STANDARDISATION OF METHODS OF VEGETATIVE PROPAGATION IN MANGO

By

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THESIS

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DECLARATION

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

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CERTIFICATE

Certified that this thesis entitled "Standardisation of methods of vegetative propagation in mango" is a record of research work done independently by Mr. Daman Bahadur Dhungana, under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

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To my Country

and

Parents

CONTENTS

LIST OF TABLES

6a. Effect of age of scion shoot on extension growth of scion shoot (pooled data at 3 monthly intervals).

7. Effect of age of scion on number of leaves (data for different months of grafting at monthly intervals).

7a. Effect of age of scion on number of leaves (consolidated data at 3 monthly intervals).

8. Effect of age of scion on girth of root stock and scion (data for different months of grafting at monthly intervals).

8a. Effect of age of scion on girth of stock and scion (consolidated data at 3 monthly intervals).

9. Effect of age of root stock on sprouting and survival (data for different month of grafting).

9a. Effect of age of root stock on sprouting and survival (pooled data).

10. Effect of age of root stocks on extension growth of scion (data for different months at monthly intervals).

10a. Effect of age of stock on extension growth of scion (consolidated data at 3 monthly intervals).

11. Effect of age of stock on number of leaves (data for different months at monthly intervals).

11a. Effect of age of root stock on number of leaves (pooled data at 3 monthly intervals).

12. Effect of age of stock on girth of stock and scion (data for different months of grafting at monthly intervals).

12a. Effect of age of root stock on girth of stock and scion (consolidated data at 3 monthly intervals).

13. Effect of season of grafting and defoliation of scion shoot on sprouting and survival of veneer grafts.

13a. Effect of season on sprouting and survival.

13b. Effect of defoliation of scion shoot on sprouting and survival.

14. Effect of season of grafting and defoliation of scion shoots on extension growth of scion (data at monthly intervals).

14a. Effect of season on extension growth of scion.

14b. Effect of defoliation (pooled data after 3 months of grafting.

15. Effect of season and defoliation of scion shoots on number of leaves (data at monthly intervals).

15a. Effect of season on number of leaves (pooled data after 3 months of grafting).

15b. Effect of defoliation on number of leaves (pooled data after 3 months of grafting.

16. Effect of season of grafting and defoliation of scion shoots on stock and scion girth (data at monthly intefvals).

16a. Effect of season on girth of stock and scion (pooled data 3 months after grafting).

16b. Effect of defoliation on girth of stock and scion (pooled data after 3 months of grafting).

17. Effect of age of scion on sprouting and survival (data for different months).

17a. Effect of age of scion on sprouting and survival.

18. Effect of age of scion on extension growth of scion (data for different months at monthly intervals).

18a. Effect of age of scion on extension growth of scion (consolidated data at 3 monthly intervals).

19. Effect of age of scion on number of leaves (data for different months at monthly intervals).

19a. Effect of age of scion on number of leaves (consolidated data at 3 monthly intervals).

20. Effect of age of scion on girth of stock and scion (data for different months of grafting at monthly intervals).

20a. Effect of age of scion on girth of stock and scion (consolidated data at 3 monthly intervals).

21. Effect of age of root stock on sprouting and survival (data for different months of grafting).

21a. Effect of age of root stock on sprouting and survival (consolidated data).

22. Effect of age of root stock on extension growth of scion (data for different months at monthly intervals).

22a. Effect of age of root stock on extension growth of scion (consolidated data after four and eight months of grafting).

23. Effect of age of root stock on number of leaves (data for different months at monthly intervals).

23a. Effect of age of root stock on number of leaves (consolidated data after four and eight months of grafting).

24. Effect of age of stock on girth of stock and scion (data for different months of grafting at monthly intervals).

25. Effect of different varieties on sprouting and survival (data for different month).

25a. Effect of varieties on sprouting and survival (consolidated data).

26. Effect of duration of storage of fresh scion sticks on sprouting and survival.

26a. Effect of duration of storage of fresh scion sticks (data for statistical analysis).

27. Effect of duration of storage of prior defoliated scion sticks on sprouting and survival.

27a. Effect of duration of storage of prior defoliated scion sticks (data for statistical analysis).

28. Effect of *in situ*, poly bag and modified trench grafting on sprouting and survival (data for different months).

28a. Effect of *in situ*, poly bag and modified trench grafting on sprouting and survival (consolidated data).

LIST OF FIGURES

LIST OF PLATES

LIST OF APPENDICES

Introduction

INTRODUCTION

The Turkoman saint and poet, Ameer Khosru, described mango as the choicest fruit of Hindustan as early as 1330 A.D. and it still continues to be so in our country. With its high adaptability to a wide range of climatic conditions as well as qualitative virtues (Rao, 1984) mango has attained a predominent position among the fruit crops grown in the country.

Kerala ranks fifth among the states of the Indian Union with respect to the area devoted for this fruit crop. The estimated area of mango in the state is 51,210 ha (Anon., 1982). Kerala has the distinction of producing the earliest mangoes in the country, besides its unparalleled wealth of pickle types of seedling mangoes.

Mango is highly heterozygous and cross pollinated and asexual propagation is the only means of producing progenies true to type. The most successful methods of vegetative propagation reported and adopted in mango are approach grafting, veneer grafting and stone grafting. Among these, the only method commercially adopted in Kerala is approach grafting. Approach grafting possess serious practical difficulties or becomes virtually impossible when trees selected for clone production are spread far and wide. Approach grafting, with its inherent inconvenience is also expensive. One of the impediments that has stood in the way of selection and multiplication of pickling types of mangoes in our state has

been due to lack of a successful method of vegetative propagation wherein scion materials from selected trees could be brought to a central place for propagation works.

Veneer and stone grafting which are comparatively of newer origin have met with high degree of success in propagating mango varieties in several other states of India. In the states, viz. Maharastra, Uttar Pradesh and Gujrat, these methods have virtually replaced approach grafting, due to the several obvious advantages. Surprisingly these methods are yet to be adopted on a commercial scale in Kerala. The few earlier attempts made on these methods of grafting in Kerala have been sporadic in nature, which lacked any systematic approach.

The need for a detailed investigation on veneer and stone grafting, in order to find out their feasibility under Kerala conditions was keenly left, which prompted to take up the present series of studies.

The main objectives of the study were:

1. To standardise the best season of grafting.
2. To study the effect of precuring of scions on the ultimate 'take' of the grafts.
3. To standardise the age of root stock and scion.
4. To find out the varietal response.

REVIEW OF LITERATURE

"Stone grafting", a novel method, developed recently, has manifold advantages over the existing methods of mango propagation. Technically it is an epicotyl grafting. This method is also known as bench grafting or poly bag method of grafting. Any grafting technique applied for propagation of sprouted seeds provided that both stock and scion are movable, is termed as bench grafting.

Traub and Auchter (1933-34) were probably the first to make use of sprouted mango embryos for grafting in Florida. In temperate fruit trees the use of germinating seeds for their regeneration was being applied for long (Garner, 1951).

Singh (1951) utilised actively growing mango seedlings of 2-3 week old in inarching for rapid healing of graft union. Although, their works created lot of interests, much attention was paid only in 1969, when Bhan et al. for the first time in India developed "Stone grafting", a new, simple and economic method of mango propagation, at State Horticulture Research Station, Krishna Nagar (West Bengal).

Later, this technique has been tried in India and abroad with good success in mango by many workers (Majumder and Rathore, 1970; Bedoes and Ramprasad, 1975; Patel and Amin, 1976; Gunjate and Limaye, 1976-77; Sing and Srivastava, 1981 and Thomas, 1981). However, only recently it was employed for the

commercial production of Alphonso mango grafts in the Konkan region of Maharastra (Gunjate et al., 1982).

Epicotyl grafting has not been tried extensively in other fruits. However, Gunjate et al. (1980) from Dapoli have reported success as high as 90 per cent in Jack fruit. This technique has also been shown to be successful in cashew (Nagabhusanam, 1982).

"Veneer grafting" method of mango propagation was first time recommended by Lynch (1941) in Florida. Ruehle (1948) also described the possibility of veneer grafting in guava although he could not obtain good success. Later, Nelson (1954) improved this technique and Lynch and Nelson (1956) recommended it for commercial propagation of guava in Florida.

Due to many drawbacks in inarching, it was realised that the veneer grafting which was successful in mango and guava in Florida could be adopted under the Indian conditions also (Mukherjee and Majumder, 1961). They tried this method first time under Delhi conditions. The percentage of success was as high as 80 per cent when grafting was done on seedlings in nursery beds.

This method has been standardised by Mukherjee and Majumder (1964) for North Indian conditions by Sukla (1964) for Gujarat State and by Gunjate et al. (1976) for Konkan region of Maharastra.

The literature on some of the factors affecting success in grafting and budding methods in tropical fruit plants in general and stone grafting and veneer grafting in mango particular have been reviewed under the following appropriate heads.

1. Effect of season

Majumder and Rathore (1970) working on stone grafting in mango at Delhi, were of the openion that stone grafting in mango might be more suitable for humid region. In another study at Anand, it was found that success in bench grafting in mango to be directly related to humidity and minimum temperature within the range of 23.15°C and 25.87°C that prevailed during the experimental period (Patel and Amin, 1976).

Mandal (1979) from Rajendra Agriculture University, Bihar reported 60-90 per cent success in stone grafting in mango during July to October. Upadhaya and Gupta (1979) from Basti (U.P.) reported 80-85 per cent success in stone grafting in mango in the July and August.

Dengale (1980) reported that June to September period was the optimum season for mango stone grafting under Konkan conditions and the success ranged from 61-70 per cent. Matti and Biswas (1980) from West Bengal reported 96 per cent success during June to July.

Nagwekar (1981) obtained no significant difference in sprouting of stone grafts in mango during June to August but

difference in survival ranging from 58.5 - 65.75 per cent was noted during this period.

Gunjate et al. (1982) in their experiments found that stone grafting in Mango could be done from June to October under Konkan conditions. They obtained 55 - 64.9 per cent success during this period. 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).

Harmekar (1980) tried epicotyl grafting with success for the first time in cashew under Konkan conditions. The highest success was achieved during the month of March and April and the rainy season appeared to be unsuitable.

Nagabhusanam (1982) reported that in the initial trial, a maximum success of 30 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.

In Jack fruit, epicotyl grafting was found to be successful under Konkan conditions (Harmekar, 1980). The maximum success of 95 per cent was obtained in the month of June followed by March and April.

Ahmad (1964) observed that the operation of veneer grafting in mango in spring gave better results than in Autumn. He further observed that the best dates for Spring and Autumn grafting were 15th March and 15th August respectively.

Mukherjee and Majumder (1964) under Delhi conditions observed 76 to 96 per cent success in all the varieties tried during March to July in veneer grafting in mango. The percentage of take was much lower from September onwards except in Langra where the success was also good in September. The maximum growth of scion was obtained in grafts prepared during March to April.

Sukla (1964) obtained 80, 60 and 30 per cent success *in situ* veneer grafting in Kesar variety of mango on 1½ year old root stocks under Gujarat conditions during August, September and March respectively, whereas more than 70 per cent take was reported during June to September under Vengurla conditions (Limaye and Phadnis, 1968).

Bhambota *et al.* (1971) obtained 88 per cent and 87 per cent success in veneer grafting in mango during the first week of August 1968 and 1969 respectively. The maximum success (96%) was obtained during July under Saharanpur conditions (Prasad *et al.*, 1973).

Gunjate *et al.* (1976) under Dapoli conditions found that veneer grafting in mango was most successful during the period from March to first fortnight of May. During this period the percentage of success obtained was 76 to 84 per cent. Though high percentage of success was obtained from March to May, the grafts prepared in the month of May did not make sufficient growth so as to plant them in the field during the

monsoon season of the same year. Therefore March to April was considered as the optimum time for this operation in ground nursery.

Ram & Bist (1982) conducted veneer grafting operation in mango cv.Dusheri on the 15th day of each month between January and August. The best months were June, July and August during which 100 per cent take could be expected.

Singh et al. (1983) observed marked differences in veneer grafting in mango done during different months. This method gave highest success (75-92%) in the rainy season and lowest (16-20%) in November and December.

Veneer grafting in cashew is comparatively of recent origin. Phadnis et al. (1974) were probably the first to try. They found maximum percentage success during June to July. They further reported that the percentage of success was maximum in July (60 per cent) followed by June (53.30 per cent) while in August and September, the lowest success of 13.30 and 6.70 per cent respectively was obtained.

Nambiar (1975-76) reported that veneer grafting in cashew continued to be successful at Bapatla and Annakayam. They obtained much better results (85 per cent) in the month of July. In the Central Plantation Crops Research Institute Kasaragod also veneer grafting was found to be most successful during July to October (Anonymous, 1976).

Appa and Nambiar (1977) found maximum success (50-96 per cent in veneer grafting in cashew from June to September in east coast. According to Dhandar (1978), on an average, 36 per cent success in veneer grafting in cashew was obtained from November to March.

Nambiar (1978) obtained maximum success in veneer grafting in cashew at Mannuthy (Kerala) during monsoon season. Similar work conducted by Damodaran et al. (1979) also resulted in 56 per cent success during June to September.

MadhavaRao and Pappiah (1979) reviewed the work on veneer grafting in cashew and felt that intensive efforts are needed 12 months cycle to determine the optimum season for each tract.

Harmekar (1980) opined that, veneer grafting was found to be successful in cashew under Konkan conditions; the maximum of 40 per cent was obtained in the month of September.

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

Tamburo et al. (1955, 56) while studying the methods of top working in guava found that, autumn grafting of guava was unsuccessful. They observed that veneer grafting with green wood scion resulted maximum take of 62.1 per cent in spring. Mukherjee and Singh (1965) reported that April, May

or June was suitable for veneer grafting guava. Bhandary and Mukherjee (1970) obtained the maximum success (85 per cent) in July compared with March (20 per cent), April (60 per cent) and August (30 per cent). Under Tarai conditions of U.P. veneer grafting in guava was most successful (77 per cent) in July and the subsequent growth and leaf production were also greatest (Rao and Kaul, 1977).

Naik (1941) observed that the weather conditions have a great influence on inarching in mango. According to him the optimum time of inarching was from February to July under South Indian conditions. Mukherjee (1953) found the optimum time to be during February to July under Punjab conditions.

Asadullah and Khan (1960) observed that inarching in mango gave better results in spring than in Autumn, the optimum period being 25th March to 5th April. Later, Maijhail and Singh (1962) in their experiments found that the percentage survival was higher in spring as compared to monsoon.

Talukdar and Ahmad (1965) reported that the success of inarching was significantly superior in mid-August than that in mid-September. According to Giri (1966) also this operation was more successful in Autumn (30th August) than in the Spring (30th April), though the results were not statistically significant. Singh et al. (1983) found that under

Lucknow conditions monsoon period was the best for inarching in mango, followed by spring. The minimum success was observed in November.

Rao and Rao (1957), in their experiments on inarching of cashew obtained the highest percentage of success (40-75 per cent between January and May.

Ahmad (1966) reported that in guava inarching gave 80 per cent success during two autumn seasons and 60 and 84 per cent success in two spring seasons.

According to Kanwar and Bajwa (1974) side grafting in mango during March-April or June-October gave the best results.

More recently, Kanwar and Jawand (1983) while top working inferior mango trees by modified side grafting suggested that the selected seaffold limbs of inferior mango trees are headed back in February-March. Numerous shoots emerged from the periphery of headed back scaffold became suitable for grafting in August-September of the same year.

Singh et al. (1983) from Lucknow reported maximum success of 76-80 per cent during August followed by 76 per cent in July. November and December proved unsuitable for carrying out side grafting when the success was only 8-12 per cent.

In cashew, side grafting was successfully accomplished by placing moist moss above and below union and covering the

whole with alkathene 100 guage film. Upto 70 per cent take was obtained and the best months being February-May (Rao et al., 1957).

Amin (1978) from Anand (Gujarat) recommended in situ soft wood grafting in mango to be carried out during March-September. Later, Patel and Amin (1981) found grafting between the third week of May and third week of August resulted in 95 to 100 per cent take.

Singh and Srivastava (1982) from Lucknow reported July to September and March to April being the best periods for soft wood grafting operation.

According to Berwick (1940) budding in mango could be done in wet weather. The budding operation has been proved most successful from June to August in Florida (Lynch, 1941).

Hiyadatullah and Sadiqali (1955) while reviewing the work on mango budding in situ in Punjab found budding in Spring superior to Autumn. In a similar study Ahmed & Ahmed (1960) obtained best results on 10th May in the spring and 30th September in the Autumn.

Singh and Srivastava (1962) reported that July budding was the best with 100 per cent success, while Teotia and Maurya (1970) at Basti (U.P.) found March being the best months for this operation in mango.

According to Rajput and Haribabu (1971) Chip budding in mango could be done over a long period (June-March) except

during periods of heavy rainfall. Later, Prasad et al.(1973) obtained 60 per cent success during the month of May. In a more recent report, Singh et al. (1983) found that August to be the best period for mango budding.

Palaniswamy and Hameed (1976) reported 71 per cent success in cashew during July. Success ranging from 50 to 58 per cent was obtained during March, April, September and October.

Patch budding in Jack fruit was 100 per cent successful when done in the middle of June and over 90 per cent when done in May or July (Teaotia et al., 1963).

Panday et al. (1979) reported that budding was successful in guava when done on May (90 per cent), April (85 per cent), June (80 per cent) and July (70 per cent). Success was minimum during August (55 per cent)in patch budding.

According to Podluzhny (1939) budding in ber in August with dormant or nondormant wood gave the best results. In top working of ber, the best results were obtained with June budding and with the tree headed back to four feet (Singh, 1952).

Jyotish et al. (1967) showed that Banaras Narma and Banaras Gol varieties of ber could be successfully grafted by forkert and 'T' budding in almost all months. Shield budding of transplanted ber seedlings in the field was more successful in August than in April particularly when budwood

was obtained from mature rather than young mother plants (Singh et al., 1972). In Haryana, the best time of budding in ber was either spring or two months before winter (Daulta and Chauhan, 1982). Singhrot and Munish (1982) also found good success from May to August.

Singh (1952) in a trial at Saharanpur found that shield budding in early June on to one year old seedlings gave 90 per cent take in aonla. Later, Nand (1962) obtained 75 per cent success in 2nd half of September on to 1-1½ year old seedlings. In Haryana, Gangwar et al. (1975) obtained 81.8 per cent success during August in 'T' budding old frost damaged aonla tree. This method was recommended for commercial propagation as well as rejuvenation of aonla trees.

2. Effect of defoliation of scion shoot

The practice of defoliation of scion shoot prior to its detachment from mother tree is advocated so as to stimulate the activity of terminal as well as axillary buds.

Persai (1974) advocated the use of defoliated scion for stone grafting in mango. Gunjate and Limaye (1976-77) observed almost equal success with and without prior defoliation of scion shoots. Maiti and Biswas (1980) from Krishna Nagar (W.Bengal) reported that the defoliated scion shoots always produced higher percentage of success in mango. Ten days prior defoliation gave better success than the other defoliation period (Singh and Srivastava, 1981). In a more recent report Gunjate et al.(1982) observed that prior

defoliation of scion shoot was not beneficial for stone grafting in mango.

In cashew, Nagabhusanam (1982) suggested that the scion shoot selected for stone grafting should be defoliated about a week before grafting leaving behind the stubs of the petiole.

Very poor success (10 per cent) in veneer grafting when scion sticks which were neither forced nor enlarged naturally were used for grafting have been reported in mango (Mukherjee and Majumder, 1964). Rajput and Haribabu (1971) also reported that best results in veneer grafting in mango was obtained when precured scion shoots were used.

Gunjate et al. (1976) working at Dapoli reported that prior defoliation of scion shoot was not necessary for veneer grafting in mango under Konkan conditions. On an average, the sprouting in defoliated shoots was (70 per cent) as against (63.83 per cent) undefoliated shoots.

Singh and Srivastava (1979) recommended defoliation as a prerequisite for veneer grafting in mango. In their experiments at Lucknow 10 days defoliation proved to be better (80 per cent success). Ram and Bist (1982) found 83-85 per cent success in Terai when pre-defoliated scion shoot were used.

Jindal (1968) opined that veneer grafting was possible in jack fruit, he obtained 10-20 per cent in defoliated scion shoots with no success in undefoliated scion shoots.

