 minutes)
70% alcohol	(2 minutes)
80% alcohol	(2 minutes)
90% alcohol	(2 minutes)
Fast green	(2 minutes)
95% alcohol	(20 seconds)
Absolute alcohol	(1 minute)
Alcohol Xylene (3 1)	(1 minute)
Alcohol Xylene (1 1)	(1 minute)
Alcohol Xylene (1 3)	(1 minute)
Pure Xylene	(1 minute)

The treated sections were mounted using D P X Mountant The slides were carefully examined through Carl Zeiss binocular research mocroscope fitted with the objectives of magnification from 3 2x to 40x and 10x eyepiece

Photomicrographs of selected specimens were taken using a photomicrography system (Leitz Wetzlar Germany) and Kodak gold colour film of 100 ASA

The following abbreviations are used to present the results in tables

R_1 Muvandan

R_2 Puliyan

R_3 Olour

R_4 - Chandrakaran

R_5 Bangalora

R_6 Tolikaipan

S_1 Neelum

S_2 Banganapally

M_1 June

M_2 July

M_3 August

Results

RESULTS

The results of the study are presented in two parts The first part deals with the effect of rootstock scion and month of grafting on success survival and growth parameters of softwood grafts of mango The second part deals with the anatomical changes in the graft union at the different stages of healing process

1 Germination percentage and extent of polyembryony

The germination percentage of seeds of the varieties of rootstock used in the study and the extent of polyembryony in the case of polyembryonic rootstocks are presented in table 1 The germination percentage of all polyembryonic varieties were comparatively higher than Bangalora the monoembryonic variety Tolikaipan recorded the highest percentage of germination (60 66) fowllowed by Puliyan (51 00) among the polyembryonic varieties and the least was recorded by Chandrakaran (29 33) Bangalora the monoembryonic variety recorded the least percentage of germi nation among all the varieties (5 67 per cent) tried

Data on the average number of seedlings produced per stone presented in table 1 showed that the maximum number of seedlings per stone was recorded for Muvandan (1 74) and the minimum (1 11) for Chandrakaran among polyembryonic varieties The variety Bangalora did not produce more than one seedling per stone It

Table 1 Germination percentage and extent of polyembryony in different varieties of mango

Varieties	Number of seeds sown	Number of seeds germinated	Percentage germinated	Number of seedlings per stone	Polyembryonic percentage
Muvandan	300	128	43 00	1 74	49 54
Puliyan	300	153	51 00	1 50	42 52
Olour	300	123	41 00	1 58	23 51
Chandrakaran	300	88	29 33	1 11	9 76
Bangalora	300	20	5 67	1 00	0 00
Tolikaipan	300	182	60 66	1 39	26 03
CD (0 05)		22 40		0 356	

Table 2 Effect of rootstock on sprouting and survival of grafts (percentage)

Rootstock	Sprouting	Survival
R_1	88 89	39 40
R_2	76 67	51 10
R_3	68 89	29 40
R_4	65 56	38 80
R_5	59 44	41 10
R_6	70 00	27 20

Homogeneous at 5% level

was observed that the percentage of polyembryony ranged from 9 76 to 49 54 for the polyembryonic varieties the lowest for Chandrakaran and the highest for Muvandan variety There is no significant difference between Muvandan and Puliyan

2 Sprouting and survival of grafts

The effect of rootstock scion month of grafting and their interactions on sprouting (initial success) and survival (final success) of grafts are presented in detail in the following paragraphs

2 1 Effect of rootstock

The observations recorded on the effect of rootstock on the sprouting and survival of grafts are presented in table 2 It is clear from t e table that there is no sigrificant difference in the percentage of success and survival among the different root stocks used for grafting However Muvandan rootstock gave the maximum percentage (88 89) of success and the least percentage take was observed for Bangalora rootstocks (59 44) With regard to the survival of grafts Puliyan roostocks gave 51 10 per cent survival while the least percentage of survival (27 20) was noted for Tolikaipan rootstock

2 2 Effect of scion

The data pertaining to the sprouting and survival of grafts with the scions of Neelum and Banganapally are given in table 3

A perusal of the data shows that the percentage of success was 72 96 for Neelum whereas it was 70 19 for Banganapally and both the scions do not differ significantly with regard to the sprouting of grafts It is also evident from the table that the Neelum and Banganapally scion produced almost same percentage of survival (21 60 and 21 33 respectively)

2 3 Effect of month of grafting

The effect of month of grafting on sprouting and survival of grafts is shown in table 4 It is seen that when grafting was done in June more percentage success was obtained (82 78) and the maximum percentage (23 68) of survival was observed for grafting done during August although there is no significant difference between the treatments

2 4 Interaction effect of rootstock and scion

The sprouting and survival of grafts with various rootstock and scion combinations are presented in table 5 Muvandan rootstock grafted with Neelum was significantly superior to other treatment combinations with respect to initial success as indicated by the sprouting of grafts (92 22 per cent) followed by Muvandan rootstock grafted with Banganapally (85 56 per cent) Sprouting was minimum for Chandrakaran grafted with Banganapally and Bangalora grafted with Neelum (58 89 per cent each) As for the survival of grafts Puliyan rootstock grafted with Neelum recorded the highest

Table 3 Effect of scion on sprouting and survival of grafts (percentage)

Scion	Sprouting	Survival
S_1	72 96	21 60
S_2	70 19	21 33
CD (0 05)	NS	NS

Table 4 Effect of month of grafting on sprouting and survival of grafts (percentage)

Month	Sprouting	Survival
M_1	82 78	19 35
M_2	57 78	21 37
M_3	74 17	23 68

Homogeneous at 5% level

percentage (66 66) of success and was found to be significantly superior over other rootstock scion combinations The survival of grafts was also high (65 00) for Puliyan Banganapally rootstock scion combination The least percentage of survival was observed for Tolikaipan rootstock grafted with Banganapally (24 40) and Neelum (30 00) scions Survival of grafts was also very low for the rootstock Olour (Table 5) grafted with Banganapally (26 67 per cent) and with Neelum scion (30 00 per cent)

2 5 Interaction effect of rootstock and month of grafting

Data furnished in table 6 shows the effect of month of grafting w th different roostocks on sprouting and survival of grafts Significant differences were not obtained among the various treat ment combinations studied However Chandrakaran rootstock grafted in June gave the highest percentage of success (95 00) and the same rootstock grafted in July gave the least percentage (36 67) With regard to survival of grafts Puliyan rootstock grafted in August recorded the highest percentage (66 60) of success while Tolikaipan rootstocks grafted in June did not survive at all

2 6 Interaction effect of scion and month of grafting

The combined influence of scion and month of grafting on sprouting and survival of grafts is clear from table 7 Initial success was higher (84 44 per cent) when grafting was done in

Table 5 Interaction effect of scion and rootstock on sprouting and survival of grafts (percentage)

Rootstock	Sprouting		Survival	
	S_1	S_2	S_1	S_2
R_1	92 22	85 56	45 50	33 30
R_2	74 44	78 89	66 66	65 00
R_3	67 78	70 00	30 00	26 67
R_4	72 22	58 89	37 77	40 00
R_5	58 89	60 00	40 00	42 20
R_6	72 22	67 78	30 00	24 40
CD (0 05)	1 080		0 207	

Table 6 Interaction effect of month of grafting and rootstock on sprouting and survival of grafts (percentage)

Rootstock	Sprouting			Survival		
	M_1	M_2	M_3	M_1	M_2	M_3
R_1	93 33	90 00	83 33	25 00	46 60	46 60
R_2	78 33	66 67	85 00	45 00	41 60	66 60
R_3	81 67	51 67	73 33	28 30	25 00	31 67
R_4	95 00	36 67	65 00	38 33	26 67	51 67
R_5	73 33	55 00	50 00	30 00	51 67	41 67
R_6	75 00	46 67	88 33	0	28 33	45 00

omogeneous at 5% leve

Table 7 Interaction effect of month of grafting and scion on sprouting and survival of grafts (percentage)

Scion	Month	Sprouting	Survival
S_1	M_1	81 11	27 77
	M_2	63 33	37 20
	M_3	74 44	48 80
S_2	M_1	84 44	30 55
	M_2	52 22	36 11
	M_3	73 89	45 50
CD (0 05)		0 763	NS

June using Banganapally as scion The success was least (52 22) when the same variety was grafted during July The different treat ment combinations did not differ significantly with regard to the percentage of survival The highest (48 80) percentage of survival was recorded for Neelum scion grafted during August Only 27 77 percentage of survival was observed for Neelum scion grafted during June

2 7 Interaction effect of rootstock scion and month of grafting

The success and survival of grafts as affected by rootstock scion and month are presented in table 8 and Fig 1 to 6 Statistical analysis showed significant differences between treatment combinat ion on sprouting and survival of grafts The maximum percentage of success (96 67) was obtained when Muvandan and Chandrakaran rootstocks were grafted with Neelum scion during June But when Chandrakaran rootstock was grafted with Banganapally scion during July the percentage of success was the lowest (33 33) Survival of grafts was maximum (76 67) for the treatment combination Puliyan rootstock grafted with Banganapally scion during August Tolikaipan rootstock grafted with Banganapally scion during June did not survive

In general of the various treatment combinations tried to study the effect on sprouting and survival of grafts the treatment combination of rootstock and scion and rootstock scion and month of grafting had significant effect on the percentage of success and

Table 8 Interaction effect of rootstock scion and month of grafting on sprouting and survival of grafts (percentage)

Rootstock	Scion	Sprouting			Survival		
		M_1	M_2	M_3	M_1	M_2	M_3
R_1	S_1	96 67	93 33	86 67	26 67	56 67	53 33
	S_2	90 00	86 67	80 00	23 33	36 67	43 33
R_2	S_1	70 00	63 33	90 00	40 00	43 33	50 00
	S_2	86 67	70 00	80 00	50 00	40 00	76 67
R_3	S_1	70 00	66 67	66 67	26 67	23 33	33 33
	S_2	93 33	36 67	80 00	23 33	26 67	30 00
R_4	S_1	96 67	40 00	80 00	23 33	26 67	63 33
	S_2	93 33	33 33	50 00	53 33	26 67	40 00
R_5	S_1	66 67	70 00	40 00	26 67	50 00	43 33
	S_2	80 00	40 00	60 00	33 33	53 33	40 00
R_6	S_1	86 67	46 67	83 33	16 67	23 33	50 00
	S_2	66 33	46 67	93 33	0	33 33	40 00
CD (0 05)			1 869			0 358	

