STANDARDISATION OF EPICOTYL AND SOFTWOOD GRAFTING IN JACK

(Artocarpus heterophyllus Lam.)

By

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THESIS

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DECLARATION

*I hereby declare that this thesis entitled "Standardisation of epicotyl and softwood grafting in jack (**Artocarpus heterophyllus** Lam)" is a bonafide record of research work done by me during the course of research and this thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar title of any other university or society to me.*

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CERTIFICATE

*Certified that this thesis entitled "Standardisation of epicotyl and softwood grafting in jack (**Artocarpus heterophyllus** Lam) is a record of research work done independently by **Miss. Mini Jose** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associate-ship to her.*

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Dr. P.K. Valsalakumari,
Chairman,
Advisory Committee.

To my Grandpa

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Introduction

INTRODUCTION

Jackfruit, known as the poor man's food is hardly regarded as a commercial fruit crop although it is very popular in the eastern and southern parts of India. It is the largest among the edible fruits and is indigenous to India. Tender jackfruit appears in the market in spring and continues until summer as a popular vegetable in Kerala. Since common vegetables are scarce and costly at that time of the year, jackfruit enjoys a reasonably good demand and fetches better price.

Vegetative propagation ensures genetic uniformity among the progeny and is preferred to seed propagation for the multiplication of heterozygous genotypes having superior traits. Neverthless, jackfruit, an important fruit crop of Kerala, inspite of being cross pollinated is mostly propagated through seeds. Vegetative methods like inarching, though successful is very cumbersome, expensive and impracticable in jackfruit where trees are very tall and scattered. The airlayers though root successfully suffer heavy mortality in the field and budding methods do not give consistent results.

In earlier days not much work has been conducted on epicotyl grafting in jack but later this method was studied in detail and standardised for jack for the Konkan region by Harmekar (1980) and Gunjate et al. (1980) who obtained a success of 50 to 90 per cent and 95 per cent respectively. Further, epicotyl grafting was standardised for mango in the Department of Pomology and Floriculture, College of Horticulture, Vellanikkara (Dhungana, 1984; Ratan, 1985 and Radhamony, 1987). Thus there existed the need to undertake studies to standardise epicotyl and softwood grafting in jack. Hence the present 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 the following objectives.

1. To standardise the season for epicotyl and softwood grafting.
2. To standardise the age of rootstock for epicotyl and softwood grafting.
3. To study the effect of intermittent mist on the percentage of success of grafting.

Review of Literature

2. REVIEW OF LITERATURE

Jackfruit, though an important fruit crop of Kerala, has not been exploited properly. Being cross pollinated and seed propagated the seedings show a lot of variation and most of them are of poor quality. This is mainly because of the lack of an easy, inexpensive and rapid method of vegetative propagation. Vegetative propagation is mainly used for the maintenance of clones, for propagating seedless plants and to avoid long juvenile phase of growth. In general, mass propagation by vegetative means is not more economical than comparable propagation by seedlings but its use is justified by the superiority and uniformity of specific clones. The major economy in vegetative propagation comes from the elimination of the juvenile phase.

Literature pertaining to the vegetative propagation methods, especially grafting and budding and the factors influencing their percentage of success in important fruit crops are briefly dealt with in this chapter.

In jackfruit not much work has been conducted in vegetative propagation. The highest rooting and survival percentage (84 per cent and 75 per cent respectively) were obtained when invigorated etiolated shoots of jack were treated with IBA at 5000 ppm (Mukherjee and Chatterjee, 1978a) Stem cuttings of jack gave cent per cent rooting when forced etiolated shoots were treated with IBA at 5000 ppm by the quick dip method (Chatterjee and Mukherjee, 1982). Studies by Dhua et al. (1983) showed that ringing and etiolating for 30 days combined with treatment with IBA at 3000 ppm + ferulic acid at 2000 ppm gave the highest rooting (90 per cent) and plant survival (100 per cent).

Sen and Bose (1959) found a significant increase in the percentage of success and the number of roots formed in air layers of jack, when IBA and NAA were used. IBA gave optimum results with a concentration

of 5000 ppm and NAA with 10,000 ppm. Singh (1961) reported that air layers came to bearing at least 5 to 6 years earlier than seedlings. Etiolated shoots when treated with IBA 5000 ppm and lanolin gave an overall average of 75 per cent rooted shoots of which 71 per cent survived after one year (Chatterjee and Mukherjee, 1980). The percentage of jack layers which rooted successfully, the number of roots per layer, the length and weight of roots, and survival of the layers in the field were greater when stems were pregirdled, etiolated and treated with IBA and NAA than when any of these treatments was applied individually (Lingarajappa, 1982). Studies done by Nazeem et al. (1984) showed that the best rooting (81.29 per cent) was obtained by air layering ringed one year old shoots of bearing plants using coconut pith as the rooting medium. Derai and Patil (1984) reported that treatment with NAA and IBA (2500 and 5000 ppm) and covering with black polythene resulted in the best rooting of jackfruit layers.

Patch budding in jack gave 100 per cent success when done in the middle of June and over 90 per cent success when done in May or July (Teaotia et al., 1963). Dhar and Chaturvedi (1976) have also reported June to be the optimum period for budding in jackfruit. Works conducted by Singh and Srivastava (1982) showed that T budding was the least successful method among patch, chip and T budding techniques. Patch budding in June and July gave the highest take of 90 and 81.6 per cent respectively. The most suitable period for jackfruit budding was from May to August. Biswas and Hossain (1984) tried five different methods of budding on one year old seedlings. Ring budding gave 80 per cent success when carried out in May but the success rate declined to 20 per cent in June. The next best results were obtained with flute budding in May and June (60 per cent and 40 per cent respectively).

About 84 per cent success was obtained in inarching of jack on its own seedlings (Sreenivasan, 1970). Nazeem et al. (1984) also found approach grafting to be successful in jack.

Kolekar (1979) found veneer grafting to be successful in jackfruit under Konkan conditions. The maximum success was 60 per cent obtained during mid April and November. Rainy season appeared to be unsuitable.

Kolekar (1979) opined that epicotyl grafting could be successfully used for vegetative propagation of jackfruit. Under Konkan conditions he got a success of 90 per cent in the month of April. Gunjate et al. (1980) from Dapoli reported success ranging from 50 to 90 per cent in jackfruit during April to mid June. Harmekar (1980) also got a maximum success of 95 per cent in the month of June followed by March and April under Konkan conditions. Contrary to mango, summer period was found to be the best time for stone grafting in jack.

2.1 Effect of season on the success of grafting

2.1.1 Stone grafting

Stone grafting also known as epicotyl grafting or bench grafting is a recently developed technique which has many advantages over the existing methods of vegetative propagation. The grafting is done on the epicotyl region of the tender seedlings. The precured terminal mature shoots having dark green colour with plumpy and dormant apical buds from selected mother trees are used as scion sticks. The rootstock is beheaded and a vertical slit is given in the centre of the epicotyl. The lower portion of scion is prepared to form a wedge and this wedge shaped scion is inserted in the vertical slit of epicotyl and then tightly wrapped with polythene tape.

Majumder and Rathore (1970) reported that stone grafting in mango was more suitable for the humid region. Under Basti conditions when grafting was done in mango during July to August a success of 80 to 85 per cent was obtained (Upadhyay and Gupta, 1979). In Bihar the highest success of 60 to 90 per cent was reported during the months of July to October (Mandal, 1979). Singh et al. (1979) stated that higher atmospheric humidity caused by high rainfall and high temperature were very congenial

for the the union of stock and scion in stone and wedge grafting of mango. When epicotyl grafting was done in mango during June-July with 3 to 4 months old defoliated scion shoots preferably of single flush the percentage of success varied from 50 to 96 per cent (Maiti and Biswas, 1980). Dhakal (1979) and Dengale (1980) recommended the period from June to September to be the best time for epicotyl grafting in mango under Konkan conditions. Subsequent studies by Gunjate et al. (1982) also showed that the period from June to September was the best period for stone grafting of mango in Konkan region. Success ranging from 62.2 to 64.7 per cent was obtained during June to September which was reduced in October (55.6 per cent) and November (35.5 per cent). Under the same conditions the sprouting and survival of grafts were found to be significantly higher in the month of June and during early part of July (Kotecha, 1982). Grafting success was more or less uniform in June, July and August when epicotyl grafting was done on mango (Chakrabarthi and Sadhu, 1983). In this study results were uniform in June, July and August because of similar warm and humid climate during the 3 months and because of uniform artificial/microclimate maintained inside the polythene chamber at the initial stages of graft take of all treatments. Gunjate (1985) had found that the percentage of survival of stone grafts made in June and July was the highest. A study by Dhungana et al. (1985) revealed the fact that the percentage of success was the highest (69.33 per cent) when stone-grafting in mango was done during August and was the lowest in May(20.6 per cent) in Kerala. Srivastava (1985) recorded a success upto 95 per cent during the last week of June when the mean temperature and humidity were 33.5°C and 88 per cent respectively.

Harmekar (1980) tried epicotyl grafting with success for the first time in cashew under Konkan conditions. The highest percentage of success was achieved during the month of June followed by March and April and the rainy season appeared to be unsuitable. Nagabhushanam (1982) reported that in the initial trial a maximum success of 50 per cent was obtained

in July in cashew epicotyl grafting. But a modification in the technique of grafting gave success upto 60 per cent from June to November. The modification adopted was to protect the scion from desiccation by capping the scion with a narrow polythene bag and securing it at the base with a rubber band. Nagabhushanam and Mohan (1982) obtained a success of 30 per cent for stone grafting in cashew when done in July followed by the month of August at the cashew seed farm, Shantigodu, Karnataka. They also observed that the success gradually declined from 15 per cent in September to 5 per cent in November. They concluded that high humidity and heavy precipitation which occurred during June, July and August months had a beneficial effect on the success of epicotyl grafting in cashew. February to May is the optimum period for epicotyl grafting in cashew under Konkan conditions and there was no success during monsoon months (Sawke, 1983). Grafting success was highest between June and August (60 to 68 per cent) and declined to 45 to 47 per cent in November. Sawke (1984) reported that the period from February to May was congenial for grafting of cashew in which success from 60 to 74 per cent was obtained. Konkar and Das (1985) reported a success of 65 to 80 per cent during April to July and 73 to 100 per cent during October to February. Works conducted by many workers showed that epicotyl grafting could be successfully used for propagating jackfruit (Kolekar, 1979; Gunjate et al. 1980 and Harmekar, 1980).

2.1.2 Softwood grafting

Amin (1978a) from Anand Gujarat recommended in situ softwood grafting in mango to be successful during March to September. Recently softwood grafting is gaining popularity with a good success in Gujarat and Konkan region, Maharashtra (Amin 1978 a, b, Nagawade et al., 1979). Maximum success (84 per cent) was obtained, when softwood grafting in mango was done in July (Singh and Srivastava, 1980). In later works conducted by Patel and Amin (1981) it was found that grafting between the third week of May and third week of August in mango resulted in 95 to 100 per cent take. Take between February and May ranged from

85 to 97 per cent but after third week in September it decreased considerably. Singh and Srivastava (1982) had conducted grafting studies in mango at Lucknow and had found out that maximum success (90 per cent) was obtained in August compared to 67 per cent in July and 70 per cent in late September.

The success of softwood grafting in mango when done in mid June was 100 per cent, however in mid July, it was only 76.6 per cent (Singh et al., 1984). Softwood grafting in mango when done during the last week of June when the mean temperature was 33.5°C and humidity 88 per cent the success had gone upto 95 per cent (Srivastava, 1985). Singh et al. (1986) had conducted studies on softwood grafting in mango and 100 per cent success was obtained in mid June.

Sawke et al. (1986) observed that the highest mean success of softwood grafting in Cashew was in August (83.66 per cent) followed by April (83.00 per cent) and the lowest (22.33 per cent) in December. Softwood grafting tried on nursery seedlings of cashew at A.R.S. Ullal had given good success during the month of March, April and May (Kumar and Khan, 1988). By in situ softwood grafting on cashew sprouts of 10-15 years old trees a success of 80 per cent was reported and April was found to be the best month for grafting (Anan, 1988).

2.1.3 Veneer grafting

Spring season was found to give better results than autumn for veneer grafting in mango (Ahmad, 1964). Further it was observed that the best dates for spring and autumn grafting were 15th March and 15th August respectively. In mango, Mukherjee and Majumder (1964) observed that March to July was the most congenial period for veneer grafting under Delhi conditions recording a success of 76 to 96 per cent. The maximum growth of scion was obtained in grafts prepared during March to April. They observed that success in veneer grafting depended upon the active growing phase of the mother trees. Sukla (1964) had got 80, 60 and 30 per cent success in in situ veneer grafting in mango on 1 1/2

year old rootstocks under Gujarat conditions during August, September and March respepctively, whereas more than 70 per cent success was reported from June to September under Vengurla conditions (Limaye and Phadnis, 1968). A success of 88 per cent and 87 per cent was reported in veneer grafting of mango during the first week of August 1968 and 1969 respectively (Bhambota et al., 1971).

Prasad et al. (1973) conducted studies in mango on the comparative success of veneer grafting and patch budding and it was concluded that veneer grafting was significantly superior to patch budding with respect to percentage of success and vigour of sprouts. It was also found that July was the best period for veneer grating in mango. Gunjate et al. (1976) under Konkan conditions observed that the success in veneer grafting of mango was quite low upto February but thereafter the success was high ranging from 76 to 84 per cent during March to first fortnight of May. Gunjate and Limaye (1978) found that success in veneer grafting of mango was quite high ranging from 68.33 to 91.00 per cent during 15th March to 1st June. Singh et al. (1979) reported that the percentage of success of veneer grafting was maximum (75 to 92 per cent) in the rainy season (July and August). The minimum success was recorded in November to December (16 to 20 per cent). Ram and Bist (1982) observed that under Tarai conditions of Punjab, the months of June, July and August were the best periods for veneer grafting during which 100 per cent take could be expected. They also observed that the low percentage of success in January corresponded with the period of low temperature and that in May and June compared to other months corresponded with the period of high humidity.

Singh et al. (1984) reported that June was the best season for veneer grafting in mango with a success of 96.6 per cent. Veneer grafting in first fortnight of July with 3 months old scions resulted in higher percentage of success and took minimum period for the sprouting of grafts. The second fortnight of June was found equally good for grafting with one month or six month old scions. Veneer grafting was also successful in the first

fortnight of August with 3 month old scions (Singh et al., 1985). Better percentage of success (85 per cent) in veneer grafting was recorded during September while in summer months i.e. April to May very poor success ranging from 0 to 5 per cent was recorded. Rainy months of August and September appeared to be favourable for veneer grafting (Ismail and Rao, 1985).

Kolekar (1979) found veneer grafting to be successful in jackfruit under Konkan conditions. The maximum percentage of success was 60 obtained during mid April and November. Rainy season appeared to be unsuitable.

Phadnis et al. (1974) reported that maximum percentage of success in veneer grafting of cashew was during June to July. The percentage of success was maximum in July (60 per cent) followed by June (53.3 per cent) while in August and September, the lowest success of 13.3 and 6.70 per cent respectively was obtained. Nambiar (1976) had found out that maximum success of veneer grafting (85 per cent) was obtained in the month of July. At CPCRI, Kasaragod also the most congenial time for veneer grafting was found to be July to October (Anon, 1976). Dhandar (1978) could get 36 per cent success in veneer grafting of cashew, from November to March. Work conducted at Mannuthy, Trichur, Kerala showed that the maximum success in veneer grafting of cashew was during the monsoon season (Nambiar, 1978).

Valsalakumari et al. (1979) also reported the highest percentage of success during the monsoon period for different methods of vegetative propagation of cashew viz., side grafting, veneer grafting and patch budding tried at Cashew Research Station, Madakkathara. Rao and Naghabhushanam (1979) also found monsoon period as the most suitable time for veneer grafting under Karnataka conditions. The rainfall and relative humidity were found to be highly correlated with percentage of success of veneer grafting. Harmekar (1980) reported that veneer grafting was found to be successful in cashew under Konkan conditions with a maximum success

of 40 per cent in the month of September. Rao and Rao (1983) opined that June to September was the best time for veneer grafting in cashew under the east coast conditions.

Mukherjee and Singh (1965) reported that April, May and June were suitable for veneer grafting in guava. Bhandary and Mukherjee (1970) obtained a maximum success of 85 per cent in July, when compared to March (20 per cent), April (60 per cent) and August (30 per cent). Rao and Kaul (1977) observed July to be the best month for veneer grafting in guava.

2.1.4 Inarching

February to July was found to be the optimum time for inarching in mango under South Indian and Punjab conditions (Naik, 1941 and Mukherjee, 1953). Singh (1960) reported that the success of inarching depended to a great extent on weather conditions prevailing during the operation. Singh *et al.* (1979) reported that the highest percentage of success for inarching was during the monsoon period (July to August) followed by spring (March to April).

Rao and Rao (1957) conducted studies on inarching in cashew and found that the highest take (100 per cent) was obtained in November followed by March (80 per cent). They found that the period between January and June was congenial for satisfactory graft union in cashew, under Kerala conditions. The period July to October was the best for undertaking inarching (Anon, 1962).

Ahamed (1966) reported that 80 per cent success was obtained by inarching in guava during two autumn seasons and 60 and 84 per cent success in two spring seasons.

2.1.5 Side grafting

Sahani and Patro (1979) found that side grafting in cashew can be done successfully in both the seasons viz. during spring (February to

April) and during monsoon (July to October). The percentage of success obtained in the above two seasons were 46.50 and 44.75 respectively. They also found that success of side grafting in cashew was maximum during spring season (53 to 58 per cent) in March and during the monsoon season in July and August. Kanwar and Bajwa (1974) reported that grafting in mango during March to April and June to October gave the best results. Kanwar and Jawanda (1983) had top worked inferior mango trees by modified side grafting and suggested heading back of scaffold limbs in February to March. Under Lucknow conditions August was found to be the best season (76 to 80 per cent success) followed by 76 per cent in July (Singh et al., 1983).

2.1.6 Budding

Berwick (1940) had opined that budding in mango could be done in wet weather conditions. June to August was found to be the most successful period for budding operation (Lynch, 1941). Ahmad and Ahmad (1960) got best results on 10th May in the spring and 30th September in the autumn. July budding was found to be the best with 100 per cent success by Singh and Srivastava (1962). But March was found to be the best season for budding in mango by Teaotia and Maurya (1970) under Uttar Pradesh conditions.

Rajput and Haribabu (1971) found that chip budding in mango could be done from June-March excepting the periods of heavy rainfall. Later Prasad et al. (1973) obtained 60 per cent success in the month of May. Singh et al. (1983) found that for budding in mango August was the best month. Patch budding jack in the middle of June gave 100 per cent success (Teaotia et al., 1963).

Naik (1949) had reported that patch budding was successful in cashew. Studies conducted by Phadnis et al. (1974) in Maharashtra revealed that patch budding was superior to veneer grafting on one year old stock plants during September to November. Patch budding in cashew when done in

July recorded 71 per cent success in Tamilnadu (Palaniswami and Hameed, 1976).

Panday et al. (1979) reported that patch budding was successful in guava when done in May (90 per cent), April (85 per cent), June (80 per cent) and July (70 per cent) and the percentage of success was the least in August (55 per cent). Patch budding on one year old rootstock gave maximum success in May (70.12 per cent) and June (68.75 per cent) which declined to 33.75 per cent in September.

2.2 Effect of age of rootstocks and scion

2.2.1 Epicotyl grafting

Age of rootstock and scion and the precuring of scion before grafting are reported to increase the percentage of success in different methods of grafting. Semimatured terminal shoots must be used for stone grafting in mango (Bhan et al., 1969). Gunjate et al. (1977) reported maximum success of 84 per cent with mature and defoliated scions of 3 to 4 months old and with immature stock (4 to 7 days old) in stone grafting of mango under Konkan conditions. According to Dhakal (1979) scion sheets of more than two months age and stocks of less than two weeks age were more suitable for stone grafting in mango. He could obtain a success of 60 per cent on one week old seedlings and 50 per cent on two week old seedlings. Dengale (1980) found that one week old seedlings were the best for stone grafting in mango and he obtained a success of 73.3 per cent. Maiti and Biswas (1980) reported from Krishnanagar that epicotyl grafting on mango could be best done with 3-4 month-old scion material and obtained a success of 50-60 per cent. Singh and Srivastava (1981) tried stone grafting using seedlings of two to ten days of age and obtained the highest percentage of success (85 per cent) with five day-old rootstock followed by four day old rootstock (80 per cent). Gunjate et al. (1982) found that seedlings less than two week old with coppery red colour were most suitable as rootstock. The highest percentage of success was got with one week old rootstock (60 per cent) followed by two week (58 per cent), four week (51 per cent)

and six week (45 per cent) old rootstocks. Success in stone grafting decreased with increase in the age of stocks. The scion shoots must be more than 2 months old. Gunjate (1985) conducted studies in the Konkan region and found out that rootstocks upto two weeks of age could be used for stone grafting in mango. Dhungana et al. (1985) had standardised epicotyl grafting in mango and found out that four month old scion material proved superior with the highest percentage of survival (61.33 per cent). Highest survival (58.0 per cent) was observed with 5 day old stocks. The survival rate decreased to 50.00 and 32.00 per cent respectively when the age of stock increased from 5 to 10 and 15 days.

Initial sprouting in stone grafts was more in the case of 6 day old stock and 7 day defoliation period and height of plant and number of leaves was highest in 4 day old stocks. The final success and the girth of stock and scion were more in four day old stock with a defoliation period of 5 days (Patil and Patil, 1985). The highest success of 80 per cent was obtained with 7 day old seedlings in side grafting and 60 per cent in tongue grafting. As the age of the stock seedlings advanced the grafting success was reduced (Singh et al., 1985). Chakrabarthi and Sadhu (1984) reported that regardless of age of the scion 5 day-old rootstock gave more success, which decreased with an increase in age. Similarly, with an increase in age of the scion, success tended to decrease in all the age groups of rootstocks. One month old scions grafted to 5 day old rootstocks gave the best result.

Bhandary et al. (1974) found that epicotyl grafting could be successfully done on cashew seedlings of 21 days age. Harmekar (1980) reported that four to eight week old seedlings were suitable for stone grafting in cashew. Nagabhushanam (1982) suggested the use of 10-15 day-old rootstock for stone grafting in cashew. He also suggested that the terminal shoots of previous seasons growth could be used for stone grafting in cashew. Sawke

(1983) reported that cashew seedlings of about 10 days of age are the best for epicotyl grafting. Shylaja (1984) had reported that there was apparently no difference in the percentage success of stone grafts prepared from 10 day old and 5 day old stocks. The effect of the age of the rootstock on success of epicotyl grafting revealed that 5 to 7 day-old seedlings were the best for this purpose and epicotyl grafting was found to give better success than softwood grafting (Konkar and Das, 1985).

2.2.2 Softwood grafting

Amin (1978 b) obtained 100 per cent success by *in situ* softwood grafting technique on 11/2 year or more aged mango seedlings. The method was tried on 11/2 year-old seedlings of many other fruit crops also. Singh *et al.* (1984) had reported a mean success of 70 per cent by softwood grafting in mango using 4 to 5 month-old scion shoots and one year old seedling rootstock.

Konkar and Das (1985) had conducted vegetative propagation studies on cashew in Orissa and found out that 15 to 60 day-old seedlings could be used as rootstock for softwood grafting.

2.2.3 Veneer grafting

In mango Ahmad (1964) obtained good results when veneer grafting was done on nine month old seelings. Mukherjee and Majumder (1964) reported that the success of veneer grafting in mango was only 4 to 12 per cent with 11/2 to 21/2 months old scion shoots. When scions of three months of age were used the success was the maximum (88 per cent). Scion sticks older than three months when used did not produce any good results. When mature scion wood was used there was an increase in the percentage of take as compared with immature scion wood. Age of rootstock did not affect per cent success of grafting (Jagirdar and Bhatti, 1968).

Limaye and Phadnis (1968) showed that veneer grafting should be done in mango seedlings of 12-14 months age. Age of the scion must be more than three months and age of rootstock of 1-2 years for better success in veneer grafting of mango (Rajput and Haribabu, 1971). Prasad et al. (1973) got 92 to 95 per cent success and better growth on two year old mango stocks against 80 per cent on one year old stock. Studies conducted by Uradya (1976) in Dapoli showed that the percentage of success of veneer grafting in mango was very high in all age groups of scions tried. Works conducted at the Central Mango Research Station, Mahanagar, Lucknow by Singh and Srivastava (1979) showed that the influence of age of the stock on the success in veneer grafting was very clear and consistent. Better success was recorded with 12 and 24 month-old stocks, while lesser success was recorded with 6 month-old stocks followed by 18 month old stocks. This might be due to the fact that the grafting operation in 12 and 24 month old stocks was done in the month of August and with 6 and 18 month old stock was done in the month of February. The age of the scions sticks had a significant effect on the success in veneer grafting. Six month old scion sticks gave better success as compared to scion sticks of three months and one year in age. Singh et al. (1985) had reported that veneer grafting in the first fortnight of July with three months old scions resulted in higher percentage of success.

Jindal (1968) reported that veneer grafting in jack had a success of 20 per cent with one to two week old defoliated scions and 10 per cent with three to four month old defoliated scions. Phadnis et al. (1974) reported that the highest percentage of success (60 per cent) was achieved by veneer grafting of five month old seedlings of cashew than on one year old seedlings. Studies conducted at the Central Plantation Crops Research Institute showed that 12-18 month old seedlings were the best for veneer grafting in cashew. Maximum success of 96 per cent was obtained by veneer grafting of cashew on six month old stocks than with 15 to 20 month-old stocks (Nagabhushanam and Rao, 1977). It was also reported out that six month old rootstock was superior to eight, five, four and three month old rootstocks (Anon, 1982).

2.2.4 Inarching

Rootstock studies conducted in Phillipines by Burns and Prayag (1921) showed that inarching was successful even when three week old seedlings were used. Naik (1941) reported that the stock can be used for inarching even when they are 41/2 months old. He further observed that there was no difference between the percentage of successful grafts when grafting was done on rootstocks of different age, but one year old mango seedlings were found to be the best (Naik, 1948). Success in inarching of mango with 2 to 3 week old seedlings was reported by Singh and Singh (1956).

2.2.5 Budding

Singh and Khan (1943) got maximum success in budding on three year old rootstocks of mango. Report by Jagirdar and Ali (1965) showed that bud take was more in nine months than two year old stocks.

Phadnis et al. (1974) used seedlings of 12 to 18 month-old and they observed that when the age of rootstock increased the percentage of success also increased. Rootstocks of three, six and nine months gave good results when patch budded (Parente and Maciel, 1973). Ferraz (1974) reported 99.7 per cent success with eight month old rootstock and 69 per cent with six month old rootstocks.

2.3 Effect of prior defoliation of scion shoots

Gunjate and Limaye (1977) observed equal success in stone grafting in mango with and without prior defoliation of scion shoots. In stone grafting of mango defoliation of scion shoots did not produce any beneficial effect (Dhakal, 1979). Maiti and Biswas (1980) from Krishna Nagar reported that scion shoots defoliated 7 days ahead of grafting operation, while still attached to the mother plant gave higher percentage of successful grafts than un-

defoliated scions. Singh and Srivastava (1981) reported that defoliation 10 days prior to grafting gave the highest success and least success was with defoliation 5 days prior to grafting. Gunjate et al. (1982) observed that there was no appreciable difference in the success obtained with precured and nonprecured scion shoots. The higher success with undefoliated scion may be due to active mango buds throughout the year because of continuous warm and humid climate in Konkan region (Gunjate et al., 1976). The number of days required for sprouting decreased significantly with the increase in scion defoliation period. Minimum days (14.39) were required in the treatment of defoliation 15 days prior to grafting and maximum days (17.70) in defoliation 5 days prior to grafting (Patil et al., 1983). The swelling of buds were observed in early defoliated scion which might have affected the early sprouting. According to Dhungana (1984) 4 month old scions defoliated 10 days prior to grafting gave maximum percentage of success. Patil and Patil (1985) conducted studies at Marathwada Agricultural University on epicotyl and wedge grafting in mango and found out that the initial and final success was highest with scion defoliated 15 days prior to grafting.

Bhandary et al. (1974) found that in wedge grafting of cashew, scions with and without defoliation produced almost the same effect. With thin scions the percentage of success was 62 per cent both with and without defoliation. Nagabhushanam (1982) reported that for stone grafting in cashew, the scion shoot selected for grafting should be defoliated about a week before grafting. Shylaja (1984) conducted studies on epicotyl grafting in cashew in KAU, Vellanikkara and observed that scion shoots defoliated 10 days before grafting gave a maximum success of 82.60 per cent in August.

Amin (1978 a) reported that the success in establishment of softwood grafts was less if the graft was prepared using a leafless branch retained on the tree for less than 8 to 10 days or more on the mother tree and

still not sprouted on the tree itself. 100 per cent success was obtained in in situ softwood grafting in mango by wedge method and the scion defoliated 10 days prior to the grafting operation. Studies on softwood grafting conducted by Venkata Reddy (1987) at UAS Hebbal, Bangabre showed that scions preconditioned before 10 days of grafting gave maximum success followed by scions preconditioned before 5 days and without precuring.

Mukherjee and Majumder (1964) had recommended the use of prior defoliated scion shoots for veneer grafting. However if the buds of scion shoots were naturally swollen the defoliation was not necessary. When undefoliated scions were used only 10 per cent success was obtained. Rajput and Haribabu (1971) opined that for obtaining maximum success in veneer grafting of mango precuring of scion shoots was necessary. Gunjate et al. (1976) reported that prior defoliation of scion shoot was not necessary for veneer grafting of mango under Konkan conditions. The average per cent of success was 48.16 per cent with undefoliated scions and 45.16 per cent with defoliated scions. Singh and Srivastava (1979) reported that a defoliation period of 10 days resulted in more success in both three and six month old scion stick whereas the same percentage of success was recorded when the defoliation period was 15 days in only one year old shoots. Ram and Bist (1982) reported that the percentage of success was higher when predefoliated scions were used when compared to that of freshly defoliated scions. This was probably because pre-defoliated scions suffered less from desiccation than those of freshly defoliated scions which retain their leaf stalk for some time after grafting and cut ends of the leaf stalk accelerate the desiccation process. Jindal (1968) found that veneer grafting in jackfruit gave 10-20 per cent success when defoliated scion was used and with no success when undefoliated scion was used.

Teaotia and Maurya (1970) found that the percentage of bud sprouts in mango increased when two weeks prior defoliation to grafting was given.

2.4 Effect of grafting and budding techniques

There was not much substantial differences between the whip and cleft method for epicotyl grafting in mango. A success of 75 to 85 per cent was got in both these methods (Bhan et al., 1969). Majumder and Rathore (1970) tried bench grafting in mango under Delhi conditions and the percentage of success was found to be 50, 46.6 and 33.3 per cent for splice, veneer and wedge grafting respectively. Work conducted by Amin (1976) under Anand conditions showed that bench grafting using whip, tongue, wedge and splice methods were equally good at the initial stages but the highest final success was for whip followed by tongue, wedge and splice methods. Singh and Srivastava (1981) found that cleft method gave better result in epicotyl grafting of mango than side, whip and tongue methods. Gunjate et al. (1982) reported that there was not much difference in the success in stone grafting when splice, wedge and modified wedge methods were used but for convenience wedge method was preferred.

Mathew and Joseph (1982) reported that splice and cleft method of grafting gave similar results in epicotyl grafting of nutmeg.

Ascenso and Milbeiro (1973) tried cleft and splice method for mini-grafting in cashew and found that both methods gave 100 per cent success. Nagabhushanam and Mohan (1982) also reported that there was no difference in percentage of epicotyl grafting by cleft and splice method in cashew.

Gaur (1984) reported that among the methods evaluated like inarching, veneer grafting, stone grafting and softwood grafting, softwood grafting gave the highest percentage of success (75 to 80 per cent) in mango. Reddy (1987) reported that among the different methods of grafting in mango softwood, wedge, veneer and splice grafting, softwood grafting recorded the maximum rate of graft take followed by wedge, veneer and splice grafting.

Singh and Srivastava (1982) reported that better success was obtained in mango when grafted by softwood grafting as than by veneer grafting.

Singh et al. (1983) reported the highest success in inarching (90 per cent) followed by veneer grafting (88 to 92 per cent) and lowest under budding (64 per cent).

Singh et al. (1982) reported that patch budding was significantly superior to chip and T budding in jack. T budding was least successful.

Work conducted by Gowda and Melanta (1988) showed that in grafting methods, significant differences were observed and whip grafting recorded the highest success rate followed by wedge and veneer grafting in cashew.

2.5 Other factors affecting success in grafting

Mukherjee and Chatterjee (1978,b) suggested the use of juvenile shoots for better success in vegetative propagation in jack. Reyes (1977) reported that maximum success of graft take of 95 per cent was obtained when mango grafts were covered with wet plastic bags and placed in the shade. Singh and Srivastava (1979) reported that for veneer grafting in mango white and green polythene tapes covering resulted in better success. Success was minimum in plants tied with gunny twine alone. Singh and Srivastava (1982) also obtained beneficial effect when budsticks of mango were covered with polythene film compared to without polythene film. The success of epicotyl grafting under glass house, green house or under partial shade of the tree was studied and it was found that the percentage of success was the highest in glass house and least in green house (Jinturkar and Narwadkar, 1985).