Kashyap et al. (1972) reported that in side grafting in mango the success of 70-80 per cent was increased to 100 pef cent when scion shoots were defoliated 10 days before grafting. Amin (1978) suggested that all the leaves from the selected branch should be removed keeping 1 cm petiole 8-10 days prior to grafting in situ in mango.

Singh and Khan (1943) in their trials on budding in mango, obtained greatest success when defoliated bud wood was used.

Jauhari and Singh (1970) obtained 50 per cent bud sprout in budding in mango by activating buds two week before budding as against 40 and 30.75 per cent by activating one week and without defoliation before budding respectively. In similar works, Teaotia and Maurya (1970) increased the percentage of bud sprouts giving two weeks prior defoliation.

In guava, Pandey et al. (1979) observed at Basti that the fresh swollen buds produced success as high as (90 per cent) over the one week earlier defoliated ones (68.3 per cent).

3. Effect of age of scion shoot

Bhan et al. (1969) reported that semi matured terminal shoots could be used for stone grafting in mango. From Vengrula, Gunjate et al. (1976-77) reported maximum success with mature and defoliated scions of 3-4 months old, in stone grafting in mango. According to Dhakal (1979) success in grafting was increased with increase in age of scion.

He further opined that scion shoots of more than two months age were suitable for stone grafting in mango under Konkan conditions.

Nagabhusanam (1982) suggested that the terminal shoots of previous season growth could be used for stone grafting in cashew.

Mukherjee and Majumder (1964) observed that the success in veneer grafting in mango was only four to 12 per cent with 1½ to 2½ months old scion shoots. The success was as high as (88 per cent) with scions aged three months age. Jagindar and Bhatti (1968) in their experiment in veneer grafting in mango observed that the percentage take was increased by the use of mature scion wood compared with immature scion wood. The percentage of success in veneer grafting in mango was very high in all the age group of scions tried in Dapoli (Uradya, 1976), whereas, Singh and Srivastava (1979) obtained maximum success with six months scion sticks as compared to the scions of three month and one year in age.

Jindal (1968) in veneer grafting obtained 20 per cent success in jack with 1-2 week old defoliated scions and 10 per cent in 3-4 months old defoliated scions.

Nelson (1954) obtained 90 per cent success in veneer grafting in guava by using scions from terminal growth flushes in which stem was still green and quadrangular. In an experiment in guava grafting, none of the mature scion

inserted as veneer survived, but 91 per cent of the green wood scions were alive (Tamburo et al., 1955, 56). Mukherjee and Singh (1965) obtained 60 per cent success with green quadrangular, terminal shoots of the current years growth as against 25 per cent with brown corky shoots in veneer grafting in guava. In similar experiments, Bhandary (1967) observed that one month old veneer grafted scion grew faster than the older scions of 2, 4 and 6 months age. Bhandry and Mukherjee (1970) found one and two months scions equally good, whereas the success with six month old scions was very poor in veneer grafting in guava.

4. Effect of age of root stock

Gunjate et al. (1976-77) achieved maximum success of 84 per cent with immature stock (4-7 days old) in stone grafting in mango under Konkan conditions. Dengale (1980) obtained maximum success of (73.3 per cent) and maximum growth of stone grafts with one week old seedlings. Singh and Srivastava (1981) reported more success when 4-5 days old seedlings were used for stone grafting in mango under Lucknow conditions.

Gunjate et al. (1982) found seedlings, less than two week old with coppery red colour to be more suitable as root-stocks. The highest success was achieved with one week old root stock (60 per cent) followed by two week (58 per cent), four week (51 per cent) and six week (45 per cent) old root stocks.

From Dapoli, Harmekar (1980) reported four to eight weeks old seedlings to be more suitable for stone grafting in cashew. Nagabhusanam (1982) however suggested use of 10-15 days old root stocks when they attain 8-10 cm height. In mango Ahmed (1964) obtained better results in veneer grafting when nine months old seedlings were used as stock. According to Limaye and Phadins (1968) veneer grafting has to be conducted when the seedlings attain 12-14 month age. Rajpur and Haribabu (1971) suggested that vigoursly growing seedlings of 1-2 years of age may be selected as root stocks. Prasad et al. (1973) obtained 92 to 95 per cent success and better growth on two year old stocks against 80 per cent one one year old stock. Singh and Srivastava (1979) obtained better success with one and two year old root stocks and lesser with six month old stocks.

In cashew Phadnis et al. (1974) achieved maximum success (60 per cent) on five month old seedlings than on one year old seedlings. Nambiar (1975-76) also obtained much better results on six month (85 per cent) than on 10-15 month old seedlings. From the Central Plantation Crops Research Institute, Kasaragod it was reported that 12-18 month old seedlings were the best for veneer grafting in cashew (Anon., 1976).

Root stock studies in mango by the earliest workers Burns and Prayag (1921) in Phyllipines showed that inarching was successful even when three week old seedlings were used.

Naik (1941) in South India reported that stock can be inarched as young as 4½ months. He observed that there was no significant difference between the percentage of grafts on root stocks of different age, but one year old mango seedlings were considered to be the best (Naik, 1948). Singh and Singh (1956) reported successful inarching of mango with 2-3 week old seedlings. They found rapid union of graft joint with such seedlings.

Singh and Khan (1942) obtained maximum success in budding on three years old seedlings stocks of mango. While, Jagirdar and Ali (1965) reported that bud take was more in nine month than two years old stocks.

Richard (1943) found maximum success (95 per cent) when Sapota was cleft grafted on four months old stocks. One year old stocks were less successful.

5. Effect of stock and scion varieties

According to Dhakal (1979), the success in stone grafting in mango was 86, 85, 70, 61, 66, 65 and 64 per cent in Kesar, Totapuri, Pairi, Alphonso, Vanraj, Fermandin and Gomankur scion varieties respectively. Maiti and Biswas (1980) reported highest success with scion variety Fazli and the least success with Krishnabhog in stone grafting in mango.

Ahmad (1964) carried out veneer grafting in seedlings of mango varieties, viz. Langra, Dusheheri and Sumar Bahishet.

According to him grafting on Sumar Bahishet was the most successful.

Singh and Srivastava (1971) conducted experiments to evaluate the success in propagation of different scion cultivars on important root stocks in mango. When Dusheheri was veneer grafted on 10 different root stocks, it was observed that Kalapady stock resulted in 90 per cent success followed by Nakkare (85 per cent). When different mango cultivars were grafted on a single root stock, Rataul and Mallika gave 85 per cent and 80 per cent success respectively whereas Chausa resulted in poor success (35 per cent).

In guava veneer grafting, Mukherjee and Singh (1965) found greater take with scions from seedless varieties than the seeded ones.

Naik (1941) opined that there existed varietal response of scion on the success of inarching in mango. He also observed that there was varietal differences in optimum time for separation of inarched grafts from the parent tree. In inarching Langra was more successful than either Dusheheri or Sumar Bahishet (Asadullah and Khan, 1960).

Talukdar and Ahmed (1965) carried out inarching in mango using the varieties Langra, Dusheheri and Sumar Bahishet. The high percentage of success was obtained with Sumar Bahishet (71 per cent) as compared to about (58 per cent for others.

6. Effect of different tying materials

Uradya (1976) concluded that tying of mango veneer grafts even during the rainy season could be done only with alkathene tape (250 guage). The use of waxed cloth tape was found to be harmful.

Singh and Srivastava (1979) found both white and green polythene tapes were better than gunny twine in mango for veneer grafting.

In approach grafting in mango, Asadullah and Khan (1960) reported that the hemp with mud plaster was superior to waxed cotton tape in spring but slightly inferior in autumn, for binding the operation.

Jauhari and Singh (1970) obtained better results in patch budding in mango using white polythene than black polythene.

7. Effect of thickness of stock and scion

For the better success in stone grafting in mango, the scion and stock should be plump, vigrous and preferably of similar thickness (Rajput and Haribabu, 1971).

According to Sigh and Srivastava (1979) in mango veneer grafting treatment combination 1.0 - 1.0, 1.0 - 1.5 and 1.5 - 1.5 cm (stock-scion) showed significantly better success.

Giri (1966) reported that the percentage of success in inarching in mango was more with vigrous stocks (1.3 - 1.6 cm girth) than those of medium (1.0 - 1.29 cm) and low girth (0.7 - 0.99 cm).

Ascenso and Milheiro (1973) reported that in cashew splice and cleft grafting, 100 per cent success was possible with stocks and scions of 3-5 mm diameter.

Singh et al. (1981) in their experiments with budded ber seedlings found that the highest take (94.7 per cent) was on seedlings of 0.55 cm in diameter budded at 10 cm height.

8. Effect of length of scion sticks

Bhan et al. (1969) opined that for better success in stone grafting in mango, the scion might be generally a terminal shoot and 10-12 cm long. Dhakal (1979) however did not observe any difference with varying length of scion. Kotecha (1982) obtained maximum sprouting (75 per cent) in 15 cm and lowest (50 per cent) in 7.5 cm long scion under Dapoli conditions.

Muckherjee and Majumder (1961) recommended 4-6" cm long scion from a terminal shoot for better success in veneer grafting in mango. Later, Majumder et al. (1972) reported that the length of scion ranging from 2.5 to 10 cm did not affect the success in mango veneer grafting. Ram and Bist (1982) in their studies on veneer grafting of mango in Tarai, grafted mango scion sticks ranging 5-10 cm long. Grafting was on an average 20, 80 and 40 per cent with 5, 10 and 15 cm long scion respectively.

Kanwar and Bajwa (1974) in their experiments used scion sticks of 7.5, 15.0 and 22.5 cm long. Scions of 7.5 cm long were the most satisfactory for side grafting in mango.

9. Effect of grafting and budding techniques

Naik (1941) opined that propagation methods affected the success of mango grafts. Singh and Singh (1954) recommended patch budding as a better method for mango when done in June.

Majumder and Rathore (1970) tried bench grafting in mango under Delhi conditions where survival percentage was reported to be 50, 46.6 and 33.3 for splice, veneer and wedge grafting respectively. Pin heiro et al. (1970) compared five methods of grafting in which the best result (97.1 per cent) was obtained with cleft grafting in mango.

According to Bhambota et al. (1971) veneer grafting in mango was slightly superior to side grafting and considerably more successful than cleft grafting.

Majumder et al. (1972) carried out splice, saddle and wedge grafting experiments in mango and maximum (80 per cent) success was achieved with splice grafting. Later Prasad et al. (1973) opined that veneer grafting was significantly superior in respect of the percentage of success and vigour of the sprouts as compared to patch budding.

In a comparative trial at Kthulia, the least bud take was obtained in stone grafting as compared to inarching, veneer grafting and different methods of budding trial (Anon., 1979).

Singh and Srivastava (1981) from Lucknow reported that among four methods of stone grafting in mango, i.e. cleft, side, whip and tongue, cleft grafting gave better results than others. Gunjate et al. (1982) considered wedge technique to be the best from commercial point of view, since it was speedier and easier technique for stone grafting in mango than other two methods, viz. splice and modified wedge.

Singh and Srivastava (1982) made a comparison between soft wood grafting and veneer grafting in mango. Better success was observed in the plants grafted by soft wood grafting. The plants grafted by soft wood grafting produced comparatively better extension growth at initial stage.

Singh et al. (1983) from Lucknow reported highest success under inarching (96 per cent) followed by veneer grafting (88-92 per cent) and lowest under budding (64 per cent) in mango.

In cashew, budding was unsatisfactory, but splice and cleft grafting were 100 per cent successful (Ascenso and Milherio, 1973). Nagabhusanam (1982) also ppined that cleft method was found easier for large scale multiplication of cashew by vegetative means.

Ahmad (1966) conducted inarching, side grafting and veneer grafting in guava. Inarching was 80 per cent successful in two autumn seasons, and 60 and 84 per cent in two spring seasons. No success was achieved with side or veneer grafts.

10. Effect of storage of scion stick

Nagwekar (1981) suggested that, scion sticks could be stored only for four days without much loss of success in stone grafting in mango. The survival was (68.33 per cent) when grafted on the day of severing and after four days it was 46.44 per cent. Majumder et al. (1972) observed that the scion material after wrapping in moist newspaper and putting in alkathene bag could be stored at room temperature for 6-9 days during April and June and for a little shorter period in May and July, before veneer grafting. Singh and Srivastava (1978) found that bud sticks stored in polythene with moss resulted in good success, while poor success was obtained with black polythene alone, in mango veneer grafting. Ram and Bist (1982) opined that, in general, storage of scions in gunny bag resulted in better success than other methods of scion storage tried in veneer grafting.

Srivastava (1963) achieved cent per cent take upto 14 days storage in mango budding. Bud wood of Dusheheri mango was packed in moist sphagnum moss, wrapped in alkathene film and stored at room temperature.

Kanwar and Singh (1981) found that the percentage bud take was nil after holding in polythene even for one day. After holding in gunny bag pieces bud take was 68.8 per cent after one day, declining to 34.2 per cent after five days.

In guava, Srivastava (1964) opined that bud wood could be kept in good condition for upto seven days in dipping in wax and wrapping in moist sphagnum in alkathene film.

11. Effect of potted root stocks

Serpa (1964) in Venezuela mentioned that side veneer method gave excellent results when potted root stocks were used in mango grafting. Sukla (1964) from Gujarat also reported 60-100 per cent success in veneer grafting on potted root stocks of mango.

Gunjate and Limaye (1978) reported that veneer grafting in mango is not feasible on seedlings raised in alkathene bags and earthen pots, though there is a possibility of getting good success if the method of raising seedlings was slightly modified. The seedlings of mixed lot were filled in earthen pots of 10 cm diameter and 13 cm height having drainage holes at the bottom containing potting mixture of soil and FYM (2:1). The selected healthy seedlings were then put in long trench of 1.0 m width and 20 cm depth.

Maighail and Singh (1962) observed that inarching in mango was more satisfactory in pots than in alkathene wraps.

A final success of (84.1 per cent) in pot was observed in against (56.6 per cent) in alkathene wraps. Lal Singh and Khan (1942) observed poor results in budding in mango on potted root stocks.

12. Effect of age of 'Mother Plant'

Uradya (1976) observed that the percentage of success in veneer grafting in mango was maximum when scion shoots were collected from younger (7 year old) mother trees. It was on an average (58 per cent) in seven year old and (32 per cent) in 35 year old mother trees scion shoots.

De La Rocha (1953) reported that the scion, from eight month old mango mother trees gave the best results in the bench grafting by splice method compared to one and two years age.

13. Effect of in situ and transplanting grafting

According to Nagwekar (1981), stone grafting of mango seedlings in situ in polybags and in earthen pots gave significantly higher survival i.e. 65.42 and 63.14 per cent respectively than grafted on uprooted seedlings which gave 52 per cent survival.

Whereas, Kanwar and Bajwa (1974) achieved 92 per cent survival when side grafting was done on transplanted seedlings of mango compared to 77 per cent for direct sowing.

14. Effect of type of scion material

Nagwekar (1981) achieved no significant difference in survival and growth of stone grafts in mango prepared from terminal and subterminal scion shoots. The survival was (63 per cent) with subterminal and (66.66 per cent) with terminal shoots.

Mukherjee and Majumder (1964) also opined that the terminal extension growth and growth below, could be utilised as scion sticks in veneer grafting in mango with equal advantage. They got (80 per cent) success in growth below terminal and (96 per cent) in terminal shoots.

Materials and Methods

MATERIALS AND METHODS

A series of experiments on epicotyl grafting (syn.stone grafting) and veneer grafting in mango were conducted at the Department of Pomology and Floriculture, College of Horticulture, Vellanikkara, Kerala from May 1982 to June 1984.

The place is under high rainfall tropical region having warm humid climate throughout the year with less fluctuations in daily temperature. It lies on 10° 32' N latitude and 76° 16' E longitude. The altitude of the place is 40.3 metres above MSL.

The procedure followed in the various experiments to standardise epicotyl and veneer grafting in mango are described in the following pages.

I. Epicotyl grafting

Expt. 1. Effect of season and defoliation of scion shoot

The experiment was conducted from May, 1982 to August, 1982. In order to study the effect of season, grafting was done on every 15th day of each month commencing from May. There were three defoliation treatments, viz. defoliation 10 days prior to grafting, 15 days prior to grafting and no defoliation. Fifty seedlings were grafted for each of the three defoliation treatments every month.

1.1. Raising of seedlings for root stock

Seed stones of mixed varieties were collected locally. They were then sown in lines, on the surface of raised seed bed 2 x 1 m, in flat position. Distance from seed to seed was 2.5 cm and from row to row 10 cm. Seeds on the surface of the bed were covered with 2.5 cm thick layer of sand. First sowing was done on 15th April, 1982 and subsequent sowings were made at 15 days interval upto 15th July, 1982. The healthy and vigrous seedlings with straight and stout epicotyl were uprooted five day after sprouting along with seed stone without causing injury to roots (Plate I). The seedlings were then transplanted in polythene bags of 20 x 15 cm. Before transplanting, the polythene bags were filled with potting mixture consisting of FYM, sand and soil in 2:1:1. Similar procedure was followed to raise and prepare the root stocks for all the subsequent experiments.

1.2. Selection and preparation of scion shoot

Healthy, semimature, terminal shoot (four months age) with pump buds were selected from the healthy mother trees. Straight scion shoots having 12-15 cm length and 1.5 - 2.5 cm girth were given 10 and 15 days prior defoliation. In the case of 'without defoliation' treatment, the leaf blades were removed on the same day of grafting, keeping the petioles intact on the scion shoot. These three type of scion shoots were severed from the mother tree on the day of grafting.

They were wrapped in banana leaf or moist gunny bag till grafting was done on the same day.

1.3. The operation of stone grafting

The grafting operation was done by wedge technique. The stock, nearly of same thickness as scion was decapited about 6 cm above the stone and a vertical incision along the length of epicotyl upto 5 cm from the top of the stock was made (Plate IV). The scion was prepared like a wedge giving 5 cm long slanting cut on the opposite sides of basal end of scion (Plate V) with a very sharp knife. The scion was inserted into the stock (Plate VI) and the graft joint was firmly tied with polythene strip of 250 guage (Plate VII). The grafting operation was done on five days old root stocks on the same day when they were uprooted.

1.4. After care of grafts

The grafts were daily watered. Suckers from root stocks were removed as and when appeared. Weeding and plant protection measures were carried out at regular intervals.

1.5. Observations

Sprouting of the grafts was recorded at weekly intervals and the final survival was recorded after three month of grafting. The following growth parameters of the grafts were recorded at monthly intervals, upto one year from the time of grafting.

1.5.1. Extension growth of scion

It was measured from the point where the scion put forth new extension growth.

1.5.2. Girth of root stock and scion

The girth of root stock and scion of each graft was measured 1 cm below and above the graft joint, respectively.

1.5.3. Number of leaves

Number of leaves of each graft was recorded.

Expt.2. Effect of age of scion

This experiment was conducted in June, July and August, 1983. Fifty seedlings were stone grafted for each age group of scion, viz. 2 months, 4 months and 6 months in all the three months.

2.1. Raising of seedlings for root stock

Method of raising of root stock was same as in experiment 1. Four to five days old, healthy and vigrous seedlings having 1.7 to 2.7 cm girth were uprooted and transplanted in polythene bags for stone grafting on the same day.

2.2. Selection of mother tree and scion shoots

From healthy mother trees, the emerging shoots from different growth flushes were levelled. The shoots which emerged during different flushes formed the different age groups. Different age groups of scions selected for the experiment were as follows.

Sl. No.	Date of emergence of flush	Scion age group in month		
		June grafting	July grafting	August grafting
1.	December Ist to 15th, 1982	6	7	8
2.	January Ist to 15th, 1983	5	6	7
3.	February Ist to 15th, 1983	4	5	6
4.	March Ist to 15th, 1983	3	4	5
5.	April Ist to 15th, 1983	2	3	4
6.	May Ist to 15th, 1983	1	2	3
7.	June Ist to 15th, 1983	-	1	2

The scion shoots in all the age groups were defoliated 10 days before grafting.

2.3. Operation of stone grafting

Scions of each age group were stone grafted in 4-5 days old seedlings. The technique of grafting and after care of grafts were same as in experiment 1.

2.4. Observations

Sprouting and final survival of the grafts were recorded in the same manner as in experiment 1. The growth parameters of each graft were recorded at monthly intervals, upto nine months, after grafting operation.

Expt.3. Effect of age of root stock

This investigation was carried out in June, July and August, 1983. Fifty seedlings of each of three age groups, viz. five days, 10 days and 15 days were stone grafted.

