STANDARDISATION OF SOFT WOOD GRAFTING IN MANGO (*Mangifera indica* L.)

By

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THESIS

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DECLARATION

I hereby declare that this thesis entitled 'Standardisation of soft wood grafting in mango (Mangifera indica L.)' 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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To my Parents

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Introduction

INTRODUCTION

Mango is highly heterozygous and cross pollinated and hence seed propagation leads to lot of variability in the seedling population. The multiplication of selected varieties is possible only through vegetative methods. Moreover, the grafts come to bear by three to four years in contrast to seedling trees which take about 8 to 10 years. The most commonly used methods of vegetative propagation are inarching, veneer grafting and epicotyl grafting.

The inarching or approach grafting, commercially adopted in mango propagation in Kerala, is very expensive and laborious process involving many practical difficulties and becomes virtually impossible when trees selected for clonal production are spread far and wide. The method of epicotyl grafting already standardised in the Department of Pomology and Floriculture, is found very successful, easy and convenient. But in this method, since very young seedlings of 5 days old are used as rootstocks, this can be done only for a limited time of two or three months when mango stones are available for raising rootstocks. Again, the incidence of die back disease is found to be serious for epicotyl grafting. Compared to epicotyl grafting, only very little care is needed for soft wood grafting.

Moreover, in this method the sprouted stones that cross the age for epicotyl grafting can be collected and used as rootstocks. Hence, the present series of studies were undertaken in the Department of Pomology and Floriculture, College of Horticulture, Vellanikkara during the period from June, 1987 to April, 1989 with the following objectives.

(i) To standardise the age of rootstock, height of grafting and time of defoliation prior to grafting with reference to success and survival by soft wood grafting in two commercial varieties of mango viz., Neelum and Banganapally.

(ii) Anatomical studies of the graft union to find out the different stages of healing process and the possible reasons for graft failures.

Review of Literature

REVIEW OF LITERATURE

Eversince the possibility of using soft wood rootstocks for mango was reported from Florida by Traub and Auchter in 1933, works on this line were carried out all over the world. The salient works done in this aspect are reviewed here briefly.

In 1951, Singh used actively growing mango stones of two to three weeks old as rootstock for inarching in mango cv. Langra. Stone grafting or epicotyl grafting was first tried successfully in mango at the State Horticultural Research Station, Krishna Nagar, West Bengal (Bhan et al., 1969). Later on many workers in India and other countries tried this technique with varying degrees of sucoess (Majumder and Rathore, 1970; Bedoes and Prasad, 1975; Gunjate and Limaye, 1976; Patel and Amin, 1976; Gunjate et al., 1980; Maiti and Biswas, 1980; Singh and Srivastava, 1981; Nagabhushanam, 1982; Sawke, 1983; Chakrabarti and Sadhu, 1984; Desai and Patil, 1984; Dhungana, 1984; Patil et al., 1984; Gunjate, 1985 and Aravindakshan et al., 1988).

Soft wood grafting is found superior to epicotyl grafting in many respects. Compared to epicotyl grafting only less care is needed for soft wood grafting and here even sprouted stones can be used as rootstocks. The seedling

rootstocks that cross the age for epicotyl grafting can be successfully used as rootstocks here. This method is best suited for in situ grafting for large scale propagation at a cheaper rate.

In situ method of soft wood grafting using one year old rootstocks was found to give 100 per cent success (Amin, 1978). This was found successful in cashew also using one year old rootstocks (Kumar and Khan, 1988). Many other workers tried this method with varying degrees of success (Ihara and Tamari, 1961; Patel and Amin, 1981; Singh and Srivastava, 1982; Singh et al., 1984; Kulwal and Tayde, 1985; Hadankar et al., 1987 and Kumar and Khan, 1988).

Several factors contribute towards the percentage of success in grafting. Some of the salient works done in this aspect are worth reviewing.

2.1 Factors affecting graft take

2.1.1 Grafting method

The percentage graft take is found to vary greatly depending upon the grafting method used. The grafting success reported with some of the important methods of grafting are reviewed hereunder.

According to Singh and Srivastava (1982), in mango, soft wood grafting is superior to veneer grafting with regard to grafting success. Gaur (1984) also reported that soft wood grafting resulted in highest success (75 to 80 per cent) under Lucknow conditions and was superior to inarching, veneer grafting and stone grafting.

As early as in 1953, De la Rocha reported that splice method could be utilized for stone grafting in mango successfully. Majumder and Rathore (1970) tried splice, veneer and wedge grafting for epicotyl grafting in mango on five, six and eight days old seedlings and they got 50.00, 46.60 and 33.30 per cent success respectively.

Pinheiro et al. (1970) compared the efficiency of five methods of grafting in mango, viz., cleft grafting, whip grafting, whip and tongue grafting, side grafting into the wood and side grafting under the bark. Cleft grafting was found to be the best method compared to others giving 91.70 per cent success. Bhambota et al. (1971) reported the superiority of veneer grafting in mango over cleft and side grafting. In another trial, veneer grafting with immediate top removal was found to be superior to veneer grafting and soft wood grafting in mango with respect to mean percentage of success (Singh et al., 1984).

In cashew, cleft grafting was found to be the best method of vegetative propagation (Nagabhushanam, 1982) whereas Valsalakumari et al. (1985) obtained the best results with wedge grafting. However, Kannan and Das (1985) concluded that epicotyl grafting was a better method in cashew for large scale multiplication as compared to soft wood grafting.

2.1.2 Age of rootstock

A number of studies had been conducted to find out the optimum age of the rootstock for different methods of grafting. Some of the salient works are worth reviewing.

2.1.2.1 Soft wood grafting

In the year 1978, Amin obtained about 100 per cent success with the use of one year old rootstocks in the in situ method of soft wood grafting in mango. From the trials conducted using variety Dasheri as scion shoot, soft wood grafting on one year old rootstock was found to give highest grafting success of 90 per cent (Singh and Srivastava, 1982). Later on, in a study at Lucknow to evaluate selected methods of mango propagation, cleft grafting on the soft wood 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 soft wood grafting using one

year old rootstock. Kulwal and Tayde (1985) also stressed the superiority of using one year old rootstock for soft wood grafting in mango.

In cashew, Kannan and Das (1985) used 15 to 60 days old rootstocks for soft wood grafting to get maximum grafting success. However, Nagabhushanam (1985) observed that cleft grafting using 8 to 10 months old seedling rootstocks can give 54 to 58 per cent success, particularly during August-September in cashew. A similar report was made by Valsalakumari et al. (1985) stating that wedge grafting with eight months old seedlings in March gives a maximum success of 75 per cent. Later on in 1986, Seshadri and Rao observed that 75 days old seedlings were most ideal rootstocks for cashew soft wood grafting followed by 90 days old stocks. In another study, it was found that wedge grafting on six months old seedlings resulted only 30 per cent union and there was no success with five to eight months old rootstocks (Gowda and Melanta, 1988). As in mango, one year old rootstock was found to be the best for in situ soft wood grafting in cashew (Kumar and Khan, 1988).

2.1.2.2 Epicotyl grafting

As early as in 1970, Majumder and Rathore, recommended the use of young germinating mango stones as rootstocks for epicotyl grafting in mango. Seedlings of four to seven days old

were proved better which resulted 73.3 per cent success (Gunjate et al., 1976). But Singh and Srivastava (1981) observed that four to five days old seedling rootstocks were most ideal for stone grafting in mango. According to Gunjate et al. (1982), seedling rootstocks of less than two weeks old were most suitable for epicotyl grafting. However, Chakrabarti and Sadhu (1984) obtained highest grafting success with the use of five days old seedling rootstock. Desai and Patil (1984) grafted scion shoots of cv. Alphonso on seven days old rootstocks and obtained a success of 70 per cent under green house conditions. In a trial to standardise the optimum age of the rootstock under Vellanikkara conditions, Dhungana (1984) obtained 58 per cent success when five days old seedling rootstocks were used. The survival rate was found to decrease from 50 to 32 per cent when the age of the 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 with 6 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 8 days old rootstocks. In a study on epicotyl grafting in mango using 7 days old rootstocks, the side grafting method produced 80 per cent success while tongue grafting method produced 60 per cent (Singh et al., 1985).

In cashew, Bhandary et al. (1974) suggested the use of 21 days old seedling rootstocks for wedge grafting where they got 64 per cent success with the use of thin scion shoots. Another study in cashew revealed that four to eight weeks old seedlings were ideal for epicotyl grafting under Dapoli conditions (Harmekar, 1980).

Nagabhushanam (1982) recommended the use of 10 to 15 days old rootstocks for stone grafting in cashew. Later, in 1983, Sawke observed that cashew seedlings of about 10 days in age were the best rootstocks for epicotyl grafting resulting 60 to 74 per cent success during February to May under Konkan conditions. Aravindakshan et al. (1984) also suggested the use of 10 days old seedling rootstocks for cashew, which gave a success of 69 per cent in May. But under Orissa conditions, seedling rootstocks of five to seven days old were found to be the best, giving a maximum success of 73 to 100 per cent during October to February period (Kannan and Das, 1985).

2.1.2.3 Veneer grafting

Ahmad (1964) obtained maximum success with the use of nine months 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).

In cashew, Phadnis et al. (1974) obtained a maximum success of 60 per cent on six months old seedling rootstocks. Studies of Nambiar (1976) revealed the superiority of 10 to 15 months old rootstocks for veneer grafting in cashew. In the trials conducted at Cashew Research Station, Bapatla, Nagabhushanam and Rao (1978) obtained encouraging results (50 to 96 per cent) for veneer grafting using six months old seedling rootstocks.

2.1.2.4 Inarching

As early as in 1921, Burns and Prayag obtained maximum success with three weeks old seedling rootstocks for inarching in mango in Philippines. But Naik (1941) suggested that

rootstocks of four and a half months old are the best for inarching in mango. Later, in 1948, Naik also revealed the suitability of older rootstocks of nine to fifteen months old for inarching was also stressed by Singh (1960). Teaotia and Srivastava (1961) suggested a new method of inarching in mango with the use of four to six weeks old seedling rootstocks. A similar report was made by Majhail and Singh (1962) in which they recommended the use of two months old seedlings as rootstocks.

2.1.2.5 Side grafting

According to Faruque and Fakir (1973) four months old seedling rootstocks are ideal for side grafting in mango and they got a grafting success of 48 to 52 per cent by using different scion varieties. Recently, from a study conducted on side grafting using rootstocks of different ages Singh et al. (1985) obtained 80 per cent success with seven days old seedlings.

2.1.3 Height of grafting

Height at which grafting is done on the rootstock is found to influence the graft take significantly. Some of the salient works done in this field are reviewed hereunder.

2.1.3.1 Soft wood grafting

Based on a study conducted in mango soft wood grafting, Singh and Srivastava (1982) suggested that the height of grafting had no appreciable effect on final success and the grafting could be done at any desirable height with good success.

In cashew, for *in situ* soft wood grafting Kumar and Khan (1988) recommended a grafting height of six to eight centimetres wherein a success of 60 per cent was obtained during May.

2.1.3.2 Epicotyl grafting

According to Patel and Amin (1976), epicotyl grafting can be best done at a height of six centimetres on the rootstock in mango, Later on Chakrabarti and Sadhu (1984) obtained better results by grafting at five centimetre height compared to other treatments. Based on a study conducted under Vellanikkara conditions, 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.

In cashew, epicotyl grafting could be best done at a height of five centimetres above the cotyledons (Nagabhushanam, 1982). Aravindakshan *et al*. (1984) also successfully conducted

epicotyl grafting in cashew at a height of four to five centimetres from the soil surface and obtained a maximum success of 69 per cent in May. The beneficial effect of epicotyl grafting at a height of five centimetres in cashew was also reported by Chakrabarti and Sadhu (1984).

2.1.3.3 Splice grafting

The optimum height of rootstock for splice grafting in mango cv. Haden was reported to be 10 cm (De la Rocha, 1953).

2.1.3.4 Side grafting

In cashew, side grafting at a height of 15 to 20 cm on the rootstocks resulted maximum success (Sahani, 1982).

2.1.4 Defoliation of scion shoots

2.1.4.1 Soft wood grafting

Amin (1978) recorded 100 per cent success for *in situ* soft wood grafting in mango by using scion shoots defoliated 10 days before grafting. According to Patil *et al*. (1983) scion shoots defoliated 15 days prior to grafting were better than those defoliated five or 10 days before grafting. Singh *et al*. (1984) successfully conducted studies on soft wood grafting

using scion shoots defoliated six days before grafting in June and they reported 100 per cent success. Recently in 1988, Subramani conducted flush grafting trials in mango using scion sticks defoliated 10 days before grafting and obtained a maximum survival of 86.50 per cent with cv. Mallika, followed by 75.50 per cent with cv. Alphonso.

In cashew, Kannan and Das (1985) conducted soft wood grafting trials successfully and the scion shoots defoliated seven to eight days before grafting were found most promising. The beneficial effect of defoliation of scion shoot 10 days before grafting was also suggested by Seshadri and Rao (1986). But according to Kumar and Khan (1988) precuring of the scion shoots for seven to eight days will be sufficient in order to get a maximum survival of 60 per cent during May.

2.1.4.2 Epicotyl grafting

Precuring of the scion shoots before grafting was found to give good success in mango epicotyl grafting (Persai, 1974 and Maiti and Biswas, 1980). However, Bhandary et al. (1974) could not find any significant difference in success when grafting was done with defoliated and non defoliated scion shoots. Gunjate and Limaye (1976) also could not find any additional advantage with the use of defoliated scion shoots.

According to Singh and Srivastava (1981), scion shoots defoliated 10 days prior to grafting were superior to other treatments. In 1984, Desai and Patil conducted stone grafting trials with the use of scions defoliated seven days prior to grafting to get 70 per cent success under greenhouse conditions. According to Dhungana (1984) highest percentage of survival (49.50 per cent) was observed when scions were defoliated 10 days prior to stone grafting compared to 15 days prior to grafting (47.50 per cent) or without any defoliation (33.50 per cent). At the same time, Patil et al. (1984) suggested the superiority of scion shoots defoliated five days before grafting over those defoliated three or seven days before grafting. Patil and Patil (1985) stated that, for mango stone grafting, the initial sprouting was more when scion shoots defoliated seven days before grafting were used. But the final success was more when defoliation was done five days prior to grafting.

In cashew stone grafting, Aravindakshan et al. (1984) recorded a maximum success of 69 per cent with scion shoots defoliated 10 days prior to grafting. Precuring of the scion shoots seven days before grafting was found most ideal for cashew stone grafting where a success of 60 to 74 per cent was recorded (Sawke, 1983). Kannan and Das (1985) also agreed with this report, stating that seven to eight days of defoliation was ideal for cashew stone grafting.

2.1.4.3 Veneer grafting

In mango, Mukherjee and Majumder (1961) obtained maximum graft take with scion shoots defoliated one to two weeks before grafting. According to Gunjate et al. (1976) under Konkan conditions, defoliated scions gave a higher sprouting of 70 per cent compared to 63.83 per cent in control. Defoliation of the scion shoots 10 days prior to grafting was found optimum by Singh and Srivastava (1979) and Singh et al. (1984). In another study the beneficial effect of defoliation of scions 15 days before grafting was stressed by Ram and Bist (1982).

2.1.4.4 Side grafting

Kashyap et al. (1972) observed that side grafting in mango using 10 days precured scions gave 100 per cent graft take. But Kanwar and Bajwa (1974) got 92 per cent survival with undefoliated scion shoots in side grafting of mango.

2.1.5 Thickness of the rootstock and scion

2.1.5.1 Soft wood grafting

For in situ soft wood grafting in mango, Amin (1978) recommended the use of scion shoots of the same thickness as that of the terminal shoot of the rootstock 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).

In cashew, recently for top working, soft wood grafting was found to be the most suitable method. In this method, scion shoots of 0.8 to 1.0 cm girth were recommended for grafting on 90 to 110 days old new shoots arising from the cut portion of the tree (Guruprasad et al., 1988).

2.1.5.2 Epicotyl grafting

Rajput and Haribabu (1971) reported that in mango, the stock and scion of uniform thickness were most ideal for epicotyl grafting.

In cashew, cleft grafting, using rootstock and scion of three to five millimetres diameter resulted in 100 per cent take (Ascenso and Milheiro, 1973). Later on in 1974, Bhandary et al. found that thin scion shoots of 0.3 cm diameter were most ideal when grafted on 21 days old rootstock and could get 62 per cent success by wedge method.

2.1.5.3 Veneer grafting

Rootstock and scion of uniform thickness were found to be most suitable for veneer grafting in mango (Singh and

Srivastava, 1979). Dhungana (1984) reported the use of scion and stock of diameter one centimetre and two centimetres respectively for mango veneer grafting.

2.1.5.4 Inarching

In a trial using rootstocks of three different girths viz., 8 to 10 mm, 11 to 14 mm and 15 to 17 mm for grafting, there was no significant difference in success between rootstocks of various thickness (Majhail and Singh, 1962). Later on, Giri (1966) reported that the percentage success was significantly high on seedling rootstocks of 1.3 to 1.6 cm girth.

2.1.6 Age of the scion

2.1.6.1 Soft wood grafting

For soft wood grafting in mango the use of scion shoots of four to five months age and detached from last seasons growth were most ideal resulting in 88 per cent success during August (Singh and Srivastava, 1982). Singh et al. (1984) also stressed the importance of four to five months old scion shoots which yielded about 100 per cent success in mid June.

In cashew, the significant influence of three to four months old scion shoot on graft take was revealed by Kannan and Das (1985). Kumar and Khan (1988) stressed the beneficial effect of three to four months old scion shoots on graft take and reported 60 per cent success in May.

2.1.6.2 Epicotyl grafting

Under Konkan conditions, mature defoliated scion shoots of three to four months old were found to be the best for epicotyl grafting (Gunjate et al., 1976). Dhakal (1979) observed that scion shoots of more than two months age were most suitable for epicotyl grafting in mango. Maiti and Biswas (1980) based on their studies reported that when stone grafting was done with three to four months old defoliated scion, the percentage of success varied from 50 to 96. Later in 1984, Chakrabarti and Sadhu, stated that the combination of one month old scion shoots with five days old rootstocks gave the highest success rate. Nagawekar et al. (1984) obtained high success ranging from 60 to 63 per cent with the use of terminal and subterminal shoots as scion in stone grafting of mango. Under Vellanikkara conditions, four months old scion shoots were found to be the best for stone grafting which gave 61.33 per cent survival (Aravindakshan et al., 1988).

In cashew, terminal shoots of previous season's growth were found ideal as scion shoots for epicotyl grafting (Nagabhushanam, 1982). In a study, Aravindakshan et al. (1984) used four months old scion shoots for cashew stone grafting and got a success of 69 per cent.

2.1.6.3 Veneer grafting

Jagirdar and Bhatti (1968) emphasised the beneficial effect of mature scion wood compared to immature wood for better success in veneer grafting. Mature scion shoots of previous year's growth having dormant but swollen terminal buds were selected as scion shoots for veneer grafting and could give an average success of 87.5 per cent (Bhambota et al., 1971).

Singh and Srivastava (1979) obtained maximum graft take with six months old scion shoots. But Singh et al. (1985) obtained maximum success with three months old scion shoots. The beneficial effect of six months old scion shoot was also stressed by Dhakal and Hoda (1986).

2.1.7 Length of scion shoot

2.1.7.1 Soft wood grafting

Iqbal (1982) conducted cleft grafting of mango under partial shade condition using 8 to 12 cm long scion shoots

having the same thickness as that of the rootstock and got 60 to 95 per cent success.

In cashew, Kumar and Khan (1988) suggested the use of scion shoots of 8 to 10 cm length for soft wood grafting and reported a maximum success of 60 per cent during May.

2.1.7.2 Epicotyl grafting

Dhakal (1979) could not observe any significant difference between scions of different lengths as far as the grafting success was concerned. But according to Gunjate et al. (1980) scion shoots of 10 cm length are the best giving 50 to 90 per cent success when grafted during April to mid June. Scion shoots of 7.5 cm length were found ideal for getting maximum sprouting of 75 per cent (Kotecha, 1982). Chakrabarti and Sadhu (1984) revealed the superiority of 10 cm long scion sticks over five or 15 cm long ones in getting maximum success. But under Vellanikkara conditions, eight centimetre long scions were found to be the best for stone grafting in mango which recorded a graft take of 87.5 per cent (Ratan, 1985).

In cashew stone grafting, Aravindakshan et al. (1984) observed that 10 cm long scion shoots were ideal and they recorded a maximum success of 69 per cent during May under Kerala conditions.

2.1.7.3 Veneer grafting

Majumder et al. (1972) in the trials conducted on veneer grafting with scions of different lengths ranging from 2.5 to 10 cm, could not observe any significant difference in success with regard to length of the scion. However, subsequent growth of the scions was more with longer scions than with the shorter ones. Later on in 1982, Ram and Bist used five to 15 cm long scion shoots of cv. Dasheri and obtained average success of 20, 80 and 40 per cent with five, ten and fifteen centimetres long scions respectively. Dhakal and Hoda (1986) successfully conducted veneer grafting trials in mango using 15 cm long scion shoots of cv. Langra.

2.1.8 Varieties of rootstock and scion

2.1.8.1 Soft wood grafting

In a trial to evaluate the response of different scion varieties to soft wood grafting in mango under Konkan conditions, Kulwal and Tayde (1985b) obtained nearly 100 per cent success for the varieties Pairi, Kesar, Pundur and Panchadarakalasa. Other varieties like Neelum, Local-1, Local-2, Totapuri and Banganappally showed an ultimate survival of 72 to 85 per cent.

2.1.8.2 Epicotyl grafting

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) studied the response of 14 scion varieties with defoliated scion shoots and obtained high percentage of successful grafts with Fazli (96 per cent), Raneepasand (94 per cent) and Kohinoor (90 per cent). However with undefoliated scion shoots, the highest take was noted in Kohinoor (85 per cent) followed by Fazli (84 per cent). Chakrabarti and Sadhu (1984) observed the variety Langra as the best scion for grafting followed by the varieties Bombai and Himasagar regardless of time of grafting. Kulwal and Tayde (1985a) studied the response of eight scion varieties to stone grafting under Akola conditions and they obtained 56 to 93 per cent success for the different varieties, viz., Dasheri, Dudhpeda, Jahangir, Langra, Mushard, Pairi and Totapuri. 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 a trial, to find out the response of six scion varieties of mango, viz., Mulgoa, Prior, Banganappalli,

Mundappa, Bangalora and Alphonso to stone grafting, Radhamony (1987) reported highest percentage of sprouting for Banganappally with scion shoots of lengths 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 centimetres recorded least survival.

2.1.8.3 Veneer grafting

Singh and Srivastava (1979) reported that Dasheri when used as scion on Kalappady rootstock resulted in 90 per cent success followed by Nakkare as scion on Kalappady rootstock (85 per cent). Scion varieties Ratna, Mallika and Chousa when grafted to a common stock resulted in 85, 80 and 35 percentage graft take respectively.

In a trial conducted at Azad University of Agriculture and Technology, Bajpai et al. (1985) tried two scion varieties, Amrapali and Mallika and obtained better survival percentage of the grafts with vigorous scion growth using Amrapali as scion compared to Mallika.

2.1.8.4 Inarching

In a study to find out the varietal response of scion to inarching in mango. Talukdar and Ahmed (1965)

observed that the variety Samar Bahishet was the better scion (71 per cent success) as compared to Langra and Dasheri.

2.1.9 Season of grafting

2.1.9.1 Soft wood grafting

In mango, soft wood 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. Dasheri as scion. Gaur (1984) reported that, under Lucknow conditions, the ideal time for soft wood grafting 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 (1985b). Temperature and humidity were reported to be major limiting factors for the success in soft wood grafting in mango. In Shaharanpur a grafting success of 95 per cent was recorded during June last week 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 temperatures

recorded were 32.0°C and 21.0°C respectively. There was no rainfall during these periods (Subramani, 1988).

In cashew, Nagabhushanam (1985) reported that the most ideal season for cleft grafting is during September (58 per cent success) followed by August (54 per cent success). For cashew wedge grafting, September-October was found to be the most congenial period (Valsalakumari et al., 1985). Recently Kumar and Khan (1988) obtained maximum success for soft wood grafting during March - April and using one year old rootstocks. The mean percentage of success was maximum in May grafting (60.0 per cent) followed by April (55.0 per cent) and March (42.5 per cent).

2.1.9.2 Epicotyl grafting

According to Patel and Amin (1976), success in stone grafting has 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-July months. 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) also reported that success is more or less uniform when epicotyl grafting was done in June, July and August.

Trials conducted at Marathwada Agricultural University revealed that stone grafting could be best done during July under glass house conditions. During this period, the relative humidity was 83 per cent and maximum temperature was 41°C in the glass house (Desai and Patil, 1984). 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. But according to Gunjate (1985), the survival of stone grafts was 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 95 per cent when grafted inside a mist chamber.

In cashew, highest grafting success of 60 to 68 per cent was obtained when epicotyl grafting was done from June to August (Nagabhushanam, 1982). Under Konkan conditions, February to May

is found optimum for epicotyl grafting in cashew (Sawke, 1983). Similar report was made by Aravindakshan et al. (1984) in which March to May was found to be the most suitable period for cashew grafting under Kerala conditions.

2.1.9.3 Veneer grafting

Bhambota et al. (1971) obtained a success of 87.5 per cent 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. But the grafts prepared during May failed to produce sufficient growth for transplanting in the field during the monsoon season of the same year.

Later on Singh et al. (1979) recorded 75 to 92 per cent success for veneer grafting in mango during rainy season i.e. 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 for veneer grafting under the agro-climatic conditions of Varanasi when they got 96.6 per cent success. Singh et al. (1984) also suggested that June to August was the ideal time for veneer grafting in mango. Ismail and Rao (1985) recorded a maximum success of 85 per cent for veneer grafting during September and minimum success (0 to 5 per cent) during April-May under Sangareddy conditions.

In cashew, in the east coast of Kerala, June to September was found to be the best season for veneer grafting, resulting in a success of 50 to 90 per cent (Rao and Nambiar, 1977). Rao and Nagabhushanam (1977) also stated the suitability of monsoon season for cashew veneer grafting giving a success of 85 to 90 per cent during July under Karnataka conditions. Studies of Dhandar (1978) also agreed with these results and reported a grafting success of 96 per cent for veneer grafting in cashew during June-July and 36 per cent during November to March. On the other hand trials conducted at Cashew Research Station, Madakkathara revealed a success of 56 per cent during June to September months (Damodaran et al., 1979).

2.1.9.4 Inarching

Inarching in mango during rainy reason was proved better under Lucknow conditions (Singh et al., 1979 and Singh et al.,

1983). But Ismail and Rao (1985) reported that inarching was successful almost throughout the year, though the best results (75 to 90 per cent) were obtained during monsoon period.

In cashew, inarching during January to May gave 40 to 75 per cent success (Rao and Rao, 1957). Rao (1985) reported 52 to 96 per cent success for cashew inarching during the period from July to December.

2.1.9.5 Side grafting

The most congenial season for side grafting in mango was found to be the period from March to April or from June to October in Punjab (Kanwar and Bajwa, 1974). In Lucknow Singh et al. (1983) obtained a success of 76 to 80 per cent during August followed by 76 per cent in July.

In cashew, Nagabhushanam (1985) observed that June, July and October were the most ideal months for side grafting. Under Vellanikkara conditions, Valsalakumari et al. (1985) observed May-June and September-October as the most ideal periods for side grafting in cashew.

2.1.10 Tying materials used for grafting

De la Rocha (1953) used rubber band coated with Paraffin wax for tying graft union in mango. The superiority of mud

plaster over waxed cotton tape was stressed by Asadullah and Khan (1960). Mukherjee and Majumder (1961) recommended the use of polythene film of 200 to 300 guage for tying the graft joint. Later, in 1976, Uradya opined that 250 gauge alkathane tape could be used for tying mango veneer grafts for better union. Singh and Srivastava (1979) obtained better success with white polythene tapes as tying material followed by green polythene.

2.2 Anatomy of the graft union

As early as in 1941, Juliano studied the anatomy of 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, arc shaped patches of fibres, resin canals, phloem, cambium, xylem, uniseriate medullary rays, biseriate medullary rays and pith region with granules.

In the trials with grafted pear-quince trees, Buchloh (1960) reported that the lignification of the cell walls was mainly responsible for the formation of graft union in pear-quince grafts. 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 unions 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 1 (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 5 (6-8 months) - formation of several cylinders of new tissues and lateral shifting of scion 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 form 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 give 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, Ratan (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 differentiated and complete union between rootstock and scion took place. Callus proliferation was found to start initially from the rootstock but later on from both the components. The various changes in the union were found to be more rapid in splice method of grafting than in cleft method.

Materials and Methods

MATERIALS AND METHODS

The present series of studies were carried out in the Department of Pomology and Floriculture, College of Horticulture, Vellanikkara during the period from June, 1987 to April, 1989 in order to standardise various aspects of soft wood grafting in mango. The following were the objectives of the study.