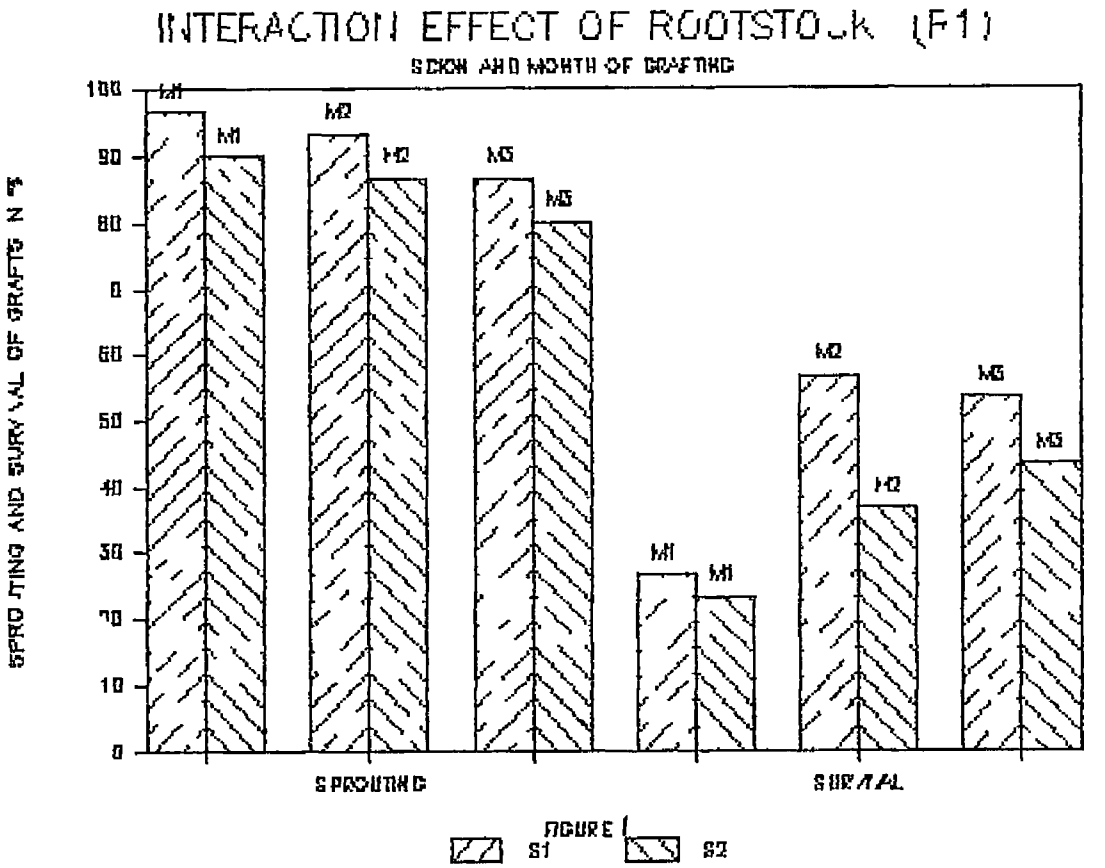


FIGURE 1

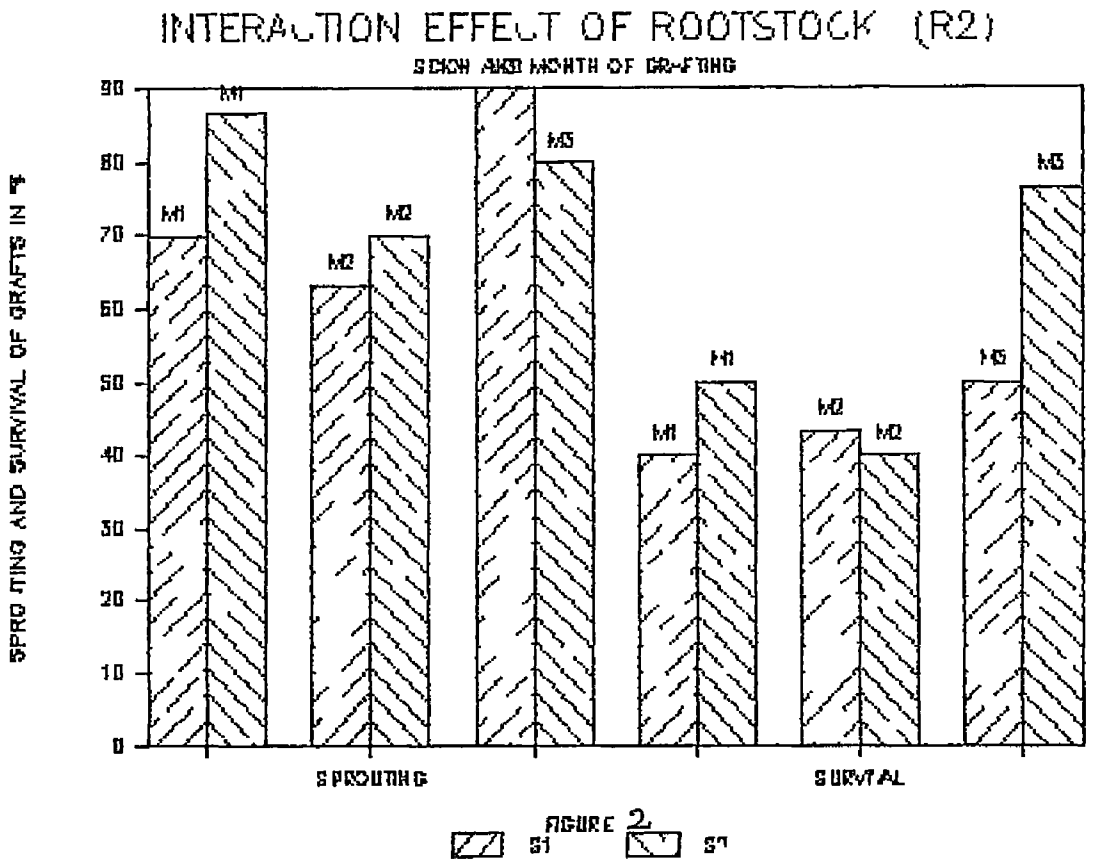


FIGURE 2

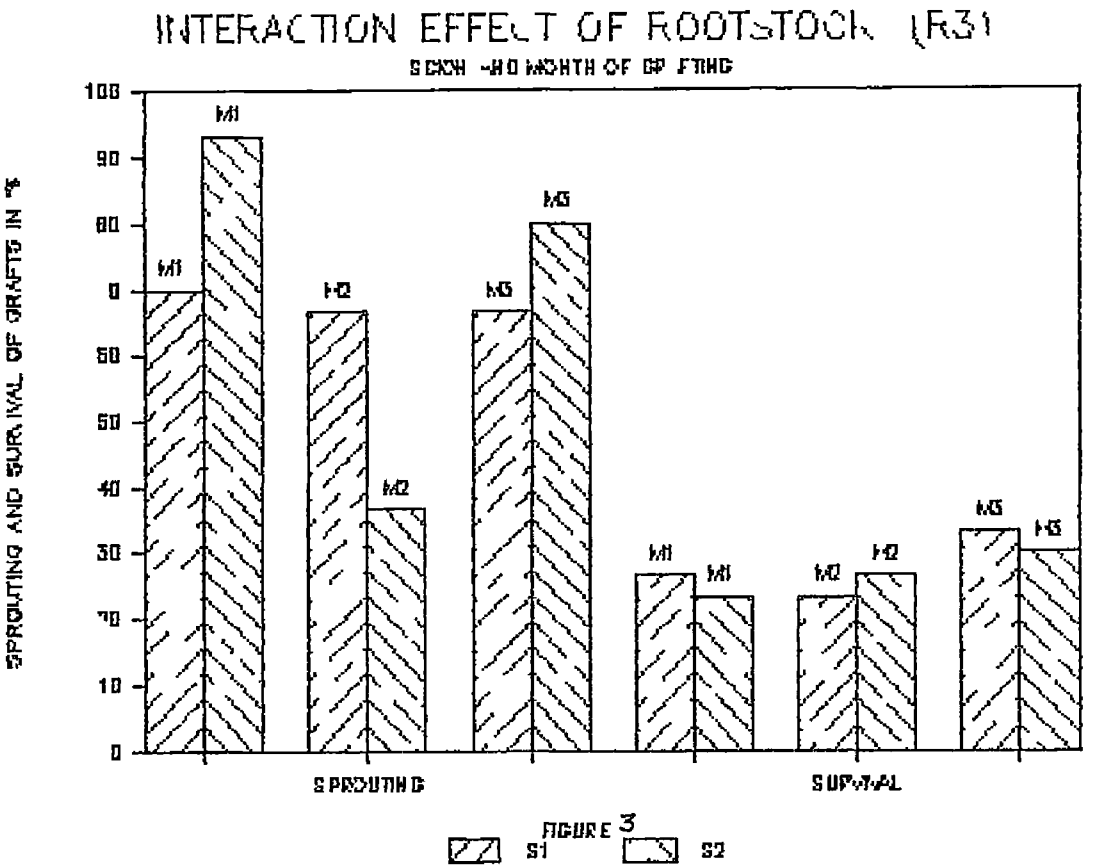


FIGURE 3

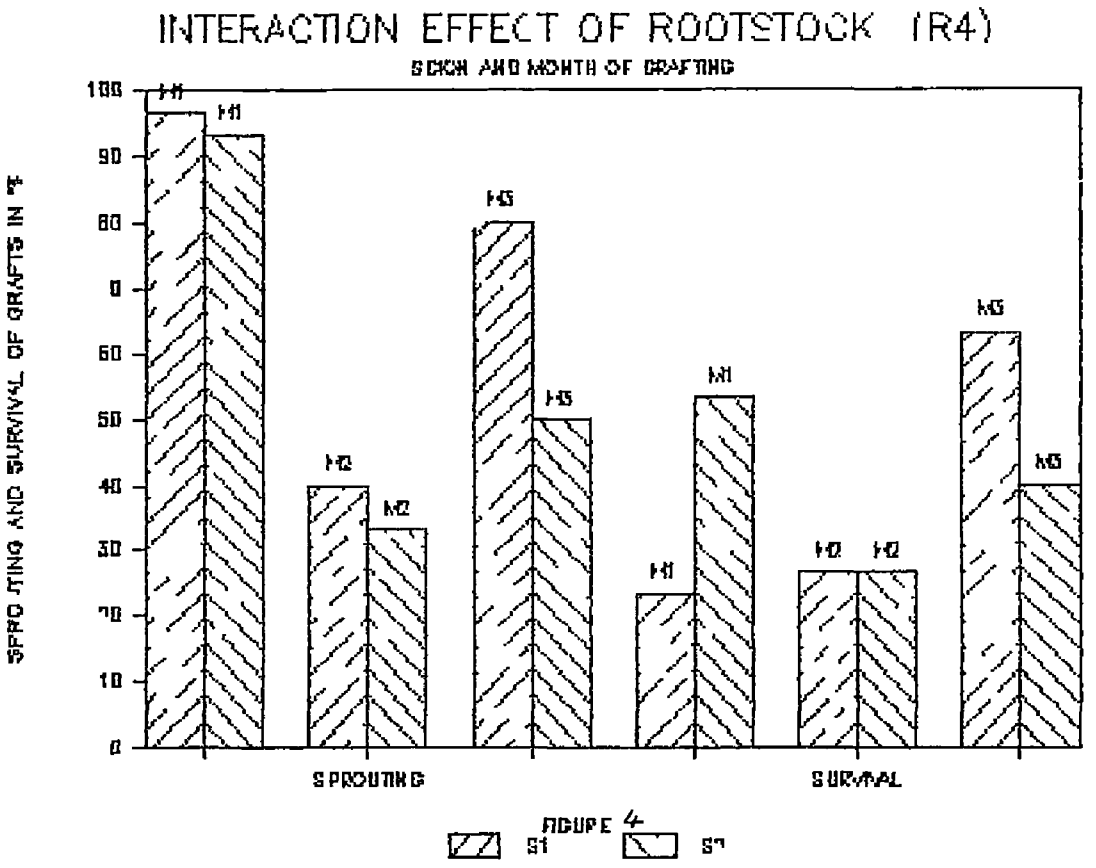


FIGURE 4

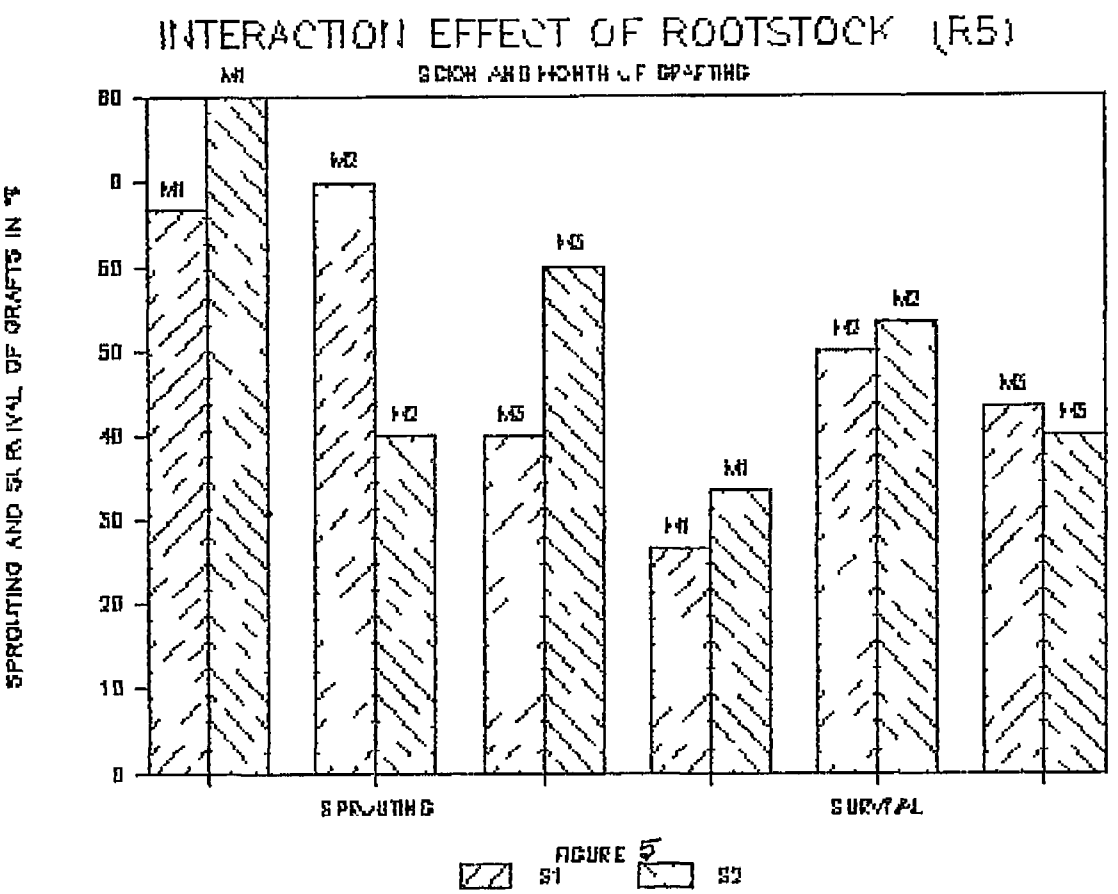


FIGURE 5

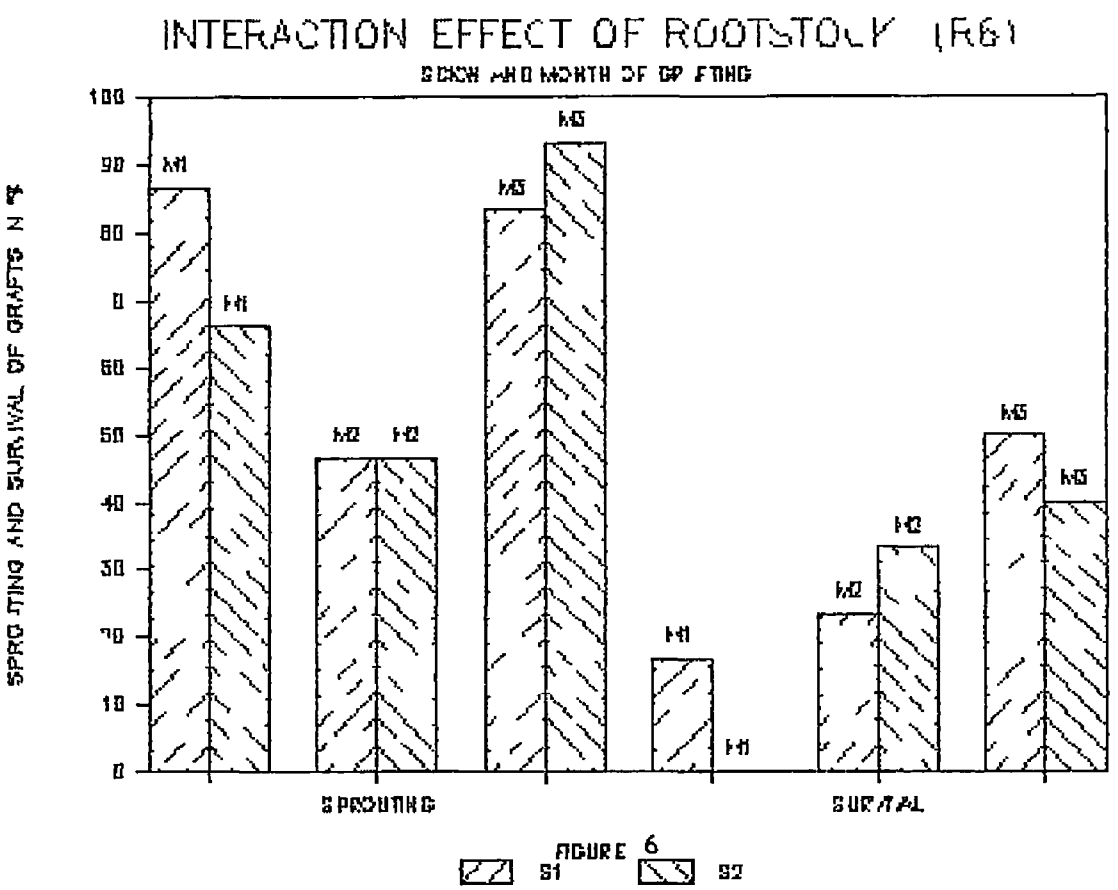


FIGURE 6

survival of grafts With regard to initial success both the scions Neelum and Banganapally gave good results Month of grafting and scion also had significant effect on the percentage of success

3 Girth of stock

The effect of rootstock scion month of grafting and their interactions on girth of stock are presented in detail in the following paragraphs

3 1 Effect of rootstock

The data on the effect of rootstock on girth of stock is furnished in table 9 An analysis of the data revealed significant variation among the rootstocks during the first three months of observation only The rootstock Bangalora was found to be superior consistently during the entire period of study recording 1 89 cm of girth of stock at 150 days after grafting In the initial period of 90 days after grafting Puliyan rootstock recorded the least stock girth From 120 days after grafting Olour rootstock produced the thinnest stock recording 1 50 cm at 150 days after grafting

3 2 Effect of scion

With regard to the effect of scion (Table 10) the variety Neelum recorded significantly higher values of stock girth over Banganapa y during the entire period of observation At 150 days

Table 9 Effect of rootstock on girth of stock (cm)

Rootstock	Days after grafting				
	30	60	90	120	150
R_1	1 48	1 49	1 58	1 72	1 83
R_2	1 27	1 33	1 41	1 48	1 57
R_3	1 35	1 37	1 43	1 47	1 50
R_4	1 33	1 36	1 41	1 47	1 53
R_5	1 58	1 60	1 70	1 80	1 89
R_6	1 30	1 34	1 57	1 59	1 67
CD (0 05)	0 139	0 137	0 135	NS	NS

Table 10 Effect of scion on girth of stock (cm)

Rootstock	Days after grafting				
	30	60	90	120	150
S_1	1 45	1 48	1 56	1 64	1 72
S_2	1 36	1 38	1 46	1 54	1 61
CD (0 05)	0 088	0 087	0 085	0 083	0 083

after grafting, Neelum scion recorded a stock girth of 1 72 cm while the stock girth of Banganapally was 1 61 cm

3 3 Effect of month of grafting

Observations tabulated in table 11 represents the effects of different months of grafting on girth of stock All the three treatments were significantly different during 30 60 and 90 days after grafting However during the entire period of study maximum stock girth (1 79 cm) was recorded for grafting done in July and minimum (1 52 cm) was recorded for grafting done in June

3 4 Interaction effect of rootstock and scion

The rootstock scion combinations had significant influence on girth of stock during the entire period of study as seen in table 12 The treatment combination Bangalora rootstock grafted with Neelum produced consistently higher values of mean stock girth Bangalora Neelum combination recorded 1 95 cm of stock girth at 150 days after grafting Next to this Muvandan rootstock grafted with Neelum recorded higher values of stock girth (1 92 cm) Tolikaipan rootstock grafted with Banganapally was found to record the minimum girth of stock upto 90 days after grafting Since then Olour rootstock grafted with Banganapally produced least girth of stock At 150 days after grafting Olour Banganapally combi nation gave 1 40 cm of girth of stock

Table 11 Effect of month of grafting on girth of stock (cm)

Month	Days after grafting				
	30	60	90	120	150
M_1	1 31	1 33	1 39	1 46	1 52
M_2	1 52	1 54	1 62	1 71	1 79
M_3	1 39	1 42	1 51	1 59	1 68
CD (0 05)	0 099	0 106	0 104	NS	NS

Table 12 Interaction effect of scion and rootstock on girth of stock (cm)

Rootstock	Days after grafting									
	30		60		90		120		150	
	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2
R_1	1 55	1 41	1 56	1 43	1 65	1 51	1 80	1 63	1 92	1 73
R_2	1 27	1 27	1 33	1 33	1 41	1 40	1 48	1 48	1 58	1 56
R_3	1 46	1 24	1 48	1 24	1 53	1 33	1 58	1 37	1 61	1 40
R_4	1 33	1 34	1 37	1 35	1 41	1 41	1 47	1 47	1 52	1 53
R_5	1 65	1 52	1 67	1 53	1 78	1 63	1 88	1 72	1 95	1 83
R_6	1 37	1 21	1 42	1 22	1 51	1 26	1 71	1 42	1 77	1 52
CD (0 05)	0 196		0 194		NS		0 012		0 184	

3 5 Interaction effect of month of grafting and rootstock

The data on girth of stock for different combinations of rootstocks grafted during different months are incorporated in table 13 A close scrutiny of the table reveals the significant impact of rootstock and month combination on girth of stock Bangalora rootstock grafted during August were found to record consistently higher mean stock diameter during the entire period of observat ion Bangalora rootstock grafted during August recorded 2 17 cm stock girth at 150 days after grafting Bangalora rootstock grafted during July also followed the same trend in performance Lower mean stock girth of 1 12 cm 1 15 cm and 1 25 cm were recorded during 30 days 60 days and 90 days after grafting by Tolikaipan rootstock grafted during August Later on Puliyan rootstock grafted during June gave least thickness of stock (1 40 cm)

3 6 Interaction effect of scion and month of grafting

Girth of stock was greatly influenced by scion and month combinations (Table 14) A perusal of the table shows that the variety Neelum grafted as scion during July gave the maximum mean stock diameter during the entire period of observation mean value being 1 89 cm at 150 days after grafting The effect of Banganapally scion grafted during June was highly inferior through out the period of study This combination recorded 1 46 cm of stock girth at 150 days after grafting

Table 13 Interaction effect of month of grafting and rootstock on girth of stock (cm)

Rootstock	Days after grafting														
	30			60			90			120			150		
	M_1	M_2	M_3	M_1	M_2	M_3	M_1	M_2	M_3	M_1	M_2	M_3	M_1	M_2	M_3
R_1	1 40	1 61	1 43	1 42	1 62	1 44	1 50	1 71	1 52	1 63	1 87	1 65	1 71	2 00	1 76
R_2	1 19	1 43	1 20	1 23	1 47	1 28	1 30	1 54	1 39	1 33	1 65	1 47	1 40	1 76	1 56
R_3	1 36	1 50	1 9	1 38	1 51	1 21	1 43	1 58	1 28	1 46	1 62	1 34	1 49	1 79	67
R	1 33	1 38	1 29	1 36	40	1 34	1 0	1 45	1 39	1 46	1 50	1 45	1 53	1 52	1 53
R_5	1 25	1 68	1 82	1 26	1 70	1 84	1 34	1 82	1 95	1 43	1 92	2 06	1 49	2 01	2 17
R_6	1 38	1 45	1 12	1 46	1 47	1 15	58	1 60	1 27	1 67	1 77	37	1 70	1 87	1 5
CD (0 05)		0 240			0 237			0 234			0 227			0 018	

Table 14 Interaction effect of scion and month of grafting on girth of stock (cm)

Scion	Month	Days after grafting				
		30	60	90	120	150
S_1	M_1	1 37	1 39	1 45	1 53	1 58
	M_2	1 61	1 63	1 71	1 80	1 89
	M_3	1 38	1 42	1 50	1 59	1 68
S_2	M_1	1 24	1 27	1 33	1 39	1 46
	M_2	1 43	1 45	1 53	1 62	1 68
	M_2	1 40	1 42	1 51	1 59	1 68
CD (0 05)		0 152	0 150	0 147	0 144	0 143

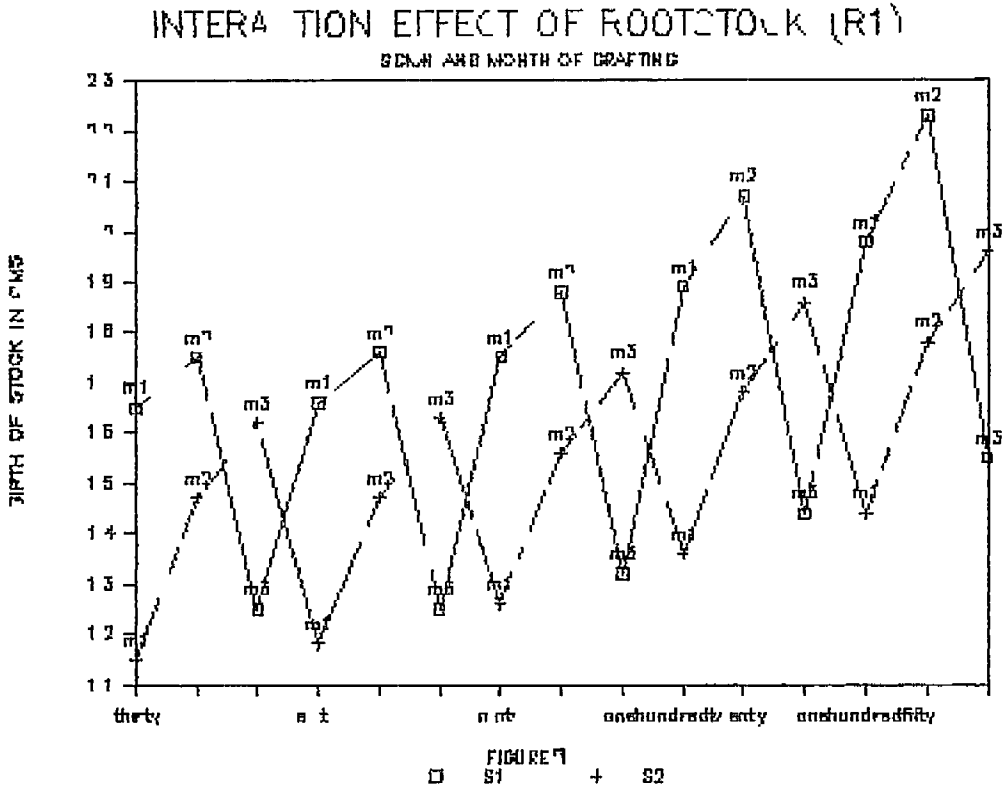
3 7 Interaction effect of rootstock scion and month of grafting

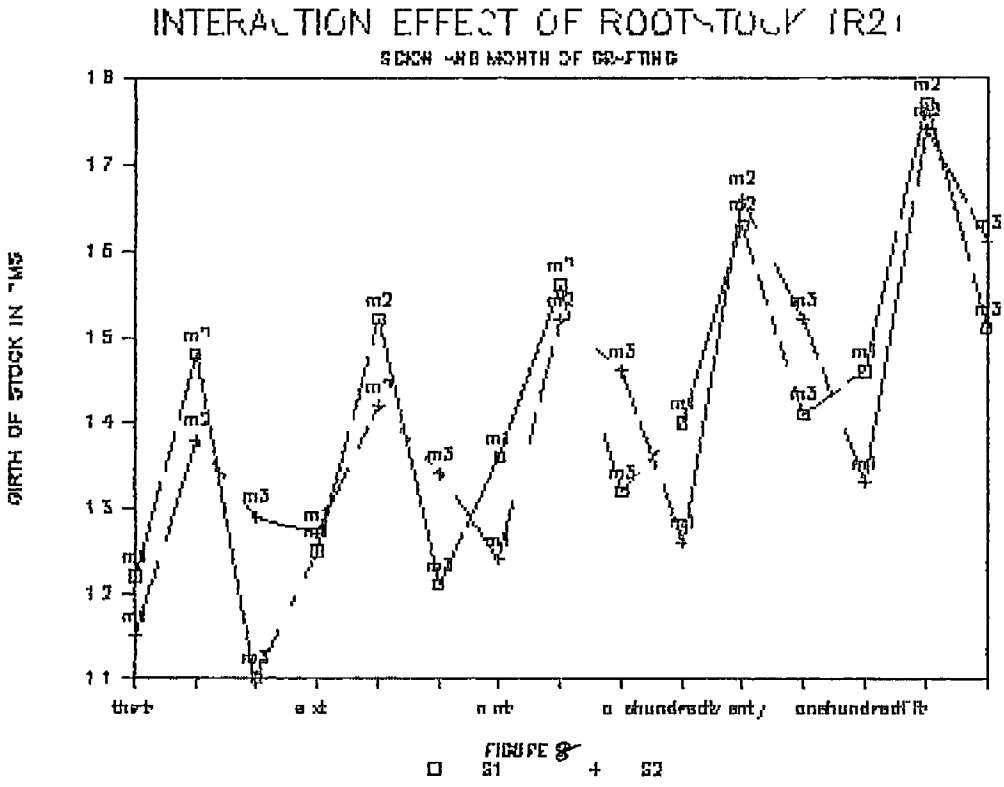
Data on the girth of stock as influenced by rootstock scion and month of grafting are presented in table 15 and Fig 7 to 12 A close examination of the table reveals that Bangalora rootstock grafted with Neelum during August recorded maximum mean stock diameter during the entire period of study with a mean stock diameter of 2 32 cms at 150 days after grafting The treatment combinations of Bangalora rootstock grafted with Neelum during July (2 16 cm) Muvandan rootstock grafted with Neelum during July (2 23 cm) and Bangalora rootstock grafted with Banganapally during August (2 02 cm) were also statistically on par with Bangalora Neelum August combination at 150 days after grafting The least girth of stock was observed for the treatment combinat ion Tolikaipan grafted with Banganapally during August upto 90 days after grafting Thereafter from 120 days after grafting Puliyan rootstock grafted with Banganapally during June produced the least growth of stock in diameter Puliyan rootstock grafted with Banganapally during June recorded 1 33 cm stock girth at 150 days after grafting

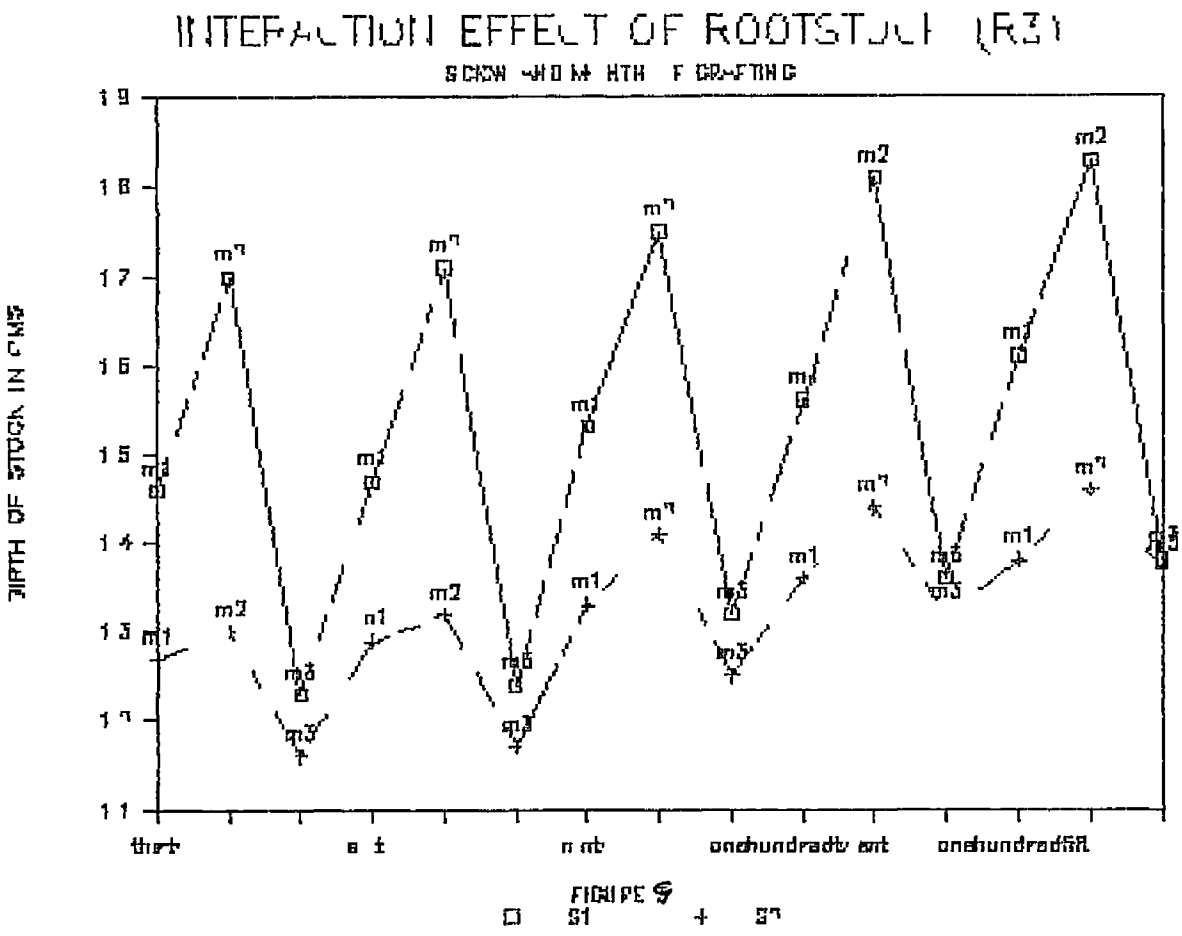
From the foregoing analysis it may be concluded that all the treatments tried under this study had significant influence on girth of stock Bangalora the monoembryonic rootstock produced the thickest stocks throughout the period of study With regard to scions used for grafting Neelum recorded higher mean stock

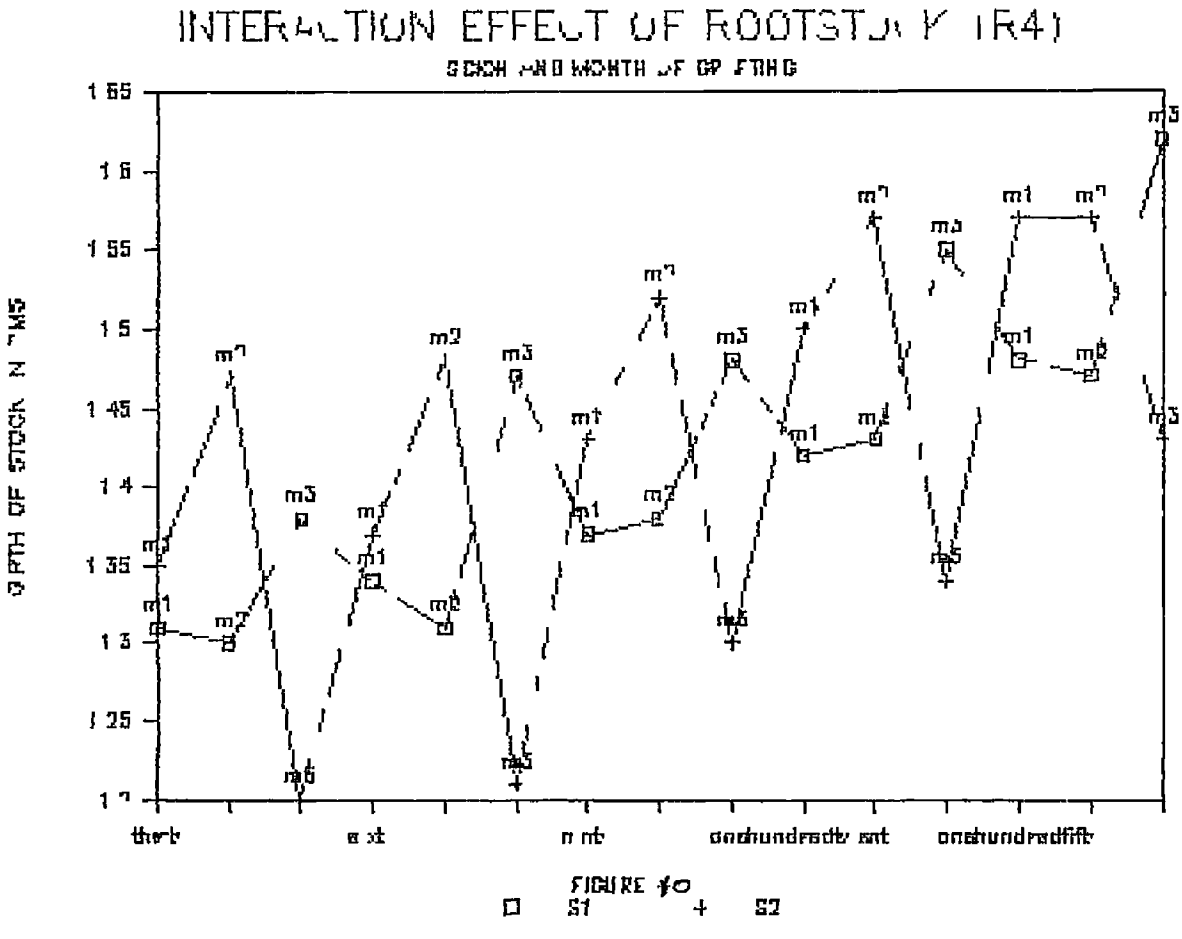
Table 15 Interaction effect of rootstock sc on and month of grafting on girth of stock (cm)