Nagabhushanam (1982) got a success of 30 per cent for stone grafting in cashew by whip and cleft method. He could increase the success to 60 per cent by capping the scion with a narrow polythene bag and securing at the base with a rubber band. The idea was to prevent desiccation by providing high humidity.

Cloudy and Cool days were reported to be the best for grafting work. Hot and bright sun causes dehydration and kills the grafts subsequently. Light rain helps in earlier graft union formation by moderating the day temperature and increasing the humidity, but rainfall during the actual grafting process slowed down the process and prevented proper graft union formation due to a thin water film formation between stock and scion (Muniswami, 1979 a). On an average 90 per cent success could be achieved by carrying out veneer grafting on 4-5 month old polypot seedlings under controlled mist conditions (Muniswami, 1979 b). A study by Reddy and Kohli (1985) showed that in mango epicotyl grafting was possible only when the grafts were kept inside the mist chamber/glass house/thatched house where temperature and humidity were higher than in the open condition.

2.6 Anatomical studies of graft union

Juliano (1941) studied the callus development in graft union of cleft grafts and found out that the first step was the formation of callus in the gap through the activity of the parenchyma of both bark and pith. In that region a cambial bridge was formed joining the cambial ends of both stock and scion. The initiation of callus tissue began from the stock but the total contribution of callus by stock and scion was almost equal. Luthra and Sharma (1964) showed that excessive growth of parenchymatous tissues (callus) between stock and scion and distortion of xylem elements blocked the conducting vessels and inhibited the movement of water from stock to scion. The important factors determining the graft take was not the nature of the union but the genetically determined interaction between stock and scion (Robert, 1949).

Histochemical tests in union of pear quince grafts revealed that the lignification of cells were mainly responsible for the formation of a strong graft union (Buchloh, 1960).

Wilson and Wilson (1961) opined that when young stems were wounded or grafted the cambium was interrupted and new vascular cambia tend to regenerate in the callus proliferating from the wounded surfaces. The

position in which such cambia arise varies according to the type of wound, but usually is such as to restore locally, the normal condition of a closed cambial cylinder. The amount of callus formation varied among varieties and was influenced by climatic conditions during the previous growing season. Auramov and Jokovic (1961) and Ciz (1969) opined that incompatability could be diagnosed through anatomical studies after 2-3 months of grafting.

The presence of fungal mycelium in graft union seemed to facilitate proper union (Shimoya et al., 1970). Soule (1971) conducted studies on the anatomy of bud union in mango and observed 4 stages. (1) Pre callus- where 4 days after budding only a wound periderm was present (2) callus where 8 days after budding proliferation from tissues near the cambium resulted in firm attachment of the components (3) Cambial bridge - where 12 days after budding cambial layers from stock and scion formed a bridge (4) Differentiation of vascular bundles - which occur in 36-48 days and complete healing of union 6-8 months after healing several cylinders of new tissues were present and lateral shift of scion to allign the stock had begun.

Esau (1972) conducted studies on graft union and observed that secondary growth and cambial activity were involved in proper graft union. Breakdown products of dead cells formed a necrotic layer on the surface of stock and scion the callus tissue filled the space between stock and scion and later differentiated to cambium cells and then to vascular tissues.

Fahn (1982) reported that the important function of cambium was to form callus in the wound portion. He also stated that union of stock and scion was not only through cambia but through wood rays which proliferated and took part in the graft union. Dave and Rao (1982) sampled cambial tissues, outerwood, inner bark and young shoots and found out that radical growth of the tree was continuous as the cambium was active

all the year round. Tangential divisions in the cambium zone resulted in differentiation of vascular elements. Climatic factors showed no relationship with cambium activity.

Chakrabarthi and Sadhu (1985) observed three anatomical stages in the formation of a graft union which are (1) Callusing stage - 10-30 days after grafting when the live cells formed callus tissue (2) cambial bridge stage - 30-60 days after grafting when cambial continuity between stock and scion was established (3) Healed union - 60-120 days after grafting when vascular tissues were differentiated and complete union occurred. Ratan (1985) observed that in successful grafts callus proliferation commenced from 5th day onwards and completion of cambial bridge of the stock and scion was got within 15 days after grafting.

Radhamony (1987) reported that failure of grafts was due to lack of callus formation even after 5 to 10 days of grafting operation. Very thick necrotic layers were seen developed in the wounded exposed surfaces of stock and scion. Some of the unsuccessful grafts also showed wide gap between stock and scion.

The works conducted by many scientists points to the fact that much importance is there for the effect of season, age of rootstock and scion and period of defoliation on the success of grafting and hence future line of work has to be directed to make use of the maximum beneficial effect of these factors on the success of grafting.

Materials and Methods

3. MATERIALS AND METHODS

Studies on two methods of vegetative propagation in jack viz. epicotyl grafting and softwood grafting were conducted in the Department of Pomology and Floriculture, College of Horticulture, Vellanikkara, Trichur, Kerala from June 1987 to April 1989. The place is under high rainfall tropical region having warm humid climate throughout the year with less fluctuations in daily temperature. The altitude of the place is 22.25 m above mean sea level at 10° 32'N latitude and 76° 16' E longitude.

The main objective of the study was to evolve an easy and economic vegetative propagation method for jack. Epicotyl grafting and softwood grafting, the two recently developed methods of vegetative propagation for fruits were tried for the standardisation of season and age of rootstock for grafting. The effect of intermittent mist on the percentage of success of grafting, anatomical changes at the different stages of graft union and factors leading to failure of graft union were also studied.

3.1 Standardisation of age of rootstock and season of grafting.

To standardise the season of grafting for epicotyl grafts and softwood grafts, grafting was done on every 15th day of each month commencing from May to August. Weather parameters like maximum temperature, minimum temperature, relative humidity and rainfall at monthly intervals during the period of grafting were recorded (Appendix I and Fig. 1). Root-stocks belonging to three age groups were used for both methods of grafting. For epicotyl grafting the different age groups of rootstock were 5, 10 and 15 days and that for softwood grafting were 2, 3 and 4 months. Thirty seedlings were grafted in each treatment every month.

3.1.1. Raising of seedlings for rootstock

Freshly extracted seeds of jackfruit were sown in polythene bags of size 20 cm x 18 cm filled with FYM, sand and soil in the ratio 1:1:1. BHC 10 per cent dust was applied around the polythene bags and in the soil

in the bag to avoid termite attack. The polythene bags were placed under shade and watered regularly. Sowing was done frequently so as to obtain 5, 10 and 15 day old rootstocks for epicotyl grafting and 2, 3 and 4 month old rootstocks for softwood grafting during the period from May to August (Plate 1 and 2).

3.1.2 Selection and preparation of scion sticks

Healthy, disease free, 3-4 months old, 10 cm long, uniform scion sticks having dark green colour with plumpy and dormant apical buds from selected mother trees were used for epicotyl and softwood grafting. Defoliation was done by clipping the leaf portion keeping the petioles intact on the twig. Defoliation was done 10 days prior to grafting. This was the precuring period that was standardised by Dhungana (1985) for mango.

3.1.3 Method of grafting

1. Epicotyl grafting

The grafting operation was done on rootstocks of age 5, 10 and 15 days, by the cleft method. The rootstocks were decapitated 5 to 6 cm above the soil surface. A vertical slit of about 4 to 5 cm is given in the centre of the epicotyl. The lower portion of the selected scion was prepared to form a wedge by giving two slanting cuts on opposite sides. The wedge shaped scion was inserted in the vertical slit of epicotyl and then tightly wrapped with polythene tape of 200 gauge thickness. The different stages of grafting are illustrated in Plates 3 to 8.

2. Softwood grafting

Cleft method of grafting was followed for softwood grafting also. 2 month, 3 month and 4 month old rootstocks were used for grafting retaining 2 leaves on the rootstocks. Grafting was done uniformly at a height of 15 cm above the soil level.

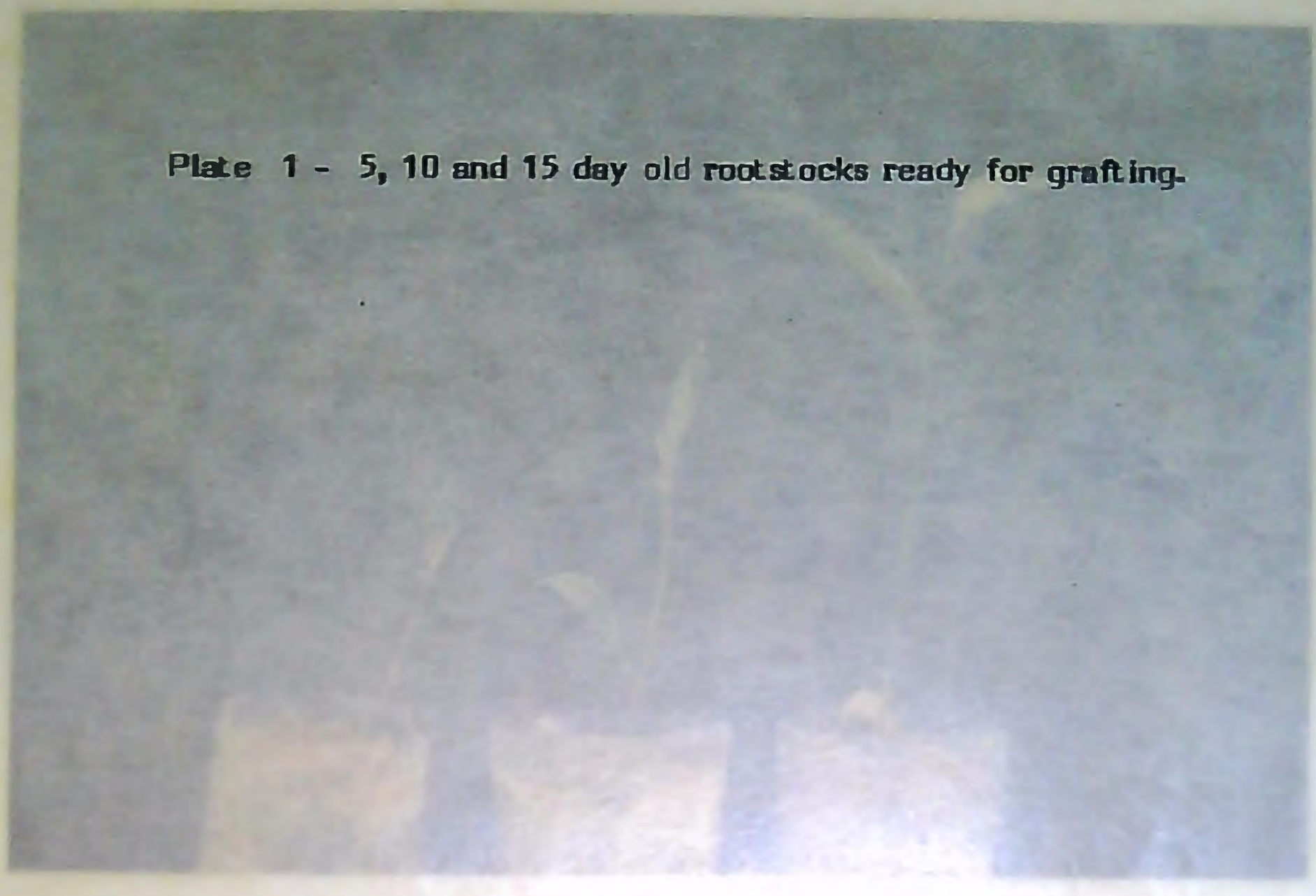


Plate 1 - 5, 10 and 15 day old rootstocks ready for grafting.

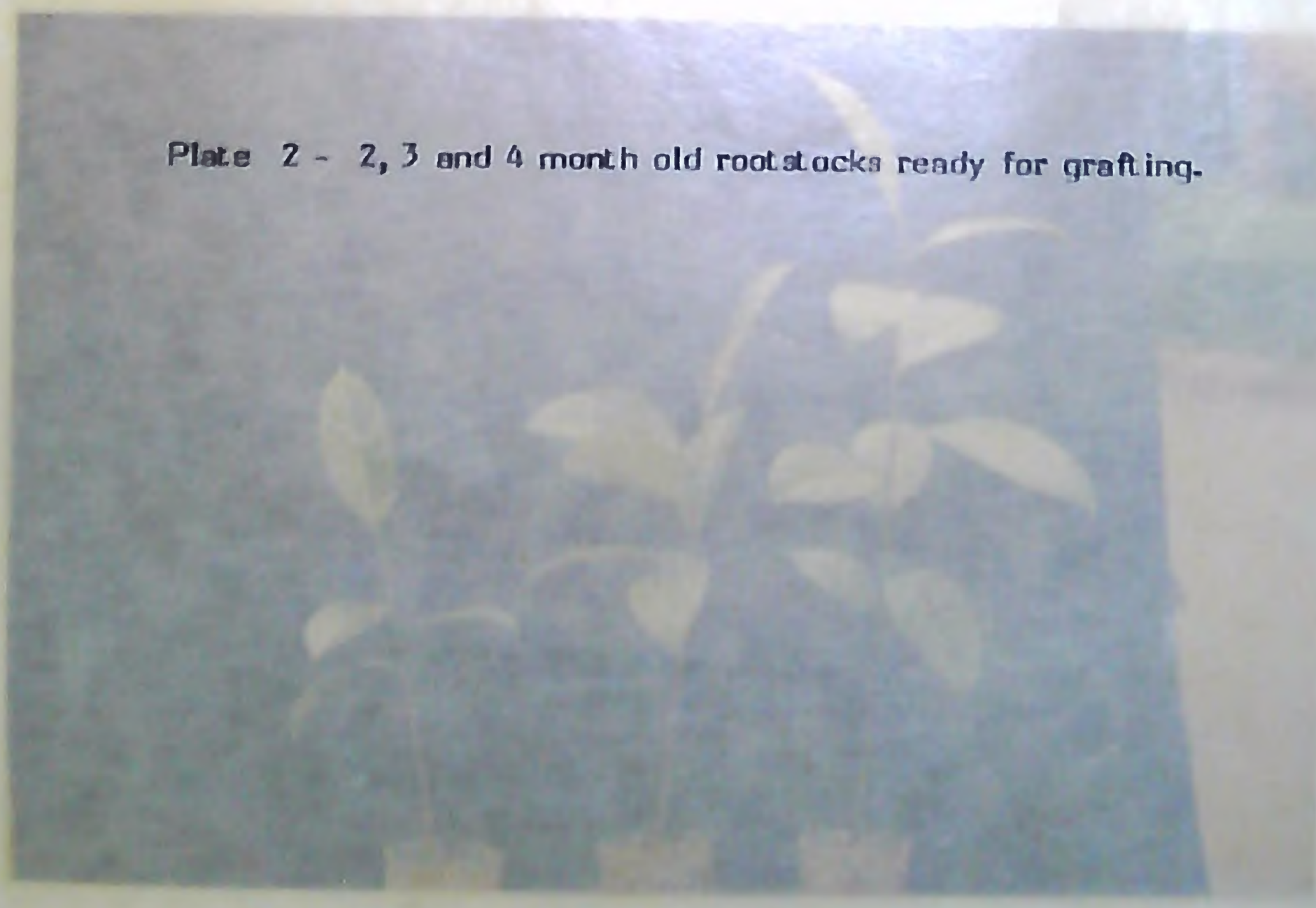


Plate 2 - 2, 3 and 4 month old rootstocks ready for grafting.

Plate 3 - A rootstock ready for grafting.

Plate - 4 Rootstock decapitated 5 - 6 cm above the soil surface.

Plate 5 - Vertical slit of about 4 - 5 cm given in the centre of the epicotyl.

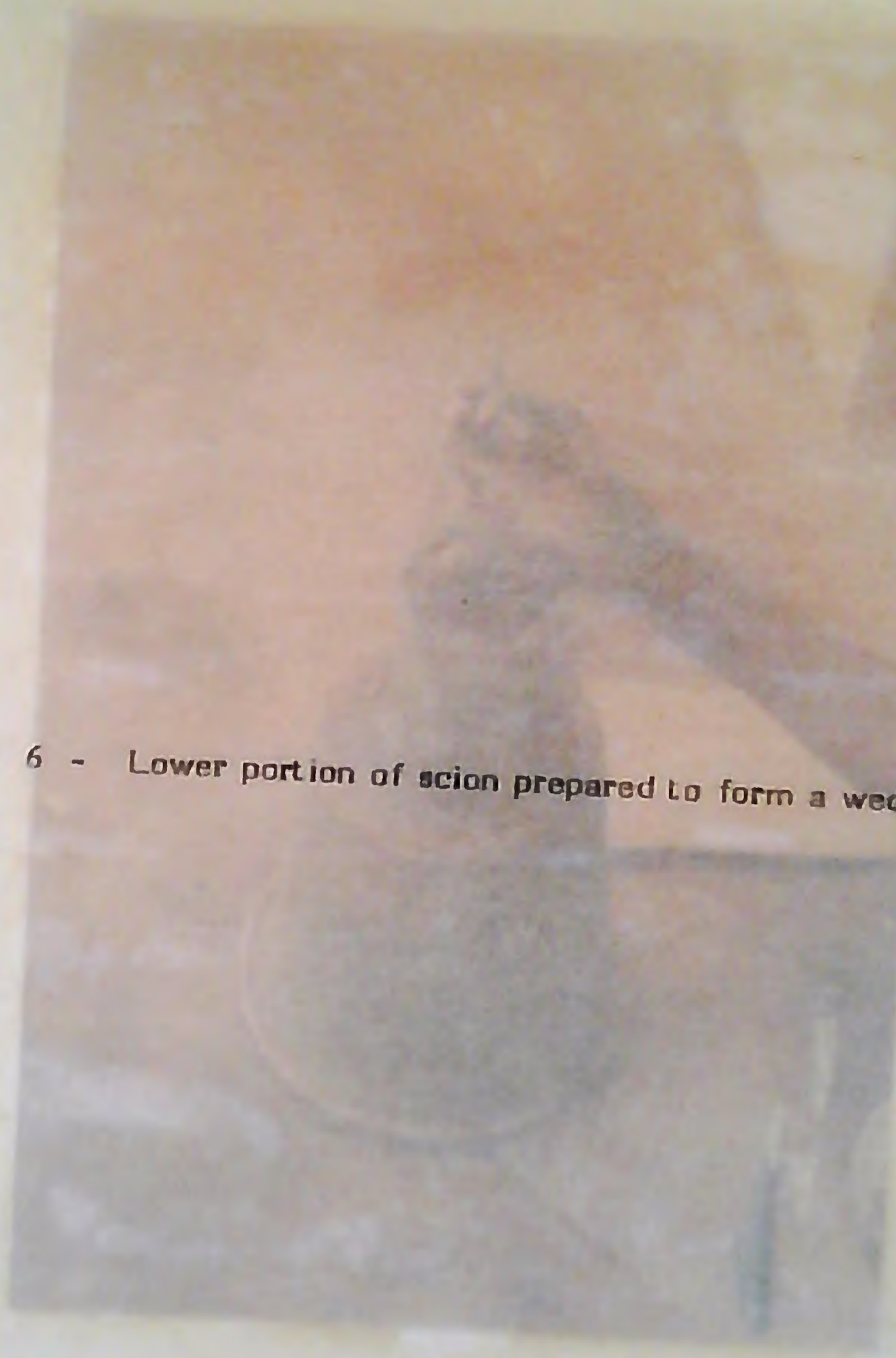


Plate 6 - Lower portion of scion prepared to form a wedge shape.

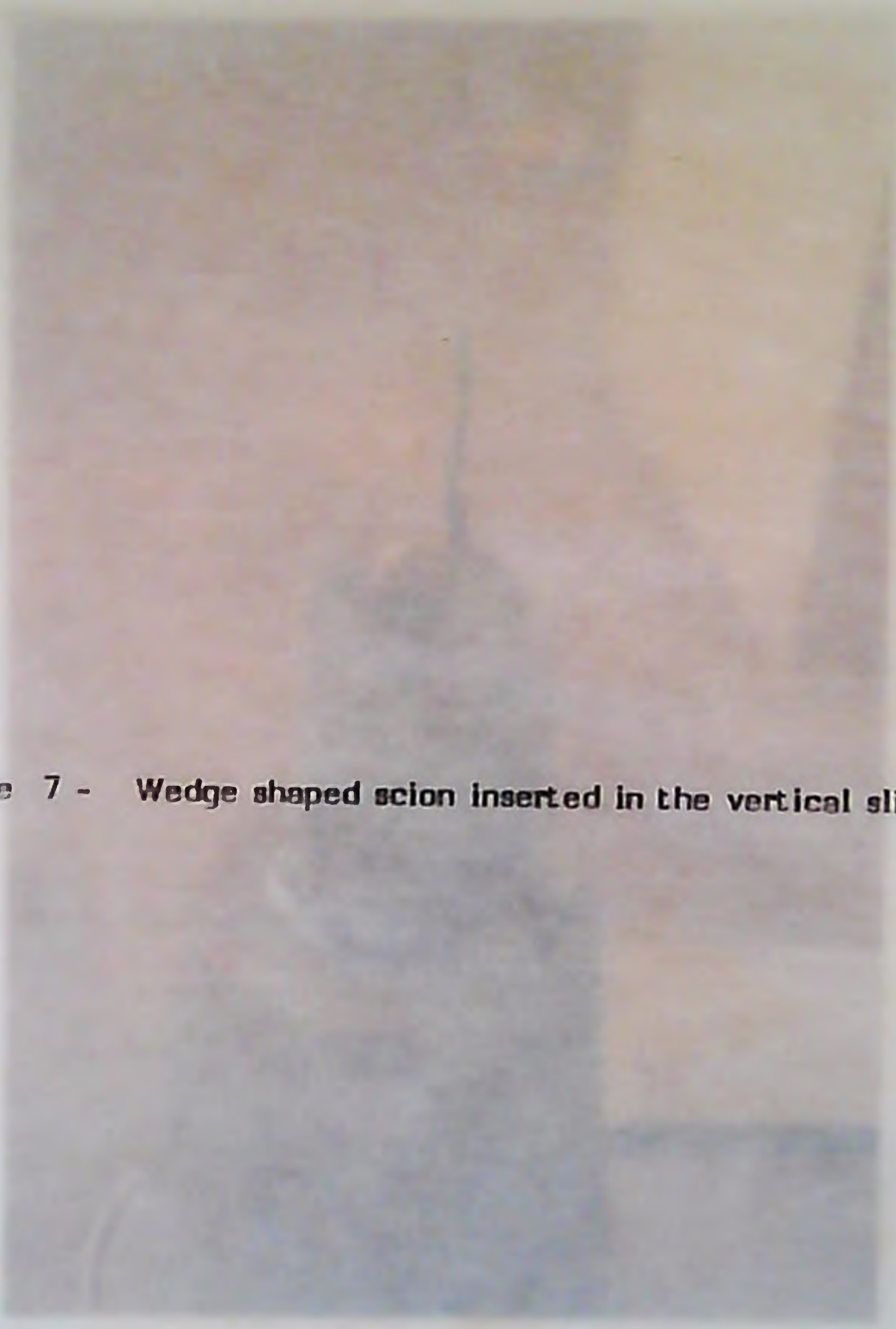


Plate 7 - Wedge shaped scion inserted in the vertical slit of epicotyl.

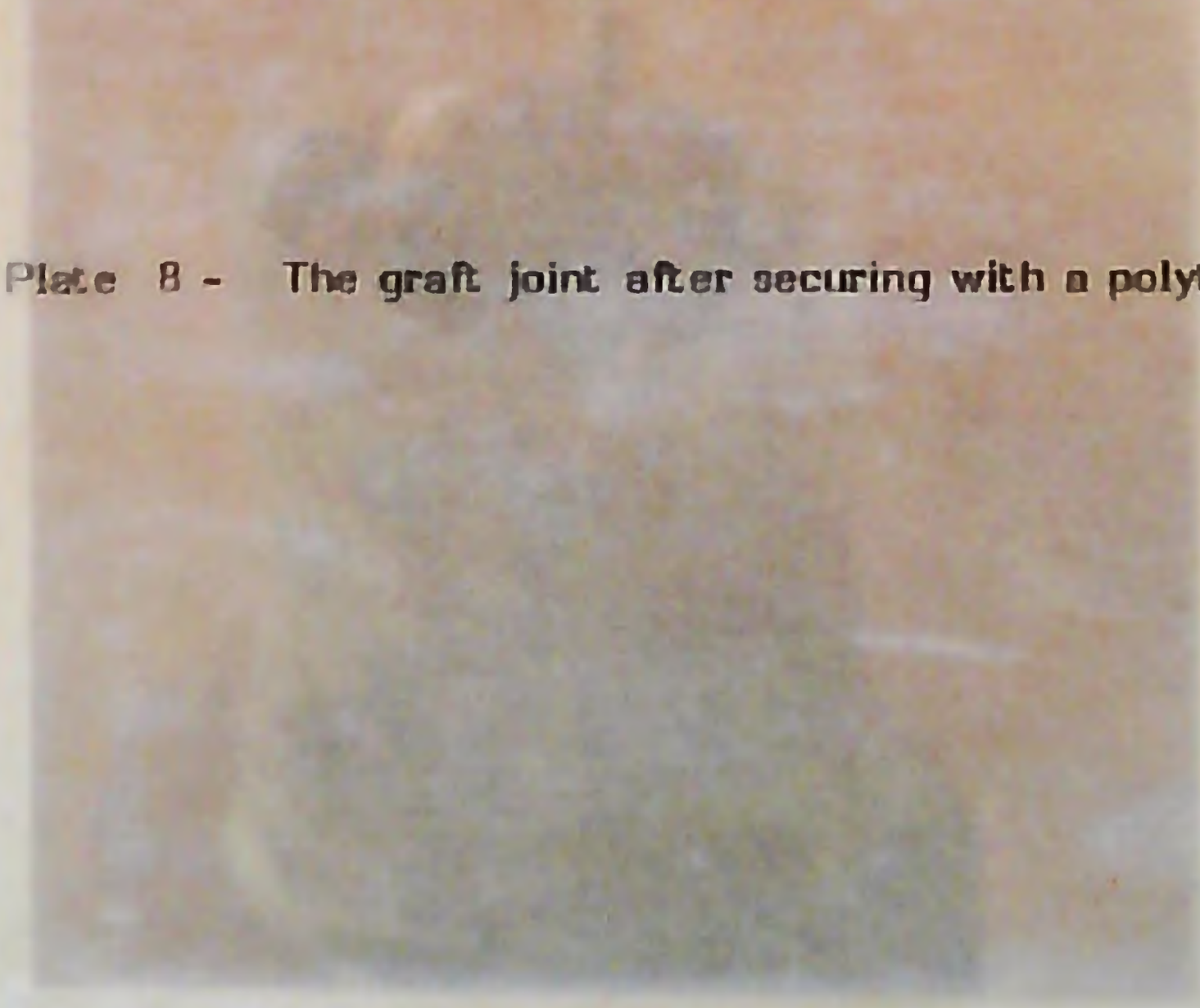


Plate 8 - The graft joint after securing with a polythene tape.

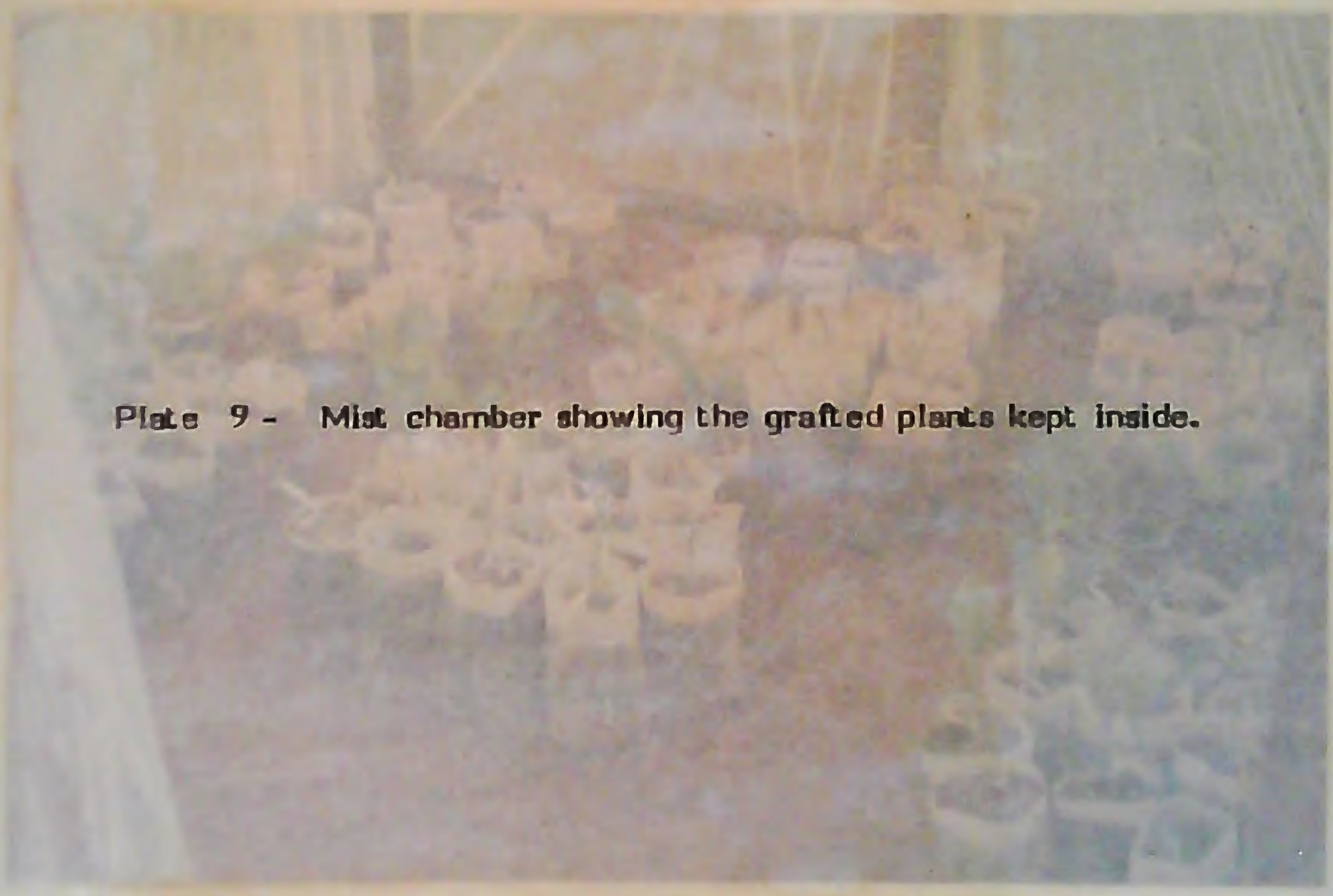


Plate 9 - Mist chamber showing the grafted plants kept inside.

3.1.4 After care of the grafts

The grafts were kept under partial shade in a thatched shed. The suckers produced from the rootstocks were removed periodically and the grafts were watered regularly. Bordeaux mixture 1 per cent and Rogor 30 EC 2 ml per litre were sprayed once in a fortnight.

3.2 Effect of mist on the percentage success of graft union

The effect of intermittent mist on the percentage success in grafting was studied. Thirty plants were grafted under each treatment and kept in the open and mist conditions. A temporary mist chamber was made using thick polythene sheet over a wooden frame of the dimension 1.95m x 1.60m x 1.20m. Mist conditions was created by spraying water to the polythene film at an interval of 45 minutes throughout the day from 9 a.m. to 5 p.m. The temperature and relative humidity inside the chamber was maintained at 30°C and 90 per cent by this interval of application of water. (Plate. 9)

3.3 Treatments

There were totally 24 treatments each for epicotyl and softwood grafting which consisted of 4 morths of grafting (May to August), 3 ages of rootstock (5 day, 10 day and 15 day for epicotyl and 2 month, 3 month and 4 month for softwood grafting) and open and mist conditions.

T_1E May-epicotyl - 5d mist

T_2E May-epicotyl - 10d mist

T_3E May-epicotyl - 15d mist

T_4E May-epicotyl - 5d open

T_5E May-epicotyl - 10d open

T_6E May-epicotyl - 15d open

T_7E June-epicotyl - 5d mist

T_8E June-epicotyl - 10d mist

T_9E	June-epicotyl	-	15d mist
$T_{10}E$	June-epicotyl	-	5d open
$T_{11}E$	June-epicotyl	-	10d open
$T_{12}E$	June-epicotyl	-	15d open
$T_{13}E$	July-epicotyl	-	5d mist
$T_{14}E$	July-epicotyl	-	10d mist
$T_{15}E$	July epicotyl	-	15d mist
$T_{16}E$	July-epicotyl	-	5d open
$T_{17}E$	July-epicotyl	-	10d open
$T_{18}E$	July-epicotyl	-	15d open
$T_{19}E$	August-epicotyl	-	5d mist
$T_{20}E$	August-epicotyl	-	10d mist
$T_{21}E$	August-epicotyl	-	15d mist
$T_{22}E$	August-epicotyl	-	5d open
$T_{23}E$	August-epicotyl	-	10d open
$T_{24}E$	August-epicotyl	-	15d open
T_1S	May-softwood	-	2m mist
T_2S	May-softwood	-	3m mist
T_3S	May-softwood	-	4m mist
T_4S	May-softwood	-	2m open
T_5S	May-softwood	-	3m open
T_6S	May-softwood	-	4m open
T_7S	June-softwood	-	2m mist
T_8S	June-softwood	-	3m mist
T_9S	June-softwood	-	4m mist

$T_{10}S$	June-softwood	-	2m open
$T_{11}S$	June-softwood	-	3m open
$T_{12}S$	June-softwood	-	4m open
$T_{13}S$	July-softwood	-	2m mist
$T_{14}S$	July-softwood	-	3m mist
$T_{15}S$	July-softwood	-	4m mist
$T_{16}S$	July-softwood	-	2m open
$T_{17}S$	July-softwood	-	3m open
$T_{18}S$	July-softwood	-	4m open
$T_{19}S$	August-softwood	-	2m mist
$T_{20}S$	August-softwood	-	3m mist
$T_{21}S$	August-softwood	-	4m mist
$T_{22}S$	August-softwood	-	2m open
$T_{23}S$	August-softwood	-	3m open
$T_{24}S$	August-softwood	-	4m open

3.4 Observations

The following observations were recorded

3.4.1 Percentage of initial and final success

The observations on number of days taken for sprouting of scions after grafting were recorded. The scions that remained green whether sprouted or unsprouted 15 days after grafting were counted for calculating the percentage of initial success. Scions which survived after 90 days were counted for calculating the percentage of final success.