1. To standardise the age of rootstock, height of grafting and time of defoliation prior to grafting with reference to success and survival by soft wood grafting in two commercial varieties of mango, viz., Neelum and Banganapally.

2. Anatomical studies of graft union to find out the different stages of healing process and the possible reasons for graft failures.

The location is under warm humid tropical climate with high humidity during July-August.

3.1 Standardisation of age of rootstock, height of grafting and defoliation effect of scion

In order to standardise the age of the rootstock for soft wood grafting in mango, seedlings coming under three age

groups, viz., one month, two months and three months wer sed for grafting (Plate I). From each of the above three age groups, 25 seedlings each were grafted at three different heights viz., 6 cm, 8 cm and 10 cm with the use of scion shoots defoliated 5 days, 10 days and 15 days prior to grafting from two varieties, Neelum and P ganapally. There were altogether 27 treatment combinations using each of the above varieties as scion. Grafting was done on rootstocks raised from a single variety during the month of August. Twenty five grafts were prepared in each treatment combination. A total of 1350 grafts were prepared for the entire study.

3.1.1 Raising of seedlings for rootstock

Healthy, well developed, plump and uniform mango stones of a common variety, moovandan where the trees were uniform 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 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 ent B.H.C. dust was applied around the beds. Seeds were sown during April, May and June, 1988 so as to get the seedlings of one month, two months and three months ready for grafting during August. The beds were always kept at a moistened condition.

The stones started sprouting after 10 days of sowing. Uniform, healthy, vigorous seedlings with straight, stout epicotyl were uprooted one week after germination without injuring the root system. They were transplanted in polythene bags of size 20 x 15 cm containing farm yard manure, sand and soil in 1:1:1 ratio. After transplanting, all the seedlings were kept under partial shade and irrigated daily.

3.1.2 Selection and preparation of scion shoots

Ten year old healthy, disease free, uniform mother trees of two varieties, Neelum and Banganappally were selected in the mango orchard at the Instructional Farm, Vellanikkara for taking scion shoots for grafting. Three to four months old terminal shoots of 8 to 10 cm long were selected as scion shoots. Scion shoots were defoliated 5 days, 10 days and 15 days prior to grafting by clipping the leaf lamina and keeping the petiole intact using a sharp knife. The scions were cut back at required length at the time of grafting.

3.1.3. Method of grafting

The wedge method of grafting was adopted. The seedlings were grafted within 10 to 15 days after transplanting in the polythene bags. The rootstocks were decapitated at three

different heights, viz., 6 cm, 8 cm, and 10 cm from the collar of the seedlings. Two slanting cuts of 2 to 3 cm deep running from the periphery towards the centre of the stock were made to form a V shaped notch using a sharp knife (Plates II & III).

The precured scion of 8 to 10 cm long were detached from the mother tree and made into a wedge giving a slanting cut of 2 to 3 cm long on both sides of the basal end with a sharp knife. The wedge shaped scions were 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 joints were tied firmly with transparent polythene tapes of 1 to 1.5 cm width and 30 cm length (Plates IV & V).

3.1.4 After care of the grafts

The grafts were kept in a thatched shed under partial shade and were watered daily. The unwanted seedlings emerged from polyembryonic seeds and other unwanted shoots produced from rootstock were removed by using a sharp blade, without causing any damage to the grafts. One per cent Bordeaux mixture was sprayed at weekly intervals for protection against die back disease. A spray of Nuvacron 0.15 per cent was given once in 15 days and Furadan granules at the rate of 1 gm per poly bag were applied once in a month for 5 months after grafting to prevent shoot midge attack. The polythene tapes around the unions were removed two to three months after grafting.

The experiment was laid out in C.R.D. with the following treatments in each of the two varieties, Neelum and Banganapally.

Treatments	Age of rootstock (months)	Height of grafting (cm)	Period of scion defoliation (days)
T_1	1	6	5
T_2	1	6	10
T_3	1	6	15
T_4	1	8	5
T_5	1	8	10
T_6	1	8	15
T_7	1	10	5
T_8	1	10	10
T_9	1	10	15
T_{10}	2	6	5
T_{11}	2	6	10
T_{12}	2	6	15
T_{13}	2	8	5
T_{14}	2	8	10
T_{15}	2	8	15
T_{16}	2	10	5
T_{17}	2	10	10
T_{18}	2	10	10
T_{19}	3	6	5
T_{20}	3	6	10
T_{21}	3	6	15
T_{22}	3	8	5
T_{23}	3	8	10
T_{24}	3	8	15
T_{25}	3	10	5
T_{26}	3	10	10
T_{27}	3	10	15

3.1.5 Observations

3.1.5.1 Percentage of sprouting and survival

The scions that remained green, whether sprouted or unsprouted, 15 days after grafting were counted as the initial success. The scions that actually sprouted and survived after 3 months of grafting were counted as the final success (Aravindakshan et al., 1988).

The following growth parameters were recorded at fortnightly intervals for a period of 5 months after grafting. Five plants were selected from each treatment at random for taking observations.

3.1.5.2 Growth of scion

The growth of the scion was measured in centimeters from the point where the scion put forth new growth.

3.1.5.3 Number of leaves

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

3.1.5.4 Girth of new growth, scion and rootstock

The girth of the new growth was measured at a height of one centimetre from the point where the scion put forth new growth.

The girth of the scion and rootstock was also recorded at one centimetre above and below the graft joint at fortnightly intervals.

3.1.5.5 Number of primaries

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

3.2 Anatomical studies of the graft union

Grafts were prepared separately for anatomical studies by using rootstocks of three different ages, viz., one month, two months and three months and grafting at three different

heights viz., 6 cm, 8 cm and 10 cm from the collar region of the rootstocks. Precured scion shoots defoliated 5 days, 10 days and 15 days prior to grafting were used.

In total there were 27 treatment combinations from each of the varieties Neelum and Banganappally. The procedure adopted here for raising the rootstocks, selection of scions, preparation of stock and scion and grafting operation was similar to the first experiment.

3.2.1 Collection and preservation of samples

Representative samples of graft union were taken from all the treatment combinations for anatomical studies. Two samples each were collected from all treatments at four different intervals, viz., 5 days, 15 days, 45 days and 90 days after grafting. Samples were also collected from the grafts showing signs of shrinking and the grafts remaining green without sprouting even after 60 to 90 days after 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 + 100 ml 40 per cent formaldehyde + 50 ml glacial acetic acid). The specimens were kept in FAA

solution for 72 hours and then transferred to 70 per cent alcohol. The samples were removed using sterilized forceps and washed in running water for 30 minutes and finally with distilled water. Uniform sections of 40 μ (micron) thickness were taken using 'Reichert sliding microtome' as per standard microtomy suggested for hard woods (Cutler, 1978).

The schedule followed for cleaning and staining the sections were as follows (Johansen, 1940).

Sections

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)

Mounted using D.P.X. Mountant

Microscopic examination

Photomicroscopy

The slides were carefully examined through Carl Zeiss binocular research microscope fitted with objectives of magnification ranging from 3.2x to 40x and an eye piece of 10x magnification.

Photomicrographs of selected sections were taken using photomicrography system orthoplan 964876 (Leitz Wetzlar Germany) and Kodak gold colour film of 100 ASA.

3.3 Statistical analysis

The repeated dues of χ^2 test was employed to form maximum sets of nonsignificant treatments as described by Panse and Sukhatme (1978).

$$\chi^2 = \frac{1}{n_1 n_2} \sum \frac{(an_2 - a^1 n_1)^2}{a + a^1}$$

Where

χ^2 - Chi-square

a - Number of grafts sprouted or survived for each treatment

a^1 - Number of grafts unsprouted or not survived for each treatment.

n_1 - Number of grafts sprouted or survived for all the treatments.

n_2 - Number of grafts unsprouted or not survived for all the treatments.

The degrees of freedom for chi-square is (k-1), where K is the number of treatments.

Pairwise comparison of treatments were also made using chi-square test of independece. The test criterion is given by

$$\chi^2 = \frac{(ad - bc)^2 \; n}{(a+b)\,(a+c)\,(b+d)\,(c+d)}$$ with one degrees of freedom

Where

a and c - Number of grafts sprouted or survived in the two treatments

b and d - Number of grafts unsprouted or not survived in two treatments.

The observations on different plant growth parameters viz., new growth, girth of scion, girth of rootstock and number of primaries produced were analysed statistically using analysis of variance technique as applied to CRD (Snedecor and Cochran, 1967).

Plate I Rootstocks of one month, two months and three months for grafting

Plate I

Plate II Rootstock ready for grafting

Plate III Prepared rootstock for grafting

Plate IV Scion inserted into the rootstock for grafting

Plate V Graft joint tied with polythene strip

Plate II

Plate III

Plate IV

Plate V

Results

RESULTS

The results of the present series of studies on the standardisation of soft wood grafting in mango are presented in the following pages.

4.1 Effect of age of rootstock, height of grafting and defoliation of the scion on sprouting and survival of grafts

4.1.1 Variety Neelum

The observations on the percentage of sprouting and survival of grafts prepared with scion variety Neelum are presented in Table 1. Age of rootstock and defoliation of the scion influenced and sprouting and survival of grafts profoundly. The highest percentage of sprouting of 100 per cent was obtained for one month old rootstock when grafted with scion shoot defoliated 15 days before grafting at a height of 10 cm from the collar region (Plate VI). The success was reduced to 97.14 per cent, when the grafting height was lowered from 10 cm to 6 cm. The data also revealed that the least sprouting of 46.51 per cent and 51.16 per cent respectively was obtained when grafting was done at 10 and 6 centimetres height on stocks of three months with scion defoliated five days prior to grafting.

Table 1. Effect of age of rootstock, height of grafting and defoliation of scion on sprouting and survival of grafts (Variety Neelum)

Age of rootstock (months)	Height of grafting (cm)	Period of scion defoliation (days)	Sprouting after 15 days (%)	Survival after 90 days (%)
1	6	5	66.66	0
		10	92.85	12
		15	97.14	36
	8	5	73.68	12
		10	97.05	44
		15	97.14	32
	10	5	71.05	4
		10	76.47	32
		15	100.00	60
2	6	5	82.05	32
		10	82.05	16
		15	92.11	36
	8	5	94.87	32
		10	94.74	59
		15	92.30	28
	10	5	77.50	32
		10	92.11	52
		15	87.17	40
3	6	5	51.16	16
		10	85.29	20
		15	73.53	20
	8	5	53.49	48
		10	94.12	40
		15	64.71	20
	10	5	46.51	20
		10	91.18	52
		15	79.41	52

It is also clear from the table that the survival was maximum (60 per cent) when grafting was done with 15 days prior defoliated scion shoots on stocks of one month old at a height of 10 centimetres. The data also indicated that two months old rootstock when grafted with scion shoots defoliated 10 days before grafting at 8 cm height recorded 59 per cent survival. There was no survival when grafting was done on one month old rootstock at a height of 6 cm using 5 days defoliated scion.

The results of the statistical analysis of the pooled data on the effect of different ages of rootstock on sprouting and survival of the grafts are presented in Table 2 and Fig.1. From the Table it is clear that two months old rootstock is superior with regard to sprouting (88.25 per cent). However, this is on par with one month old rootstock. Survival was also more with two months old rootstock. There was no significant difference between two months and three months old rootstock with regard to survival. The sprouting was minimum for three months old rootstock (69.37 per cent) while survival was minimum for one month old rootstock (25.78 per cent).

The results on statistical analysis of the pooled data on the effect of different heights of grafting on the sprouting and survival of grafts furnished in Table 3 and Fig.2 revealed no significant difference between the treatments. However, a

Table 2. Effect of age of rootstock on sprouting and survival of grafts (Variety Neelum)

Age of rootstock (months)	Sprouting after 15 days (%)	Survival after 90 days (%)
1	85.13*	25.78
2	88.25*	35.11*
3	69.37	31.56*

*Homogeneous at 5% level

Table 3. Effect of height of grafting on sprouting and survival of grafts (Variety Neelum)

Height of grafting (cm)	Sprouting after 15 days (%)	Survival after 90 days (%)
6	79.33*	19.11
8	84.13*	35.11*
10	79.40*	38.22*

*Homogeneous at 5% level

FIG. 1. EFFECT OF AGE OF ROOTSTOCK ON SPROUTING AND SURVIVAL OF GRAFTS

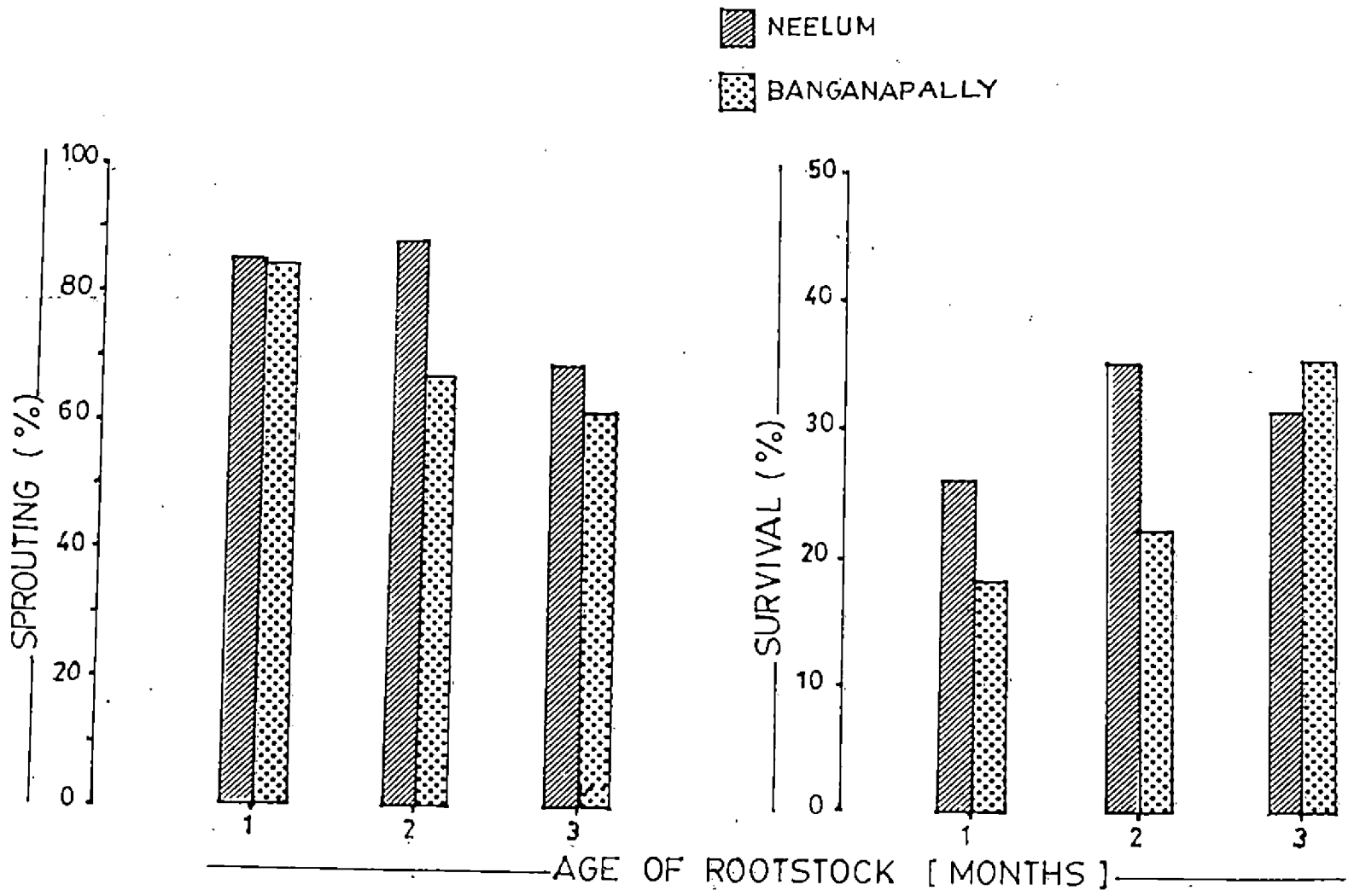
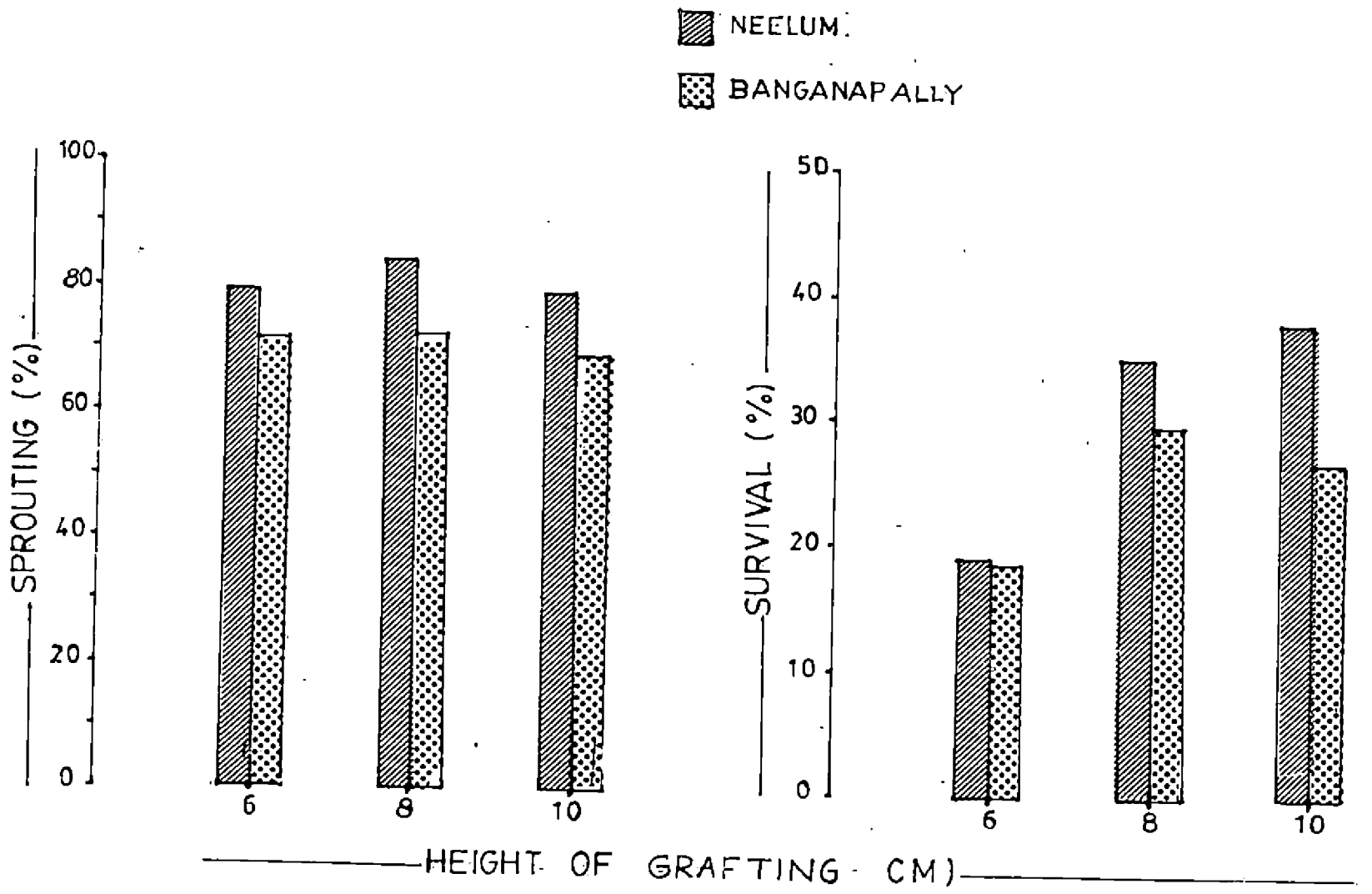


FIG. 2. EFFECT OF HEIGHT OF GRAFTING ON SPROUTING AND SURVIVAL OF GRAFTS.



higher sprouting was obtained when grafting was done at a height of 8 cm. Survival was better when grafting was performed at 10 cm height and this was also on par with grafting at 8 cm height. Though not significant, the grafting done at a height of 6 cm recorded minimum sprouting.

The pooled data on the effect of defoliation of scion on sprouting and survival of the grafts are shown in Table 4 and Fig.3. From the Table it is clear that the defoliation of the scion has significant effect on the sprouting and survival of the grafts. The scion shoots defoliated 10 days prior to grafting recorded maximum sprouting and survival of 89.46 per cent and 36.44 per cent respectively which were statistically on par with the grafts prepared with 15 days prior defoliated scions. The scions defoliated 5 days prior to grafting recorded the minimum sprouting and survival of 67.96 per cent and 21.78 per cent respectively.

4.1.2 Variety Banganapally

The observations on the percentage of sprouting and survival of the grafts prepared with the scion variety Banganapally are presented in Table 5. Age and height of rootstock and defoliation of the scion were found to have significant influence on sprouting and survival of the grafts.

Table 4. Effect of defoliation of scion shoot on sprouting and survival of grafts (Variety Neelum)

Period of scion defoliation (days)	Sprouting after 15 days (%)	Survival after 90 days (%)
5	67.96	21.78
10	89.46*	36.44*
15	87.31*	34.22*

* Homogeneous at 5% level

FIG. 3. EFFECT OF DEFOLIATION OF SCION ON SPROUTING AND SURVIVAL OF GRAFTS.

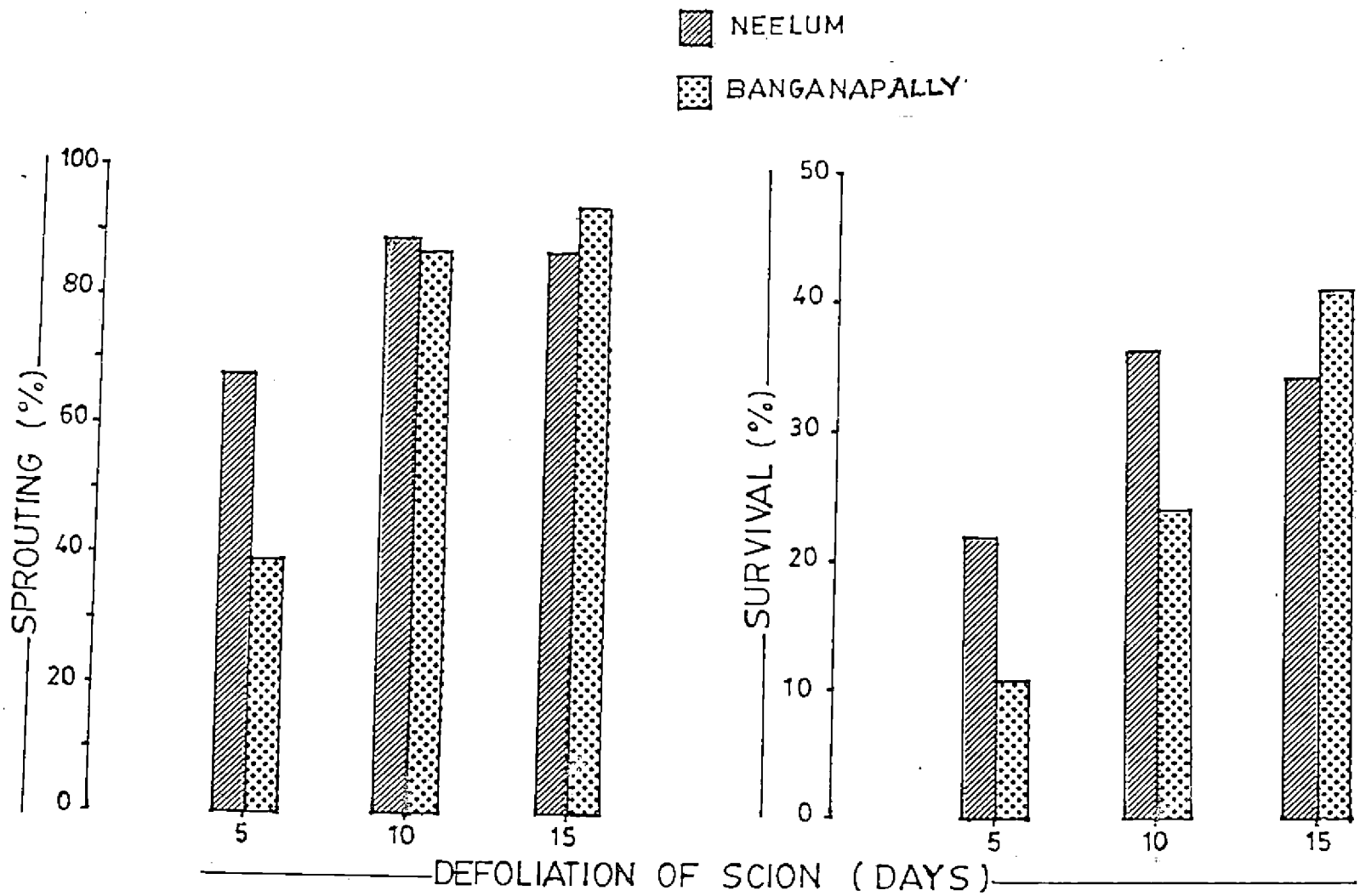


Table 5. Effect of age of rootstock, height of grafting and defoliation of scion on sprouting and survival of grafts (Variety Banganapally)

Age of rootstock (months)	Height of grafting (cm)	Period of scion defoliation (days)	Sprouting after 15 days (%)	Survival after 90 days (%)
1	6	5	84.21	0
		10	85.71	0
		15	100.00	24
	8	5	76.31	12
		10	85.71	12
		15	97.14	52
	10	5	52.63	0
		10	88.57	12
		15	97.14	44
2	6	5	23.26	12
		10	82.05	16
		15	91.17	12
	8	5	30.23	20
		10	94.74	24
		15	88.54	40
	10	5	32.56	28
		10	92.11	24
		15	91.18	24
3	6	5	27.91	12
		10	70.58	40
		15	97.14	48
	8	5	20.93	4
		10	97.06	48
		15	88.00	56
	10	5	18.60	0
		10	88.24	40
		15	96.00	68

Highest sprouting (100 per cent) was recorded when grafting was done on one month old rootstock at a height of 6 cm with scion shoot defoliated 15 days prior to grafting (Plate VII). The sprouting was 97.14 per cent when the grafting height was increased to 8 and 10 centimetres. The sprouting was very poor (18.60per cent) for the rootstock of three months old grafted at a height of 10 cm with the scion shoot defoliated 5 days prior to grafting.

Maximum survival (68 per cent) was obtained for three months old rootstock grafted at a height of 10 cm using scion shoot defoliated 15 days prior to grafting. From the Table it is clear that the survival was zero per cent for four treatment combinations. Grafting on one month old rootstock at a height of 6 and 10 cm using scion shoot defoliated 5 days before grafting recorded no survival. The same rootstock when grafted at 6 cm height using 10 days defoliated scion also resulted no survival. Three months old rootstock grafted at a height of 10 cm when combined with scion shoot defoliated 5 days before grafting also gave zero per cent survival.

Results of the statistical analysis of the pooled data on the effect of age of the rootstock on the sprouting and survival of the grafts are presented in Table 6 and Fig.1. Maximum sprouting (84.88 per cent) was obtained with one month

old rootstock which is significantly superior to two and three months old rootstocks. However, the survival was maximum for three months old rootstock (35.11 per cent) which was statistically significant compared to one month old rootstock (18.22 per cent) and two months old rootstock (22.22 per cent).

The influence of height of grafting on sprouting and survival of graft is clearly evident from the pooled data furnished in Table 7 and Fig.2. Grafting at 8 cm height gave maximum sprouting (72.69) and is on par with grafting at 6 cm (71.43 per cent) and 10 cm height (69.85 per cent). With regard to survival, there was no significant difference when the grafting was done at 8 cm and 10 cm heights. However, grafting at 8 cm height tended to record maximum survival (29.78 per cent).

The results of the statistical analysis of the pooled data on the effect of defoliation of the scion on sprouting and survival of the grafts are summarized in Table 8 and Fig.3. From the Table it is evident that scions defoliated 15 days prior to grafting recorded significantly maximum sprouting (94.19 per cent) over the scions defoliated five and ten days before grafting. A similar trend was obtained with regard to survival also.