3.1. Raising of seedlings for root stock

Method followed for raising of root stock was same as in experiment 1. The seedlings were grouped into three categories on the basis of stage of growth and development of seedlings. Each category of seedlings formed corresponding age group of root stocks. Different stages of growth and development of root stocks were as follows.

Sl. No.	Stage of growth	Description of seedlings	Approximate age
1.	First	When epicotyl was just straight and leaves were very small with coppery red colour.	5 days (Plate I)
2.	Second	Leaves somewhat developed and with coppery red colour.	10 days (Plate II)
3.	Third	When leaves were fully developed but still with prominent coppery red colour.	15 days (Plate III)

3.2. Selection of mother tree and preparation of scion shoots

Scion shoots of one age group (four month) were selected for grafting varying age group of seedlings. The selected scion shoots were defoliated 10 days before grafting.

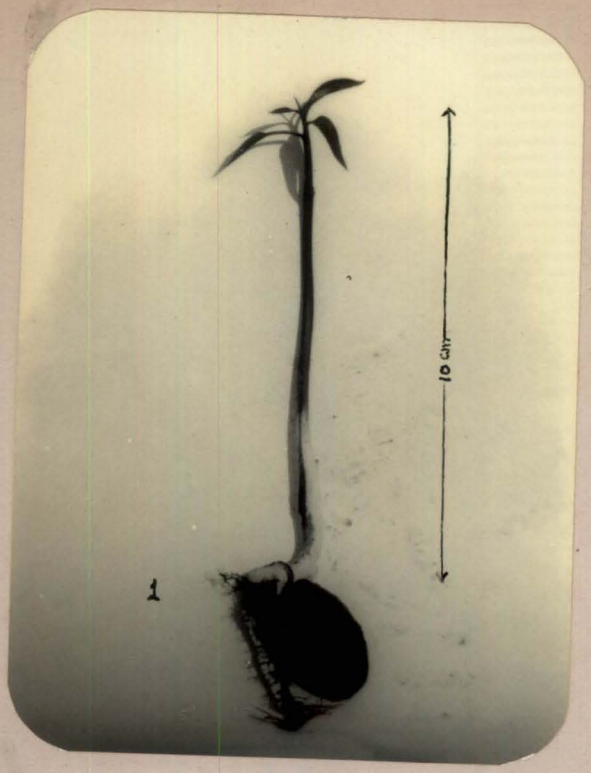
The technique of grafting, after care of grafts and observations recorded were same as in experiment 1.

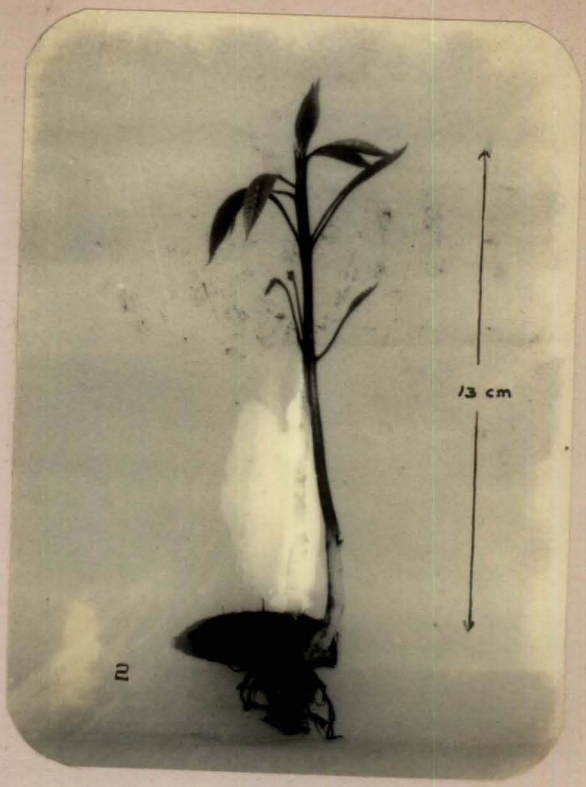
Plate 1. Five days old root stock for epicotyl grafting.

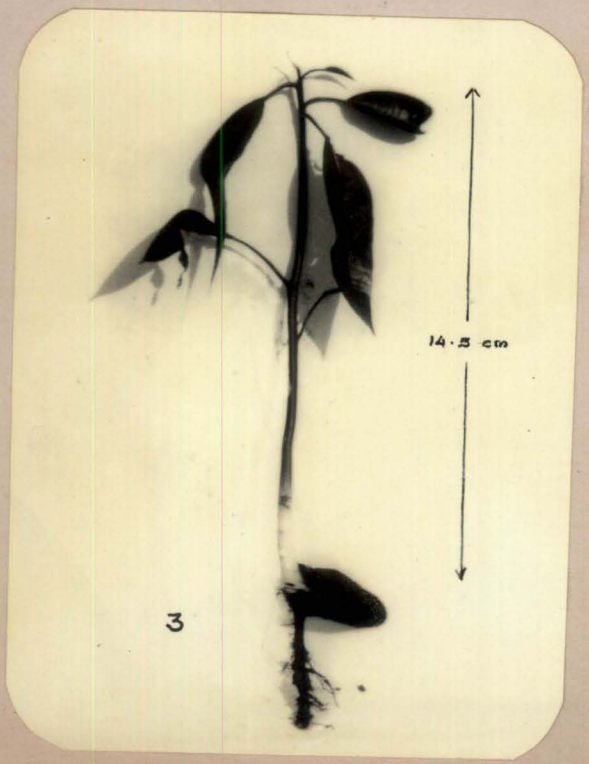
Plate 2. Ten days old root stock for epicotyl grafting.

Plate 3. Fifteen days old root stock for epicotyl grafting.

Plate 4. Preparation of stock for epicotyl grafting.


10 cm
1


13 cm
2


14·5 cm
3

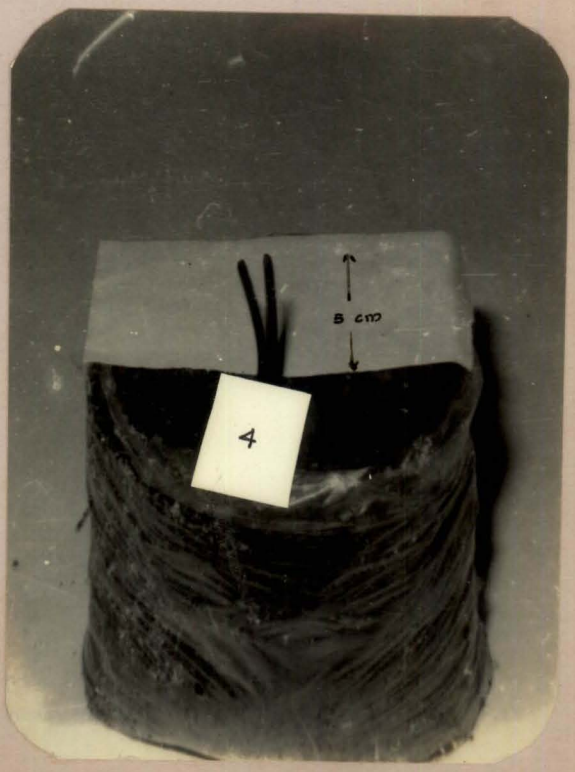
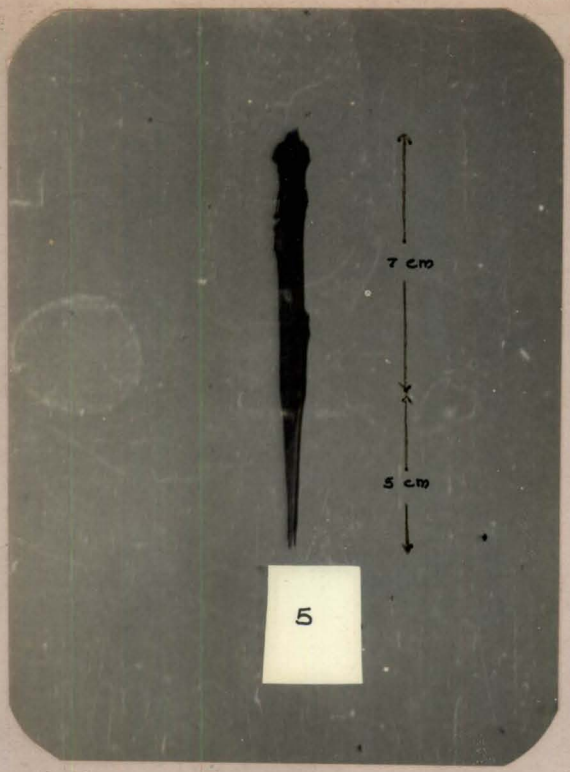

5 cm
4

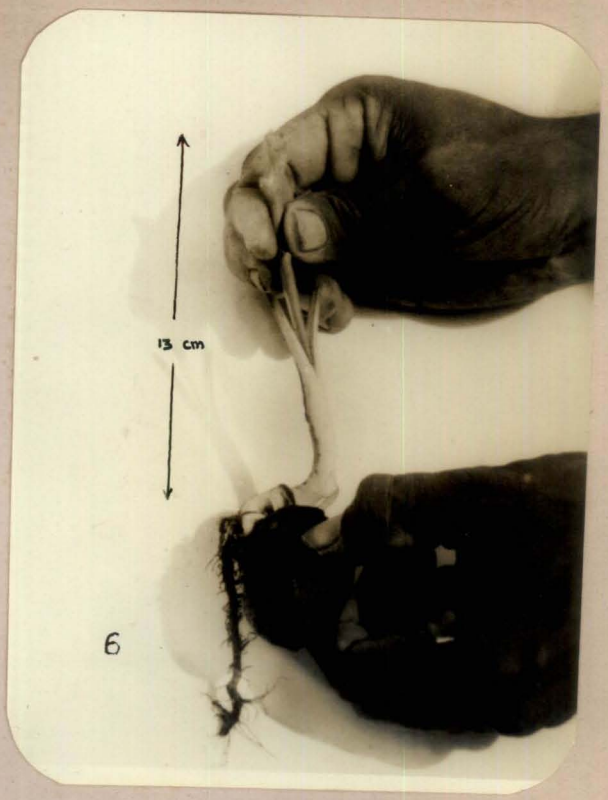
Plate 5. Preparation of scion for epicotyl grafting.

Plate 6. Insertion of scion into the stock in epicotyl grafting.

Plate 7. Tying of graft joint with polythene strip in epicotyl grafting.

Plate 8. Just sprouted stone grafts.


7 cm
5 cm
5


13 cm
6

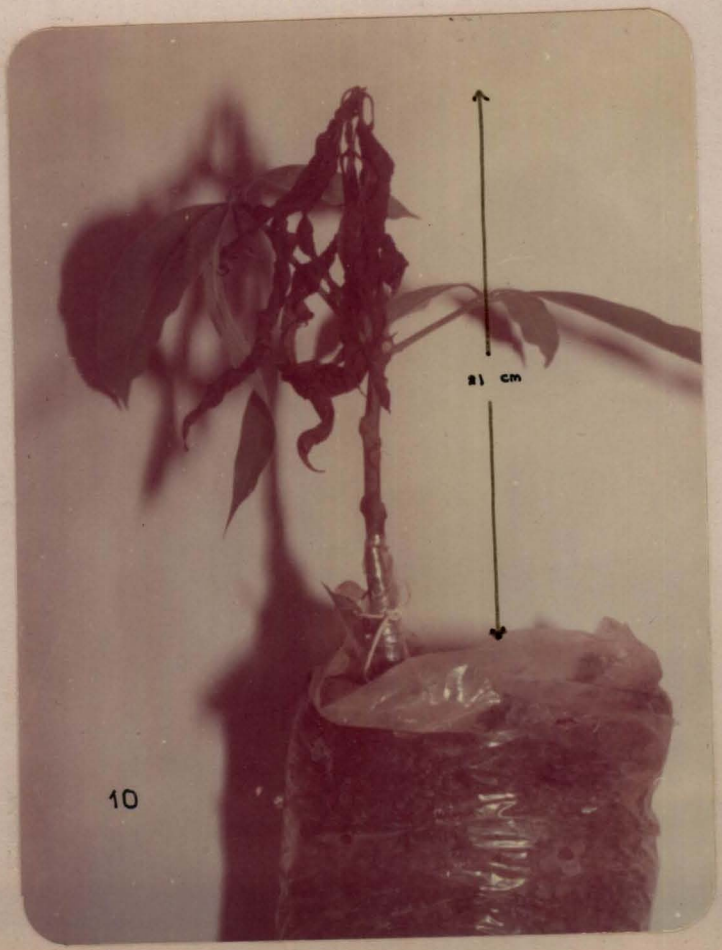

13 cm
7


17 cm
8

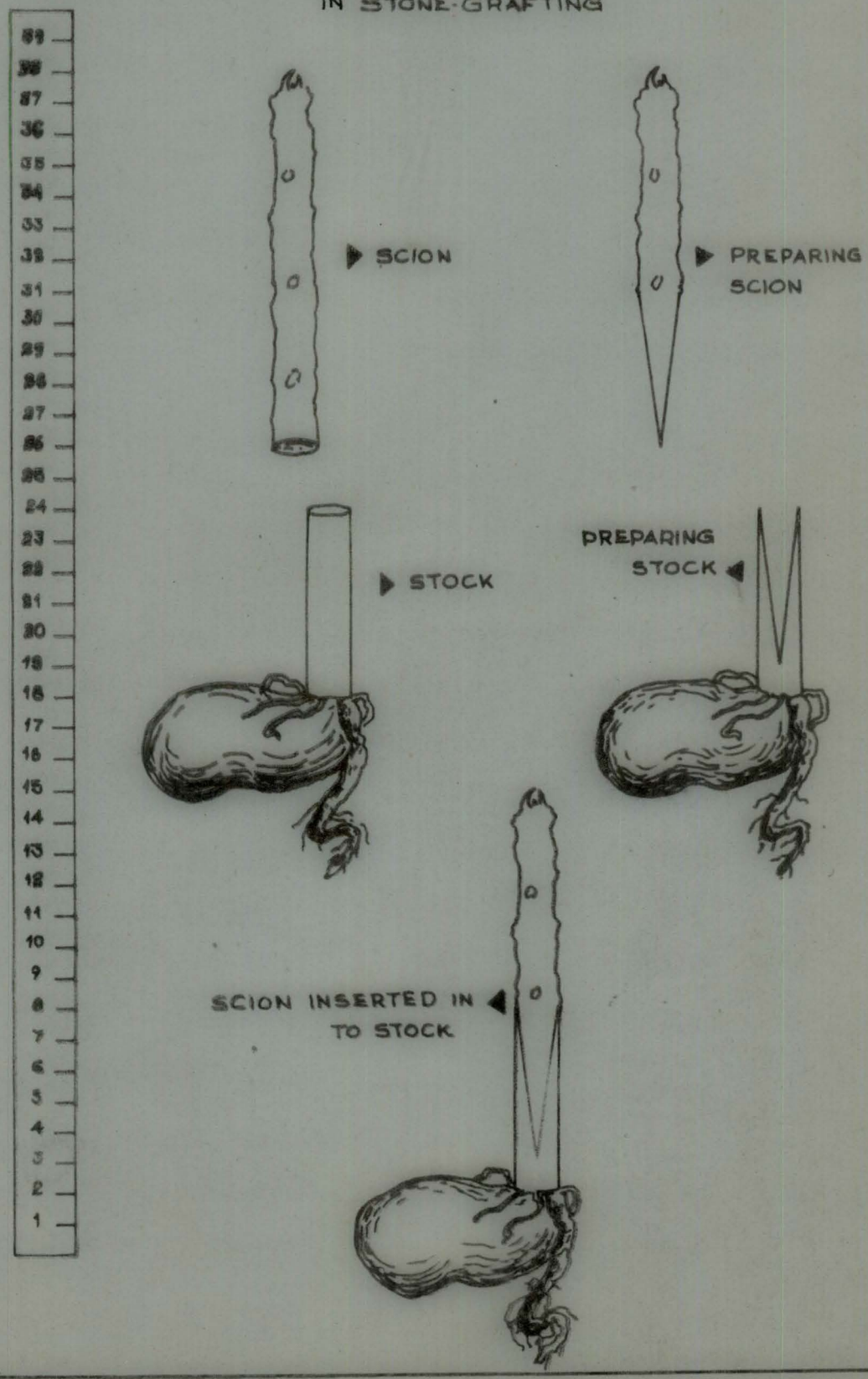
Plate 9. A stone grafted plant after nine months.

Plate 10. A stone graft damaged by pest/disease.


40 cm
60 cm
9


21 cm
10

DIAGRAMMATIC REPRESENTATION OF SIZE OF STOCK AND SCION IN STONE-GRAFTING



II. Veneer grafting

Expt.1. Effect of season and defoliation of scion shoot

Effect of season and defoliation of scion shoot on success were studied from April, 1983 to March, 1984. One hundred and fifty seedlings were veneer grafted on 15th day of each month. For grafting, scions of three defoliation treatments, viz. 10 days defoliation, 15 days defoliation and without defoliation were used. Fifty seedlings were veneer grafted for each of three defoliation treatments every month.

1.1. Raising of root stocks

Recently sprouted mango seedlings were collected locally. These seedlings of mixed lots were planted in Polythene bags of 20 x 15 cm and 300 guage, during last week of June, 1982. The polythene bags were filled with potting mixture consisting of FYM, Soil and sand in 2:1:1. The bags were provided with drainage holes at many places. After two months, urea was applied at the rate of 10-15 g per plant to hasten the growth of seedlings. The seedlings were allowed to grow with single stem by removing the lateral sprouts as and when they appeared. The seedlings became ready for grafting in April, 1983.

1.2. Preparation of scion shoot

Mature, terminal growth of six month age, with dark green foliage and round shoot was used (Plate XII).

For defoliation treatments leaf blades from the selected shoots were removed keeping the petioles intact, 10 days (Plate XIV) and 15 days (Plate XV) before the actual grafting. By the time of grafting debladed petioles dropped down and the buds on the scion shoot swelled and became plumpy. These shoots, about 10-15 cm long were severed from the mother tree on the day of grafting. For "without defoliation" treatment, the shoots were selected as above except that defoliation was not given earlier. In this case, the leaves were removed after the selected shoots were severed from the mother tree on the day of grafting (Plate XIII).

1.3. Grafting operation

Seedling stocks of nearly pencil thickness (Plate XI) were given a slanting cut of about 5 cm long on one side of the stock. Then the bark along with wood was removed giving an oblique cut (Plate XVI) at the lower end with a sharp grafting knife. This cut was made at the height of about 15 cm from the soil level of polythene bag. A similar cut was made on one side of the scion giving a small oblique cut on the opposite side at lower end (Plate XVII). The scion was placed in position (Plate XVIII) in such a way that the cambia of both stock and scion came in close contact. It was then wrapped tightly with 1.5 to 2 cm wide alkathene tape keeping the terminal end of scion free (Plate XIX). When the scions sprouted and started growing (usually after 3 weeks), the upper part of the stock was removed (Plate XX), thus forcing

the buds to grow more rapidly. The plastic wrap was removed after three months of grafting operation.

1.4. After care of grafts

Same as in epicotyl grafting.

1.5. Observations

Sprouting of the grafts was recorded at weekly intervals and the final survival was recorded as 'success' after three months of grafting.

The growth parameters of the grafts were recorded at monthly intervals for a period of three months, method followed being the same as in epicotyl grafting.

Expt. 2. Effect of age of scion shoot

This experiment was conducted in June, July and August, 1983. Scions of two months, six months and one year old were used for grafting. There were 50 seedlings grafted per treatment.

The method followed for raising of root stock was same as in experiment 1. The healthy and pencil sized 12-14 month old root stocks were selected for veneer grafting.

2.3. Preparation of scion shoots

The scion shoots were selected from healthy mother plant and defoliated 10 days before grafting. The shoots from different growth flushes were levelled at the time of their emergence starting from July, 1982 to June, 1983. The shoots

which emerged during different flushes formed the different age groups.

The technique of veneer grafting, after care of grafts and observations recorded were same as in experiment 1.

Expt. 3. Effect of age of root stock

Seedlings (root stocks) of three age groups, viz. three months, 14 months and 26 months were veneer grafted in August, September and October, 1983. Fifty, uniform and healthy seedlings from each of the age groups were grafted.

3.1. Raising of root stocks

The method was followed separately for raising root stocks of different age groups.