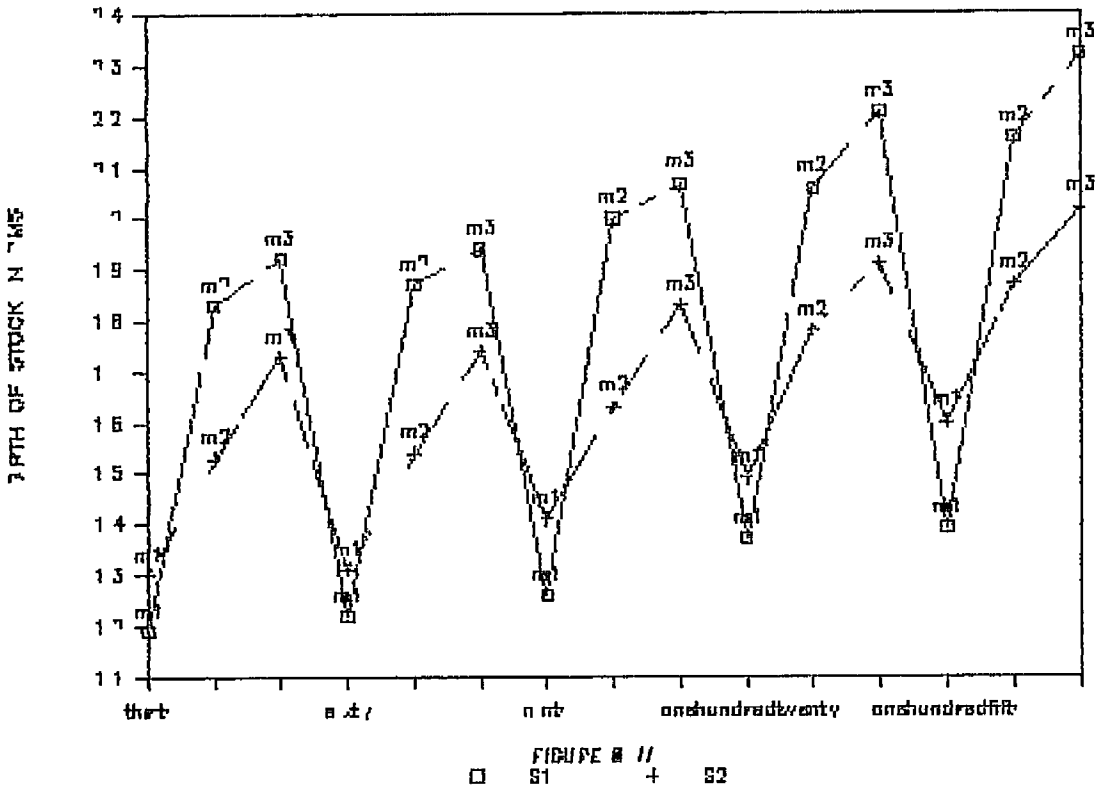
Ro t stock	Scion	Days after grafting														
		30			60			90			120			150		
		M_1	M_2	M_3	M_1	M_2	M_3	M_1	M_2	M_3	M_1	M_2	M_3	M_1	M_2	M_3
R_1	S_1	1 65	1 75	1 25	66	76	25	1 75	1 88	1 32	89	2 07	1 4	1 98	2 23	55
	S_2	1 15	1 47	1 62	1 18	1 47	1 63	1 26	1 56	1 72	1 36	1 68	1 86	1 44	1 78	96
R_2	S_1	1 22	1 48	1 10	1 25	1 52	1 21	1 36	1 56	1 32	1 40	1 63	1 41	1 46	1 77	1 51
	S_2	1 15	1 38	1 29	1 27	1 42	1 34	1 24	52	46	1 26	1 66	1 52	33	1 74	1 6
R_3	S_1	1 46	1 70	1 23	1 47	1 71	1 24	1 53	1 75	1 32	1 56	1 81	1 36	1 61	1 83	1 38
	S_2	1 27	1 30	1 16	29	1 32	1 17	1 33	1 4	1 25	1 36	1 44	1 32	1 38	1 46	1 37
R_4	S_1	1 31	1 30	1 38	1 34	31	1 47	1 37	1 38	1 48	1 42	1 43	1 55	1 48	1 47	1 62
	S_2	1 35	1 47	1 20	1 37	1 48	1 21	1 43	1 52	1 30	1 50	1 57	1 34	1 57	1 57	1 43
R_5	S_1	1 19	1 83	1 92	1 22	1 87	1 94	1 26	2 00	2 07	1 37	2 06	2 21	1 39	2 16	2 32
	S_2	1 30	1 53	1 73	1 31	1 54	1 74	1 41	1 63	1 83	1 49	1 78	1 91	1 60	1 87	2 02
R_6	S_1	1 38	1 50	1 22	1 46	1 54	1 27	1 57	68	1 42	1 67	1 95	1 51	1 70	2 05	56
	S_2		1 40	1 02		1 4	03		1 51	1 12		1 60	1 24		1 70	1 3
CD (0 05)			0 340			0 335			0 330			0 321			0 319	

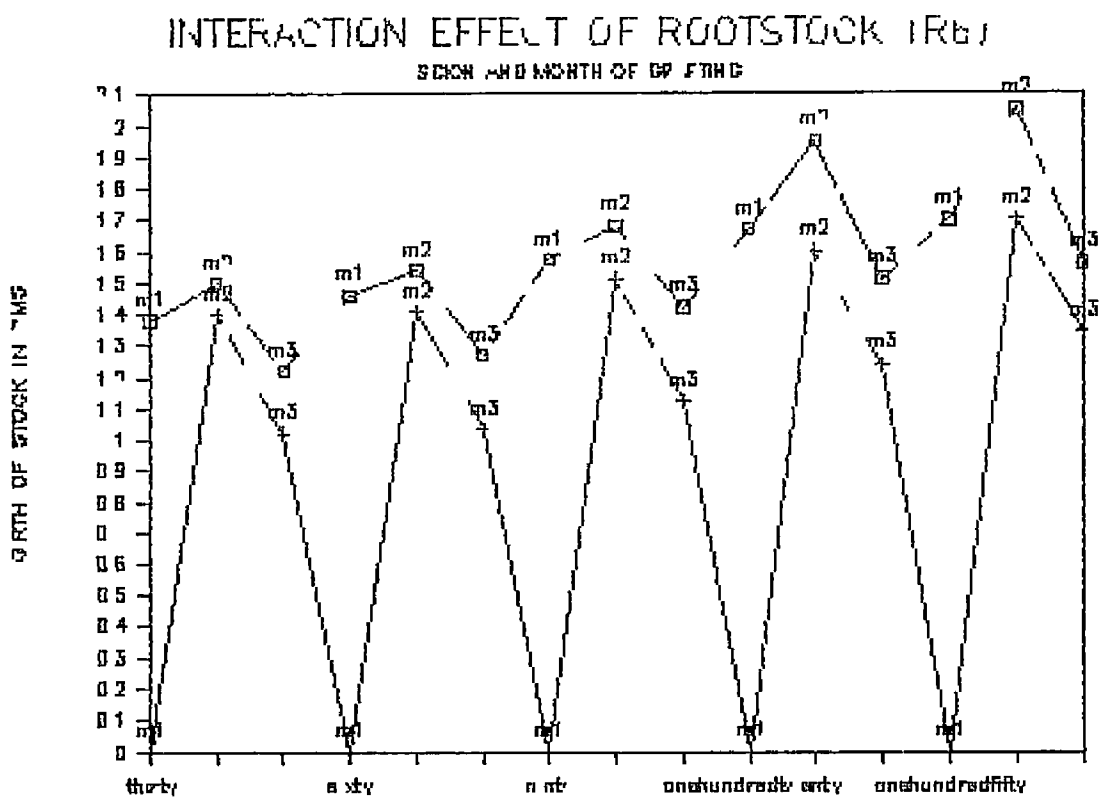

INTERA TION EFFECT OF ROOTSTOCK (R1)
SCION AND MONTH OF GRAFTING
GIRTH OF STOCK IN CMS
thirty
a t
n nb
onehundredty enty
onehundredfifty
FIGURE 7
S1
S2


INTERACTION EFFECT OF ROOTSTOCK (R2)
SCION AND MONTH OF GRAFTING
GIRTH OF STOCK IN CMS
thirty
a t
n nb
o ehundredty ent y
onehundredfifty
FIGURE 8
S1
S2


INTERACTION EFFECT OF ROOTSTOCK (R3)
STOCK AND MONTH OF GRAFTING
DEPTH OF STOCK IN CMS
FIGURE 9
S1
S2


INTERACTION EFFECT OF ROOTSTOCK (R4)
STOCK AND MONTH OF GRAFTING
DEPTH OF STOCK IN CMS
FIGURE 10
S1
S2


INTERACTION EFFECT OF ROOTSTOCK (R5)
SCION AND MONTH OF GRAFTING
GIRTH OF STOCK IN MMS
thirty
sixty
ninety
one hundred twenty
one hundred fifty
FIGURE 8 11
S1
S2


INTERACTION EFFECT OF ROOTSTOCK (R6)
SCION AND MONTH OF GRAFTING
GIRTH OF STOCK IN MMS
thirty
sixty
ninety
one hundred twenty
one hundred fifty
FIGURE 8 12
S1
S2

diameter Grafting done in July gave the maximum girth of stock during all the period under observation Of the various treatment combinations tried Bangalora with Neelum Bangalora grafted in August and Neelum scion grafted in July gave the maximum stock diameter As to the combined effect of rootstock scion and month of grafting Bangalora Neelum August combination was found to be ideal for the development of girth of stock

4 Girth of scion

The results on the effect of rootstock scion month and their interactions on girth of scion are presented in the following paragraphs

4 1 Effect of rootstock

The data furnished in table 16 indicate the significant effect of different rootstock on girth of scion The data again confirm that Bangalora is a vigorous rootstock recording maximum mean (1 65 cm) scion diameter However Muvandan rootstock also produced higher mean scion diameter (1 61 cm) but next to Bangalora Chandrakaran when used as rootstock recorded least scion girth (1 48 cm) at 150 days after grafting

4 2 Effect of scion

The significant differences in the growth of scion with respect to girth is clear from table 17 Grafting with Neelum scion

Table 16 Effect of rootstock on girth of scion (cm)

Rootstock	Days after grafting				
	30	60	90	120	150
R_1	1 34	1 35	1 43	1 53	1 61
R_2	1 25	1 27	1 35	1 44	1 51
R_3	1 34	1 36	1 40	1 43	1 52
R_4	1 29	1 30	1 38	1 43	1 48
R_5	1 40	1 41	1 50	1 58	1 65
R_6	1 24	1 25	1 39	1 46	1 55
CD (0 05)	0 147	0 147	0 146	0 148	0 158

resulted in maximum girth during all the periods under study Mean scion girth was 1 61 cm for grafting done with Neelum scion whereas with Banganapally scion it was 1 49 cm at 150 days after grafting

4 3 Effect of month of grafting

The observations on mean average girth of scion recorded at monthly intervals are presented in table 18 A perusal of the data reveals that grafting done in July produced higher values of circumference of scion than other months of grafting eventhough the difference is not significant Mean scion girth of 1 50 cm 1 59 cm and 1 57 cm were recorded when grafting was done in June July and August respectively at 150 days after grafting

4 4 Interaction effect of rootstock and scion

Data furnished in table 19 shows the effect of rootstock and scionic combinations on the girth of scion Bangalora rootstock with Neelum as scion produced the maximum scion growth during the entire period of observation Scion girth was 1 82 cm after 150 days of grafting for this treatment combination Rootstock scion combinations Muvandan Neelum and Tolikaipan Neelum were also statistically on par with Bangalora Neelum combination They produced mean scion diameter of 1 66 cm and 1 65 cm respectively at 150 days after grafting The least mean scion girth was observed for Tolikaipan rootstock grafted with Banganapally at all periods under study

Table 17 Effect of scion on girth of scion (cm)

Scion	Days after grafting				
	30	60	90	120	150
S_1	1 40	1 42	1 48	1 55	1 61
S_2	1 25	1 26	1 34	1 42	1 49
CD (0 05)	0 093	0 093	0 092	0 093	0 100

Table 18 Effect of month of grafting on girth of scion (cm)

Month	Days after grafting				
	30	60	90	120	150
M_1	1 29	1 30	1 38	1 44	1 50
M_2	1 36	1 37	1 45	1 53	1 59
M_3	1 33	1 34	1 41	1 48	1 57

Homogeneous at 5% level

Table 19 Interaction effect of variety of scion and rootstock on girth of scion (cm)

Rootstock	Days after grafting									
	30		60		90		120		150	
	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2
R_1	1 39	1 28	1 41	1 29	1 48	1 38	1 57	1 49	1 66	1 56
R_2	1 25	1 26	1 26	1 27	1 34	1 36	1 41	1 46	1 49	1 53
R_3	1 46	1 23	1 47	1 24	1 52	1 29	1 54	1 33	1 58	1 45
R_4	1 34	1 24	1 35	1 26	1 43	1 33	1 48	1 39	1 51	1 45
R_5	1 56	1 23	1 58	1 25	1 66	1 34	1 75	1 41	1 82	1 47
R_6	1 27	1 20	1 28	1 21	1 47	1 27	1 57	1 29	1 65	1 41
CD (0 05)	0 208		0 208		0 207		0 210		0 224	

4 5 Interaction effect of rootstock and month of grafting

The different combination of rootstocks grafted during different months had significant effect on girth of scion during the entire period of observation (Table 20) Rootstock Bangalora grafted during August was significantly superior over other treatment combinations recording a mean scion diameter of 1 93 cm at 150 days after grafting Beyond 90 days Bangalora grafted in July also produced higher values of girth of scion Interestingly it could be noted that at 150 days after grafting Muvandan grafted in June also attained the same girth of scion (1 69 cm) as that of Bangalora grafted in July Tolikaipan grafted in August was found to record significantly lower values of girth of scion during the entire period study

4 6 Interaction effect of scion and month of grafting

Though none of the scion month combinations have significant effect on girth of scion Neelum grafted in July consistently produced higher values of mean scion diameter (Table 21) Neelum grafted in July recorded mean scion girth of 1 66 cm at 150 days after grafting while Banganapally grafted in June registered lesser values of scion girth (1 43 cm)

4 7 Interaction effect of rootstock scion and month of grafting

Data on girth of scion as influenced by the rootstock scion and month of grafting are expressed in table 22 and Fig 13 to 18

Table 20 Interact on effect of month of graft ng and rootstock on girth of scion (cm)

Rootstock	Days after grafting														
	30			60			90			120			150		
	M_1	M_2	M_3	M_1	M_2	M_3	M_1	M_2	M_3	M_1	M_2	M_3	M_1	M_2	M_3
R_1	1 38	1 38	1 25	1 40	1 38	26	1 48	1 47	1 35	1 58	1 58	1 43	1 69	1 64	1 50
R_2	1 21	1 28	1 27	1 22	1 30	1 28	1 31	1 39	1 36	1 37	1 47	1 46	1 44	1 55	1 55
R_3	1 41	1 40	1 21	1 43	1 41	1 23	1 49	1 46	1 26	1 50	1 49	1 30	1 53	1 55	1 47
R_4	1 32	1 32	1 23	1 34	1 33	1 24	1 4	40	1 30	1 8	1 46	1 35	1 54	1 51	39
R_5	1 09	1 43	1 67	1 1	1 45	1 67	1 19	1 54	1 76	1 26	1 63	1 85	1 32	1 69	1 93
R_6	1 32	1 32	1 13	1 33	1 33	1 14	1 47	1 52	1 21	1 52	1 65	1 23	1 60	1 78	1 31
CD (0 05)		0 255			0 255			0 254			0 257			0 274	

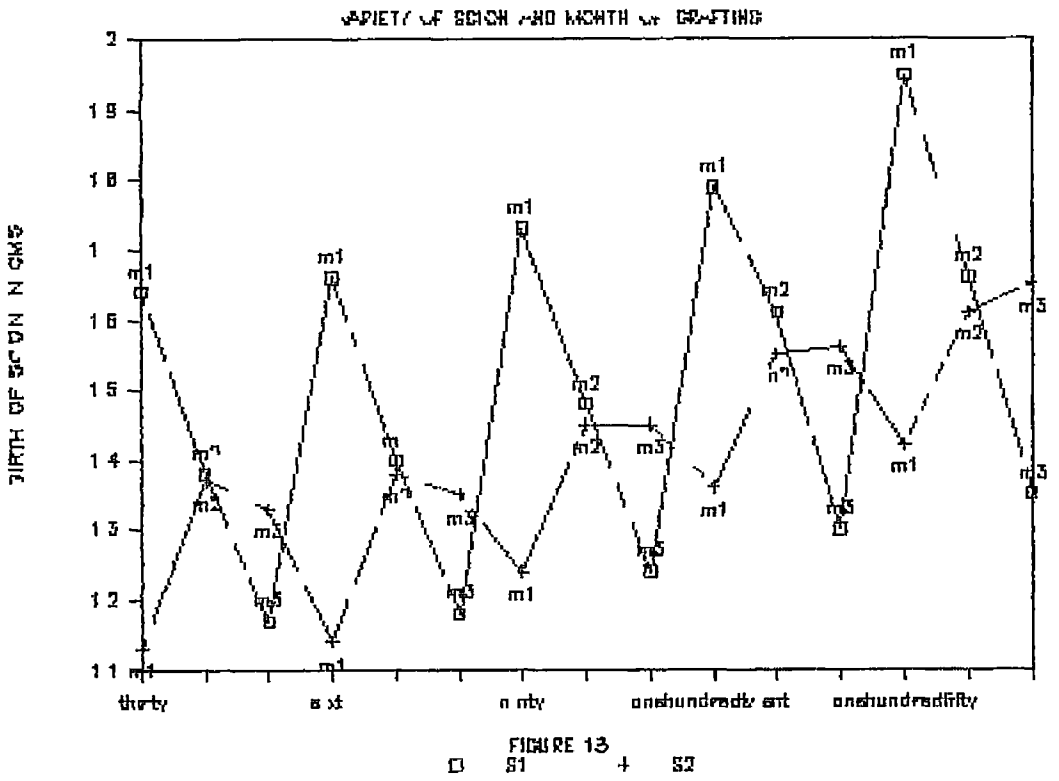
Table 21 Interaction effect of variety of scion and month of grafting on girth of scion (cm)

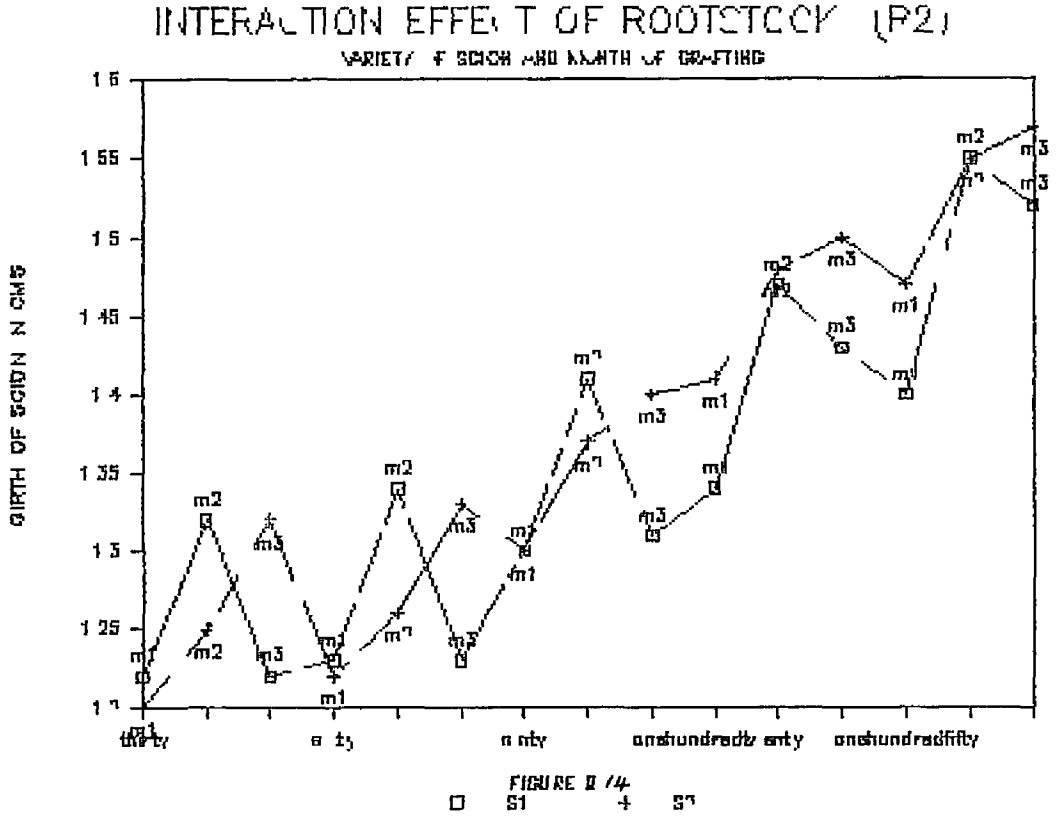
Scion	Month	Days after grafting				
		30	60	90	120	150
S_1	M_1	1 37	1 39	1 46	1 50	1 57
	M_2	1 44	1 46	1 53	1 61	1 66
	M_3	1 39	1 40	1 47	1 54	1 61
S_2	M_1	1 20	1 21	1 29	1 38	1 43
	M_2	1 28	1 29	1 38	1 45	1 52
	M_3	1 26	1 28	1 35	1 42	1 53

Homogeneous at 5% level

Table 22 Interaction effect of rootstock sc on and month of grafting on girth of scion (cm)

Root stock	Scion	Days after grafting														
		30			60			90			120			150		
		M_1	M_2	M_3	M_1	M_2	M_3	M	M_2	M_3	M_1	M_2	M_3	M_1	M_2	M_3
R_1	S_1	1 64	1 38	1 17	1 66	1 40	1 18	1 73	1 48	1 24	1 79	1 61	1 30	1 95	1 66	1 35
	S_2	1 13	1 37	1 33	1 14	38	1 35	1 24	1 45	1 45	1 36	1 55	1 56	1 42	1 61	65
R_2	S_1	1 22	1 32	1 22	1 23	1 34	1 23	1 30	1 41	1 31	1 34	1 47	1 43	1 0	1 55	52
	S_2	1 20	1 25	1 32	1 22	1 26	1 33	1 30	1 37	1 40	1 41	1 48	1 50	1 47	1 55	1 57
R_3	S_1	50	1 58	1 30	1 52	1 60	1 31	1 57	1 63	1 35	1 59	1 65	1 38	1 62	1 70	1 43
	S_2	1 33	1 22	1 13	1 35	23	1 47	40	1 29	1 18	1 41	1 34	1 22	1 45	1 40	1 50
R_4	S_1	1 29	1 30	1 42	1 31	1 30	1 43	1 38	1 38	1 50	1 42	1 45	1 56	1 45	1 48	1 65
	S_2	1 35	1 33	1 03	1 37	1 35	1 05	1 45	1 43	1 11	1 54	1 48	1 14	1 63	1 55	1 16
R_5	S_1	1 22	1 63	1 83	1 23	65	1 85	30	1 75	1 92	1 39	1 85	2 02	1 44	1 92	2 10
	S_2	0 97	1 23	1 50	0 98	1 26	51	1 09	1 33	1 59	1 14	1 42	1 68	1 18	1 47	1 76
R_6	S_1	1 32	1 33	1 17	1 33	1 35	1 17	1 7	1 67	1 26	1 52	1 87	1 32	1 60	1 97	1 37
	S_2		1 30	1 10		31	1 10		1 37	1 16		1 43	1 14		1 58	1 23
CD (0 05)			0 361			0 361			0 359			0 047			0 388	


INTERACTION EFFECT OF ROOT_TOCK (R1)
VARIETY OF SCION AND MONTH OF GRAFTING
GIRTH OF SCION IN CMS
2
1.9
1.8
1
1.6
1.5
1.4
1.3
1.2
1.1
m1
m2
m3
thirty
one hundredth ant
one hundred fifty
FIGURE 13
S1
S2


INTERACTION EFFECT OF ROOTSTOCK (R2)
VARIETY OF SCION AND MONTH OF GRAFTING
GIRTH OF SCION IN CMS
1.6
1.55
1.5
1.45
1.4
1.35
1.3
1.25
m1
m2
m3
thirty
one hundredth anty
one hundred fifty
FIGURE 14
S1
S2