Table 6. Effect of age of rootstock on sprouting and survival of grafts (Variety Banganapally)

Age of rootstock (months)	Sprouting after 15 days (%)	Survival after 90 days (%)
1	84.88	18.22*
2	67.15*	22.22*
3	62.03*	35.11

*Homogeneous at 5% level

Table 7. Effect of height of grafting on sprouting and survival of grafts (Variety Banganapally)

Height of grafting (cm)	Sprouting after 15 days (%)	Survival after 90 days (%)
6	71.43*	18.67
8	72.69*	29.78*
10	69.85*	27.11*

* Homogeneous at 5% level

Table 8. Effect of defoliation of scion shoot on sprouting and survival of grafts (Variety Banganapally)

Period of scion defoliation (days)	Sprouting after 15 days (%)	Survival after 90 days (%)
5	39.52	10.67
10	87.27	24.00
15	94.197	40.89

Treatments are significantly different at 5% level

4.2 Effect of age of rootstock, height of grafting and defoliation of scion on growth parameters of grafts

4.2.1 Growth of scion

4.2.1.1 Variety Neelum

The observations on the growth of scion shoot for various treatment combinations are furnished in Table 9. Statistical analysis of the data revealed significant difference between different treatment combinations upto 6th fortnight and thereafter the effect was found to be insignificant. Grafting using one month old rootstock with scion shoots defoliated 10 days prior to grafting recorded maximum new growth throughout the period of observation. In the 2nd and 3rd fortnights, the above mentioned combination grafted at 8 cm height produced maximum mean growth of 5.09 cm and 5.35 cm respectively and was found significantly superior to most of the other treatments. The same treatment grafted at 10 cm height recorded maximum mean growth from the 4th fortnight till the end of the observational period. In general, the least growth in 2nd and 5th fortnight was recorded when grafting was done on one month old rootstock at a height of 8 cm using scion shoot defoliated 5 days prior to grafting. But during 6th, 7th and 9th fortnights, the combination of 3 months old stock grafted at a height of 6 cm

Table 9. Effect of age of rootstock, height of grafting and defoliation of scion on growth of scion (cms) at fortnightly intervals (Variety Neelum)

Age of rootstock (months)	Height of grafting (cm)	Period of scion defoliation (days)	Fortnights after grafting								
			2	3	4	5	6	7	8	9	10
1	6	5	-	-	-	-	-	-	-	-	-
		10	2.32	2.48	2.50	3.75	4.00	4.00	4.13	4.25	4.62
		15	2.82	3.75	3.81	3.97	4.52	4.63	5.08	5.28	5.70
	8	5	1.98	2.46	2.52	2.93	3.56	-	-	-	-
		10	5.09	5.35	5.45	7.08	7.24	7.28	7.35	7.41	7.99
		15	4.02	4.20	4.30	4.30	4.49	4.62	5.37	5.21	5.33
	10	5	-	-	-	-	-	-	-	-	-
		10	2.95	5.07	6.92	7.63	7.69	8.35	8.35	8.35	8.35
		15	3.98	4.17	4.29	4.29	4.34	4.54	4.24	4.79	4.84
2	6	5	2.13	2.27	2.47	3.18	3.76	3.88	3.88	4.60	5.15
		10	2.01	2.22	2.22	3.97	4.31	4.31	4.31	4.47	5.93
		15	3.23	3.34	3.41	3.16	3.37	3.83	4.35	4.84	5.59
	8	5	2.57	4.05	4.05	4.02	6.54	6.66	6.66	6.73	7.12
		10	2.89	3.32	3.54	4.12	4.69	5.46	5.46	5.46	5.46
		15	4.15	4.63	5.36	5.67	5.85	6.23	7.22	7.32	7.51
	10	5	3.27	3.36	3.36	4.80	5.77	5.82	5.82	6.29	6.39
		10	3.56	3.80	5.10	6.58	6.63	6.72	6.72	6.85	6.95
		15	3.35	4.62	4.91	5.81	5.97	6.40	7.23	7.61	7.79
3	6	5	2.86	3.89	4.24	3.98	4.34	4.56	4.56	4.56	5.38
		10	2.75	3.49	3.23	3.23	3.29	3.29	3.97	4.20	5.02
		15	4.66	3.74	4.22	4.22	4.40	4.40	4.93	5.12	5.64
	8	5	4.46	4.97	5.11	5.98	6.28	6.44	6.49	6.49	7.22
		10	4.28	4.19	4.19	4.19	5.28	5.28	5.70	6.10	6.10
		15	4.91	4.91	5.32	5.41	5.83	5.83	6.48	6.65	6.89
	10	5	4.17	4.74	5.41	7.25	7.25	7.25	7.25	7.89	7.89
		10	4.21	4.64	5.40	5.40	5.77	5.77	6.29	6.50	6.50
		15	4.95	4.86	4.86	4.98	5.39	5.39	5.14	5.55	6.04

with 10 days prior defoliated scion recorded the least growth of scion.

The figures furnished in Table 10 and Fig.4 relate to the statistical analysis of the pooled data on the effect of different ages of rootstock on the new growth of scion. In this respect, three months old rootstock was significantly superior to one month and two months old rootstocks till the end of 5th fortnight. Three months old rootstock recorded maximum mean growth of 4.14 cm, 4.38 cm, 4.66 cm and 4.96 cm respectively in 2nd, 3rd, 4th and 5th fortnights. From 6th fortnight onwards this treatment was found to be on par with one month and two months old rootstocks. Two months old rootstock was significantly inferior in relation to growth of the scion till the end of 5th fortnight.

The height of grafting also significantly influenced the new growth of scion shoot throughout the period of study. The data furnished in Table 11 and Fig.5 revealed that the grafts prepared at 10 cm height recorded maximum mean new growth of 4.41 cm, 5.03 cm, 5.84 cm, 6.10 cm, 6.28 cm, 6.44 cm, 6.73 cm and 6.84 cm respectively from 3rd to 10th fortnights of observation. While the grafts prepared at 6 cm height showed least mean new growth throughout the period of observation.

Table 10. Effect of age of rootstock on growth of the scion (cm) at fortnightly intervals (Variety Neelum)

Age of rootstock (months)	Fortnights after grafting								
	2	3	4	5	6	7	8	9	10
1	3.31_a	3.93_a	4.26_a	4.85_a	5.12_a	5.57_a	5.84_a	5.88_a	6.10_a
2	3.12_b	3.51_b	3.82_b	4.59_b	5.21_a	5.48_a	5.74_a	5.79_a	6.43_b
3	4.14_c	4.38_c	4.66_c	4.96_a	5.31_a	5.36_a	5.65_a	5.89_a	6.29_{ab}
CD (5%)									
1 & 2	0.16*	0.16*	0.19*	0.21*	0.22	0.23	0.24	0.24	0.25*
2 & 3	0.16*	0.16*	0.18*	0.19*	0.19	0.20	0.21	0.21	0.22
1 & 3	0.17*	0.18*	0.19*	0.22	0.22	0.23	0.24	0.24	0.25

(Treatments with same letter are not significantly different within the fortnight)

FIG. 4. EFFECT OF AGE OF ROOTSTOCK ON GROWTH OF SCION AT FORTNIGHTLY INTERVALS.

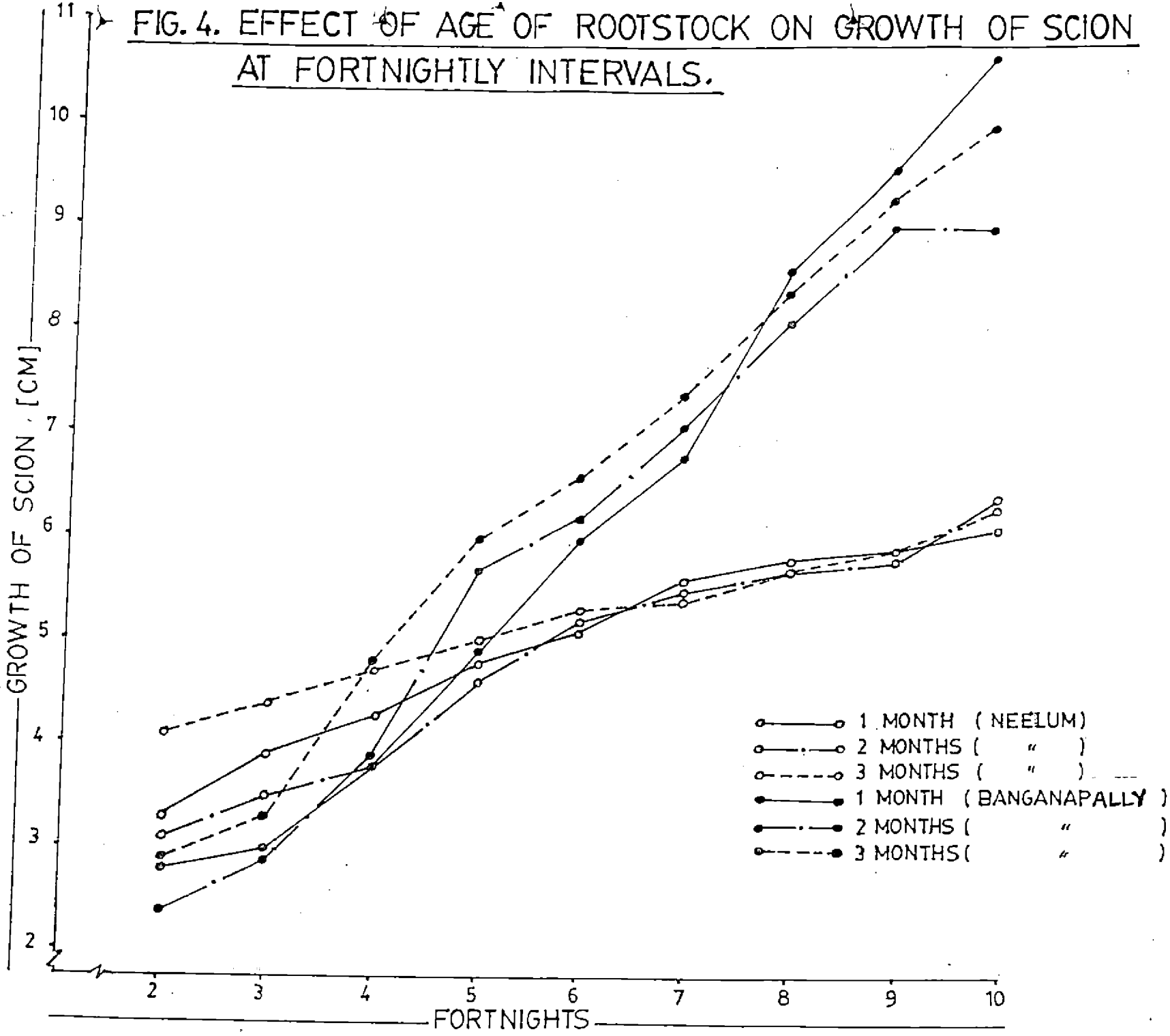
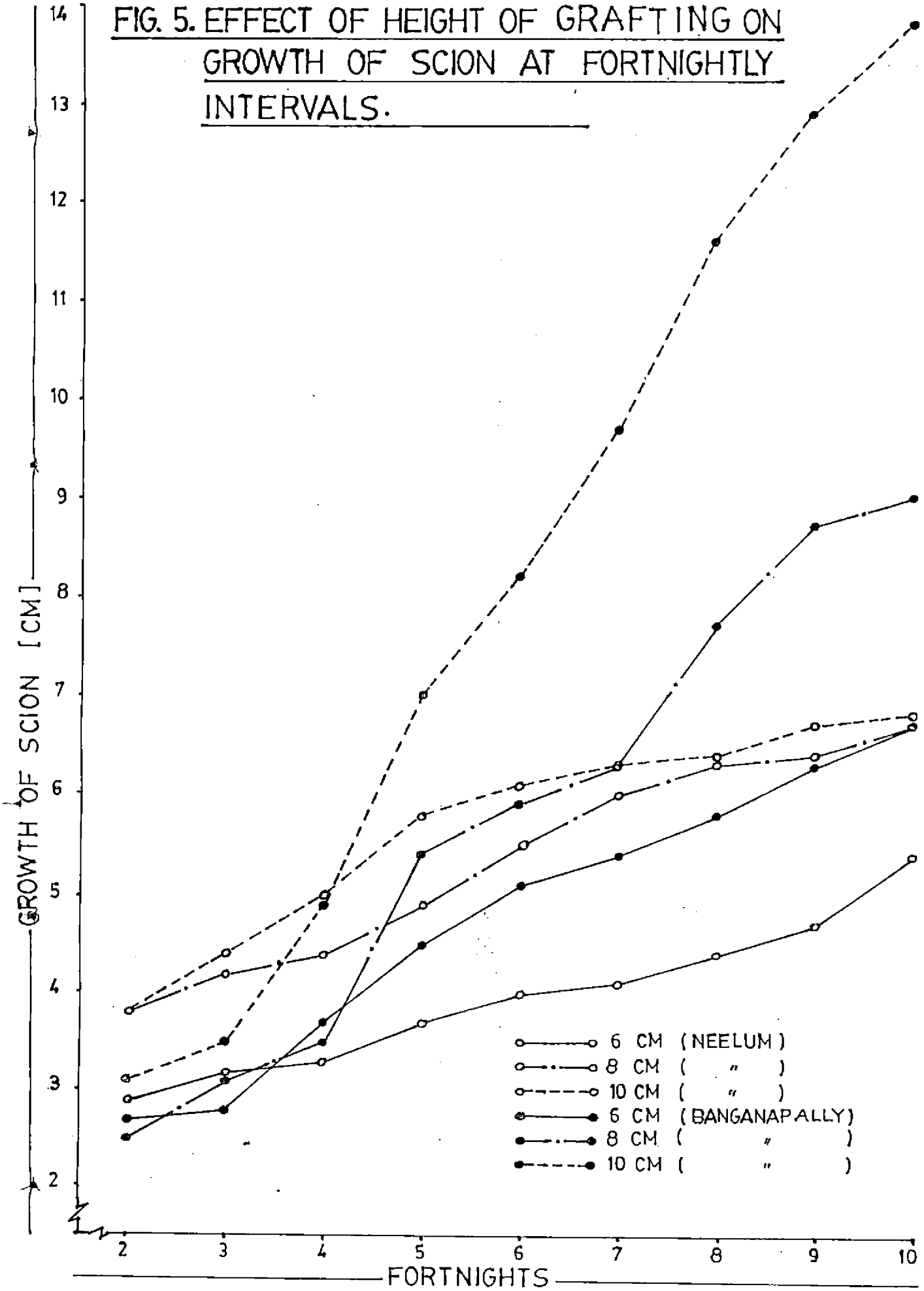


Table 11. Effect of height of grafting on growth of scion (cm) at fortnightly intervals (Variety Neelum)

Height of grafting (cm)	Fortnights after grafting								
	2	3	4	5	6	7	8	9	10
6	2.85_a	3.15_a	3.26_a	3.68_a	3.99_a	4.11_a	4.40_a	4.67_a	5.38_a
8	3.82_b	4.23_b	4.43_b	4.86_b	5.53_b	5.98_b	6.34_b	6.42_b	6.70_b
10	3.81_b	4.41_c	5.03_c	5.84_c	6.10_c	6.28_c	6.44_b	6.73_c	6.84_b
C.D. (5%)									
6 and 8	0.16*	0.17*	0.19*	0.20*	0.21*	0.22*	0.23*	0.23*	0.24*
8 and 10	0.16	0.16*	0.18*	0.19*	0.20*	0.21*	0.21	0.22*	0.23
6 and 10	0.17*	0.18*	0.19*	0.21*	0.22*	0.22*	0.23*	0.24*	0.24*

(Treatments with same letter are not significantly different within the fortnight)

FIG. 5. EFFECT OF HEIGHT OF GRAFTING ON GROWTH OF SCION AT FORTNIGHTLY INTERVALS.



The data on the effect of defoliation on the growth of the scion shoot are presented in Table 12 and Fig.6. Scion shoots defoliated 15 days prior to grafting were found significantly superior to the scions defoliated 5 and 10 days prior to grafting with regard to mean new growth of scion during 2nd, 3rd and 4th fortnights. Interestingly thereafter the scion shoots, defoliated 5 and 10 days prior to grafting, recorded maximum mean growth, the least extension growth was produced by scion shoots defoliated 5 days prior to grafting upto 5th fortnight, thereafter 15 days prior defoliated scions recorded least value in this regard.

4.2.1.2 Variety Banganapally

The data on the new growth of the scion shoot at fortnightly intervals for various treatment combinations are presented in Table 13. Analysis of variance of the data revealed significant difference between different treatment combinations throughout the period of study. Treatment combination of three months old rootstock and scion shoot defoliated 10 days before grafting was found significantly superior to all other treatments almost throughout the period of observation. The growth of the scion was 5.63, 5.50 and 8.17 cm respectively during 2nd, 3rd and 4th fortnights when grafting was done at a height of 6 cm. Thereafter for the same

Table 12. Effect of defoliation of scion shoot on growth of scion (cm) at fortnightly intervals (Variety Neelum)

Period of scion defoliation (days)	Fortnights after grafting								
	2	3	4	5	6	7	8	9	10
5	3.06_{a}	3.68_{a}	3.88_{a}	3.96_{a}	5.36_{a}	5.77_{a}	5.78_{a}	6.09_{a}	6.53_{a}
10	3.34_{b}	3.84_{b}	4.28_{b}	5.11_{b}	5.43_{a}	5.61_{a}	5.81_{a}	5.95_{ab}	6.32_{ab}
15	4.01_{c}	4.25_{c}	4.49_{c}	4.65_{c}	4.91_{b}	5.09_{b}	5.62_{a}	5.82_{b}	6.15_{b}
C.D. (5%)									
5 and 10	0.17*	0.18*	0.19*	0.22*	0.22	0.23	0.24	0.24	0.25
10 and 15	0.16*	0.16*	0.18*	0.19*	0.20*	0.21*	0.21	0.22	0.23
5 and 15	0.18*	0.17*	0.19*	0.21*	0.22*	0.22*	0.23	0.24*	0.25*

(Treatments with same letter are not significantly different within the fortnight)

FIG. 6. EFFECT OF DEFOLIATION OF SCION ON GROWTH OF SCION AT FORTNIGHTLY INTERVALS.

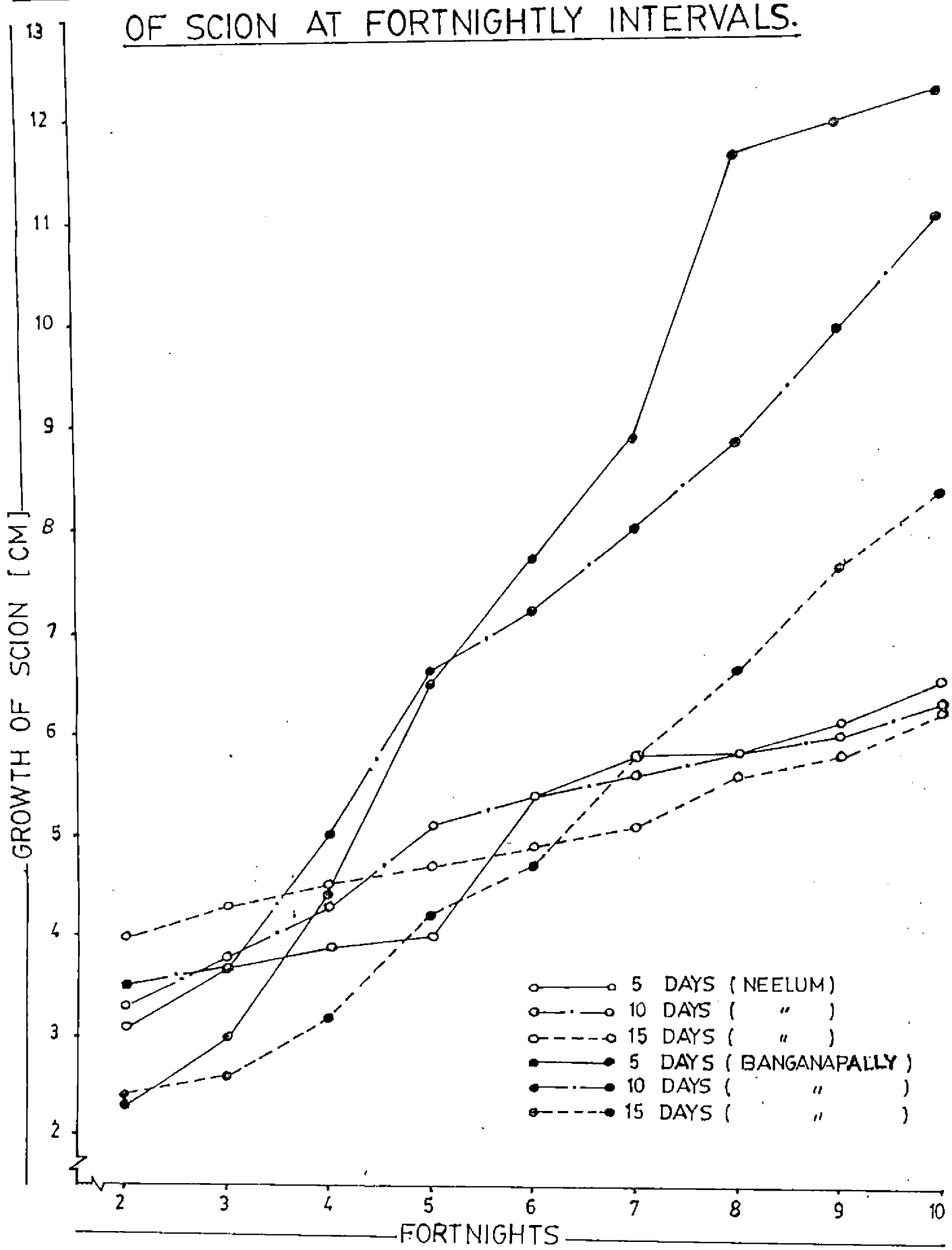


Table 13. Effect of age of rootstock, height of grafting and defoliation of scion on growth of scion (cm) at fortnightly intervals (Variety Banganapally)

Age of rootstock (months)	Height of grafting (cm)	Period of scion defoliation (days)	Fortnights after grafting								
			2	3	4	5	6	7	8	9	10
1	6	5	2.75	2.33	1.83	2.00	-	-	-	-	-
		10	3.50	-	-	-	-	-	-	-	-
		15	2.08	2.40	3.00	3.00	3.50	3.50	4.50	5.08	5.27
	8	5	1.83	3.63	4.50	7.17	7.33	8.00	13.00	13.13	13.13
		10	3.33	3.4	3.40	4.50	6.00	-	-	-	-
		15	2.50	2.60	3.30	3.75	4.70	5.10	5.85	7.00	8.59
	10	5	-	-	-	-	-	-	-	-	-
		10	5.00	5.00	7.75	9.25	10.50	10.50	12.75	12.75	15.50
		15	1.70	2.10	2.75	4.60	5.00	7.05	7.30	9.85	10.78
2	6	5	3.33	3.67	4.50	7.67	7.83	9.17	10.00	10.50	10.83
		10	2.50	3.50	3.63	5.13	5.25	5.38	5.38	6.00	6.19
		15	1.00	1.13	1.50	1.88	2.00	2.00	2.00	2.00	2.00
	8	5	3.00	4.38	7.13	8.75	8.75	9.00	11.50	11.50	12.50
		10	2.00	2.0	2.33	3.5	4.5	5.17	5.17	7.17	8.17
		15	2.50	2.75	3.20	5.2	5.40	6.4	6.65	8.70	9.30
	10	5	1.42	2.50	4.00	6.75	7.00	9.00	11.75	12.25	12.50
		10	-	-	-	-	-	-	-	-	-
		15	3.50	3.50	4.60	6.80	9.20	10.50	12.00	14.20	15.10
3	6	5	1.25	1.50	-	-	-	-	-	-	-
		10	5.63	5.50	8.17	8.50	8.50	8.50	8.50	9.83	11.00
		15	2.08	2.38	3.05	3.25	3.55	4.00	4.10	4.10	4.80
	8	5	2.50	-	-	-	-	-	-	-	-
		10	2.60	2.70	4.10	6.00	6.15	6.20	6.60	8.15	9.70
		15	-	3.17	3.25	4.00	4.17	4.42	5.33	5.33	5.75
	10	5	-	-	-	-	-	-	-	-	-
		10	3.20	4.10	5.50	9.40	9.50	12.00	14.30	15.60	15.60
		15	3.60	3.65	4.50	4.90	7.70	9.20	11.75	12.50	13.00

combination, growth was maximum when grafting was done at 10 cm height till the end of observational perio.. In the present study, the treatment combination of two months old rootstock and 15 days defoliated scion when grafted at 6 cm height produced least mean growth throughout the course of study.

Results of the analysis of the pooled data on the effect of age of rootstock on new growth of the scion are presented in Table 14 and Fig.4. The data revealed that the age of the rootstock did not influence the growth of scion significantly during the entire period of observation.

The pooled data on the effect of height of grafting on new growth of scion are presented in Table 15 and Fig.5. Effect was not significant during the 2nd and 3rd fortnights but was significant thereafter. Grafting at 10 cm height recorded maximum mean growth throughout the course of observation. The maximum mean values recorded during 2nd, 3rd, 4th, 5th, 6th, 7th, 8th, 9th and 10th fortnights were respectively 3.07 cm, 3.48 cm, 4.85 cm, 6.95 cm, 8.15 cm, 9.71 cm, 11.60 cm, 12.86 cm, and 13.75 cm. Grafting at 6 cm height recorded poor growth during the entire period of observation. The data presented in Table 16 and Fig.6 indicated that the scion shoots defoliated 10 days prior to grafting resulted maximum mean growth in the 2nd, 3rd, 4th and 5th fortnights and thereafter the scions

Table 14. Effect of age of rootstock on growth of scion (cm) at fortnightly intervals (Variety Banganappally)

Age of rootstock (months)	Fortnights after grafting								
	2	3	4	5	6	7	8	9	10
1	2.84_a	3.07_a	3.79_a	4.89_a	6.17_a	6.83_a	8.63_a	9.56_a	10.65_a
2	2.41_a	2.93_a	3.86_a	5.69_a	6.24_a	7.08_a	8.06_a	9.04_a	8.99_a
3	2.88_a	3.29_a	4.76_a	6.01_a	6.59_a	7.39_a	8.43_a	9.25_a	9.95_a
C.D. (5%)									
1 and 2	0.66	0.86	1.11	1.36	1.65	1.94	2.19	2.45	2.52
2 and 3	0.68	0.86	1.11	1.32	1.53	1.74	1.95	2.17	2.23
1 and 3	0.66	0.86	1.15	1.41	1.69	1.98	2.23	2.49	2.55

(Treatments with same letter are not significantly different within the fortnight)

Table 15. Effect of height of grafting on growth of scion (cm) at fortnightly intervals (Variety Banganapally)

Height of grafting (cm)	Fortnights after grafting								
	2	3	4	5	6	7	8	9	10
6	2.68 a	2.80 a	3.67 ac	4.49 a	5.11 a	5.43 a	5.75 a	6.25 a	6.68 a
8	2.53 a	3.08 a	3.49 a	5.36 a	5.88 a	6.33 a	7.73 a	8.71 b	9.00 a
10	3.07 a	3.48 a	4.85 bc	6.95 b	8.15 b	9.71 b	11.60 b	12.86 c	13.75 b
C.D. (5%)									
6 and 8	0.66	0.83	1.10	1.29	1.61	1.86	2.09	2.35*	2.41
8 and 10	0.68	0.86	1.12*	1.32*	1.55*	1.79*	1.99*	2.24*	2.29*
6 and 10	0.67	0.78	1.19	1.36*	1.64*	1.93*	2.17*	2.41*	2.48*

(Treatments with same letter are not significantly different within the fortnight)

Table 16. Effect of defoliation of scion on growth of scion (cm) at fortnightly intervals (Variety Banganappally)

Period of scion defoliation (days)	Fortnights after grafting								
	2	3	4	5	6	7	8	9	10
5	2.29 a	3.00 ab	4.39 ab	6.47 a	7.73 a	8.79 a	11.56 a	11.85 a	12.24 a
10	3.47 b	3.74 a	4.98 a	6.62 a	7.20 a	7.96 a	8.78 b	9.92 a	11.03 a
15	2.37 a	2.63 b	3.24 b	4.15 b	4.69 b	5.79 b	6.61 b	7.64 b	8.29 b
C.D. (5%)									
5 and 10	0.71*	0.95	1.34	1.64	2.00	2.32	2.64*	2.94	3.02
10 and 15	0.61*	0.80*	1.04*	1.25*	1.47*	1.72*	1.92*	2.14*	2.19*
5 and 15	0.68	0.89	1.26	1.52*	1.87*	2.13*	2.45*	2.73*	2.80*

(Treatments with same letter are not significantly different within the fortnight)

defoliated 5 days before grafting produced maximum mean growth. The 5 days and 10 days defoliation effect on mean extension growth of scion shoot was found to be on par during the 3rd, 4th, 5th, 6th, 7th, 9th, and 10th fortnights. The effect of 5 and 15 days defoliation was found statistically on par upto the end of 4th fortnight.

4.2.2 Number of leaves

4.2.2.1 Variety Neelum

The significant effect of various treatments on the number of leaves produced by grafts is clearly evident from the data furnished in Table 17. Three months old rootstock when grafted at 10 cm height using the scion defoliated 5 days prior to grafting produced maximum of 14.46 and 11.58 leaves respectively during the 4th and 5th fortnights. From the 6th fortnight onwards the effect of various treatment combinations on leaf production was insignificant. Treatment combination of two months old rootstocks grafted at a height of 8 cm and scion defoliated 5 days prior to grafting recorded maximum number of leaves during the 6th, 7th and 10th fortnights. On the contrary, the treatment combination of three months old rootstock grafted at a height of 6 cm and scion defoliated 5 days prior to grafting produced minimum number of leaves during the 7th, 8th, 9th and 10th fortnights.