3.1.1. Raising of 3 months old root stocks

Mixed varieties of seed stones were collected locally. They were sown in third week of April, May and June. The method followed for raising the seedlings was same as in epicotyl grafting. After one month of sowing, the sprouted stones were planted in polythene bags of 20 x 15 cm size filled with potting mixture consisting of FYM, sand and soil by 2, 1 and 1 part respectively.

3.1.2. Raising of 14 month old root stocks

Seedlings of mixed lots were collected locally and they were planted in polythene bags of 20 x 15 cm in the last week of June, July and August, 1982. The seedlings, when they were 14 months old were used for grafting. Method of raising the seedlings was same as in experiment 1.

3.1.3. Raising of 26 month old seedlings

Earthen potted 17 to 19 months old mango seedlings of mixed varieties were procured from Instructional Farm, Mannuthy in November 1982. The seedlings were supplied with urea at the rate of 10 g per plant. The healthy and vigrous seedlings were selected as root stock in August, September and October, 1983 when they were 26 months old for veneer grafting.

3.2. Grafting operation

Scion shoots were given 10 days prior defoliation. Scions from one age group (six months) were used in veneer grafting for three different age groups of root stocks.

The technique of grafting, after care of grafts and observations recorded were same as in experiment 1.

Expt. 4. Varietal response

For the investigation of varietal response six mango varieties, viz. Alphonso, Bennet Alphonso, Bangalora, Banganapalli, Mundappa and Neelum were used as scion. In each variety fifty grafts were prepared in June, July and August, 1983 with common root stocks (mixed variety).

Healthy, pencil sized 12-14 months old root stocks were selected for veneer grafting. The scion shoots used were six month old matured and 10 days prior defoliated.

The methods of raising root stocks, selection and preparation of scion shoots, technique of grafting, after care of grafts and observations recorded for sprouting and survival were same as in experiment 1.

Expt. 5. Effect of duration of storage of scion sticks

The effect of storage of scion sticks was studied in the month of June, July and August, 1982. For this experiment scion shoot from the variety Mundappa was used. Freshly defoliated and ten days prior defoliated scions were excised and stored for three, six and nine days before grafting. In both the type of defoliation of scions, two storage treatments, viz. wrapping in moist gunny bag with sphagnum moss and polythene wrapper with sphagnum moss were given to each set of scions kept for three storage periods.

5.1. Storage of scion sticks

Scion shoots, both freshly defoliated and defoliated prior to 10 days were cut away from mother trees and packed in sphagnum moss in a bundle containing 50 scion sticks. Six bundles were wrapped with gunny bags and six with polythene wrapper and each was stored for three, six and nine days for three months. The scion sticks were frequently moistered by spraying water during the storage period.

The operations of raising of root stocks, selection and preparation of scions, veneer grafting technique and observation on sprouting and survival of the grafts were done in the same manner as in experiment 1.

Expt. 6. Effect of in situ (in beds), poly bag and modified trench grafting.

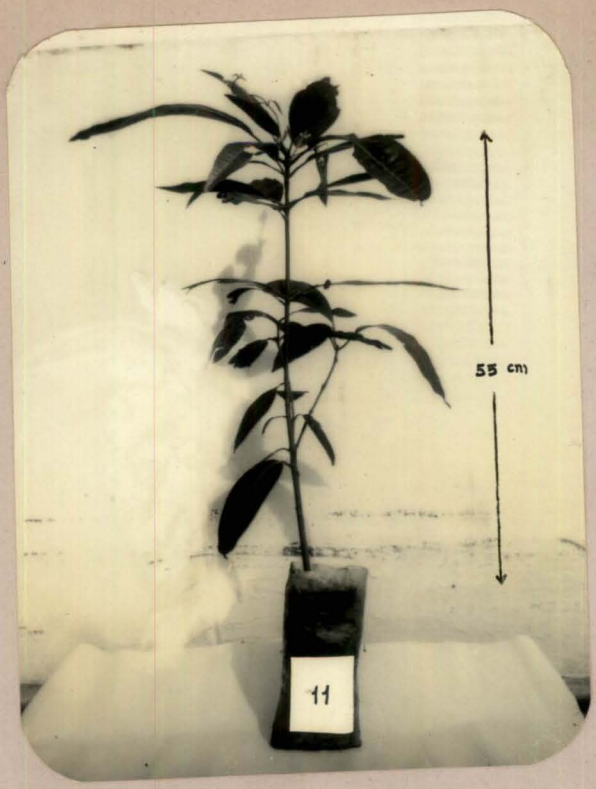
This investigation was carried out in the month of January, February and March, 1984. In each treatment 50

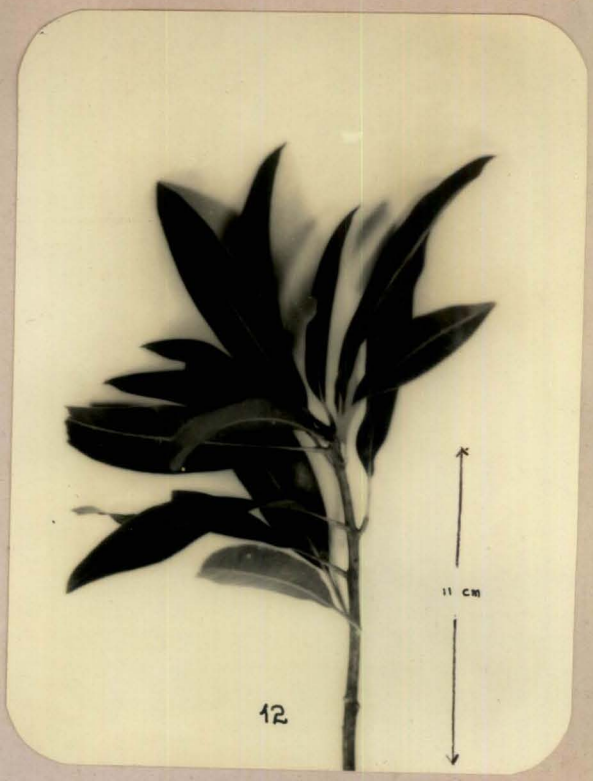
Plate 11. Fourteen month old root stock for veneer grafting.

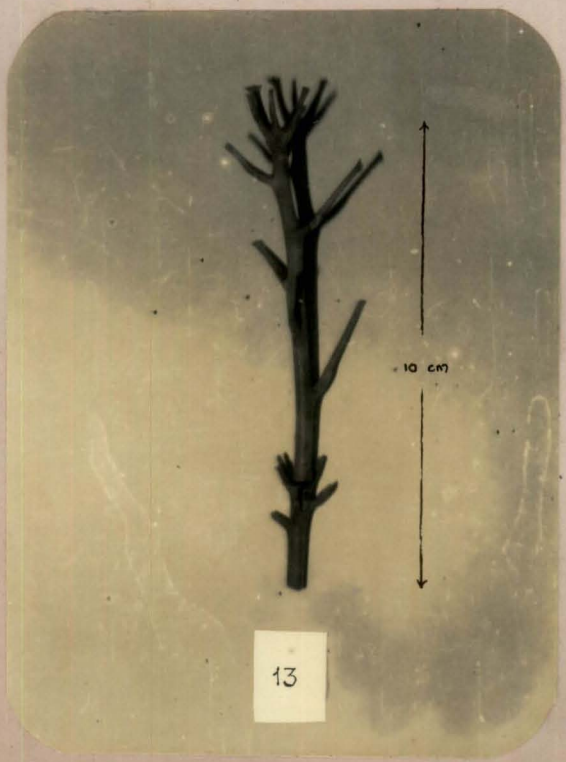
Plate 12. Mature and round shoot with dark green foliage six month old scion for veneer grafting.

Plate 13. Immediate defoliated scion but with intact petioles.

Plate 14. Ten days prior defoliated scion shoot.


55 cm
11


11 cm
12


10 cm
13

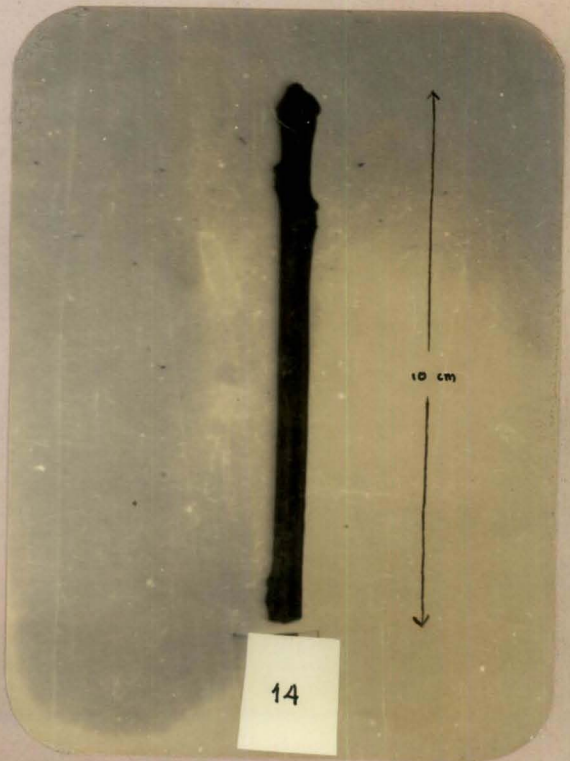
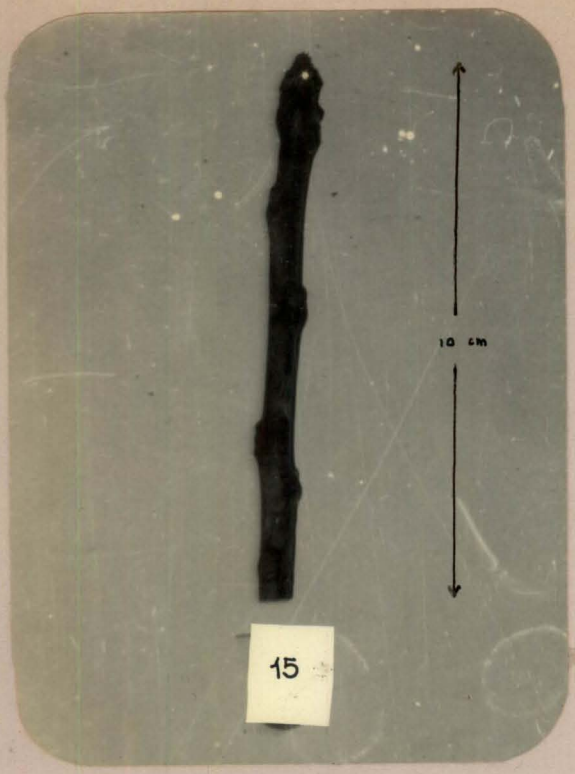

10 cm
14

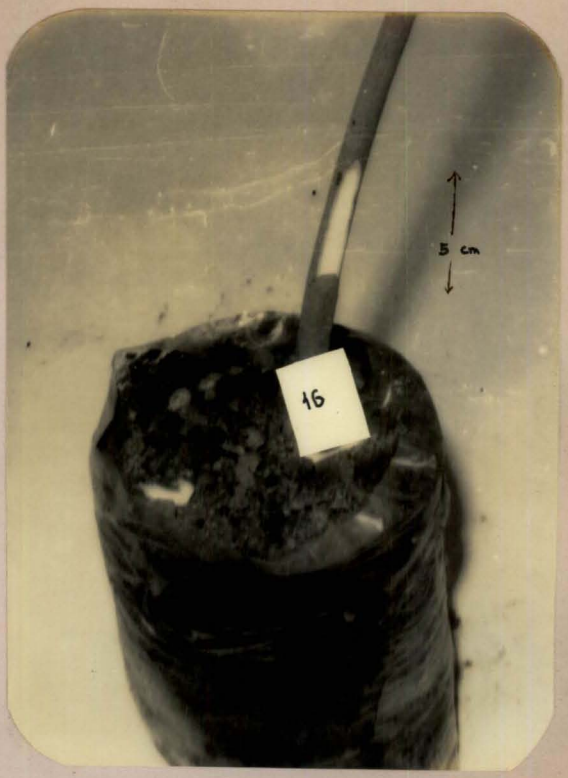
Plate 15. Fifteen days prior defoliated scion shoot.

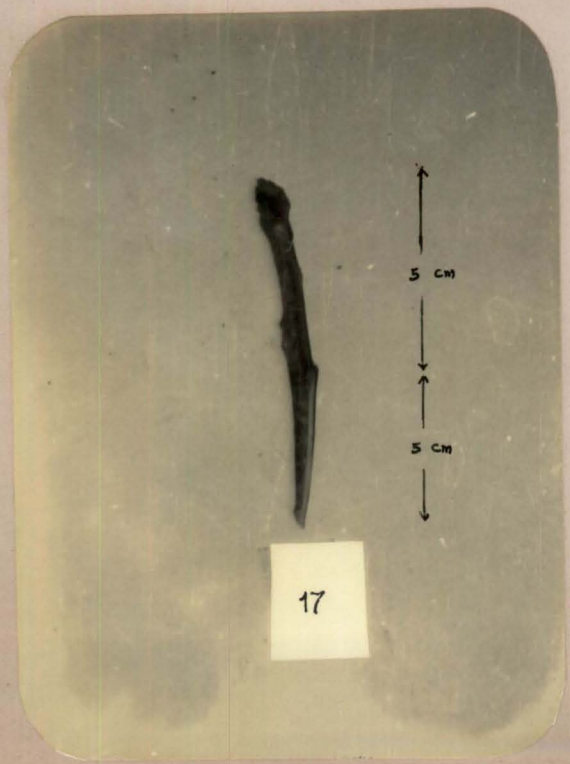
Plate 16. Preparation of root stock for veneer grafting.

Plate 17. Preparation of scion for veneer grafting.

Plate 18. Fitting of scion into the stock in veneer grafting.


10 cm
15


5 cm
16


5 cm
5 cm
17

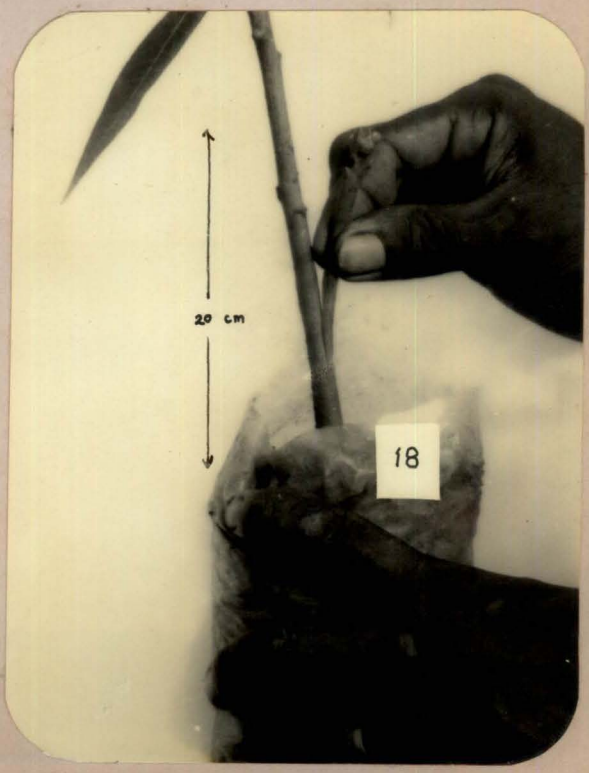
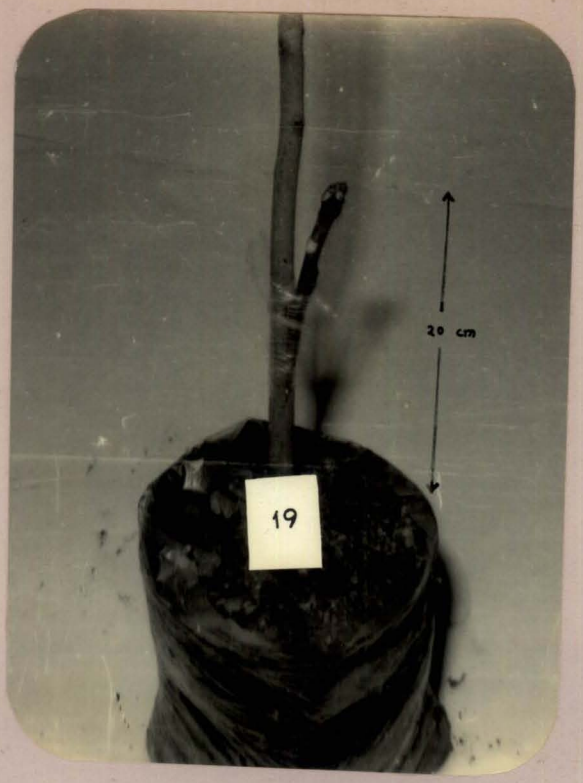

20 cm
18

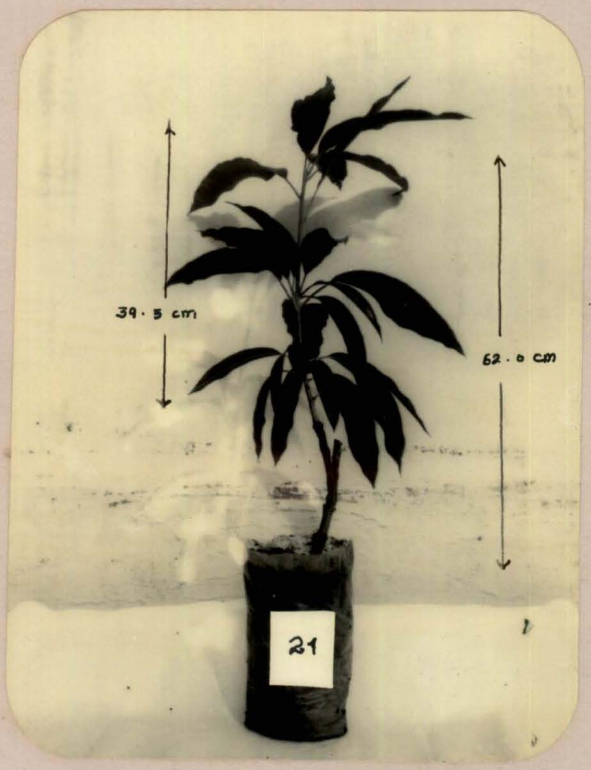
Plate 19. Tying of graft joint with polythene strip in veneer grafting.

Plate 20. Just sprouted veneer grafts.

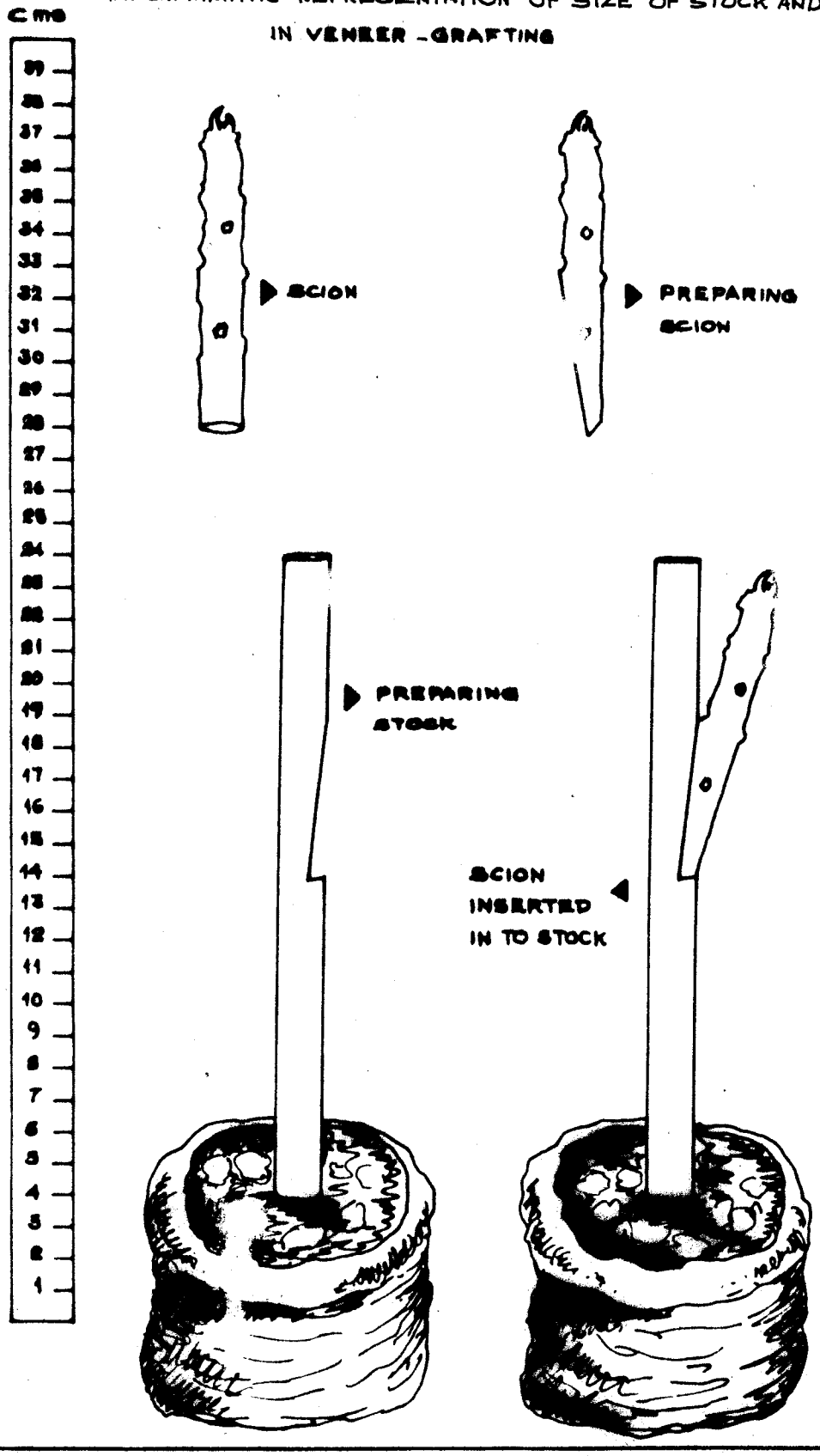

20 cm
19


22·5 cm
20

Plate 21. A veneer grafted plants after eight months.