3.4.2 Extension growth of scion

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

3.4.3 Number of leaves

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

3.4.4. Girth of stock

A fixed circular mark was made on the stock at one cm below the graft joint. The girth of stock was measured in centimetres at this point at fortnightly intervals.

3.4.5 Girth of scion

A fixed circular mark was made on the scion at one cm above the graft joint. The girth of scion was measured in centimetres at this point at fortnightly intervals.

3.4.6 Girth of extension growth

The girth of extension growth was also measured in centimetres at a height of one cm above the point were the scion produced new growth.

3.5 Anatomical studies of graft union

Grafts were prepared separately for anatomical studies by using different ages of rootstocks both epicotyl and softwood. Totally there were 24 treatments each for epicotyl (4 months - May to August, 3 ages of rootstock, 5, 10 and 15 days and open and mist conditions) and for softwood grafts (4 months - May to August, 3 ages of rootstocks 2, 3 and 4 months, and open and mist conditions) for which specimens were collected separately. Here also, the similar procedure was followed for raising rootstocks, selection of scion sticks, scion preparation and grafting operation. Samples were collected for anatomical studies as per the procedure given below.

3.5.1 Collection and storage of specimens

Representative samples of graft union from all the treatment combinations were taken for the anatomical studies. Two samples were collected from each treatment combination at intervals of 5 days, 15 days, 45 days and 90 days after grafting. Samples were also taken from those grafts which showed signs of shrinking or drying from 5th day onwards. Immediately after collection the samples were processed as follows.

3.5.2 Processing

FAA (850 ml of 70 per cent alcohol + 100 ml 40 per cent formaldehyde + 50 ml glacial acetic acid) solution was used for fixing and preservation of the samples. Specimens were kept in FAA solution for a minimium period of 72 hours and were transfered to 70 per cent alcohol. They were then removed using a sterlized forceps and washed in running water for 30 minutes and later with glass distilled water. Uniform thin secetions of 40 (micron) thickness were taken using "Reichert sliding microtome" as per standard microtomy suggested for hardwoods (Cutler, 1978). For cleaning and staining the sections the schedule suggested by Johanson, (1940) which is outlined below, was followed.

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)

Pure xylene (1 minute)

Mounted on slides with Dpx mountant

Microscopic examination

Photomicroscopy

3.5.3 Microscopic Examination

The slides were examined carefully through "Olympus binocular research microscope fitted with objective of magnification ranging from 3.2 x to 40 x and 10 x eyepiece.

3.5.4 Photomicroscopy

Photomicrographs of selected specimens were taken using a photomicrography system (Orthoplan Germany 964876) and ORWO film of 125 ASA.

3.6 Statistical analysis

Differences among the treatments with regard to the number of sprouted grafts and survival of grafts were tested by repeated chi-square test described by Panse and Sukhatme (1968)

$$x^2 \quad \frac{1}{n_1 n_2} \quad \leq \quad \frac{(an_2 \cdot a^1 n_1)2}{a + \dot{a}\, n}$$

Where X^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.

Degrees of freedom for Chi-square is (K-1) where K is the number of treatments.

Statistical analysis of the observations on the effect of treatments on the quantitative characters like extension growth of scion, number of leaves, girth of rootstocks, scion and new growth was done using the analysis of variance technique as described by Snedecor and Cochran (1967).

Results

4. RESULTS

Results of the experiment to standardise the season, age of rootstock and the effect of intermittent mist on the sprouting (15 days after grafting) and survival (90 days after grafting) of epicotyl and softwood grafts are given below.

4.1 Standardisation of the optimum season of grafting

Epicotyl grafting

Data on the effect of season on sprouting (15 days after grafting) and survival (90 days after grafting) of epicotyl grafts are presented in Table 1. The percentage of sprouting and survival of grafts in June differed significantly from other months. The maximum sprouting of epicotyl grafts was for the month of June (83.3 per cent) whereas all the other months of grafting had only very little success as in July (7.22 per cent), May (5 per cent) and August (3.89 per cent). The maximum survival also was in the month of June (61.67 per cent) whereas all other months of grafting had only very little success as in July (5 per cent), May (3.89 per cent) and August (2.78 per cent). Among the different seasons tried only June was found to be suitable for epicotyl grafting in jack (Fig. 2).

Softwood grafting

Data on the effect of season on sprouting and survival of softwood grafts are presented in Table 2. Similar to epicotyl grafts, the percentage of sprouting and survival of softwood grafts in June differed significantly from other months. The percentage of success in softwood grafts was very poor. Maximum sprouting was recorded for the month of June (7.22 per cent) followed by July and August with 1.1 per cent and May with no success. Likewise maximum survival which was only 5 per cent was

Fig. 1. RELATIONSHIP OF WEATHER PARAMETERS WITH SPROUTING/ SURVIVAL (%)

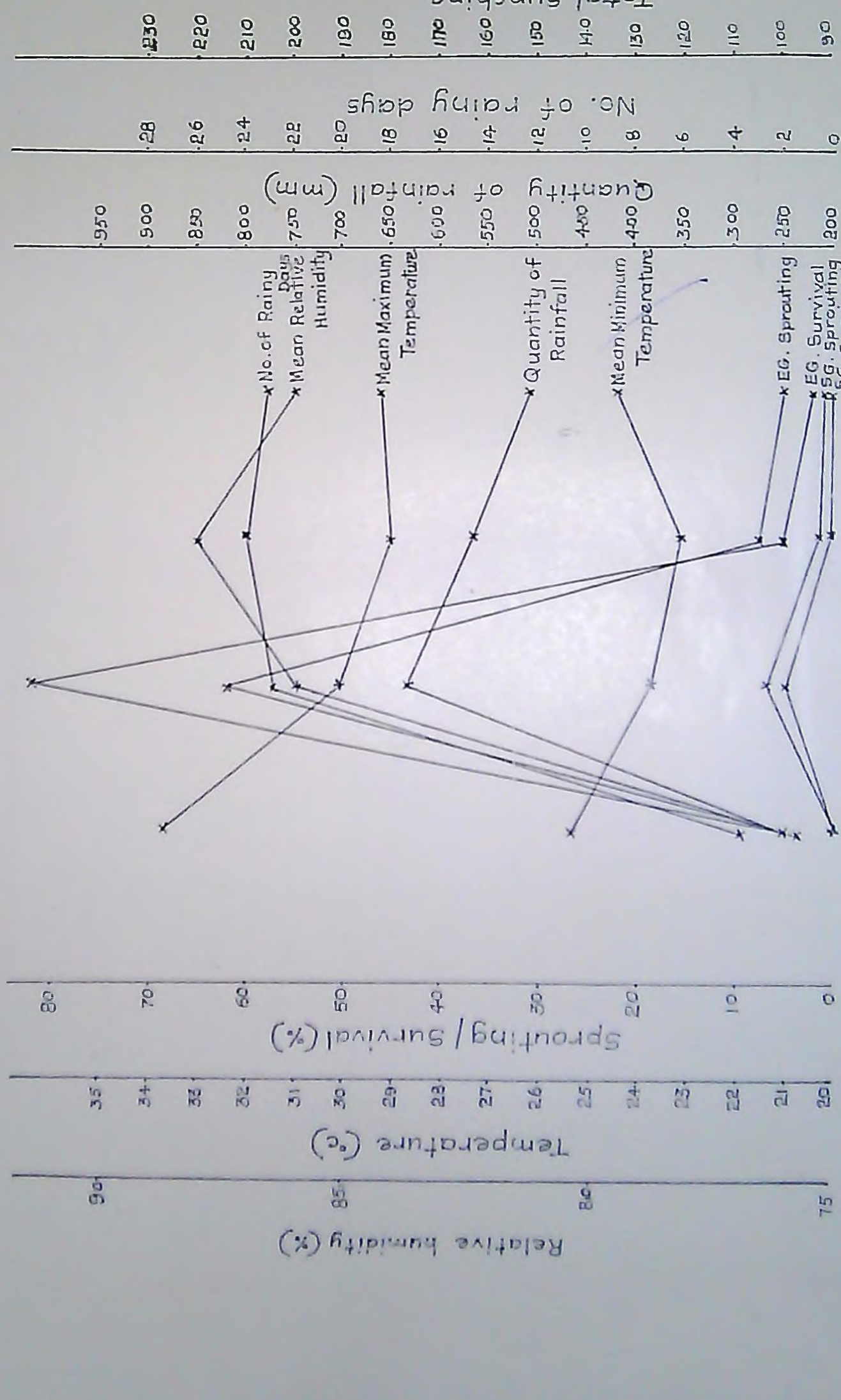


Table 1 Effect of season of grafting on the success in epicotyl grafting

Treatments	No. of grafts prepared	Sprouting		Survival	
		Number	Percentage	Number	Percentage
May	180	9 a	5.00	7 a	3.89
June	180	150 b	83.30	111 b	61.67
July	180	13 a	7.22	9 a	5.00
August	180	7 a	3.89	5 a	2.78

Values having the same letter are homogenous.

X^2 analysis was done

Fig. 2. EFFECT OF DIFFERENT SEASONS ON SPROUTING AND SURVIVAL OF EPICOTYL GRAFTS

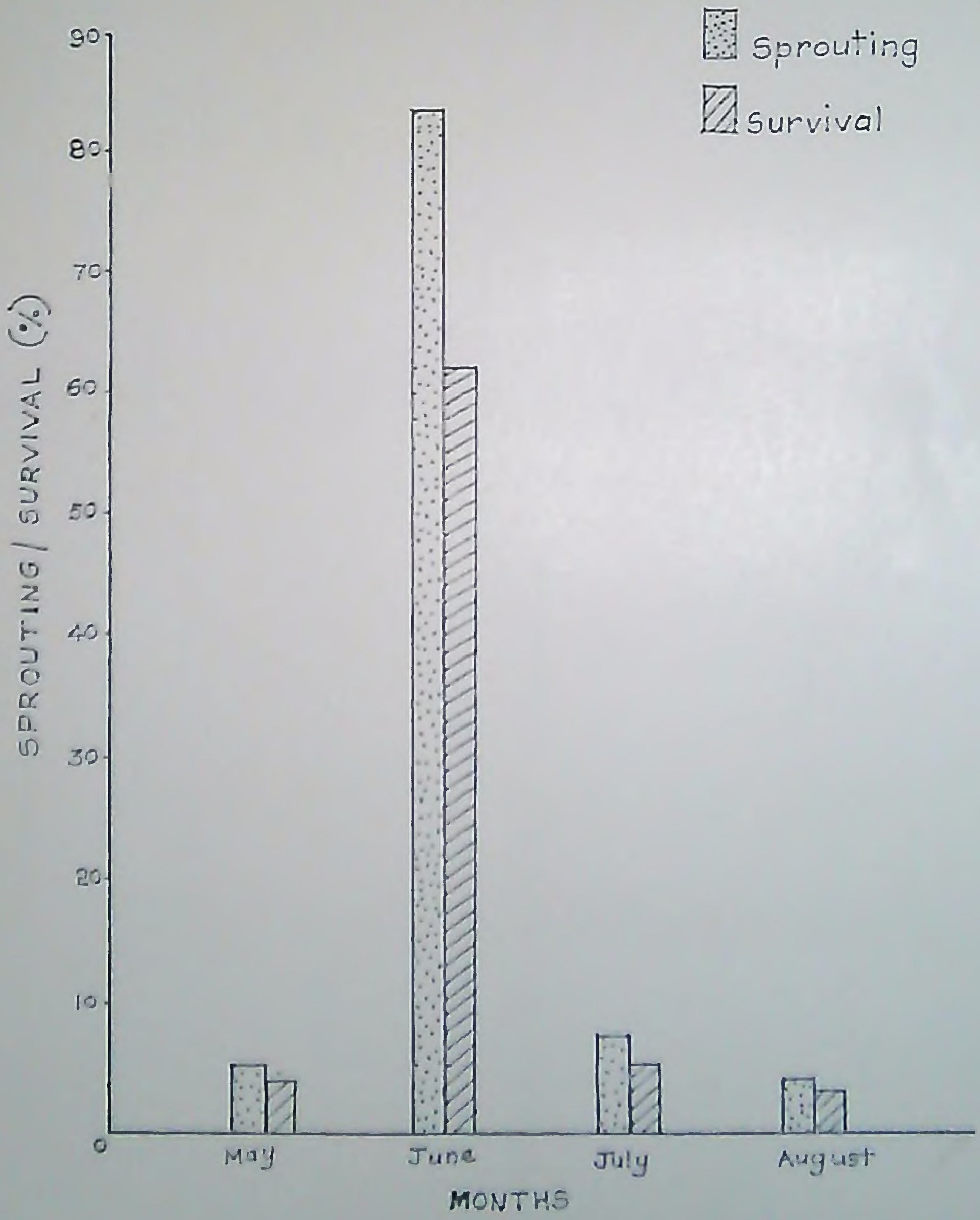


Table 2 Effect of season of grafting on the success in softwood grafting

Treatments	No. of grafts prepared	Sprouting		Survival	
		Number	Percentage	Number	Percentage
May	180	0 a	0.00	0 a	0.00
June	180	13 b	7.22	9 b	5.00
July	180	2 a	1.1	1 a	0.55
August	180	2 a	1.1	1 a	0.55

Values having the same letter are homogenous

X^2 analysis was done

recorded for the month of June followed by July and August (0.55 per cent) and May with no success. June was found to be the only season suitable for softwood grafting in jack, though with a very low percentage of success. Eventhough softwood grafting is not very successful, to find any success it has to be done in June (Fig. 3).

4.2 Standardisation of the age of rootstock for grafting

Epicotyl grafting

The data on the effect of the age of rootstock on the success in epicotyl grafting are presented in Table 3 and illustrated in Fig. 4. Of the three age groups of rootstocks tried viz., five, ten and fifteen day, maximum sprouting was obtained for five day old rootstock (29.58 per cent) followed by 10 day old rootstock (27.08 per cent) and 15 day-old rootstock (17.98 per cent). Statistically significant difference was there only for 15 day-old rootstock from five day and 10 day-old rootstock in the sprouting, but data on survival of grafts showed that there was no significant difference among the three age groups, the survival percentages being 21.67, 18.33 and 15 respectively for 5, 10 and 15 day old rootstocks. There was significant effect of age of rootstock on the success of grafting in the month of June 5 day and 10 day - old rootstocks grafted in June and kept under mist conditions recorded an initial success of 100 per cent each and survival of 76.67 per cent and 63.33 per cent respectively and 15 day old rootstocks grafted and kept under mist condition recorded an initial success of 73.33 per cent and survival of 60 per cent respectively. 5, 10 and 15 day-old rootstocks grafted in June and kept under open conditions gave a sprouting of 86.67, 80 and 60 per cent respectively and a survival of 60, 56.67 and 53.33 per cent respectively.

Softwood grafting

In the case of softwood grafts only 2 month-old rootstock sprouted and hence no comparison could be made.(Table 4)

Fig.3. EFFECT OF DIFFERENT SEASONS ON SPROUTING AND SURVIVAL OF SOFTWOOD GRAFTS

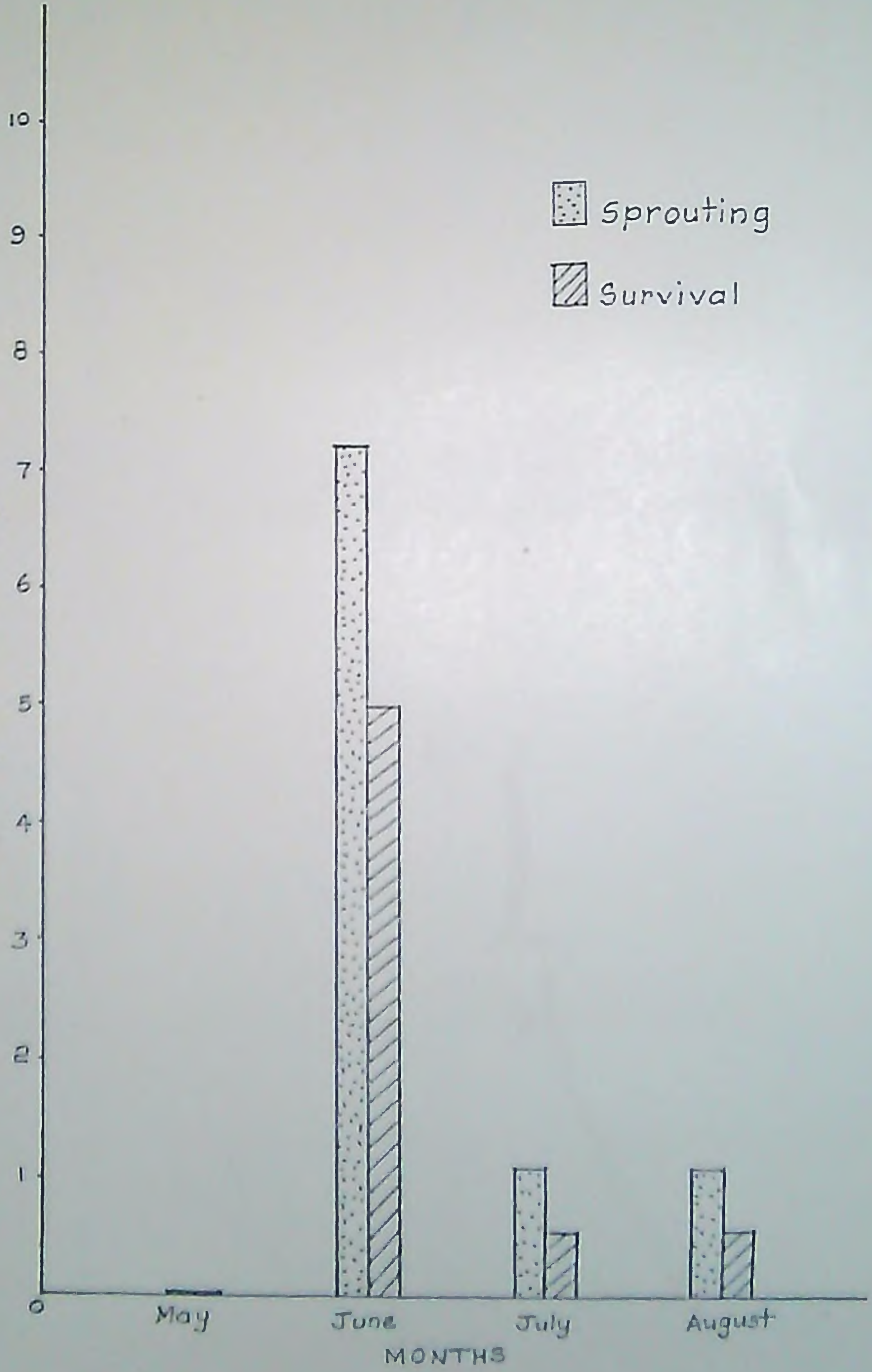


Table 3 Effect of age of rootstock on the success in epicotyl grafting

Treatments	No. of grafts prepared	Sprouting		Survival	
		Number	Percentage	Number	Percentage
5 days old	240	71 b	29.58	52 a	21.67
10 days old	240	65 b	27.08	44 a	18.33
15 days old	240	43 a	17.92	36 a	15.00

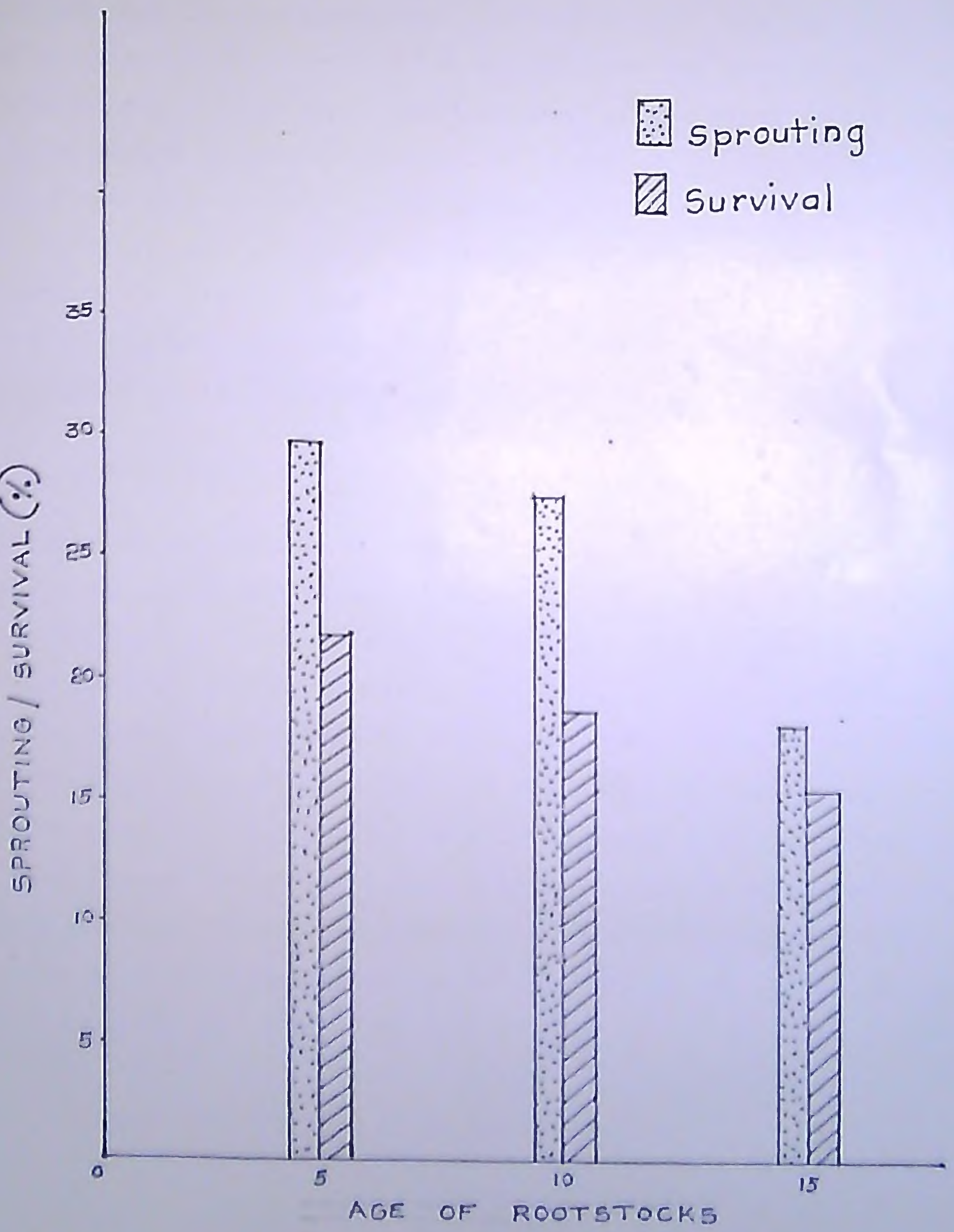
Values having the same letter are homogenous.

X^2 analysis was done

Table 4. Effect of age of rootstock on the success in softwood grafting

Treatments	No. of grafts prepared	Sprouting		Survival	
		Number	Percentage	Number	Percentage
2 months old	240	17	7.08	11	4.58
3 months old	240	0	0	0	0
4 months old	240	0	0	0	0

Fig. 4. EFFECT OF AGE OF ROOTSTOCK ON SPROUTING AND SURVIVAL OF EPICOTYL GRAFTS



4.3 Effect of mist conditions on the success of grafting

Epicotyl grafting

Data on the effect of mist conditions on the sprouting and survival of epicotyl grafts are given in Table 5 and illustrated in Fig.5. Data obtained by chi-square analysis showed that there was significant difference between the mist and open conditions on the sprouting and survival of epicotyl grafts. Sprouting was more in mist condition (30.88 per cent) as against 18.89 per cent in open conditions. Likewise the survival rate was also high in mist condition (22.5 per cent) as against 14.17 per cent in open condition. In the month of June mist condition had a significant effect over open condition on the success of grafting. 5, 10 and 15 day-old rootstocks grafted in June and kept under mist conditions gave a sprouting of 100, 100 and 73.33 per cent and a survival of 76.67, 63.33 and 60 per cent respectively whereas 5, 10 and 15 day-old rootstocks grafted in June and kept under open condition gave only a sprouting of 86.67, 80 and 60 per cent respectively and a survival of 60, 56.67 and 53.33 per cent respectively.

Softwood grafting

Data on the effect of mist conditions on the sprouting and survival of softwood grafts are given in Table 6 and illustrated in Fig. 6. There was significant difference between mist and open conditions on sprouting and survival of grafts. Sprouting was more in mist condition (3.89 per cent) as against open condition (0.833 per cent). Likewise the survival rate was also high in mist condition (2.5 per cent) as against open condition (0.56 per cent). In the month of June for softwood grafts also mist condition had a significant effect over open condition. 2 month-old rootstocks grafted in June and kept under mist condition gave a sprouting of 33.33 per cent and survival of 23.33 per cent respectively whereas that under open condition gave a sprouting of 10 per cent and survival of 6.67 per cent respectively. The growth stages of grafts of different age groups are shown in plates 10 to 13 (under mist and open conditions)

Table 5 Effect of mist conditions on the success in epicotyl grafting

Treatments	No. of grafts prepared	Sprouting		Survival	
		Number	Percentage	Number	Percentage
Mist	360	111 a	30.83	81 a	22.50
Open	360	68 b	18.89	51 b	14.17

Values having the same letter are homogenous

X^2 analysis was done

Fig.5. EFFECT OF MIST CONDITIONS ON SPROUTING AND SURVIVAL OF EPICOTYL GRAFTS

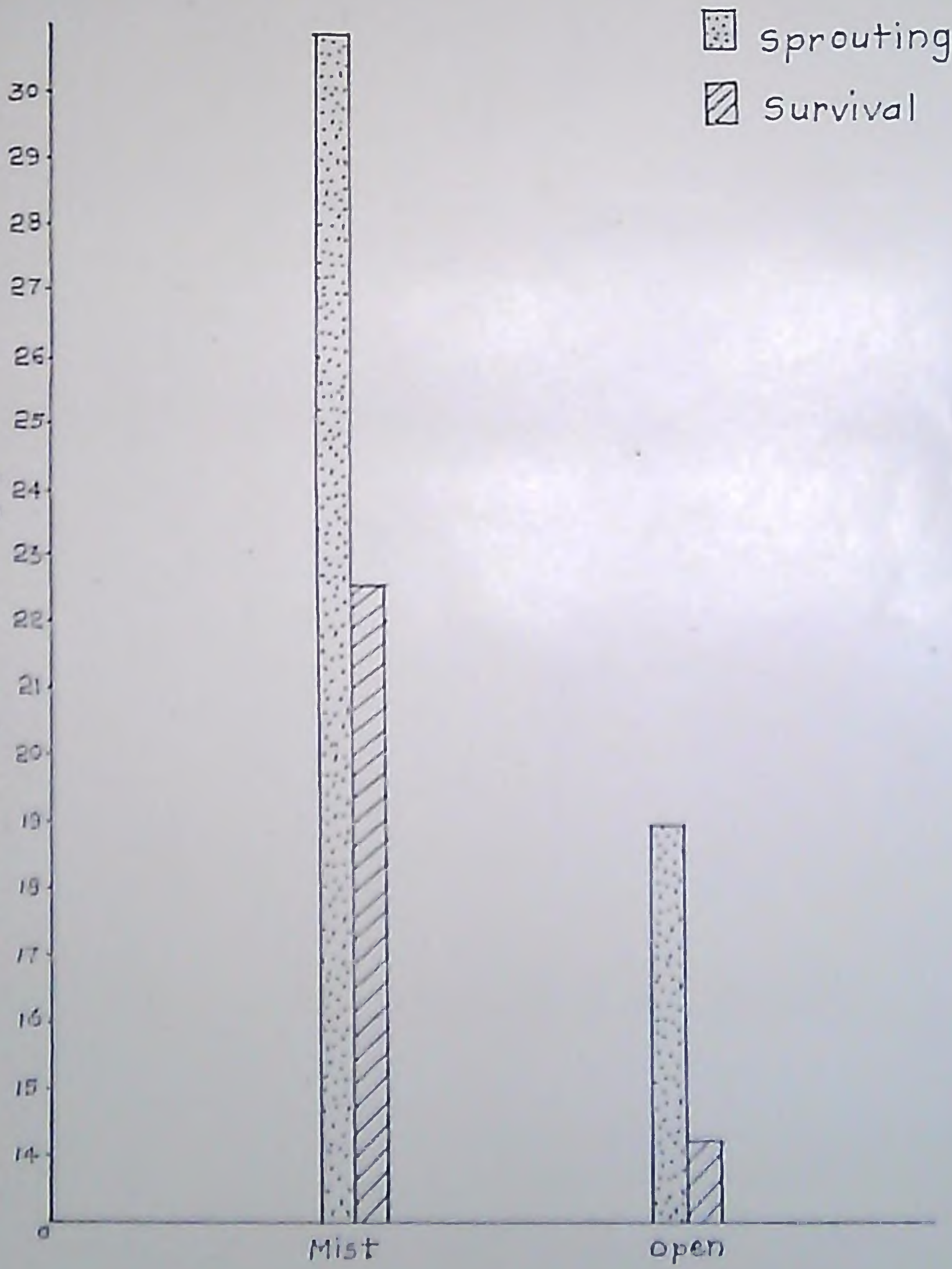


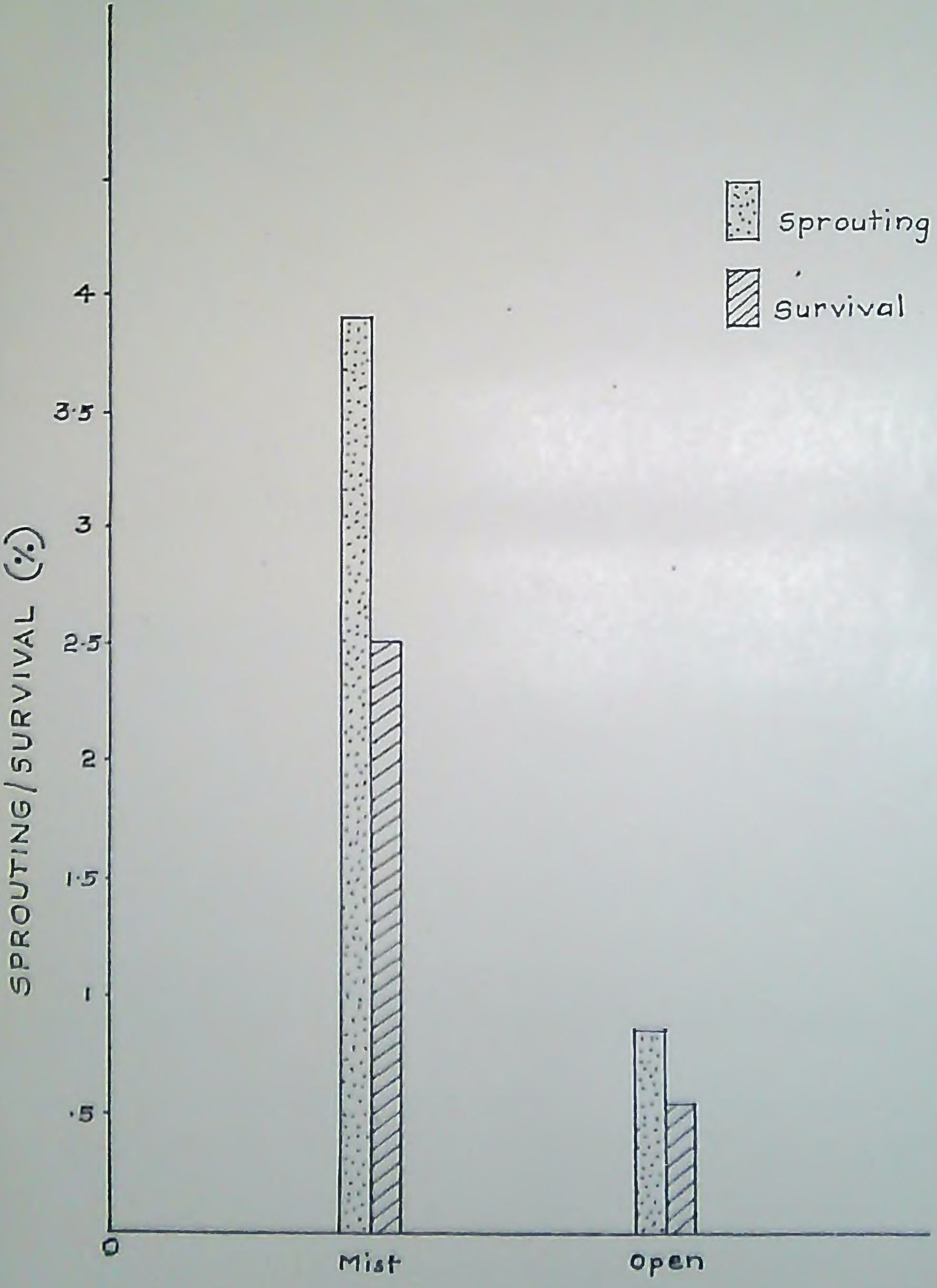
Table 6 Effect of mist conditions on the success in softwood grafting

Treatments	No. of grafts prepared	Sprouting		Survival	
		Number	Percentage	Number	Percentage
Mist	360	14 a	3.89	9 a	2.50
Open	360	3 b	0.833	2 b	0.56

values having the same letter are homogenous

X^2 analysis was done

Fig. 6. EFFECT OF MIST CONDITIONS ON SPROUTING AND SURVIVAL OF SOFTWOOD GRAFTS




OPEN
MIST
5 DAY OLD ROOTSTOCK


OPEN
MIST
10 DAY OLD ROOTSTOCK

Plate 12 - 15 day old rootstock grafted and kept under mist and open conditions.