Table 17: Effect of age of rootstock, height of grafting and defoliation of scion on number of leaves produced at fortnightly intervals (Variety Neelum)

Age of rootstock (months)	Height of grafting (cm)	Period of scion defoliation (days)	Fortnights after drafting								
			2	3	4	5	6	7	8	9	10
1	6	5	-	-	-	-	-	-	-	-	-
		10	4.11	4.53	4.53	7.97	8.44	8.44	8.44	8.44	10.0
		15	6.31	7.22	7.41	7.88	7.18	7.69	7.69	9.56	10.52
	8	5	3.56	5.88	5.88	4.94	4.48	-	-	-	-
		10	7.35	7.35	7.97	10.38	10.38	10.38	10.38	10.38	12.59
		15	8.18	8.37	8.37	8.37	8.57	8.57	9.37	9.37	9.37
	10	5	-	-	-	-	-	-	-	-	-
		10	8.49	9.40	11.30	11.30	11.30	11.30	11.79	11.79	12.0
		15	8.74	8.74	8.97	8.97	8.97	8.97	9.53	9.53	9.53
2	6	5	5.60	5.70	5.88	8.14	8.14	8.68	8.68	9.42	10.31
		10	4.27	4.60	4.27	9.17	9.17	9.17	9.17	9.17	11.40
		15	6.46	6.98	6.98	5.92	8.81	8.81	9.69	9.69	11.05
	8	5	5.16	8.36	8.75	12.31	12.49	12.49	12.49	12.49	13.68
		10	6.29	6.45	6.45	8.59	8.84	9.43	9.43	9.43	9.43
		15	6.25	6.91	7.35	7.35	8.03	8.03	10.27	10.41	10.87
	10	5	4.69	6.40	6.40	8.35	9.19	9.19	9.19	10.05	10.05
		10	7.87	7.87	8.88	11.28	11.28	11.28	11.28	11.28	11.28
		15	4.98	8.43	9.49	10.36	10.36	10.94	13.08	13.08	13.08
3	6	5	5.15	5.15	6.59	5.47	5.93	6.63	6.63	7.07	7.72
		10	3.76	4.53	4.65	4.65	4.65	6.87	6.87	7.32	8.36
		15	6.28	5.95	6.64	6.64	7.66	7.66	8.35	8.35	10.01
	8	5	10.66	10.66	10.81	12.16	12.16	11.79	11.79	11.79	12.92
		10	6.40	6.40	6.24	6.24	8.95	8.95	9.33	10.03	10.03
		15	8.56	8.56	8.44	8.64	9.58	9.41	10.45	10.45	10.70
	10	5	-	10.91	14.46	11.58	11.58	11.58	11.88	11.88	11.88
		10	6.17	6.93	7.94	7.94	7.94	7.94	9.42	10.51	10.51
		15	7.17	6.47	7.52	7.52	7.52	8.45	8.45	8.98	9.85

The pooled data on the effect of age of rootstock on the number of leaves produced are furnished in Table 18 and Fig.7. The rootstock age had profound effect on the leaf production throughout the period of observation. From the table it is clear that three months old rootstock was superior during the 2nd and 4th fortnights (mean value being 6.77 and 8.14 respectively). But from the 5th fortnight onwards, the beneficial effect of two months old rootstock on leaf production is clearly evident from the table.

The results of the analysis of the pooled data on the effect of height of grafting on mean number of leaves produced are presented in Table 19 and Fig.8. Grafting at 10 cm height was found to be significantly beneficial over others in leaf production during all the fortnights of observation except 2nd and 10th fortnights. Grafting at a height of 8 cm proved better in 2nd and 10th fortnights when the leaf production was 6.94 and 11.19 respectively. Grafting at 6 cm height produced minimum leaf number throughout the period of observation.

The significant effect of defoliation of scion on leaf production is clearly amplified from the data furnished in Table 20 and Fig.9. From the Table the superiority of 5 days scion defoliation is very clear which produced maximum number of leaves throughout the observational period except during the 2nd

Table 18. Effect of age of rootstock on number of leaves produced at fortnightly intervals (Variety Neelum)

Age of rootstock (months)	Fortnights after grafting								
	2	3	4	5	6	7	8	9	10
1	6.68 ac	7.36 ac	7.78 a	8.54 a	8.47 a	9.23 a	9.53 ac	9.85 ac	10.67 a
2	5.73 b	6.86 b	7.16 b	9.05 b	9.59 b	9.78 b	10.36 b	10.56 b	11.24 b
3	6.77 c	7.28 c	8.14 c	7.87 c	8.44 a	8.81 c	9.24 c	9.59 c	10.22 c
C.D. (5%)									
1 and 2	0.23*	0.23*	0.24*	0.28*	0.28*	0.28*	0.29*	0.29*	0.31*
2 and 3	0.23*	0.22*	0.23*	0.26*	0.26*	0.25*	0.26*	0.26*	0.27*
1 and 3	0.24	0.24	0.25*	0.29*	0.28	0.28*	0.29	0.29	0.31*

(Treatments with same letter are not significantly different within the fortnight)

FIG. 7. EFFECT OF AGE OF ROOTSTOCK ON NUMBER OF LEAVES PRODUCED AT FORTNIGHTLY INTERVALS.

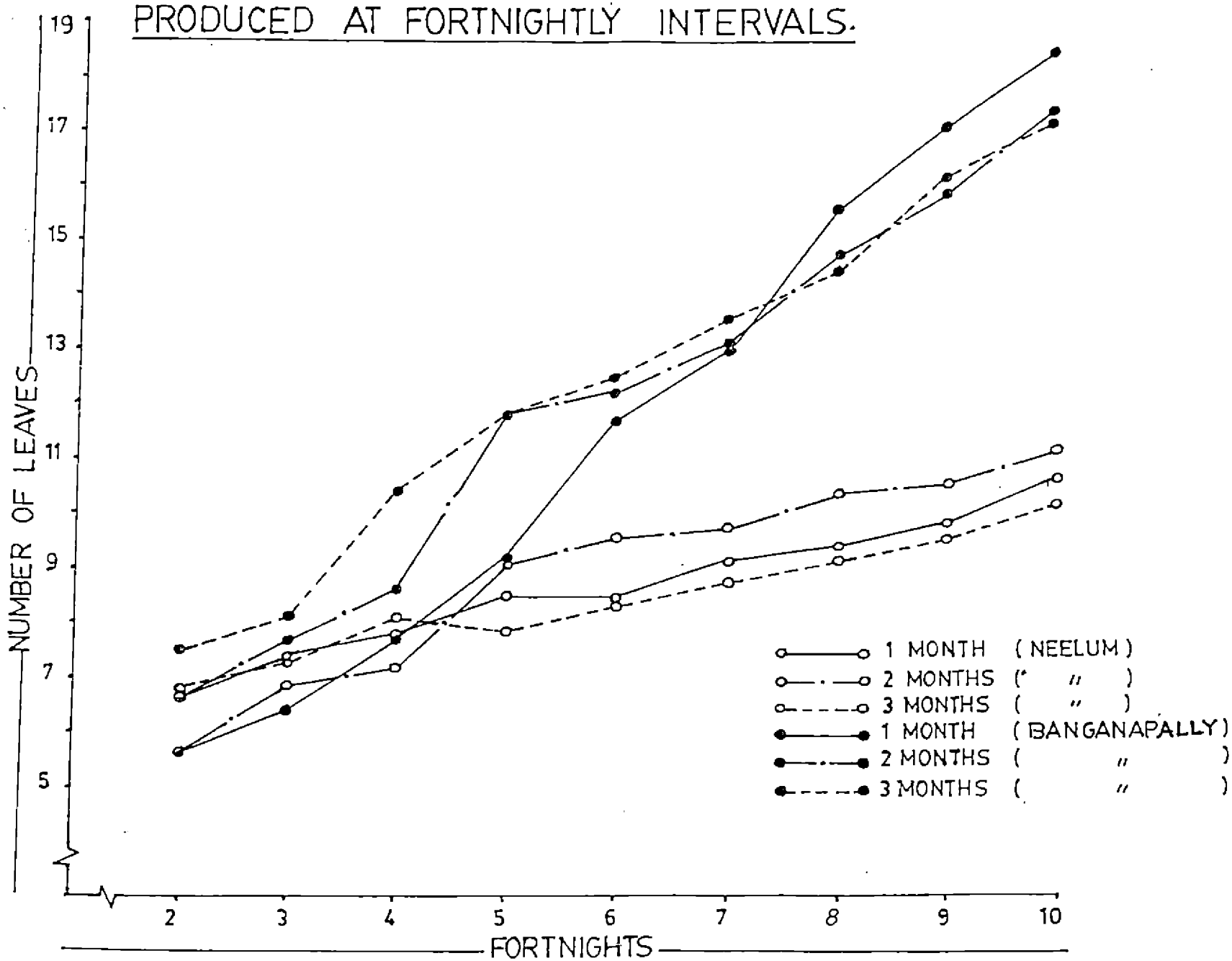


Table 19. Effect of height of grafting on number of leaves produced at fortnightly intervals (Variety Neelum)

Height of grafting (cm)	Fortnights after grafting								
	2	3	4	5	6	7	8	9	10
6	5.24 a	5.58 a	5.87 a	6.98 a	7.49 a	7.99 a	8.19 a	8.63 a	9.92 a
8	6.94 b	7.66 b	7.81 b	8.78 b	9.28 b	9.88 b	10.44 b	10.54 b	11.19 b
10	6.87 b	8.14 c	9.37 c	9.66 c	9.77 c	9.96 b	10.58 b	10.89 c	11.02 b
C.D. (5%)									
6 and 8	0.23*	0.22*	0.24*	0.28*	0.28*	0.27*	0.28*	0.28*	0.29*
8 and 10	0.22	0.22*	0.23*	0.26*	0.26*	0.26	0.27	0.26*	0.28
6 and 10	0.25*	0.23*	0.25*	0.28*	0.28*	0.28*	0.28*	0.28*	0.29*

(Treatments with same letter are not significantly different within the fortnight)

FIG. 8. EFFECT OF HEIGHT OF GRAFTING ON NUMBER OF LEAVES PRODUCED AT FORTNIGHTLY INTERVALS.

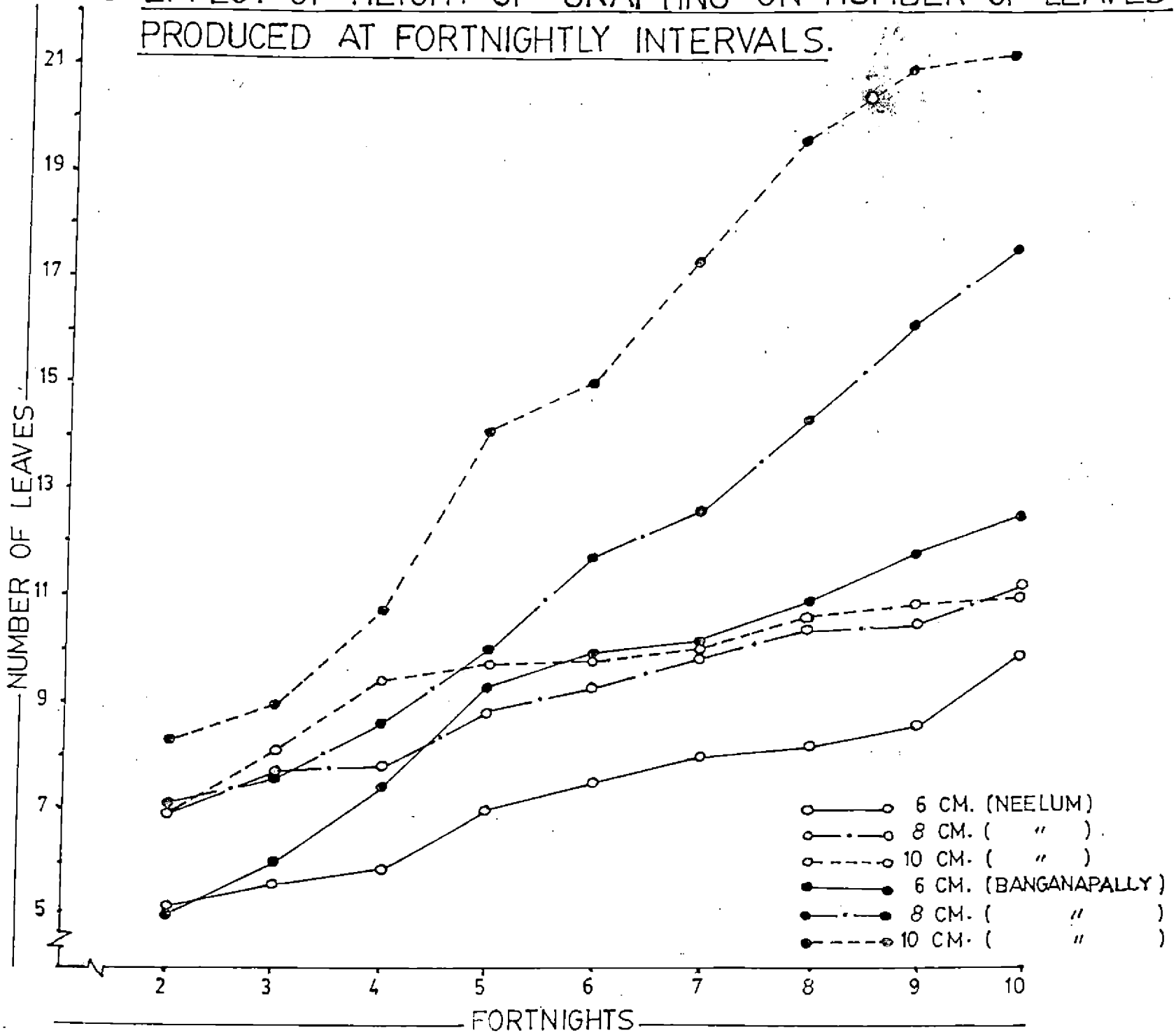
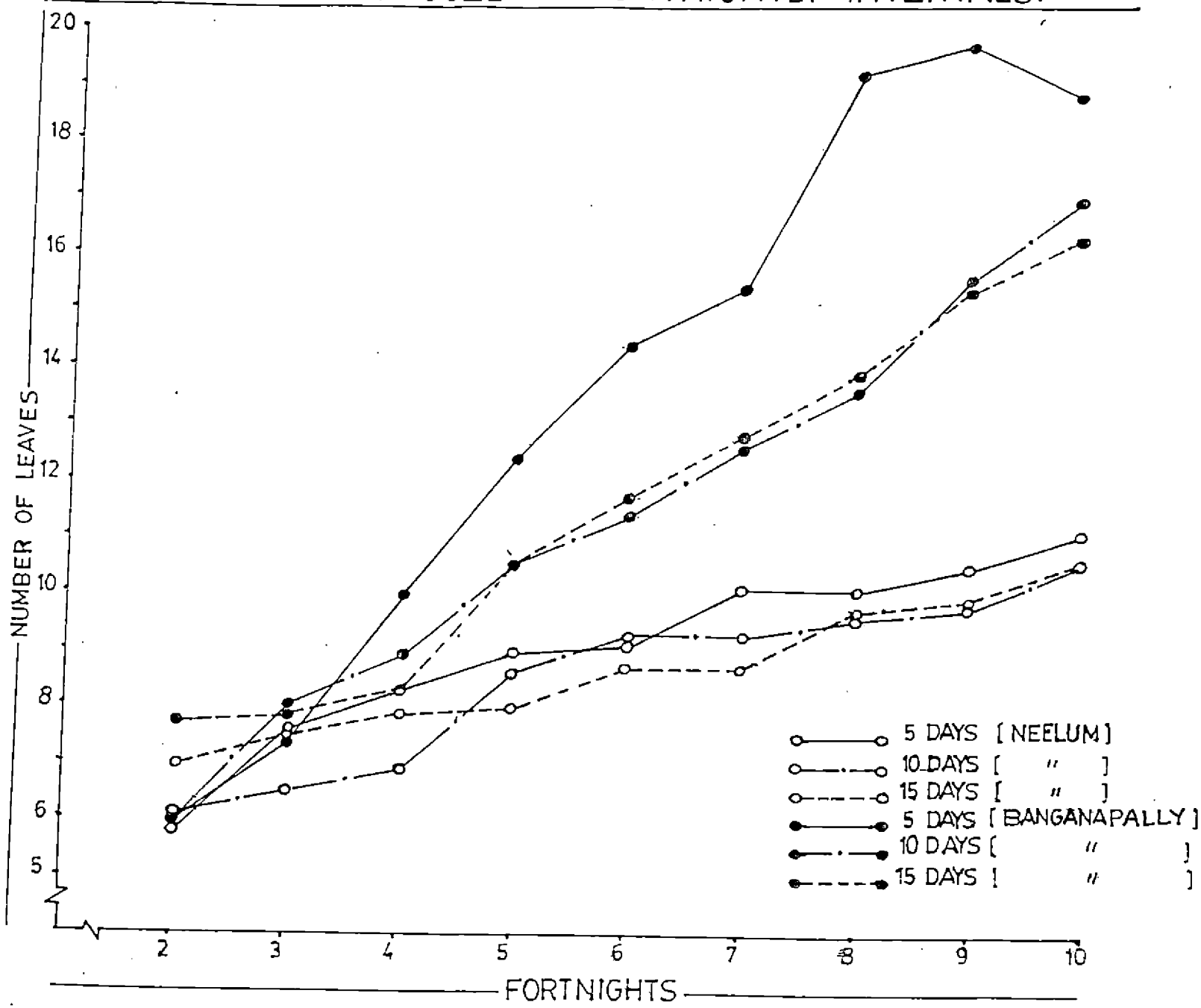


Table 20. Effect of defoliation of scion on number of leaves produced at fortnightly intervals (Variety Neelum)

Period of scion defoliation (days)	Fortnights after grafting								
	2	3	4	5	6	7	8	9	10
5	5.8 a	7.58 a	8.34 a	8.99 a	9.14 a	10.06 a	10.11 a	10.45 a	11.09 a
10	6.08 b	6.45 b	6.91 b	8.61 b	9.31 a	9.31 b	9.57 b	9.82 b	10.62 b
15	6.99 c	7.51 a	7.91 c	7.96 c	8.73 b	8.73 c	9.65 b	9.94 b	10.55 b
C.D. (5%)									
5 and 10	0.25*	0.24*	0.25*	0.29*	0.28	0.28*	0.29*	0.29*	0.31*
10 and 15	0.21*	0.21*	0.22*	0.26*	0.26*	0.25*	0.26	0.26	0.28
5 and 15	0.25*	0.24*	0.25*	0.28*	0.28*	.28*	0.29*	0.29*	0.30*

(Treatments with same letter are not significantly different within the fortnight)

FIG. 9. EFFECT OF DEFOLIATION OF SCION ON NUMBER OF LEAVES PRODUCED AT FORTNIGHTLY INTERVALS.



and 6th fortnights. The effect of defoliation of scion shoot 10 days and 15 days prior to grafting was found to be on par during the last three fortnights.

4.2.2.2 Variety Banganapally

The observations on the effect of different treatment combinations on leaf production are given in Table 21. The effect of various treatments on leaf production was significant throughout the course of investigation. Grafts prepared with scion shoots defoliated 5 days prior to grafting on rootstocks of two months old at a height of 8 cm produced maximum number of leaves of 11.50, 15.00, 17.75 and 17.50 respectively during the 3rd, 4th, 5th and 6th fortnights. Leaf production was least when grafting was done on two months old rootstock at a height of 6 cm using scion defoliated 10 days prior to grafting.

The pooled data showing the effect of different ages of rootstock on the mean number of leaves produced are shown in Table 22 and Fig.7. The effect of rootstock age on leaf production was found insignificant from the 5th fortnight onwards till the end of observational period. Maximum number of leaves were produced by three months old rootstock which was immediately followed by two months old rootstock. This trend was noticed upto 8th fortnight after which one month old stock

Table 21. Effect of age of rootstock, height of grafting and defoliation of scion on number of leaves produced at fortnightly intervals (Variety Banganapally)

Age of rootstock (months)	Height of grafting (cm)	Period of scion defoliation (days)	Fortnights after drafting								
			2	3	4	5	6	7	8	9	10
2	6	5	4.33	4.33	6.00	7.00	-	-	-	-	-
		10	2.00	-	-	-	-	-	-	-	-
		15	5.33	5.33	5.33	7.67	7.67	7.67	10.67	12.33	12.33
	8	5	5.00	6.27	8.67	8.00	11.33	11.67	18.00	18.50	18.50
		10	6.00	5.33	5.33	5.33	9.00	-	-	-	-
		15	8.00	8.00	9.00	10.20	12.60	12.60	15.40	15.20	17.40
	10	5	-	-	-	-	-	-	-	-	-
		10	6.00	6.00	9.50	12.50	14.50	14.50	17.00	17.00	20.50
		15	9.20	9.20	10.20	14.00	14.80	18.60	18.80	22.40	23.60
	6	5	7.00	9.00	9.00	14.33	14.67	15.00	17.33	18.33	18.33
		10	2.75	4.75	5.00	8.00	7.00	7.00	7.00	8.25	8.25
		15	5.00	4.00	4.25	6.00	7.33	7.33	7.00	7.00	8.50
	8	5	10.25	11.50	15.00	17.75	17.50	17.50	20.50	20.25	21.50
		10	5.00	5.00	6.00	7.33	9.0	9.67	9.67	13.33	15.33
		15	7.50	7.50	7.20	11.60	11.40	13.40	15.20	17.20	18.00
	10	5	7.50	9.00	11.50	15.00	14.00	17.50	21.00	21.50	17.00
		10	-	-	-	-	-	-	-	-	-
		15	8.60	10.60	10.60	14.20	16.60	17.80	21.00	21.00	22.00
3	6	5	2.00	4.25	-	-	-	-	-	-	-
		10	9.00	9.00	12.67	12.67	12.67	13.00	13.00	14.33	15.67
		15	7.50	7.50	9.40	9.40	10.00	10.40	10.60	10.60	11.60
	8	5	6.00	-	-	-	-	-	-	-	-
		10	9.40	9.40	11.20	13.80	13.80	13.80	13.80	16.80	18.80
		15	-	-	6.33	6.00	8.67	9.67	9.67	11.67	12.67
	10	5	-	-	-	-	-	-	-	-	-
		10	8.00	8.20	10.60	14.00	14.00	17.80	21.00	23.60	23.60
		15	10.40	10.20	12.00	15.00	15.80	17.60	19.00	20.00	21.00

Table 22 Effect of age of rootstock on number of leaves produced at fortnightly intervals (Variety Banganappally)

Age of rootstock (months)	Fortnights after grafting								
	2	3	4	5	6	7	8	9	10
1	5.73 a	6.35 a	7.72 a	9.24 a	11.65 a	13.01 a	15.57 a	17.09 a	18.47 a
2	6.7 ab	7.67 ab	8.57 ab	11.78 b	12.19 a	13.14 a	14.83 a	15.86 a	17.36 a
3	7.47 b	8.09 b	10.37 b	11.81 b	12.48 a	13.58 a	14.51 a	16.17 a	17.20 a
C.D. (5%)									
1 and 2	1.27	1.48	1.93	2.08*	2.28	2.28	2.67	2.94	3.09
2 and 3	1.30	1.49	1.88	1.98	2.12	2.05	2.37	2.61	2.76
1 and 3	1.28*	1.51*	1.99*	2.14*	2.33	2.33	2.67	2.94	3.09

(Treatments with same letter are not significantly different within the fortnight)

showed its superiority in this regard. The effects of one month, two months and three months old rootstocks on the leaf production were found to be on par from the 6th fortnight onwards.

The pooled data furnished in Table 23 and Fig.8 revealed that grafting at 10 cm height is significantly superior to other two treatments resulting in maximum leaf number throughout the course of observation. This was soon followed by the treatment where grafting was done at 8 cm height.

The data on the effect of defoliation of scion on the number of leaves produced are given in Table 24 and Fig.9. The treatments showed significant effect on the number of leaves produced throughout the course of experiment except during the 3rd, 4th, 5th and 10th fortnights. From 4th fortnight onwards maximum number of leaves was produced by the scion shoots defoliated 5 days prior to grafting. The effects of 10 and 15 days precuring were found to be on par during all the fortnights of observation except during the 2nd fortnight.

4.2.3 Girth of new growth

4.2.3.1 Variety Neelum

The different treatment combinations showed significant effect on the girth of new growth during the 2nd, 3rd and 4th

Table 23. Effect of height of grafting on number of leaves produced at fortnightly intervals (Variety Banganapally)

Height of grafting (cm)	Fortnights after grafting								
	2	3	4	5	6	7	8	9	10
6	4.99 a	6.02 a	7.38 a	9.29 a	9.89 a	10.07 a	10.93 a	11.80 a	12.45 a
8	7.14 b	7.57 b	8.59 ab	10.00 a	11.66 a	12.62 b	14.32 b	16.14 b	17.46 b
10	8.28 c	8.87 b	10.73 b	14.12 b	14.95 b	17.30 c	19.63 c	20.92 c	21.28 c
C.D. (5%)									
6 and 8	1.27*	1.51*	1.89	2.03	2.26	2.19*	2.6*	2.82*	3.02*
8 and 10	1.26*	1.54	1.91	2.03*	2.15*	2.12*	2.39*	2.59*	2.798*
6 and 10	1.26*	1.49*	2.01*	2.17*	2.34*	2.27*	2.67*	2.94*	3.097*

(Treatments with same letter are not significantly different within the fortnight)

Table 24. Effect of defoliation of scion on number of leaves produced at fortnightly intervals (Variety Banganappally)

Period of scion defoliation (days)	Fortnights after grafting								
	2	3	4	5	6	7	8	9	10
5	5.98 a	7.39 a	10.03 a	12.42 a	14.38 a	15.42 a	19.21 a	19.65 a	18.83 a
10	6.02 a	7.95 a	8.93 a	10.52 a	11.42 b	12.63 b	13.58 b	15.55 b	17.03 a
15	7.69 b	7.79 a	8.26 a	10.45 a	11.65 b	12.79 b	13.93 b	15.38 b	16.34 a
C.D. (5%)									
5 and 10	1.39	1.63	2.29	2.53	2.77*	2.73*	3.15*	3.47*	3.67
10 and 15	1.17*	1.42	1.79	1.89	2.03	2.03	2.31	2.55	2.69
5 and 15	1.34*	1.54	2.13	2.36	2.59*	2.51*	2.94*	3.24*	3.42

(Treatments with same letter are not significantly different within the fortnight)

fortnights (Table 25). The effect of one month old rootstock at a height of 8 cm with scion shoots defoliated 10 days prior to grafting was significantly superior over other treatments during 2nd fortnight. Though not significant, the same treatment combination recorded maximum girth of new growth during the 7th, 8th and 10th fortnights also. Grafting at 10 cm height recorded maximum values during the rest of the fortnights. The minimum girth was recorded by the treatment combination of two months old rootstock at a height of 6 cm with scion defoliated 5 days prior to grafting particularly during the 3rd, 4th, 5th, 8th, 9th and 10th fortnights.

The data on the effect of different ages of rootstock on the girth of new growth are presented in Table 26. From the Table it is clear that one month old rootstock resulted maximum girth of new growth in all the fortnights of observation except during the 2nd fortnight. The effects of two and three months old rootstocks on the girth of new growth were found to be on par in all fortnights except during 2nd and 4th fortnights.