39.5 cm
62.0 cm
21

DIAGRAMMATIC REPRESENTATION OF SIZE OF STOCK AND SCION IN VENEER - GRAFTING



seedlings raised by different methods, viz. in situ, polybag and modified trench were veneer grafted.

6.1. Raising of seedlings for root stocks

The method followed for the raising of seedling in in situ and polybag was same as in experiment 1. Where as in modified trench method, attempt was made to invigorate the polybagged seedlings by modifying the method of rearing the seedlings for veneer grafting.

The seedlings of mixed lot were transplanted in polythene bags of 20 x 15 cm with potting mixture FYM, sand and soil (2:1:1) in May, June and July, 1983. The selected healthy seedlings were then placed in a long trenches of 1.0 m width and 20 cm depth, in September, October and November, 1983 respectively.

Technique of selection and preparation of scions, veneer grafting operation and sprouting and survival record was same as in Experiment 1.

Statistical analysis

The data relating to the different aspects of stone grafting and veneer grafting were statistically analysed by using the following techniques as described by Panse and Sukhatme (1978).

Sprouting and final survival

Differences among treatments with regard to the qualitative characters such as sprouting and final survival

were tested for significance using chi-square test. Whenever the number of treatments was more than two, chi-square was calculated as

$$\chi^2 = \frac{1}{n1\ n2}\sum\frac{(an_2 - a'n1)^2}{a + a'}$$

where χ^2 = chi-square

a is the number sprouted or survived as the case may be for each treatment.

a' is the number not sprouted or not survived for each treatment as the case may be.

n1 is the number of sprouted or survived for all the treatments.

n2 is the number of not sprouted or not survived for all the treatments.

Whenever there was only two treatments chi-square was calculated as

$$\chi^2 = \frac{(|ad - bc| - n/2)^2 n}{(a+b)\ (c+d)\ (a+c)\ (b+d)}$$

where

a and c are the numbers sprouted or survived as the case may be for the two treatments.

b and d are the number not sprouted or not survived as the case may be for the two treatment.

and n = a+b+c+d.

Growth parameters

Differences among treatments with respect to quantitative characters, viz. scion extension, girth of root stock, girth of

scion and ratio of the girth of root stock to the girth of scion were tested for significance using analysis of variance.

The linear growth rates of scion extension for various treatments were obtained by using the formula

$$b = \frac{\Sigma xy - \frac{\Sigma x \times \Sigma y}{n}}{\Sigma x^2 - \Sigma x \times \bar{X}}$$

where

b = Linear growth rate of the scion

x = Time after grafting

y = Scion extension in time x

n = Total number of observation

To find out the correlation coefficient (r) between time and extension of scion for various treatments the formula used was as below.

$$r = \frac{\Sigma xY - \frac{\Sigma xx \Sigma y}{n}}{\sqrt{(\Sigma x^2 - \Sigma xx \bar{X})\ (\Sigma x^2 - \frac{\Sigma yx \Sigma y}{n})}}$$

Correlation coefficient between time and scion extension was significant at one per cent level for all the treatments. The expected growth of scion in various treatment during different periods was therefore estimated by fitting a simple linear regression equation.

$$Y = a + bx$$

where

y = expected value of the scion extension at time X.

b = linear growth rate

$a = \bar{y} - b\,\bar{x}$

$\bar{y}$ = mean of y

$\bar{x}$ = mean of x

For testing the significance of differences in growth rates of scion between pairs of treatments students 't' test was used. The relevent formula used was as given below.

$$t = \frac{b1 - b2}{\sqrt{\frac{1 - r1^2}{n1 - 2} + \frac{1 - r2^2}{n2 - 2}}}$$

where

b1 and b2 are the growth rate of the treatments

r1 and r2 are the correlation coefficients and

n1 and n2 are the total number of observation.

Since, the total number of observation in the pair between the treatment was same. Hence, the critical value of student 't' was compared for n - 2 degree of freedom.

Correlation coefficients between the weather parameters, viz. mean maximum temperature, mean minimum temperature, mean rainfall, number of rainy days and mean relative humidity and the percentage of sprouting and survival for each treatment were calculated and tested for significance.

Results

RESULTS

The results obtained from the experiments conducted under epicotyl grafting and veneer grafting are presented with the details of statistical analysis in this chapter.

I. Epicotyl grafting

Expt.1. Effect of season and defoliation of scion shoot

A. Effect of season and defoliation on sprouting and survival.

Table 1 presents the percentage of sprouting and final survival of the stone grafts along with the details of precuring and season of grafting. Tables 1a and 1b show the pooled data used for the statistical analysis.

Effect of season

The results indicated that the season of grafting had perfound influence on the sprouting of scions as well as their final survival. It was observed that grafting during the month of August gave maximum sprouting (88 per cent) with a percentage of survival of 69.33. The minimum percentage of sprouting as well as survival was observed when grafting was done during May (50.66 and 20.66 per cent respectively). This has been depicted in Fig.1.

The chi-square test conducted to compare the number of sprouts and survival between the treatments has shown that

there is significant difference between season (chi-square value 59.487 and 88.995 both significant at 1 per cent level). The pair wise comparison of the treatments also confirmed that sprouting and survival was best when the grafting was done during August (Appendix I).

The relationship for the factors under study with weather parameters was examined by working out the correlation coefficients which indicated that there was no consistant relationship for the sprouting and survival percentage with the parameters such as mean maximum temperature, mean minimum temperature, mean relative humidity and number of rainy days (Appendix IV).

Effect of defoliation

The observations on the effect of defoliation as a pre-treatment on the sprouting and survival of stone grafts indicated that defoliation of the scion prior to the grafting could give better results (Table 1b and Fig.2). It was found that there was significant difference for the sprouting as well as survival when the three treatments i.e. without defoliation, defoliation 10 days, and 15 days prior to grafting were compared. But the difference between the treatments with the defoliation 10 days and 15 days prior to grafting was not significant (Appendix II).

Table 1. Effect of season of grafting and defoliation of scion shoot on sprouting and survival of stone grafts

Month	Precuring period	Number of grafts prepared	Percentage sprouting	Percentage survival
May	Without	50	30	14
	10 days	50	58	24
	15 days	50	64	24
June	Without	50	34	20
	10 days	50	66	32
	15 days	50	68	32
July	Without	50	54	40
	10 days	50	86	66
	15 days	50	84	62
August	Without	50	70	52
	10 days	50	96	76
	15 days	50	98	72

Table 1a. Effect of season of grafting

Treatments	Number of grafts prepared	Sprouting		Survival	
		Number	percentage	Number	percentage
May	150	76	50.66	31	20.66
June	150	84	56.00	42	28.00
July	150	112	74.67	84	56.00
August	150	132	88.00	100	69.33
Value of chi-square		59.487**		88.995**	

** Significant at 1% level of probability.

Table 1b. Effect of defoliation of scion shoot

Treatments	Number of grafts prepared	Sprouting		Survival	
		Number	Percentage	Number	Percentage
Without	200	94	55.00	63	33.50
10 days	200	153	76.50	99	49.50
15 days	200	157	78.50	95	47.50
Value of chi-square		56.572**		15.90**	

** Significant at 1% level of probability.

FIG: 1 - EFFECT OF DIFFERENT SEASONS ON SPROUTING AND SURVIVAL OF STONE-GRAFTS

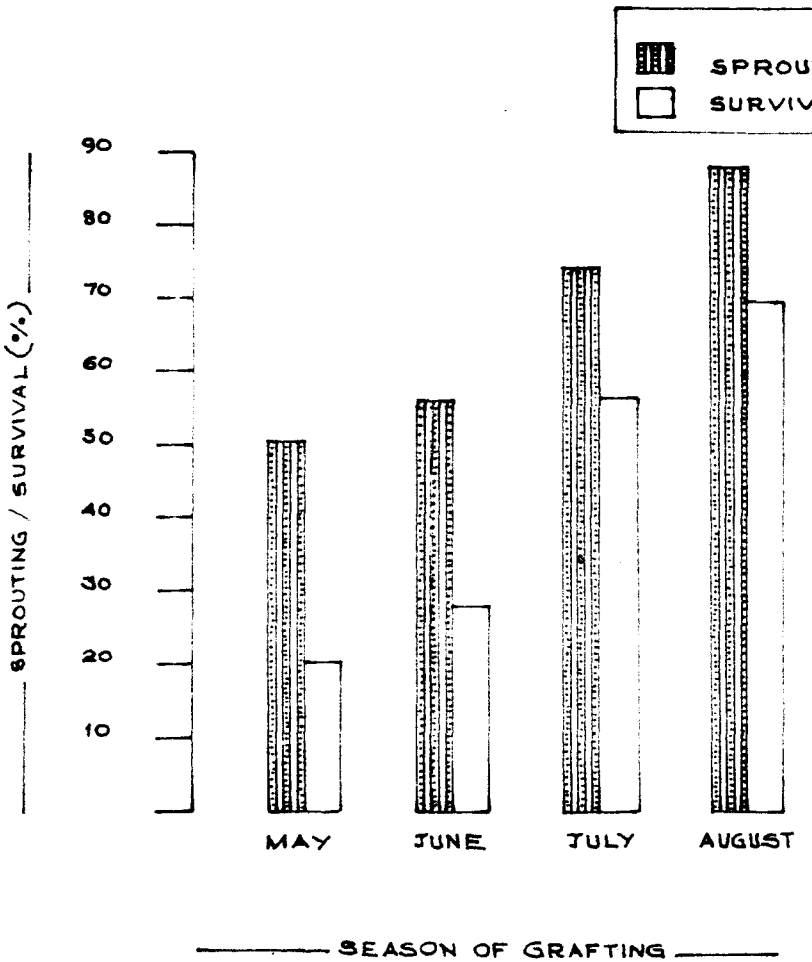
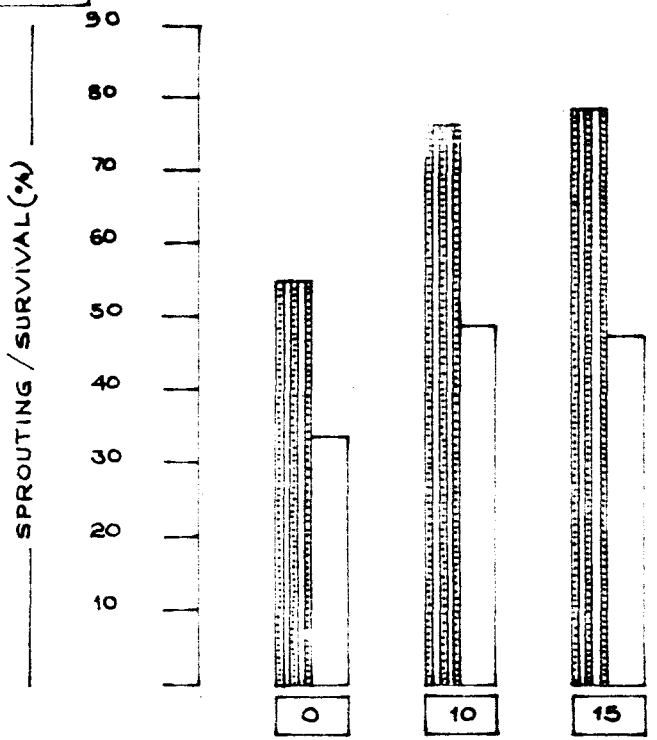


FIG: 2 - EFFECT OF DEFOLIATION OF SCIONS ON SPROUTING AND SURVIVAL OF STONE-GRAFTS



Maximum percentage of sprouting (78.5) was observed when defoliation was done 15 days prior to grafting compared to 10 days prior defoliation or treatment without prior defoliation. However maximum survival of 49.5 per cent was recorded in the treatment with 10 days prior defoliation.

From the observations it was concluded that both season of grafting as well as defoliation as a pre-treatment had considerable effect on the overall success of stone grafting, and that grafting during the month of August using scion materials with 10 days prior defoliation as pre-treatment could give best results.

B. Effect of season and defoliation on growth parameters

Extension growth of scion

Table 2 shows the observations taken at monthly intervals on the extension growth of scion under various treatments. The pooled data used for statistical interpretations appear in tables 2a and 2b.

Maximum scion extension was recorded on the plants on which grafting was conducted during August. This was true irrespective of the pre-treatment given to the scion material. The extension growth recorded after 12 months of grafting came to the tune of 49-55 cm on the August grafted plants while the variation was between 31-40 cm in the other treatments.

Table 2. Effect of season of grafting and defoliation of scion shoot on extension growth of scion (data at monthly intervals)

Month of grafting	Precuring period	Scion extension (cm)											
		1	2	3	4	5	6	7	8	9	10	11	12
May	Without	5.83	7.53	12.05	15.17	16.65	19.91	21.00	21.98	23.77	27.73	29.65	31.82
	10 days	6.88	8.72	13.35	15.34	17.43	24.60	26.61	27.17	29.57	31.97	35.76	37.99
	15 days	6.67	8.96	12.37	13.49	15.57	20.73	21.53	22.56	25.27	30.16	32.50	36.06
June	Without	5.15	6.39	9.41	12.55	15.19	15.53	17.91	19.30	23.17	26.36	31.66	32.07
	10 days	6.47	8.70	13.25	14.78	17.41	19.66	20.90	22.25	29.11	30.50	35.72	37.40
	15 days	6.47	7.70	11.30	12.73	15.07	17.47	18.47	19.90	24.64	25.33	30.16	32.80
July	Without	7.43	8.90	14.83	16.00	17.21	20.49	21.33	27.33	28.84	30.94	31.78	34.83
	10 days	8.50	9.52	14.88	16.73	18.19	19.64	22.14	26.19	28.11	31.08	33.22	37.33
	15 days	10.02	11.25	16.61	16.74	19.40	21.79	23.44	24.48	31.80	35.00	26.66	40.40
August	Without	12.02	13.53	20.81	22.61	24.98	29.50	32.16	36.90	39.27	40.22	44.05	49.84
	10 days	13.19	14.91	22.73	22.87	26.59	32.47	34.80	38.77	42.10	42.67	47.81	55.73
	15 days	13.05	14.84	22.47	23.21	27.72	32.30	36.21	39.61	41.84	44.70	48.01	54.00

The analysis of variance on the effect of season on this growth parameter conducted using the pooled data after three months, six months and 12 months indicated that the difference between the treatments was statistically significant. A graphical presentation of this aspect is given in Fig.3.

The growth rate of scion on the different treatments was compared and the linearity of the growth rate was tested using the correlation coefficient between time and extension growth of scion. It was observed that the correlation coefficients were significant and the linear nature was confirmed. Based on this finding linear regression equations were fitted to get the expected extension growth of scions (Appendix VII). The correlation observed for August grafted plants was maximum ($r = 0.997$) and so was the linear growth rate ($b = 3.503$). A pair wise comparison of the growth rate also lead to the conclusion that grafting during August resulted in better performance (Appendix VIII).

The defoliation as a pre-treatment given to the scion material had shown a positive effect on the extension growth of scion. The analysis of variance with regard to this aspect based on the pooled data as shown in Table 2b indicated statistically significant enhancement effect for the precuring of scion materials given as defoliation prior to grafting. But the difference between the two treatments where the defoliation was practised was not significant.

Table 2a. Effect of season on scion extension (data at 3 monthly intervals)

Treatments	Scion extension (cm)			
	3 month	6 month	9 month	12 month
May	12.59	21.75	26.20	35.29
June	11.32	17.55	25.64	34.09
July	15.44	20.64	29.59	37.52
August	22.00	31.42	41.07	53.19
F value	106.231**	145.361**	99.944**	106.091**
C.D.	1.302	1.401	2.024	2.433
SEm.	0.462	0.497	0.718	0.863

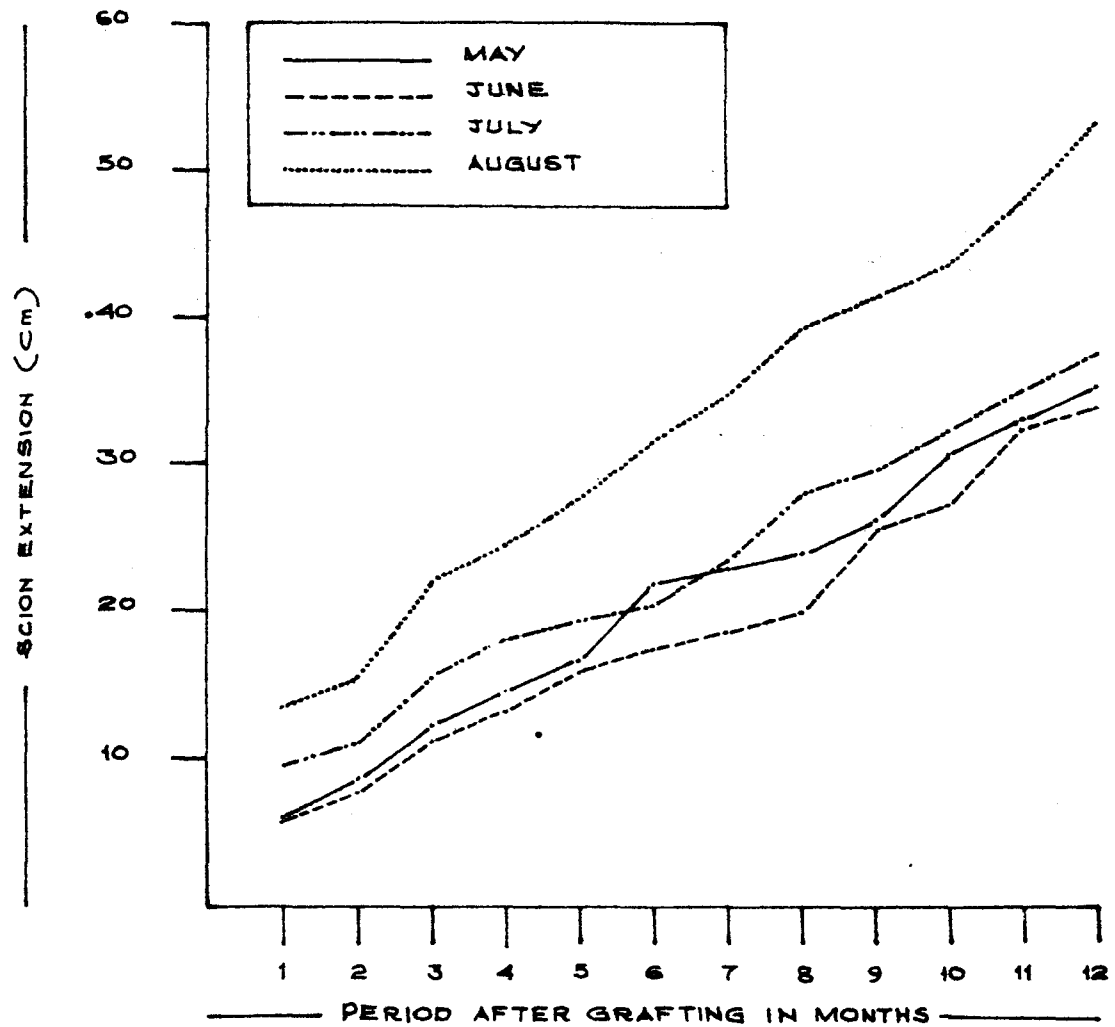
** Significant at 1% level.