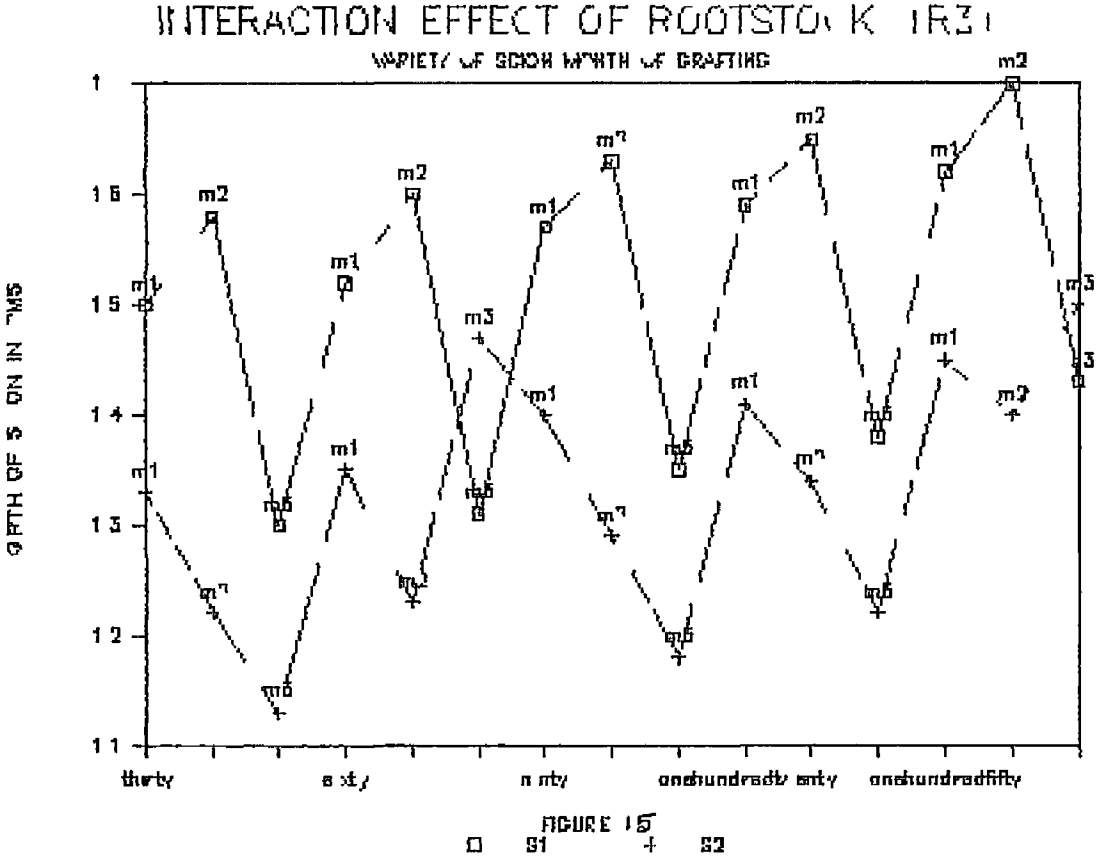


FIGURE 15

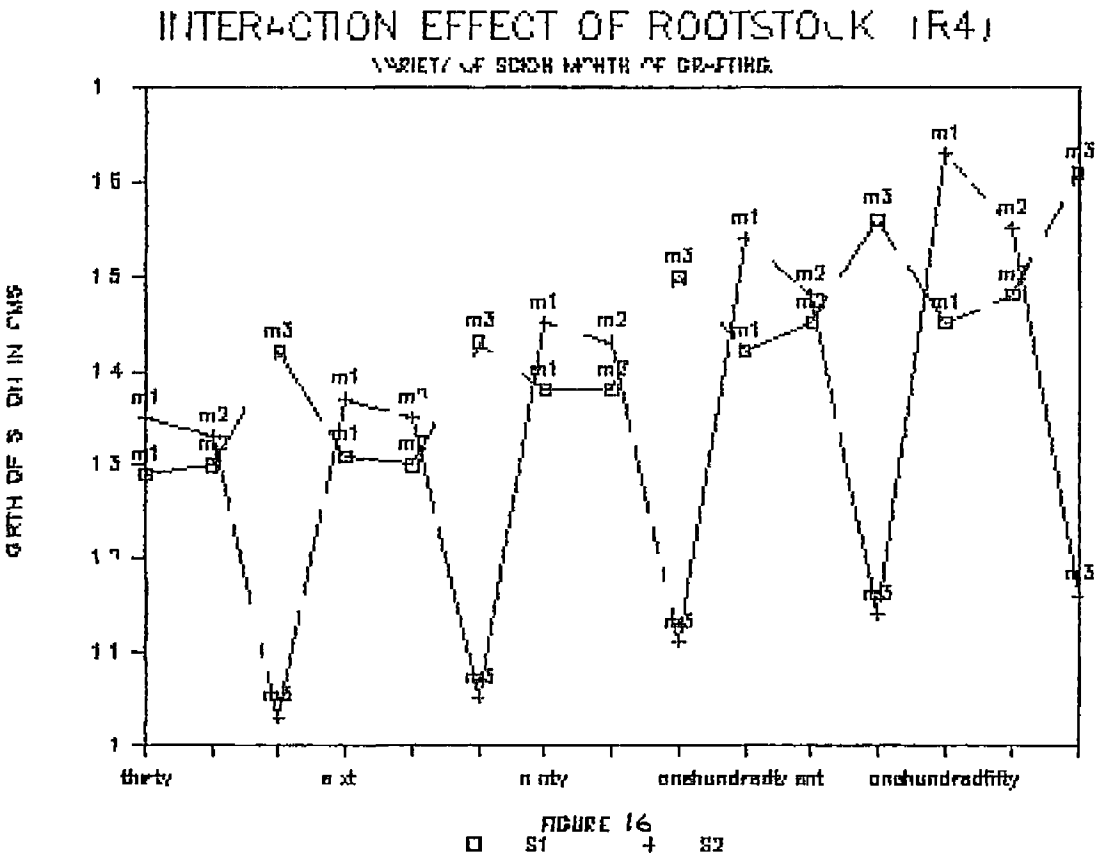
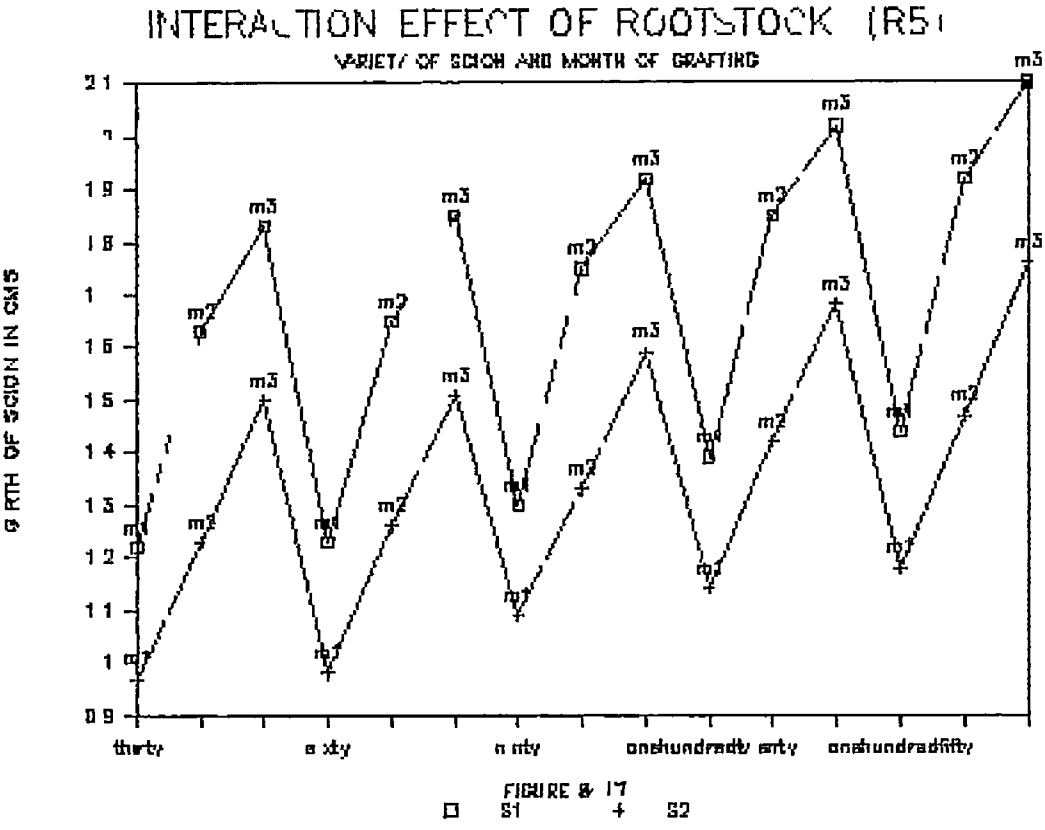
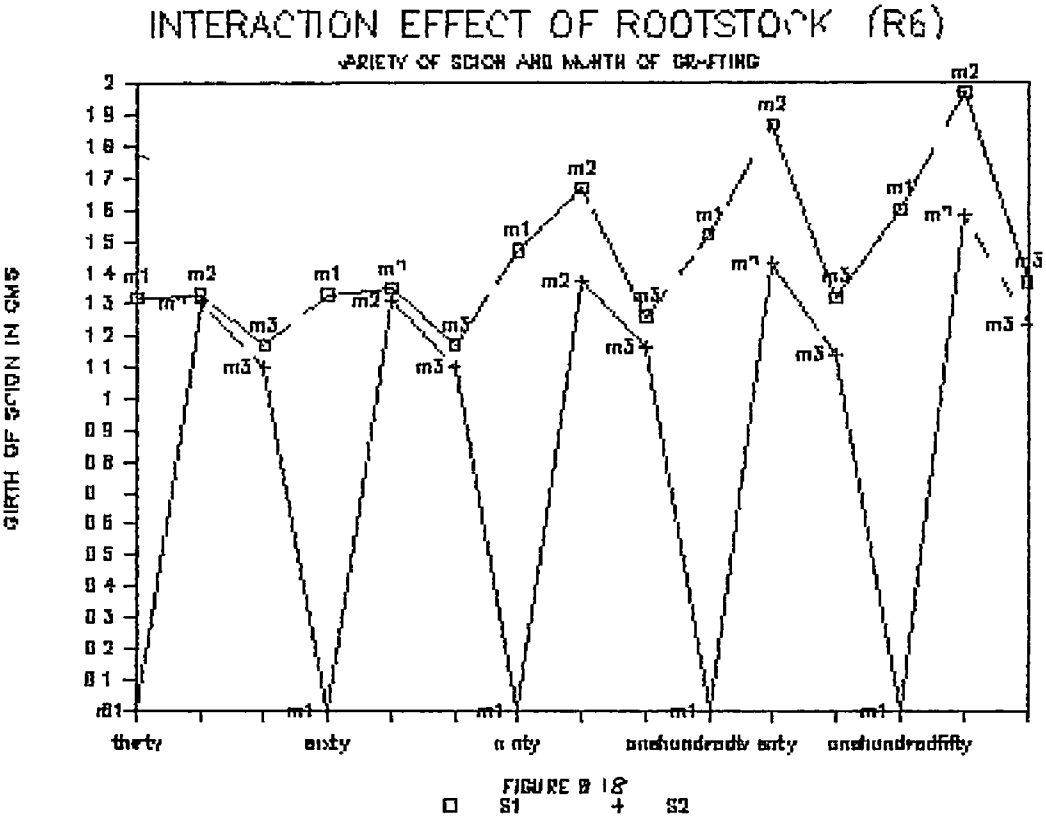


FIGURE 16


INTERACTION EFFECT OF ROOTSTOCK (R5)
VARIETY OF SCION AND MONTH OF GRAFTING
GIRTH OF SCION IN CMS
thirty
sixty
ninety
onehundredthirty
onehundredfifty
FIGURE 8 17
S1
S2


INTERACTION EFFECT OF ROOTSTOCK (R6)
VARIETY OF SCION AND MONTH OF GRAFTING
GIRTH OF SCION IN CMS
thirty
sixty
ninety
onehundredthirty
onehundredfifty
FIGURE 8 18
S1
S2

It is clearly evident from the table that there is significant difference with regard to girth of scion for different treatment combinations throughout the period of observation Maximum girth of scion at 150 days after grafting (2 10 cm) was noted when grafting was done on Bangalora using Neelum in the month of August Further Bangalora grafted with Neelum in July (1 92 cm) Muvandan grafted with Neelum in June (1 95 cm) also produced consistently higher circumference of girth throughout the period under study In the later stages Tolikaipan grafted with Neelum in July also recorded higher (1 97 cm) scion diameters The least values were found throughout the period under study for graftings done in August with Tolikaipan rootstock and Banganapally scion

In the light of the above results it may be stated that the rootstock scion and their combinations have significant influence on girth of scion after grafting Bangalora the monoembryonic rootstock is superior than all the polyembryonic rootstock tried in this study Among the polyembryonic rootstocks Muvandan ranks first With respect to scions the ideal one is Neelum Bangalora Neelum August combination was found best for scion growth with respect to girth

5 Girth of new growth

The effect of rootstock scion month and their interactions on girth of new growth are presented in detail in the following paragraphs

5 1 Effect of rootstock

Girth of sprout is not significantly influenced by rootstock (Table 23) Though none of the rootstocks have given significantly more values than Bangalora (1 18 cm) it can be observed that Taolikaipan is putting up comparatively higher values (1 19 cm) over other rootstocks at the later stage of this study It can also be seen that Muvandan rootstock is late in sprouting

5 2 Effect of scion

Scions did not show significant effect on circumference of new growth (Table 24) But Neelum scion consistently produced higher values than Banganapally

5 3 Effect of month of grafting

The data pertaining to the effect of months are given in table 25 Though not significant grafting done in July produced higher values of mean girth of new growth throughout the period of observation

5 4 Interaction effect of rootstock and scion

On perusal of the data presented in table 26 it is seen that rootstock scion combination have no significant effect on girth of new growth However Bangalora with Banganapally recorded the maximum (1 26 cm) mean girth of new growth closely followed by Bangalora Neelum combination (1 22 cm) at 150 days after grafting

Table 23 Effect of rootstock on girth of sprout (cm)

Rootstock	Days after grafting				
	30	60	90	120	150
R_1	0	0 76	0 87	0 95	0 99
R_2	0 69	0 89	0 95	0 99	1 05
R_3	0 67	0 81	0 90	0 93	0 96
R_4	0 68	0 78	0 85	0 88	0 91
R_5	1 01	1 05	1 09	1 15	1 18
R_6	0 81	0 84	0 91	0 94	1 19

Homogeneous at 5% level

Table 24 Effect of scion on girth of sprout (cm)

Scion	Days after grafting				
	30	60	90	120	150
S_1	0 61	0 90	0 97	1 01	1 05
S_2	0 60	0 81	0 90	0 95	0 98

Homogeneous at 5% level

Table 25 Effect of month of grafting on girth of sprout (cm)

Month	Days after grafting				
	30	60	90	120	150
M_1	0 54	0 85	0 93	0 97	0 99
M_2	0 65	0 89	0 99	1 05	1 11
M_3	0 63	0 82	0 89	0 92	0 95

Homogeneous at 5 % level

Table 26 Interaction effect of rootstock and scion on girth of sprout (cm)

Rootstock	Days after grafting									
	30		60		90		120		150	
	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2
R_1	0	0	0 77	0 75	0 91	0 83	0 96	0 94	0 99	1 00
R_2	0 65	0 73	0 87	0 91	0 92	0 98	0 98	1 01	1 07	1 03
R_3	0 74	0 59	0 99	0 62	1 03	0 77	1 07	0 79	1 09	0 82
R_4	0 70	0 65	0 89	0 67	0 95	0 75	0 98	0 78	1 01	0 80
R_5	0 96	1 05	0 99	1 10	1 02	1 17	1 07	1 22	1 09	1 26
R_6	0 88	0 69	0 92	0 71	1 06	0 78	1 03	0 79	1 06	0 82

Homogeneous at 5% level

5 5 Interaction effect of rootstock and month of grafting

The observations on the effect of rootstock and month are presented in table 27 It is seen that, though not significant the polyembryonic varieties registered lesser values than the mono embryonic variety Bangalora Among the polyembryonic varieties the least girth of new growth was recorded for Tolikaipan and Chandrakaran rootstocks when grafted in August

5 6 Interaction effect of scion and month of grafting

The effect of scion and month of grafting on girth of new growth is incorporated in table 28 None of the treatment combi nations differ significantly with respect to this parameter However Banganapally scion grafted in July showed comparatively higher values (1 13 cm) of girth of new growth

5 7 Interaction effect of rootstock scion and month of grafting

It can be seen from table 29 that no treatment combinations have significant effect on girth of sprout Bangalora rootstock grafted with Banganapally in July recorded comparatively higher values (1 70 cm) of mean girth of sprout at 150 days after graft ing It can also be noted that whatever may be the scion or month of grafting the rootstock Muvandan sprouted later than other root stocks

Table 27 Interaction effect of month of grafting and rootstock on g rth of sprout (cm)

Rootstock	Days after grafting														
	30			60			90			120			150		
	M_1	M_2	M_3	M_1	M_2	M_3	M_1	M_2	M_3	M_1	M_2	M_3	M_1	M_2	M_3
R_1	0	0	0	0 80	0 75	0 72	0 89	0 92	0 80	0 98	1 0	0 85	1 04	1 07	0 88
R_2	0 54	0 72	0 80	0 86	0 92	0 88	0 94	0 98	0 93	0 97	05	0 97	1 00	1 17	0 98
R_3	0 53	0 79	0 70	0 87	0 81	0 73	0 93	0 97	0 78	0 97	1 02	0 81	0 98	1 06	0 83
R	0 89	0 59	0 56	0 91	0 78	0 65	1 00	0 84	0 73	1 02	0 89	0 73	1 04	0 92	0 75
R_5	0 75	1 17	09	0 81	1 20	1 13	0 88	1 24	1 17	0 90	28	1 26	0 91	1 32	1 30
R_6	0 92	0 93	0 63	1 00	0 95	0 65	1 00	07	0 7	1 06	1 08	0 74	1 10	1 11	0 75

Homogeneous at 5% level

Table 28 Interaction effect of scion and month of grafting on girth of sprout (cm)

Scion	Month	Days after grafting				
		30	60	90	120	150
S_1	M_1	0 47	0 88	0 95	0 99	1 02
	M_2	0 63	0 90	0 96	1 02	1 09
	M_3	0 73	0 93	0 99	1 02	1 04
S_2	M_1	0 61	0 83	0 90	0 94	0 97
	M_2	0 68	0 90	1 02	1 08	1 13
	M_3	0 53	0 72	0 78	0 85	0 85

Homogeneous at 5% level

Table 29 Interact on effect of rootstock sc on and month of graft ng on g rth of sprout (cm)

Root stock	Scion	Days after graft ng														
		30			60			90			120			150		
		M	M_2	M_3	M_1	M_2	M_3	M_1	M_2	M_3	M_1	M_2	M_3	M	M_2	M_3
R_1	S_1	0	0	0	0 79	0 83	0 68	0 90	09	0 76	0 97	1 12	0 80	1 00	1 15	0 83
	S_2	0	0	0	0 82	0 68	0 77	0 88	0 76	0 86	0 99	0 9	0 90	1 08	0 99	0 93
R_2	S	0 33	0 89	0 73	0 87	0 93	0 80	0 96	0 94	0 87	0 99	1 05	0 90	1 0	1 25	0 9
	S_2	0 75	0 56	0 87	0 85	0 92	0 96	0 92	02	1 00	0 94	04	04	0 95	1 08	05
R_3	S_1	0 28	02	0 92	0 95	1 05	0 97	0	06	1 00	05	13	03	1 06	1 16	1 0
	S_2	0 77	0 55	0 7	0 80	0 56	0 50	0 85	0 89	0 56	0 88	0 91	0 59	0 91	0 95	0 6
R_4	S_1	0 91	0 42	0 78	0 93	0 80	0 94	00	0 85	1 0	02	0 89	03	1 06	0 93	1 05
	S_2	0 87	0 76	0 33	0 89	0 77	0 35	0 99	0 83	0 44	1 01	0 89	0 43	03	0 9	0 6
R_5	S_1	0 82	0 8	22	0 85	0 87	1 25	0 89	0 88	29	0 93	0 93	36	0 95	0 9	38
	S_2	0 69	1 50	0 97	0 78	53	00	0 86	1 60	1 05	0 86	64	1 16	0 87	1 70	1 22
R_6	S	0 92	0 93	0 79	1 00	0 96	0 81	1 06	1 13	0 88	1 06	3	0 91	0	1 15	0 93
	S_2		0 92	0 47		0 94	0 48		1 0	0 54		1 03	0 56		07	0 58

Homogeneous at 5% eve

The foregoing analysis leads to the conclusion that none of the treatments tried in this study have significant effect on girth of sprout Generally in the present study polyembryonic varieties recorded lesser circumference of sprout compared to Bangalora the monoembryonic variety

6 Length of sprout

The results of the effect of rootstock scion month of grafting and their interactions were analysed and presented in detail in the following paragraphs

6 1 Effect of rootstock

Data furnished in table 30 reveals the effect of different rootstocks on the length of sprout Statistical differences were noted only from 90 days after grafting Among the various rootstocks tried polyembryonic varieties recorded lesser values of sprout length It may also be noted that when grafting was done with rootstock Olour sprout length was minimum, 6 38 cm at 150 days after grafting Maximum sprout length (12 91 cm) was recorded by Bangalora

6 2 Effect of scion

Scions also significantly influenced the length of sprout throughout the period of study (Table 31) Neelum scion produced consistently higher values of sprout length Mean sprout length

Table 30 Effect of rootstock on length of sprout (cm)

Rootstock	Days after grafting				
	30	60	90	120	150
R_1	0 30	3 99	6 44	8 96	9 64
R_2	1 35	2 89	6 37	8 95	9 44
R_3	2 14	3 35	5 41	5 84	6 38
R_4	1 91	3 98	7 10	8 13	8 89
R_5	2 21	6 81	10 93	11 78	12 91
R_6	2 30	3 51	5 94	6 42	8 32
CD (0 05)	NS	NS	2 262	2 295	2 324

of 10 36 cm was recorded for Neelum at 150 days after grafting whereas Banganapally recorded only 8 00 cm

6 3 Effect of month of grafting

Effect of different months on length of sprout is presented in table 32 It can be seen that the different months tried in this study have a significant influence on sprout length Maximum growth of scion 9 76 cm at 150 days after grafting was recorded for grafting done in July closely followed by graftings done in August (9 75 cm)

6 4 Interaction effect of rootstock and scion

Rootstock scion combination have a significant influence on length of sprout as is evident from table 33 A perusal of the table shows higher values of sprout length for the rootstock Bangalora irrespective of the variety of scion Bangalora-Neelum combination produced the maximum (13 42 cm) sprout length at 150 days after grafting while Olour rootstock grafted with Bangana pally recorded the least (4 52 cm) sprout length followed by Chandrakaran Banganapally combination (5 83 cm)

6 5 Interaction effect of rootstock and month of grafting

The data furnished in table 34 shows the combined effect of rootstock and month on growth of scion It is seen that Bangalora rootstock grafted during August recorded the maximum sprout length

Table 31 Effect of scion on length of sprout (cm)

Scion	Days after grafting				
	30	60	90	120	150
S_1	1 79	4 50	8 24	9 84	10 36
S_2	1 37	3 91	6 26	7 62	8 00
CD (0 05)	0 363	0 860	1 431	1 451	1 673

Table 32 Effect of month of grafting on length of sprout (cm)

Month	Days after grafting				
	30	60	90	120	150
M_1	1 35	3 31	5 90	7 41	8 04
M_2	2 31	4 57	7 77	9 36	9 76
M_3	1 07	4 73	8 08	9 43	9 75
CD (0 05)	NS	1 053	1 752	1 777	1 800

Table 33 Interaction effect of scion and rootstock on length of sprout (cm)

Rootstock	Days after grafting									
	30		60		90		120		150	
	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2
R_1	0 34	0 26	4 13	3 85	7 29	5 59	9 37	8 55	9 95	9 06
R_2	1 40	1 30	2 75	3 03	6 10	6 64	9 07	8 83	9 37	9 29
R_3	2 73	1 55	4 58	2 11	6 98	3 84	7 32	4 35	7 65	4 52
R_4	2 04	1 77	5 00	2 96	9 28	4 91	10 78	5 47	11 42	5 83
R_5	2 42	1 99	6 04	7 58	11 54	10 31	12 67	10 90	13 42	11 33
R_6	3 07	1 16	4 62	1 86	7 48	3 62	7 79	4 38	9 01	9 75
CD (0 05)	0 811		1 922		3 199		3 245		3 286	

Table 34 Interact on effect of month of graft ng and rootstock on length of sprout (cm)