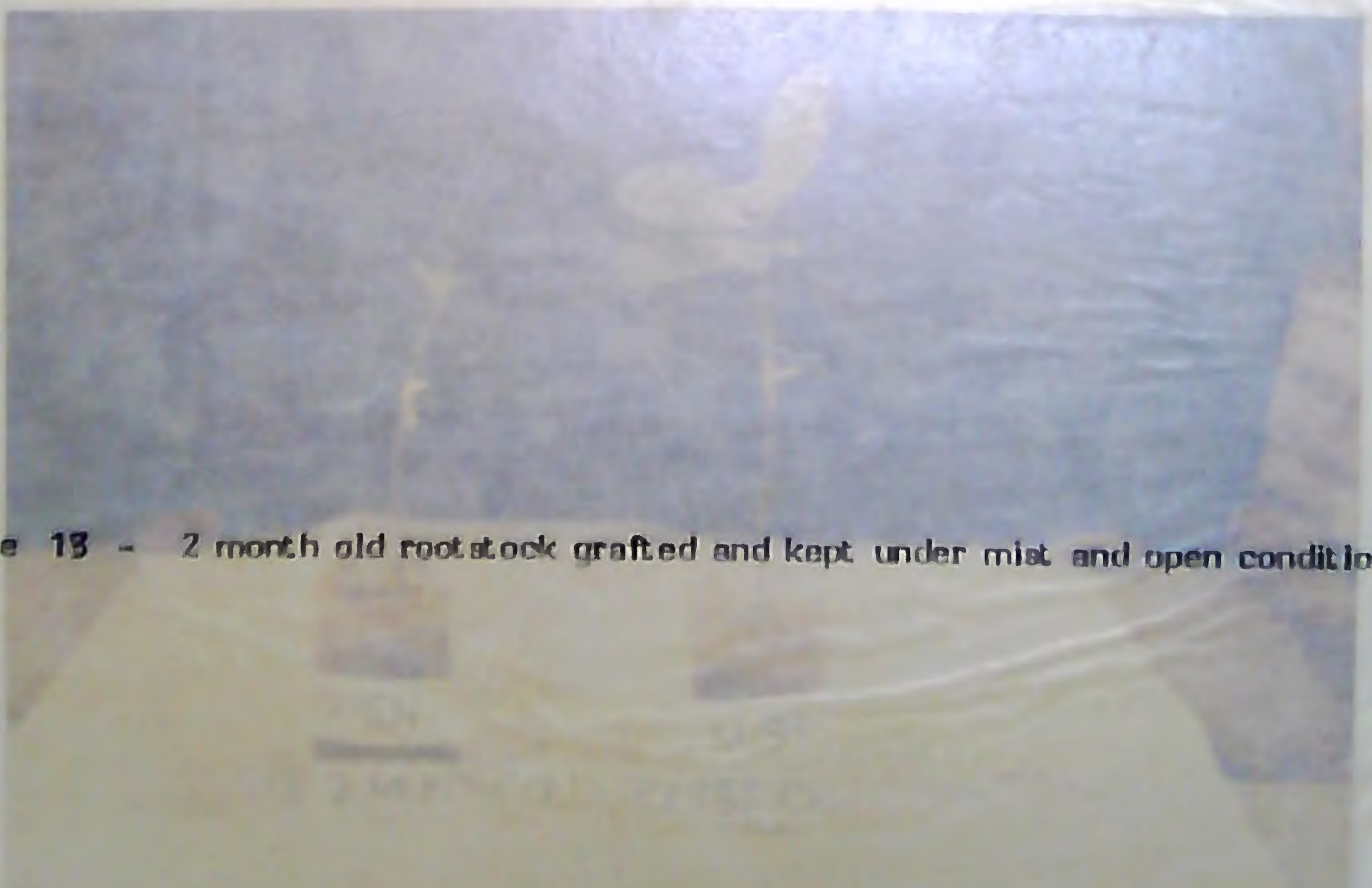


Plate 13 - 2 month old rootstock grafted and kept under mist and open conditions.


OPEN
MIST
15 DAY OLD ROOTSTOCK


OPEN
MIST
2 MONTH OLD ROOTSTOCK

4.4 Effect of different seasons on the success of grafting under mist and open conditions

Epicotyl grafting

Data of the effect of different seasons on the success of epicotyl grafting under mist and open conditions are given in Table 7. There was no significant difference in sprouting between the open and mist conditions in June, but there was significant difference between the open and mist conditions in May, July and August months. The maximum sprouting was for June mist (91.11 per cent) and grafts kept under mist in July, May and August recorded percentage success of 14.44, 10 and 7.78 respectively. The maximum survival was also for the June mist (66.67 per cent) and grafts under mist in July, May and August recorded percentage success of 10, 7.78 and 5.56 respectively and open conditions in July, May and August gave no success.

Softwood grafting

Data on the effect of different seasons on the success of softwood grafting under mist and open conditions are given in Table 8. Only June mist showed a significant difference over the other treatments with regard to sprouting of grafts. June mist showed a percentage success of 11.11, followed by June open (3.33 per cent), July mist and August mist (2.22 per cent) and others with no success. Similarly the maximum survival was also for June mist (7.78 per cent) followed by June open (2.22 per cent), July and August mist (1.11 per cent) and others with no success. In all the seasons of grafting only 2 months-old rootstock survived and it gave a sprouting of 33.33, 6.67 and 6.67 per cent respectively in June, July and August whereas it gave a survival of 23.33, 3.33 and 3.33 per cent respectively in the months of June, July and August.

4.5 Effect of season of grafting, age of rootstock and mist conditions on the success of grafting.

Epicotyl grafting

The results indicated that season of grafting had very pronounced

Table 7 Effect of different seasons on the success in epicotyl grafting under mist and open conditions

Treatments		No. of grafts prepared	Sprouting		Survival	
			Number	Percentage	Number	Percentage
May	Mist	90	9 b	10.00	7 b	7.78
	Open	90	0 a	0.00	0 a	0.00
June	Mist	90	82 c	91.11	60 c	66.67
	Open	90	68 c	75.56	51 c	56.67
July	Mist	90	13 b	14.44	9 b	10.00
	Open	90	0 a	0.00	0 a	0.00
August	Mist	90	7 b	7.78	5 b	5.56
	Open	90	0 a	0.00	0 a	0.00

Values having the same letter are homogenous

X^2 analysis was done

Table 8 Effect of different seasons on the success in softwood grafting under mist and open conditions

Treatments		No. of grafts prepared	Sprouting		Survival	
			Number	Percentage	Number	Percentage
May	Mist	90	0 a	0.00	0 a	0.00
	Open	90	0 a	0.00	0 a	0.00
June	Mist	90	10 b	11.11	7 b	7.78
	Open	90	3 a	3.33	2 a	2.22
July	Mist	90	2 a	2.22	1 a	1.11
	Open	90	0 a	0.00	0 a	0.00
August	Mist	90	2 a	2.22	1 a	1.11
	Open	90	0 a	0.00	0 a	0.00

Values having the same letter are homogenous

X^2 analysis was done

effect on the percentage success of grafting. June was found to be the best season for epicotyl grafting in jack. 5 day and 10 day old rootstock grafted in June and kept under mist condition gave a maximum sprouting of 100 per cent followed by 15 day old rootstock grafted in June and kept under mist condition (73.33 per cent) 5, 10 and 15 day old rootstocks grafted in June and kept under open conditions gave a sprouting of 86.67, 80 and 60 per cent respectively. There was no significant difference in the sprouting of 5, 10 and 15 day old rootstock grafted and kept under mist and open conditions in the months of May, July and August.

Analysis of the data on the survival of epicotyl grafts also showed that June was the best month for epicotyl grafting in jack. Maximum survival was obtained in 5 day old rootstock grafted in June and kept under mist (76.67 per cent) followed by 10 day old rootstock grafted in June and kept under mist (63.33 per cent), but statistically they did not differ significantly. The next best treatments were 15 day old rootstock grafted in June and kept under mist conditions (60 per cent) and 5, 10 and 15 day old rootstock grafted in June and kept under open condition (60,56.67 and 53.33 per cent respectively). All the other treatments 5, 10 and 15 day old rootstock grafted and kept under open and mist conditions in the months of May, July and August showed no statistical difference and the percentage of survival was 13.33 or less. (Tables 9 &10).

Softwood grafting

Analysis of data on the sprouting and survival of softwood grafts indicated that June was the only season suitable for softwood grafting in jack. Maximum sprouting was obtained when grafting was done in the month of June using 2 month old rootstock under mist condition (33.33 per cent). Only 2 month old rootstocks were effective and all other age groups of rootstock dried off. 2 month old rootstock grafted in the month of July and August under mist condition gave a sprouting of 6.67 per cent each, 2 month old rootstock grafted in the month of June under open condition gave a sprouting of 10 per cent whereas in all other months all the open treatments dried off.

Table 9 Effect of season of grafting, age of rootstock and mist conditions on the success in epicotyl grafting (success 15 days after grafting)

Treatments		May		June		July		August	
Age of rootstock	Mist/open conditions	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage
5 days	Mist	6 a	20	30 b	100.00	5 a	16.67	4 a	13.33
10 days	Mist	3 a	10	30 b	100.00	5 a	16.67	3 a	10.00
15 days	Mist	0 a	0	22 b	73.33	3 a	10.00	0 a	0.00
5 days	Open	0 a	0	26 b	86.67	0 a	0.00	0 a	0.00
10 days	Open	0 a	0	24 b	80.00	0 a	0.00	0 a	0.00
15 days	Open	0 a	0	18 b	60.00	0 a	0.00	0 a	0.00

Values having the same letter are homogenous

X^2 analysis was done

Table 18 Effect of season of grafting age of rootstock and mist conditions on the success in epicotyl grafting (success 90 days after grafting)

Treatments		May		June		July		August	
Age of rootstock	Mist/open conditions	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage
5 days	Mist	4 a	13.33	23 c	76.67	4 a	13.33	3 a	10.00
10 days	Mist	3 a	10.00	19 c	63.33	3 a	10.00	2 a	6.67
15 days	Mist	0 a	0.00	18 b	60.00	2 a	6.67	0 a	0.00
5 days	Open	0 a	0.00	18 b	60.00	0 a	0.00	0 a	0.00
10 days	Open	0 a	0.00	17 b	56.67	0 a	0.00	0 a	0.00
15 days	Open	0 a	0.00	16 b	53.33	0 a	0.00	0 a	0.00

Values having the same letter are homogenous

x^2 analysis was done

Similar results were obtained when data on survival of softwood grafts were analysed. Maximum survial was for 2 month old rootstock grafted in June under mist condition (23.33 per cent) followed by 2 month old root-stock grafted in June and kept under open condition (6.67 per cent). 2 month old rootstock grafted in the month of July and August and kept under mist condition gave a success of 3.33 per cent each. Excepting the month of June in all other months open treatments of 2 month-old rootstock also dried off. (Tables 11 & 12).

4.6 Effect of different treatments on growth parameters of grafts

Epicotyl grafting

4.6.1 Girth of rootstock

Observations on girth of rootstock for various treatments are presented in Table 13 and illustrated in Fig. 7 . It is clear from the table that there was significant difference among the treatments in the girth of rootstock except for the 5th to 8th fortnight. The maximum girth of rootstock was for the treatment T_7E (5 day old rootstock grafted in June and kept under mist conditions) in all the fortnights except the 1st fortnight in which maximum girth of rootstock was for the treatment $T_{19}E$ (1.425 cm) (5 day old rootstock grafted in August and kept under mist conditions) which was on par with T_7E. The least girth of rootstock was for the treatment $T_{20}E$ (10 day old rootstock grafted in August and kept under mist condition) in the 1st and 9th fortnight and was for the treatment $T_{12}E$ (15 day old rootstock grafted in June and kept under open condition) in the 2nd, 3rd and 10th fortnight and in the 4th fortnight the least girth of rootstock was for the treatment $T_{15}E$ (15 day-old rootstock grafted in July and kept under mist condition). The maximum girth and minimum girth of rootstock in the 10th fortnight are 2.080 cm and 1.880 cm respectively. (Appendix II).

Analysis of variance of the data on rootstock girth was done only for the month June during the 10 fortnights of observation. Interaction effect of age of rootstock and mist/open conditions was not significant

Table 11 Effect of season of grafting age of rootstock and mist conditions on the success in softwood grafting (success 15 days after grafting)

Treatments		May		June		July		August	
Age of rootstock	Mist/open conditions	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage
2 months	Mist	0 a	0	10 b	33.33	2 a	6.67	2 a	6.67
3 months	Mist	0 a	0	0 a	0.00	0 a	0.00	0 a	0.00
4 months	Mist	0 a	0	0 a	0.00	0 a	0.00	0 a	0.00
2 months	Open	0 a	0	3 a	10.00	0 a	0.00	0 a	0.00
3 months	Open	0 a	0	0 a	0.00	0 a	0.00	0 a	0.00
4 months	Open	0 a	0	0 a	0.00	0 a	0.00	0 a	0.00

Values having the same letter are homogenous

X^2 analysis was done

Table 12 Effect of season of grafting age of rootstock and mist conditions on the success in softwood grafting (success 90 days after grafting)

Treatments		May		June		July		August	
Age of rootstock	Mist/open conditions	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage
2 months	Mist	0 a	0	7 b	23.33	1 a	3.33	1 a	3.33
3 months	Mist	0 a	0	0 a	0.00	0 a	0.00	0 a	0.00
4 months	Mist	0 a	0	0 a	0.00	0 a	0.00	0 a	0.00
2 months	Open	0 a	0	2 a	6.67	0 a	0.00	0 a	0.00
3 months	Open	0 a	0	0 a	0.00	0 a	0.00	0 a	0.00
4 months	Open	0 a	0	0 a	0.00	0 a	0.00	0 a	0.00

Values having the same letter are homogenous

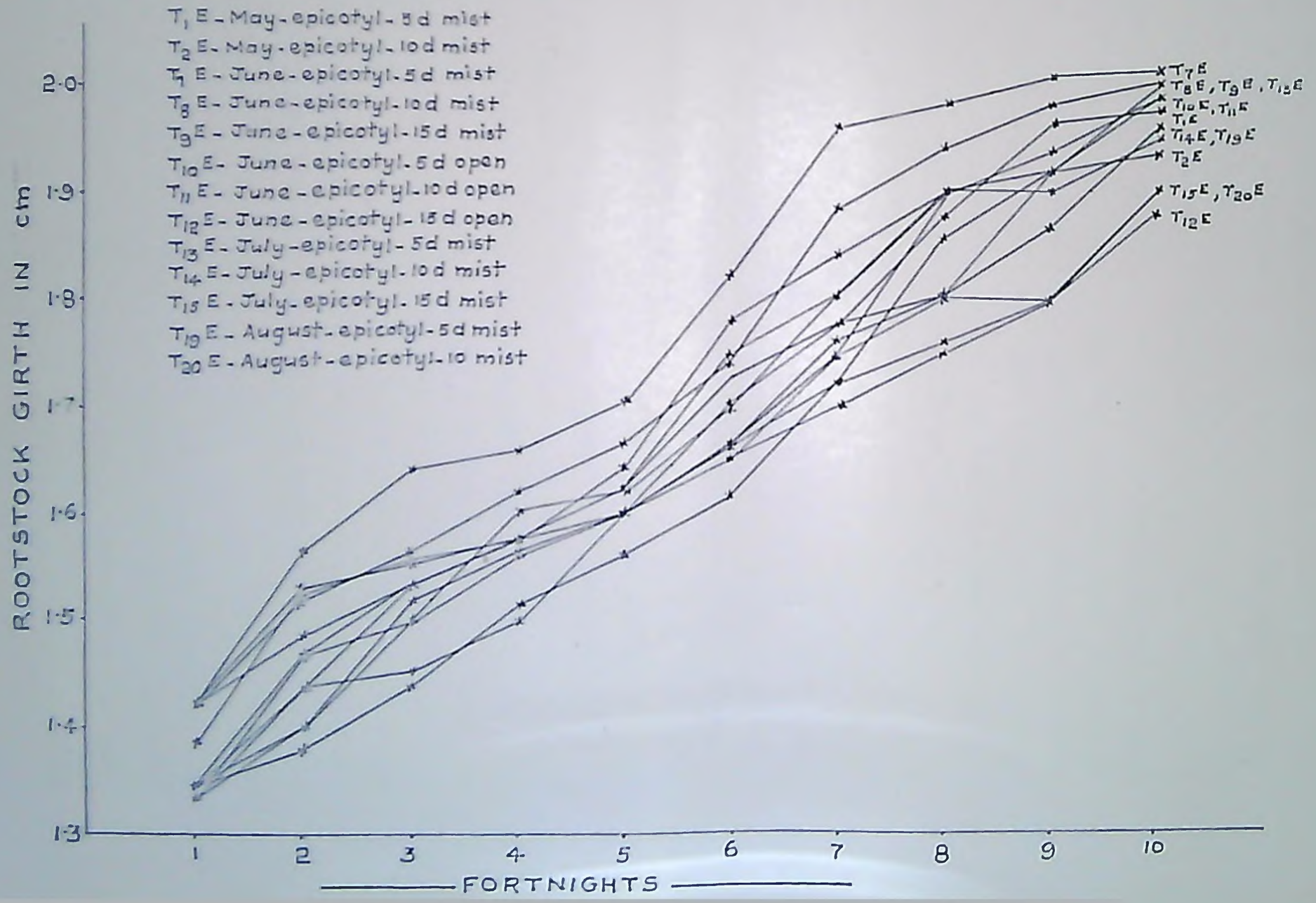
X^2 analysis was done

Table 13 Effect of different treatments on girth of rootstock at fortnightly intervals in cm.

Treatments	1	2	3	4	5	6	7	8	9	10
T_1E	1.420 ab	1.525 abc	1.550 bcd	1.575 bcd	1.625	1.725	1.775	1.875	1.967 a	1.975 bd
T_2E	1.333 bc	1.467 bcd	1.533 bcd	1.567 bcd	1.600	1.667	1.767	1.800	1.910 a	1.933 abcd
T_7E	1.420 a	1.560 a	1.640	1.660 a	1.700	1.820	1.960	1.980	2.060 ab	2.080 a
T_8E	1.380 ab	1.520 ab	1.560 a	1.620 ab	1.660	1.740	1.880	1.940	1.980 abc	2.020 ab
T_9E	1.340 bc	1.460 bc	1.500 ab	1.600 abc	1.620	1.700	1.800	1.900	1.940 abcd	2.020 abc
T_{10}^8	1.340 bcd	1.440 cd	1.540 abc	1.580 bc	1.640	1.780	1.840	1.900	1.940 abcd	1.980 bcd
$T_{11}E$	1.340 bcd	1.400 cd	1.520 abcd	1.560 bcd	1.600	1.660	1.720	1.860	1.920 abcd	1.980 bd
$T_{12}E$	1.340 bcd	1.380 cd	1.440 ab	1.520 d	1.560	1.620	1.720	1.760	1.800 abcd	1.880 e
$T_{13}E$	1.420 ab	1.525 abcd	1.550 bcd	1.575 bcd	1.625	1.750	1.800	1.900	1.925 abcd	2.000 abcd
$T_{14}E$	1.340 bcd	1.467 bcd	1.500 abcd	1.553 cd	1.600	1.700	1.767	1.800	1.867 abcd	1.967 abcd
$T_{15}E$	1.333 bd	1.433 cd	1.450 abcd	1.500 d	1.600	1.650	1.700	1.750	1.800 abcd	1.900 acd
$T_{19}E$	1.425 bc	1.467 bcd	1.533 abcd	1.567 bcd	1.600	1.667	1.750	1.900	1.900 abcd	1.950 abcd
$T_{20}E$	1.333 bcd	1.400 cd	1.500 abcd	1.550 bcd	1.600	1.650	1.750	1.800	1.800 abcd	1.900 ad
					NS	NS	NS	NS		

Values having the same letter are homogenous

Fig.7. EFFECT OF DIFFERENT TREATMENTS ON GIRTH OF ROOTSTOCK AT FORTNIGHTLY INTERVALS



in any fortnight. There was no significant effect of mist condition and age of rootstock on the girth of rootstock in the 1st, 6th, 7th, 8th and 9th fortnights. In the 2nd, 3rd, 4th, 5th and 10th fortnight mist condition was found to be superior to open condition. In the 2nd and 10th fortnight the mean value of girth of rootstock under mist condition was 1.57 cm and 2.04 cm respectively whereas that for open was 1.50 cm and 1.95 cm respectively. In the 2nd, 3rd, 4th, 5th and 10th fortnights age of rootstock also had significant effect on girth of rootstock. In these fortnights there was significant difference between 5 day old rootstock and 15 day old rootstock and in the 3rd fortnight there was significant difference between 5 day and 10 day-old rootstocks. The mean value of girth of rootstock of 5 day and 10 day old rootstock in the 2nd fortnight are 1.50 cm and 1.42 cm and that for the 10th fortnight are 2.03 cm and 1.95 cm.

Girth of scion

The data on the girth of scion at fortnightly intervals for various treatments are presented in table 14 and illustrated in Fig. 8. In the 1st, 5th, 6th, 7th, 8th and 9th fortnight there was no significant difference between the treatments regarding the girth of scion. The maximum girth of scion was for the treatment T_7E (5 day-old rootstock grafted in June and kept under mist conditions) in the 3rd, 4th and 10th fortnights whereas it was for the treatment $T_{13}E$ (5 day old rootstock grafted in July and kept under mist condition) in the 2nd fortnight. The least girth of scion was for the treatment $T_{12}E$ (15 day old rootstock grafted in June and kept under open condition) in the 2nd, 4th and 10th fortnights whereas it was for the treatment $T_{11}E$ (10 day old rootstock grafted in June and kept under open condition) in the 3rd fortnight. The maximum and minimum girth of scion in the 10th fortnight were 1.960 cm and 1.700 cm respectively. (Appendix III)

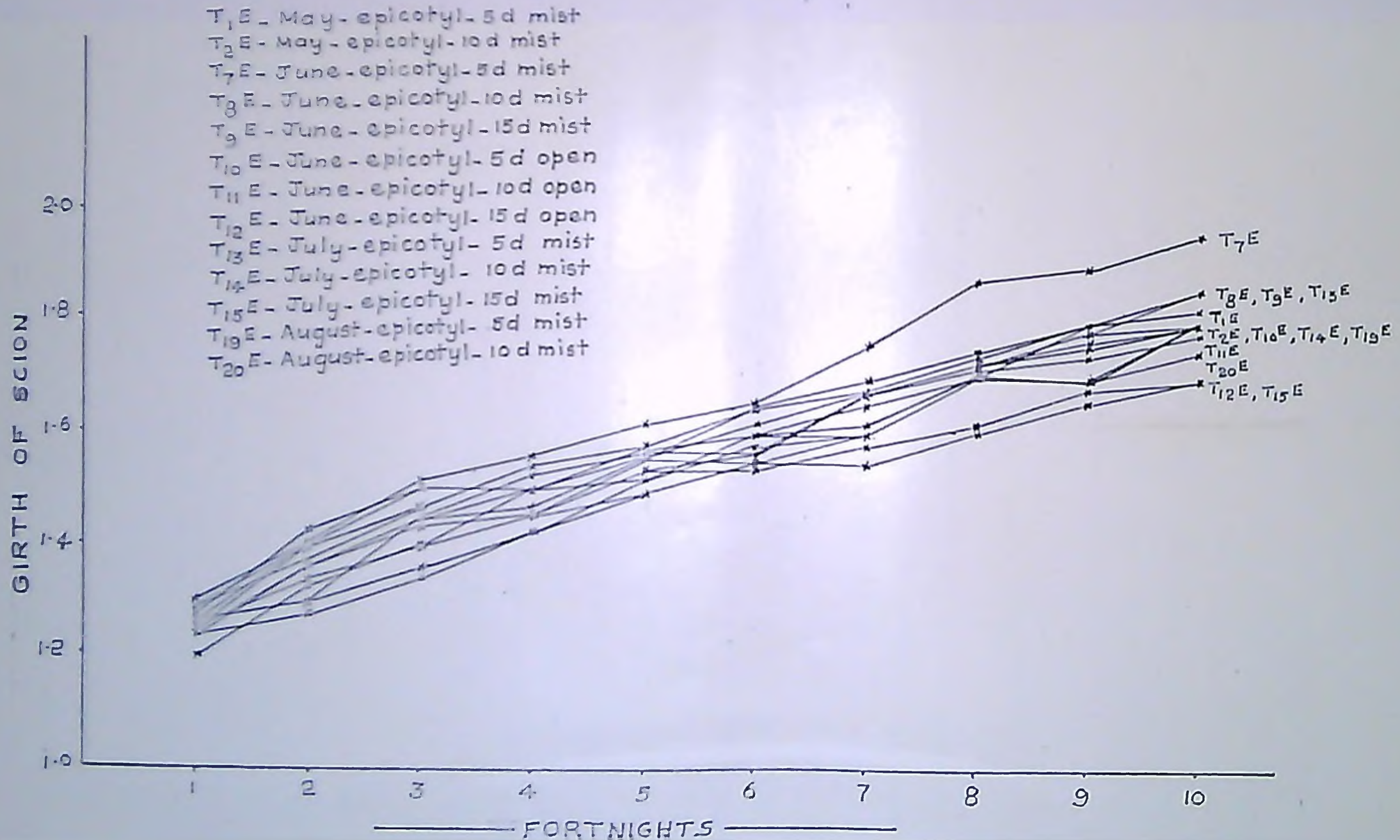
Interaction effect of age of rootstock and mist/open conditions was not significant at all the fortnights. In the 2nd, 3rd, 4th, 5th and 10th fortnights mist condition had a significant effect over open condition.

Table 14 Effect of different treatments on girth of scion at fortnightly intervals in cm

Treatments	1	2	3	4	5	6	7	8	9	10
T_1E	1.280	1.400 bcd	1.450 abc	1.475 cd	1.550 bc	1.650	1.700	1.750	1.800	1.825 abcd
T_2E	1.233	1.367 abcd	1.433 cd	1.467 cd	1.533 bc	1.567	1.667	1.733	1.767	1.800 abcd
T_7E	1.300	1.400 a	1.520 a	1.560 a	1.620 a	1.660	1.760	1.880	1.900	1.960 a
T_8E	1.280	1.380 ab	1.480 ab	1.540 ab	1.580 ab	1.640	1.680	1.740	1.800	1.860 a
T_9E	1.260	1.360 abc	1.440 bc	1.500 bc	1.520 bc	1.600	1.600	1.700	1.800	1.860 ab
$T_{10}E$	1.260	1.340 abcd	1.400 c	1.500 bcd	1.560 abc	1.620	1.680	1.740	1.760	1.800 abc
$T_{11}E$	1.260	1.300 cd	1.360 cd	1.420 e	1.520 bc	1.580	1.620	1.720	1.740	1.780 bcd
$T_{12}E$	1.240	1.280 d	1.340 cd	1.420 e	1.500 c	1.540	1.580	1.620	1.680	1.700 d
$T_{13}E$	1.280	1.425 abc	1.500 abc	1.525 abcd	1.550 bc	1.650	1.700	1.750	1.775	1.850 abcd
$T_{14}E$	1.240	1.400 abc	1.467 abc	1.533 abcd	1.567 abc	1.567	1.667	1.733	1.767	1.800 abcd
$T_{15}E$	1.200	1.333 abcd	1.400 bcd	1.450 cd	1.500 bc	1.550	1.550	1.600	1.650	1.700 cd
$T_{19}E$	1.250	1.400 abc	1.500 abcd	1.500 abcd	1.567 abc	1.600	1.650	1.700	1.700	1.800 abcd
$T_{20}E$	1.267	1.300 bcd	1.450 abcd	1.500 abcd	1.550 abc	1.550	1.600	1.700	1.700	1.750 abcd
		NS				NS	NS	NS	NS	

Values having the same letter are homogenous

Fig. 8. EFFECT OF DIFFERENT TREATMENTS ON GIRTH OF SCION AT FORTNIGHTS INTERVALS



The mean values of girth of scion under mist in the 2nd and 10th fortnights are 1.38 cm and 1.57 cm and that under open condition are 1.31 cm and 1.53 cm respectively. Age of rootstock also had significant effect in the 3rd, 4th, 5th and 10th fortnights. 5 day old rootstock and 15 day old rootstock had significant difference and the mean values of girth of scion in the 3rd fortnight were 1.46 cm and 1.39 cm and that for the 10th fortnight were 1.88 cm and 1.78 cm respectively. In the 4th fortnight there was significant difference between 5 day and 10 day old rootstock, the mean values of girth of scion being 1.53 cm and 1.48 cm respectively.

Length of extension growth

The observations recorded on length of extension growth are presented in Table 15 and illustrated in Fig.9. From the table it is evident that there is significant difference with regard to length of extension growth for different treatments studied through the period of observation. The maximum length of extension growth throughout the period of observation was for the treatment T_7E (5 day old rootstock grafted in June and kept under mist conditions). The minimum length of extension grwoth was for the treatment $T_{12}E$ (15 day old rootstock grafted in June and kept in open condition) in all the fortnights during the period of observation except during the 5th fortnight in which minimum length of extension growth was for the treatment $T_{11}E$ (10 day old rootstock grafted in June and kept in open condition). The maximum and minimum length of extension growth during the 10th fortnight was 11.700 cm and 7.880 cm respectively. (Appendix IV).