Table 2b. Effect of defoliation on scion extension (data at 3 monthly intervals)

Treatments	Scion extension (cm)			
	3 month	6 month	9 month	12 month
Without	14.27	21.36	28.76	37.14
10 days	16.06	24.09	32.22	42.11
15 days	15.69	23.07	30.89	40.81
F value	5.519**	10.319**	7.877**	11.877**
C.D.	1.126	1.213	1.753	2.107
SEm.	0.400	0.430	0.622	0.748

** Significant at 1% level.

FIG. 3 EFFECT OF SEASON OF GRAFTING ON THE GROWTH OF SCION OF STONE-GRAFTS



Number of leaf

The observations recorded with regard to the number of leaves produced on grafts under various treatments at monthly intervals are presented in Table 3. The lowest number of leaves at the end of twelve months after grafting (27.86) was on the June grafted plants while the highest number of leaves (45.24) was observed on the August grafted plants.

The analysis of variance conducted based on the consolidated data as in Table 3a showed that the effect of season of grafting on the number of leaf produced on the scion was significant.

There was no marked effect for the defoliation treatments on the number of leaves produced. The analysis of variance based on the data given as in Table 3b also did not reveal any consistant trend.

Girth of stock and scion

The monthly observations recorded on these two parameters under the different treatments are shown in Table 4. The statistical comparison was done based on the consolidated data as in Table 4a. It was observed that at all the stages the girth of stock and scion was maximum when the grafting was done during August. This was confirmed by the statistical analysis which indicated highly significant difference. The ratios of the girth of stock and scion was also compared

Table 3. Effect of season of grafting and defoliation of scion shoot on number of leaves (data at monthly intervals)

Month of grafting	Precuring period	Leaves in number											
		1	2	3	4	5	6	7	8	9	10	11	12
May	Without	6.12	7.17	10.57	14.67	18.33	18.71	19.50	21.17	23.14	24.67	28.83	29.57
	10 days	6.11	6.89	10.71	12.00	15.53	18.14	19.11	20.44	22.00	25.67	28.11	30.00
	15 days	5.86	7.57	10.29	11.43	13.86	17.00	17.28	20.28	20.43	24.28	25.28	29.71
June	Without	4.37	5.00	8.29	10.37	12.62	13.29	14.12	16.87	20.71	21.75	25.75	27.00
	10 days	4.60	5.40	8.29	10.80	13.50	14.43	14.90	15.90	21.43	22.50	26.20	28.57
	15 days	4.28	4.86	8.29	9.43	11.57	13.14	14.43	15.57	20.86	21.14	25.43	28.00
July	Without	3.50	4.00	6.29	9.10	9.90	10.86	14.40	18.10	20.14	22.80	25.10	29.14
	10 days	3.40	4.00	6.86	9.10	10.50	12.71	15.40	18.80	21.14	24.20	26.50	29.28
	15 days	3.20	4.20	6.57	9.50	10.90	11.86	15.60	19.00	20.86	23.50	25.60	27.43
August	Without	4.70	5.90	11.86	14.60	16.30	19.57	25.20	29.30	30.57	35.10	39.90	42.00
	10 days	3.90	5.60	11.71	12.80	16.20	20.43	24.60	28.80	30.14	33.00	38.40	46.57
	15 days	4.40	5.80	12.27	14.50	18.30	23.00	25.70	30.70	33.14	34.80	38.50	47.14

Table 3a. Effect of season on number of leaves (data at 3 monthly intervals)

Treatments	Leaves in number			
	3 month	6 month	9 month	12 month
May	10.52	17.95	21.86	29.76
June	8.29	13.62	21.00	27.86
July	6.57	11.81	20.71	28.62
August	11.95	21.00	21.29	45.24
F value	37.165**	42.628**	46.365**	72.573**
C.D.	1.101	1.797	2.099	2.740
SEm.	0.391	0.638	0.745	0.972

** Significant at 1% level

Table 3b. Effect of defoliation on number of leaves (data at 3 monthly intervals)

Treatments	Leaves in number			
	3 month	6 month	9 month	12 month
Without	9.25	15.61	23.64	31.93
10 days	9.39	16.43	23.68	33.61
15 days	9.36	16.25	23.82	33.07
F value	0.048	0.612	0.021	1.037
C.D.	0.953	1.557	1.818	2.373
SEm.	0.338	0.552	0.645	0.842

Table 4a. Effect of season on girth of stock and scion (data at 3 monthly intervals)

Treatments	Girth in cm							
	3 month		6 month		9 month		12 month	
	Stock	Scion	Stock	Scion	Stock	Scion	Stock	Scion
May	2.03	1.90	2.34	2.11	2.54	2.30	2.81	2.54
June	2.10	2.00	2.37	2.16	2.60	2.40	2.93	2.64
July	2.16	1.97	2.39	2.16	2.61	2.37	3.00	2.70
August	2.13	1.96	2.34	2.13	2.66	2.37	3.10	2.76
F value	3.770*	3.258*	0.319	1.473	9.761**	8.731**	16.02**	14.985**
C.D.	0.067	0.058	0.075	0.053	0.082	0.064	0.085	0.068
SEm.	0.024	0.021	0.027	0.019	0.029	0.023	0.030	0.024

** Significant at 1% level.
* Significant at 5% level.

Table 4b. Effect of defoliation on girth of stock and scion (data at 3 monthly intervals)

Treatments	Girth in cm							
	3 month		6 month		9 month		12 month	
	Stock	Scion	Stock	Scion	Stock	Scion	Stock	Scion
Without	2.10	1.96	2.36	2.14	2.60	2.36	2.96	2.66
10 days	2.10	1.97	2.36	2.15	2.61	2.37	3.00	2.70
15 days	2.10	1.96	2.32	2.12	2.59	2.33	2.94	2.65
F value	0.009	0.039	0.963	0.994	0.130	1.267	1.380	1.333
C.D.	0.058	0.051	0.065	0.046	0.071	0.056	0.074	0.051
SEm.	0.021	0.018	0.023	0.016	0.025	0.020	0.026	0.021

between the treatments and it was observed that there was no remarkable difference between these ratios (Appendix IX).

The girth of the stock and scion was in no way related with the pre-treatments of the scion shoots (Table 4b).

Expt.2. Effect of age of scion

A. Sprouting and survival

Scion materials of three different ages, viz. two months, four months and six months were used to study their effect on sprouting and final survival of the grafts during June, July and August. The observations pertaining to this study may be seen in Table 5. Table 5a relates to the pooled data used for statistical interpretation and a graphical representation of that appears in Fig.4.

The results indicated that scion materials aged four months, would give higher sprouting percentage as well as better survival. A maximum of 92 per cent sprouting was recorded when grafting was done during August using four months old scion material. The highest survival percentage (74) was also recorded in this month. The sprouting and survival rate for the June and July grafted plants were also higher when four months old scions were used compared to others, although general performance was inferior compared to August grafts. The chi-square analyses of the number of sprouts as well as survival indicated highly significant difference.

Table 5. Effect of age of scion on sprouting and survival (data for different months of grafting)

Month of grafting	Age of scion	Number of grafts prepared	Sprouting percentage	Survival percentage
June	2 month	50	42	24
	4 month	50	76	42
	6 month	50	50	30
July	2 month	50	54	38
	4 month	50	84	68
	6 month	50	72	50
August	2 month	50	72	52
	4 month	50	92	74
	6 month	50	80	58

Table 5a. Effect of age of scion on sprouting and survival (pooled data)

Treatment	Number of grafts prepared	Sprouting		Survival	
		Number	Percentage	Number	percentage
2 month	150	83	55.33	57	38.00
4 month	150	126	84.00	92	61.33
6 month	150	101	67.33	69	46.00
Value of chi-square		29.01**		11.58**	

** Significant at 1% level of probability.

A pair wise comparison of the performance of grafts using scion materials of different ages also proved that the four months old scion materials are superior to others (Appendix V).

B. Growth parameters

Extension growth of scion

The observations recorded on this aspects are presented in Table 6 and pooled data used for statistical analysis appears in Table 6a.

It was observed that there was a general trend for the two month old scion materials to grow more vigrously compared to four months and six month old scion (Fig.5). From the study conducted during the months of June, July and August it was recorded that the two months old scions grafted during August showed maximum extension growth (53.80 cm) after nine months compared to June and July grafted plants (32.92 and 34.87 cm respectively). The extension growth was minimum when six months old scions were used (25.9 cm on an average). Statistical significance at 1 per cent level was also observed when treatments were compared through chi-square analyses.

The growth rate of the scion computed in the similar manner as was described earlier proved to be linear and significant in this case also (Appendix VII and VIII).

Number of leaves

In order to compare the effect of age of scions, on this parameter, the observations were recorded as in Table 7.

Table 6. Effect of age of scion shoot on extension growth of scion (data for different months of grafting recorded at monthly intervals)

Month of grafting	Age of scion	Scion extension in cm								
		1	2	3	4	5	6	7	8	9
June	2 month	9.45	12.19	15.89	18.71	21.43	24.52	26.13	29.36	32.92
	4 month	8.20	9.96	13.93	15.87	18.28	19.29	21.35	24.11	27.02
	6 month	4.87	6.51	9.37	11.28	13.43	15.86	18.16	19.91	22.07
July	2 month	8.47	10.90	15.44	18.78	22.30	24.81	28.85	31.78	34.87
	4 month	6.39	8.66	11.41	14.14	17.38	19.57	22.03	23.68	27.73
	6 month	4.76	7.06	9.30	11.88	14.72	16.22	18.36	22.15	24.23
August	2 month	13.71	18.28	26.30	28.24	31.87	37.16	39.50	42.17	53.82
	4 month	10.65	12.16	16.69	18.22	22.23	26.33	28.31	30.17	38.54
	6 month	7.84	9.38	13.02	14.47	16.74	20.90	22.59	25.96	31.40

Table 6a. Effect of age of scion shoot on extension growth of scion (pooled data at 3 monthly intervals)

Treatments	Scion extension in cm		
	3 month	6 month	9 month
2 month	19.21	28.830	40.53
4 month	14.01	21.730	31.09
6 month	10.56	17.660	25.90
F value	90.747**	199.031**	207.747**
C.D.	1.285	1.127	1.448
SEm.	0.457	0.401	0.515

** Significant at 1% level.

FIG: 4. EFFECT OF DIFFERENT AGE OF SCION ON SPROUTING AND SURVIVAL OF STONE-GRAFTS

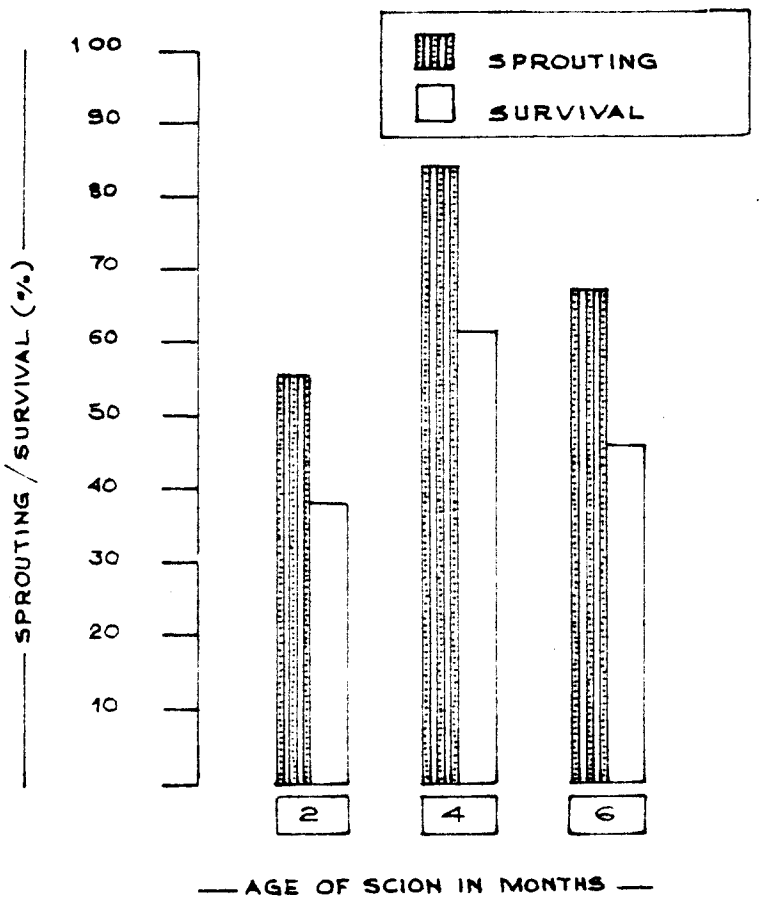
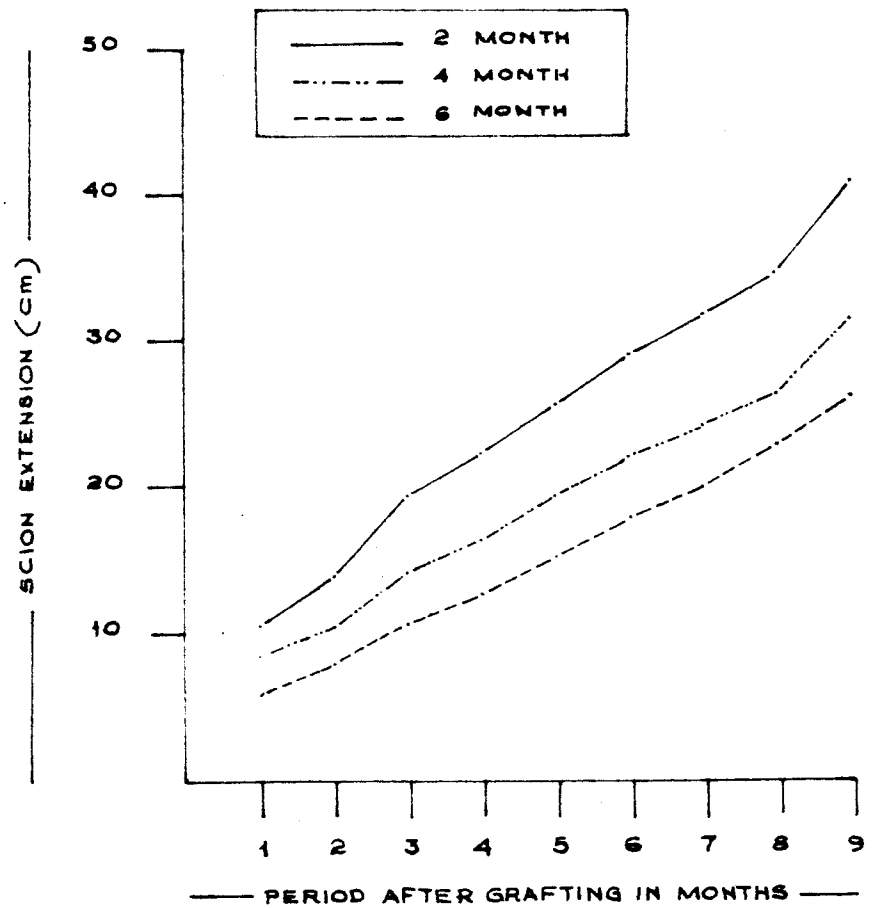


FIG: 5. EFFECT OF DIFFERENT AGE OF SCION STICK ON THE GROWTH OF SCION OF STONE-GRAFTS



From the data it could be concluded that the two month old scions were superior with the general trend in conformity with the extension growth of scion. The maximum number of leaves were produced on the grafted plants using two month old scions (32.3) while it was minimum (19.40) for June grafted plants with six month old scions. The statistical analyses of the data as indicated in Table 7a proved that there was significant effect for the age of scion on number of leaves produced.

Girth of root stock and scion

The observations collected on the girth of stock and scion as affected by the age of scion materials on the grafts have been presented in Table 8. Results indicated that a general increase on the girth of stock and scion could be observed as the age of scion material increased. The increasing trend observed for the girth parameters when seasons of grafting were compared, were similar to the observations on the other growth parameters. After a period of nine months of grafting the girth of root stock on which six months old scion materials were used for grafting measured to 2.87 cm while that of the scion was 2.7 cm. The girths of stocks and scions were lower in the other treatments corresponding to the age of scion shoots used. The statistical analyses (Table 8a) had indicated significant difference between the treatments.

Table 7. Effect of age of scion on number of leaves (data for different months of grafting at monthly intervals)

Month of grafting	Scion Age	Leaves in number								
		1	2	3	4	5	6	7	8	9
June	2 month	5.40	8.10	11.50	13.40	17.90	21.60	23.0	25.30	27.50
	4 month	4.70	6.00	8.80	10.50	13.70	17.30	17.70	20.20	22.20
	6 month	4.40	5.90	8.60	10.10	12.70	15.80	17.20	18.10	19.40
July	2 month	5.20	7.50	10.90	13.20	16.80	21.50	23.40	24.90	26.30
	4 month	4.60	6.70	9.30	11.80	14.90	17.70	19.20	20.90	22.70
	6 month	4.70	6.20	7.90	9.50	11.90	15.30	16.30	19.00	20.40
August	2 month	7.00	8.40	12.10	14.40	18.90	22.90	24.00	26.20	32.30
	4 month	7.00	8.40	11.40	13.20	16.60	20.40	22.20	23.50	28.30
	6 month	5.50	6.90	9.70	11.30	15.50	19.20	20.00	22.60	24.90

Table 7a. Effect of age of scion on number of leaves (consolidated data at 3 monthly intervals)

Treatments	Leaves in number		
	3 month	6 month	9 month
2 month	11.50	22.00	28.70
4 month	9.83	18.47	24.40
6 month	8.73	16.77	21.57
F value	15.727**	33.583**	41.675**
C.D.	0.988	1.296	1.565
SEm.	0.351	0.461	0.556

** Significant at 1% level.

Expt.3. Effect of age of root stock

A. On sprouting and survival

Sprouting and survival rates of the stone grafts were found to have a bearing on the age of stock matter used for grafting. The observations pertaining to this as shown in Table 9 and Fig.6 showed that there was a negative relationship between the age of stock and sprouting and survival percentage. Maximum sprouting as well as survival was observed in the treatments with five days old stocks. A sprouting rate 94 per cent was observed in August during which season there was 72 per cent survival. The sprouting rate decreased to 88 and 66 per cent respectively when the age of stock increased from five to 10 days and from 10 to 15 days. The trend was same during June and July endorsing the comparatively poor sprouting and survival observed during these months. These effects were also proved as statistically significant when chi-square analysis was conducted (Table 9a). The pair wise comparison of the three different age groups with reference to its effect on sprouting and survival could not prove any statistically significant difference between the effects of five days and 10 days old stocks but their differences with 15 days old stocks were statistically significant (Appendix VI).

B. On growth parameter

Extension growth of scion

The observations recorded during the course of the experiment with regard to the extension growth of scion

Table 9. Effect of age of root stocks on sprouting and survival (data for different months of grafting)

Month	Age of root-stocks	Number of grafts prepared	Sprouting percentage	Survival percentage
June	5 days	50	66	38
	10 days	50	58	32
	15 days	50	34	18
July	5 days	50	86	64
	10 days	50	74	54
	15 days	50	48	32
August	5 days	50	94	72
	10 days	50	88	64
	15 days	50	66	46

Table 9a. Effect of age of root stock on sprouting and survival (pooled data)

Treatments	Number of grafts prepared	Sprouting		Survival	
		Number	Percentage	Number	Percentage
5 days	150	123	82.0	87	58.0
10 days	150	110	73.33	75	50.0
15 days	150	74	49.33	48	32.0
Value of chi-square		39.63**		21.37**	

** Significant at 1% level of probability.

projected the already observed trend of superiority of the 5 days old stocks over others (Table 10 and Fig.7). In this case also the maximum growth was observed on August grafted plants which amounted to 43.52 cm over a period of nine months. At similar stage it was 31.08 cm for July grafted plant and 30.91 cm for June grafted plants. The extension growth observed on 10 days old and 15 days old stocks were considerably low during all the seasons. The statistical analysis on the pooled data proved this superiority (Table 10a).