The pooled data showing the influence of height of grafting on the girth of new growth are presented in Table 27. Grafting at 10 cm height was found to be significantly superior over grafting at 6 and 8 cm height in all the fortnights and this was immmediately followed by grafting at 8 cm height. The

Table 25. Effect of age of rootstock, height of grafting and defoliation of scion on girth of new growth (cm) at fortnightly intervals (Variety Neelum)

Age of rootstock (months)	Height of grafting (cm)	Period of scion defoliation (days)	Fortnights after grafting								
			2	3	4	5	6	7	8	9	10
1	6	5	-	-	-	-	-	-	-	-	-
		10	1.03	1.10	1.10	1.15	1.15	1.20	1.25	1.25	1.30
		15	0.95	1.18	1.24	1.26	1.30	1.30	1.32	1.32	1.42
	8	5	1.17	1.23	1.23	1.25	1.27	-	-	-	-
		10	1.28	1.32	1.36	1.38	1.42	1.42	1.50	1.50	1.56
		15	1.02	1.20	1.20	1.20	1.24	1.24	1.24	1.28	1.30
	10	5	-	-	-	-	-	-	-	-	-
		10	1.23	1.37	1.38	1.40	1.40	1.40	1.42	1.42	1.48
		15	1.16	1.30	1.36	1.36	1.36	1.38	1.40	1.42	1.42
2	6	5	1.10	1.00	1.02	1.12	1.20	1.22	1.22	1.22	1.24
		10	1.17	1.20	1.22	1.27	1.30	1.33	1.33	1.37	1.37
		15	1.02	1.05	1.12	1.12	1.15	1.15	1.17	1.20	1.28
	8	5	1.14	1.20	1.26	1.34	1.36	1.38	1.38	1.46	1.50
		10	1.11	1.11	1.22	1.28	1.30	1.32	1.32	1.34	1.36
		15	0.95	1.03	1.16	1.24	1.32	1.32	1.35	1.35	1.39
	10	5	1.18	1.20	1.22	1.26	1.30	1.32	1.32	1.38	1.42
		10	1.25	1.27	1.31	1.36	1.38	1.38	1.38	1.40	1.43
		15	1.25	1.30	1.36	1.36	1.36	1.38	1.38	1.38	1.44
3	6	5	1.03	1.07	1.19	1.29	1.29	1.37	1.37	1.40	1.42
		10	0.99	1.10	1.22	1.25	1.27	1.27	1.30	1.32	1.35
		15	1.07	1.10	1.17	1.17	1.20	1.20	1.20	1.25	1.25
	8	5	1.03	1.33	1.30	1.30	1.34	1.36	1.36	1.38	1.42
		10	1.06	1.12	1.24	1.24	1.24	1.24	1.26	1.28	1.28
		15	1.27	1.27	1.30	1.30	1.30	1.30	1.32	1.34	1.36
	10	5	-	1.20	1.35	1.32	1.37	1.37	1.37	1.40	1.45
		10	1.22	1.24	1.26	1.28	1.28	1.28	1.30	1.32	1.32
		15	1.12	1.10	1.18	1.20	1.20	1.24	1.26	1.28	1.36

Table 26. Effect of age of the rootstock on girth of new growth (cm) at fortnightly intervals (Variety Neelum)

Age of rootstock (months)	Fortnights after drafting								
	2	3	4	5	6	7	8	9	10
1	1.12 a	1.24 a	1.27 a	1.29 a	1.31 a	1.32 a	1.36 a	1.37 a	1.41 a
2	1.13 a	1.15 b	1.21 b	1.26 b	1.29 ab	1.31 ab	1.32 b	1.34 b	1.38 b
3	1.09 b	1.17 b	1.25 a	1.26 b	1.28 b	1.29 b	1.30 b	1.33 b	1.36 b
C.D. (5%)									
1 and 2	.027	.027*	.026*	.026*	.026	.027	.027*	.027*	.027*
2 and 3	.026*	.025	.025*	.024	.024	.024	.024	.024	.024
1 and 3	.029*	.028*	.027	.026*	.026*	.027*	.027*	.027*	.027*

(Treatments with same letter are not significantly different within the fortnight)

Table 27. Effect of height of grafting on girth of new growth (cm) at fortnightly intervals (Variety Neelum)

Height of grafting (cm)	Fortnights after drafting								
	2	3	4	5	6	7	8	9	10
6	1.05 a	1.10 a	1.16 a	1.20 a	1.23 a	1.26 a	1.27 a	1.29 a	1.33 a
8	1.11 b	1.20 b	1.25 b	1.28 b	1.31 b	1.32 b	1.34 b	1.37 b	1.39 b
10	1.20 c	1.25 c	1.31 c	1.32 c	1.33 b	1.34 b	1.35 b	1.38 b	1.42 c
C.D. (5%)									
6 and 8	.027*	.026*	.026*	.026*	.026*	.026*	.026*	.026*	.026*
8 and 10	.026*	.025*	.025*	.024*	.024	.025	.025	.025	.025*
6 and 10	.029*	.027*	.027*	.026*	.026*	.026*	.026*	.026*	.026*

(Treatments with same letter are not significantly different within the fortnight)

effect of grafting at 8 and 10 cm height was found to be on par during the 6th, 7th, 8th and 9th fortnights with regard to girth of new growth.

Data on the girth of new growth as influenced by the defoliation of the scion shoot is expressed in Table 28. Defoliation of scion 10 days prior to grafting recorded maximum girth of new growth especially during the early periods. However, from 6th fortnight onwards scions defoliated 5 days prior to grafting recorded maximum value.

4.2.3.2 Variety Banganapally

The observations recorded on the girth of new growth for various treatments are summarised in Table 29. It is clearly evident from the Table that there is significant difference with regard to the girth of new growth for different treatment combinations throughout the period of observation. Maximum girth of new growth was noticed when grafting was done on three months old rootstock at a height of 10 cm using scion defoliated 15 days before grafting during the 2nd, 3rd and 4th fortnights. From 5th fortnight onwards the treatment combination of two months old rootstock with 5 days prior defoliated scion grafted at 6 and 8 cm height ranked first with regard to this parameter.

Table 28. Effect of defoliation of scion on the girth of new growth (cm) at fortnightly intervals (Variety Neelum)

Period of scion defoliation (days)	Fortnights after drafting								
	2	3	4	5	6	7	8	9	10
5	1.11 ab	1.18 a	1.22 ab	1.27 a	1.30 a	1.34 a	1.34 a	1.37 a	1.41 a
10	1.15 b	1.20 a	1.26 b	1.29 a	1.30 a	1.32 a	1.34 a	1.36 a	1.38 b
15	1.09 a	1.17 b	1.23 a	1.25 b	1.27 b	1.28 b	1.29 b	1.31 b	1.36 b
C.D. (5%)									
5 and 10	.029*	.028	.027*	.026	.026	.027	.027	.027	.027*
10 and 15	.025*	.025*	.024*	.024*	.024*	.024*	.024*	.024*	.024
5 and 15	.029	.027	.027	.026	.026*	.027*	.027*	.027*	.027*

(Treatments with same letter are not significantly different within the fortnights)

Table 29. Effect of age of rootstock, height of grafting and defoliation of scion on girth of new growth (cm) at fortnightly intervals (Variety Banganapally)

Age of rootstock (months)	Height of grafting (cm)	Period of scion defoliation (days)	Fortnights after grafting								
			2	3	4	5	6	7	8	9	10
1	6	5	0.67	0.73	0.93	1.00	-	-	-	-	-
		10	0.63	-	-	-	-	-	-	-	-
		15	0.95	1.13	1.13	1.13	1.20	1.23	1.27	1.27	1.33
	8	5	0.93	1.10	1.17	1.27	1.30	1.30	1.30	1.35	1.35
		10	0.57	0.63	0.93	1.13	1.20	-	-	-	-
		15	0.92	1.14	1.20	1.26	1.24	1.28	1.28	1.26	1.34
	10	5	-	-	-	-	-	-	-	-	-
		10	0.75	0.85	1.15	1.30	1.30	1.40	1.40	1.40	1.45
		15	1.00	1.16	1.16	1.20	1.22	1.24	1.24	1.34	1.34
2	6	5	1.13	1.23	1.30	1.43	1.43	1.43	1.43	1.47	1.53
		10	1.00	1.03	1.10	1.23	1.23	1.25	1.25	1.28	1.28
		15	0.80	0.85	1.05	1.08	1.07	1.07	-	-	-
	8	5	1.05	1.20	1.28	1.43	1.45	1.45	1.45	1.45	1.55
		10	0.97	1.03	1.17	1.17	1.17	1.17	1.20	1.23	1.30
		15	1.08	1.13	1.16	1.22	1.26	1.32	1.34	1.36	1.36
	10	5	1.05	1.20	1.20	1.40	1.40	1.40	1.45	1.45	1.50
		10	-	-	-	-	-	-	-	-	-
		15	1.22	1.26	1.26	1.32	1.34	1.36	1.46	1.46	1.48
3	6	5	0.65	0.83	-	-	-	-	-	-	-
		10	1.00	1.27	1.30	1.30	1.37	1.37	1.40	1.43	1.43
		15	1.03	1.15	1.18	1.20	1.20	1.22	1.22	1.24	1.26
	8	5	0.75	-	-	-	-	-	-	-	-
		10	0.88	0.98	1.04	1.18	1.22	1.22	1.24	1.24	1.28
		15	-	0.85	0.85	1.10	1.17	1.30	1.40	1.43	1.43
	10	5	-	-	-	-	-	-	-	-	-
		10	0.94	1.08	1.12	1.26	1.26	1.28	1.36	1.36	1.38
		15	1.22	1.32	1.34	1.34	1.34	1.38	1.38	1.46	1.48

The effect of different ages of rootstock on the girth of new growth was not significant throughout the course of observation except during 2nd and 3rd fortnights as shown in Table 30. In the second fortnight, two months old rootstock was found to be significantly superior over one and three months resulting a maximum mean girth of 1.04 cm. Interestingly, there was no significant difference between the treatment effect during rest of the period.

In the present study the girth of new growth was not found to be influenced significantly by grafting height throughout the course of investigation (Table 31). However, during the 2nd, 3rd and 8th fortnights, grafting at 10 cm height was found significantly superior over other treatments producing maximum girth of 1.03, 1.15 and 1.38 cm respectively.

Data showing the effect of defoliation on mean girth of new growth are furnished in Table 32. The observations on 6th fortnight indicated high significant difference between the treatments. The scion defoliated 15 days prior to grafting recorded maximum girth of new growth (1.31 cm) followed by 5 days prior defoliation (1.25 cm) during the 6th fortnight.

Table 30. Effect of age of rootstock on the girth of new growth (cm) at fortnightly intervals (Variety Banganappally)

Age of rootstock (months)	Fortnights after grafting								
	2	3	4	5	6	7	8	9	10
1	0.80 a	0.96 a	1.095 a	1.18 a	1.24 a	1.29 a	1.29 a	1.32 a	1.36 a
2	1.04 b	1.12 b	1.19 a	1.29 a	1.29 a	1.31 a	1.37 a	1.39 a	1.43 a
3	0.92 c	1.06 b	1.14 a	1.23 a	1.26 a	1.29 a	1.33 a	1.36 a	1.38 a
C.D. (5%)									
1 and 2	0.09*	0.069*	0.59	0.485	0.056	0.06	0.08	0.08	0.08
2 and 3	0.09*	0.069	0.59	0.474	0.053	0.053	0.069	0.069	0.069
1 and 3	0.09*	0.072*	0.614	0.506	0.06	0.060	0.08	0.08	0.080

(Treatments with same letter are not significantly different within the fortnight)

Table 31. Effect of height of grafting on the girth of new growth (cm) at fortnightly intervals (Variety Banganapally)

Height of grafting (cm)	Fortnights after grafting								
	2	3	4	5	6	7	8	9	10
6	0.87 a	1.03 a	1.14 a	1.195 a	1.25 a	1.26 a	1.31 a	1.34 ab	1.37 a
8	0.89 a	1.01 a	1.10 ab	1.21 a	1.25 a	1.29 ab	1.32 a	1.33 a	1.37 a
10	1.03 b	1.15 b	1.21 b	1.30 a	1.31 a	1.34 b	1.38 a	1.41 b	1.44 a
C.D. (5%)									
6 and 8	0.09	0.07	0.58	0.48	0.06	0.06	0.08	0.077	0.078
8 and 10	0.09*	0.07*	0.59	0.48	0.06	0.06	0.07	0.075*	0.072
6 and 10	0.09*	0.07*	0.62*	0.51	0.06	0.06*	0.08	0.082	0.08

(Treatments with same letter are not significantly different within the fortnight)

Table 32. Effect of defoliation of scion on the girth of new growth (cm) at fortnightly intervals (Variety Banganappally)

Period of scion defoliation (days)	Fortnights after grafting								
	2	3	4	5	6	7	8	9	10
5	0.85 a	1.05 a	1.14 a	1.195 a	1.25 a	1.25 a	1.31 a	1.34 ab	1.37 a
10	0.84 a	1.00 a	1.10 a	1.21 a	1.11 b	1.29 ab	1.32 a	1.33 a	1.37 a
15	1.03 b	1.15 b	1.21 a	1.30 a	1.31 c	1.34 b	1.38 a	1.41 b	1.44 a
C.D. (5%)									
5 and 10	0.09	0.08	0.70	0.58	0.07*	0.07	0.09	0.09	0.09
10 and 15	0.08*	0.06*	0.55	0.45	0.05*	0.05	0.07	0.07*	0.09
5 and 15	0.09*	0.07*	0.66	0.55	0.07*	0.07*	0.09	0.09	0.09

(Treatments with same letter are not significantly different within the fortnight)

4.2.4 Girth of scion

4.2.4.1 Variety Neelum

The observations on the effect of different treatment combinations on the girth of scion are presented in Table 33. The treatments did not differ significantly throughout the period except during 4th fortnight. During 4th fortnight, treatment combination of one month old rootstock grafted at 6 cm height and 15 days defoliated scion was found to be significantly superior to other treatments giving maximum scion girth (2.13 cm). The combination of two months old rootstock grafted at 6 cm height and 10 days prior defoliated scion recorded least scion girth from 5th fortnight onwards till the end of the study.

The significant effect of various ages of rootstock on the mean girth of scion shoot is evident from the data furnished in Table 34. Three months old rootstock resulted in maximum scion girth in all the fortnights studied. The effect of two months old rootstock was highly inferior throughout the study period.

The data furnished in Table 35 indicate that grafts prepared at 10 cm height tended to produce maximum mean girth of scion shoot throughout the course of experimentation. However,

Table 33. Effect of age of rootstock, height of grafting and defoliation of scion on girth of scion (cm) at fortnightly intervals (Variety Neelum)

Age of rootstock (months)	Height of grafting (cm)	Period of scion defoliation (days)	Fortnights after grafting								
			2	3	4	5	6	7	8	9	10
1	6	5	1.60	1.60	1.62	-	-	-	-	-	-
		10	1.82	1.82	1.82	1.84	1.84	1.87	1.90	1.90	1.95
		15	1.66	2.07	2.13	2.13	2.21	2.21	2.21	2.23	2.29
	8	5	1.63	1.63	1.67	1.87	1.87	-	-	-	-
		10	1.82	1.82	1.84	1.90	1.96	1.98	2.02	2.08	2.14
		15	1.63	1.75	1.93	1.93	1.93	1.95	1.97	2.01	2.03
	10	5	1.82	1.90	1.92	1.94	-	-	-	-	-
		10	1.68	1.74	1.75	1.75	1.78	1.78	1.86	1.86	1.89
		15	1.84	1.88	1.94	1.94	1.94	1.98	2.02	2.04	2.04
2	6	5	1.74	1.71	1.73	1.81	1.85	1.85	1.85	1.89	1.89
		10	1.62	1.66	1.66	1.70	1.70	1.73	1.73	1.73	1.80
		15	1.71	1.71	1.71	1.74	1.76	1.76	1.82	1.82	1.84
	8	5	1.72	1.72	1.82	1.82	1.90	1.90	1.90	1.90	2.02
		10	1.79	1.81	1.81	1.87	1.99	2.01	2.01	2.03	2.05
		15	1.76	1.76	1.80	1.82	1.88	1.90	1.94	1.94	2.03
	10	5	1.86	1.86	1.86	1.90	1.90	1.94	1.94	2.04	2.06
		10	1.84	1.86	1.88	1.90	1.96	2.02	2.02	2.15	2.17
		15	1.78	1.80	1.84	1.88	1.90	1.92	1.96	1.98	2.00
	6	5	1.78	1.82	1.86	1.95	2.00	2.05	2.05	2.05	2.05
		10	1.85	1.85	1.95	1.95	1.99	1.92	1.96	2.01	2.04
		15	1.67	1.69	1.71	1.71	1.77	1.77	1.80	1.87	1.87
	8	5	1.99	2.03	2.05	2.07	2.09	2.09	2.09	2.13	2.20
		10	1.86	1.88	1.92	1.92	1.92	1.92	1.98	2.02	2.02
		15	1.94	1.95	1.95	2.01	2.02	2.02	2.02	2.04	2.12
	10	5	1.90	1.94	2.07	2.09	2.08	2.08	2.12	2.12	2.14
		10	1.94	1.94	2.08	2.08	2.10	2.10	2.12	2.18	2.18
		15	1.86	1.88	1.88	1.90	1.92	1.96	2.00	2.00	2.04

Table 34. Effect of age of rootstock on the girth of scion (cm) at fortnightly intervals (Variety Neelum)

Age of rootstock (months)	Fortnights after grafting								
	2	3	4	5	6	7	8	9	10
1	1.72 a	1.80 a	1.85 a	1.91 a	1.93 a	1.96 a	2.00 a	2.00 a	2.06 a
2	1.76 b	1.77 b	1.79 b	1.83 b	1.87 b	1.89 b	1.91 b	1.95 b	1.98 b
3	1.87 c	1.89 c	1.94 c	1.96 c	1.99 c	1.99 a	2.02 a	2.05 c	2.07 a
C.D. (5%)									
1 and 2	.029*	.029*	.029*	.044*	.032*	.037*	.038*	.035*	.035*
2 and 3	.029*	.029*	.029*	.042*	.030*	.034*	.034	.031*	.035*
1 and 3	.029*	.029*	.029*	.044*	.033*	.037	.038	.035*	.035

(Treatments with same letter are not significantly different within the fortnights)

Table 35. Effect of height of grafting on the girth of scion (cm) at fortnightly intervals (Variety Neelum)

Height of grafting (cm)	Fortnights after grafting								
	2	3	4	5	6	7	8	9	10
6	1.72 a	1.77 a	1.79 a	1.85 a	1.89 a	1.89 a	1.92 a	1.94 a	1.97 a
8	1.79 b	1.82 b	1.87 b	1.91 b	1.95 b	1.97 b	1.99 b	2.02 b	2.08 a
10	1.84 c	1.87 c	1.91 c	1.93 b	1.95 b	1.97 b	2.01 b	2.05 b	2.08 a
C.D. (5%)									
6 and 8	.029*	.029*	.029*	.044*	.032*	.036*	.037*	.037*	.037
8 and 10	.029*	.029*	.029*	.042	.031	.035	.035	.035	.035
6 and 10	.029*	.029*	.029*	.044*	.032*	.036*	.037*	.037*	0.037

(Treatments with same letter are not significantly different within the fortnight)

this treatment was on par with the treatment where grafting was done at 8 cm height during 5th, 6th, 7th, 8th, 9th and 10th fortnights. The treatment where grafting was done at a height of 6 cm ranked least with regard to this parameter throughout the course of study.

Table 36 represents the effect of different days of scion defoliation on the girth of scion. All the three treatments were significantly different during the 2nd fortnight. During the 3rd and 4th fortnights, scions defoliated 15 days before grafting recorded a maximum scion girth of 1.83 cm and 1.88 cm respectively. Thereafter scions defoliated 5 days before grafting topped first in this regard.

4.2.4.2 Variety Banganapally

The data on the girth of scion shoot at fortnightly intervals for various treatment combinations are tabulated in Table 37. Analysis of variance of the data revealed that there is high significant difference between different treatment combinations throughout the course of study. The treatment combination of two months old rootstock with 5 days prior defoliated scion when grafted at 8 cm height recorded maximum scion girth throughout the observational period. This treatment is statistically on par with the treatment combination of three months old rootstock when grafted at 10 cm height with 15 days

Table 36. Effect of defoliation of scion on the girth of scion (cm) at fortnightly intervals (Variety Neelum)

Period of scion defoliation (days)	Fortnights after grafting								
	2	3	4	5	6	7	8	9	10
5	1.78 a	1.80 a	1.84 a	1.93 a	1.96 a	1.99 a	1.99 a	2.03 a	2.06 a
10	1.80 b	1.82 ab	1.86 ab	1.88 b	1.92 b	1.93 b	1.96 a	2.00 ab	2.03 a
15	1.76 c	1.83 b	1.88 b	1.89 ab	1.93 ab	1.94 b	1.97 a	1.99 b	2.03 a
C.D. (5%)									
5 and 10	.029*	.029	.029	.044*	.032*	.037*	.038	.035	.035
10 and 15	.029*	.029	.029	.042	.030	.034	.034	.031	.031
5 and 15	.029*	.029*	.029*	.044	.033	.037*	.037	.034*	.034

(Treatments with same letter are not significantly different within the fortnight)

Table 37. Effect of age of rootstock, height of grafting and defoliation of scion on girth of scion (cm) at fortnightly intervals (Variety Banganapally)

Age of rootstock (months)	Height of grafting (cm)	Period of scion defoliation (days)	Fortnights after grafting								
			2	3	4	5	6	7	8	9	10
1	6	5	1.62	1.58	1.57	1.60	-	-	-	-	-
		10	1.64	-	-	-	-	-	-	-	-
		15	1.96	2.02	2.02	2.02	2.06	2.08	2.08	2.14	2.20
	8	5	1.66	1.66	1.70	1.73	1.73	1.73	1.85	1.95	-
		10	1.64	1.64	1.64	1.80	1.80	-	-	-	-
		15	1.58	1.66	1.74	1.74	1.76	1.82	1.80	1.84*	1.86
	10	5	1.68	1.68	1.68	-	-	-	-	-	-
		10	1.62	1.73	1.75	1.85	1.85	1.85	1.85	1.95	1.95
		15	1.50	1.70	1.74	1.80	1.80	1.84	1.86	1.90	1.88
2	6	5	2.07	2.07	2.13	2.13	2.13	2.13	2.17	2.17	2.17
		10	1.43	1.43	1.50	1.53	1.53	1.53	1.55	1.55	1.60
		15	1.62	1.58	1.60	1.60	1.60	1.60	-	-	-
	8	5	2.26	2.28	2.23	2.30	2.38	2.40	2.40	2.40	2.42
		10	1.68	1.68	1.74	1.76	1.82	1.82	1.82	1.84	1.88
		15	1.64	1.70	1.74	1.76	1.88	1.92	1.94	1.98	2.02
	10	5	1.52	1.62	1.62	1.66	1.66	1.68	1.70	1.74	1.74
		10	1.68	1.72	1.78	1.86	1.88	1.90	1.90	1.94	1.98
		15	1.72	1.74	1.78	1.84	1.84	1.88	1.88	1.88	2.00
3	6	5	1.38	1.53	-	-	-	-	-	-	-
		10	1.94	2.00	2.00	2.00	2.05	2.06	2.08	2.16	2.16
		15	1.76	1.80	1.82	1.84	1.90	1.94	1.98	2.00	2.04
	8	5	1.90	2.03	-	-	-	-	-	-	-
		10	1.64	1.68	1.68	1.68	1.74	1.74	1.80	1.86	1.86
		15	1.66	1.66	1.70	1.74	1.76	1.76	1.78	1.88	1.90
	10	5	1.60	-	-	-	-	-	-	-	-
		10	1.84	1.94	1.94	1.98	2.02	2.02	2.04	2.08	2.10
		15	2.04	2.10	2.12	2.14	2.14	2.16	2.16	2.26	2.22

prior defoliated scion shoot. The same trend was noticed throughout the observational period but for 7th fortnight. Minimum increment in girth of scion was observed when grafting was done at a height of 6 cm on stock of two months old using 10 days prior defoliated scion.

The effect of age of rootstock on girth of scion is evident from the data summarized in Table 38. Though the treatment effects were on par from the 5th fortnight onwards, three months old rootstock tended to produce more girth throughout the experimental period and this was followed by two months old rootstock.

The pooled data on the effect of height of grafting on scion shoot is given in Table 39. The grafting height did not affect the scion girth significantly throughout the period of observation.

The effect of defoliation periods on girth of scion shoot is clearly evident from Table 40. Though the effect of three scion defoliations was found not significantly different in all the fortnights, scions defoliated 5 days before grafting tended to record maximum girth increment in all the fortnights of observation and this was immediately followed by grafting using 15 days prior defoliated scions.

Table 38. Effect of age of rootstock on girth of scion (cm) at fortnightly intervals (Variety Banganappally)

Age of rootstock (months)	(Fortnights after grafting)								
	2	3	4	5	6	7	8	9	10
1	1.66 a	1.71 a	1.73 a	1.79 a	1.83 a	1.86 a	1.89 a	1.96 a	1.97 a
2	1.74 b	1.76 a	1.79 a	1.83 ab	1.86 a	1.87 a	1.92 a	1.95 a	1.98 a
3	1.75 b	1.84 b	1.88 b	1.90 b	1.93 a	1.95 a	1.97 a	2.04 a	2.05 a
C.D. (5%)									
1 and 2	0.079*	0.723	0.086	0.093	0.097	0.104	0.111	0.109	0.111
2 and 3	0.079	0.723*	0.089*	0.089	0.089	0.092	0.097	0.095	0.090
1 and 3	0.079*	0.741*	0.093*	0.101*	0.103	0.109	0.120	0.114	0.114

(Treatments with same letter are not significantly different within the fortnight)

Table 39. Effect of height of grafting on girth of scion (cm) at fortnightly intervals (Variety Banganapally)

Height of grafting (cm)	Fortnights after grafting								
	2	3	4	5	6	7	8	9	10
6	1.71 a	1.75 a	1.81 a	1.82 a	1.88 a	1.89 a	1.97 a	2.00 a	2.03 a
8	1.74 a	1.77 a	1.77 a	1.79 a	1.86 a	1.88 a	1.92 a	1.96 a	1.99 a
10	1.69 a	1.78 a	1.80 a	1.88 a	1.88 a	1.90 a	1.91 a	1.98 a	1.98 a
C.D. (5%)									
6 and 8	0.079	0.701	0.089	0.093	0.097	0.099	0.105	0.107	0.106
8 and 10	0.079	0.715	0.079	0.091	0.089	0.093	0.097	0.979	0.096
6 and 10	0.079	0.727	0.089	0.095	0.097	0.102	0.105	0.107	0.105

(Treatments with same letter are not significantly different within the fortnight)

Table 40. Effect of defoliation of scion on girth of scion (cm) at fortnightly intervals (Variety Banganappally)

Period of scion defoliation (days)	Fortnights after grafting								
	2	3	4	5	6	7	8	9	10
5	1.73 a	1.79 a	1.82 a	1.88 a	1.98 a	1.99 ac	2.03 ac	2.07 ac	2.11 ac
10	1.67 a	1.73 a	1.75 a	1.81 a	1.84 b	1.85 b	1.86 b	1.91 b	1.94 b
15	1.72 a	1.77 a	1.81 a	1.83 a	1.86 b	1.89 ba	1.94 ba	1.99 ba	2.02 ba
C.D. (5%)									
5 and 10	0.079	0.757	0.097	0.109	0.108*	0.116*	0.135*	0.123*	0.125*
10 and 15	0.0769	0.711	0.084	0.084	0.085	0.089	0.094	0.093	0.092
5 and 15	0.079	0.728	0.093	0.104	0.104*	0.111	0.119	0.118	0.122

(Treatments with same letter are not significantly different within the fortnight)

4.2.5 Girth of rootstock

4.2.5.1 Variety Neelum

The observations recorded on the girth of rootstock are presented in Table 41. From the Table, it is evident that there is significant difference with regard to this parameter for different treatments tried. Maximum girth of rootstock was noticed when grafting was done on three months old rootstock at a height of 10 cm using scions defoliated 5 days prior to grafting. The effect of this treatment was not statistically significant compared to treatments where grafting was done on three months old stock at a height of 8 and 10 cm using 10 and 15 days prior defoliated scion. In general initially the least girth of rootstock was recorded by the treatment combination of one month old rootstock with scions defoliated 5 days and grafted at 6 cm height. Gradually towards the end of the study the combination of two months old stock grafted at 6 cm height using 10 days prior defoliated scion recorded the least value.

Table 42 shows the effect of different rootstock ages on the girth of rootstock. From the Table it could be seen that three months old rootstock produced maximum girth in all periods of observation. The effect of three ages of rootstock were found to be on par during the 6th fortnight of observation.