Rootstock	Days after grafting														
	30			60			90			120			150		
	M_1	M_2	M_3	M_1	M_2	M_3	M_1	M_2	M_3	M_1	M_2	M_3	M_1	M_2	M_3
R_1	0 22	0 31	0 37	4 10	4 42	3 45	4 69	9 41	5 22	5 51	13 97	7 41	6 27	14 74	7 50
R_2	1 51	1 53	1 0	2 67	3 74	2 26	6 7	7 34	5 6	10 71	8 38	7 77	11 14	8 77	8 08
R_3	1 44	3 63	1 35	1 91	4 70	3 43	4 68	6 69	4 85	5 42	6 90	5 19	5 52	7 04	5 68
R_4	0 94	2 81	1 97	2 38	6 09	3 47	6 06	7 55	7 69	7 36	8 22	8 81	8 30	8 32	9 26
R_5	2 65	3 29	0 68	5 49	3 92	11 02	7 90	7 87	17 01	8 07	9 33	17 95	8 97	9 94	18 22
R_6	2 67	2 01	2 42	3 4	4 44	2 60	4 34	7 03	5 64	4 50	7 41	6 39	5 13	8 65	9 59
CD (0 05)		0 993			NS			3 919			NS			NS	

of 18 22 cm at 150 days after grafting At the same time Olour rootstock grafted during August recorded the least growth of scion (5 68 cm) in terms of length

6 6 Interaction effect of scion and month of grafting

Observation on the combined effect of scion and month are tabulated in table 35 Significant differences were noted only during the earlier part of the study However Neelum scion grafted in July produced the maximum (11 11 cm) values during the entire period of investigation It can also be seen that longer sprouts were produced by Neelum scions irrespective of the month of graft ng

6 7 Interaction effect of rootstock scion and month of grafting

Significant effects of rootstock scion month combination on length of sprout is clearly evident from table 36 and Fig 19 to 24 A close examination of the table reveals that Bangalora rootstock grafted with Neelum or Banganapally in August recorded higher values of sprout length after 60 days of grafting Bangalora root stock grafted in August with Neelum and Banganapally recorded 17 67 cm and 18 76 cm sprout length respectively at 150 days after grafting Among the polyembryonic varieties Muvandan grafted with Neelum in July also produced significantly higher values (17 02 cm) Lower values were recorded by Olour (3 29 cm) and Chandrakaran (4 40 cm) grafted with Banganapally in August

Table 35 Interaction effect of month of grafting and scion on length of sprout (cm)

Scion	Month	Days after grafting				
		30	60	90	120	150
S_1	M_1	1 27	3 10	6 35	8 39	9 41
	M_2	2 86	5 81	9 40	10 89	11 11
	M_3	1 24	4 59	8 77	10 25	10 56
S_2	M_1	1 44	3 52	5 25	6 44	6 67
	M_2	1 77	3 33	6 14	7 82	8 41
	M_3	0 91	4 87	7 39	8 60	8 93
CD (0 05)		0 628	1 489	NS	NS	NS

Table 36 Interact on effect of rootstock scion and month of graft ng on length of sprout (cm)

Root stock	Scion	Days of grafting														
		30			60			90			120			150		
		M_1	M_2	M_3	M_1	M_2	M_3	M_1	M_2	M_3	M_1	M_2	M_3	M_1	M_2	M_3
R_1	S_1	0 23	0 37	0 43	4 20	6 33	1 85	4 91	12 58	4 39	5 04	16 86	6 22	6 51	17 02	6 33
	S_2	0 21	0 25	0 31	4 00	2 50	5 05	4 47	6 24	6 05	5 97	11 09	8 60	6 04	12 47	8 66
R_2	S_1	1 26	1 52	1 42	2 87	3 00	2 38	7 97	6 26	4 09	14 28	6 47	6 46	4 79	6 68	6 63
	S_2	1 77	1 53	0 61	2 47	4 47	2 14	4 38	8 41	7 13	7 13	10 28	9 07	7 48	10 85	9 53
R_3	S_1	1 43	5 41	1 33	2 15	6 51	5 08	5 57	8 56	6 81	6 02	8 60	7 35	6 09	8 78	8 07
	S_2	1 45	1 85	1 36	1 67	2 89	2 77	3 80	4 83	2 89	4 82	5 20	3 03	4 95	5 31	3 29
R	S_1	0 86	2 68	2 58	1 62	8 39	5 00	5 21	10 90	11 73	7 35	11 06	13 44	10 91	11 23	14 11
	S_2	1 02	2 93	1 35	3 15	3 79	1 93	6 90	4 19	3 65	7 36	5 37	3 69	7 69	5 41	4 40
R	S_1	2 55	29	0 2	68	83	8 61	9 10	8 69	16 81	9 25	11 48	17 28	10 75	11 85	17 67
	S_2	2 75	2 29	0 94	6 30	3 02	13 3	6 70	7 04	17 20	6 90	7 17	18 61	7 18	8 03	18 76
R_4	S_1	2 67	2 27	28	3 4	5 87	5	3	10 16	7 95	9 50	10 52	8 35	5 13	12 29	9 62
	S_2		1 75	0 57		3 05	0 66		3 90	3 30		4 31	4 45		5 00	9 56
CD (0 05)			1 405			3 329			5 542			5 621			5 693	

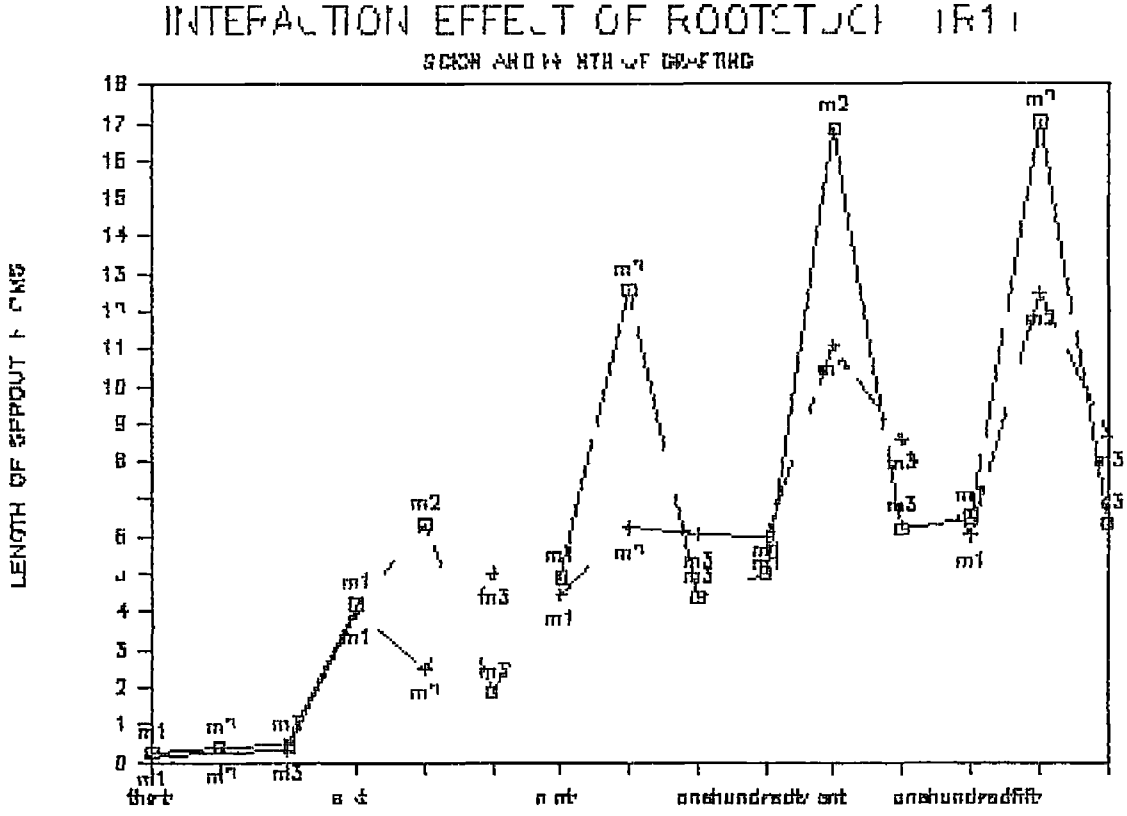


FIGURE 19

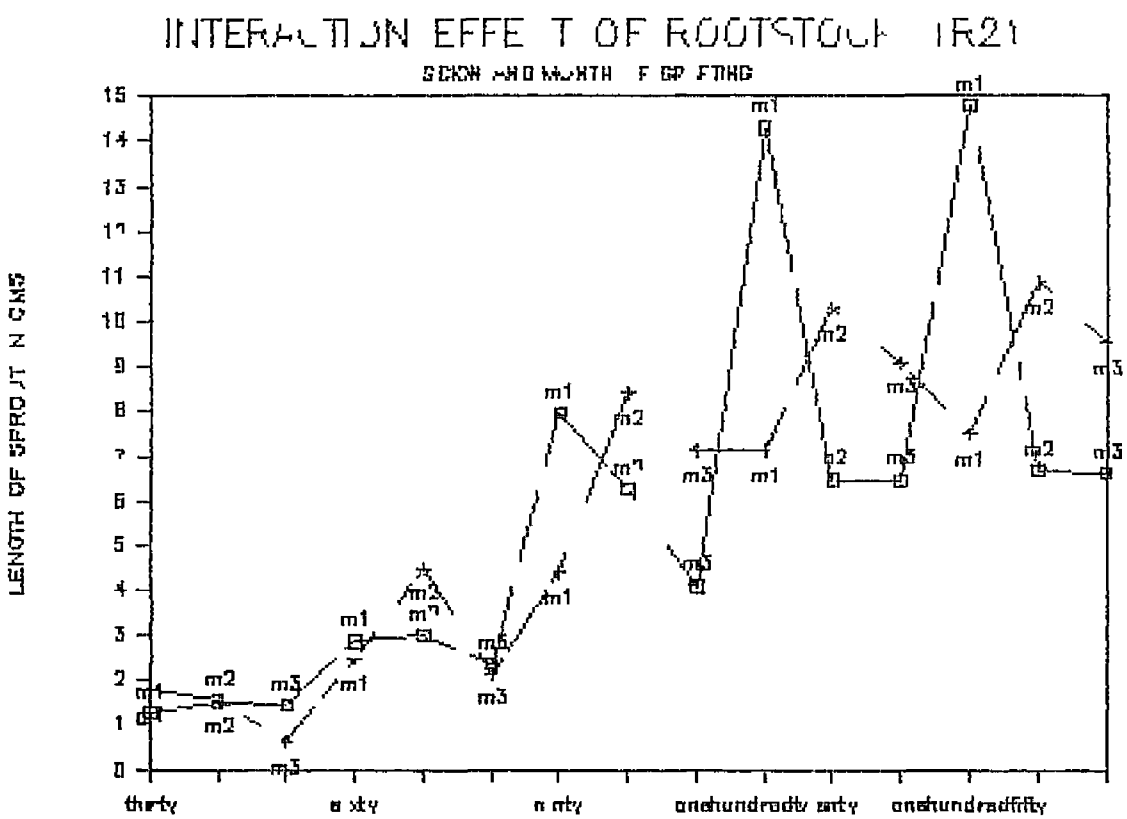
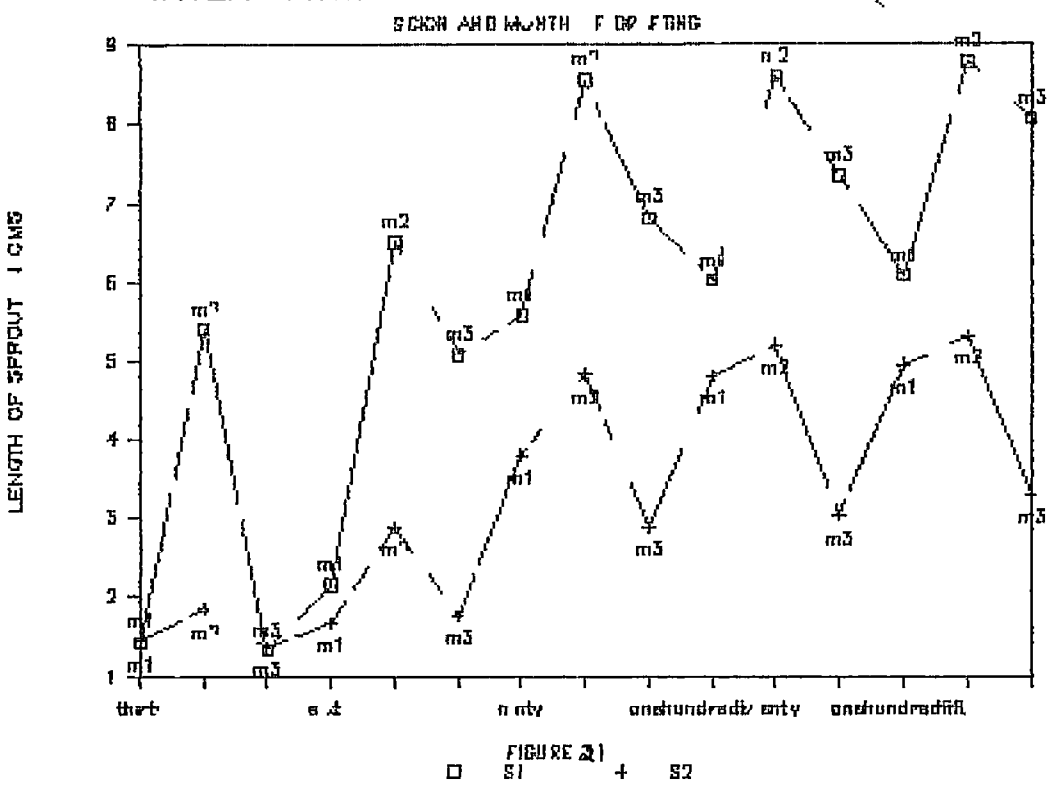
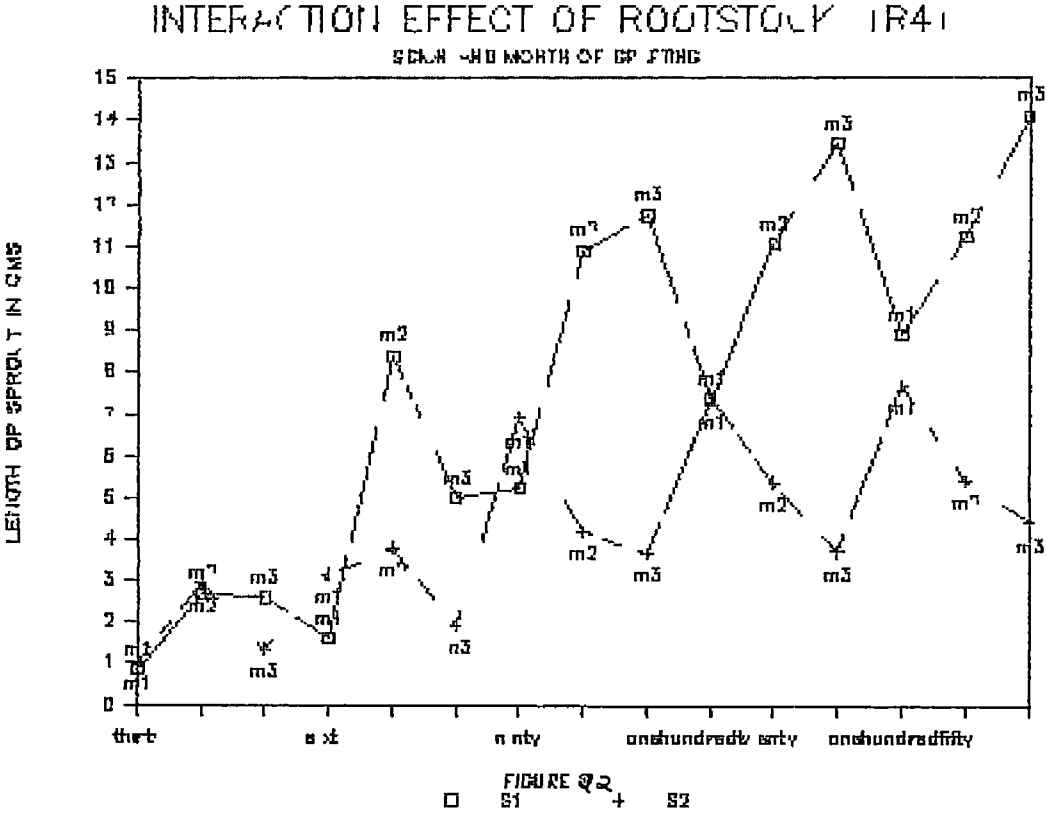


FIGURE 20


INTERACTION EFFECT OF ROOTSTOCK (R3)
LENGTH OF SPROUT IN CMS
FIGURE 21
S1
S2


INTERACTION EFFECT OF ROOTSTOCK (R4)
LENGTH OF SPROUT IN CMS
FIGURE 22
S1
S2

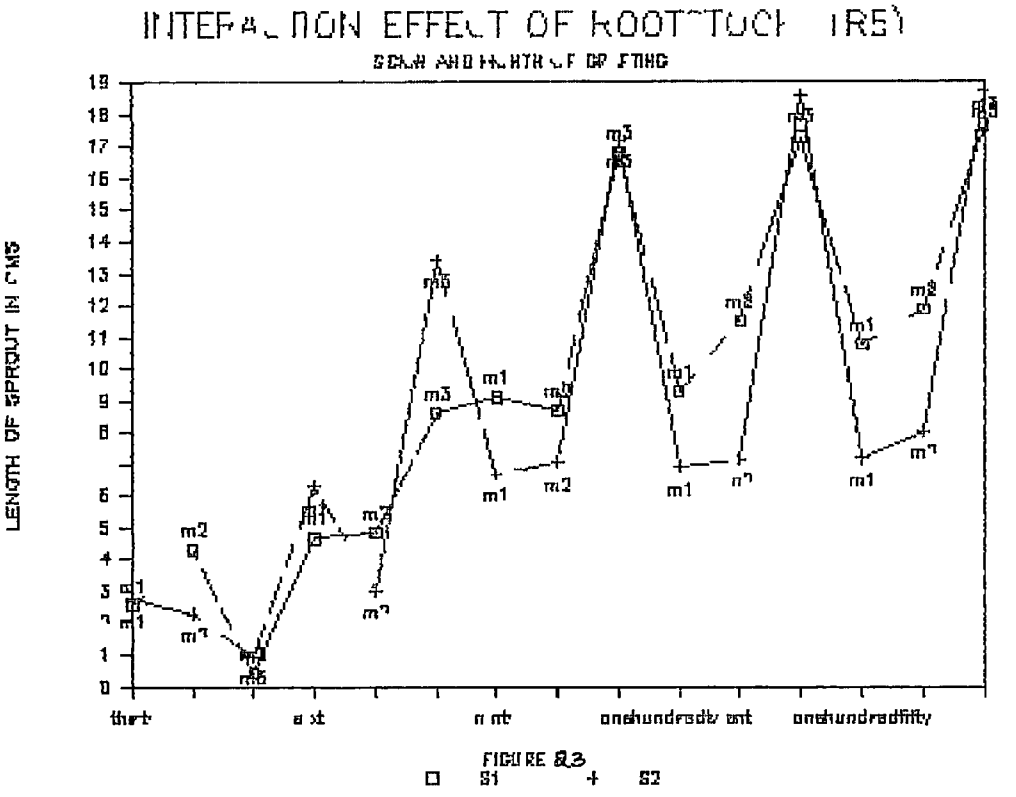


FIGURE 83

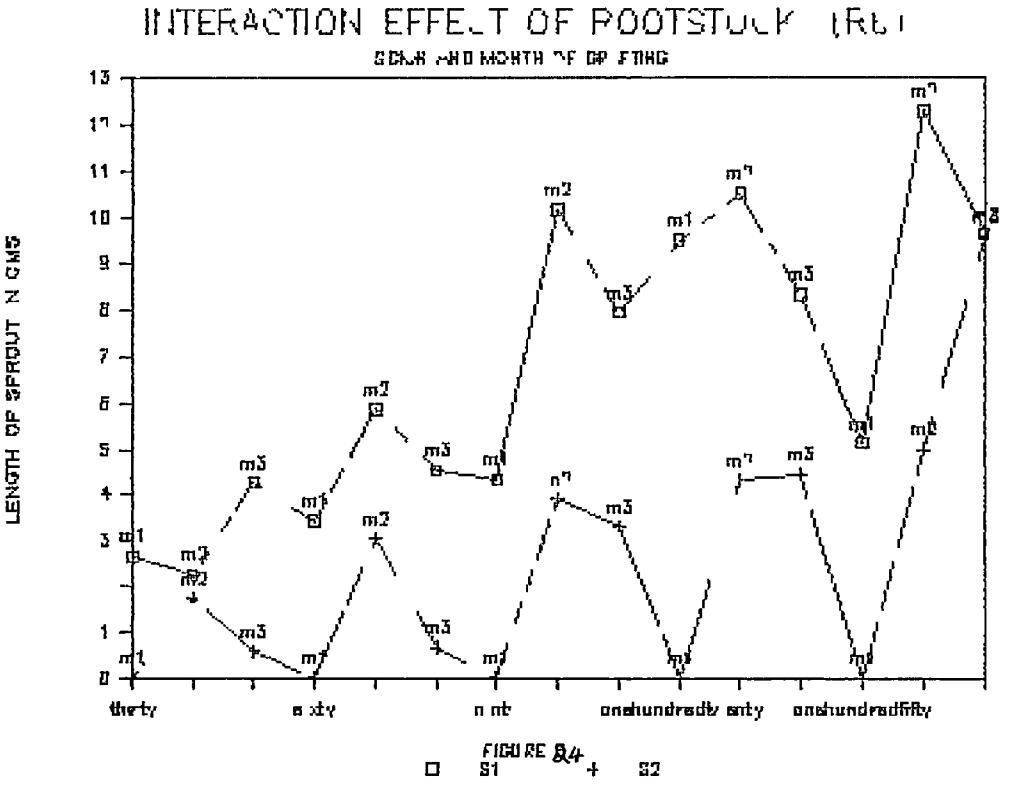


FIGURE 84

From the above results it may be inferred that rootstock scion and month of grafting have influence on growth of the sprout Polyembryonic rootstocks produced lesser sprout length With respect to scions graftings done with Neelum registered higher length of sprouts As to the effect of month both July and August induced longer sprouts during the entire period of observation Polyembryonic rootstocks grafted with Banganapally generally produced shorter sprouts With regard to the combined effect Bangalora the monoembryonic rootstock grafted with Neelum or Banganapally in August gave longer sprouts

7 Number of leaves

The effect of rootstock scion month and their interactions on production of leaves are analysed in detail in the following pages

7 1 Effect of rootstock

Result of the analysis on effect of rootstock are presented in table 37 This parameter was found to be insignificant through out the period of observation However the maximum (19 62) number of leaves were produced by Puliyan rootstock and the minimum (13 92) by Tolikaipan at 150 days after grafting

7 2 Effect of scion

Effect of scion on the production of leaves is presented in table 38 Though not consistently significant Neelum produced

Table 37 Effect of rootstock on number of leaves

Rootstock	Days after grafting				
	30	60	90	120	150
R_1	0	7 74	11 23	14 17	14 99
R_2	5 30	9 63	15 19	18 49	19 62
R_3	4 68	6 65	11 56	13 15	13 99
R_4	6 30	9 89	15 67	17 17	18 28
R_5	6 36	11 09	15 45	19 10	18 97
R_6	6 43	8 66	13 09	12 73	13 92

Homogeneous at 5% level

more number of leaves throughout the period of study At 150 days after grafting the mean number of leaves produced by this variety was 17 53 while Banganapally produced 16 81 leaves

7 3 Effect of month

The month of grafting has no significant influence on the production of leaves (Table 39) However graftings done in July was consistently superior over the other months of grafting with regard to this parameter recording 18 39 leaves at 150 days after grafting The number of leaves produced in June and August graft ing after 150 days were 17 06 and 16 06 respectively

7 4 Interaction effect of scion and rootstock

Rootstock scion combinations had expressed no significant influence on production of leaves during the entire period of observation (Table 40) It can be seen from the table that Chandra karan and Puliyan grafted with Neelum produced more number of leaves than Bangalora Neelum combination at 150 days after grafting Chandrakaran Neelum Puliyan Neelum and Bangalora Neelum combinat ions produced 20 32 19 90 and 19 53 leaves respectively

7 5 Interaction effect of rootstock and month of grafting

Table 41 shows the effect of rootstock and month on product ion of leaves No significant differences are seen between treatment combinations studied with respect to this parameter But Chandra karan rootstock grafted in July produced maximum (22 01) number

Table 38 Effect of scion on number of leaves

Scion	Days after grafting				
	30	60	90	120	150
S_1	4 63	9 01	14 16	16 43	17 53
S_2	4 43	8 99	13 48	15 60	16 81
CD (0 05)	0 289	NS	0 470	NS	0 459

Table 39 Effect of month of grafting on number of leaves

Month	Days after grafting				
	30	60	90	120	150
M_1	4 45	9 10	13 84	15 81	17 06
M_2	5 78	9 40	14 84	17 32	18 39
M_3	3 36	8 50	12 77	14 91	16 06