Effect of age of stock on extension growth of scion were found to be linear and the students 't' test conducted to compare the three treatments indicated statistical significance. Accordingly the growth rates were computed as 3.14 for five days old root stocks, 2.51 for 10 days old and 2.29 for 15 days old stocks. It was possible to fit the linear regression equation models to give the expected growth (Appendix VII and VIII).

Number of leaves

The production of leaves recorded at monthly intervals for a period of nine months lead to the conclusion that the effect of age of stock on this parameter was similar to its effect on extension growth of scion. The number of leaves produced after nine months on the scions grafted using five days old stocks were 23.6, 22.3 and 29.5 respectively corresponding to June, July and August (Table 11). The statistical analysis also supported this finding (Table 11a).

Table 10. Effect of age of root stock on extension growth of scion (data for different months at monthly intervals)

Month	Age of root-stock	Scion extension in cm								
		1	2	3	4	5	6	7	8	9
June	5 days	6.17	8.14	11.94	13.67	18.50	20.89	23.21	27.42	30.91
	10 days	5.02	7.02	9.79	12.22	15.18	18.11	19.98	22.35	24.99
	15 days	2.36	4.05	7.03	8.19	10.45	13.98	14.54	16.50	20.37
July	5 days	9.56	11.54	13.89	17.85	20.87	23.21	25.68	28.53	31.08
	10 days	9.28	9.35	11.86	14.20	16.76	18.05	20.90	23.38	26.07
	15 days	2.45	3.74	6.55	8.86	11.37	13.47	15.82	18.42	20.58
August	5 days	13.17	14.99	19.45	21.27	24.28	29.10	32.01	34.51	43.52
	10 days	7.91	10.61	13.98	15.55	17.19	21.40	23.33	24.96	31.35
	15 days	5.29	7.28	10.78	12.31	13.96	18.10	19.36	20.77	25.24

Table 10a. Effect of age of stock on extension growth of scion (consolidated data at 3 monthly intervals)

Treatments	Scion extension in cm		
	3 month	6 month	9 month
5 days	15.09	24.40	35.17
10 days	11.87	19.19	27.47
15 days	8.12	15.18	22.06
F value	115.244**	159.80**	228.681**
C.D.	0.915	1.028	1.225
SEm.	0.325	0.366	0.436

** Significant at 1% level.

FIG: 6. EFFECT OF DIFFERENT AGE OF ROOT-STOCK ON SPROUTING AND SURVIVAL OF STONE-GRAFTS

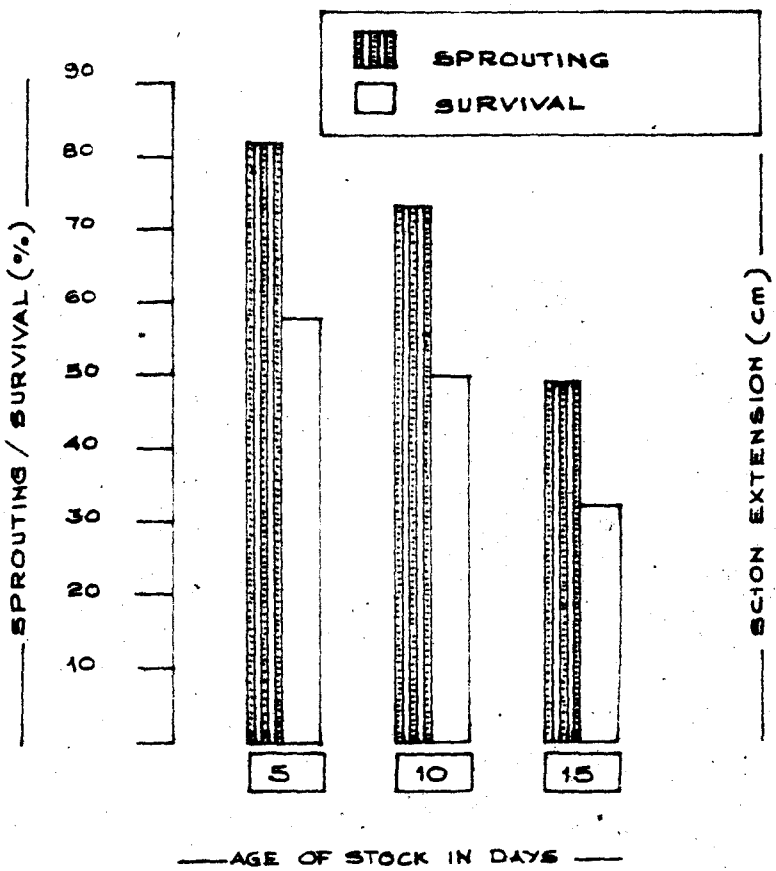


FIG: 7 - EFFECT OF DIFFERENT AGE OF ROOT-STOCK ON THE GROWTH OF SCION OF STONE-GRAFTS

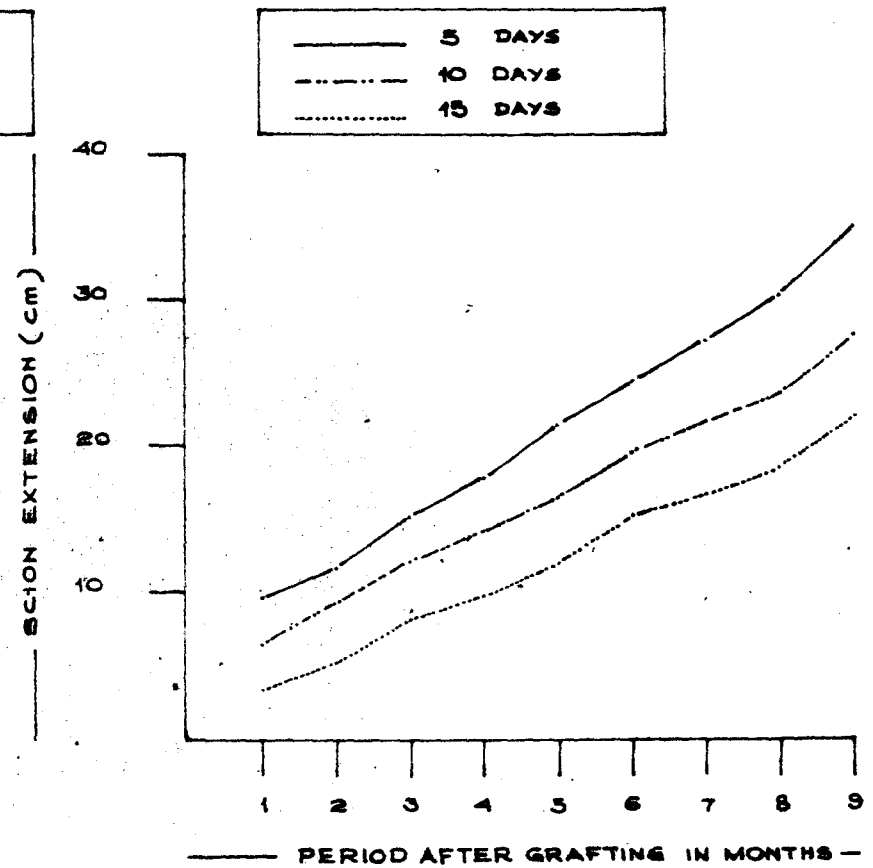


Table 11. Effect of age of stock on number of leaves (data for different months at monthly intervals)

Month	Age of stocks	Leaves in number								
		1	2	3	4	5	6	7	8	9
June	5 days	5.2	6.5	9.5	10.6	15.0	18.1	19.0	21.5	23.6
	10 days	4.4	5.9	7.4	9.4	12.0	15.9	16.3	17.7	20.0
	15 days	3.5	4.8	7.1	7.6	9.2	12.6	13.0	14.4	17.6
July	5 days	5.1	6.5	8.6	12.2	15.0	18.0	19.3	20.8	22.3
	10 days	4.6	6.2	8.5	10.2	13.0	14.8	16.9	18.5	18.9
	15 days	4.2	5.3	7.7	8.8	11.9	12.3	14.1	16.3	16.9
August	5 days	6.9	7.7	11.4	12.8	16.6	21.3	21.8	23.6	29.5
	10 days	6.1	6.9	10.7	12.4	16.3	20.1	21.0	22.1	25.1
	15 days	5.5	6.6	9.7	11.2	14.4	18.3	18.7	19.6	21.3

Table 11a. Effect of age of root stock on number of leaves (pooled data at 3 monthly intervals)

Treatments	Leaves in number		
	3 month	6 month	9 month
5 days	9.83	19.13	25.13
10 days	8.87	16.93	21.33
15 days	8.17	14.80	18.60
F value	7.292**	41.692**	45.403**
C.D.	0.872	1.032	1.370
SEm.	0.310	0.367	0.487

** Significant at 1% level.

Girth of stock and scion

The girth of the stock and scion measured 1 cm below and above the graft union at monthly intervals have been recorded in Table 12. The data showed that both the parameters were inversely related with the age of stock. The grafting done during the most congeneal season i.e. August using five days old stock gave the maximum growth interms of girth of stock and scion (2.72 and 2.52 cm respectively). It was 2.60 and 2.43 cm respectively when 10 days old stocks were used while with 15 days old stocks it was 2.41 and 2.32 cm.

The analysis of variance on the pooled data had shown significance at 1 per cent level (Table 12a) and the 5 days old stock were superior to others both in terms of girth of stock as well as scion.

II. Veneer grafting

Expt.1. Effect of season and defoliation of scion shoots

A. Effect of season and defoliation on sprouting and survival.

Veneer grafting trials were conducted for a period of 12 months using scion materials with and without defoliation treatments to study their effects on the sprouting and survival rate. The data given in Table 13 shows the observations on sprouting and survival of the grafts.

Effect of season

Sprouting percentage was maximum during the period between July to November during which it ranged from 84 to 96 per cent when defoliation was done as pre-treatment. Under similar circumstances grafting conducted during December-June period gave 42 to 76 per cent sprouting only. With regard to the final survival of the grafts judged after 90 days of grafting the range was between 40 and 64 per cent during July-November period with the precured scion materials while it was between 18 and 36 per cent during December-June period. During all the months grafting conducted with scion materials without pretreatment gave very poor sprouting as well as survival.

Month-war pooled data regarding the number of sprouting and survival was statistically analysed and the significant influence of the season of grafting on these two aspects were confirmed (Table 13a). A pair-wise comparison of the number of sprouts and survival as shown in Appendix X indicated the difference between August, September and October were not significant.

The correlation of weather parameters such as mean maximum temperature, mean minimum temperature, mean relative humidity, mean rainfall and number of rainy days during the 12 months period with sprouting and survival percentages were worked out. It was observed that a significant negative correlation exists between sprouting and survival percentages

Table 13. **Effect of season of grafting and defoliation of scion shoot on sprouting and survival** of veneer grafts

Month	Precuring period	Number of grafts prepared	Sprouting percentage	Final survival percentage
January	Without	50	18	12
	10 days	50	48	24
	15 days	50	44	18
February	Without	50	20	12
	10 days	50	42	20
	15 days	50	46	20
March	Without	50	28	14
	10 days	50	68	26
	15 days	50	68	24
April	Without	50	22	12
	10 days	50	60	20
	15 days	50	68	22
May	Without	50	26	14
	10 days	50	60	26
	15 days	50	60	22
June	Without	50	28	18
	10 days	50	70	40
	15 days	50	76	36
July	Without	50	36	22
	10 days	50	84	24
	15 days	50	84	40
August	Without	50	38	28
	10 days	50	88	56
	15 days	50	90	52
September	Without	50	48	36
	10 days	50	94	64
	15 days	50	96	60
October	Without	50	34	22
	10 days	50	90	56
	15 days	50	88	52
November	Without	50	36	22
	10 days	50	86	44
	15 days	50	90	44
December	Without	50	20	14
	10 days	50	64	34
	15 days	50	64	28

FIG: 8. EFFECT OF RELATIVE HUMIDITY (R.H.) AND MAXIMUM TEMPERATURE ON SPROUTING AND SURVIVAL OF VENEER-GRAFTS

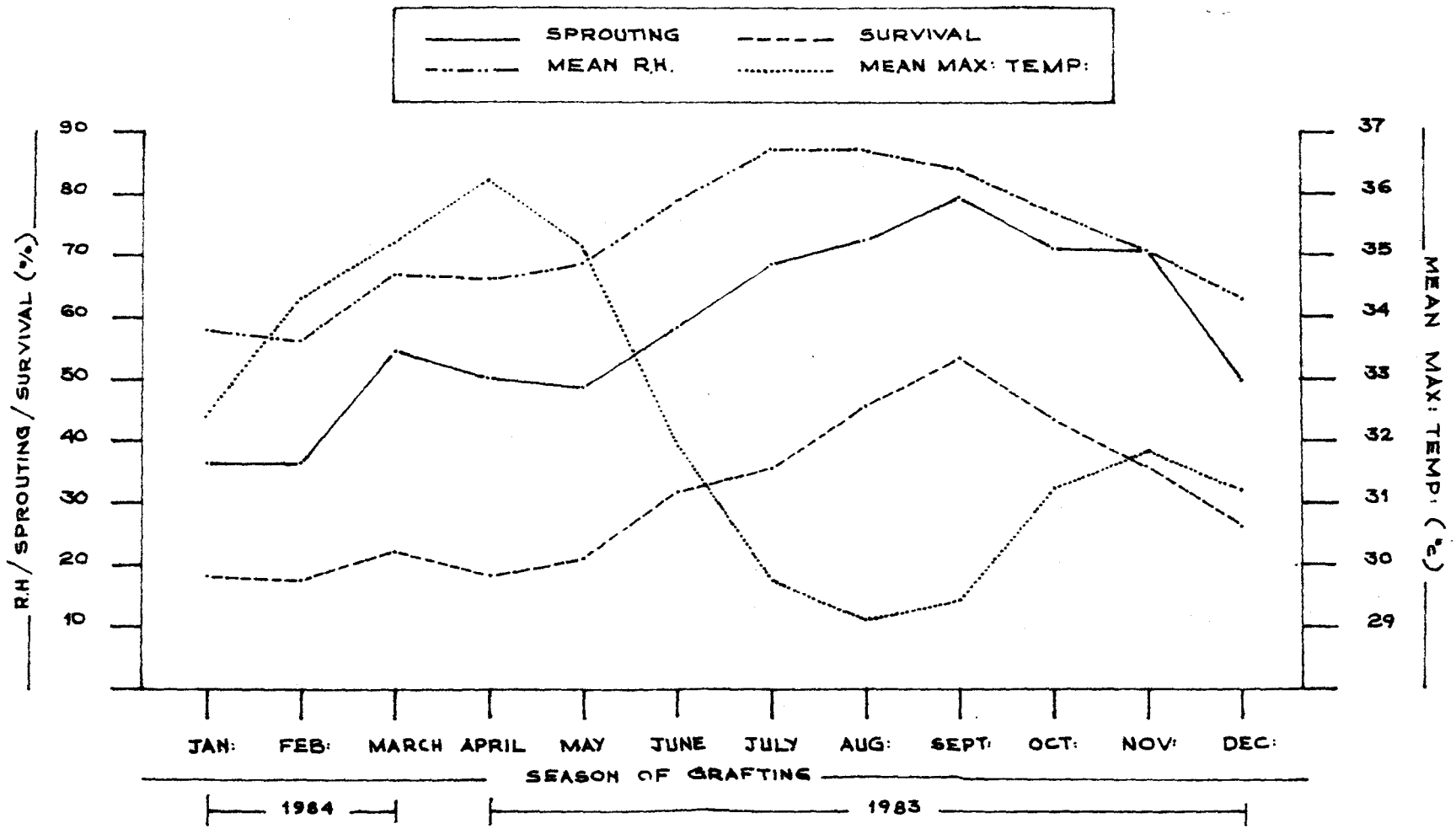


Table 13a. Effect of season on sprouting and survival

Treatments	Number of grafts prepared	Sprouting		Survival	
		Number	Percentage	Number	Percentage
January	150	55	36.67	27	18.00
February	150	54	36.00	26	17.33
March	150	82	54.67	32	21.33
April	150	75	50.00	27	18.00
May	150	73	48.67	31	20.67
June	150	87	58.00	47	31.33
July	150	102	68.00	53	35.33
August	150	108	72.00	68	45.33
September	150	119	79.33	80	53.33
October	150	106	70.67	65	43.33
November	150	106	70.67	55	36.67
December	150	74	49.33	38	25.33
Value of chi-square		113.60**		113.20**	

** Significant at 1% level of probability.

Table 13b. Effect of defoliation of scion shoot on sprouting and survival

Treatments	Number of grafts prepared	Sprouting		Survival	
		Number	Percentage	Number	Percentage
Without	600	177	29.50	113	18.83
10 days	600	427	71.16	227	37.83
15 days	600	437	72.83	209	34.83
Value of chi-square		296.61**		99.54**	

** Significant at 1% level of probability.

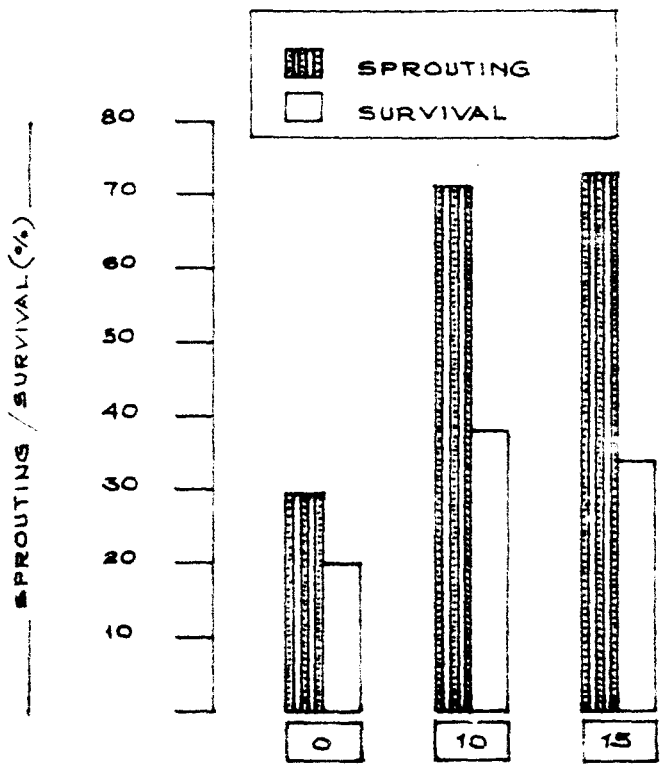
and mean maximum temperature while mean relative humidity, mean rainfall and number of rainy days exhibited positive correlation (Appendix XIII and Fig.8).

Effect of defoliation

The precuring of scion materials by prior defoliation was found to enhance the rate of sprouting and consequently the final survival. As it is evident from the data from Table 13, the sprouting and survival percentages during June-November period were considerably higher when the precured scion materials were used for grafting compared to the treatments which involved no precuring. The sprouting percentage for the treatment without precuring was 29.5 on an average with a final survival of 18.83 per cent. The corresponding figures with 10 days prior defoliation were 71.16 and 37.83 per cent. With 15 days prior defoliation there were 72.83 and 34.83 per cent (Table 13b). An overall picture of the effect of defoliation is shown graphically in Fig.9.

The chi-square analyses employed to detect the comparative superiority of individual precuring treatments over others proved that both the treatments involving defoliation as a pretreatment gave better sprouting as well as survival compared to that without precuring. But when the difference among the two defoliated treatments, viz. 10 and 15 days were compared no statistical significance was observed (Appendix XI).

FIG. 9 - EFFECT OF DEFOLIATION OF SCION SHOOTS ON SPROUTING AND SURVIVAL OF VENEER-GRAFTS



B. Effect of season and defoliation on growth parameters

Extension growth of scion

The monthly increments in the extension growth of scion materials grafted during the three months period have been inscribed in Table 14. The extension growth with respect to different seasons of grafting were compared using the average rate of extension of scion as shown in Table 14a. It was observed that the extension growth during the period between April and July was considerably lower (6.54 to 9.92 cm) compared to the period August and March with extension growth ranging between 14.47 and 18.77 cm. The analysis of variance indicated statistical significance for the effect of seasons on extension growth of scion at 1 per cent level.