Table 41. Effect of age of rootstock, height of grafting and defoliation of scion on girth of rootstock (cm) at fortnightly intervals (Variety Neelum)

Age of rootstock (months)	Height of grafting (cm)	Period of scion defoliation (days)	Fortnights after grafting								
			2	3	4	5	6	7	8	9	10
1	6	5	1.50	1.50	1.52	-	-	-	-	-	-
		10	1.60	1.70	1.70	1.72	1.72	1.77	1.77	1.80	1.90
		15	1.74	2.07	2.20	2.20	2.20	2.32	2.32	2.32	2.34
	8	5	1.52	1.52	1.54	1.60	1.60	-	-	-	-
		10	1.68	1.74	1.74	1.82	1.92	1.98	2.02	2.04	2.06
		15	1.73	1.87	1.99	1.99	1.99	2.01	2.09	2.16	2.30
	10	5	1.76	1.76	1.88	1.90	-	-	-	-	-
		10	1.70	1.79	1.82	1.82	1.82	1.82	1.90	1.92	1.96
		15	1.86	1.86	1.88	1.88	1.98	2.06	2.06	2.10	2.12
2	6	5	1.69	1.69	1.69	1.77	1.79	1.79	1.79	1.83	1.87
		10	1.50	1.66	1.66	1.70	1.70	1.73	1.73	1.73	1.80
		15	1.74	1.74	1.76	1.80	1.80	1.82	1.84	1.93	1.93
	8	5	1.70	1.74	1.82	1.86	1.90	1.90	1.90	1.94	1.98
		10	1.76	1.76	1.77	1.87	1.89	1.91	1.95	1.99	2.01
		15	1.74	1.74	1.78	1.84	1.88	1.92	1.97	1.97	2.03
	10	5	1.89	1.95	1.95	1.97	2.03	2.03	2.05	2.07	2.17
		10	1.83	1.83	1.87	1.96	2.07	2.09	2.09	2.17	2.29
		15	1.80	1.82	1.90	1.92	1.96	1.96	2.05	2.07	2.13
3	6	5	1.70	1.76	1.76	1.75	1.82	1.87	1.87	1.92	1.92
		10	1.84	1.84	1.90	1.90	1.92	1.90	1.90	1.95	1.97
		15	1.68	1.70	1.72	1.72	1.77	1.80	1.82	1.85	1.87
	8	5	2.03	2.05	2.05	2.09	2.19	2.21	2.21	2.21	2.25
		10	1.88	1.90	1.98	1.98	2.00	2.00	2.02	2.06	2.06
		15	2.00	2.00	2.04	2.16	2.21	2.21	2.21	2.23	2.29
	10	5	2.11	2.15	2.27	2.29	2.34	2.24	2.24	2.24	2.48
		10	1.94	1.94	2.06	2.10	2.10	2.10	2.10	2.16	2.18
		15	2.01	2.13	2.13	2.15	2.15	2.24	2.26	2.06	2.34

Table 42. Effect of age of rootstock on girth of rootstock (cm) at fortnightly intervals (Variety Neelum)

Age of rootstock (months)	Fortnights after grafting								
	2	3	4	5	6	7	8	9	10
1	1.68 a	1.76 a	1.81 a	1.87 a	1.89 a	1.99 ac	2.03 a	2.06 a	2.11 a
2	1.74 b	1.77 a	1.80 a	1.85 a	1.89 a	1.91 b	1.93 ab	1.97 ab	2.02 b
3	1.91 c	1.94 b	1.99 b	2.02 b	2.05 a	2.08 bc	2.09 b	2.11 b	2.15 a
C.D. (5%)									
1 and 2	.029*	.029	.029	.031	.035	.038*	.041	.041	.041*
2 and 3	.029*	.029*	.029*	.029*	.033	.034	.036	.036	.036*
1 and 3	.029*	.029*	.029*	.031*	.036	.038	.041*	.041*	.041

(Treatments with same letter are not significantly different within the fortnight)

The beneficial effect of grafting height on its girth is clearly evident from the data furnished in Table 43. Grafting at 10 cm height produced maximum girth of rootstock throughout the study period and was significantly superior to all other treatments. This was soon followed by the treatment where grafting was done at 8 cm height.

The data on the effect of defoliation of scion on the girth of rootstock are furnished in Table 44. From the Table it is evident that the scions defoliated 15 days prior to grafting resulted in maximum rootstock girth throughout the period of investigation.

4.2.5.2 Variety Banganapally

The observations at fortnightly intervals for various treatment combinations on girth of rootstock are tabulated in Table 45. Analysis of variance of the data revealed high significant difference in the girth of rootstock for different treatment combinations throughout the study period. The treatment combination of three months old rootstock grafted at a height of 6 cm with 10 days prior defoliated scion recorded maximum rootstock girth throughout the study period except during the 2nd fortnight.

Table 43. Effect of height of grafting on girth of grafting (cm) at fortnightly intervals (Variety Neelum)

Height of grafting (cm)	Fortnights after grafting								
	2	3	4	5	6	7	8	9	10
6	1.67 a	1.74 a	1.77 a	1.82 a	1.84 a	1.88 a	1.88 a	1.92 a	1.95 a
8	1.78 b	1.81 b	1.86 b	1.91 b	1.95 b	2.02 b	2.05 b	2.08 b	2.12 b
10	1.88 c	1.91 c	1.98 c	1.99 c	2.07 c	2.09 c	2.12 c	2.14 c	2.21 c
C.D. (5%)									
6 and 8	.029*	.029*	.029*	.031*	.035*	.036*	.039*	.039*	.039*
8 and 10	.029*	.029*	.029*	.030*	.034*	.035*	.037*	.037*	.037*
6 and 10	.029*	.029*	.029*	.031*	.035*	.036*	.039*	.039*	.037*

(Treatments with same letter are not significantly different within the fortnight)

Table 44. Effect of defoliation of scion on girth of rootstock (cm) at fortnightly intervals (Variety Neelum)

Period of scion defoliation (days)	Fortnights after grafting								
	2	3	4	5	6	7	8	9	10
5	1.77 a	1.79 a	1.83 a	1.90 a	1.95 a	2.03 a	2.04 a	2.06 a	2.11 a
10	1.78 a	1.79 a	1.84 a	1.87 b	1.90 b	1.92 b	1.95 b	1.98 b	2.03 b
15	1.81 b	1.88 b	1.93 b	1.96 c	1.99 c	2.04 a	2.07 a	2.09 a	2.15 a
C.D. (5%)									
5 and 10	.029	.029	.029	.031*	.036*	.038*	.041*	.041*	.041*
10 and 15	.029*	.029*	.029*	.029*	.033*	.034*	.036*	.037*	.037*
5 and 15	.029*	.029*	.029*	.031*	.036*	.037	.039	.039	.041

(Treatments with same letter are not significantly different within the fortnight)

Table 45. Effect of age of rootstock, height of grafting and defoliation of scion on girth of rootstock (cm) at fortnightly intervals (Variety Banganapally)

Age of rootstock (months)	Height of grafting (cm)	Period of scion defoliation (days)	Fortnights after grafting								
			2	3	4	5	6	7	8	9	10
1	6	5	1.56	1.54	1.47	1.55	-	-	-	-	-
		10	1.58	-	-	-	-	-	-	-	-
		15	1.84	1.98	2.04	2.04	2.12	2.12	2.14	2.20	2.22
	8	5	1.66	1.66	1.70	1.73	1.73	1.73	1.85	1.95	-
		10	1.54	1.58	1.60	1.63	1.55	-	-	-	-
		15	1.66	1.70	1.76	1.74	1.76	1.80	1.82	1.86	1.84
	10	5	1.78	1.78	1.78	-	-	-	-	-	-
		10	1.58	1.65	1.75	1.85	1.85	1.85	1.85	1.98	1.95
		15	1.54	1.64	1.74	1.80	1.82	1.84	1.86	1.90	1.92
2	6	5	1.97	1.97	1.97	2.03	2.07	2.07	2.07	2.07	2.10
		10	1.48	1.52	1.53	1.53	1.53	1.53	1.58	1.58	1.73
		15	1.58	1.58	1.58	1.58	1.53	1.53	-	-	-
	8	5	2.24	2.28	2.32	2.34	2.34	2.38	2.40	2.48	2.50
		10	1.78	1.28	1.80	1.82	1.92	1.92	1.92	1.94	1.96
		15	1.58	1.70	1.74	1.84	1.92	1.94	1.94	1.98	2.02
	10	5	1.52	1.58	1.62	1.64	1.68	1.74	1.74	1.76	1.80
		10	1.66	1.84	1.86	1.96	1.96	2.00	2.00	2.10	2.16
		15	1.76	1.80	1.82	1.96	2.00	2.02	2.07	2.12	2.22
3	6	5	1.50	1.70	-	-	-	-	-	-	-
		10	2.20	2.42	2.42	2.54	2.56	2.66	2.68	2.74	.74
		15	1.84	1.90	1.94	1.96	1.96	1.98	1.98	2.02	2.04
	8	5	2.26	2.30	-	-	-	-	-	-	-
		10	1.62	1.62	1.62	1.68	1.68	1.68	1.76	1.78	1.80
		15	1.74	1.76	1.76	1.80	1.86	1.86	1.86	1.90	1.92
	10	5	1.97	-	-	-	-	-	-	-	-
		10	2.04	2.14	2.14	2.20	2.20	2.20	2.22	2.30	2.30
		15	2.30	2.30	2.32	2.34	2.34	2.36	2.40	2.48	2.48

The effect of different rootstock ages on the girth of rootstock are furnished in Table 46. The pronounced effect of three months old rootstock on rootstock girth throughout the study period is clearly evident from the Table. This was soon followed by two months old rootstock.

The observations on the effect of different heights of grafting on the girth of rootstock are given in Table 47. The effect of grafting at 6, 8 and 10 cm height was found to be on par during the 2nd, 3rd and 4th fortnights. Grafting at 10 cm height recorded maximum rootstock girth during the 3rd, 4th, 5th, 6th and 7th fortnights.

Table 48 clearly shows the effect of defoliation of scion on the girth of rootstock. In the present study effects of different defoliation periods were not found significantly different throughout the course of observation except during 2nd fortnight when the scion defoliated 5 days before grafting was found to give maximum rootstock girth.

4.2.6 Number of primary branches

In variety Neelum, the treatments did not differ profoundly with regard to number of primaries. However, in the case of Banganappally, the treatment where grafting was done on

Table 46. Effect of age of rootstock on girth of rootstock (cm) at fortnightly intervals (Variety Banganappally)

Age of rootstock (months)	Fortnights after grafting								
	2	3	4	5	6	7	8	9	10
1	1.64 a	1.69 a	1.73 a	1.76 a	1.81 a	1.87 a	1.90 ac	1.97 a	1.98 a
2	1.73 b	1.78 a	1.804 a	1.86 a	1.88 a	1.90 a	1.97 a	2.00 a	2.06 a
3	1.94 c	2.02 b	2.03 b	2.09 b	2.10 b	2.12 a	2.15 bc	2.20 b	2.21 b
C.D. (5%)									
1 and 2	2.093*	0.097	0.092	0.102	0.107	0.111	0.116	0.107	0.109
2 and 3	0.093*	0.097*	0.096*	0.096*	0.098*	0.098	0.100*	0.094*	0.092*
1 and 3	0.092*	0.099*	0.099*	0.109*	0.113	0.117	0.120	0.111*	0.113*

(Treatments with same letter are not significantly different within the fortnight)

Table 47. Effect of height of grafting on girth of rootstock (cm) at fortnightly intervals (Variety Banganapally)

Height of grafting (cm)	Fortnights after grafting								
	2	3	4	5	6	7	8	9	10
6	1.73 a	1.83 a	1.85 a	1.89 ab	1.961 a	1.98 ab	2.09 a	2.12 a	2.17 a
8	1.79 a	1.82 a	1.79 a	1.82 a	1.85 b	1.90 a	1.94 b	1.98 b	2.00 b
10	1.79 a	1.84 a	1.88 a	1.96 b	1.98 a	2.00 b	2.02 ab	2.09 a	2.12 a
C.D. (5%)									
6 and 8	0.092	0.097	0.096	0.102	0.106*	0.108	0.113*	0.106	0.106*
8 and 10	0.092	0.095	0.091	0.098*	0.099*	0.099*	0.102	0.094*	0.096*
6 and 10	0.094	0.099	0.098	0.104	0.108	0.108	0.113	0.106	0.104

(Treatments with same letter are not significantly different within the fortnight)

Table 48. Effect of defoliation of scion on girth of rootstock (cm) at fortnightly intervals (Variety Banganappally)

Period of scion defoliation (days)	Fortnights after grafting								
	2	3	4	5	6	7	8	9	10
5	1.83 a	1.85 a	1.81 a	1.86 a	1.95 a	1.98 a	2.02 a	2.07 a	2.13 a
10	1.72 b	1.82 a	1.84 a	1.90 a	1.91 a	1.98 a	2.00 a	2.06 a	2.09 a
15	1.76 b	1.82 a	1.86 a	1.89 a	1.92 a	1.94 a	2.01 a	2.06 a	2.08 a
C.D. (5%)									
5 and 10	0.094*	0.101	0.104	0.118	0.123	0.125	0.129	0.119	0.123
10 and 15	0.092	0.095	0.089	0.091	0.094	0.096	0.098	0.092	0.089
5 and 15	0.094*	0.098	0.099	0.113	0.118	0.118	0.125	0.115	0.119

(Treatments with same letter are not significantly different within the fortnight)

two months old rootstock at a height of 10 cm using 10 days prior defoliated scion produced 1.5 number of primaries upto 5th fortnight and thereafter two primaries upto 10th fortnight. The mean length of primary branches at the end of observation was 7.15 cm and with 10 leaves. In general, primary production was more in the grafts prepared with scion variety Banganappally than Neelum.

4.3 Anatomical studies of graft union

4.3.1 Anatomy of the stem

The microscopic examination of young mango stem of one month old revealed the following anatomical details. The outermost cellular layer was constituted by single layered epidermis followed by subepidermis consisting of three to seven layers of collenchymatous cells, the corners of which were highly thickened. Following the subepidermis 5 to 10 layers of parenchymatous cells were found with larger intercellular spaces constituting the cortical region. Of these, the outer two to three layers were found to be chlorenchymatous the rest were parenchymatous. It was found that the parenchymatous cells in the deeper layers in the cortical region produced the cork. A discontinuous layer of sclerenchymatous pericyle (pericyclic patches) was observed just below the cortex and below this pericycle, resin ducts were observed.

Five to eight groups of vascular bundles were observed in young mango stem. The primary phloem was almost indistinct below which was found the secondary phloem composed of sieve tubes and companion cells. Phloem cells were having phenolic deposits. The secondary phloem was followed by the cambial ring, made up of four to seven layers of radially flat cells. The secondary xylem which was next to cambium was composed of three different types of cells viz., xylem vessels, rays and xylem parenchyma. Towards the centre, endarch patches of primary xylem were seen as slightly discoloured wedge shaped masses embedded in the parenchymatous pith with starch grains (Plate VIII).

4.3.2 Anatomy of the graft union

Detailed anatomical studies were conducted to find out the stages of graft union and the possible reasons for graft failure. The process of graft union was almost similar in the grafts prepared using rootstocks of different ages and heights. Moreover, no noticeable anatomical difference was observed in the process of graft union between the grafts prepared using two scion varieties, Neelum and Banganapally with different periods of defoliation. The various stages of graft union at different periods of observation are illustrated in Plates IX to XII.

Generally in all the treatments, the following four main stages could be distinguished in the process of graft union.

Stage 1 (Precallus - 5 days after grafting)

The wounded exposed tissues were found to be brownish in colour when the graft joint was examined five days after grafting. This was due to the formation of wound periderm along the cut surfaces of stock and scion which were wide apart at the graft joint. Callus formation was observed from the cambial region of the scion. The tissues at the cambial region had started rapid multiplication in order to produce callus. In some grafts, pith cells were also found to multiply rapidly producing callus (Plate XIII).

Stage 2 (Callus - 15 days after grafting)

The wound periderm was found broken and the callus had started proliferating out in this stage. The callus proliferated either from the stock or from the scion or from both depending upon their cellular activity. In general callus production was more from the scion side, particularly in the case of Neelum as scion shoot. Most of the callus was produced from the cambium, xylem and phloem of the stock and scion. Tissues of the stock and scion that were in contact at the graft

joint are very important for proper graft union. Between vascular tissues and cambium there was callus production and proper graft union. The gap between the stock and scion was only partly filled up by the callus tissue after 15 days of grafting.

Stage 3 (Cambial bridge - 45 days after grafting)

After 45 days of grafting, a clear cambial bridge was formed between the stock and scion. In some grafts with gap, there was more callus production mainly from the original cambia of both stock and scion. Major portion of the callus bridge formed was converted into cambium so that a distinct cambial connection was established circumferentially connecting the rootstock and scion (cambial bridge). Callus production was mostly from the scion especially in the case of variety Neelum.

Stage 4 (Healed union - 90 days after grafting)

The graft union was complete after 90 days and the new cambium formed was in line with the original cambial regions of rootstock and scion resulting in an intact cambial ring. However, the cambial bridge was not always intact at certain regions even after 90 days of grafting. Newly formed callus tissue adjacent to the cambium of the stock and scion was found converted into cambium so as to form an intact cambial bridge between rootstock and scion.

In soft wood grafting, callus production was mainly from the cambium, xylem and phloem of the rootstock or scion depending on the scion variety used. When there was no gap between stock and scion, there was little callus production at the central region of the graft joint (Plate XIV). Pith and the cortex cells of the stock and scion were also found to produce callus to a limited extent in some grafts.

In the present study, two types of graft failures were observed, viz., drying up of the scion shoots within 10 days of grafting and the scions remaining green without sprouting even after 45 to 90 days of grafting. Anatomy of the dried up grafts showed no callus production but the wound periderm was found to be very thick and dark when compared to successful grafts (Plate XV). Some graft failures were due to the wide gap between the stock and scion (Plate XVI).

In the second type of graft failure where the graft remained green without sprouting even after 45 to 90 days, there was very little callus production, that too from the stock side only (Plate XVII). The newly formed callus was in contact with the bark surface of the scion and hence could not make any cambial contact or graft union mainly due to the misaligned arrangement of cambia of stock and scion (Plate XVIII).

Plate VI Successful grafts of the variety Neelum, 6 months after grafting

Plate VII Successful grafts of the variety Banganappally, 6 months after grafting

plate VI

plate VII

Plate VIII Cross section of young mango stem

Plate IX Anatomical stages of graft union - 5 days after grafting

Plate VIII

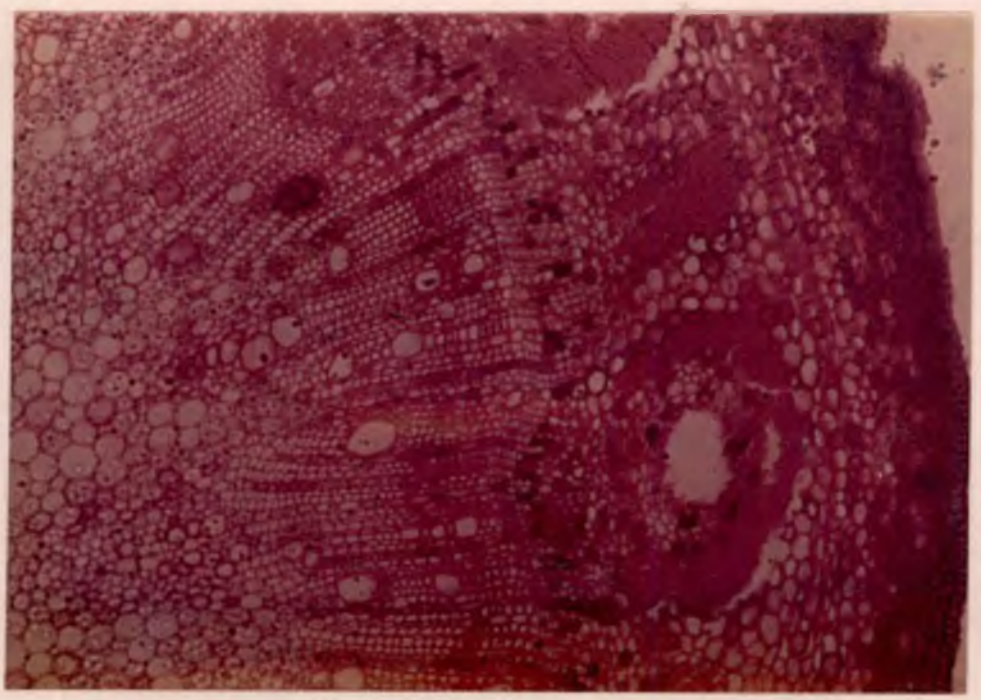


Plate IX

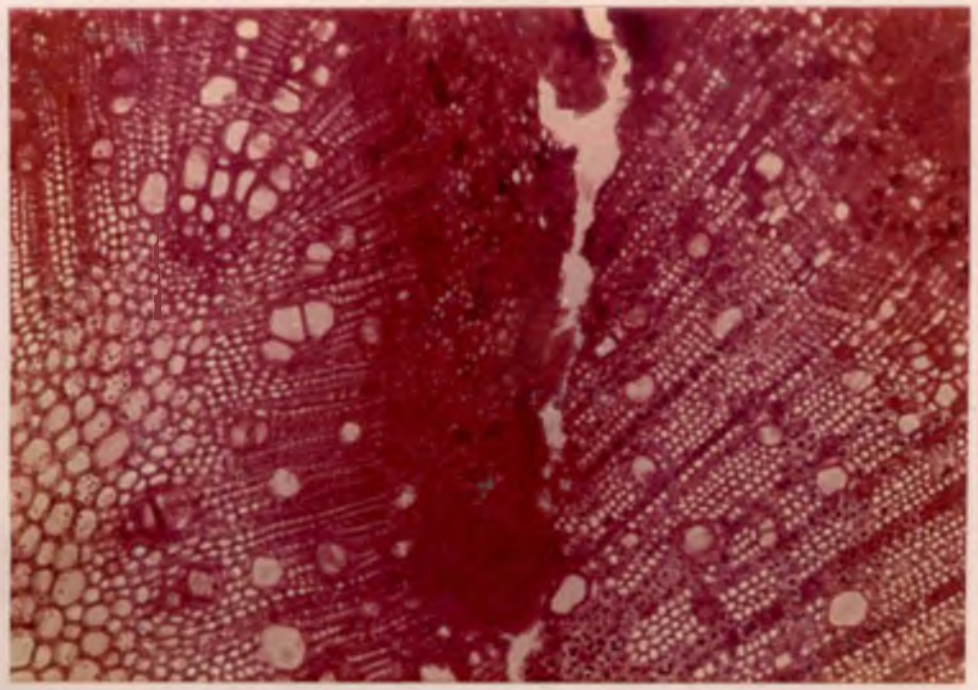


Plate X Anatomical stages of graft union - 15 days after grafting

Plate XI Anatomical stages of graft union - 45 days after grafting

plate X

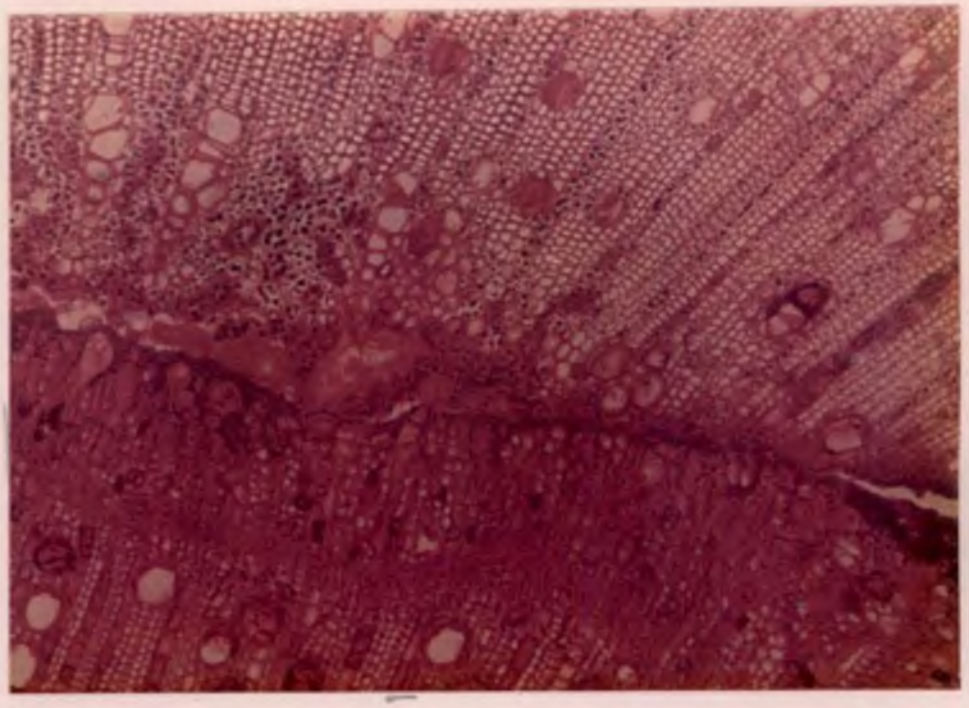


plate XI

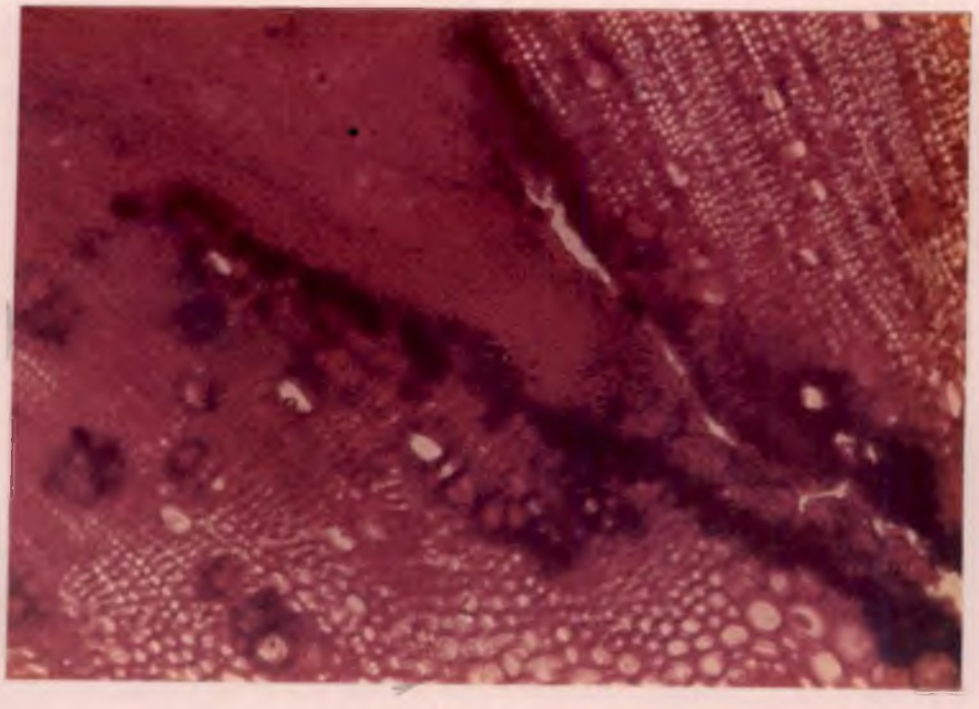


Plate XII Anatomical stages of graft union - 90 days after grafting

Plate XIII Section showing callus production from the pith region - 5 days after grafting

plate XII

plate XIII

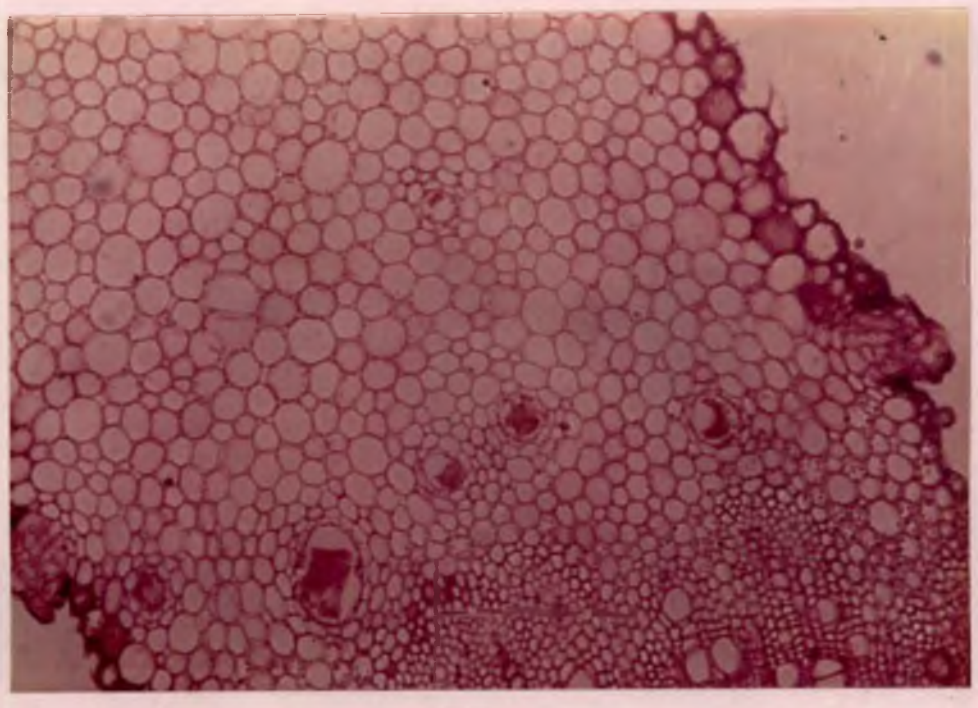


Plate XIV A successful graft without gap - 90 days after grafting

Plate XV Anatomy of unsuccessful graft showing very thick necrotic layer and no callus production - 45 days after grafting