Homogeneous at 5% level

Table 40 Interaction effect of s ion and rootstock on number of leaves

Rootstock	Days after grafting									
	30		60		90		120		150	
	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2
R_1	0	0	7 32	8 15	10 98	11 48	14 32	14 02	16 22	14 76
R_2	4 44	6 16	8 36	10 91	15 06	15 34	18 81	18 17	19 90	19 33
R_3	4 32	5 03	7 29	6 00	11 61	11 51	12 38	13 92	12 68	15 32
R_4	6 00	6 60	11 64	8 14	17 45	13 88	18 50	15 83	20 32	16 23
R_5	8 37	4 37	10 44	11 72	15 72	15 17	18 16	16 04	19 53	18 42
R_6	5 84	7 37	8 79	8 32	13 68	12 21	12 04	13 75	13 35	14 78

Ho no gene us at 5% level

Table 41 Interaction effect of month of grafting and rootstock on number of leaves

Rootstock	Days after grafting														
	30			60			90			120			150		
	M_1	M_2	M_3	M_1	M_2	M_3	M_1	M_2	M_3	M_1	M_2	M_3	M_1	M_2	M_3
R_1	0	0	0	10 14	5 55	7 31	10 115	12 25	10 61	12 24	15 76	14 50	13 14	16 58	15 25
R_2	4 74	7 46	3 71	9 87	11 02	8 01	15 0	6 78	13 31	20 44	18 36	16 66	21 26	19 96	17 63
R_3	3 63	7 08	3 32	6 00	7 52	6 2	12 0	12 43	10 05	14 45	14 22	10 79	15 37	15 15	11 48
R_4	7 25	7 22	4 44	9 13	12 52	8 03	15 3	18 09	13 38	16 26	20 78	14 45	17 72	22 01	15 10
R_1	6 61	7 13	5 34	10 35	10 37	12 56	15 14	14 67	16 53	15 66	17 50	18 14	17 82	18 26	20 8
R	4 50	8 00	5 89	10 87	9 77	6	11 6	12 60	14 55	11 94	13 78	12 07	14 03	14 71	13 09

Homog neou at 5% level

of leaves at 150 days after grafting and the minimum (11 48) by Olour rootstock grafted in August

7 6 Interaction effect of scion and month of grafting

Data presented in Table 42 on this aspect shows that there is no consistent significant effect between treatment combinations studied It can also be seen that during the entire period of observation the maximum number of leaves was produced by Neelum scion grafted in July and minimum number of leaves was produced by Banganapally scion grafted in August recording 18 83 and 15 24 mean number of leaves respectively at 150 days after grafting

7 7 Interaction effect of rootstock scion and month of grafting

Significant differences were not obtained between the treatment combinations (Table 43) It was observed that Chandrakaran grafted with Neelum in July produced the maximum number of leaves from 60 days after grafting The treatment combination produced 24 45 leaves at 150 days after grafting Minimum number of leaves was recorded by the treatment combination Olour root stock grafted with Neelum in August (9 63)

In the light of the above results it might be concluded that rootstock scion month and their combinations have no significant influence on the production of leaves Puliyan and Chandrakaran rootstocks comparatively produced more number of leaves Similarly

Table 42 Interaction effect of month of grafting and scion on number of leaves

Scion	Month	Days after grafting				
		30	60	90	120	150
S_1	M_1	4 11	8 56	13 76	15 64	16 88
	M_2	5 89	9 85	15 68	17 90	18 83
	M_3	3 89	8 62	13 06	15 76	16 88
S_2	M_1	4 79	illegible	illegible	illegible	illegible
	M_2	5 67	illegible	0	illegible	illegible
	M_3	2 83	8 39	12 49	14 06	15 24
CD (0 05)		NS	NS	0 814	NS	0 796

Table 43 Interaction effect of rootsto k sc1on and month of grafting on number of leaves

R ot s ck	Scion	Days after grafting														
		30			60			90			120			150		
		M_1	M_2	M_3	M_1	M_2	M_3	M_1	M_2	M_3	M_1	M_2	M_3	M_1	M_2	M_3
I_1	S_1	0	0	0	9 09	5 45	7 42	10 12	12 45	10 38	10 47	17 12	15 35	11 87	17 48	16 30
	S_2	0	0	0	11 19	5 06	7 60	57	12 0	10 83	14 01	14 40	13 65	14 41	15 67	14 19
I_2	S_1	3 28	7 17	2 87	10 00	8 58	6 8	16 87	16 06	12 25	23 25	16 75	16 42	23 97	18 40	17 33
	S_2	6 20	7 75	4 54	9 73	13 46	9 54	14 14	17 50	4 37	17 62	19 97	16 91	18 56	21 52	17 92
R_3	S_1	2 33	9 67	0 97	6 86	10 28	4 75	12 20	14 28	8 34	13 52	14 43	9 19	13 72	14 68	9 63
	S_2	4 92	4 50	5 67	5 15	4 77	8 08	12 19	0 58	11 75	15 38	14 01	12 38	17 02	15 61	13 32
R_4	S_1	7 33	5 33	5 35	9 15	15 08	10 69	19	21 58	16 58	15 17	22 32	18 02	17 52	24 45	19 00
	S_2	7 17	9 11	3 53	9 10	9 95	5 36	6 87	14 60	10 17	17 35	19 25	10 89	17 92	19 57	11 20
R_5	S_1	7 58	7 28	10 25	7 72	9 86	13 75	16 43	14 01	17 72	15 78	18 87	19 83	17 33	19 13	22 2
	S_2	5 64	6 99	0 43	12 97	10 88	11 36	1 85	15 33	15 33	15 5	16 12	16 45	18 31	17 39	19 57
R_6	S_1	4 50	7 85	5 18	10 87	10 0	5 7	1 16	13 03	16 84	11 44	13 56	10 63	14 03	14 68	1 3
	S_2		8 14	6 60		9 50	7 42		12 17	12 25		14 00	13 50		14 73	14 83

Homo_jeneou at 5% evel

the scion Neelum and the month July produced higher number of leaves

8 Number of primary branches

The results of the analysis of data on the effect of root stock scion month and their interact ons on product on of primary branches are presented in detail in the following pa phs

8 1 Effect of rootstock

None of the rootstocks studied had any significant effect on the production of primary branches (Table 44) However Puliyan (3 94) and Muvandan (3 90) rootstocks produced more number of primary branches than Bangalora from 120 days after grafting

8 2 Effect of scion

No consistent trend can be observed on production of primary branches with respect to the effect of scion (Table 45) Neelum and Banganapally produced 3 15 and 3 14 primary branches respectively at 150 days after grafting

8 3 Effect of month of grafting

Though not consistently significant grafting done in July produced lesser number of primary branches from 60 days after grafting (Table 46) Grafting done in August produced maximum number of primary branches

Table 44 Effect of rootstock on number of primary branches

Rootstock	Days after grafting				
	30	60	90	120	150
R_1	0	1 50	2 24	3 85	3 90
R_2	0 75	1 71	2 78	3 59	3 94
R_3	0 67	1 18	1 94	2 22	2 61
R_4	0 74	1 55	2 40	2 92	3 16
R_5	0 69	1 62	2 77	2 50	2 82
R_6	0 77	1 30	1 68	2 22	2 42

Homogeneous at 5% level

Table 45 Effect of scion on the number of primary branches

Scion	Days after grafting				
	30	60	90	120	150
S_1	0 57	1 48	2 34	2 88	3 15
S_2	0 56	1 55	2 31	2 15	3 14
CD (0 05)	NS	0 084	NS	0 089	NS

Table 46 Effect of month of grafting on the number of primary branches

Month	Days after grafting				
	30	60	90	120	150
M_1	0 65	1 55	2 28	2 80	3 19
M_2	0 53	1 39	2 21	2 65	3 04
M_3	0 52	1 60	2 48	3 01	3 20
CD (0 05)	0 139	NS	NS	NS	0 101

8 4 Interaction effect of scion and rootstock

The data furnished in table 47 reveals that there is no significant effect of rootstock scion combination on production of primary branches But it can be seen that Puliyan Neelum combinat ion produced maximum number (3 96) of primary branches 150 days after grafting closely followed by Puliyan Banganapally combi nation (3 92) The least number of primary branches was produced by Tolikaipan Neelum combination (2 17)

8 5 Effect of rootstock and month of grafting

Rootstock and month combination had significant effect on production of primary branches only upto 90 days after grafting (Table 48) Puliyan rootstock grafted in June gave maximum mean number of primary branches (4 5) and the least (2 53) by olour rootstock grafted in August at 150 days after grafting

8 6 Effect of scion and month of grafting

Table 49 reveals the effec of scion and month on production of primary branches during the period of investigation Significant differences were noted among the treatment combinations after 60 days of grafting Maximum (3 29) primary branches were recorded for Banganapally scion grafted in June at 150 days after grafting

Table 47 Interaction effect of scion and rootstock on number of primary branches

Rootstock	Days after grafting									
	30		60		90		120		150	
	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2
R_1	0	0	1 51	1 50	2 33	2 11	3 03	2 67	3 35	3 04
R_2	0 65	0 84	1 65	1 78	2 52	3 04	3 52	3 65	3 96	3 92
R_3	0 67	0 67	1 18	1 19	1 92	1 96	2 16	2 28	2 38	2 83
R_4	0 75	0 74	1 72	1 38	2 85	1 96	3 35	2 49	3 46	2 86
R_5	0 79	0 59	1 35	1 89	2 07	2 48	2 35	2 65	2 59	3 04
R_6	0 68	0 70	1 09	1 62	2 01	2 32	2 01	2 35	2 17	2 46

Homogeneous at 5% level

Table 48 Interaction effect of month of g afting and rootstock on number of primary branches

R ot t ck	Days after grafting														
	30			60			90			120			150		
	M_1	M_2	M_3	M	M_2	M_3	M_1	M_2	M_3	M_1	M_2	M_3	M_1	M_2	M_3
R_1	0	0	0	1 71	1 30	1 50	2 2)	2 17	2 23	2 64	2 68	3 24	2 97	3 23	3 38
R_2	0 79	0 66	0 79	1 79	1 62	1 74	2 78	2 61	2 94	3 99	3 08	3 69	4 57	3 28	3 97
R_3	0 85	0 65	0 51	1 30	0 92	1 33	1 9)	1 62	2 31	2 35	1 91	2 40	2 95	2 35	2 53
R_4	0 86	0 58	0 78	1 42	1 60	1 63	2 1	2 47	2 59	2 58	3 03	3 16	2 77	3 53	3 19
R_5	0 76	0 78	0 53	1 56	53	1 79	2 2)	2 20	2 34	2 43	2 53	2 55	2 70	2 81	2 9
R_6	0 81	0 67	0 68	1 63	1 49	1 68	2 0 1	2 01	2 25	2 61	2 67	2 73	3 01	3 06	2 99
CD (0 05)		0 312			0 088			0 319			NS			NS	

Table 49 Interaction effect of month of grafting and scion on the number of primary branches

Scion	Month	Days after grafting				
		30	60	90	120	150
S_1	M_1	0 65	1 43	2 17	2 75	3 09
	M_2	0 55	1 45	2 34	2 82	3 12
	M_3	0 52	1 56	2 51	3 09	3 24
S_2	M_1	0 65	1 68	2 40	2 85	3 29
	M_2	0 52	1 33	2 09	2 4	2 96
	M_3	0 53	1 64	2 45	2 93	3 18
CD (0 05)		NS	0 145	0 202	0 183	0 154

Table 50 Interact on effect of ootstock sc on and month of graft ng on product on of pr mary branches (No s)

R ot stock	Sc on	Days after grafting														
		30			60			90			120			150		
		M_1	M_2	M_3	M_1	M_2	M_3	M	M_2	M_3	M	M_2	M_3	M_1	M_2	M_3
R_1	S	0	0	0	1 77	48	1 26	2 39	2 4	2 20	2 6	3 6	3 33	2 78	3 82	3
	S_2	0	0	0	1 64	1 1	74	2 17	1 92	2 26	2 67	2 9	3 5	3 17	2 6	3 32
2	S_1	0 47	0 68	0 73	1 56	38	2 00	2 55	2 48	2 52	4 12	3 08	3 35	4 98	3 30	3 58
	S_2	10	0 63	0 79	2 0	1 85	47	3 02	2 73	3 37	3 85	3 08	03	4 15	3 26	35
R_3	S_1	1 03	0 72	0 27	27	1 07	9	69	1 57	2 50	1 98	1 89	2 6	2 34	2 1	2 69
	S_2	0 67	0 58	0 75	33	0 77	47	2 1	1 67	2 11	2 72	1 92	2 9	3 55	2 58	2 36
R_4	S	1 00	0 50	0 74	1 8	89	1 78	2	3 7	3 26	2 78	3 50	3 79	2 78	3 81	3 79
	S_2	0 72	0 67	0 82	36	1 3	8	2 18	1 77	1 93	2 38	2 57	2 52	2 75	3 25	2 59
R_5	S_1	0 75	0 83	0 78	1 08	1 44	1 53	2 08	2 06	2 08	2 25	2 44	2 37	2 58	2 58	2 62
	S_2	0 78	0 72	0 27	2 03	6	2 0	2 50	2 34	2 59	2 6	2 61	2 7	2 81	3 05	3 26
R_6	S_1	0 62	0 69	0 5	02	1	08	1 96	2 11	2 0	1 97	2 2	2 05	1 99	2 32	2 25
	S_2		0 62	0 73		1 41	1 85		2 22	2 43		2 28	2 47		2 30	2 51
CD (0 05)			0 441			NS			0 45			NS			NS	

Fifteen days after grafting wound periderm was found broken and the callus had started proliferating out in this stage in all the rootstock scion combination The callus proliferated either from the stock or from the scion depending upon their cellular activity The degree of callus formation varied considerably between varieties at this stage Wound periderm was seen to start brokening and callus formation started proliferating in grafts grafted with Muvandan rootstocks whereas for all other varieties callus tissue has filled the space between stock and scion partially or completely For the varieties Bangalora Puliyan (Plate I) and Olour the callus formation was noticed at a higher rate than Chandrakaran and Tolikaipan Most of the callus was produced from the cambium xylem and phloem of the stock and scion Tissues of the graft joint that was in contact were very important for proper graft union Between vascular tissues and cambium there was callus production and proper graft union

Thirty days after grafting when observed a continuous cambial bridge was formed across the stock and the scion Callus tissues developed into cambial cells which forms into a continuous cambial bridge In all the graft unions cambial bridge was formed In graft unions where Bangalora and Puliyan were used as rootstocks vascular elements were seen differentiated by 45 days

8 7 Interaction effect of rootstock scion and month of grafting

With respect to the combined effect also the data are not consistently significant (Table 50) However Puliyan Neelum combination grafted in June produced maximum number of primary branches (4 98) at 150 days after grafting and the minimum (1 99) by Tolikaipan Neelum combination in June

On the whole it could be concluded that production of primary branches is not much influenced by rootstock scion and month of grafting However Puliyan rootstock with Neelum scion grafted in June produced more number of primary branches than the other combinations studied

a Anatomical studies of graft union

Detailed anatomical studies were conducted for the different rootstock scion combinations The results obtained are summarised below

Five days after grafting when the graft joint was examined the wounded exposed tissues were found to be brownish in colour indicating the formation of wound periderm along the cut surfaces of stock and scion which were wide apart the graft joint The tissues at the cambial region had started rapid multiplication in order to produce callus

Sixty days after grafting vascular elements have differentiated in all combinations In Bangalora Puliyan Tolikaipan and Muvandan the gap between stock and scion have been completely filled with almost no interspaces But in other varieties there was gap between stock and scion (PlatesII to VII)

After 90 days of grafting complete healing of the union and formation of several cylinders of new tissues could be observed Bangalora and Puliyan was observed to have faster graft take due to more rapid formation of callus and vascular continuity Though Muvandan and Tolikaipan was late in callus initiation by 90 days complete healing of the union could be observed (Plates VIII to XIII)

It was also noted that in some grafts a necrotic layer was formed between stock and scion In some other grafts the exposed tissues were found to be brown but no callus initiation It was also seen that in certain graftings callus initiation and bridge formation had started in certain regions of the graft joint but in other areas no production of callus It might me due to improper allignment of stock and scion

Plate I Anatomy of the graft union using Puliyan rootstock (x 63)
(15 days after grafting)

Plate II Anatomy of the graft union using Bangalora rootstock (x 63)
(30 days after grafting)

Table 50 Interaction effect of rootstock scion and month of graft ng on production of primary branches (No s)

R ot stock	Scion	Days after grafting														
		30			60			90			120			150		
		M_1	M_2	M_3	M_1	M_2	M_3	M_1	M_2	M_3	M_1	M_2	M_3	M_1	M_2	M_3
R_1	S_1	0	0	0	1 77	1 48	26	2 39	2 41	2 20	2 61	3 16	3 33	2 78	3 82	3
	S_2	0	0	0	1 64	1 11	1 74	2 17	1 92	2 26	2 67	2 19	3 15	3 17	2 64	3 32
R_2	S_1	0 7	0 68	0 73	1 56	1 38	2 00	2 55	2 48	2 52	4 2	3 08	3 35	4 98	3 30	3 58
	S_2	1 10	0 63	0 79	2 01	1 85	1 47	3 02	2 73	3 37	3 85	3 08	4 03	4 15	3 26	35
R_3	S_1	1 03	0 72	0 27	1 27	1 07	1 19	1 69	1 57	2 50	1 98	1 89	2 61	2 34	2 11	2 69
	S_2	0 67	0 58	0 75	1 33	0 77	1 47	2 1	1 67	2 11	2 72	1 92	2 19	3 55	2 58	2 36
R_4	S	1 00	0 50	0 74	1 48	1 89	1 78	2 11	3 17	3 26	2 78	3 50	3 79	2 78	3 81	3 79
	S_2	0 72	0 67	0 82	36	1 31	48	2 18	1 77	1 93	2 38	2 57	2 52	2 75	3 25	2 59
R_5	S_1	0 75	0 83	0 78	1 08	44	1 53	2 08	2 06	2 08	2 25	2 44	2 37	2 58	2 58	2 62
	S_2	0 78	0 72	0 27	2 03	1 61	2 04	2 50	2 34	2 59	2 61	2 61	2 7	2 81	3 05	3 26
R_6	S_1	0 62	0 69	0 54	1 02	1 41	1 08	1 96	2 11	2 04	1 97	2 12	2 05	1 99	2 32	2 25
	S_2		0 62	0 73		1 41	1 85		2 22	2 43		2 28	2 47		2 30	2 51
CD (0 05)			0 441			NS			0 451			NS			NS	

Fifteen days after grafting wound periderm was found broken and the callus had started proliferating out in this stage in all the rootstock scion combination The callus proliferated either from the stock or from the scion depending upon their cellular activity The degree of callus formation varied considerably between varieties at this stage Wound periderm was seen to start brokening and callus formation started proliferating in grafts grafted with Muvandan rootstocks whereas for all other varieties callus tissue has filled the space between stock and scion partially or completely For the varieties Bangalora Puliyan (Plate I) and Olour the callus formation was noticed at a higher rate than Chandrakaran and Tolikaipan Most of the callus was produced from the cambium xylem and phloem of the stock and scion Tissues of the graft joint that was in contact were very important for proper graft union Between vascular tissues and cambium there was callus production and proper graft union

Thirty days after grafting when observed a continuous cambial bridge was formed across the stock and the scion Callus tissues developed into cambial cells which forms into a continuous cambial bridge In all the graft unions cambial bridge was formed In graft unions where Bangalora and Puliyan were used as rootstocks vascular elements were seen differentiated by 45 days

Plate I

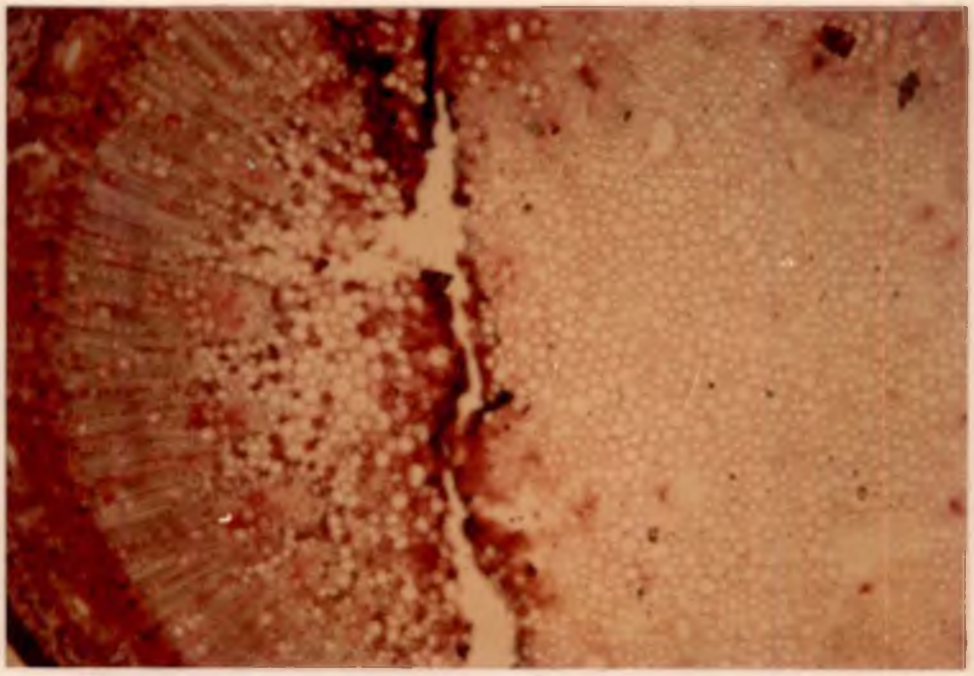


Plate II

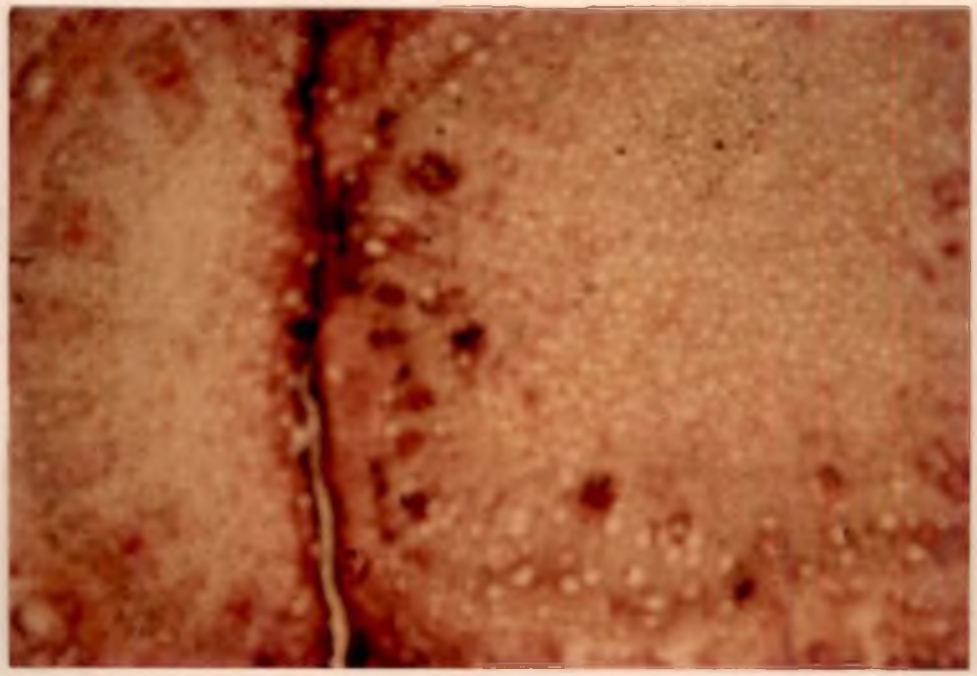


Plate III Anatomy of the graft union using Puliyan rootstock (x 63) (60 days after grafting)

Plate IV Anatomy of the graft union using Muvandan rootstock (x 63) (60 days after grafting)