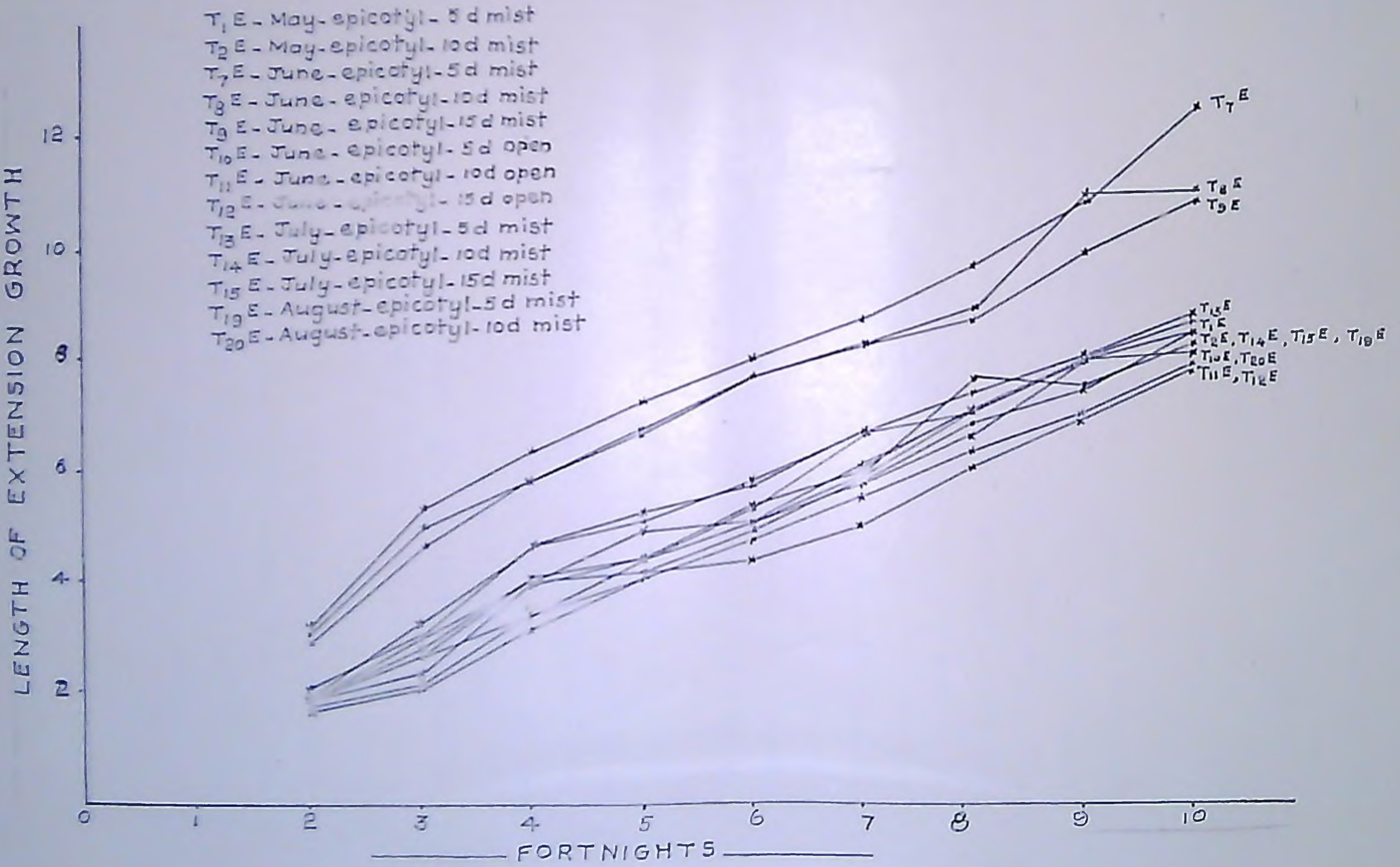
In the 1st and 7th fortnight there was no significant effect of mist conditions and age of rootstock on the extension growth of scion. In the 2nd, 3rd, 4th, 5th, 6th, 8th, 9th and 10 fortnight mist conditions had a significant effect over open conditions on extension growth of scion. The mean values of length of extension growth under mist condition in the 2nd and 10th fortnights are 3.15 cm and 11.24 cm and that in the open condition are 1.79 cm and 8.09 cm respectively. Age of rootstock also had significant effect on extension growth of scion in the 3rd, 5th, 6th and 10th fortnights. In the 3rd fortnight the mean values of extension growth of 5 day and 15 day old rootstock were 3.87 cm and 3.40 cm and that for 10th fortnight

Table 15 Effect of different treatments on length of extension growth at fortnightly intervals in cm

Treatments	1	2	3	4	5	6	7	8	9	10
T_1E		2.000 c	3.200 e	4.550 cd	5.050 e	5.675 b	6.700 abcd	7.100 bcd	8.000 bcd	8.825 b
T_2E		1.967 c	2.633 c	3.333 cd	4.400 bcd	5.267 bc	6.033 cd	7.100 bcd	7.967 bcd	8.467 d
T_7E		3.270 a	5.420 a	6.440 a	7.320	8.080 a	8.760 a	9.820 a	10.880 a	11.700
T_8E		3.150 ab	5.010 ab	5.920 ab	6.820 a	7.780 a	8.400 ab	9.000 ab	10.120 ab	11.060 a
T_9E		3.020 ab	4.740 b	5.920 ab	6.840 a	7.720 a	8.280 abc	8.820 abc	10.120 abc	10.950 b
$T_{10}E$		1.900 c	2.320 c	3.910 c	4.430 b	5.080 b	5.960 d	6.680 cd	7.120 d	8.400 b
$T_{11}E$		1.760 c	2.160 cd	3.380 cd	4.040 bc	4.760 bc	5.560 d	6.400 d	7.060 d	7.980 b
$T_{12}E$		1.700 c	2.060 cd	3.220 cd	4.060 bcd	4.440 cd	5.420 d	6.060 bd	6.960 d	7.880 b
$T_{13}E$		2.050 c	3.050 e	4.700 e	5.300 e	5.750 e	6.750 bcd	7.450 bcd	8.050 bcd	8.925 b
$T_{14}E$		1.967 c	2.767 c	4.067 bcd	4.433 bcd	5.367 bc	6.700 abcd	7.133 bcd	8.000 bcd	8.533 b
$T_{15}E$		1.933 c	2.250 d	3.900 bcd	4.350 bcd	4.950 bcd	5.750 d	6.850 bcd	7.500 abcd	8.500 b
$T_{19}E$		2.000 c	2.967 e	4.000 b	4.900 b	5.233 bc	6.050 bcd	7.100 abcd	7.950 abcd	8.400 b
$T_{20}E$		1.900 c	2.700 cd	4.050 bcd	4.200 bcd	4.950 bcd	5.850 bcd	6.750 bcd	7.950 abcd	8.200 b

Values having the same letter are homogenous

Fig.9. EFFECT OF DIFFERENT TREATMENTS ON LENGTH OF EXTENSION GROWTH AT FORTNIGHTLY INTERVALS



were 10.05 cm and 9.42 cm respectively. There was significant difference between 5 day and 10 day old rootstock in the 5th and 10th fortnight the mean values of extension growth being 5.88 cm and 5.43 cm for the former and 10.05 cm and 9.52 cm for the latter respectively.

Girth of extension growth

The observations recorded on girth of extension growth are presented in Table 16 and illustrated in Fig.10. There was no significant difference between the treatments regarding the girth of extension growth in the 5th, 7th, 8th and 9th fortnights. The maximum girth of extension growth was for the treatment T_7E (5 day old rootstock grafted in June and kept under mist conditions) in the 2nd, 3rd, 4th, 6th and 10th fortnights. The minimum girth of extension growth was for the treatment $T_{12}E$ (15 day-old rootstock grafted in June and kept under open condition) in the 2nd, 3rd, 4th, 6th and 10th fortnights. The maximum and minimum girth of extension growth in the 10th fortnight are 1.520 cm and 1.160 cm respectively (Appendix V).

In the 1st, 7th, 8th and 9th fortnights there was no significant effect of mist condition and age of rootstock on girth of extension growth. In the 2nd, 3rd, 4th, 5th, 6th and 10th fortnight there was significant effect of mist condition on girth of extension growth compared to open. In the 2nd and 10th fortnight the values for girth of extension growth under mist condition was 0.79 cm and 1.40 cm and under open condition was 0.70 cm and 1.23 cm respepctively. Age of rootstock also had significant effect on girth of extension growth in the 3rd, 4th, 6th and 10th fortnight. There was significant difference between 5 day and 10 day-old rootstock and 5 day and 15 day old rootstock in all these fortnights. In the 10th fortnight the girth of extension growth of 5 day and 10 day and 5 day and 15 day old rootstock are 1.41 cm and 1.29 cm and 1.41 cm and 1.24 cm respectively.

Number of leaves

The observations on the number of leaves are presented in Table 17 and illustrated in Fig 11. It is evident from the table that there is significant

Table 16 Effect of different treatments on girth of extension growthat fortnightly intervals in cm

Treatments	1	2	3	4	5	6	7	8	9	10
T_1E		0.800 abc	0.950 ac	1.000 bd	1.025	1.100 abcd	1.150	1.200	1.300	1.325 abcd
T_2E		0.733 bc	0.900 abc	0.967 abcd	1.033	1.100 abcd	1.133	1.167	1.200	1.300 abcd
T_7E		0.800 a	1.020	1.040 a	1.040	1.180 a	1.220	1.320	1.460	1.520
T_8E		0.780 ab	0.920 a	1.000 ab	1.020	1.120 ab	1.200	1.260	1.280	1.360 a
T_9E		0.720 bc	0.840 ab	0.880 ac	1.020	1.120 abc	1.140	1.200	1.240	1.320 ab
$T_{10}E$		0.700 bc	0.860 abc	0.960 bcd	0.980	1.080 bcd	1.120	1.200	1.220	1.300 abc
$T_{11}E$		0.700 bc	0.780 bcd	0.920 bcd	0.940	0.980 bc	1.020	1.120	1.180	1.220 bcd
$T_{12}E$		0.700 bc	0.740 d	0.840 c	0.940	0.980 bc	1.000	1.080	1.120	1.160 cd
$T_{13}E$		0.875 abc	0.925 abc	1.000 abd	1.050	1.100 abcd	1.150	1.200	1.300	1.350 abcd
$T_{14}E$		0.767 abc	0.900 abc	1.000 abd	1.033	1.100 abcd	1.670	1.200	1.233	1.333 abcd
$T_{15}E$		0.700 bc	0.750 bcd	0.900 abcd	1.000	1.050 abcd	1.100	1.150	1.200	1.250 abcd
$T_{19}E$		0.833 abc	0.900 abc	1.000 abd	1.033	1.100 abcd	1.100	1.150	1.200	1.300 abcd
$T_{20}E$		0.733 bc	0.850 abcd	0.950 abcd	1.000	1.050 abcd	1.100	1.100	1.150	1.200 bcd
					NS		NS	NS	NS	

Values having the same letter are homogenous

Fig.10. EFFECT OF DIFFERENT TREATMENTS ON GIRTH OF EXTENSION GROWTH AT FORTNIGHTLY INTERVALS

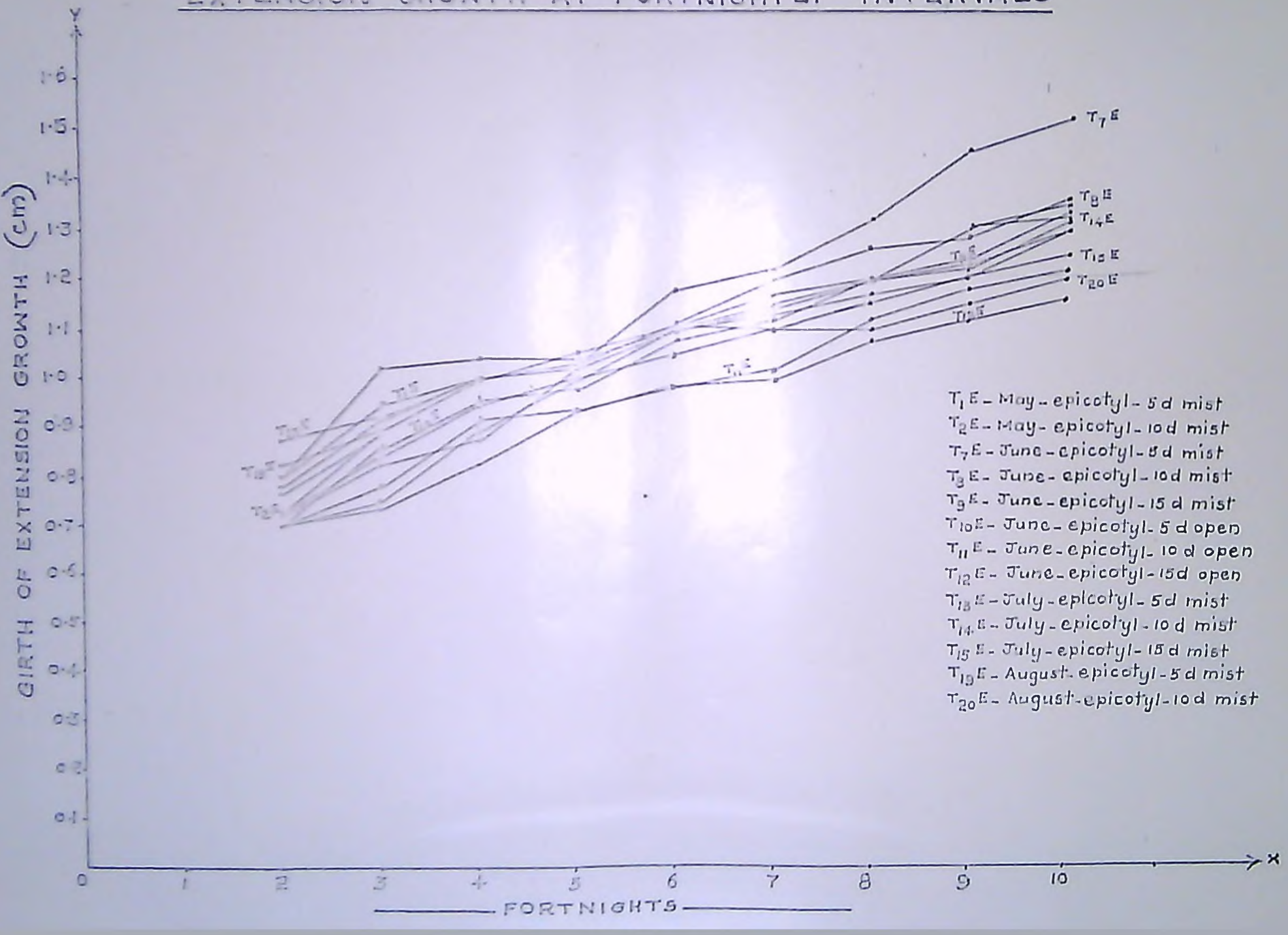
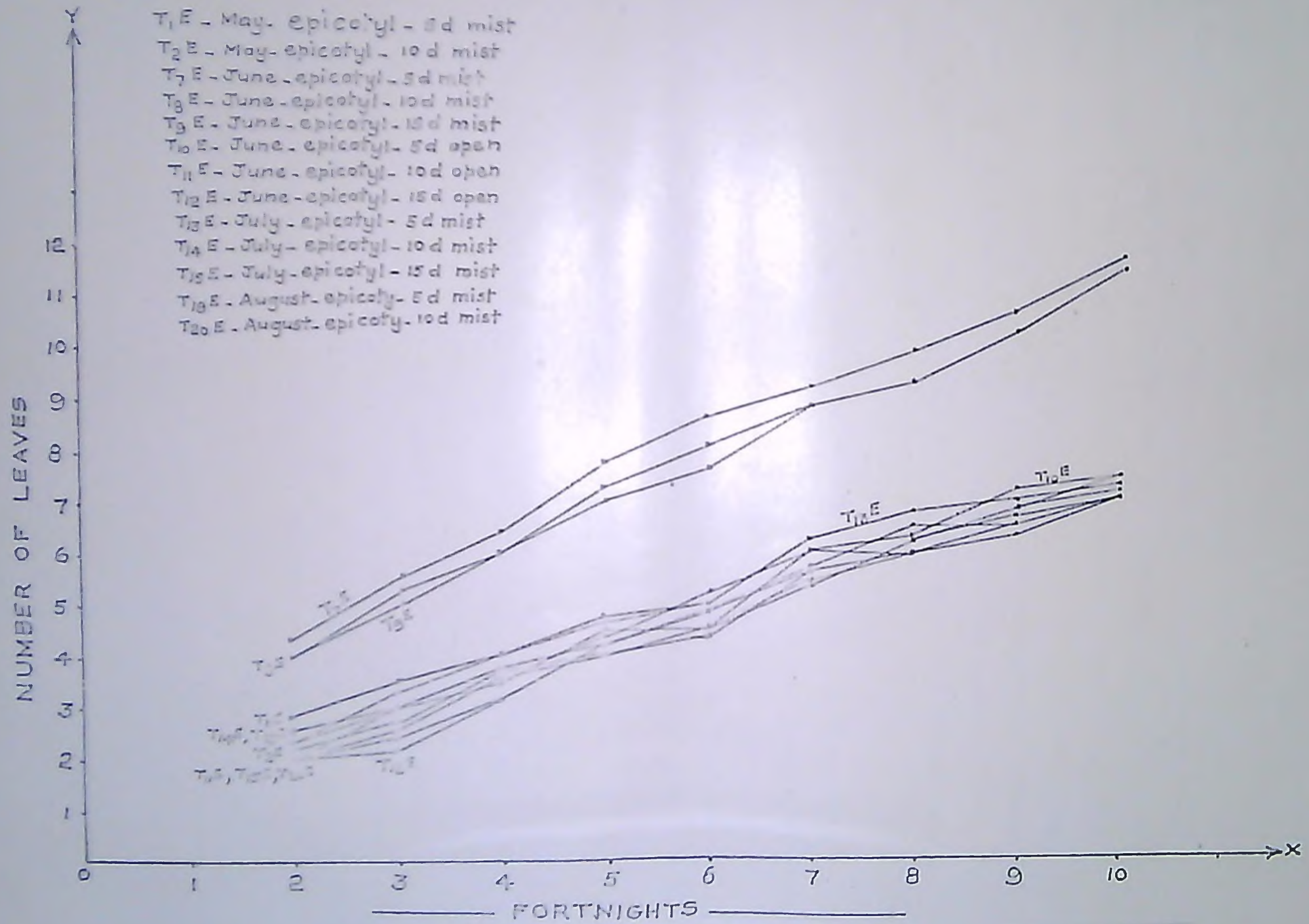


Table 1: Effect of different treatments on number of leaves at fortnightly intervals

Treatments	1	2	3	4	5	6	7	8	9	10
T_1E		2.500 c	3.000 cd	3.750 bcd	4.250 b	4.750 c	5.750 b	6.500 b	6.500 b	7.00 b
T_2E		2.000 c	3.000 cd	3.667 bcd	4.000 b	4.333 c	5.667 b	6.000 b	6.333 b	7.000 b
T_7E		4.400 a	5.600 a	6.400 a	7.800 a	8.600 a	9.200 a	9.800 a	10.600 a	11.600 a
T_8E		4.000 ab	5.200 ab	6.000 ab	7.200 a	8.000 ab	8.800 a	9.200 a	10.200 a	11.400 a
T_9E		4.000 ab	5.000 ab	6.000 a	7.000 a	7.600 b	8.800 a	9.200 a	10.200 a	11.400 a
$T_{10}E$		2.200 c	2.800 c	3.600 b	4.400 b	5.200 c	6.000 b	6.400 b	7.200 b	7.400 b
$T_{11}E$		2.000 c	2.400 cd	3.200 bc	4.200 b	4.800 c	5.600 b	6.200 b	6.800 b	7.400 b
$T_{12}E$		2.000 c	2.200 cd	3.200 bcd	4.200 b	4.800 c	5.400 b	6.200 b	6.800 b	7.200 b
$T_{13}E$		2.750 c	3.500 c	4.000 b	4.750 b	5.000 c	6.250 b	6.750 b	7.000 b	7.250 b
$T_{14}E$		2.333 c	3.333 c	4.000 bd	4.667 b	5.000 c	6.000 b	6.330 b	6.667 b	7.000 b
$T_{15}E$		2.000 c	2.500 cd	3.500 bcd	4.500 b	4.500 c	6.000 b	6.000 b	6.500 b	7.000 b
$T_{19}E$		2.333 c	3.000 cd	3.667 bcd	4.333 b	4.667 c	5.500 b	6.500 b	7.000 b	7.000 b
$T_{20}E$		2.000 c	3.000 cd	3.500 bcd	4.000 b	4.500 c	5.500 b	6.000 b	6.500 b	7.000 b

Values having the same letter are homogenous

Fig. 11. EFFECT OF DIFFERENT TREATMENTS ON NUMBER OF LEAVES PRODUCED



difference between the treatments on the number of leaves produced throughout the period of observation. The maximum number of leaves was for the treatment T_7E (5 day old rootstock grafted in June and kept under mist condition) throughout the period of observation. The minimum number of leaves was for the treatments T_2E (10 day old rootstock grafted in May and kept under mist condition), $T_{11}E$ (10 day-old rootstock grafted in June and kept under open condition), $T_{12}E$ (15 day-old rootstock grafted in June and kept under open condition), $T_{20}E$ (10 day-old rootstock grafted in August and kept under mist condition) in the 2nd fortnight. The maximum and minimum number of leaves in the 10th fortnight were 11.600 and 7.000 respectively (Appendix VI).

The effect of mist conditions was significant in all the fortnights but there was no significant effect of age of rootstock on the number of leaves produced. In the 2nd and 10th fortnight the number of leaves under mist condition was 4.13 and 11.47 and under open condition was 2.07 and 7.33 respectively. The different treatments at various stages of growth are given in plates 14 to 17.

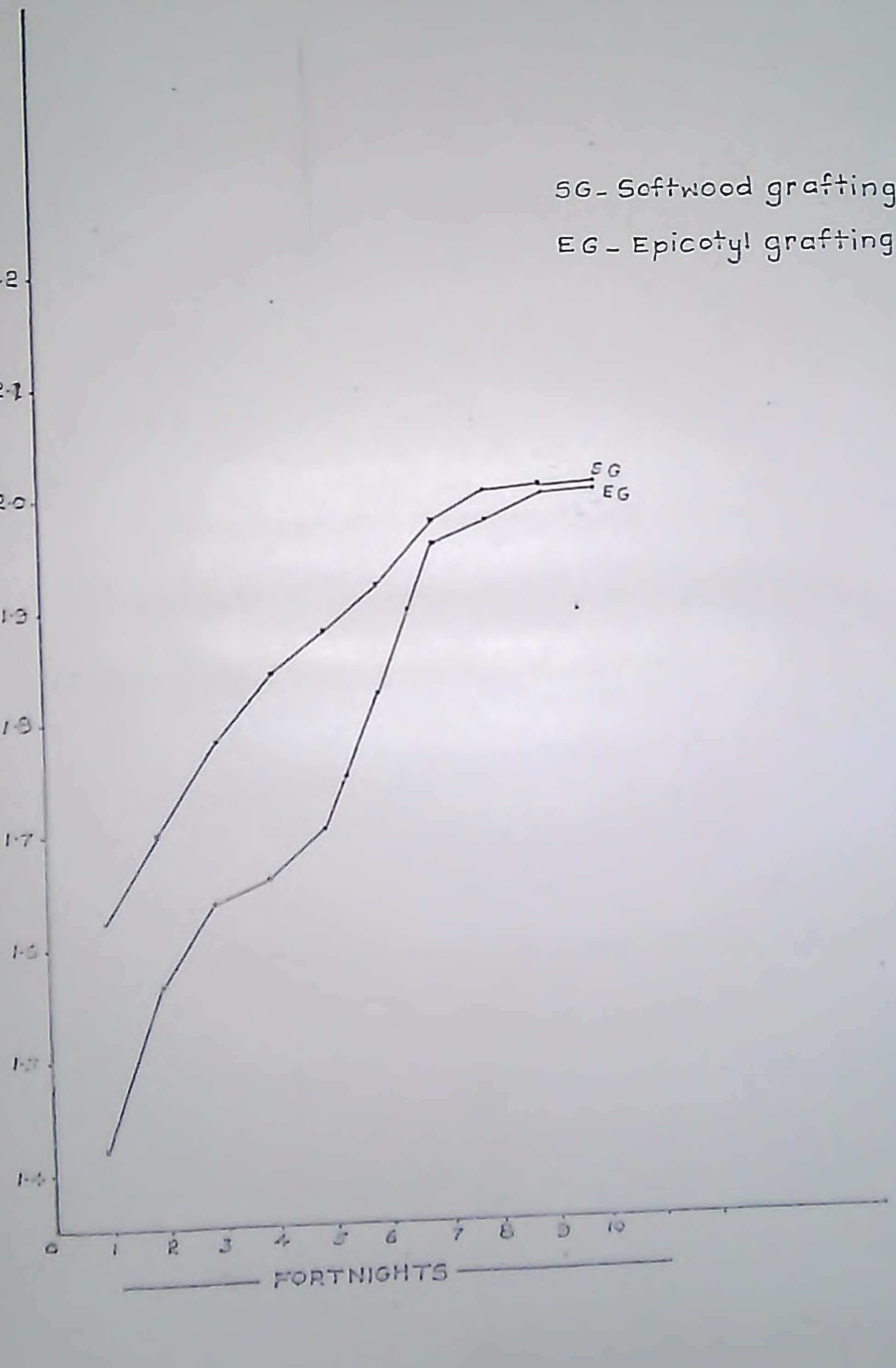
4.7 Comparison between epicotyl and softwood grafting

A comparison was made between the best treatments viz., 5 day old rootstock grafted and kept under mist in June for epicotyl grafting and 2 month old rootstock grafted and kept under mist in June for softwood grafting. A general comparison was made on the various growth parameters like girth of rootstock, girth of scion, length of extension growth, girth of extension growth and number of leaves. An abstract of the analysis of variance of the various growth parameters are given in Appendix VII to XI.

Girth of rootstock

The observations recorded on the girth of rootstock at fortnightly intervals are presented in Table 18 and illustrated in Fig. 12. From the table it is evident that eventhough during the 1st to 5th fortnight there

Fig.12. EFFECT OF EPICOTYL AND SOFTWOOD GRAFTING ON GIRTH OF ROOTSTOCK AT FORTNIGHTLY INTERVALS




120 DAYS
90 DAYS
60 DAYS
30 DAYS
5 DAY OLD ROOTSTOCK


120 DAYS
90 DAYS
60 DAYS
30 DAYS
10 DAY OLD ROOTSTOCK

Plate 16 - 15 day old rootstock 30, 60, 90 and 120 days after grafting.

Plate 17 - 2 month old rootstock 60, 90 and 120 days after grafting.


120 DAYS
90 DAYS
60 DAYS
30 DAYS
15 DAY OLD ROOTSTOCK


120 DAYS
90 DAYS
60 DAYS
2 MONTH OLD ROOTSTOCK

Table 18 Effect of epicotyl and softwood grafting on rootstock girth (cm)

	Rootstock girth at fortnightly intervals									
Treatments	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
Softwood grafting	1.620	1.700	1.780	1.840	1.880	1.920	1.980	2.040	2.080	2.140
Epicotyl grafting	1.420	1.560	1.640	1.660	1.700	1.820	1.960	1.980	2.060	2.080
SEm ±	0.0300	0.0283	0.0316	0.0332	0.0412	0.0436	0.0387	0.0224	0.0224	0.0224
CD (0.05)	0.0978	0.0922	0.1031	0.1082	0.1345	NS	NS	NS	NS	NS

Table 19 Effect of epicotyl and softwood grafting on scion girth (cm)

	Scion girth at fortnightly intervals									
Treatments	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
Softwood grafting	1.500	1.560	1.660	1.700	1.780	1.840	1.900	1.960	1.980	2.020
Epicotyl grafting	1.300	1.400	1.520	1.560	1.620	1.660	1.760	1.880	1.900	1.960
SEm ±	0.0316	0.0361	0.0316	0.0283	0.0200	0.0400	0.0424	0.0387	0.0469	0.0316
CD (0.05)	0.1031	0.1176	0.1031	0.0922	0.0652	0.1304	0.1384	NS	NS	NS

Table 20 Effect of epicotyl and softwood grafting on length of extension growth (cm)

	Length of extension growth at fortnightly intervals									
Treatments	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
Softwood grafting		2.920	3.360	3.680	4.220	4.560	4.740	5.320	6.300	7.120
Epicotyl grafting		3.270	5.420	6.440	7.320	8.080	8.760	9.820	10.880	11.700
SEm ±		0.2649	0.1449	0.1673	0.1715	0.2711	0.2193	0.2189	0.2832	0.2659
CD (0.05)		NS	0.4726	0.5457	0.5592	0.8841	0.7152	0.7137	0.9235	0.8671

was significant difference between the two treatments from the 6th fortnight onwards there was no significant difference between the two. During the 1st fortnight the girth of rootstock for softwood grafts was 1.620 cm and that for epicotyl grafts 1.420 cm and during the 6th fortnight the girth of rootstock for softwood grafts was 1.920 cm and that for epicotyl grafts 1.820 cm. The girth of rootstock during the 10th fortnight for softwood and epicotyl grafts are 2.140 cm and 2.080 cm respectively.

Girth of scion

The data on the girth of scion at fortnightly intervals for various treatments are presented in Table 19 and illustrated in Fig. 13. Analysis of variance of the data revealed that there was significant difference among the treatments and softwood grafts had higher girth of scion during the first 7 fortnights but from the 8th fortnight onwards there was no significant difference between the treatments. In the 7th fortnight the girth of scion for softwood grafts was 1.900 cm and that for epicotyl grafts 1.760 cm.

Length of extension growth

The effect of treatments on the length of extension growth produced by grafts is clearly evident from the data furnished in Table 20 and illustrated in Fig. 14. In the 2nd fortnight there was no significant difference between the treatments. From the 3rd fortnight onwards epicotyl grafts appeared to have higher length of extension growth compared to softwood grafts. In the 3rd fortnight the length of extension growth of softwood grafts and epicotyl grafts are 3.360 cm and 5.420 cm respectively. In the 10th fortnight the softwood grafts had a length of extension growth of 7.120 cm and that of epicotyl grafts 11.700 cm.

Girth of extension growth

The observations recorded on girth of extension growth are presented in Table 21 and illustrated in Fig.15. From the table it is clearly evident that there is no significant difference with regard to girth of extension Growth for the treatments studied throughout the period. The girth of extension