Plate XIV

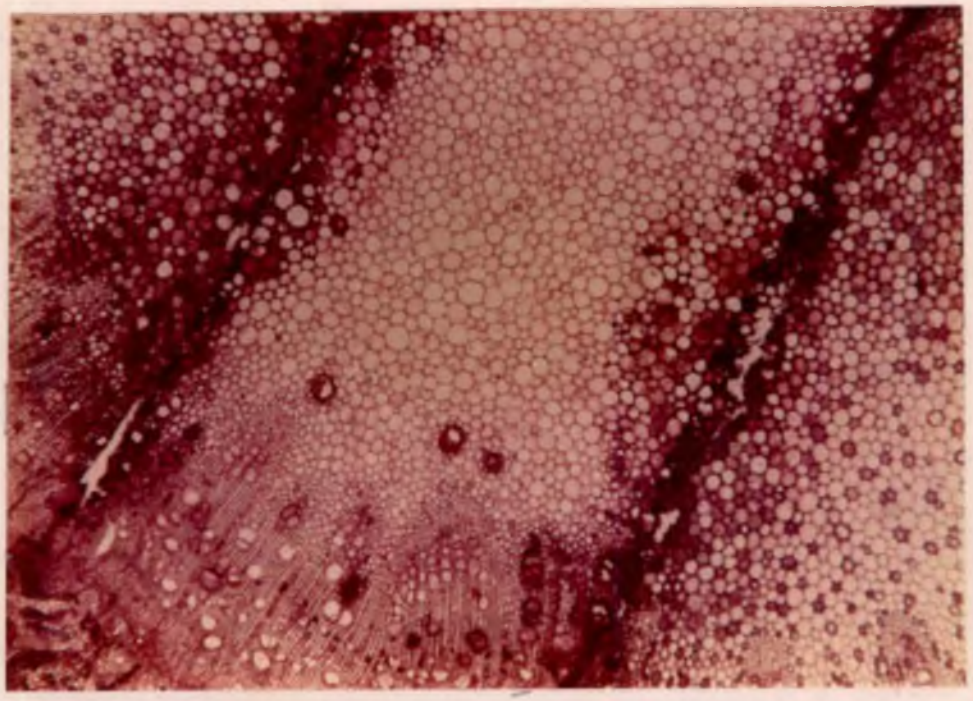


Plate XV

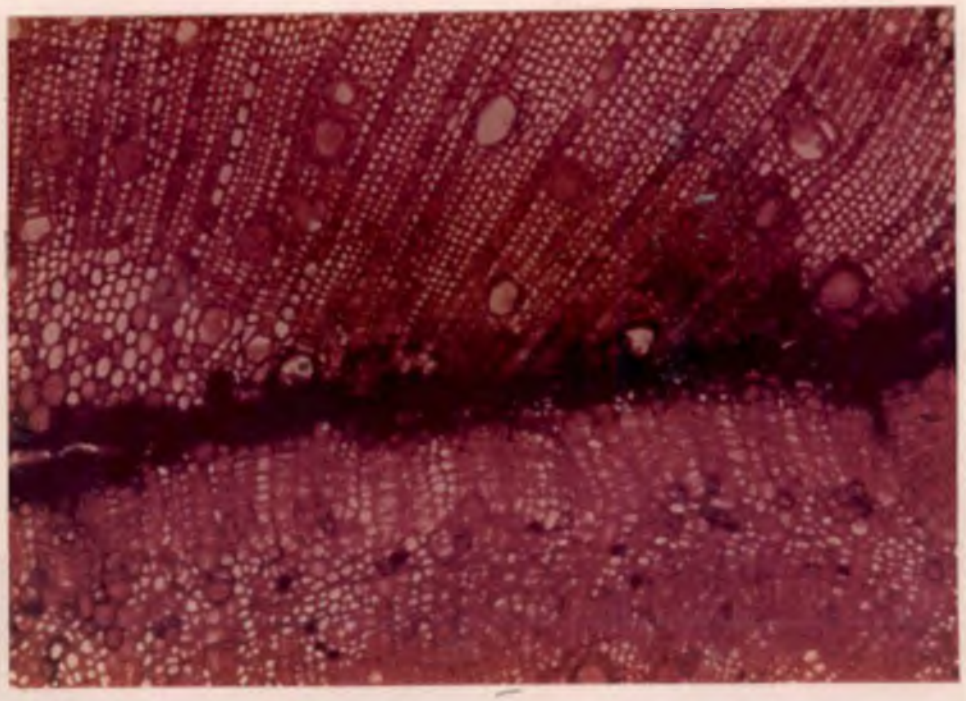


Plate XVI Anatomy of unsuccessful graft showing gap between rootstock and scion

Plate XVII Anatomy of unsuccessful graft showing very few callus production, that too from the stock side only

plate XVI

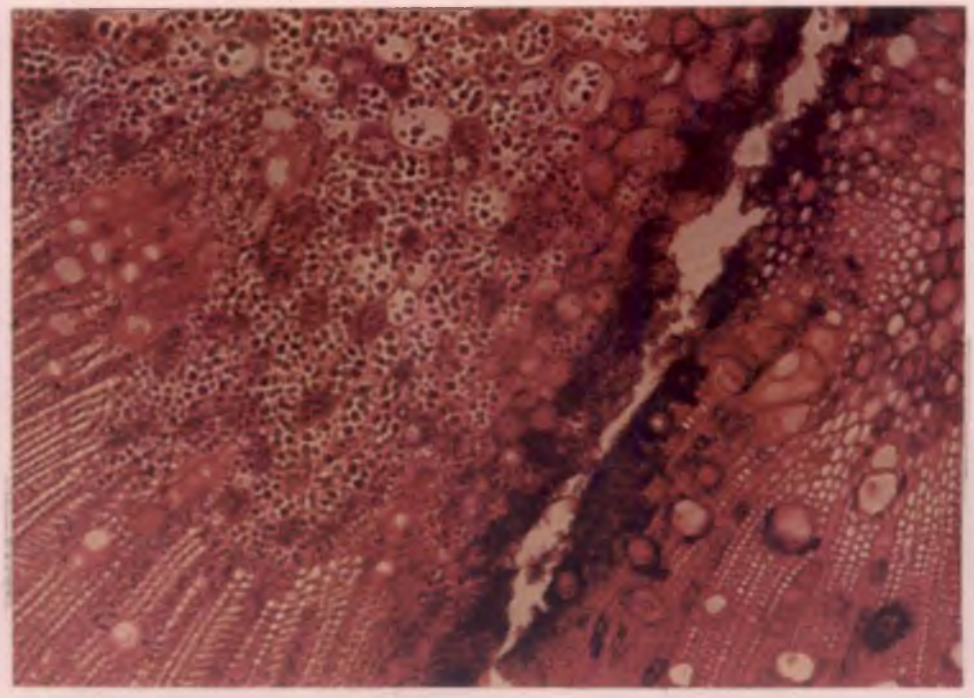


plate XVII

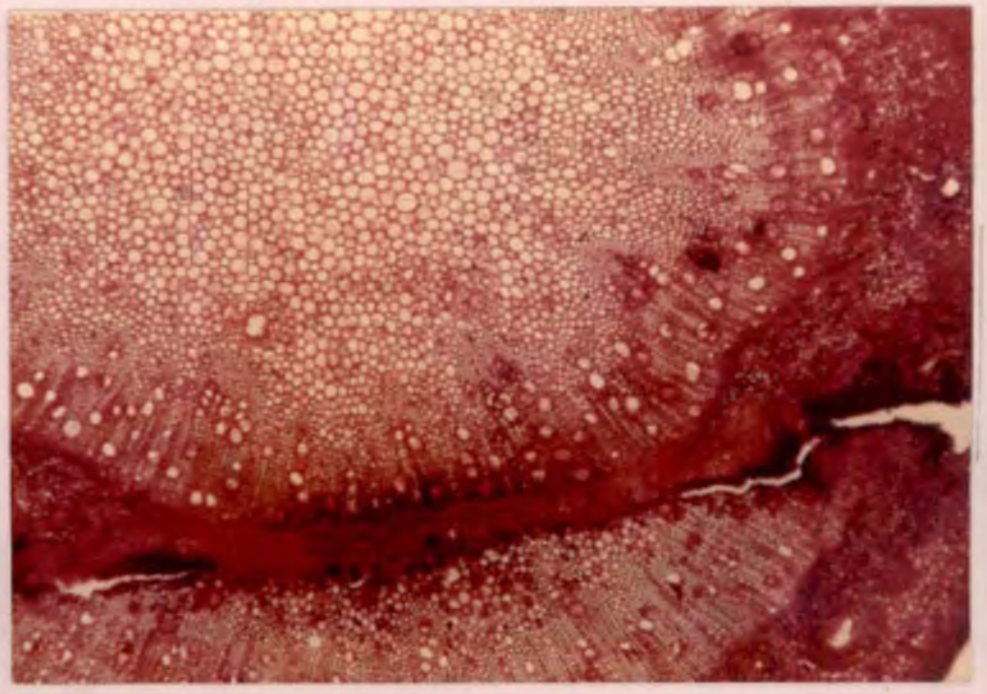
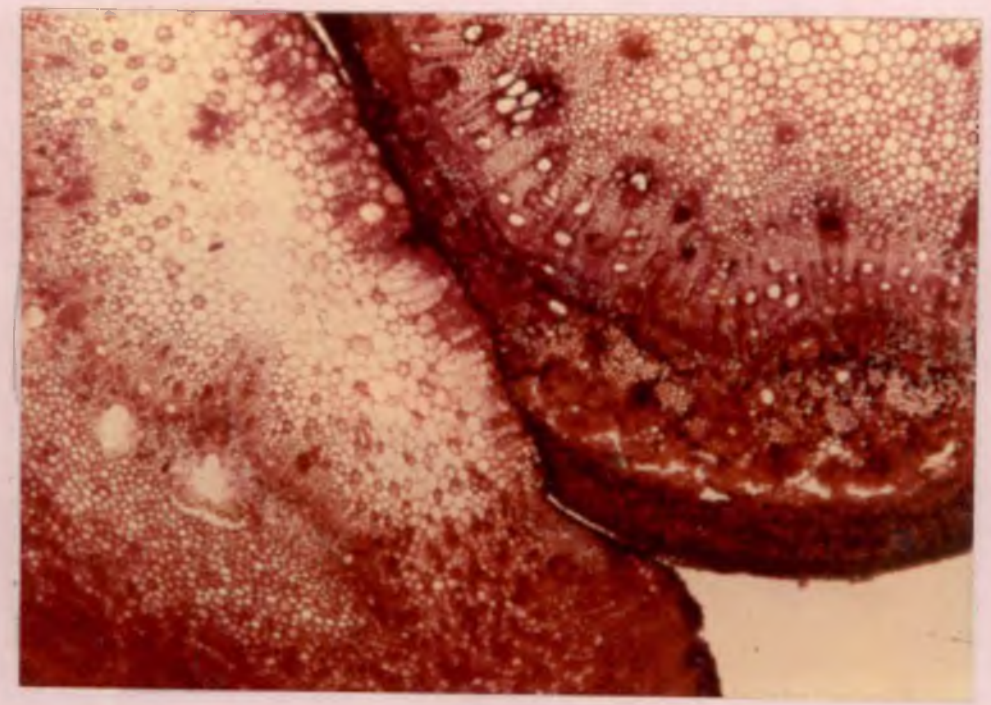


Plate XVIII Anatomy of unsuccessful graft showing the misaligned arrangement of rootstock and scion

plate XVIII



Discussion

DISCUSSION

Mango, the king of fruits, is the most important commercial fruit crop of India. Though the varietal wealth of mango in our country is very high, the highly cross pollinated nature of the crop and seed propagation lead to lot of variability in the seedling population. Hence, multiplication of selected varieties is possible only through vegetative methods. According to Singh (1960), vegetative propagation methods in mango are known since very ancient times in India. The most commonly used methods of vegetative propagation ir mango are inarching, veneer grafting and stone grafting.

The inarching or approach grafting commercially adopted in mango propagation in Kerala, is a very expensive and laborious process. It involves many practical difficulties or is virtually impossible when the trees selected for clone production are spread far and wide. The method of stone grafting already standardised in the Department of Pomology and Floriculture is found very successful, easy and convenient. But in this method since the rootstock used are only five days old, this can be done only during a limited time when mango stones are available for raising rootstocks. Further, since very young seedlings are used here, the incidence of die back

disease is found to be more. Compared to stone grafting only little care is needed in soft wood grafting and even the sprouted stones collected elsewhere also can be used as rootstocks for grafting. Moreover, the seedling rootstocks that cross the age recommended for epicotyl grafting can be successfully used as rootstocks here. This method is best suited for in situ grafting for large scale propagation at a cheaper rate (Amin, 1978; Patel and Amin, 1981; Singh and Srivastava, 1982; Singh et al., 1984; Kulwal and Tayde, 1985; Hadankar et al., 1987; Kumar and Khan, 1988 and Subramani, 1988). In view of these advantages, it was found necessary to standardise the various aspects of soft wood grafting in mango under Kerala conditions.

In any method of grafting, success depends on the compatibility between the rootstock and scion used. In mango there exist varietal responses of scion to grafting as reported by many workers (Mukherjee and Majumder, 1964; Jagirdar and Bhatti, 1968; Dhakal, 1979; Maiti and Biswas, 1980; Singh and Srivastava, 1981; Dhungana, 1984; Kulwal and Tayde, 1985a; Radhamony, 1987). Hence, the present series of studies were undertaken in the Department of Pomology and Floriculture, College of Horticulture, Vellanikkara during the period 1987-'89 to standardise the age of rootstock, height of grafting and defoliation effect of scion using two scion varieties, Neelum and

Banganapally for commercial propagation in mango. Detailed anatomical studies were also carried out to find out the various stages of graft union and also the possible reasons for graft failures.

5.1 Effect of age of rootstock, height of grafting and defoliation of scion on sprouting and survival of grafts

The results of the present study using the variety Neelum as the scion indicated that the age of rootstock and defoliation of scion have profound effect on sprouting and survival of grafts. Maximum sprouting was obtained for one month old rootstock grafted at 10 cm height with 15 days prior defoliated scion (100 per cent). The same treatment combination recorded maximum survival (60 per cent) also. The survival was least (zero per cent) when grafting was done on one month old rootstock at a height of 6 cm using 5 days prior defoliated scion. In the variety Banaganappally also age and height of rootstock and defoliation of scion were having significant influence on sprouting and survival of grafts. Highest percentage of sprouting (100 per cent) was recorded when grafting was done on one month old rootstock at a height of 6 cm with scion shoots defoliated 15 days prior to grafting. Maximum survival was obtained (68 per cent) for three months old

rootstock at a height of 10 cm using scion shoots defoliated 15 days prior to grafting. The varietal differences in sprouting and survival must be due to the variation in genetic make up which would have influenced the histological and physiological development within the scion shoots. Radhamony (1987) also observed differences in the responses of varieties to stone grafting in mango. The pooled data on the effect of ages of rootstock on soft wood grafting with scion variety Neelum showed that two months old rootstock was most ideal with regard to sprouting (88.25 per cent) and survival (35.11 per cent). The effect of age of rootstock on graft take was also reported by many workers (Singh and Srivastava, 1972; Amin, 1978; Kannan and Das, 1985; Kulwal and Tayde, 1985 and Kumar and Khan, 1988). In the present study using scion variety Banganappally, one month old rootstock resulted in maximum sprouting (84.88 per cent). However, three months old rootstock showed significantly maximum survival (35.11 per cent). In cashew, Seshadri and Rao (1986) also suggested that 75 to 90 days old seedlings are most ideal rootstocks for soft wood grafting.

The similarity in the thickness of stock and scion might be one of the favourable factors for proper fitting of the stock and scion and thereby resulting in maximum sprouting and survival (Aravindakshan et al., 1988). Amin (1978) stated that for in situ soft wood grafting in mango, scion shoots of the

same thickness as that of the terminal shoots of the rootstock are to be used for getting 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 are to be used (Subramani, 1988). Rajput and Haribabu (1971) also emphasised the uniformity in the thickness of stock and scion for obtaining maximum success in mango stone grafting. Singh and Srivastava (1979) indicated that the scion should fit tightly into the rootstock which activated the combial activity resulting in better union.

In the variety Neelum, the results on the effect of different heights of rootstock on sprouting and survival of the grafts revealed no significant difference between the treatments. The result obtained in this study also agrees with the findings of Singh and Srivastava (1982) who suggested that the height of grafting had no appreciable effect on success and hence the grafting can be done at any convenient height. The results of the present study using the scion variety Banganappally also revealed that the height of grafting did not affect the sprouting of the grafts. Interestingly in this case the grafting at 8 cm height recorded maximum survival (29.78 per cent). However, this was on par with the treatment where grafting was done at 10 cm height. Such observations were also recorded by Patel and Amin (1976) in mango.

In the present series of investigations using Neelum as scion, defoliation of the scion shoot influenced the sprouting and survival of the grafts significantly. Scion shoot defoliated 10 days prior to grafting recorded maximum sprouting (89.46 per cent) and survival (36.44 per cent). This was on par with the scion shoots defoliated 15 days prior to grafting. The scion shoots defoliated 5 days prior to grafting recorded the minimum. This result is in accordance with the findings of Amin (1978) who got 100 per cent success for in situ soft wood grafting in mango by using scion shoots defoliated 10 days before grafting. Singh et al. (1984) also reported 100 per cent success for mango soft wood grafting with the use of 10 days prior defoliated scion particularly in mid June. Recently in 1988, Subramani noticed a better survival of 86.5 per cent with the use of 10 days prior defoliated scion for flush grafting in mango.

The studies on defoliation of scion variety Banganappally revealed that the scion defoliated 15 days prior to grafting recorded significantly maximum sprouting (94.19 per cent) and survival (40.89 per cent). Dhungana (1984) stressed the beneficial effect of scions defoliated 10 to 15 days prior to grafting. Many workers have reported that the defoliation enhanced the meristematic activity in the axillary and terminal bud regions finally resulting in a better graft take (Mukherjee

and Majumder, 1964; Jindal, 1968; Teotia and Maurya, 1970; Rajput and Haribabu, 1971; Kashyap et al., 1972; Persai 1974; Singh and Srivastava, 1979; Maiti and Biswas, 1980; Nagabhushanam, 1982 and Patil et al., 1983). In Kerala due to the prevalence of warm humid tropical climate, mango seldom remains in an active condition and hence the possibility of obtaining the scion materials with naturally active buds does not exist and thus any treatment that leads to forced activation of buds could be advantageous (Dhungana, 1984). Ram and Bist (1982) stated that predefoliated scions suffer less from dessication than the freshly defoliated ones. The better efficacy of defoliated scions over undefoliated scion shoots may also be due to the fact that defoliation causes a minute rise in the sucrose level of phloem sap of the shoot (Zimmerman, 1958). This in turn increases the osmotic value and thereby causing the movement of solutes towards the apex of the shoot. This will initiate high meristematic activity at the bud level which helps in better sap flow and good callus formation finally stimulating the cambial divisions, favouring better graft union (Munch, 1930).

5.2 Effect of age of rootstock, height of grafting and defoliation of scion on growth parameters of grafts

In the variety Neelum, the observations on new growth of scion showed that grafting using one month old rootstock with

scion shoots defoliated 10 days prior to grafting produced maximum new growth throughout the course of observation. But in the variety Banganappally, the treatment combination of three months old rootstock and scion shoot defoliated 10 days prior to grafting produced maximum new growth throughout the observational period. In both the varieties, grafting at 10 cm height produced maximum new growth particularly in the second half of observation. From the pooled data using the scion variety Neelum, it could be stated that three months old rootstock recorded maximum new growth and was significantly superior to other treatments till the end of 5th fortnight, thereafter the effect of different age groups were on par with regard to this parameter. In the variety Banganappally the age of the rootstock did not influence the new growth of scion significantly during the entire period of observation. Dhungana (1984) obtained maximum growth of scion with older rootstock materials in mango veneer grafting. However, an evaluation based on growth of new growth alone may lead to faulty conclusions as the percentage of sprouting and survival forms the basic considerations for commercial adoption of a practice.

Regarding the height of grafting, the pooled data revealed maximum new growth of scion when grafted at 10 cm height with both the scion varieties Neelum and Banganappally. Chakrabarti and Sadhu (1984) also obtained maximum new growth of

scion when grafting was done at 5 or 7 cm above the collar region, though the effect was not statistically significant. Ratan (1985) did not observe any significant difference in growth of scion with regard to grafting height in epicotyl grafting.

The present study using Neelum as scion revealed that the scion shoots defoliated 15 days prior to grafting were significantly superior to other treatments and produced maximum new growth during the early periods of study. But subsequently, scion shoots defoliated 5 and 10 days prior to grafting recorded maximum value. In the case of Banganappally as scion, the results indicated that the scion shoots defoliated 10 days prior to grafting recorded maximum new growth till the end of 5th fortnight. Thereafter 5 days prior defoliated scions recorded maximum new growth. Patil et al. (1983) opined that in mango wedge grafting defoliation of scion shoots 15 days prior to grafting increased the new growth. Dhakal and Hoda (1986) reported that for mango veneer grafting, scion shoots defoliated 10 days prior to grafting had the longest elongation of sprouts at the end of 6 months. Aravindakshan et al. (1988) also suggested that in mango stone grafting, defoliation as a pretreatment given to scion material had shown a positive effect on the extension growth of scion, though the difference between the two treatments 10 and 15 days prior defoliation was not significant.

In both the varieties, Neelum and Banganappally, the various treatment combinations significantly affected the leaves produced by the new growth of scion. From the pooled data using scion variety Neelum, the beneficial effect of two months old rootstock on the leaf production was clearly evident from the 5th fortnight of observation, while in Banganappally, the effect of three months old rootstock was significant during the first five fortnights of observation. Dhungana (1984) obtained maximum leaf production with older rootstock materials in veneer grafting of mango. An evaluation based on the number of leaves produced alone may lead to faulty conclusions as discussed earlier.

The height of rootstock appears to be more concerned with graft union rather than the subsequent growth of grafts (Ratan, 1985). According to him the number of leaves produced was not influenced by height of rootstock during grafting. In the present study using Neelum and Banganappally, grafting at 10 cm height resulted in maximum number of leaves. In general, in both varieties, scions defoliated 5 days prior to grafting produced maximum number of leaves. But Dhakal and Hoda (1986) obtained more number of leaves in mango veneer grafts when 10 days prior defoliated scions were used. However, Dhungana (1984) did not observe any marked effect for defoliation treatments on the number of leaves produced by stone grafts or veneer grafts in mango.

In the present investigation, out of the three rootstock ages studied, with scion variety Neelum and Banganappally, three months old rootstock was significantly superior over others resulting in maximum girth of scion throughout the study period. Amin (1978) observed differential response for age of rootstock with regard to scion girth in soft wood grafting. Dhungana (1984) also obtained maximum scion girth when older rootstocks were used in mango veneer grafting.

In the variety Neelum, grafting at 10 cm height produced maximum scion girth throughout the study period. In contrast, the effect of grafting height on scion girth was not significant in case of variety Banganappally. This is in accordance with the finding of Ratan (1985) who stated that the height of rootstock did not affect the scion girth significantly in epicotyl grafting in mango.

In the variety Neelum, scions defoliated 15 days prior to grafting recorded maximum scion girth during the early periods of observation, but after 4th fortnight of observation, scions defoliated 5 days before grafting recorded maximum scion girth. On the other hand, in Banganappally scion defoliated 5 days prior to grafting tended to record maximum scion girth throughout the study period. Patil et al. (1983) obtained maximum scion girth with 15 days prior defoliated scion in case

of mango wedge grafting. But Dhungana (1984) found that defoliation of scion did not exhibit any commendable influence on the girth of the scion in case of epicotyl grafting and veneer grafting in mango.

With regard to girth of rootstock, in both the varieties there was significant difference between various treatment combinations. The pooled data showed that out of the three rootstock ages tried, three months old rootstock gave maximum stock girth throughout the course of observations. Dhungana (1984) also obtained maximum rootstock girth with older rootstocks in case of mango veneer grafting. But Ratan (1985) reported that the stock girth is free from the effect of height of rootstock for mango epicotyl grafting.

The pooled data of the present study revealed the significant effect of grafting height and scion defoliation on rootstock girth and with scion variety Neelum grafting at 10 cm height gave maximum stock girth throughout the study period and was significantly superior to other treatments. Though the effect was not significant, in Banganappally, grafting at 10 cm height tended to record maximum stock girth till the end of 7th fortnight. With regard to scion defoliation in the variety Neelum, scions defoliated 15 days before grafting resulted in maximum stock girth throughout the study period and was

significantly superior to other treatments. But effect of scion defoliation was found insignificant on stock girth when Banganappally was used as scion. Patil et al. (1983) also emphasised the beneficial effect of scion defoliation on girth of stock in wedge grafting of mango. However, Dhungana (1984) did not observe any relation between the girth of stock and pretreatment of scion in veneer and epicotyl grafting in mango.

5.3 Anatomical studies of the graft union

In the present study to find out the various stages of graft union, four distinct stages were observed viz., formations of precallus, callus, cambial bridge and healed union. This was in accordance with the finding of Radhamony (1987) who also observed the four main stages in the formation of graft union in epicotyl grafting. However, Chakrabarti and Sadhu (1985) observed three main stages in the formation of graft union. 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 activity between rootstock and scion was established and healed union stage - extending from 60 to 120 days after grafting when vascular tissues were differentiated and complete union between stock and scion took place. Juliano (1941) stated that the first stage in the formation of graft union was

the formation of callus cushion in the gap through the activity of parenchyma of both bark and pith From this callus a cambial bridge developed joining the cambial ends of both stock and scion. In the present study, tissues at the cambial region started multiplication producing precallus after 5 days and callus production after 15 days of grafting. Most of the callus production was observed from the cambium of either stock or scion or from both depending upon cellular activity. Xylem, phloem and cortical tissues were also produced callus to some extent. Occasionally cells in the pith also produced callus. Ratan (1985) and Radhamony (1987) also observed this type of phenomenon in mango grafts. Studies conducted by Luthra and Sharma (1946) showed that callus development took place both from stock and scion in Langra when used as scion. In the present study, callus production was found more from the scion side, particularly in the case of Neelum scions. But with Banganappally as scion, callus production was more from the stock side. Avramov and Jokovic (1961) also observed that callus formation differed between the varieties and was highly influenced by rootstocks and weather conditions that prevailed during previous growing season. After 45 days of grafting, a distinct callus connection was found to be established in the present study circumferentially connecting the rootstock and scion.

The graft union was completed after 90 days and the new cambium formed was in line with the original cambial regions of stock and scion resulting in an intact cambial bridge. Secondary xylem and phloem were not produced in the graft joint even after 90 days of grafting. Esau (1979) observed that secondary growth and cambial activity were involved in the proper graft union. The breakdown products of dead cells on surface of stock and scion formed a necrotic layer. Intact cells next to necrotic layer enlarged, divided and formed callus tissue which filled the space left between stock and scion. Eventually, cambia between stock and scion became continuous across the callus by the callus cell differentiation into cambial callus which later formed vascular tissues.

In the present study, two types of graft failures were observed, viz., drying up of the scion shoots within 10 days after grafting and the scions remaining green without sprouting even after 45 to 90 days of grafting. Anatomy of the dried up grafts showed no callus production, but the wound periderm was found very thick and dark when compared to successful grafts. According to Soule (1971) thick necrotic layers were due to deep crushing of the cells during wrapping with polythene strip which contributed to graft failures. Wide gap existing between stock and scion also found to cause graft failure. The observations of Copes (1969) revealed that poorly matched stock and scion

resulted in very slow cambial union and delayed bud sprouting. The skill and care are therefore most important for better success in grafting. In the case of grafts which remained green without sprouting even after 45 to 90 days after grafting, there was callus production only from the stock side. Luthra and Sharma (1946) observed excessive growth of parenchymatous cells between stock and scion and distortion of xylem elements that blocked the conducting vessels which later inhibited the movement of water from stock to scion resulting in graft failures.

In some other unsuccessful grafts the newly formed callus lying against the bark surface of scion could not establish any cambial contact but just grew as an undifferentiated mass. This might be due to the misaligned arrangement of cambia of stock and scion. Turkovac (1961) observed excessive undifferentiated callus or other irregular growths at the union of incompatible stock and scion. The genetic factors interfering the healing process of grafts have been stressed by Robert (1949). In mango, although the stock and scion are not biochemically or genetically far apart, the possibility of some of these factors interfering with the healing process cannot be ruled out. In the present series of studies the factors discussed above might have been responsible for the graft failures.

Summary

SUMMARY

The present series of investigations were conducted in the Department of Pomology and Floriculture, College of Horticulture, Vellanikkara with a view to standardise the ideal age of rootstock, height of grafting and the time of defoliation of scion shoot for soft wood grafting in mango using two scion varieties, Neelum and Banganapally. Detailed anatomical studies of the graft union were also made to find out the various stages of graft union and the possible reasons for graft failure. The results of the studies are summarised below.

1. The results of the study on the response of age of the rootstock on soft wood grafting in mango using the scion variety Neelum showed that two months old rootstock was most ideal with regard to sprouting (88.25 per cent) and survival (35.11 per cent). The sprouting was minimum for three months old rootstock (69.37 per cent) while survival was minimum for one month old rootstock (25.78 per cent).

2. With the scion variety Banganapally, out of the three rootstock ages tried, one month old rootstock recorded significantly maximum sprouting (84.88 per cent) over two months old rootstock (67.15 per cent) and three months old rootstock (62.03 per cent). On

the other hand survival was significantly maximum with three months old rootstock (35.11 per cent) and minimum with one month old rootstock (18.22 per cent).

3. The height of grafting was found to have no significant effect on sprouting and survival of grafts in both the scion varieties, Neelum and Banganapally.

4. Results of the present study on the effect of defoliation of scion in the variety Neelum indicated that scion shoot defoliated 10 days prior to grafting resulted in maximum sprouting (89.46 per cent) and survival (36.44 per ent) which was also on par with the scions defoliated 15 days prior to grafting, while those defoliated 5 days before grafting recorded minimum sprouting (67.96 per cent) and survival (21.78 per cent).