Plate III

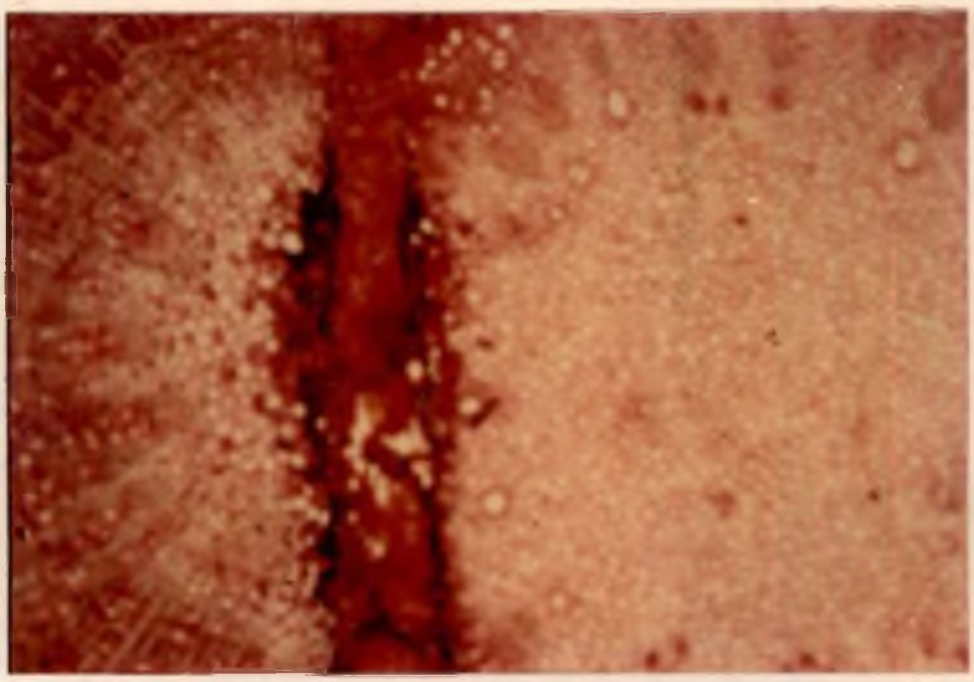


Plate IV

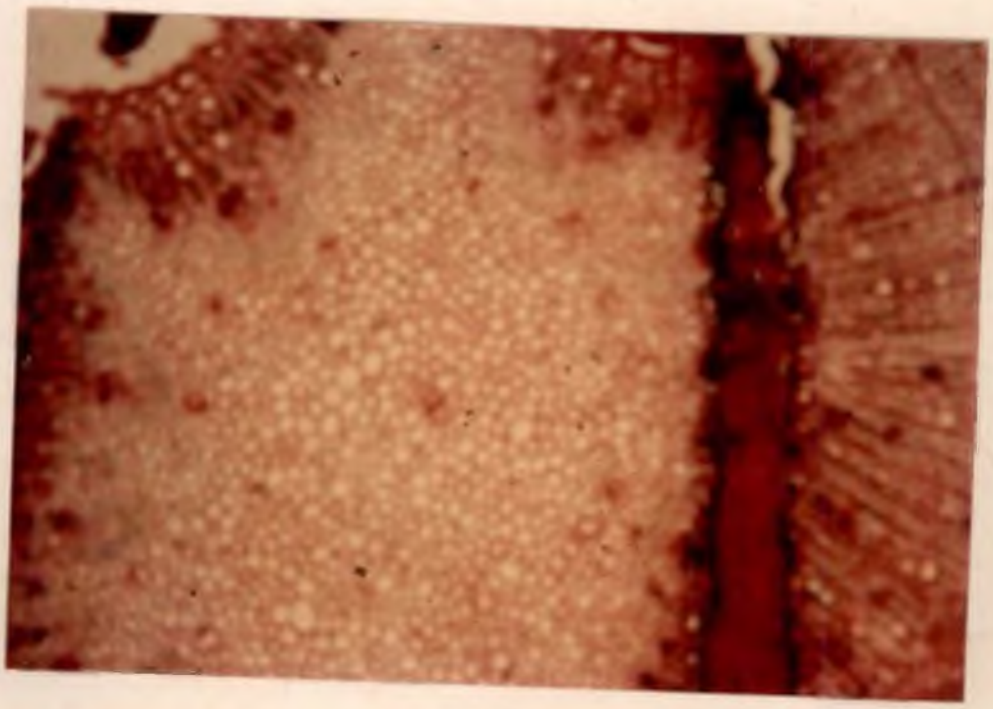


Plate V Anatomy of the graft union using Tolikaipan rootstock (x 63) (60 days after grating)

Plate VI Anatomy of the graft union using Olour rootstock (x 63) (60 days after grafting)

Plate V

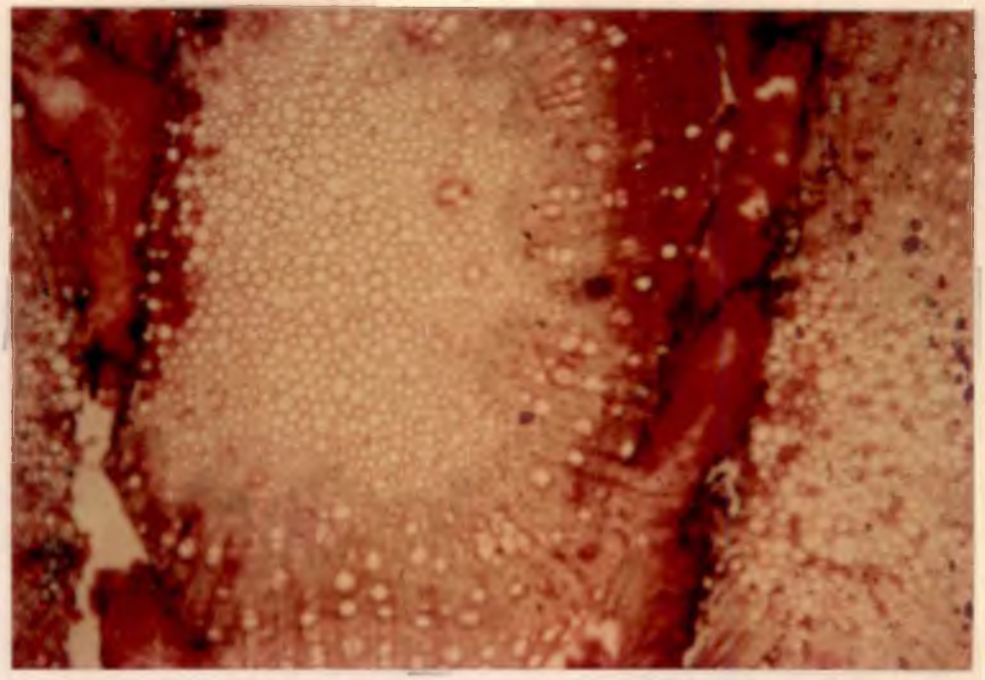


Plate VI

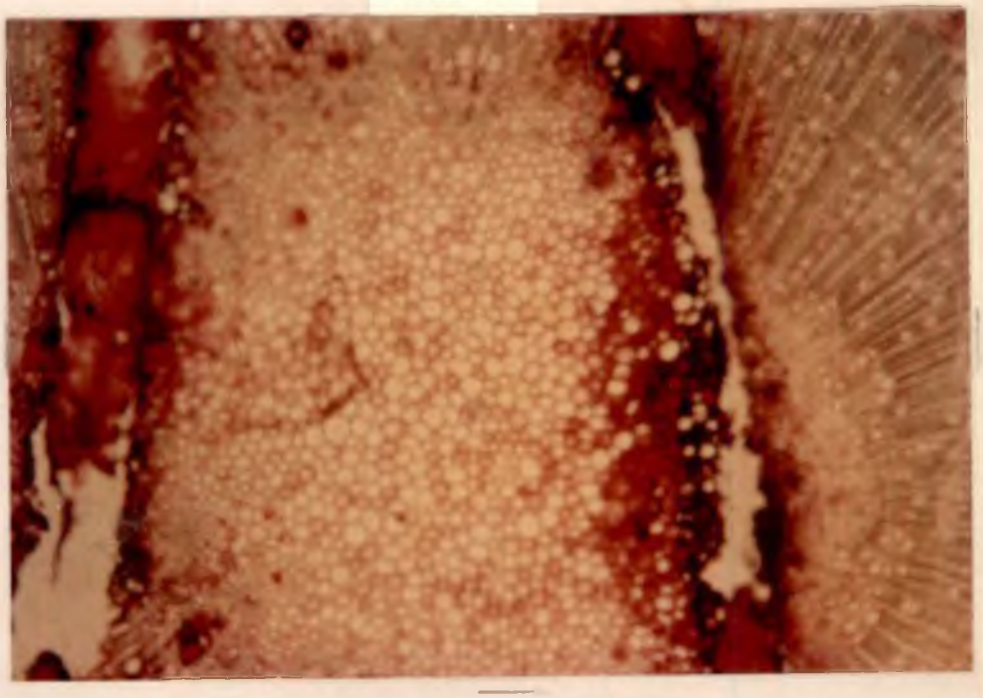


Plate VII Anatomy of the graft union using Chandrakaran rootstock (x 6
(60 days after grafting)

Plate VIII Anatomy of the graft union using Bangalora rootstock (x 63)
(90 days after grafting)

Plate VII

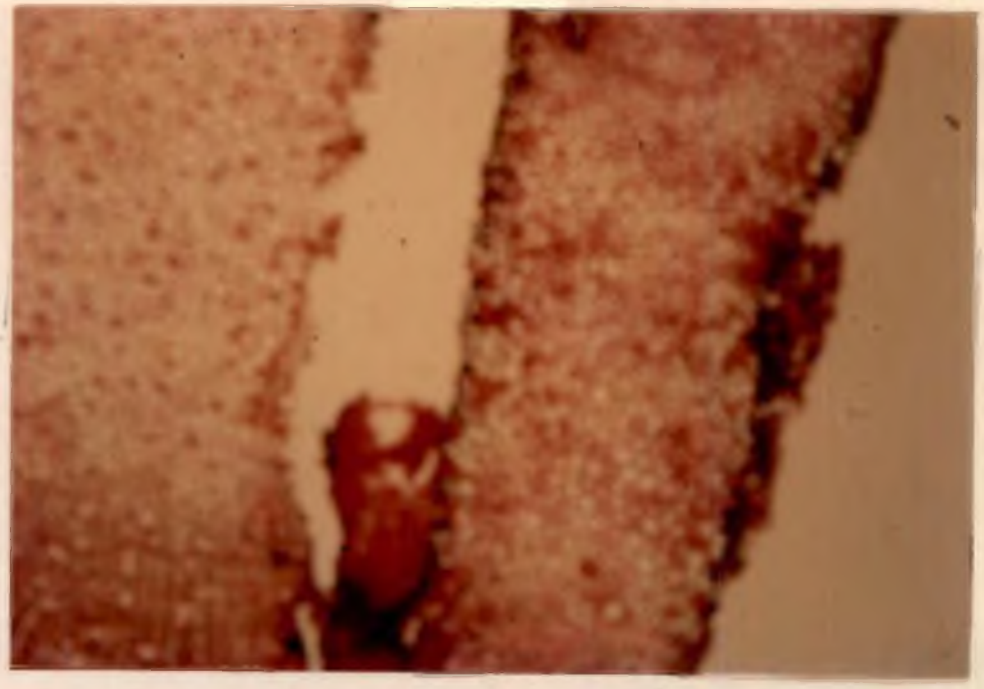


Plate VIII

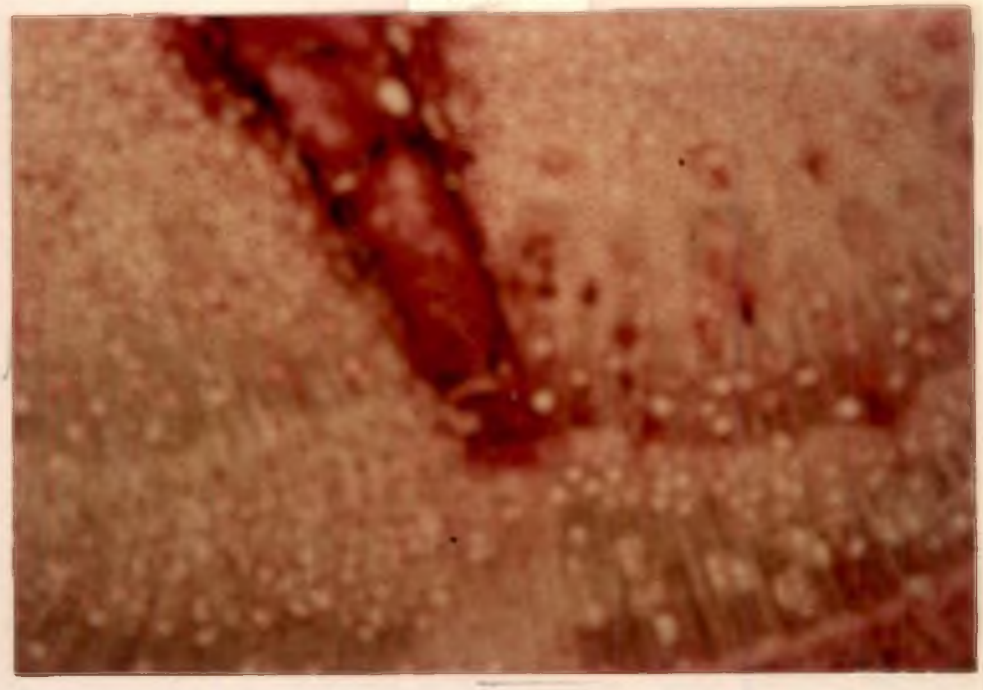


Plate IX Anatomy of the graft union using Puliyan rootstock (x 63) (90 days after grafting)

Plate X Anatomy of the graft union using Muvandan rootstock (x 63) (90 days after grafting)

Plate IX

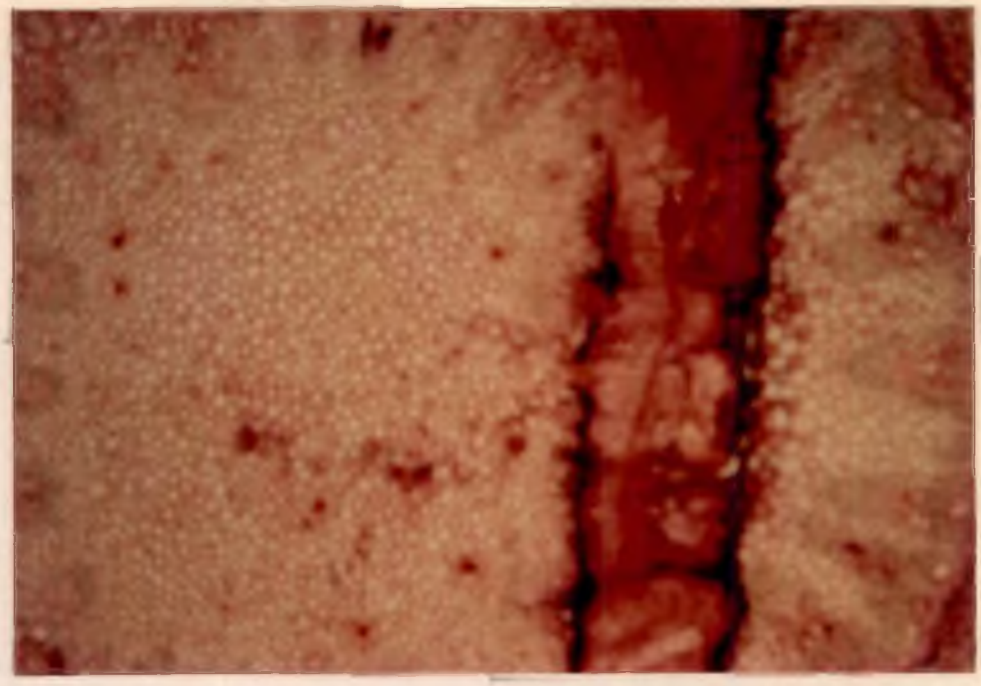


Plate X

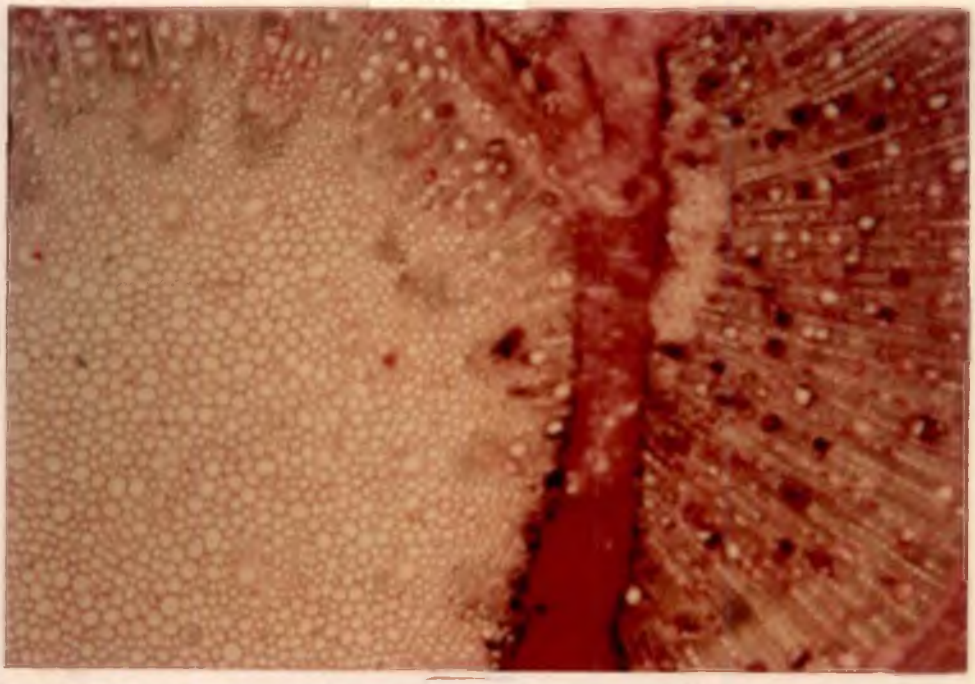


Plate XI Anatomy of the graft union using Tolikaipan rootstock (x 63) (90 days after grafting)

Plate XII Anatomy of the graft union using Olour rootstock (x 63) (90 days after grafting)

Plate XI

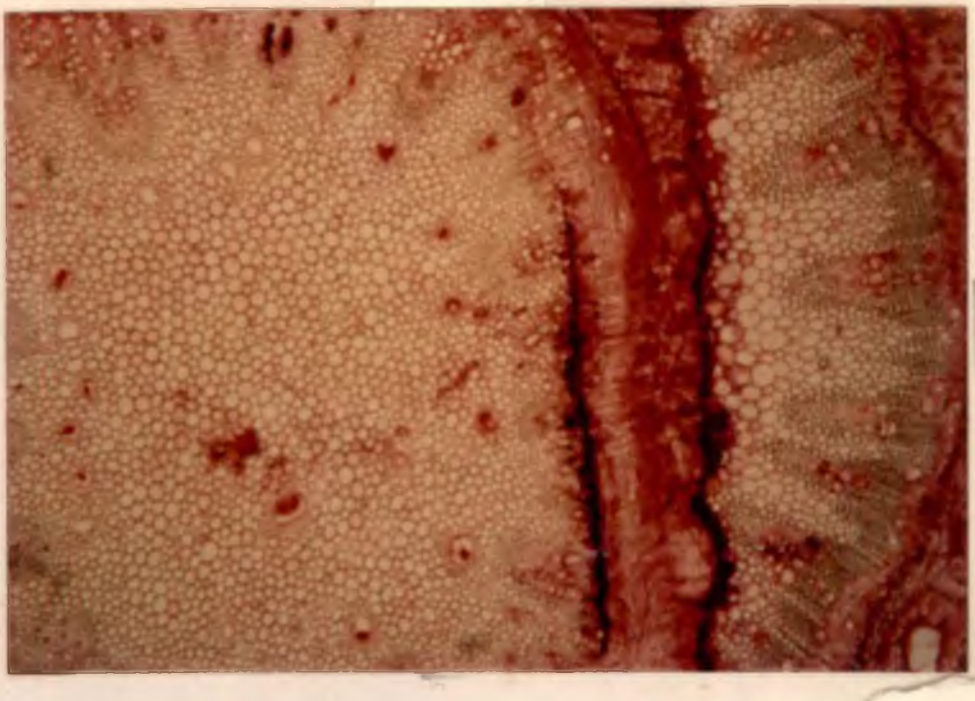


Plate XII

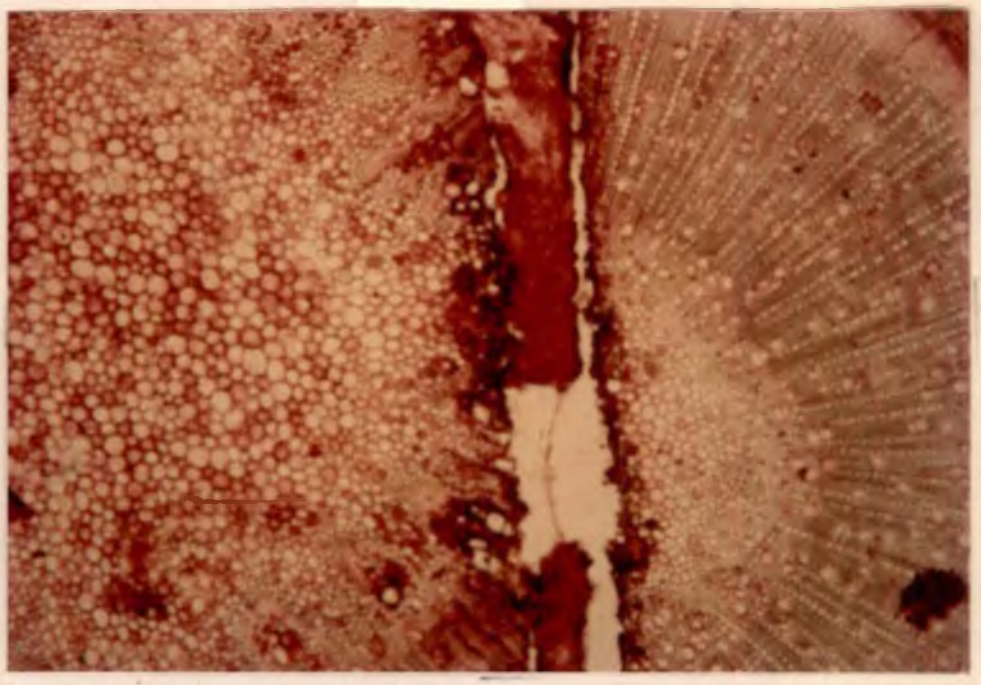
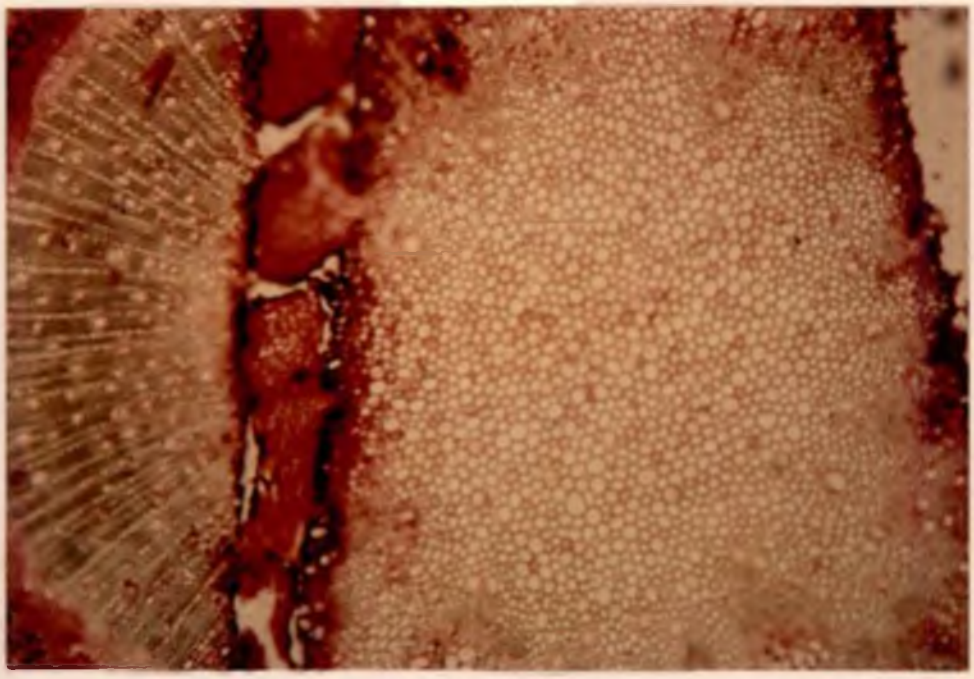


Plate XIII Anatomy of the graft union using Chandrakaran rootstock (x 63) (90 days after grafting)