Fig. 13. EFFECT OF EPICOTYL AND SOFTWOOD GRAFTING ON GIRTH OF SCION AT FORTNIGHTLY INTERVALS

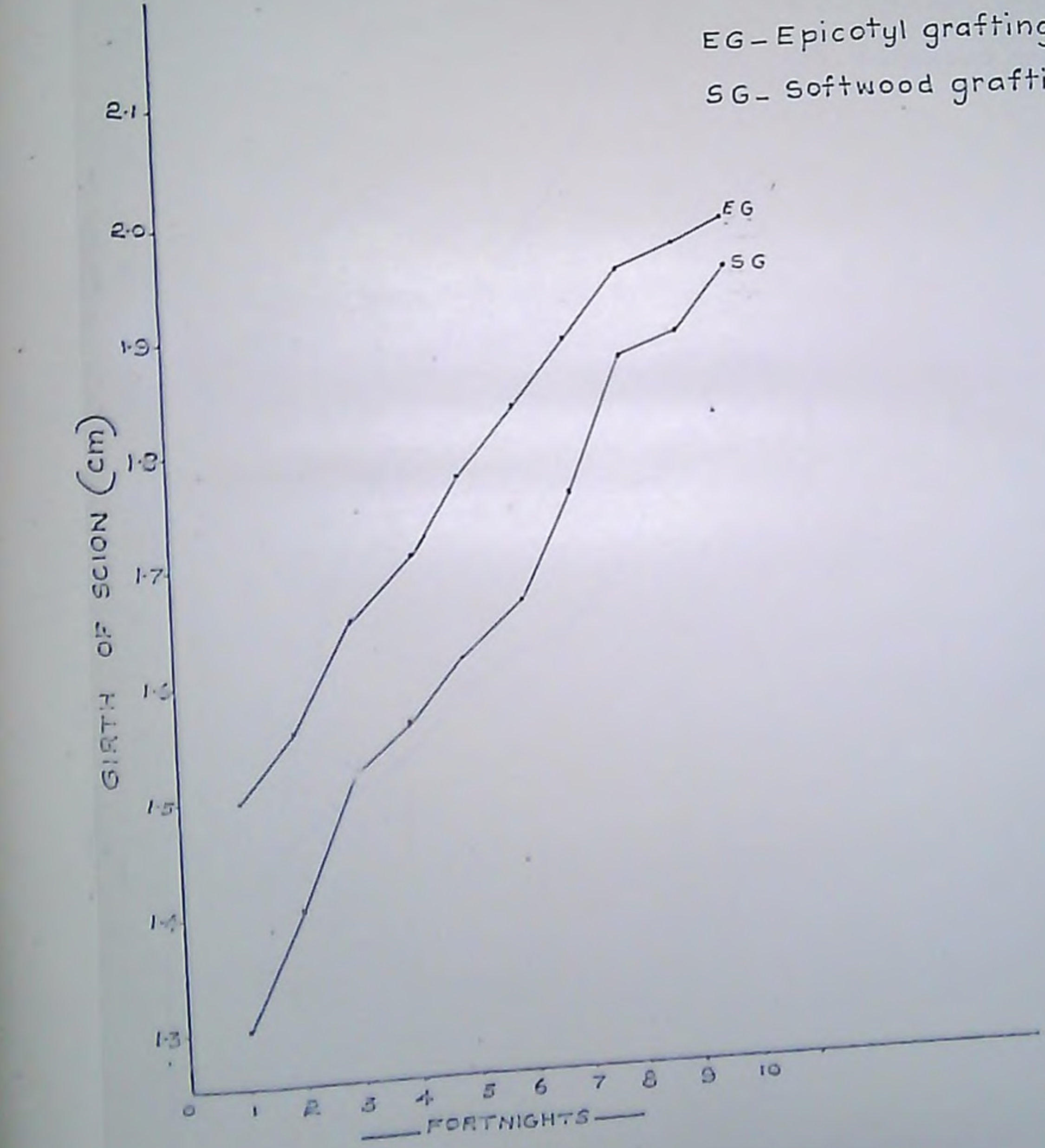


Fig. 14. EFFECT OF EPICOTYL AND SOFTWOOD GRAFTS ON LENGTH OF EXTENSION GROWTH AT FORTNIGHTLY INTERVALS

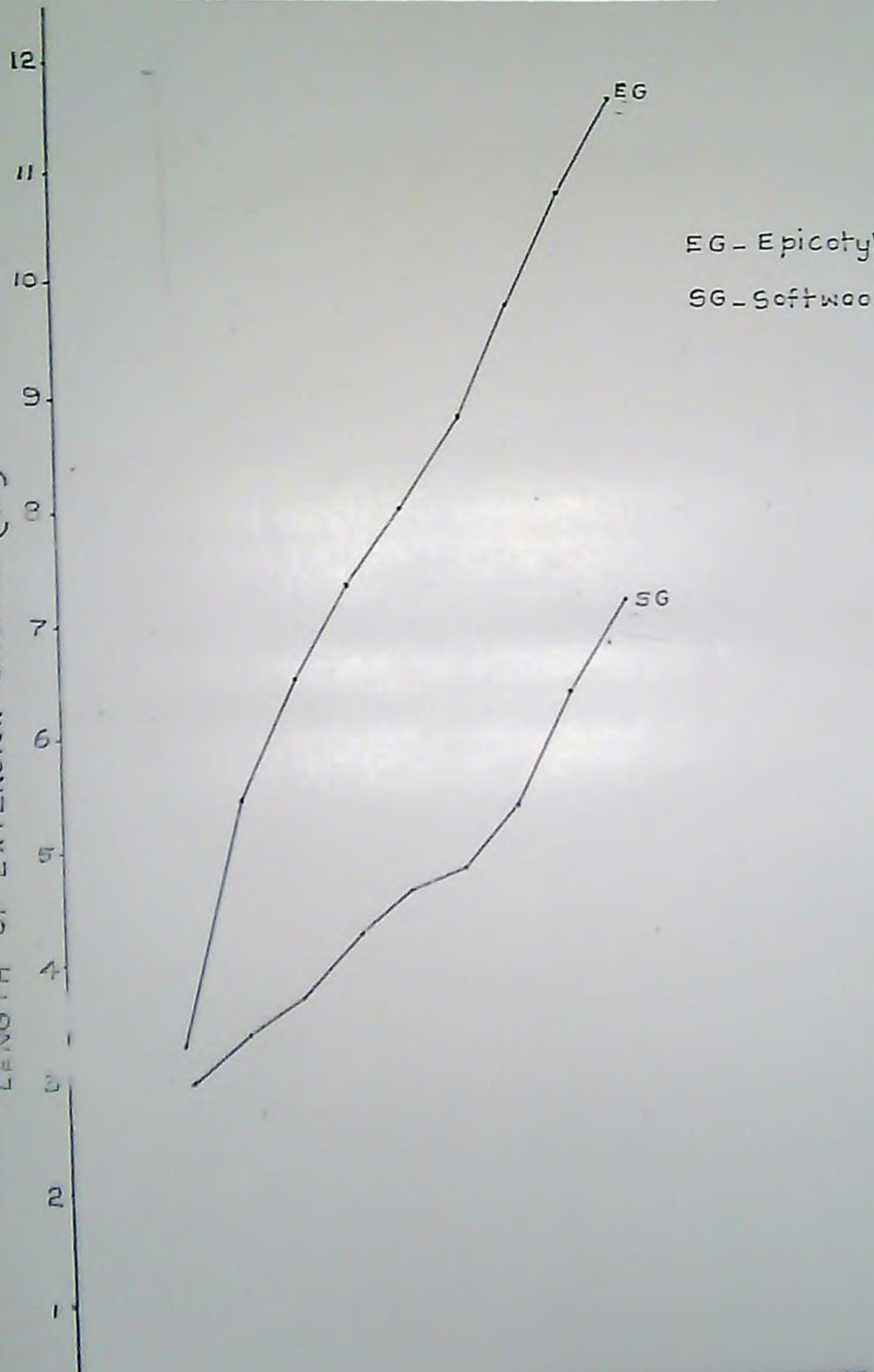


Fig.15. EFFECT OF EPICOTYL AND SOFTWOOD GRAFTING ON GIRTH OF EXTENSION GROWTH AT FORTNIGHTLY INTERVALS

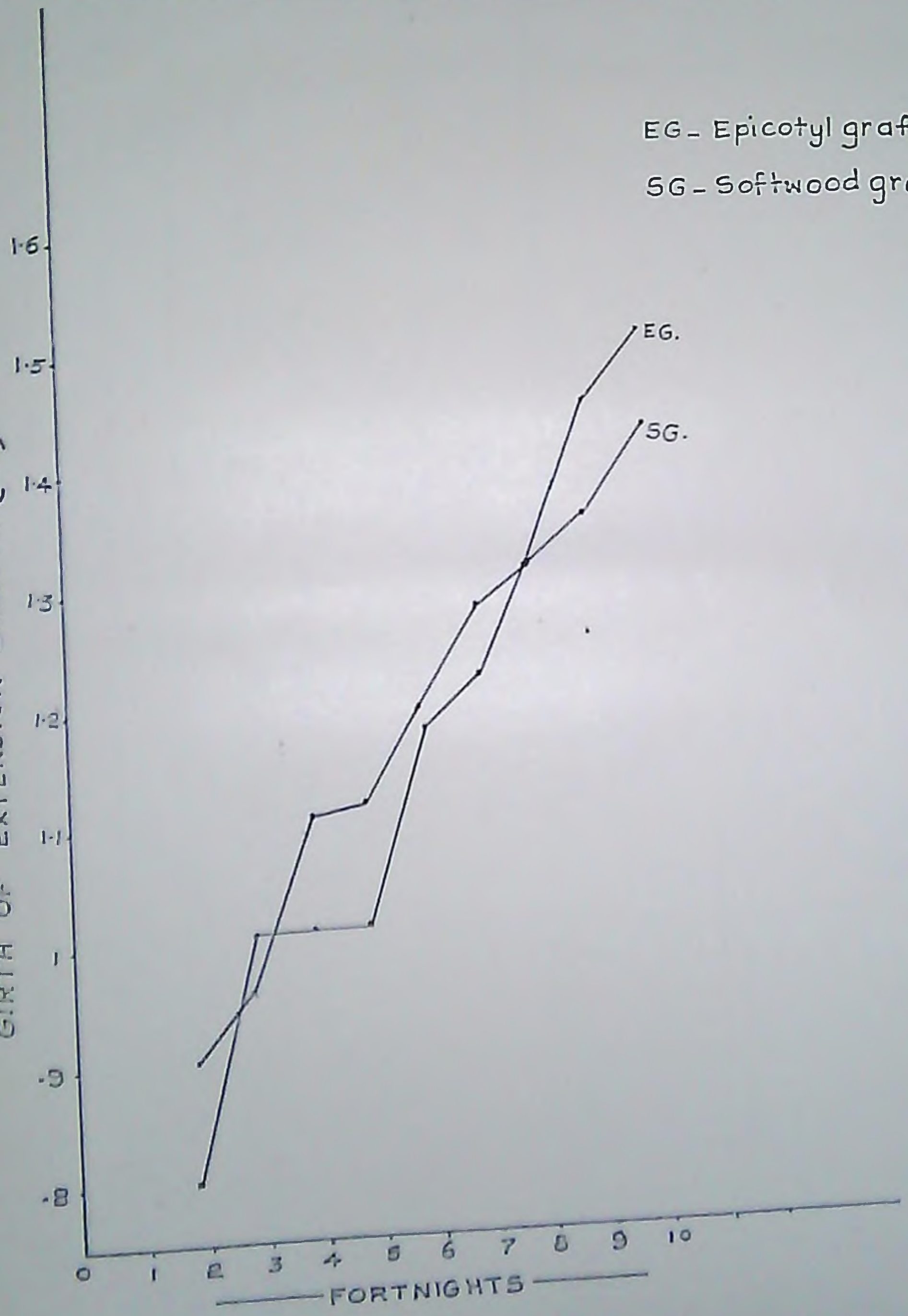


Table 21 Effect of epicotyl and softwood grafting on girth of extension growth (cm)

	Girth of extension growth at fortnightly intervals								
Treatments	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
Softwood grafting		0.900	0.960	1.020	1.140	1.200	1.280	1.320	1.360	1.440
Epicotyl grafting		0.800	1.020	1.040	1.040	1.180	1.220	1.320	1.460	1.520
SEm ±		0.0721	0.0447	0.0447	0.0400	0.0346	0.0374	0.0490	0.0458	0.0592
CD (0.05)		NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 21 Effect of epicotyl and softwood grafting on number of leaves

	Number of leaves at fortnightly intervals								
Treatments	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
Softwood grafting		2.200	2.400	3.200	3.800	4.400	4.600	5.400	5.600	6.200
Epicotyl grafting		4.400	5.600	6.400	7.800	8.600	9.200	9.800	10.600	11.600
SEm ±		0.2236	0.2449	0.2236	0.3000	0.4000	0.3162	0.3873	0.4000	0.3162
CD (0.05)		0.7292	0.7988	0.7292	0.9784	1.3045	1.0313	1.2630	1.3045	1.0313

growth had an increasing trend from the 2nd to 10th fortnight. For softwood grafts the girth of extension growth increased from 0.900 cm to 1.440 cm and for epicotyl grafts from 0.800 cm to 1.520 cm.

Number of leaves

The effect of treatments on the number of leaves produced by the grafts is clearly evident from the Table 21 and illustrated in Fig. 16. Epicotyl grafts appeared to have more number of leaves compared to softwood grafts throughout the course of study. In the 10th fortnight the softwood grafts had an average leaf number of 6.200 and that of epicotyl grafts 11.600.

In an overall comparison of growth parameters of epicotyl and softwood grafts it was found that during the 1st to 5th fortnight there was significant difference among the treatments with respect to girth of rootstock, but from the 6th fortnight onwards there was no significant difference between the two treatments. Similarly in the case of girth of scion also there was significant difference between the treatments upto 7th fortnight but there was no significant difference among the treatments from 8th fortnight onward. There was significant difference between the treatments with regard to length of extension growth and number of leaves produced by the graft throughout the period of observation, but there was no significant difference between the treatments on girth of extension growth throughout the period of study.

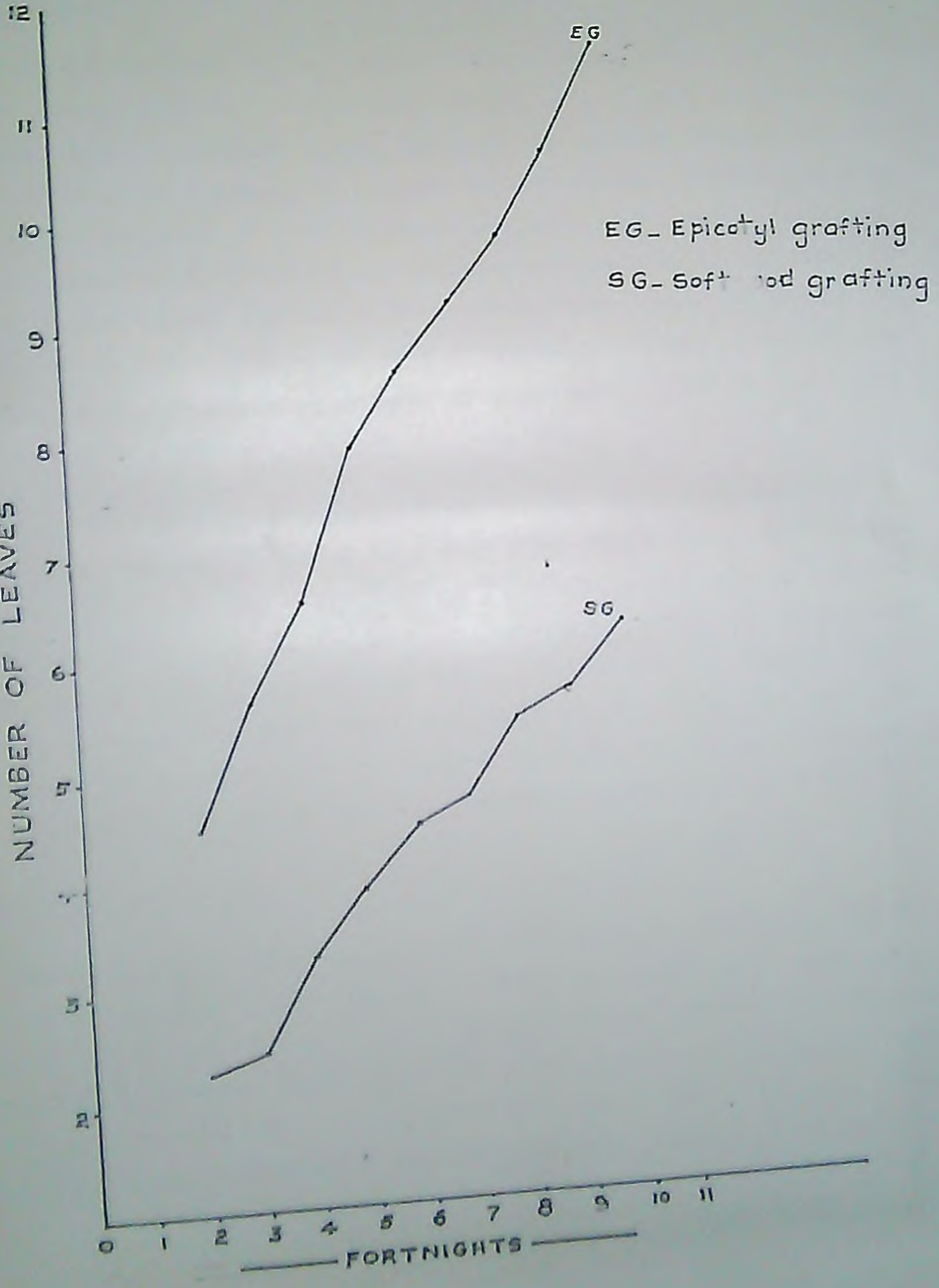
4.8 Anatomical studies

Anatomy of the stem

In order to understand the type of cells from which callus formation and graft union occurs, the structure, of both young and mature stem was studied in detail. The details are given below.

The outermost layer of a young stem with primary growth was the epidermis. The epidermal cells were tabular in shape and appeared rectangular in a cross sectional view. Epidermal hairs were sparse, multicellular and

Fig-16. EFFECT OF EPICOTYL AND SOFTWOOD GRAFTING ON NUMBER OF LEAVES AT FORTNIGHTLY INTERVALS



seen developed from the cells in the epidermal layer. Below the epidermis were 7 to 8 mixed layers of sclerenchyma and collenchyma. Sclerenchyma consisted of thick walled lignified darkly stained cells, whereas collenchyma consisted of cells with thick primary nonlignified walls thickened much at the corners. Below this were 15 to 17 layers of thin walled lightly stained parenchyma cells. An endodermis layer was not very distinct.

Latiferous elements were seen in the primary cortex, primary and secondary phloem and in the pith cells. There were 3 to 4 layers of latex filled cells and intercellular spaces between the vascular bundles and the pith. There were as many as 40 vascular bundles present. Phloem contained fibres. Xylem consisted of fibres, vessels and parenchyma. The vessels were mostly in radial rows. Sclerenchyma patches were present on the outerside of the vascular bundles forming a discontinous layer. Below the cortex and extending to the pith were xylem rays composed of radially elongated cells containing large quantities of cytoplasmic inclusions. Some of the xylem vessels contained membrane like tyloses (Plate 18).

In stems showing secondary thickening the epidermis was lined by a thick dark layer. Multicellular hairs were seen distributed sparsely. Below the cortex, sclerenchyma patches consisting of thick walled cells were present on the outerside of the bundles capping the phloem (Plate 19). Starch was present in the form of minute granules in the parenchyma cells of cortex and pith, however the distribution was more in pith cells. The pith cells consisted of large lightly stained parenchyma cells. In the pith cells there were large number of crystals and also laticiferous cells.

Formation of graft union

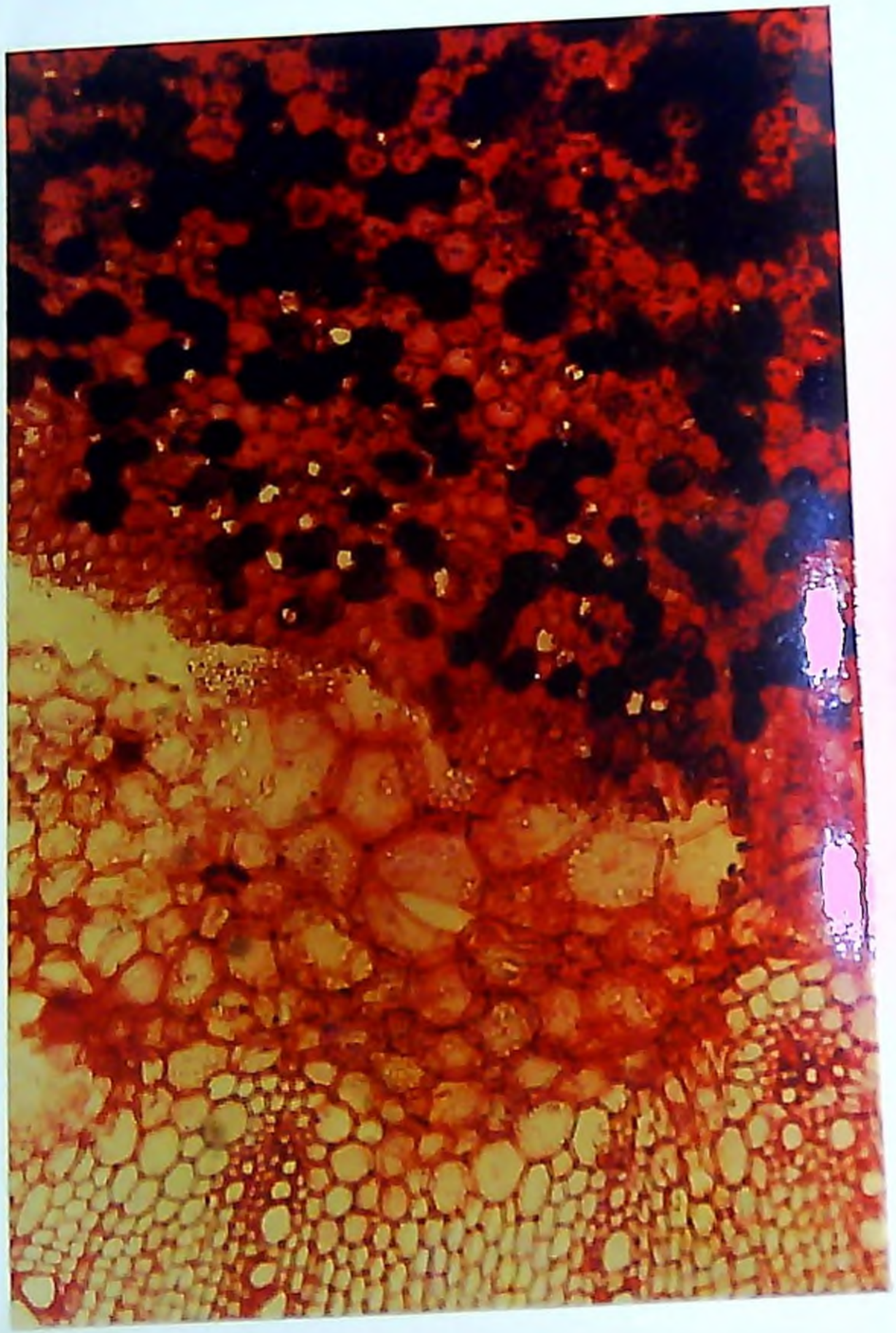
When the graft union was examined five days after grafting in epicotyl grafts the wounded exposed tissues of stock and scion were found to be brownish. There was a thick coating of dark brown materials on external walls of exposed cells. There were some rapid divisions at the cut surface. The cut surface was found to be ruptured at many spots (Plate 20). Callus formation had just started from the stockside only. In the case of softwood

Plate 18 - Cross section of an epicotyl stem.

Plate 19 - Cross section of a softwood stem.

Plate 20 - Epicotyl graft - 5 days after grafting.

Plate 21 - Softwood graft - 5 days after grafting.



grafts callus formation had not yet started 5 days after the grafting operation. The cells at the cut end had been ruptured and darkened (Plate 21).

Profuse callus formation was observed in the material collected 15 days after grafting in epicotyl grafts. The cell walls at the cut surface was darker in colour than 5 days after grafting and was ruptured at many spots. Callus was proliferated either from stock, or scion or from both components depending upon their activity. Mainly cells in the pith region produced more callus (Plate 22). For softwood grafts also callus formation was observed mostly from the pith cells, but callus production was lesser compared to epicotyl grafts. The gap between the stock and scion was partly filled by callus tissues (Plate 23). The original cut was easily traced where stock and scion tissues were necrotic.

A callus bridge was seen formed at abaout 45 days after grafting. The gap between the stock and scion was completely filled up. There was remarkable difference in the response of different cells to produce callus. Callus production was very high when pith cells came in contact with pith cells compared, to pith cells in contact with cortex, xylem and pholem tissue (Plate 24). For softwood grafts also callus production was almost complete by this stage (Plate 25).

The graft union was complete by about 3 months after the grafting operation. Excessive callus production was seen in the case of epicotyl grafts and also there were large number of tangential longitudnal divisions in the pith region of the stock of the epicotyl grafts (Plate 26). Callus had been differentiated to cambial layers and proper healing of the union had occurred (Plate 27). For softwood grafts also union was complete about 90 days after the grafting operation, but the cambial bridge formation was not so distinct as in the case of epicotyl grafts (Plate 28).

Callus formation occurred from the cells of pith, pl oem, xylem and cambium and the intensity with which different cells produced callus varied greatly. Pith cells produced callus most frequently (Plate 29).

Plate 22 - Epicotyl graft - 15 days after grafting.

Plate 23 - Softwood graft - 15 days after grafting.

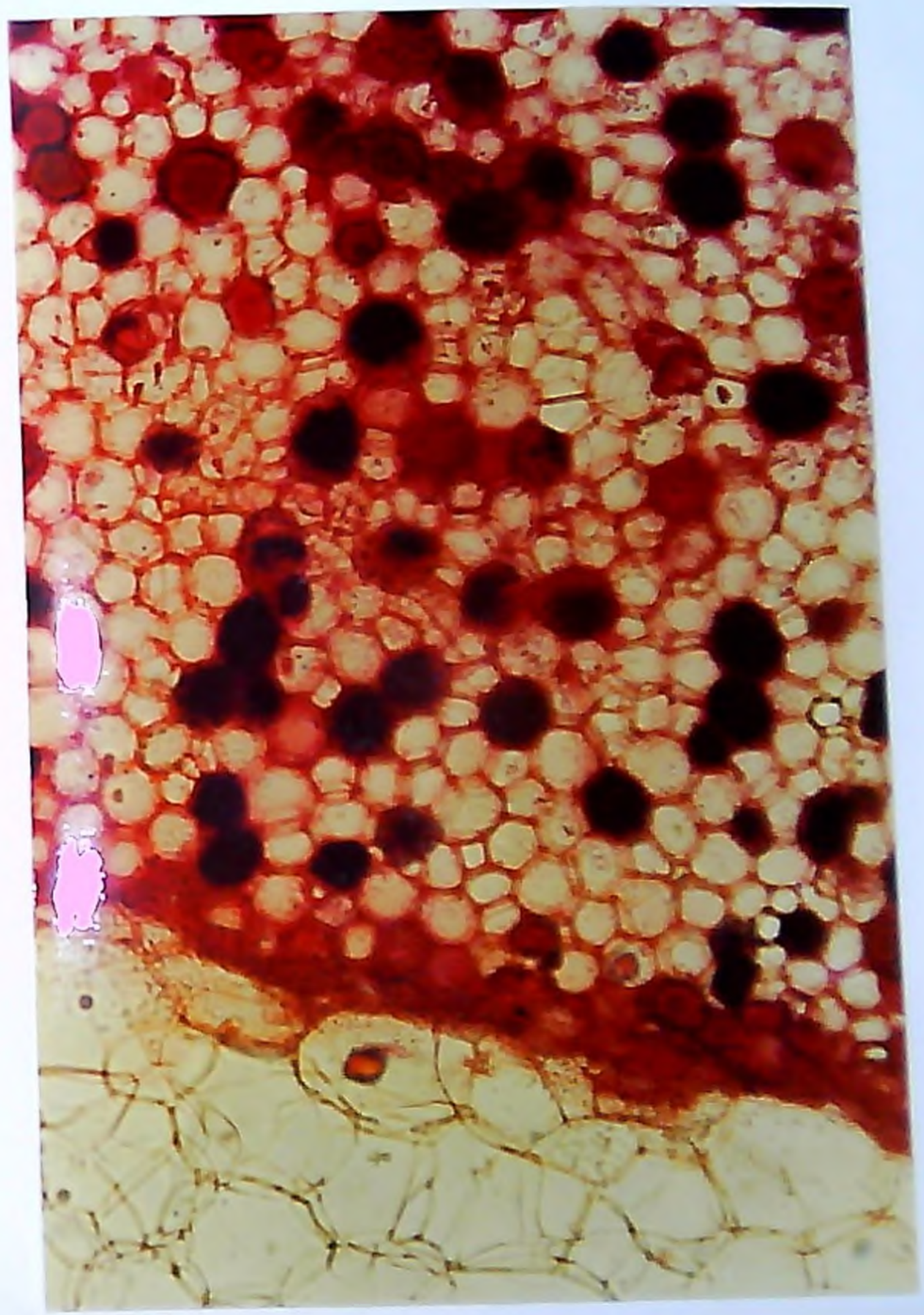


Plate 24 - Epicotyl graft - 45 days after grafting.

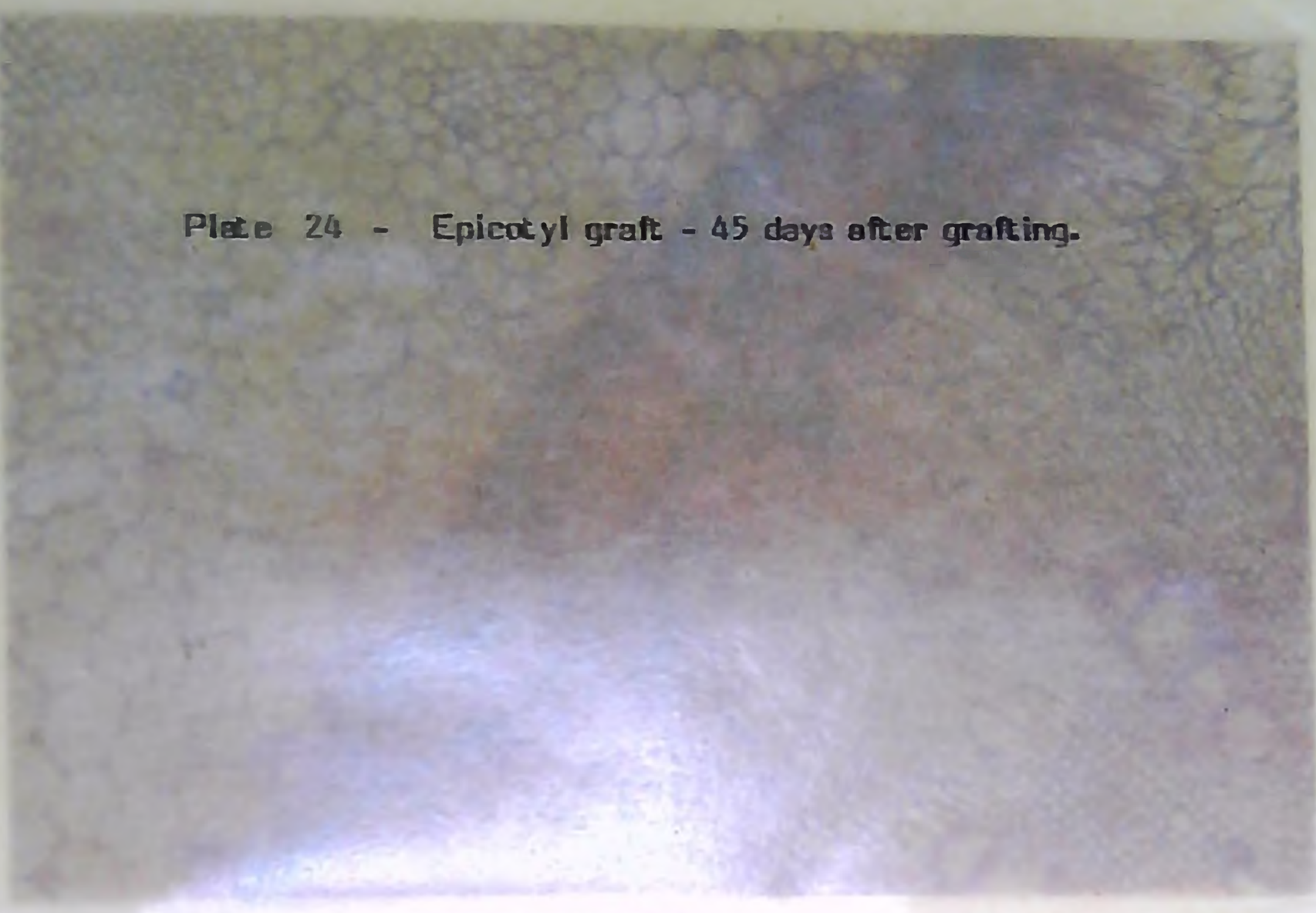
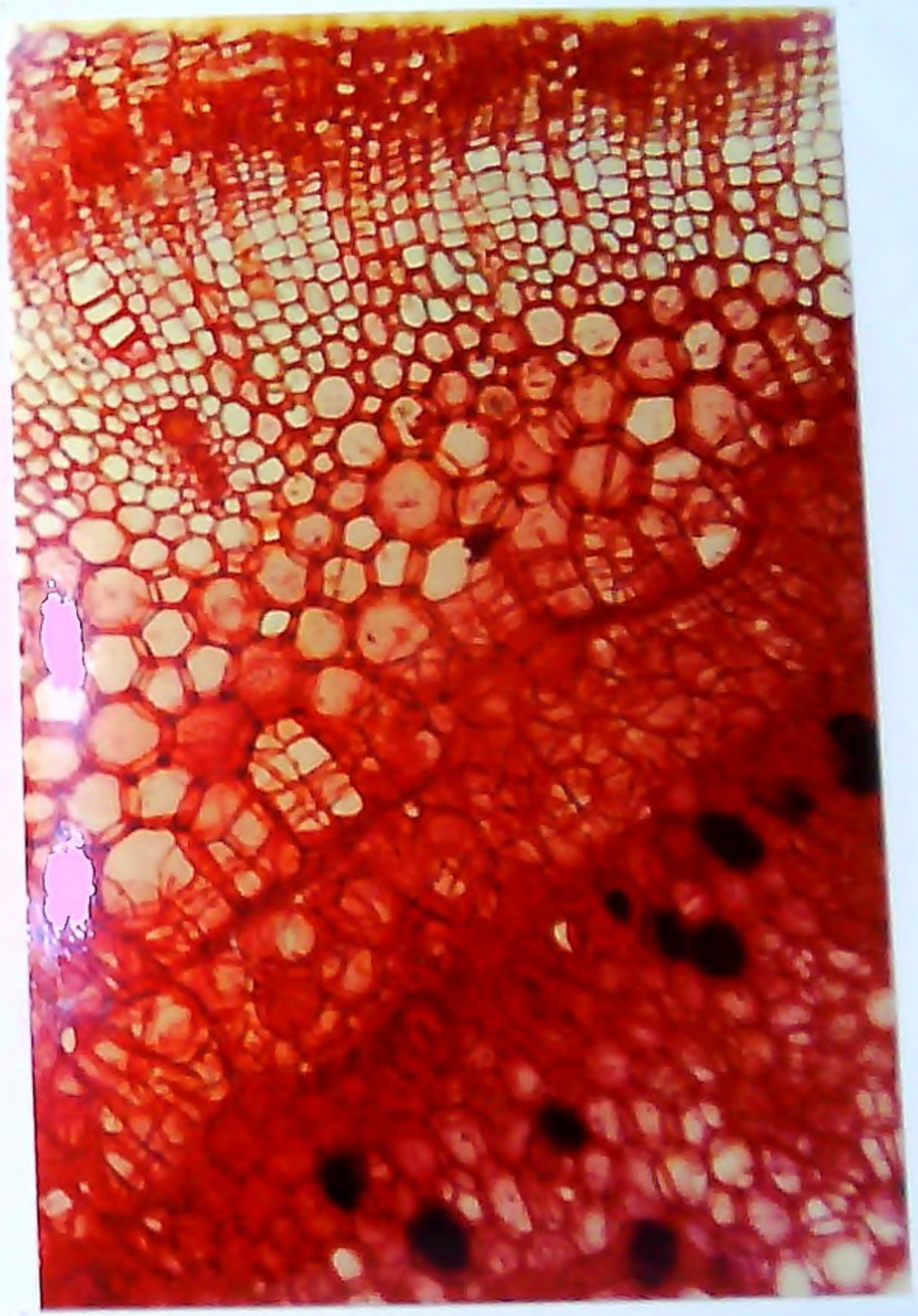


Plate 25 - Softwood graft - 45 days after grafting.