5. In the variety Banganapally the scions defoliated 15 days prior to grafting recorded significantly maximum sprouting (94.19 per cent) and survival (40.89 per cent).

6. The observations on growth parameters revealed that three months old rootstock recorded significantly maximum new growth in scion variety Neelum till the end of 5th fortnight. But with Banganapally as scion, age of rootstock did not influence the new growth of scion significantly.

7. Regarding height of grafting, the pooled data revealed maximum new growth of scion when grafted at 10 cm height in both the scion varieties Neelum and Banganapally.

8. In the variety Neelum, scions defoliated 15 days prior to grafting recorded significantly superior new growth during early periods of observations. But in Banganapally, scions defoliated 10 days prior to grafting were found superior with regard to new growth particularly during the early periods of observation.

9. Regarding leaf production, in the variety Neelum, the pooled data revealed that two months old rootstock produced maximum number of leaves from 5th fortnight of observation onwards, while in Banganapally, the effect of three months old rootstock was found to be more superior. Grafting at 10 cm height recorded

maximum number of leaves in both the varieties Neelum and Banganapally. In general, in both the varieties, scions defoliated 5 days prior to grafting pr duced maximum number of leaves.

10. In the variety Neelum, the girth of new growth, scion and rootstock were significantly influenced by the age of rootstock, height of grafting and defoliation of scion shoot while in Banganapally the effects were not found to be significant.

11. The anatomical studies revealed four distinct stages in the healing process of graft union, viz., formations of pre-callus, callus, cambial bridge and healed union. Callus proliferated either from the stock or from the scion or from both depending upon cellular activity after 15 days of grafting. The cambial bridge was well established across the graft union after 45 days of grafting. The union was healed after 90 days of grafting operation.

12. In the present study two types of graft failures were observed, viz., drying up of the scion shoots within 10 days after grafting and the scions remaining green without sprouting even after 45 to 90 days of grafting. Anatomy of dried up grafts showed no callus production, but the wound periderm was found

to be very thick and dark when compared to successful grafts. Some such failures were due to the wide gap between stock and scion. In the second type of graft failure where the grafts remained green without sprouting even after 45 to 90 days, there was very little callus production, that too from the stock side only. In some other failures, the newly formed callus was touching the bark portion of the scion and hence could not make any cambial contact mainly due to the misaligned arrangement of stock and scion.

References

REFERENCES

Ahmad, S. 1964. Propagation of mango by veneer grafting. W. Pakist. J. agric. Res. 2 (1 & 2): 32-44.

Amin, R.S. 1978. In situ Soft wood grafting in mango. Indian Hort. 23 (3): 7-10.

Aravindakshan, K., George, T.E., Veeraraghavan, P.G. and Balakrishnan, S. 1984. Studies on epicotyl grafting in cashew (Anacardium occidentale L.). Cashew Causerie 6 (4): 3-5.

Aravindakshan, M., Gopikumar, K., Dhungana, D.B. and Ratan, J. 1988. Stone grafting in mango. Directorate of extension, Kerala Agricultural University, Mannuthy.

Asadullah, M. and Khan, M.U.D. 1960. Studies of various factors affecting success in grafting by approach (inarching) in mangoes. Punjab Fruit J. 23: 59-70.

*Ascenso, J.C. and Milheiro, A.V. 1973. A preliminary note on the mini grafting on cashew. Nota preliminar sobre a mini exertia do cajueiro Agron Mocamb. 7 (2): 69-72.

*Avramov, L. and Jokovic, D. 1961. A contribution to the study of callus formation at the union of vine grafts in the stratification room. Arh Poljopr Nauke. 14 (43): 65-67.

Bajpai, P.N., Yati, V., Singh, A.R. and Chadurvedi, O.P. 1985. Effect of cultivars and age of rootstocks on the success of veneer grafting in mango. Abs. papers, Second International Symposium on Mango. Bangalore, May 20-24.

Bedoes, T.W. and Prasad, R. 1975. Propagation of mango. J. agric. Soc. 75 (74): 317-333.

Bhambota, J.R., Rajput, M.S. and Sandhu, K.S. 1971. Veneer grafting - a successful method of mango propagation. The Punjab hort. J. 11 (1 & 2): 40-43.

Bhan, K.C., Sammadhar, H.N. and Yadav, P.S. 1969. Chip budding and stone grafting of mango in India. Trop. Agric. 46: 247-253.

Bhandary, K.P., Shetty, K.P.V. and Shet, M. 1974. Propagation of cashew by wedge grafting. J. of Plantation Crops. 2 (1): 37.

Buchloh, G. 1960. Lignification in stock scion junctions and its relation to compatability. Phenolics in plants on health and diseases, Pergamon Press, Oxford, pp: 67-71.

*Burns, W. and Prayag, H.S. 1921. The book of mango. Dept. Agric. Bombay Bull. 103. p. 5-8.

Chakrabarti, U. and Sadhu, M.K. 1983. Effect of grafting time, variety and nature of scions on the success of epicotyl grafting in mango. Indian J. agric. Sci. 53 (8): 637-41.

Chakrabarti, U. and Sadhu, M.K. 1984. Effect of age and length of the rootstock and scion on the success of epicotyl grafting in mango. Indian J. agric. Sci. (54): 1066-1072.

Chakrabarti, U. and Sadhu, M.K. 1985. Anatomy of graft union in epicotyl grafting of mango. (Mangifera indica L.) Abs. papers, Second International Symposium on Mango, Bangalore, India, May, 20-24.

Copes, D.A. 1969. Graft union formation in Douglas fir. Amer. J. Bot., 56 (3): 285-289.

Cutler, D.F. 1978. Applied plant anatomy. Longman group limited, London. pp: 56.

Damodaran, V.K., Vilasachandran, T. and Valsalakumari, P.K. 1979. Research on cashew in India. Kerala Agricultural University, Directorate of Extension Education, Vellanikkara, Trichur. pp. 38-54.

*Dave, Y.S. and Rao, K.S. 1982. Cambial activity in Mangifera indica L. Acta Bot. Acad. Scientiarum, Hungarae 28 1/2: 73-79.

*De la Rocha, G.G. 1953. Mango grafting. Results of Propagation trials at La Molina Agrl. Experiment Station. Bol. Estac. exp. agric. La Molina 49: pp. 20.

Desai, J.B. and Patil, V.K. 1984. Success of stone grafting in mango in glass house and in open. Prog. Hort., 24 (1-4): 7-10.

Dhakal, B.R. and Hoda, M.N. 1986. Vigour of mango veneer grafts in relation to defoliation period and storage of scion shoots. South Indian Hort. 34 (3): 184-186.

Dhakal, D.D. 1979. Studies on stone grafting in mango. Thesis submitted to the Konkan Krishi Vidyapeeth, Dapoli Dist. Ratnagiri for the award of M.Sc. degree in Agriculture.

Dhandar, D.G. 1978. Vegetative propagation to increase cashew production in Goa. A paper presented at the 4th workshop of A.I.C.S.I. Project, Panaji, September.

Dhungana, D.B. 1984. Standardisation of methods of vegetative propagation in mango. Thesis submitted to the Kerala Agricultural University, Vellanikkara, Trichur for the award of M.Sc. degree in Horticulture.

Esau, K. 1979. Anatomy of seed plant. Wiley Eastern limited, 4835/24. Anseri Road, Daryaganj, New Delhi-110 002, 2nd Ed. p. 304-305.

Fahn, A. 1982. Plant Anatomy. Pergamon Press, Oxford, 3rd Ed. p. 304-305.

Faruque, A.H.M., Fakir, M.M.A.S. 1973. Propagation of mango by different methods of grafting. Bangladesh Horticulture 1 (2): 25-28.

Gaur, N.V.S. 1984. Comparative evaluation of selected methods of mango propagation. Prog. Hort. 24 (1-4): 1-6.

*Giri, A. 1966. Effect of varying girth of seedling stocks on percentage success in inarching in spring and autumn season in Mango. Pakist. J. Sci. 18: 76-78.

Gowda, B.J. and Me lanta, K.R. 1988. Vegetative propagation of Cashew (Anacardium occidentale Linn.) Cashew Bull. 25 (2): 17-20.

Gunjate, R.T. 1985. Standardisation of stone grafting for the Konkan region. Abs. Papers, Second International Symposium on mango, Bangalore, India, May 20-24.

Gunjate, R.T., Dhakal, D.D. and Limaye, V.P. 1982. Stone grafting in mango under Konkan conditions. Indian J. Hort., 39 (1 & 2): 45-50.

Gunjate, R.T., Kolekar, D.T. and Limaye, V.P. 1980. Epicotyl grafting in Jack fruit (Artocarpus heterophyllus Lam.) Curr. Sci. 49 (17): 667.

Gunjate, R.T. and Limaye, V.P. 1976. Effect of maturity of stock and scion and method of grafting on success in stone grafting in mango. Dapoli Agric. Coll. Mag. 7: 20-24.

*Gunjate, R.T., Urdya, A.S. and Limaye, V.P. 1976. Effect of season and defoliation of the scion shoot on success in veneer grafting in Alphonso mango. Marathwada Agricultural University 1 (Addi): 293-295.

Guruprasad, T.R., Khan, M.M., Iqlasahmed, Hanumanthappa, H. and Jagadeesh, G.B. 1988. Success of cashew top working technology at farmer's doors. The Cashew 2 (1): 10-11.

Hadankar, P.M., Salvi, M.J. and Joshi, G.D. 1987. Soft wood grafting, viable propagation technique for Konkam production (Garcinia indica). Indian Hort. 32 (3): 21.

Harmekar, M.A. 1980. Studies on vegetative propagation of cashew nut (Anacardium occidentale Linn.) and jack fruit (Artocarpus heterophyllus Lam.) thesis submitted to Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri, for the award of M.Sc. degree in Agriculture.

Ihara, Y. 1966. Studies on the greenwood grafting of horticultural plants. III. Histological observations on the process of graft union formation in green wood grafting and in grafting one year old wood. J. Jap. Soc. hort. Sci. 35: 183-9.

Ihara, Y. and Tamari, K. 1961. Studies on soft wood grafting of horticultural plants. 1. The possibility of, and suitable season for soft wood grafting in certain fruit and ornamental trees. J. Jap. Soc. hort. Sci. 30: 253-8.

Iqbal, M. 1982. Review of mango research and production in Fiji. Fiji agric. Journal 44 (1): 21-26.

Ismail, S and Rao, S.N. 1985. Standardisation of time and method of propagation for Banganappally mango. Abs. papers presented at second International Symposium on Mango India, Bangalore, May 20-24.

Jagirdar, S.M.P. and Bhatti, M.S. 1968. Effect of type of wood and age of root stock on the success of veneer grafting in mango. W. Pakist. J. agric. Res. 6 (1): 88-97.

*Jindal, K.K. 1968. Studies on vegetative propagation of annona (Annona squamosa Mill.) and Jack fruit (Artocarpus heterophyllus Lam.).M.Sc. (Agri.) thesis submitted to IARI, New Delhi.

Johansen, D.A. 1940. Plant microtechniques Mc Grew Hill, New York, 2nd Ed. p: 62-113.

Juliano, J.B. 1941. Callus development in graft union. Philipp J. Sci. 75: 245-554.

Kannan, T. and Das, G.C. 1985. "Epicotyl and soft wood grafting New techniques of vegetative propagation of cashew in Orissa. Cashew Causerie 4 (1): 5-7.

Kanwar, J.S. and Bajwa, M.S. 1974. Propagation of mango by sid grafting. Indian J. agric. Sci. 44 (5): 270-272.

Kashyap, R., Jyothish, R.P. and Sharma, A.B. 1972. Techniques c side grafting in mango. Acta Hort., 24: 97-100.

Kotecha, S.M. 1982. Studies on improving survival of mang (Mangifera indica L.) Stone grafts: Thesis submitte to Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagi for the award of M.Sc. degree in Agriculture.

Kulwal, L.U. and Tayde, G.S. 1985a. Studies on propagation c mango by stone grafting. Extent of mortality. Post presented at Second International Symposium on Mango Bangalore, India. May 20-24.

Kulwal, L.U. and Tayde, G.S. 1985b. Studies on propagation mango varieties by soft wood grafting under Ako conditions. Abs. paper, Second Internation Symposium on Mango. Bangalore, India, May 20-24.

Kumar, D.P. and Khan, M.M. 1988. In situ soft wood grafting cashew. The Cashew 2 (2): 3-5.

Luthra, N.C. and Sharma, M.M.L. 1946. Some of studies on t conductivity and histology of grafted mango shoot Indian Bot. Soc. J., 25: 221-329.

Maiti, S.C. and Biswas, P. 1980. Effect of scion variety a type of scion shoot on success of epicotyl grafti of mango (Mangifera indica L.) Punjab hort. J. (3 & 4): 152-155.

Majhail, M.S. and Singh, K.K. 1962. Inarching in mango. 1. The effect of alkathene wrapper, time of inarching and size of seedlings. 2. The optimum period of grafting and age of stock seedlings. Punjab hort. J. 2 (2): 109-113.

Majumder, P.K., Mukherjee, S.K. and Rathore, D.S. 1972. Further researchs on propagation techniques in mango. Acta Hort.124: 72-76.

Majumder, P.K. and Rathore, D.S. 1970. Bench grafting in mango Indian Hort. 14 (2): 11-12.

Mandal, G. 1979. Standardisation of propagation techniques i mango. Research paper presented in the mango worker meeting. All India Co-ordinated fruit Improvemen Project, Lucknow. pp. 112-117.

Mukherjee, S.K. and Majumder, P.K. 1961. Veneer grafting i mango has its own advantages. Indian Hort. 6 (1) 3 & 30.

Mukherjee, S.K. and Majumder, P.K. 1964. Effect of differer factors on the success of veneer grafting. Indian Hort. 21 (1): 46-51.

*Munch, E. 1930. Dic Shoft bewegumgen inder pflanze cust fisher varley K.G., Jeva. (cf. Maiti and Biswa 1980; Punjab Hort. J. 20 (3 & 4): 152-155.

Nagabhushanam, S. 1982. Epicotyl grafting in cashew. Cash Casuserie 4 (1): 8-9.

Nagabhushanam, S. 1985. Vegetative propagation in cashew - review of work done at Vittal. Acta Hort. (108): 57-63.

Nagabhushanam, S. and Rao, V. 1978. Propagational trials ir cashew (Anacardium occidentale L.) Indian Cashew J 11 (3): 7-11.

Nagawekar, D.D. 1981. Studies on survival and growth of mang (Mangifera indica L.). Stone grafts. Thesi submitted to Konkan Krishi Vidyapeeth, Dapoli, Dist Ratnagiri for the award of M.Sc. degree i Agriculture.

Nagawekar, D.D., Gunjate, R.T. and Salvi, M.J. 1984. Effect c various factors on survival of mango stone grafts. J Maharastra Agric. Univ. 9: p. 281-284.

Naik, K.C. 1941. Studies on the propagation of mango (Mangife indica L.)., Indian J. agric. Sci. 11: 756-768.

Naik, K.C. 1948. Vegetative propagational methods and the relation to tree performance in mango. (Mangife indica L.), Indian J. agric. Sci. 1948, 18: 1147-56

Nambiar, M.C. 1976. Annual Report, All India Co-ordinat Spices and Cashewnut Improvement Project.

Panse, V.G., Sukhatme, P.V. 1978. Statistical methods f Agricultural Workers. I.C.A.R., New Delhi. 3rd Ed. 75-77.

Patel, M.H. and Amin, R.S. 1976. Possibilities of bench grafti on young seedlings of mango under Anand conditio Indian J. Hort. 33 (2): 156-161.

Patel, B.M. and Amin, R.S. 1981. Investigation into the best period for soft wood grafting in mango in situ South Indian Hort. 21 (2): 90-94.

Patil, J.D., Warke, D.C., Patil, V.K. and Gunjkar, S.N. 1983 Studies on wedge grafting in mango. Punjab hort. J 23 (1 & 2): 29-34.

Patil, J.D., Warke, D.C., Patil, V.K. and Gunjkar, S.N. 1984 Studies on epicotyl grafting in mango. Indian J Hort. 41: 69-72.

Patil, V.K. and Patil, J.D. 1985. Effect of defoliation of t scion and age of rootstock in epicotyl and wed grafting in mango. Abs. papers, second Internation Symposium on mango. Bangalore, India, May 20-24.

Persai, P.S. 1974. Stone grafting on mango. Leaflet. Add Director of Agriculture, Madhyapradesh.

Phadmis, N.A., Choudhary, K.G. and Bandekar, D.O. 1974. Studi in the raising of cashew (Anacardium occident Linn.) clonal material in situ. Indian Cashew J (2): 7-13.

Pinheiro, K.V.R., Anderson, O. and Fortes, J.M. 1970. Compari of grafting methods for the propagation of man Rev. Ceres. 17: 264-273.

Prasad, A., Singh, R.D. and Sirohi, R.S. 1973. Comparat study of veneer grafting and patch budding Mangifera indica L. cv. Dasheri. Punjab hort. J. (1): 30-55.

Radhamony, P.S. 1987. Varietal responses of scion to ston grafting in mango for commercial propagation. Thesi submitted to Kerala Agricultural University for th award of M.Sc. degree in Horticulture.

Rajput, C.B. and Haribabu, R. 1971. Recent techniques of man propagation. World Crops: 23 (3): 146-148.

Ram, S. and Bist, L.D. 1982. Studies on veneer grafting mango in Tarai. Punjab hort. J. 22 (1 & 2): 64-71.

Rao, A. and Nambiar, M.C. 1977. Propagational trials in cashe (Anacardium occidentale Lin.). Indian Cashew J. (3): 7-11.

Rao, P.V. and Nagabhushanam, S. 1977. Further studies propagational trials in cashew. Indian Cashew 13 (2): 5-7.

Rao, S.N. 1985. Vegetative propagation in cashew - review of work done at Baptla. Acta Hort. (108): 64-66.

Rao, V.N.M. and Rao, I.K.S. 1957. Studies on the vegetat propagation of cashew (Anacardium occidentale Li Approach grafting with and without plastic f wrappers. Indian J. agric. Sci. 27 (3): 267-275.

Ratan, J. 1985. Standardisation of epicotyl grafting in man Thesis submitted to Kerala Agricultural Universi Vellanikkara, Trichur, for the award of M.Sc. deg in Horticulture.

Reddy, Y.T.N. and Kohli, R.K. 1985. Rapid multiplication mango by epicotyl grafting. Abs. papers, Sec International Symposium on Mango. Bangalc May 20-24.

Robert, R.H. 1949. Theoretical aspects of graftage. Bot. Rev. 15: 423-463.

Sahani, J. 1982. Some tips for the successful raising of "in situ" grafts of cashew (Anacardium occidentale Linn.) through technique of side grafting. Cashew causerie, 4 (1): 5-7.

Sawke, D.P. 1983. Effect of season and age of stock on success in epicotyl grafting in cashew. Cashew Causerie 5 (2): 7-9.

Seshadri, K.V. and Rao, R.R. 1986. Effect of age of the rootstock and pretreating scion on success of soft wood grafting in cashew. South Indian Hort. 34 (4): 255-257.

Singh, B., Singh, D.S. and Pathak, R.A. 1985. Standardisation of time and age of scion for veneer grafting in mango. Abs. papers, Second International Symposium on mango, Bangalore, May 20-24.

Singh, L.B. 1951. Mango grafting in 8 weeks. Curr. Sci. 144: 393.

Singh, L.B. 1960. The Mango, Botany, Cultivation and Utilization, Leonard Hill (books) Ltd., London. pp. 166.

Singh, M.P., Gill, S.S. and Khajuria, H.N. 1985. Standardisation of propagation techniques in mango. Abs. papers, Second International Symposium on mango. Bangalore, India, May 20-24.

Singh, N.P. and Srivastava, R.P. 1979. Studies on the different aspects involved in veneer grafting in mango. Prog. Hort. 11 (1): 67-73.

Singh, N.P. and Srivastava, R.P. 1981. Success in stone grafting of mangoes as influenced by the method of grafting and the age of the rootstock. Punjab Hort. J. 21 (3 & 4): 166-171.

Singh, N.P. and Srivastava, R.P. 1982. Studies on various factors involved in soft wood grafting in mango. Prog. Hort. 14 (2-3): 117-120.

Singh, N.P., Srivastava, R.P., Rajput, C.B. and Singh, H. 1983. Effect of seasonal variation on different methods of mango propagation. Indian Hort. 27 (4): 11-13.

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

Singh, R.N., Rao, O.P. and Singh, G. 1984. Propagational studies in mango. (M. indica L.) cv. Langra. Prog. Hort. 16 (3/4): 161-165.

Snedecor, G.W. and Cochran, W.G. 1967. Statistical Methods. Oxford and IBH Publishing Co., New Delhi, 6th Ed. p : 339-379.

Soule, J.I. 1971. Anatomy of the bud union in mango (Mangifera indica L.) Amer. Soc. hort. Sci. 96 (3): 380-383.

Srivastava, R.P. 1985. Propagation of mango by newer techniques. Abs. paper presented at the Second International Symposium on Mango. Bangalore, May 20-24.

Subramani, K.K. 1988. Flush grafting - an advancement in mango propagation for easy and economical multiplication. Farm jagat 1 (8): 11.

Talukdar, M.R. and Ahmed, S. 1965. Success of inarching done on three varieties of mango on young rootstocks at Lyallpur, Pakist. J. Sci. 17: 72-74.

Teaotia, S.S. and Maurya, V.N. 1970. Studies on propagation of mango by budding. Prog. Hort. 2 (1): 35-44.

Teaotia, S. and Srivastava, R.P. 1961. Here is a new method of inarching in mangoes. Indian Hort. 5 (3): 5-6.

Traub, H.P. and Auchter, E.C. 1933. Propagation experiment with avocado, mango and papaya. Proc. Amer. Soc. hort. Sci. 30: 385-386.

*Turkovac, Z. 1961. Reflections on the relationships between the vine rootstock and its scion. Mitt. Klosterenburg, Seri, A. 11A: 297-304.

Uradya, A.S. 1976. Studies on veneer grafting in mango. Thesis submitted to Kondan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri for the award of M.Sc. degree in Agriculture.

Valsalakumari, P.K., Vidyadharan, K.K. and Damodaran, V.K. 1985. A comparative study of different methods of vegetative propagation of cashew, Acta Hort. 108: 289.

*Wilson, J. and Wilson, P.M.V. 1961. The position of regenerating cambia - a new hypothesis. New Phytol. 60: 63-73.

*Zimmerman, M.H. 1958. Translocation of organic substances in the phloem of trees. The physiology of fruit trees. Ed. by Thimman, K.V. The Ronald Press Company, New York. p : 381-400.

(ef Maiti and Biswas, 1980. Punjab Hort. J. 20 (3 & 4): 152-155)

*Originals not seen

Appendices

APPENDIX - I

Statistical comparison using chi-square values for sprouting and survival (Variety Neelum)

Treatments	Sprouting	Survival
T_1	66.66 AB	0
T_2	92.85 BCDE	12 A
T_3	97.14 E	36 CD
T_4	73.68 ABC	12 A
T_5	97.05 DE	44 D
T_6	97.14 E	32 CD
T_7	71.05 AB	4 A
T_8	76.47 ABCD	32 CD
T_9	100 E	60 D
T_{10}	82.05 ABCDE	32 CD
T_{11}	82.05 ABCDE	16 A
T_{12}	92.11 BCDE	36 CD
T_{13}	94.87 DE	32 CD

(Contd...)

Appendix - I (contd.)

Treatments	Sprouting	Survival
T_{14}	94.74 CDE	59 D
T_{15}	92.30 BCDE	28 CD
T_{16}	77.5 ABCDE	32 CD
T_{17}	92.11 BCDE	52 D
T_{18}	87.17 ABCDE	40 CD
T_{19}	51.16 A	16 A
T_{20}	85.29 ABCDE	20 BC
T_{21}	73.53 AB	20 AB
T_{22}	53.49 A	48 D
T_{23}	94.12 BCDE	40 D
T_{24}	64.71 A	20 CD
T_{25}	46.51 A	20 BC
T_{26}	91.18 ABCDE	52 D
T_{27}	79.41 ABCDE	52 D

Treatments with same letters are not significantly different

APPENDIX - II

Statistical comparison using chi-square values for sprouting and survival (Variety Banganappally)

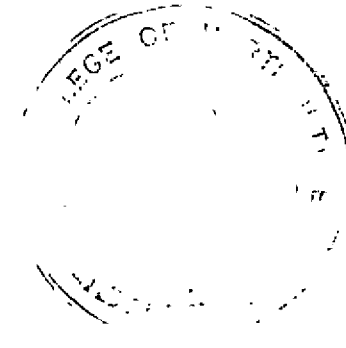
Treatments	Sprouting	Survival
T_1	84.21 ABCDEFG	0
T_2	85.71 ABCDEFG	0
T_3	100 G	24 ABCDEFG
T_4	76.31 ABCDEF	12 A
T_5	85.71 ABCDEFG	12 AB
T_6	97.14 EFG	52 EFG
T_7	52.63 ABCDE	0
T_8	88.57 ABCDEFG	12 AB
T_9	97.14 FG	44 CDEFG
T_{10}	23.26 ABC	12 ABC
T_{11}	82.05 ABCDEFG	16 ABCDE
T_{12}	91.17 BCDEFG	12 ABC
T_{13}	30.23 ABCD	20 ABCDEF
T_{14}	94.74 BCDEFG	24 ABCDEF

(Contd....)

Appendix - II (contd.)

Treatments	Sprouting	Survival
T_{15}	88.54 ABCDEFG	40 ABCDEFG
T_{16}	32.56 ABCDE	28 ABCDEFG
T_{17}	92.11 BCDEFG	24 ABCDEF
T_{18}	91.18 BCDEFG	24 ABCDEFG
T_{19}	27.91 ABCD	12 ABCD
T_{20}	70.58 ABCDEF	40 ABCDEFG
T_{21}	97.14 EFG	48 DEFG
T_{22}	20.93 AB	4 A
T_{23}	97.06 DEFG	48 DEFG
T_{24}	88 ABCDEFG	56 FG
T_{25}	18.60 A	0
T_{26}	88.24 ABCDEFG	40 BCDEFG
T_{27}	96 CDEFG	68 G

Treatments with the same letters are not significantly different



STANDARDISATION OF SOFT WOOD GRAFTING IN MANGO (*Mangifera indica* L.)

By

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ABSTRACT OF THESIS

Submitted in partial fulfilment of the
requirement for the degree

Master of Science in Horticulture

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ABSTRACT

The present series of investigations were carried out in the Department of Pomology and Floriculture, College of Horticulture, Vellanikkara during the period from June 1987 to April 1989 with a view to standardise the ideal age of rootstock, height of grafting and the time of defoliation of scion shoot for soft wood grafting in mango using two scion varieties, Neelum and Banganapally. Detailed anatomical studies of the graft union were also conducted to find out the various stages of graft union and the possible reasons for graft failure.

The results of the study on the response of age of rootstock on soft wood grafting using scion variety Neelum showed that two months old rootstock was most ideal with regard to sprouting and survival. The sprouting was minimum for three months old rootstock while survival was minimum for one month old rootstock. With the scion variety Banganapally, one month old rootstock recorded significantly maximum sprouting over two and three months old rootstock. However, survival was maximum with three monthd old rootstock. The height of grafting did not influence the sprouting and survival of grafts in both Neelum and Banganapally. With regard to scion defoliation, variety Neelum recorded maximum sprouting and survival with 10 days prior defoliation. While in Banganapally scion shoots

defoliated 15 days prior to grafting recorded maximum sprouting and survival.

The observations on growth parameters revealed that three months old rootstock recorded significantly maximum new growth in scion variety Neelum till the end of 5th fortnight. But with Banganapally as scion, age of the rootstock did not influence the new growth of scion significantly. With regard to height of grafting, the pooled data revealed maximum new growth of scion when grafted at 10 cm height in both the scion varieties Neelum and Banganapally. In the variety Neelum, scions defoliated 15 days prior to grafting recorded maximum new growth during early periods of observation. But in Banganapally, scions defoliated 10 days before grafting were found superior with respect to new growth particularly during the early periods of observation. Regarding leaf production, in variety Neelum, the pooled data revealed the superiority of two months old rootstock particularly from 5th fortnight onwards. While in Banganapally, three months old rootstock was found to be the best in this regard. Grafting at 10 cm height produced maximum number of leaves in both the varieties Neelum and Banganapally. In general, in both the scion varieties, scions defoliated 5 days prior to grafting produced maximum number of leaves. In the variety Neelum, the girth of new growth, scion and rootstock were significantly influenced by the age and

height of rootstock and defoliation of scion shoots while in Banganappally, the effects were not found to be significant.

Anatomical studies of the graft union revealed four distinct stages in the healing process of graft union. Secondary xylem and phloem were not differentiated even after 90 days of grafting. In the unsuccessful grafts, where the scion shoots dried up within 10 days after grafting, there was no callus production and here the wound periderm was thick and dark. Some others were with wide gap. In grafts that remained green without sprouting even after 45 to 90 days of grafting, there was very little callus production that too from stock side only. Some graft failures were due to the misaligned arrangement of cambia of stock and scion.