Plate XIII



Discussion

DISCUSSION

Different methods of vegetative propagation are in vogue in mango with varying degrees of success Among these grafting is the most acceptable one in which the use of rootstocks equips the difficult to root scion with a root system of another using various grafting methods It has been reported that in mango root stocks have strong influence on the growth and longevity of the grafted tree its yield fruit quality time of ripening disease and pest resistance (Openheimer 1958 Teaotia et al 1967 George and Nair 1969 Majumdar et al 1972 Swamy et al 1972 Singh and Singh 1976 Reddy and Singh 1988 Reddy et al 1989 and Thakur et al 1989) Use of heterogenous rootstock is a serious concern in the commercial propagation of mango as it results high level of variability in growth performance of scion Many workers have suggested that seeds of polyembryonic varieties due to their uniformity can be used as rootstocks with ad antage to minimize variability (Gunaratnam 1946 Rangacharlu 1955 Openheimer 1958 Bakshi 1963 and Swamy et al 1972)

No such studies were seem to be done under Kerala condi tions Hence the p esent study was conducted in the Department of Pomology and Floriculture College of Horticulture Vellanikkara Thrissur The study examines the effect of rootstock scion month of grafting and their combinations on success survival and growth

parameters of softwood grafts of mango Anatomical studies were also carried out to find out the various stages of graft union and possible reasons for graft failure The results of the experiments conducted are being discussed in detail in the following pages

1 Germination percentage and extent of polyembryony

Experiments conducted revealed that polyembryonic varieties generally had higher percentage of germination The variety Tolikai pan recorded maximum (60 66) percentage of germination and Bangalora, the monoembryonic variety recorded minimum (5 67) percentage Studies conducted in Bangalora conditions by Singh and Reddy (1990) also gave similar results They observed that most of the polyembryonic mango varieties gave higher percentage of germination compared to monoembryonic varieties like Alphonso and Dashehari The higher percentage of germination for polyembryonic varieties may be due to the presence of more than one embryos in their seed

The average number of seedlings per stone for polyembryonic varieties ranged from 1 11 to 1 64 The percentage of polyembryony was maximum for Muvandan On the other hand Bangalora variety was not polyembryonic as reported earlier The variety did not produce more than one seedling per stone Horn as early as in 1943 while conducting similar studies using 20 varieties of mango obtained polyembryonic percentage ranging from

zero to 51 41 Giraffe variety of mango recorded 51 41 per cent polyembryony Singh and Reddy (1990) observed that the mean range of seedling formation per stone was between 2 33 to 2 75 for the mango varieties they studied

2 Sprouting and survival of grafts

The experiments conducted showed no significant difference among rootstocks on the sprouting and survival of grafts However it could be seen that maximum percentage of success (88 89) was recorded by Muvandan rootstock followed by Puliyan (76 67) Survival percentage was highest for Puliyan rootstock (51 10) and least (27 20) for Tolikaipan Similar studies were conducted by Srivastava and Singh (1981) in Uttar Pradesh They observed that when Dasheheri scion was veneer grafted on ten different rootstocks Kalapady stock gave maximum (90 per cent) success followed by Nakkare (85 per cent) But for inarching using Dasheheri scion itself Nakkare and Langra rootstocks gave maximum (97 per cent) success However they observed high survival percentage for Goa rootstock

The results on the effect of scion on sprouting of grafts showed significant difference between the treatments but regarding survival percentage the treatments showed no significant difference However Neelum scion recorded maximum success (72 96 per cent) and survival (21 60 per cent) The results obtained in this study

also agrees with the varietal differences in success of grafting as reported by Radhamony (1987) She observed that the variety Prior recorded better survival while the survival rate of variety Mulgao was poor In softwood grafting of mango Kulwal and Tayde (1985) obtained 100 per cent success for the varieties Pairi Kesar Pundur and Panchadarakalasa under Konkan conditions But other varieties like Neelum Local 1 Totapuri and Banganapally showed an ultimate survival of 72 to 85 per cent Reddy and Melanta (1989) also obtained varietal differences in in situ softwood grafting of mango Cent per cent success was obtained when Dashehari scion was used followed by Totapuri and Langra In epicotyl grafting also varietal differences of scion were noted by Dhakal 070 Mat and Biswas 080 Chakrabarti and Sadh 1984 Reddy and Kohli 1985 and Madalageri et al 1989 Scion varieties differed with regard to success and survival in veneer grafting also (Singh and Srivastava 1979 Bajpai et al 1985)

Though the different months of grafting did not differ significantly sprouting was maximum when grafting was done during June (82 78) and survival of grafts was maximum when done during August (23 68) Nagawekar (1981) also did not observe any significant difference in the sprouting of mango graft prepared during the months of June July or August Similarly Chakrabarti and Sadhu (1983) also reported that success is more or less uniform when epicotyl grafting was done in June July and August Dhungana

(1984) suggested that stone grafting in mango can be done successfully in Kerala from May to August the best being August Gunjate (1985) and Singh et al (1989) also obtained higher success rate during June to August Several workers have stressed the need to do softwood grafting during May to August (Patel and Amin 1981 Singh and Srivastava 1982 Gaur 1984 Singh et al 1984 Srivastava 1985 and Srivastava 1989) High humidity and saturation and low fluctuation in temperature may probably the factors associated with better success during June In veneer grafting Bhambota et al (1971) obtained maximum success during August But Gunjate et al (1976) got success of 76 to 84 per cent for mango veneer grafting during March to May Later on Singh et al (1979) recorded 75 to 92 per cent success during rainy season i e July and August Singh and Srivastava (1979) stated that grafting can be best done during August under Lucknow conditions Ram and Bist (1982) in Uttar Pradesh observed 100 per cent success for veneer grafting in June July and August The significance of rainy season was stressed by Singh et al (1983) Singh et al (1984) also suggested that June to August is ideal time for veneer grafting Several workers have found temperature and humidity are the main limiting factors for success in softwood grafting stone grafting and veneer grafting (Patel and Amin 1976 Kulwal and Tayde 1985 Reddy and Kohli 1985 and Srivastava 1989)

Rootstock scion combination have significant effect on sprouting and survival of softwood grafts of mango Among the various combinations tried Muvandan Neelum combination recorded maximum percentage (92 22) of sprouting followed by Muvandan Banganapally combination (85 56 per cent) Puliyan grafted with Banganapally or Neelum also produced higher percentage of sprouting With regard to survival of grafts Puliyan Neelum combination recorded the highest percentage (66 66) closely followed by Puliyan Banganapally combination (65 00 per cent) The least percentage of survival was observed for Tolikaipan rootstock grafted with Banganapally and Neelum It is worthnoting that Muvandan rootstocks grafted with both the scion gave good results with regard to initial success But their survival percentage was less Muvandan was also observed to be late sprouting and remain green even after 15 days of grafting On the contrary Puliyan rootstock grafted with either Neelum or Banganapally produced higher percentage of success and survival Therefore on the basis of the present study it could be said that Puliyan is the best stock for Neelum and Banganapally scions Earlier studies conducted by Srivastava and Singh (1981) to find the response of different rootstock scion combinations for grafting obtained appreciable success percentage for the rootstock scion combinations Mallika/Kalapady Mallika/Muvandan Dasheheri/Kalapady and Langra/Muvandan in veneer grafting under Lucknow conditions But success was too low for Chausa/Nakkare combination In Pakistan Hussain et al (1989)

obtained maximum grafting success with Malda for Langra scions (83 9 per cent) and with Anwar Rataul for Samar Bahisht (55 5 per cent) Varietal variation might be due to the differences in the genetic make up The differential response of varieties might have some relationship with the growing habit as other genetic factors (Mukherjee and Majumdar 1964)

There is no significant effect of rootstock and month combinations on sprouting and survival of grafts As for the effect of scion and month of grafting significant difference was noted only for sprouting of grafts Banginapally scion grafted in June gave maximum (84 44) sprouting percentage Highest (48 80) survival percentage was noted for Neelum scion grafted during August With respect to the combined effect of rootstock scion and month of grafting maximum sprouting percentage was obtained (96 67), when Muvandan and Chandrakaran rootstocks were grafted with Neelum scion during June Whereas highest survival percentage (76 67) was obtained for Puliyan/Banganapally combination grafted in August

3 Growth parameters

Significant influences are exerted by rootstock scion month and its various combinations on growth parameters like girth of stock girth of scion and length of sprout At the same time, there is no significant influence by these factors on growth parameters like girth of new growth production of leaves and primary branches

3 1 Girth of stock

Rootstock scion month of grafting and their combinations have significant influence on girth of stock Bangalora the mono embryonic rootstock produced the thickest stocks throughout the period under study Among tl e polyembryonic varieties Muvandan recorded maximum girth of stock Similarly among the scion varieties tried Neelum scions produced higher values of stock girth throughout the period u nder observation Varietal differences of scion was also observed by Radhamony (1987) in stone grafting of mango Girth of stock wa also found to be affected by the month of grafting recordi ng t e maximum values for graftings done in July

Accordingly of the various rootstock scion combinations tried in the study Bangalo a Neelum combination was found to be significantly superior over other combinations with regard to girth of stock Similarly Muvandan Neelum combination also recorded higher values of st ck girth Similar studies conducted by Hussain et al (1989) under Pakisthan conditions observed that the greatest girth was i nduced by Samar Bahist rootstock when grafted with the same scion For Langra scion greatest girth was obtained (0 8 cm) when gr fted with Langra rootstock itself

Girth of stock wa si gnificantly different for the various rootstock month combinatio r s Bangalora grafted in August recorded maximum stock girth closely followed by Bangalora July combination

Similarly scion month combinations also significantly influenced the girth of stock Neelum scion grafted in July had the maximum stock diameter

Accordingly as to the combined effect of rootstock scion and month of grafting mean stock diameter was maximum for Bangalora rootstock grafted with Neelum scions in August The treatment combinations like Bangalor Neelum July Bangalora Banganapally August and Muvandan Neelum July also produced higher values of stock diameter

3 2 Girth of scion

Rootstock scion mo th of grafting and their combinations have significant influence n girth of scion Bangalora the mono embryonic rootstock gave th maximum (1 65 cm) mean scion diameter Among polyembryonic varieties it was maximum (1 61 cm) for Muvandan and the least (1 48 cm) for Chandrakaran rootstocks at 150 days after graftin) Similarly among the scion varieties tried Neelum scions produced maximum girth of scion during all the period under observatio Anin (1978) also observed differential response of varieties with regard to girth of scion in softwood grafting of mango Radhamony (1987) also obtained varietal differ ences of scion with regard to scion girth in the studies conducted in stone grafting of mango at Vellanikkara conditions

Girth of scion was significantly different for the various rootstock scion combinations tried in the study Bangalora Neelum combination is significantly superior over other rootstock scion combinations recording 1 82 cm at 150 days after grafting Muvandan Neelum combination also recorded higher values of mean scion diameter while the least (1 41 cm) was observed for Tolikai pan Banganapally combination during all the period under study

Rootstock month combination have significant influence on girth of scion Bangalora grafted during August recorded higher values over other treatment combinations But none of the scion month combinations tried in this study had any significant influence on girth of scion However significant differences were noted when interaction effect of rootstocks and month of grafting were observed Here also as in the case of girth of stock Bangalora grafted with Neelum in August gave the maximum (2 10 cm) mean girth of scion at 150 days after grafting

3 4 Girth of sprout

The present study reveals that rootstock scion month of grafting and their combinations have no significant effect on girth of sprout But it could be observed that polyembryonic varieties have recorded lesser circumference of sprout compared to Bangalora the monoembryonic variety Similarly though not significant Neelum scion consistently produced higher values than

Banganapally Radhamony (1987) in stone grafting of mango obtained significant differences between scion varieties on girth of new sprout

3 5 Length of sprout

Rootstock scion month of grafting and their combinations have significant effect on length of sprout Polyembryonic rootstocks produced lesser sprout length compared to Bangalora the mono embryonic rootstocks While Olour rootstock recorded the least Among the scion varieties tried Neelum produced more length of sprout throughout the period of study Similarly maximum length of sprout was recorded for grafting done in July closely followed by grafting done in August

Length of sprout is significantly influenced by rootstock scion combinations Bangalora Neelum combination produced the maximum sprout length at 150 days after grafting Differences could also be seen in the interaction effect of rootstock and month of grafting Bangalora grafted in August produced the maximum length of sprout while the least was recorded for Olour August combination Similarly as to the effect of scion and month of grafting it was noted that longer sprouts were produced by Neelum scions irrespective of the month of grafting

Significant effect of rootstock scion and month combination was also clearly evident in the study Bangalora rootstock grafted

with Neelum or Banganapally in August recorded higher values of sprout length after 60 days of grafting Among the polyembryonic varieties Muvandan grafted with Neelum in July also produced significantly higher values Olour and Chandrakaran rootstocks grafted with Banganapally in August recorded the least

3 6 Production of leaves

Varieties of rootstocks scions months of grafting and their combinations do not have any significant influence on production of leaves in softwood grafts of mango However Puliyan and Chandrakaran rootstocks produced comparatively more number of leaves Similarly among the scion varieties Neelum produced more leaves than Banganapally Radhamony (1987) conducted similar studies in stone grafting of mango and observed differential response of scion varieties to production of leaves Banganapally scion produced more leaves than Malgoa Priur Mundappa Bangalora and Alphonso varieties

3 7 Production of primary branches

Varieties of rootstock scion month of grafting and their combinations have no significant effect on production of primary branches However Puliyan rootstock produced the maximum number of primary branches

Several workers have conducted studies on several varieties of mango to find the effect of rootstocks on grafts at nursery stage

based on several methods They have also obtained differential response of varieties of rootstocks on growth parameters Jauhari et al (1972) found Dasheheri and Chousa as vigorous rootstock both in nursery and in rootstock trials Mukkerjee and Das (1976) classified Belkhas and Parikhas as dwarf and Atibombai as vigorous rootstock based on anatomical characters At nursery stage itself based on stomatal count, Srivastava et al (1980) classified Bappakai Goa Kurukkan Taimuria and Kalapady as dwarf rootstocks whereas Dasheheri and ST 9 were classified as vigorous rootstocks Singh et al (1981) classified Kurukkan Chandrakaran Olour Goa Taimuria and Rumani as dwarf rootstocks based on morphological characters They also classified Chausa Dasheheri ST 9 Sakarchina Langra and Muvandan as vigorous rootstocks Present study also revealed the vigorous nature of Muvandan among polyembryonic varieties Pal et al (1981) classi fied Goa Bappakai Chausa Vellaicolumban as vigorous and Taimuria Muvandan and Kalapady under dwarf category based on chlorophyll fractions and dry matter content

Studies on the varietal responses of scion were conducted by Amin (1978) and he observed differential response of varieties to girth of scion in softwood grafting of mango In stone grafting Radhamony (1987) conducting similar studies also observed different ial response of varieties with regard to growth parameters like girth of stock scion new growth and production of leaves

Temperature and Humidity are the main limiting factors for successful graft take and growth Girth of stock and length of sprout was maximum in July and August

A proper combination of rootstock and scion is a must for successful graft union In this study, rootstock scion combination is found to have significant influence on girth of stock scion and length of sprout Under Pakistan conditions similar studies conducted by Hussain et al (1989) showed that Anwar Rataul roostock induced greatest length (8 40) with Samar Bahist scion While the greastest girth was induced by the Samar Bahist rootstock grafted with same scion They also observed that in Langra scion greatest length (27 1 cm) girth (0 8 cm) were induced by the Langra root stock The phys ological factors that control vigour are supposed to affect the reciproca influence of stock and sc o S ngr e al 1986) It is believed that the graft union introduces additional resistance in the translocation of materials from the root to scion and of elaborating food materials from the scion to roots Alteration in growth behaviour may also be induced due to interference in the downward flow of natural harmones to the roots thus causing the observed effect

4 Anatomical studies of the graft union

Anatomical studies of the graft union of various rootstock scion combinations revealed four stage viz (1) callus initiation

stage (5-15 days) (2) callus tissue formation stage and cambial cell development stage (15 30 days) (3) cambial bridge formation stage (30 60 days) and (4) a healed union stage (60 90 days) Several workers like Juliano (1941) and Wilson and Wilson (1961) also of the same opinion that the first step in the process of graft union is the formation of callus cushion and callus prolifer ation from the wounded surface Soule (1971) has described five important stages of bud union in mango They are stage 1 wound periderm development stage 2 callus proliferation and enlarge ment from the cambium resulting in firm attachment of both stock and scion stage 3 completion of cambial bridge stage 4 differ entiation of vascular tissue and healing and stage 5 formation of several cylinders of new tissues The secondary growth and cambial activity were observed by Esau (1979) in proper graft union formation The important function of cambium was found to be the formation of callus in the wounded portion

The studies conducted at the College of Horticulture Vellani kkara by Ratan (1985) showed four stages of graft union for epicotyl grafting in Mango cv Neelum But Chakrabarti and Sadhu (1985) are of opinion that only three main stages of union are there for splice grafting in mango i e callusing stage (10 to 30 days) cambial bridge stage (30 to 60 days) and healed union stage (60 to 120 days) Savithri (1990) while conducting studies at Vellnik kara conditions observed four stages of graft union for softwood grafting of mangc

In the present studies in all the rootstock scion combinations four stages of graft union were noted But in graftings where Bangalora and Puliyan were used as rootstocks all the four stages occurred at a faster rate In varieties Tolikaipan and Muvandan though the initial stages were slow the union was healed by 90 days after grafting In Chandrakaran and Olour all these stages occurred in a slower rate After 90 days of grafting also inter spaces occurred between stock and scion Similar results were obtained by Auramov and Jokovic (1961) They reported that the degree of callus formation varied considerably between varieties According to them this is influenced by rootstock and weather conditions that prevailed during previous growing season Chakrabarti and Sadhu (1985) have also observed that graft take was faster for Langra than for Bombai and Himsagar due to more rapid formation of callus and vascular continuity

Anatomical studies also showed that graft failure was mainly due to failure in callus initiation and formation of necrotic layer between the stock and scion Luthra and Sharma (1946) have reported that distorted xylem elements are responsible for graft failure blocking the conducting vessels and preventing movement of water from stock to scion Auramov and Jokovic (1961) observed excessive undifferentiated callus at unions of incompatible stock and scion Savithri (1990) has also observed the formation of necrotic layer and excessive undifferentiated callus between stock and scion of unsuccessful grafts

Summary

SUMMARY

The results of the studies on the effect of polyembryonic rootstocks in the success survival and subsequent growth of soft wood grafts of mango and the anatomical changes in the graft union at the different stages of healing process are summarised hereunder

1 The germination percentage of all the polyembryonic varieties studied were comparatively higher than Bangalora the mono embryonic variety (5 67 per cent) Among the polyembryonic varieties Tolikaipan recorded the highest (60 66) percentage of germination Mean number of seedlings produced per stone was maximum for Muvandan (49 54 per cent) and the minimum 9 76 per cent) for [illegible]

2 Individually rootstock scion and month of grafting had no significant effect on sprouting and survival of grafts But root stock scion combination showed significant effect Muvandan Neelum combination was superior to other treatment combinations with respect to initial success (92 22 per cent) whereas Puliyan Neelum combination recorded the highest (66 66) survival percentage However the interaction effect of rootstock month and scion month did not show any significant influence on sprouting and survival of grafts Rootstock scion and month combination also showed significant influence The maximum percentage of success (96 67) was obtained when Muvandan and

Chandrakaran rootstocks were grafted with Neelum during June Survival percentage was maximum (76 67) for Puliyan Banganapally August combination

3 Girth of stock after grafting was significantly influenced by rootstock scion month of grafting and their various combinat ions Bangalora rootstock produced the thickest (1 89 cm) stocks Neelum as scions (1 72 cm) recorded higher stock girth than Banganapally (1 61 cm) Grafting in July recorded maximum (1 79 cm) stock girth The highest stock diameter was recorded by Bangalora Neelum (1 95 cm) Bangalora August (2 17 cm) Neelum July (1 89 cm) and Bangalora Neelum August (2 32 cm) combinations

4 Girth of scion after grafting was found to be influenced by rootstock scion and their combinations Bangalora is observed to be superior than all the polyembryonic varieties studied Least scion girth (1 48 cm) was recorded by Chandrakaran rootstock Grafting with Neelum scion gave the maximum scion girth (1 61 cm) during all the period under study Though July month of grafting recorded greater scion girth no signifi cant differences were noted between the months tried Scion girth was maximum for the combinations Bangalora Neelum (1 82 cm) Bangalora August (1 93 cm) Neelum July (1 66 cm) and Bangalora Neelum August (2 10 cm)

5 Neither rootstock scion month of grafting nor its various combinations tried in this study was found to influence girth of new growth However polyembryonic varieties have recorded lesser circumference of sprout compared to Bangalora the mono embryonic variety

6 Length of sprout was greatly influenced by rootstock scion month of grafting and its various combinations Maximum sprout length (12 91 cm) was recorded by Bangalora rootstock and minimum (6 38 cm) by Olour Neelum scion was found to be superior than Banganapally Grafting done in July recorded max mum growth of scion (9 76 cm) Banga_ora Neelum combinat ion produced maximum (13 42 cm) sprout length Polyembryonic rootstocks grafted with Banganapally generally produced shorter sprouts Bangalora grafted with Neelum or Banganapally in August gave longer sprouts

7 Rootstock scion month and their combinations have no signifi cant influence on production of leaves Puliyan rootstock produced maximum (19 62) number of leaves Neelum scion and grafting done in July produced more number of leaves Chandrakaran Neelum Chandrakaran July and Neelum July combinations recorded maximum number of leaves

8 Production of primary branches was not influenced by rootstock scion and month of grafting But it could be seen that Puliyan rootstock produced more number of primary branches than

Bangalora rootstock Grafting done in August produced maximum (3 20) number of primary branches Puliyan Neelum combination produced maximum number (3 96) of primary branches Puliyan grafted in June gave maximum mean number of primary branches (4 57)

9 Four different stages of graft union viz (1) callus initiation stage (5 15 days) (2) callus tissue formation and cambial cell development stage (15 30 days) (3) cambial bridge formation (30 60 days) and (4) healed union stage (60 90 days) were observed Graft take was found to occur at a faster rate in Bangalora and Puliyan varieties In Chandrakaran and Olour graft take was at slower rate

10 Graft failure occured mainly due to failure in callus initiation formation of necrotic layer and improper allignment of stock and scion

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ABSTRACT

Investigations were carried out in the Department of Pomology and Floriculture College of Horticulture Vellanikkara Thrissur 680 654 Kerala during the period from April 1990 to March 1991 with a view of find the varietal differences of poly embryonic rootstocks with respect to percentage of success survival and growth parameters of softwood grafts of mango Also anatomical studies of graft union were done to find out the differ ent stages of healing process and the possible reasons for graft failure

Five polyembryonic varieties of mango (Puliyan Chandra karan Olour Tolikaipan and Muvandan) and one monoembryonic variety (Bangalora) were selected as rootstocks Scions of two varieties viz Neelum and Banganapally were used for softwood grafting One month old of each of the above rootstocks were grafted in June July and August

The results of the study showed that the germination percentage of all polyembryonic varieties are comparatively higher than Bangalora the monoembryonic variety Tolikaipan gave the maximum germination percentage It was observed that percentage of polyembryony ranged from 9 76 to 49 54 for the polyembryonic varieties the lowest for Chandrakaran and highest for Muvandan variety

The observations on the effect of rootstock scion and month of grafting on sprouting and survival of grafts revealed that Puliyan rootstock was most ideal with regard to sprouting and survival Success percentage was higher for Muvandan Neelum and Muvandan Banganapally combinations followed by Puliyan Neelum and Puliyan Banganapally combinations However Puliyan rootstock grafted with Neelum and Banganapally scions gave higher survival percentage Poor success rate was noted for Chandrakaran Bangana pally and Bangalora Neelum combinations Survival of grafts was least for Tolikaipan rootstock grafted with Neelum or Banganapally scions As to the combined effect Muvandan and Chandrakaran rootstocks grafted with Neelum during June resulted in better initial success Whereas survival was higher for Puliyan Bangana pally August combination

With regard to growth parameters studied girth of stock girth of scion and length of sprout are much influenced by root stock scion month of grafting and their interactions Bangalora the monoembryonic rootstock, produced the thickest stock and scion throughout the period of study Among the polyembryonic varieties Muvandan produced thicker stock and scion Olour and Chandrakaran rootstocks produced lesser girth of stock and girth of scion respectively Longer sprouts were also produced by Bangalora Sprout lengtl wa minimum for Olour Among the scions Neelum was found to be superior producing thicker stock

scion and longer sprouts Similarly grafting in July was found to be better with respect to these growth parameters The mono embryonic rootstock Bangalora grafted with Neelum either in July or August recorded higher girth of stock scion and sprout length Polyembryonic rootstocks grafted with Banganapally generally found to be less vigorous with respect to these parameters

Anatomical studies revealed four different stages of graft union i e callus initiation stage callus tissue formation and cambial cell development stage cambial bridge formation stage and a healed union stage Graft take was faster in Bangalora and Puliyan varieties where as it was slower in Chandrakaran and Olour varieties Graft failure was mainly due to failure in callus initiation formation of necrotic layer and improper allign ment of stock and scion