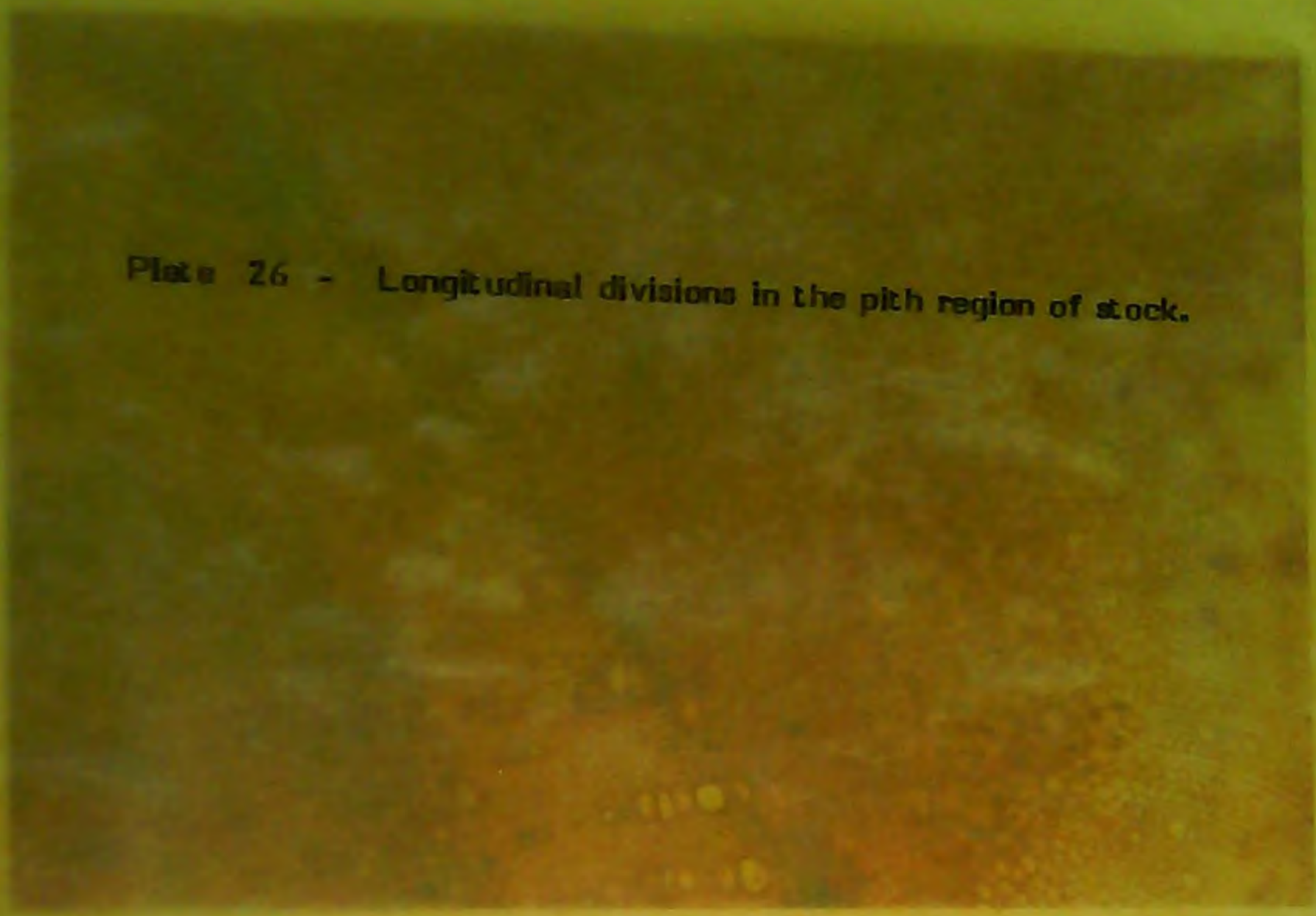


Plate 26 - Longitudinal divisions in the pith region of stock.

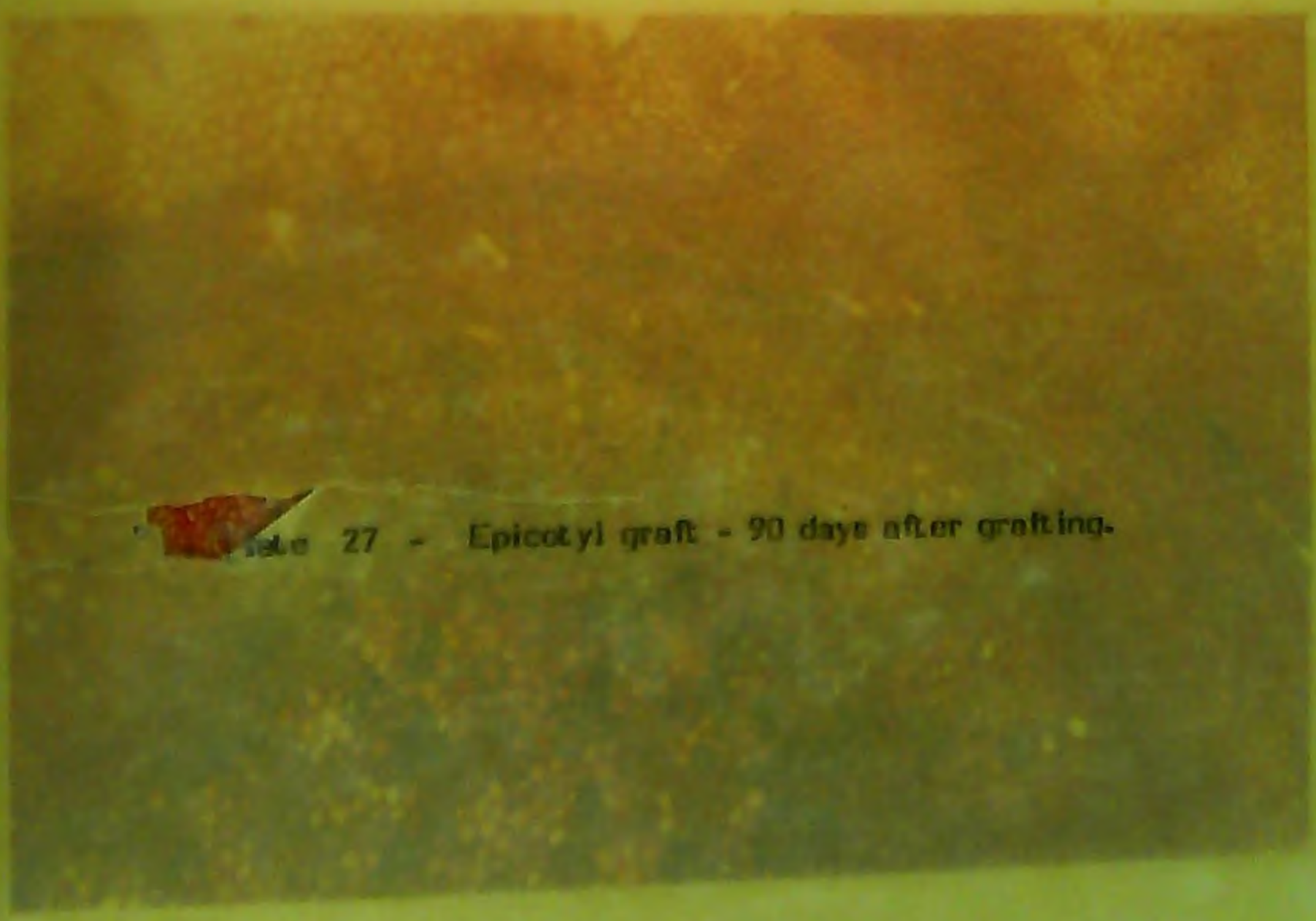
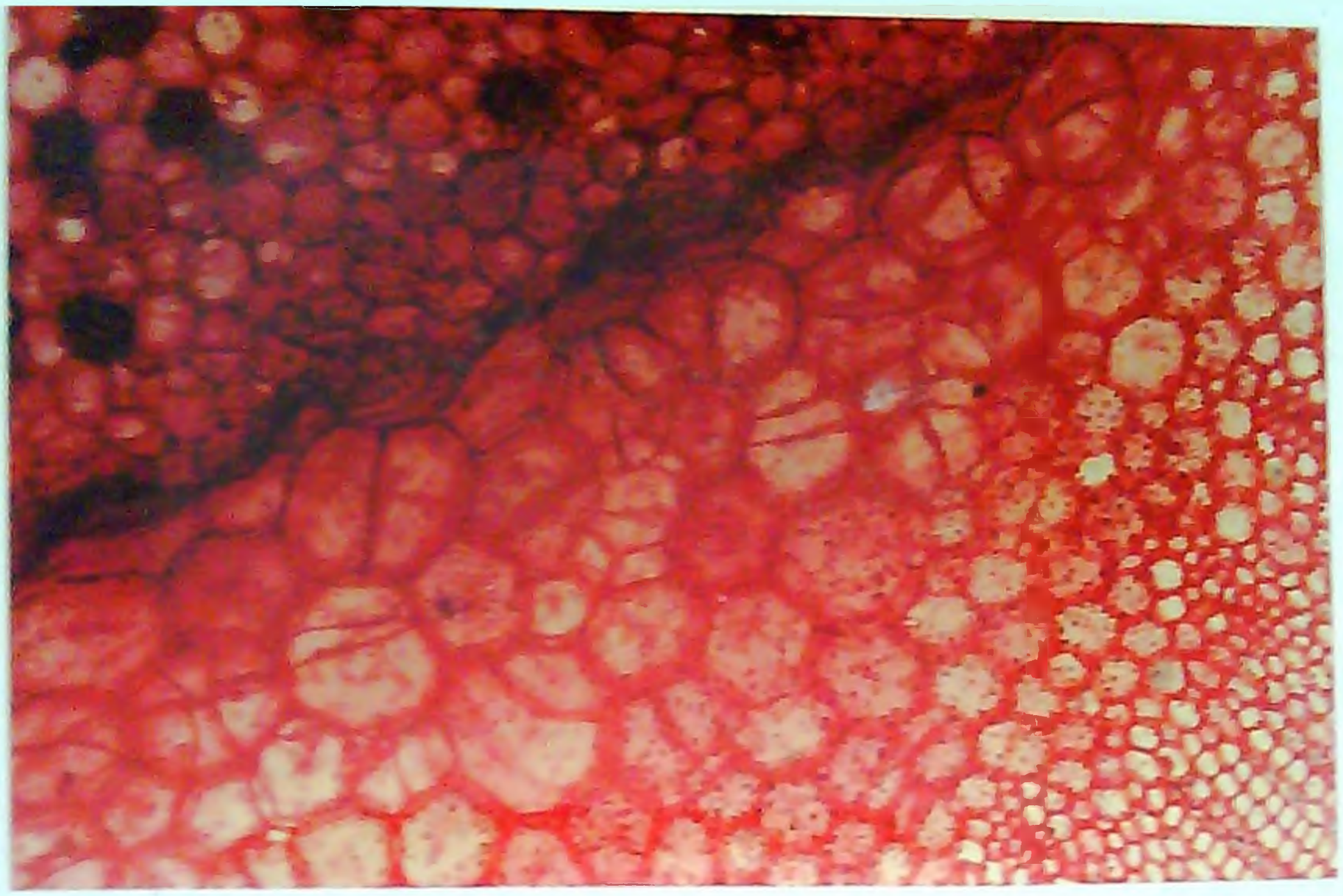
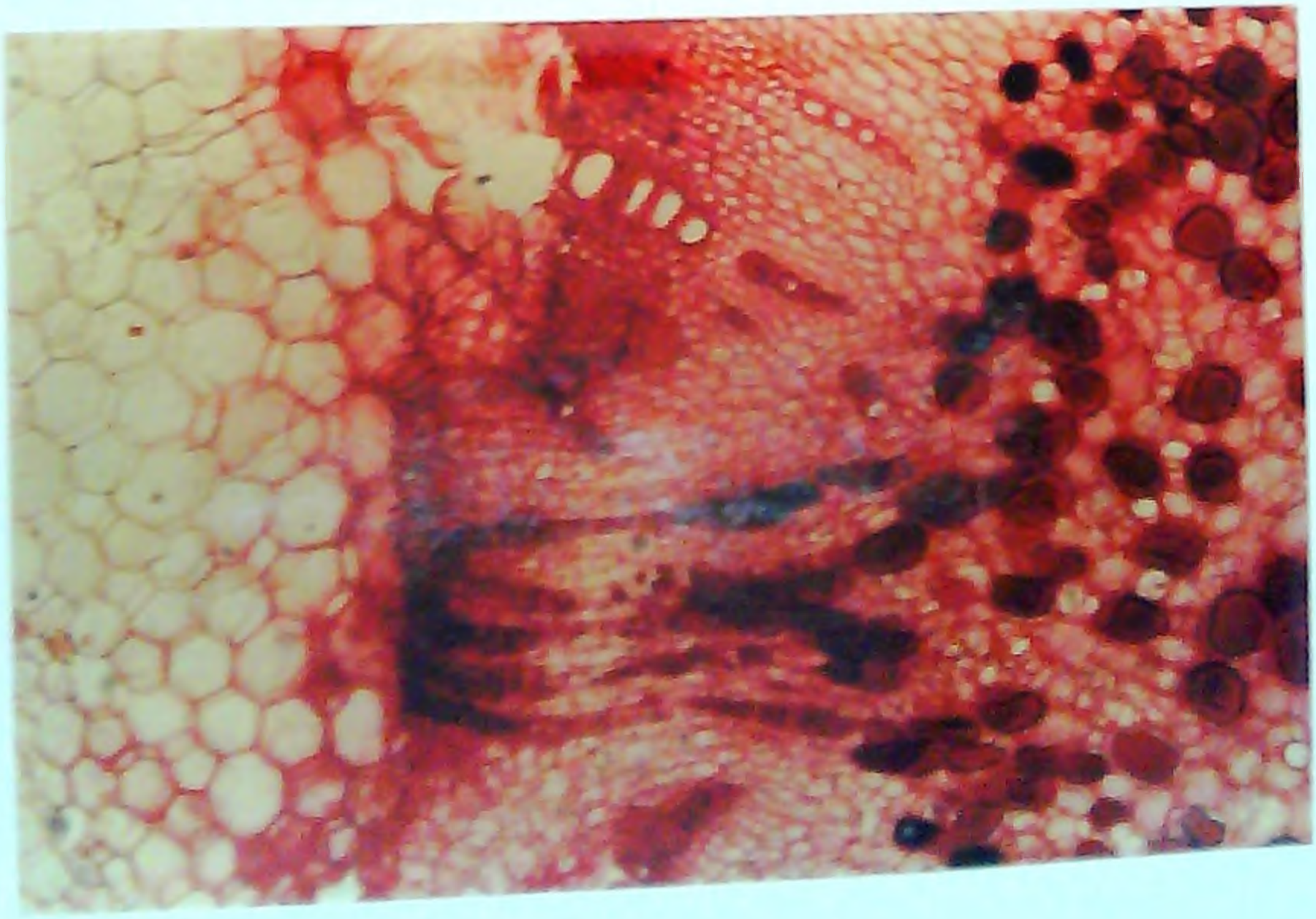


Plate 27 - Epicotyl graft - 90 days after grafting.

Plate 28 - Softwood graft - 90 days after grafting.

Plate 29 - High callus production in the pith region.





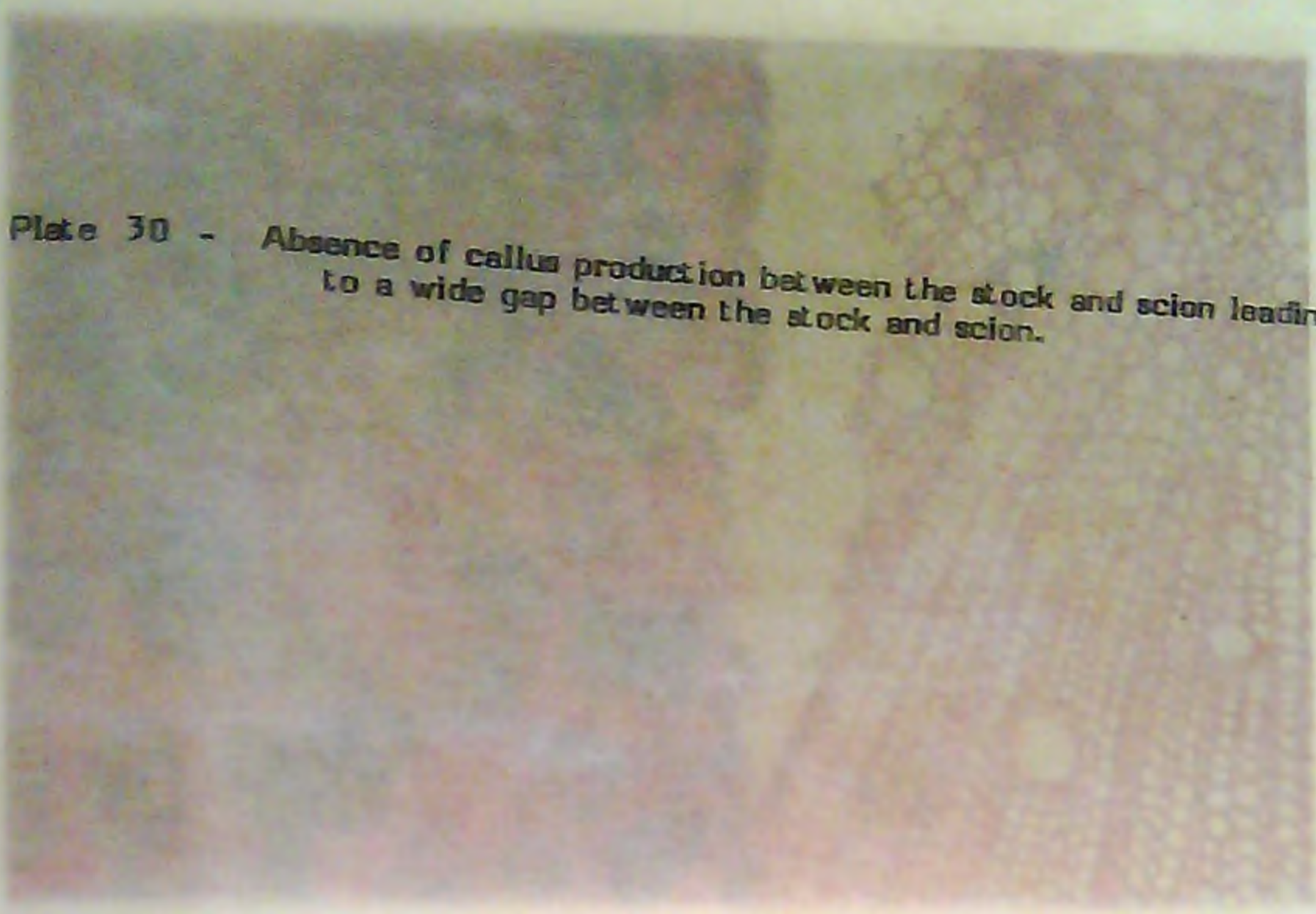


Plate 30 - Absence of callus production between the stock and scion leading to a wide gap between the stock and scion.

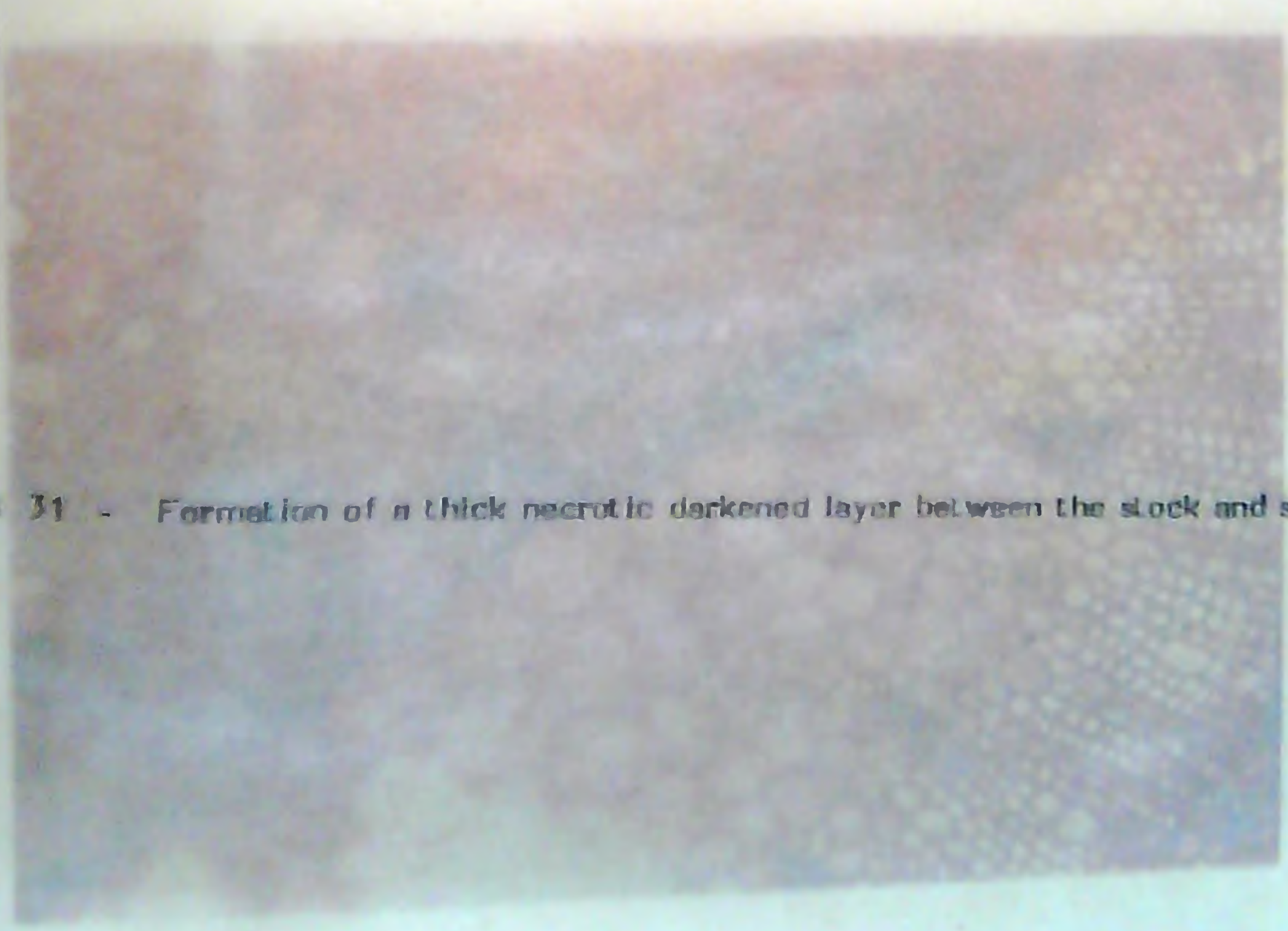
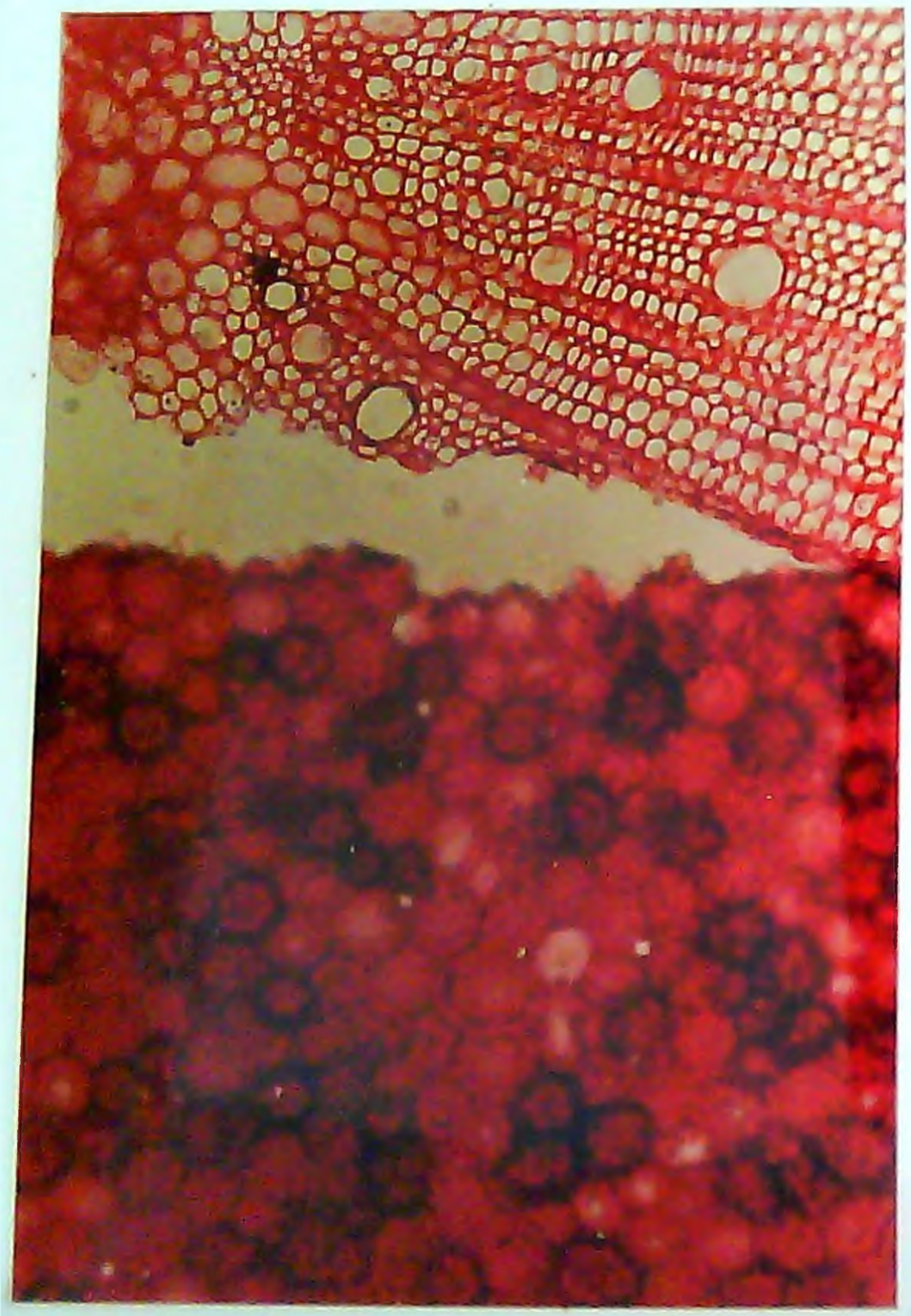
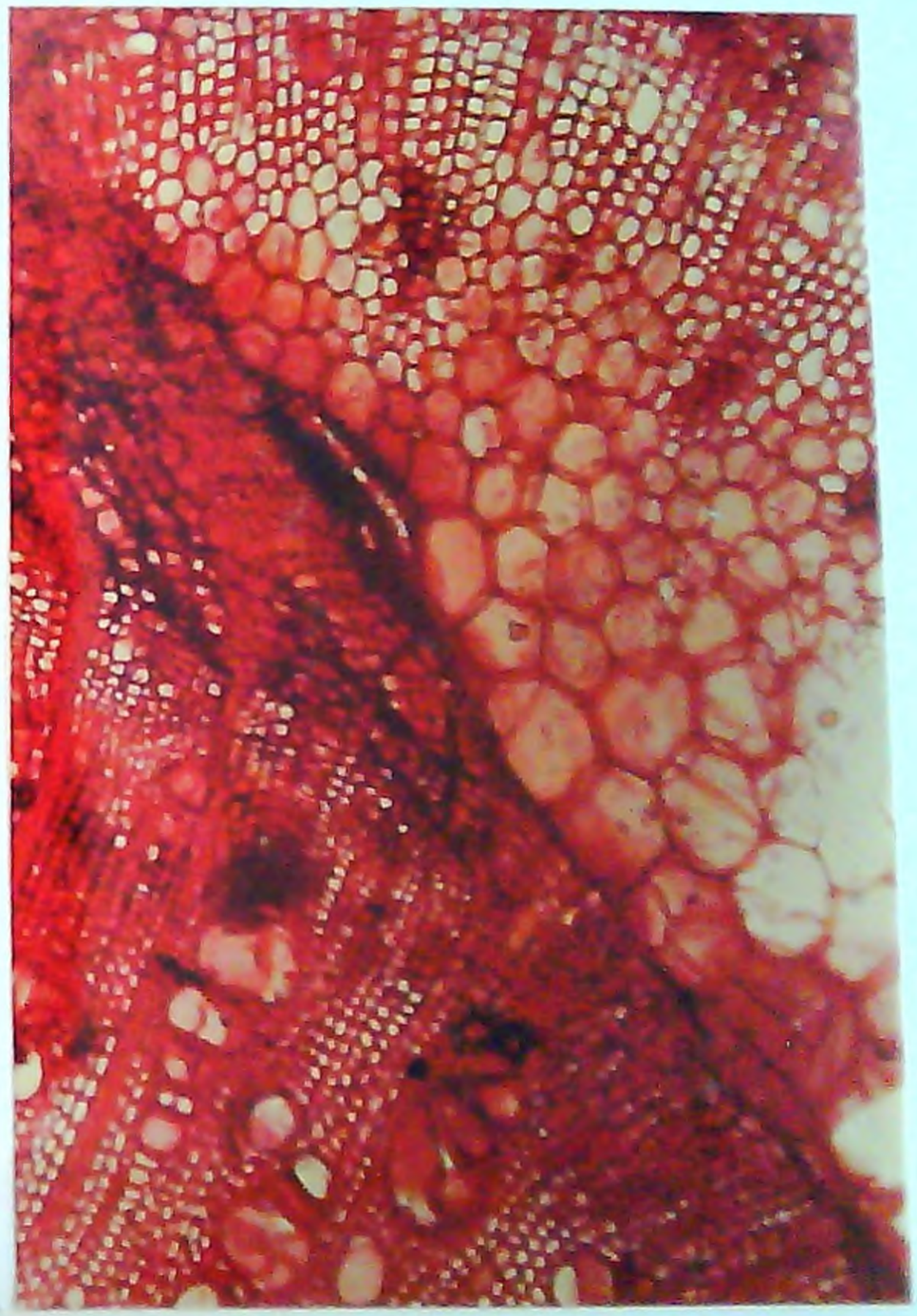


Plate 31 - Formation of a thick necrotic darkened layer between the stock and scion.





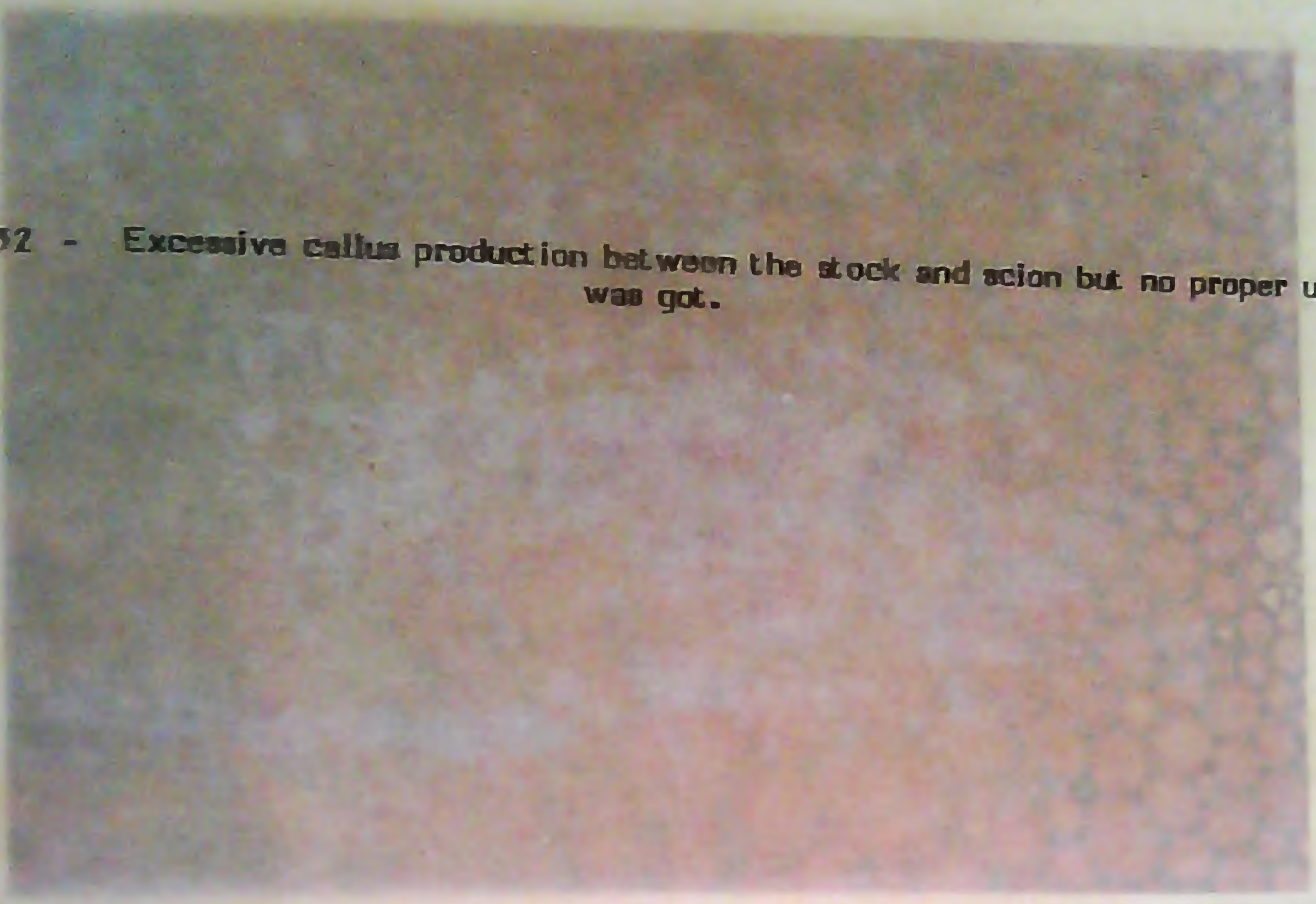


Plate 32 - Excessive callus production between the stock and scion but no proper union was got.

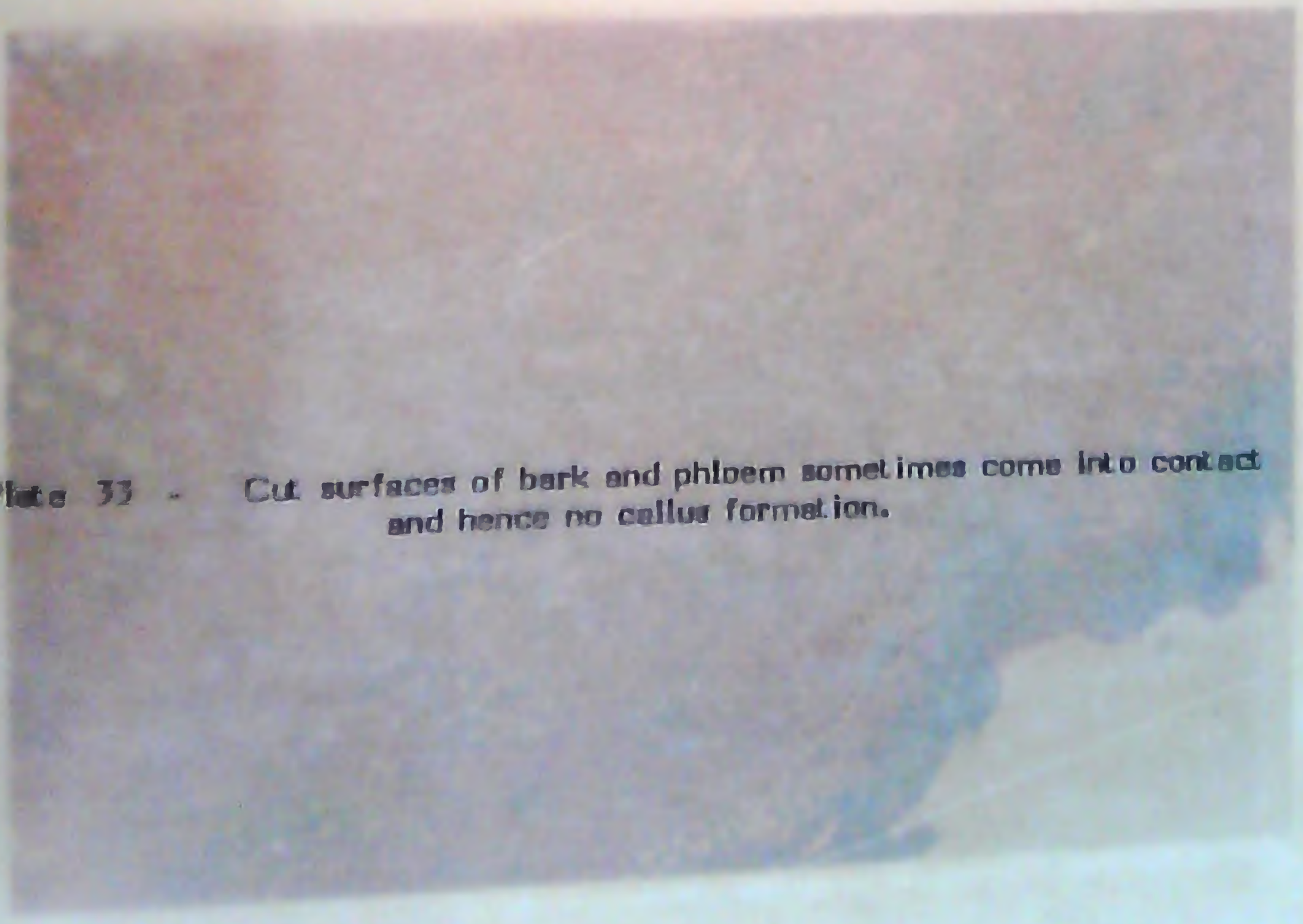
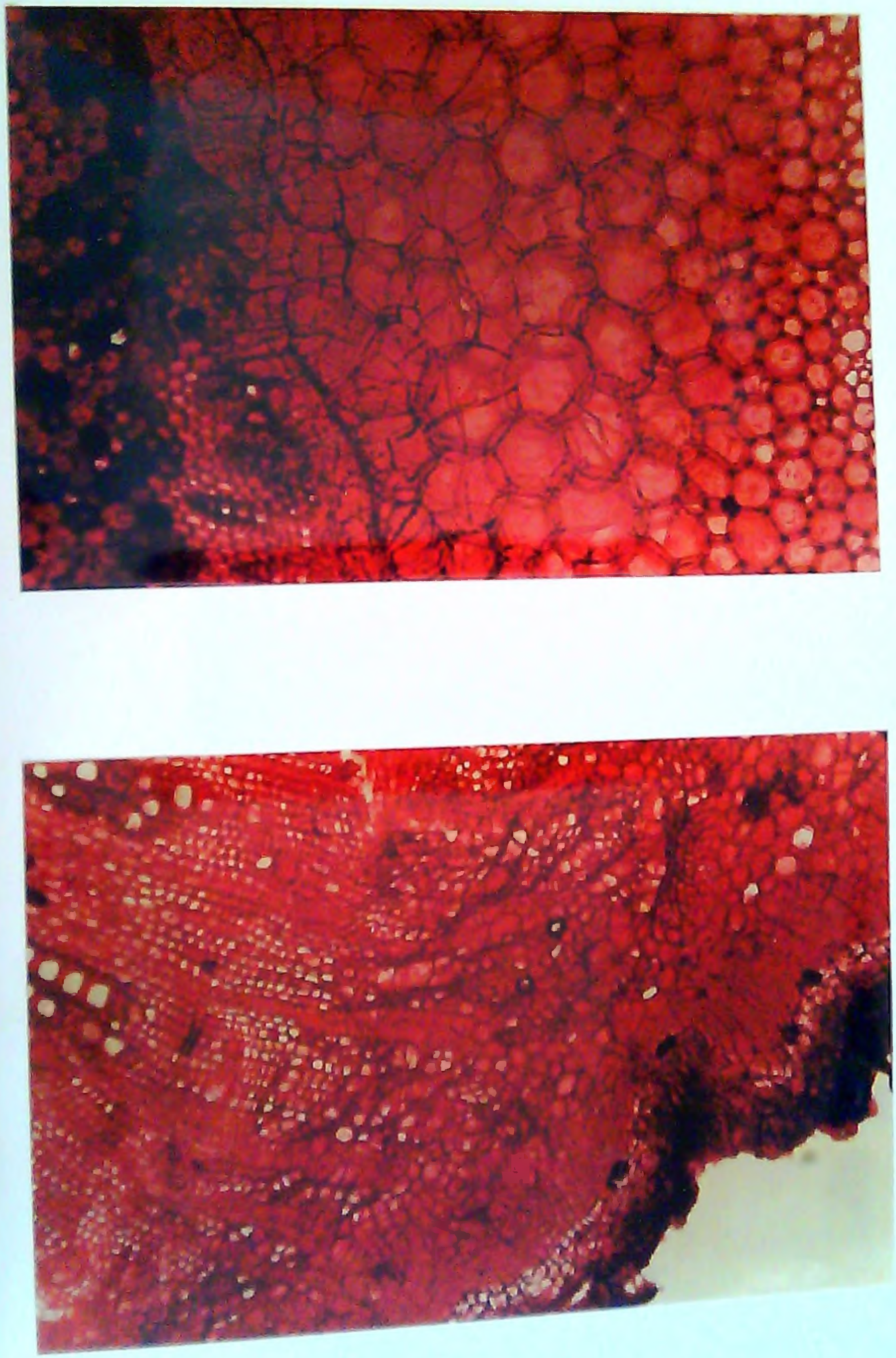


Plate 33 - Cut surfaces of bark and phloem sometimes come into contact and hence no callus formation.



Reasons for graft failure

Examination of dried up grafts showed that the absence of callus production between stock and scion resulted in a wide gap between the stock and scion (Plate 30) which led to failure of grafts. In some grafts there was the formation of a thick necrotic darkened layer between the stock and scion (Plate 31). Also there were grafts in which there was excessive callus production between the stock and scion, but proper union was not got which led to failure of the grafts (Plate 32). In some other grafts the cut surface of bark and phloem tissues came in contact and hence there no proper callus production and hence drying up of grafts was seen (Plate 33).

Discussion

5. DISCUSSION

The most popular method of propagation in jack is by seeds obtained from mature ripe fruits, but here the progenies exhibit wide variation on account of the heterozygous nature of the tree. Studies have been made by various workers on the possibility of vegetative propagation in jack. Propagation by means of cuttings though possible (Chatterjee and Mukherjee, 1982) is not very consistent. Air layering has been suggested as a new technique for inducing early bearing in jack (Singh, 1961) but field mortality is very high and hence not recommended. Approach grafting eventhough successful in jack (Sreenivasan, 1970 and Nazeem et al., 1984) is very cumbersome, because of the tall and scattered nature of trees. Hence the need for a suitable method of vegetative propagation of selected types is severely felt in jack.

Recently, epicotyl grafting has been standardised in jack for the Konkan conditions (Kolekar, 1979; Gunjate et al., 1980 and Harmekar, 1980). The encouraging results obtained in the Konkan region of Maharashtra on the large scale multiplication of jack, cashew and mango through epicotyl grafting, gave an initiative to try this method and also softwood grafting systematically at the College of Horticulture, Vellanikkara, Trichur, Kerala. The success of vegetative propagation mainly depends on season, age of rootstock and scion. Here an attempt was made to standardise these factors for epicotyl and softwood grafting.

5.1 Standardisation of season

Seasonal influence on the success of vegetative propagation in fruit crops is an established fact (Naik, 1941; Singh, 1952; Asadullah and Khan, 1960; Sukla, 1964; Hartmann and Kester, 1978; Upadhyay and Gupta, 1979; Dengale, 1980; Daulta and Chauhan, 1982). Studies by Harmekar (1980) showed that for epicotyl grafting in jack maximum success of 95 per cent was obtained in the month of June followed by March and April. Success ranging 62.2 to 64.7 per cent was obtained from June to September which

was reduced in October (55.6 per cent) and November (35.5 per cent) (Gunjate et al., 1982). A study by Dhungana (1984) on stone grafting in mango revealed that the percentage of success was highest (69.38 per cent) when grafting was done during August and was lowest in May (20.6 per cent). The highest percentage of success was recorded during the month of August (30.66 per cent) followed by September (22 per cent), May (21 per cent) and March (18.66 per cent), (Shylaja, 1984). The results of the present investigation indicated that the best period for both epicotyl and softwood grafting was during the month of June under Kerala conditions. There was a very high percentage of sprouting of epicotyl grafts during the month of June (83.3 per cent), whereas sprouting percentage was very low during all other months of grafting as in July (7.22 per cent), May (5 per cent) and August (3.89 per cent). Compared to epicotyl grafts softwood grafts gave a low percentage of success. But for softwood grafts also maximum sprouting was in the month of June (7.22 per cent) followed by July and August with 1.1 per cent and May with no success. Likewise there was also a very high percentage of survival of epicotyl grafts during the month of June (61.67 per cent), whereas survival percentage was very low during all other months of grafting as in July (5 per cent), May (3.89 per cent) and August (2.78 per cent). Survival of softwood grafts was also maximum in the month of June (5 per cent), followed by July and August (0.55 per cent) and May with no success. These observations led to the conclusion that epicotyl grafting was the best method of propagation for jack and June was the best month suitable and that softwood grafting, though with a low percentage of success was only possible in June. This is in accordance with the report of many workers (Dhakal, 1979; Gunjate et al., 1980; Harmekar, 1980 and Gunjate 1982). Studies by Maiti and Biswas (1980) showed that when epicotyl grafting was done in mango during June-July, the percentage of successful grafts varied from 50 to 96 per cent. The success percentage of softwood grafting when done in mid June was 100 per cent, however in mid July the success was much lower (76.6 per cent) as compared to mid June (Singh et al., 1984). Maximum success in the month of June might be attributed to high rainfall and high relative humidity which are very essential for growth. The rainfall and relative

humidity under Vellanikkara conditions in the month of June were 632.1 mm and 86 per cent respectively. Success upto 95 per cent was reported when softwood grafting was done during June last week when the mean temperature was 33.5°C and humidity 88 per cent (Srivastava, 1985). The high percentage of success obtained during June could not be attributed to weather parameters alone. The possibility of the physiological conditions of stock and scion influencing the success in grafting cannot be overruled. The success of grafting may also be influenced by growth habit of the mother tree (Mukherjee and Majumder, 1964).

5.2 Standardisation of age of rootstock

Among the three age groups of rootstocks tried for epicotyl grafting during the course of investigation it was found out that initially, eventhough there was significant difference between 5 day and 15 day old rootstock, finally there was no difference among the three age groups tried viz., 5, 10 and 15 day old rootstock. Maximum sprouting of epicotyl grafts was obtained for 5 day old rootstock (29.58 per cent) followed by 10 day old rootstock (27.08 per cent) and 15 day old rootstock (17.92 per cent). Statistically there was no difference between 5 day and 10 day old rootstock. But survival rates of 5, 10 and 15 day old rootstocks were 21.67, 18.33 and 15 per cent and they were on par. Only 2 month old rootstock survived in the case of softwood grafts. Studies by Dhungana (1984) showed that the highest survival (58.0 per cent) was obtained with 5 day old stocks and that the survival rate decreased to 50.00 and 32.00 per cent respectively when the age of stock increased from 5 to 10 and 15 days. Studies by Shylaja (1984) on epicotyl grafting in cashew revealed the fact that 5 day and 10 day old rootstocks were equally good and that 15 day old rootstocks were unsuitable. Gunjate (1985) had conducted studies in the Konkan region and found out that rootstocks upto two week age could be used for stone grafting in mango. As the age of stock seedlings advanced the grafting success was reduced (Singh et al., 1985). The high percentage of success of epicotyl grafts over softwood grafts might be due to more

reserve food material available in the cotyledons and higher meristematic activity compared to relatively older stocks as reported by Singh and Srivastava (1981).

There was significant difference between 5 day, 10 day and 15 day old rootstock in many fortnights with regard to growth parameters in the month of June. In the 1st, 6th, 7th, 8th and 9th fortnight there was no significant effect of age of rootstock on the girth of rootstock. In the 2nd, 3rd, 4th, 5th and 10th fortnights age of rootstock also had significant effect on girth of rootstock. In these fortnights there was significant difference between 5 day and 15 day old rootstocks and in the 3rd fortnight there was significant difference between 5 day and 10 day old rootstocks. The mean value of girth of rootstock of 5 day and 10 day old in the 2nd fortnight were 1.50 cm and 1.42 cm and that for 10th fortnight were 2.03 and 1.95 cm. Age of rootstock also had significant effect in the 3rd, 4th, 5th and 10th fortnights on the girth of scion. 5 day and 15 day old rootstock had significant difference and the mean values of girth of scion in the 3rd fortnight were 1.46 cm and 1.39 cm and that for 10th fortnight were 1.88 cm and 1.78 cm respectively. In the 4th fortnight there was significant difference between 5 day and 10 day old rootstocks, the mean values of girth of scion being 1.53 cm and 1.48 cm respectively. Age of rootstock also had significant effect on extension growth of scion in the 3rd, 5th, 6th and 10th fortnights. In the 3rd fortnight the mean values of extension growth of 5 day and 15 day old rootstock were 3.87 cm and 3.40 cm and that for 10th fortnight were 10.05 cm and 9.42 cm respectively. There was significant difference between 5 day and 10 day old rootstock in the 5th and 10th fortnight the mean values of extension growth being 5.88 cm and 5.43 cm for the 5 day and 10.05 cm and 9.52 cm for the 10 day old rootstock respectively. There was significant effect of age of rootstock on girth of extension growth in the 2nd, 3rd, 4th, 5th, 6th and 10th fortnights. There was difference between 5 day and 10 day old rootstock and 5 day and 15 day old rootstock in all these fortnights. In the 10th fortnight

the girth of extension growth of 5 day and 10 day and 5 day and 15 day old rootstocks were 1.41 cm and 1.29 cm and 1.41 cm and 1.24 cm respectively. Age of rootstock had no significant effect on number of leaves produced. The difference in the growth parameters might be due to the fact that younger stocks contain more reserve food material and due to higher meristematic activity.

5.3 Effect of intermittent mist

The analysis of the data indicated the beneficial effect of mist on grafting success both in epicotyl and softwood grafts. Mist condition ultimately increased the percentage take of grafts. About 90 per cent success was achieved by carrying out veneer grafting on 4-5 months old polypot seedlings under controlled mist conditions (Muniswami, 1979 b). The results of the present investigation showed that there was significant difference between mist and open conditions on sprouting and survival of epicotyl grafts. The sprouting was more in mist condition (30.83 per cent) as against open condition (18.89 per cent) and survival rate was also high in mist condition (22.5 per cent) as against open condition (14.17 per cent). For softwood grafts also there was significant difference between mist and open condition on sprouting and survival of grafts. The sprouting was more in mist condition (3.89 per cent) as against open (0.833 per cent) and survival rate, was also more in mist condition (2.5 per cent) as against open condition (0.56 per cent). Reddy and Kohli (1985) showed that in mango epicotyl grafting was successful only when grafts were kept in the mist chamber where temperature and humidity were higher.

Superiority of mist over open condition was clearly apparent with respect to growth parameters in the/of June. Mist condition was significantly superior to open condition in the 2nd, 3rd, 4th, 5th and 10th fortnights with respect to girth of rootstock. In the 2nd and 10th fortnight the mean value of girth of rootstock under mist condition was 1.57 cm and 2.04 cm respectively whereas that for open was 1.50 cm and 1.95 cm respectively. The girth of scion also showed significant difference between mist and

and open condition in the 2nd, 3rd, 4th, 5th and 10th fortnights. The mean values of girth of scion under mist condition in the 2nd and 10th fortnights were 1.38 cm and 1.57 cm and that under open condition were 1.31 cm and 1.53 cm respectively. In the 2nd, 3rd, 4th, 5th, 6th, 8th, 9th and 10th fortnights mist conditions had a significant effect over open condition on length of extension growth. In the 2nd and 10th fortnights the values for length of extension growth under mist condition were 3.15 cm and 11.24 cm and that under open condition were 1.79 cm and 8.09 cm respepctively. Similarly girth of extension growth under mist condition was significantly superior than under open condition in the 2nd, 3rd, 4th, 5th, 6th and 10th fortnight. In the 2nd and 10th fortnight the values for girth of extension growth under mist condition were 0.79 cm and 1.40 cm and under open condition were 0.70 cm and 1.23 cm respectively. The effect of mist conditions was significant in all the fortnights on the number of leaves produced. In the 2nd and 10th fortnight the number of leaves under mist condition were 4.13 and 11.47 and under open condition were 2.07 and 7.33 respectively. The beneficial effect of mist could be attributed to the presence of high humidity which prevents desiccation and keeps the cuttings cool thus reducing transpiration and respiration rates resulting in a condition most ideal for rooting and sprouting (Bose et al., 1972; Singh, 1976 and 1980 and Singh and Motilal, 1981).

5.4 Anatomical studies of the graft union

Detailed anatomical studies of the graft union of both epicotyl and softwood grafts revealed four distinct stages in graft union viz., development of pre-callus, formation of callus, callus bridge and cambial bridge. Radhamony (1987) also reported these 4 stages in the graft union and that graft union was complete 90 days after grafting in mango. Juliano (1941) studied the callus development and observed 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. In this

study also 5 days after grafting there was a pre-callus stage, and callus formation started profusely 15 days after grafting. By 90 days after grafting the graft union was perfectly complete. Callus proliferated either from stock or scion or from both components depending upon the activity. Studies conducted by Luthra and Sharma (1946) showed that callus production occurred occasionally from cells in the cortex and rarely from cells in the pith also. Cambial layers extended circumferentially straight into the callus on stockside but were strongly arched on scion side as reported by Ratan (1985). The growth was less active on the part of scion for some grafts and less active on the part of stock for some other grafts. Auranov and Jokovic (1961) also observed that callus formation differed between the varieties and was highly influenced by rootstock and prevalent weather conditions during previous growing season.

Generally in this study callus was seen produced from cambium, xylem, phloem and mostly from pith cells. The graft union was complete by 3 months after grafting. Several continuous layers of tissues were seen between the stock and scion, healing the wound and the graft union was completed. Work conducted by Chakrabarthi and Sadhu (1985) showed that new xylem produced subsequent to grafting was shifted circumferentially in the direction of scion at the point directly beneath the original wound. The breakdown products of dead cells on the 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 (Esau, 1979).

Reasons for failure of grafts were studied and mainly graft failures due to four reasons were seen. In some grafts failure was due to the lack of callus formation even several days after grafting, resulting in a wide gap between the stock and scion. Graft failures might also be due to formation of a very thick necrotic layer in the wounded exposed surfaces of stock and scion. Soule (1971) reported that thick necrotic layers were formed due to deep crushing of cells during wrapping which contributed to graft failures. Another reason for the failure could be misaligned arrange-

ment of cambia of stock and scion (i.e. cambia not lying opposite to each other). In some cases the cut end was between phloem and bark and hence no proper callus formation occurred.

Ratan (1985) observed no cell differentiation in the cut portions of stock even after 7 days of grafting. Copes (1978) stated that poorly matched stock and scion resulted in very low cambial union and delayed bud sprouting. This stresses the importance of skill and care in grafting operations.

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. Turkovac (1961) observed excessive undifferentiated callus or other irregular growth at the union of incompatible combinations of stock and scion.

Generally softwood grafts produced less amount of callus and the graft union formation was slow compared to epicotyl grafts. This might be due to the fact that the epicotyl region being tender might be in the actively growing stage and hence respond faster and graft union is completed easily. This may be the reason for the high percentage of graft take in epicotyl grafts compared to softwood grafts.

Epicotyl grafting was found to have a very high percentage of success when done on 5 day-old seedling under mist conditions in the month of June. Similarly softwood grafting also gave its maximum success in the month of June. Anatomical studies revealed 4 stages of growth (1) Pre-callus stage (2) Callus stage (3) Callus bridge formation (4) Cambial bridge formation.

Summary

SUMMARY

Investigations on epicotyl and softwood grafting in jack were undertaken at the College of Horticulture, Vellanikkara, Trichur, Kerala from June 1987 to April 1989, to standardise the season of grafting, age of rootstock and effect of intermittent mist under humid tropical conditions of Kerala. The salient results of this study are summarised below.

Epicotyl grafting was found to be superior compared to softwood grafting. There was a very high percentage of sprouting of epicotyl grafts during the month of June (83.3 per cent), whereas sprouting percentage was very low during all other months of grafting as in July (7.22 per cent), May (5 per cent) and August (3.89 per cent). Similarly there was also a very high percentage of survival of epicotyl grafts during the month of June (61.67 per cent), whereas survival percentage was very low during all other months of grafting as in July (5 per cent), May (3.89 per cent) and August (2.78 per cent). June was found to be the only season suitable for epicotyl grafting in jack. Softwood grafts recorded during the month of June a sprouting of 7.22 per cent followed by July and August with 1.1 per cent and May with no success. June though with a low percentage of success was found to be the only season suitable for softwood grafting in jack.

In epicotyl grafting 5 day - old rootstock recorded the maximum percentage of success in the initial stage (29.58 per cent) followed by 10 day old rootstock (27.08 per cent) and 15 day old rootstock (17.92 per cent). Statistically only 15 day old rootstock differed significantly from 5 day and 10 day old rootstock. Survival rate of grafts showed that there was no significant difference between the three age groups, the survival percentages being 21.67, 18.33 and 15 respectively for 5, 10 and 15 day old rootstock. In the case of softwood grafts only 2 month old rootstock sprouted and hence considered to be the best.

The percentage of success of grafting i.e. sprouting and survival of both epicotyl and softwood grafts was compared using chi-square test and

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* *Originals not seen*

Appendices

Appendix I

Monthly weather data with per cent sprouting and survival of epicotyl grafts

Month of grafting	Sprouting (%)	Survival (%)	Temperature °C		Mean relative humidity (%)	Rainfall	
			Mean maximum	Mean minimum		Quantity (mm)	No. of rainy days average
May 1988	5.00	3.89	33.7	25.4	76.00	242.6	6
June 1988	83.30	61.67	30.0	23.7	86.00	632.1	25
July 1988	7.22	5.00	29.0	23.2	88.00	545.0	26
August 1988	3.89	2.78	29.2	24.3	86.00	507.8	25

Appendix II

Analysis of variance for the effect of different treatments on girth of rootstock at fortnightly intervals

		Mean squares at fortnightly intervals									
Source	df	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
Treatment	12	0.007**	0.014**	0.011**	0.007**	0.006^{NS}	0.232^{NS}	0.213^{NS}	0.231^{NS}	0.264**	0,013**
Error	45	0.003	0.003	0.004	0.002	0.003	0.205	0.174	0.184	0.118	0.005
M's	1	0.012	0.065	0.033	0.040	0.027	0.033	0.108	0.075	0.705	0.065
D's	2	0.004	0.016	0.036	0.009	0.016	0.052	0.052	0.031	0.890	0.016
Interaction	2	0.004	0.001	0.002	0.000	0.000	0.001	0.004	0.003	0.182	0.006
Total	57	-	-	-	-	-	-	-	-	-	-

* Significant at 5% level

** Significant at 1% level

Appendix III

Analysis of variance for the effect of different treatments on girth of scion at fortnightly intervals.

		Mean squares at fortnightly intervals									
Source	df	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
Treatment	12	0.003^{NS}	0.009**	0.013**	0.009**	0.005**	0.199^{NS}	0.160^{NS}	0.188^{NS}	0.197^{NS}	0.020**
Error	45	0.003	0.004	0.003	0.002	0.002	0.178	0.154	0.164	0.172	0.005
M's	1	0.005	0.004	0.096	0.056	0.016	0.021	0.021	0.048	0.085	0.133
D's	2	0.002	0.006	0.012	0.013	0.016	0.012	0.042	0.056	0.021	0.025
Interaction	2	0.000	0.000	0.000	0.002	0.001	0.000	0.002	0.009	0.004	0.005
Total	57	-	-	-	-	-	-	-	-	-	-

* Significant at 5% level

** Significant at 1% level

Appendix IV

Analysis of variance for the effect of different treatments on length of extension growth at fortnightly intervals.

		Mean squares at fortnightly intervals								
Source	df	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
Treatment	12		1.441**	6.015**	7.218**	6.057**	7.147**	9.538**	9.375**	12.919**	7.600**
Error	40		0.112	0.118	0.972	0.125	0.193	2.336	2.988	3.597	0.195
M's	1		13.872	62.064	11.224	59.502	72.075	60.209	60.209	83.000	74.419
D's	2		0.128	0.561	3.841	0.632	0.637	0.703	1.710	0.637	1.159
Interaction	2		0.003	0.112	28.095	0.010	0.061	0.002	0.190	0.358	0.042
Total	52		-	-	-	-	-	-	-	-	-

* Significant at 5% level

** Significant at 1% level

Appendix V

Analysis of variance for the effect of different treatments on girth of extension growth at fortnightly intervals.

		Mean squares at fortnightly intervals								
Source	df	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
Treatment	12		0.019**	0.027**	0.015**	0.006^{NS}	0.015**	0.076^{NS}	0.075^{NS}	0.111^{NS}	0.036**
Error	40		0.007	0.004	0.005	0.005	0.004	0.076	0.056	0.091	0.008
M's	1		0.065	0.133	0.033	0.040	0.120	0.147	0.120	0.176	0.225
D's	2		0.016	0.057	0.052	0.003	0.021	0.025	0.036	0.067	0.76
Interaction	2		0.016	0.002	0.001	0.000	0.001	0.004	0.000	0.014	0.004
Total	52		-	-	-	-	-	-	-	-	-

* Significant at 5% level

** Significant at 1% level

Appendix VI

Analysis of variance for the effect of different treatments on number of leaves at fortnightly intervals

Source	df	Mean squares at fortnightly intervals								
		1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
Treatment	12		3.561**	5.805**	6.021**	8.241**	9.822**	12.806**	13.402**	17.454**	16.413**
Error	40		0.277	0.394	0.239	0.467	0.510	2.555	2.616	0.000	0.251
M's	1		32.033	58.800	58.800	70.533	73.633	80.033	73.633	86.700	128.133
D's	2		0.300	0.933	0.533	0.700	1.300	0.700	0.533	0.533	0.100
Interaction	2		0.033	0.000	0.000	0.233	0.233	0.033	0.133	0.000	0.033
Total	52		-	-	-	-	-	-	-	-	-

* Significant at 5% level

** Significant at 1% level

Appendix VII

Analysis of variance for the effect of epicotyl and softwood grafting on girth of rootstock at fortnightly intervals

		Mean squares at fortnightly intervals									
Source	df	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
Treatment	1	0.100 **	0.49 **	0.049 *	0.081 *	0.081 *	0.025	0.001	0.009	0.001	0.009
Error	8	0.004	0.004	0.005	0.005	0.008	0.010	0.007	0.002	0.002	0.002
Total	9	-	-	-	-	-	-	-	-	-	-

* Significant at 5% level

** Significant at 1 % level

Appendix VIII

Analysis of variance for the effect of epicotyl and softwood grafting on girth of scion at fortnightly intervals

		Mean squares at fortnightly intervals									
Source	df	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
Treatment	1	0.100 **	0.064 *	0.049 *	0.049**	0.064 **	0.081 *	0.049 *	0.016	0.016	0.009
Error	8	0.005	0.007	0.005	0.004	0.002	0.008	0.009	0.008	0.011	0.005
Total	9	-	-	-	-	-	-	-	-	-	-

* Significant at 5% level

** Significant at 1 % level

Appendix IX

Analysis of variance for the effect of epicotyl and softwood grafting on length of extension growth

		Mean squares at fortnightly intervals									
Source	df	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
Treatment	1	-	0.306	10.609**	19.044**	24.025**	30.976**	40.401**	50.625**	52.441**	52.441**
Error	8	-	0.351	0.105	0.140	0.147	0.367	0.240	0.239	0.401	0.353
Total	9	-	-	-	-	-	-	-	-	-	-

* Significant at 5% level

** Significant at 1 % level

Appendix X

Analysis of variance for the effect of epicotyl and softwood grafting on girth of extension growth at fortnightly intervals

		Mean squares at fortnightly intervals									
Source	df	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
Treatment	1	-	0.001	0.009	0.001	0.025	0.001	0.009	0.000	0.025	0.016
Error	8	-	0.026	0.010	0.010	0.005	0.006	0.007	0.012	0.010	0.017
Total	9	-	-	-	-	-	-	-	-	-	-

* Significant at 5% level

** Significant at 1 % level

Appendix XI

Analysis of variance for the effect of epicotyl and softwood grafting on number of leaves at fortnightly intervals

		Mean squares at fortnightly intervals								
Source	df	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
Treatment	1	-	12.100**	25.600**	25.600**	40.000**	44.100**	52.900**	48.400**	62.500**	72.900**
Error	8	-	0.250	0.300	0.250	0.450	0.800	0.500	0.750	0.800	0.500
Total	9	-	-	-	-	-	-	-	-	-	-

* Significant at 5% level

** Significant at 1 % level

STANDARDISATION OF EPICOTYL AND SOFTWOOD GRAFTING IN JACK

(*Artocarpus heterophyllus* Lam.)

By

MINI JOSE

ABSTRACT OF A THESIS

Submitted in partial fulfilment of the
requirements for the degree of

Master of Science in Horticulture

Faculty of Agriculture
Kerala Agricultural University

Department of Horticulture
(Pomology & Floriculture and Landscaping)
COLLEGE OF HORTICULTURE
Vellanikkara - Trichur

1989

ABSTRACT

The investigation on epicotyl and softwood grafting methods in jack was carried out in the Department of Pomology and Floriculture, College of Horticulture, Vellanikkara, Trichur during the period from June 1987 to April 1989. The objective of the study was to standardise the season, age of rootstock and to find out the effect of intermittent mist on the percentage of success of both epicotyl and softwood grafts, and to study the anatomical changes at the different stages of graft union and factors leading to failure of grafts.

The studies revealed that the month of June was most suitable for both epicotyl (83.3 per cent sprouting and 61.67 per cent survival) and softwood grafting (7.22 per cent sprouting and 5 per cent survival) under Kerala conditions, eventhough percentage of success was low for softwood grafting. Initially though, there was significant difference in the percentage of success of grafting using 5 day and 15 day old rootstock finally all the three age groups of rootstocks showed apparently no difference in the percentage of success in epicotyl grafting. Survival percentages of 5, 10 and 15 day old rootstocks were 21.67, 18.33 and 15 per cent respectively. In the case of softwood grafts only 2 month old rootstocks survived. Mist condition was found to be significantly superior to open condition with regard to ultimate take of grafts. The sprouting of epicotyl grafts under mist and open conditions were 30.83 per cent and 18.89 per cent respectively and that of softwood grafts 3.89 per cent and 0.833 per cent. The survival of epicotyl grafts under mist and open condition were 22.5 per cent and 14.17 per cent respectively and that of softwood grafts 2.5 per cent and 0.56 per cent respectively. The percentage of success of grafting was significantly higher in epicotyl grafts compared to softwood grafts. Of the different treatments tried the treatment T_7 (5 day old rootstock grafted in June and kept under mist condition) was found to be significantly superior to all other treatments. The observations on growth parameters like girth of rootstock, girth of scion, girth of extension growth,

length of extension growth and number of leaves produced at fortnightly intervals showed that there was significant difference between treatments and T_7E (5 day old rootstock grafted in June and kept under mist condition) was found to give the maximum values.

The values are 2.08 cm, 1.96 cm, 1.52 cm, 11.70 cm and 11.60 respectively for girth of rootstock, girth of scion, girth of extension growth, length of extension growth and number of leaves in the 10th fortnight.

Anatomical studies revealed four distinct stages in the formation of graft union. Proper graft union was obtained 90 days after the grafting operation. Callus proliferation was mostly from the pith cells. In the unsuccessful grafts failure was due to the absence of callus formation between stock and scion forming a wide gap, formation of a thick necrotic layer between stock and scion, excessive callus production without differentiation to cambium leading to failure of grafts, cut surfaces of bark and phloem sometimes come into contact with each other which resulted in the lack of proper callus formation and consequent drying of grafts.