The data given in Table 14 and the treatment wised pooled data with respect to defoliation appearing under Table 14b showed that the defoliation as a pretreatment for the scion materials had apperently no effect on their extension growth.

Number of leaves

Table 15 describes the effect of season and defoliation of scion shoots on the number of leaves produced. The average number of leaves produced during the first three months after grafting, when compared indicated similar trend to that observed for the extension growth of scion. The number of leaves produced during April-July period were minimum compared

Table 14. Effect of season of grafting and defoliation of scion shoots on extension growth of scion (data at monthly intervals)

Month of grafting	Precuring period	Scion extension in cm		
		1	2	3
January	Without	10.27	14.87	18.38
	10 days	9.82	14.52	16.68
	15 days	8.45	13.60	16.92
February	Without	11.15	15.35	18.56
	10 days	11.36	14.92	18.43
	15 days	11.22	15.42	19.30
March	Without	9.03	12.75	17.43
	10 days	9.04	12.67	18.50
	15 days	8.75	11.45	16.62
April	Without	2.32	4.55	6.38
	10 days	2.05	4.16	6.40
	15 days	1.95	4.33	6.85
May	Without	3.27	5.93	10.10
	10 days	2.72	4.52	6.62
	15 days	3.10	5.76	7.08
June	Without	3.57	5.60	7.37
	10 days	3.19	5.27	7.43
	15 days	3.12	5.20	7.67
July	Without	4.17	7.62	10.08
	10 days	5.10	7.77	9.90
	15 days	5.06	7.66	9.78
August	Without	9.78	11.97	15.95
	10 days	8.78	11.44	16.87
	15 days	8.81	10.98	14.63
September	Without	11.71	15.06	15.53
	10 days	13.01	16.21	16.86
	15 days	12.42	15.08	16.61
October	Without	11.75	13.10	14.68
	10 days	12.30	13.88	15.68
	15 days	11.92	13.43	15.15
November	Without	9.43	13.18	15.12
	10 days	10.91	11.72	14.15
	15 days	9.95	10.80	14.15
December	Without	8.17	9.00	14.45
	10 days	6.58	8.86	15.48
	15 days	6.05	8.12	14.73

Table 14a. Effect of season on extension growth of scion (pooled data after 3 months of grafting)

Treatments	Scion extension (cm)
January	17.34
February	18.77
March	17.52
April	6.54
May	7.93
June	7.49
July	9.92
August	15.82
September	16.33
October	15.17
November	14.47
December	14.89
F value	125.283**
C.D.	1.072
SEm.	0.387

** Significant at 1% level.

Table 14b. Effect of defoliation on extension growth of scion (pooled data after 3 months of grafting)

Treatments	Scion extension (cm)
Without	13.67
10 days	13.58
15 days	13.29
F value	1.064
C.D.	0.536
SEm.	0.193

Table 15. **Effect of season and defoliation of scion shoots on number of leaves** (data at monthly intervals)

Months of grafting	Procuring period	Leaves in number		
		1	2	3
January	Without	5.33	10.00	12.83
	10 days	5.80	10.00	11.00
	15 days	5.67	10.50	12.00
February	Without	6.50	9.00	12.00
	10 days	6.00	8.00	11.00
	15 days	6.20	8.60	11.83
March	Without	5.00	6.67	10.67
	10 days	5.28	7.57	11.67
	15 days	4.17	6.33	11.50
April	Without	2.80	3.00	4.83
	10 days	3.00	3.40	4.00
	15 days	2.67	3.33	4.67
May	Without	3.33	4.33	6.50
	10 days	3.00	4.00	5.33
	15 days	3.60	4.40	5.66
June	Without	3.25	4.00	5.67
	10 days	3.12	3.50	5.17
	15 days	3.33	3.89	5.50
July	Without	3.75	6.25	7.00
	10 days	2.70	4.40	6.16
	15 days	3.20	4.70	6.18
August	Without	4.00	6.28	10.00
	10 days	4.00	6.20	10.17
	15 days	3.70	6.20	10.17
September	Without	4.00	6.25	10.17
	10 days	3.90	5.10	10.33
	15 days	3.30	8.90	11.00
October	Without	2.83	4.00	10.50
	10 days	3.30	5.80	11.33
	15 days	2.90	4.00	10.50
November	Without	3.67	4.83	9.83
	10 days	3.60	4.00	9.83
	15 days	3.90	4.80	9.83
December	Without	3.75	6.00	9.83
	10 days	4.60	5.60	10.00
	15 days	3.80	4.80	9.33

Table 15a. Effect of season on number of leaves (pooled data after 3 months of grafting)

Treatments	Number of leaves
January	11.94
February	11.61
March	11.27
April	4.50
May	5.83
June	5.44
July	6.44
August	10.11
September	10.50
October	10.79
November	9.83
December	9.72
F value	52.45**
C.D.	1.020
SEm.	0.368

** Significant at 1% level.

Table 15b. Effect of defoliation on number of leaves (pooled data after 3 months of grafting)

Treatments	Number of leaves
Without	9.15
10 days	8.83
15 days	9.01
F value	0.759
C.D.	0.510
SEm.	0.184

Table 16. Effect of season of grafting and defoliation of scion shoots on stock and scion girth (data at monthly intervals)

Months of grafting	Precuring period	Girth in cm					
		1		2		3	
		Stock	Scion	Stock	Scion	Stock	Scion
January	Without	2.27	2.07	2.37	2.13	2.48	2.30
	10 days	2.20	2.02	2.30	2.10	2.31	2.20
	15 days	2.28	2.12	2.37	2.18	2.42	2.33
February	Without	2.35	2.15	2.35	2.20	2.50	2.30
	10 days	2.32	2.14	2.34	2.18	2.47	2.28
	15 days	2.28	2.10	2.32	2.16	2.40	2.25
March	Without	2.37	2.23	2.40	2.27	2.43	2.32
	10 days	2.40	2.27	2.46	2.33	2.57	2.42
	15 days	2.45	2.28	2.50	2.33	2.57	2.42
April	Without	2.34	2.05	2.35	2.05	2.38	2.15
	10 days	2.22	2.00	2.22	2.04	2.35	2.07
	15 days	2.22	2.00	2.25	2.02	2.30	2.07
May	Without	2.23	2.03	2.27	2.03	2.35	2.11
	10 days	2.17	1.95	2.23	1.98	2.28	2.05
	15 days	2.16	1.94	2.20	1.96	2.27	2.00
June	Without	2.12	1.90	2.17	1.90	2.23	2.07
	10 days	2.17	2.00	2.19	2.01	2.30	2.08
	15 days	2.14	1.95	2.17	2.01	2.23	2.05
July	Without	2.27	2.02	2.30	2.10	2.36	2.15
	10 days	2.34	2.13	2.37	2.16	2.40	2.18
	15 days	2.31	2.09	2.34	2.13	2.35	2.18
August	Without	2.30	2.10	2.36	2.11	2.40	2.20
	10 days	2.30	2.11	2.36	2.16	2.38	2.15
	15 days	2.30	2.11	2.34	2.13	2.42	2.21
September	Without	2.26	2.06	2.31	2.11	2.35	2.13
	10 days	2.32	2.09	2.36	2.13	2.42	2.17
	15 days	2.21	2.09	2.35	2.13	2.40	2.18
October	Without	2.35	2.13	2.40	2.17	2.43	2.20
	10 days	2.28	2.10	2.32	2.11	2.37	2.17
	15 days	2.26	2.09	2.29	2.11	2.32	2.13
November	Without	2.37	2.12	2.38	2.13	2.42	2.22
	10 days	2.26	2.09	2.28	2.11	2.40	2.17
	15 days	2.27	2.09	2.30	2.12	2.35	2.17
December	Without	2.27	2.10	2.40	2.15	2.40	2.18
	10 days	2.34	2.16	2.38	2.20	2.45	2.25
	15 days	2.30	2.12	2.38	2.16	2.47	2.25

Table 16a. Effect of season on girth of stock and scion (pooled data 3 months after grafting)

Treatments	Girth in cm	
	Root stock	Scion
January	2.41	2.25
February	2.46	2.29
March	2.52	2.38
April	2.34	2.09
May	2.30	2.06
June	2.16	2.07
July	2.37	2.17
August	2.39	2.19
September	2.39	2.16
October	2.37	2.17
November	2.39	2.18
December	2.44	2.23
F value	7.370**	18.799**
C.D.	0.071	0.060
SEm.	0.026	0.022

** Significant at 1% level.

Table 16b. Effect of defoliation on girth of stock and scion (pooled data after 3 months of grafting)

Treatments	Girth in cm	
	Root stock	Scion
Without	2.40	2.20
10 days	2.39	2.18
15 days	2.37	2.18
F value	0.812	0.743
C.D.	0.035	0.030
SEm.	0.013	0.011

to the rest of the seasons. The statistical significance of this observation was also proved through analysis of variance (Table 15a).

The results also indicated that number of leaves produced on the scion had no relationship with the defoliation treatments for the scion material (Table 15b).

Girth of stock and scion

The observations on girth paramters of stock and scion were recorded for a period of three months after grafting in order to judge the effect of season and defoliation of scion on these (Table 16, 16a and 16b). The observations lead to a general conclusion that season of grafting could influence the growth of stock and scion in terms of girth which was found to be significant. But the defoliation of scion could not exhibit any commandable effect on these parameters.

Expt.2. Effect of age of scion

A. Sprouting and survival

In order to study the effect of age of scion on sprouting and survival trials were conducted with scions of two months, six months and 12 months age during June, July and August period. The observations pertaining to this study have been included in Table 17. The chi-square analyses was conducted on the pooled data as shown in Table 17a. Appendix XIV gives pair-wise comparison through chi-square analysis. There is also a pictorial representation of this aspect Fig.10.

Table 17. Effect of age of scion on sprouting and survival (data for different months)

Month	Age of scion	Number of grafts prepared	Sprouting percentage	Survival percentage
June	2 month	50	26	12
	6 month	50	62	34
	12 month	50	46	24
July	2 month	50	46	20
	6 month	50	80	46
	12 month	50	68	36
August	2 month	50	56	32
	6 month	50	96	56
	12 month	50	72	44

Table 17a. Effect of age of scion on sprouting and survival

Treatments	Number of grafts prepared	Sprouting		Survival	
		Number	Percentage	Number	Percentage
2 month	150	64	42.67	32	21.33
6 month	150	119	79.33	68	45.33
12 month	150	93	62.00	52	34.67
Value of chi-square		42.56**		19.39**	

** Significant at 1% level of probability.

FIG: 10. EFFECT OF DIFFERENT AGE OF SCION SHOOTS ON SPROUTING AND SURVIVAL OF VENEER-GRAFTS

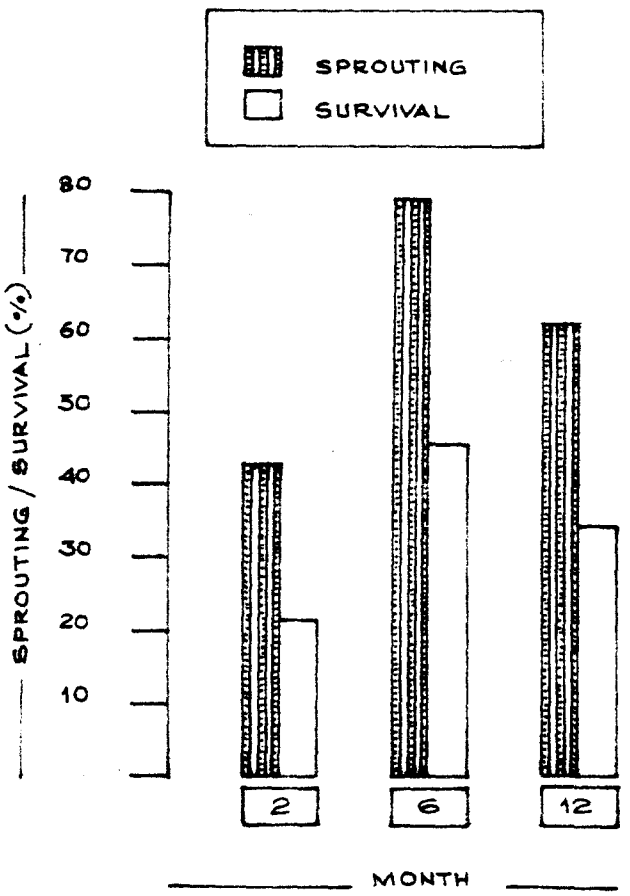
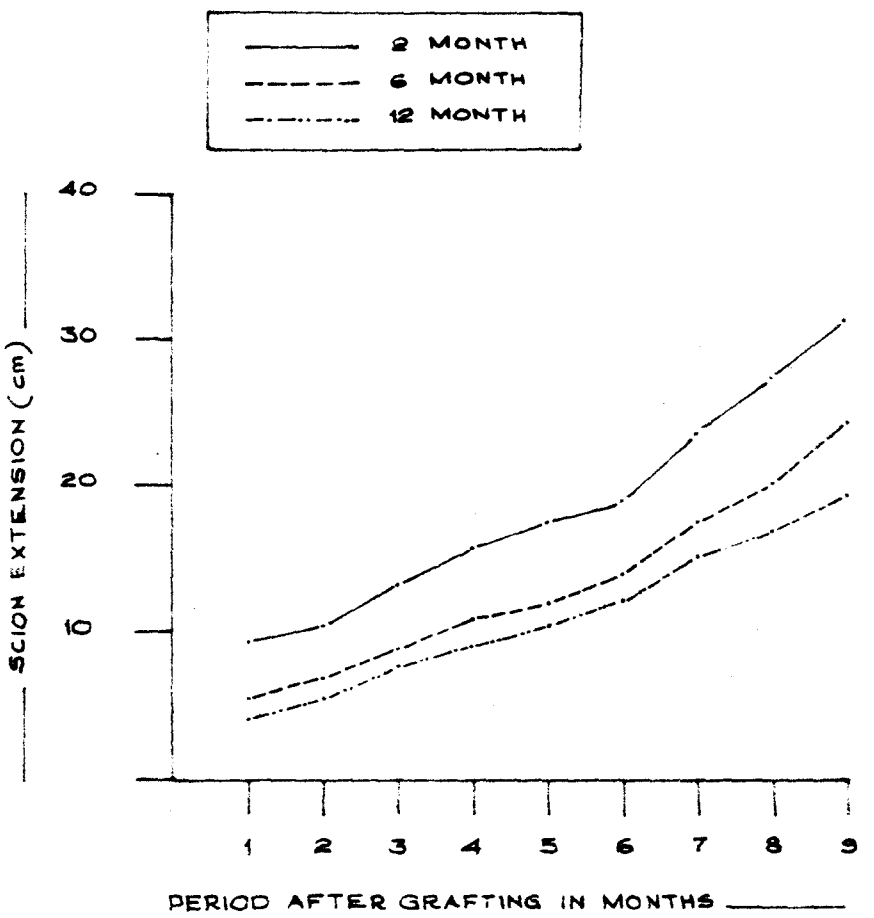


FIG: 11 - EFFECT OF DIFFERENT AGE OF SCION SHOOTS ON SCION GROWTH OF VENEER-GRAFTS



The results indicated that the sprouting and survival percentages were maximum when 6 month old scion shoots were used for grafting irrespective of the season. A maximum sprouting of 96 per cent was obtained on the August grafted plants with 6 month old scions compared to 56 per cent with two month old scions and 72 per cent with 12 month old scions. The final survival judged after 90 days of grafting was to the tune of 56, 32 and 44 per cent respectively. The trend was similar during other months also.

The chi-square analyses of the data as in Table 17a put this observation, on affermative. The pair-wise comparison showed that performance of 6 month old scions were significantly superior to that of two and 12 months old scions.

B. Growth parameters

Extension growth of scion

The extension growth of scion was followed for a period of nine months on the experimental plants where scions of two month, six months and 12 months of age were used for grafting (Table 18 and Fig.11). The older scion materials putforth correspondingly lower scion extension. The extent of growth was recorded as 39.58, 28.57 and 24.28 cm for the two months, six months and 12 months old scion respectively grafted during August.

The Table 18a which shows the consolidated data and the details of statistical analysis substantiates the age effect of scion on its extension growth after grafting.

Table 18. Effect of age of scion on extension growth of scion (data for different months at monthly intervals)

Month of grafting	Age of scion	Scion extension in cm								
		1.	2.	3	4	5	6	7	8	9
June	2 month	6.37	7.75	11.17	12.67	15.47	17.37	19.75	20.72	23.70
	6 month	3.50	4.92	5.83	8.70	10.18	11.08	12.67	15.40	16.33
	12 month	2.11	3.51	4.92	6.62	7.89	10.58	11.57	12.42	15.53
July	2 month	8.13	9.36	10.32	14.08	15.55	16.65	21.65	26.65	30.58
	6 month	5.05	6.60	8.53	11.11	12.48	14.48	17.93	20.57	28.18
	12 month	3.31	4.83	7.47	8.94	11.00	13.22	14.94	17.50	18.20
August	2 month	13.33	14.47	18.78	20.66	21.64	22.83	29.34	34.56	29.58
	6 month	7.97	8.99	12.30	13.20	14.00	15.42	21.35	24.58	28.57
	12 month	6.70	7.98	10.75	11.77	12.38	13.23	19.32	21.12	24.28

Table 18a. Effect of age of scion on extension growth of scion (consolidated data at 3 monthly intervals)

Treatments	Scion extension in cm		
	3 month	6 month	9 month
2 months	13.42	18.95	31.29
6 months	8.89	13.83	24.36
12 months	7.71	12.34	19.34
F value	35.587**	32.879**	74.426**
C.D.	1.440	1.722	2.010
SEm.	0.505	0.604	0.706

** Significant at 1% level.

It was possible to describe the growth behaviour of scion based on the age of scion materials since it was found that the growth rate was a linear function of the age of scion. The maximum growth rate (2.7) in this case coincided with the minimum aged scion (Appendix XIX and XX).

Number of leaves

The data presented in Table 19 shows the number of leaves produced during the course of 9 months after grafting when scions of different ages were used. The observations followed a similar pattern of that of the extension growth of scion with a maximum number of 25.5 leaves recorded on August grafted plants using two months old scions. Corresponding figures with six months and twelve months old scions were 21.83 and 20.33. A further evaluation of this observation done through a analysis of variance of the pooled data as in Table 19a confirmed the finding that two months old scion could produce more number of leaves compared to others.

Girth of stock and scion

The girth of stock and scion as affected by the age of scion materials used for grafting was recorded for a period of nine months as in Table 20. It was observed that the age of scion had a positive influence on these parameters. Under the present study it was shown that when 12 months old scions were used, the girth of stocks and scions were more. The data were put under statistical analysis which indicated that the

Table 19. Effect of age of scion on number of leaves (data for different months at monthly intervals)

Month of grafting	Age of scion	Leaves in number								
		1	2	3	4	5	6	7	8	9
June	2 month	4.00	5.00	6.67	7.75	9.50	10.67	11.75	13.50	16.50
	6 month	3.40	4.70	5.00	7.10	7.00	7.50	9.80	12.80	13.33
	12 month	3.75	4.00	4.50	6.62	7.25	8.33	9.62	10.25	10.83
July	2 month	4.70	5.80	8.00	10.90	11.80	13.17	18.10	21.80	22.83
	6 month	4.50	5.90	7.50	9.00	10.00	13.00	14.60	15.60	21.83
	12 month	4.10	4.90	6.83	7.30	8.50	10.50	11.90	14.60	16.83
August	2 month	4.00	4.40	9.17	10.30	10.50	12.50	17.80	21.70	25.50
	6 month	3.90	4.20	7.50	8.30	9.00	12.17	16.60	18.50	21.83
	12 month	3.70	4.10	7.67	7.50	8.30	11.50	15.40	16.00	20.33

Table 19a. Effect of age of scion on number of leaves (consolidated data at 3 monthly intervals)

Treatments	Number of leaves		
	3 month	6 month	9 month
2 month	7.94	12.11	21.61
6 month	6.67	10.89	19.00
12 month	6.33	10.11	16.00
F value	6.906**	6.129**	24.389**
C.D.	0.922	1.160	1.619
SEm.	0.324	0.407	0.569

** Significant at 1% level.

observations recorded were significant (Table 20a).

Expt. 3. Effect of age of stock

A. Sprouting and survival

The material under investigation for studying the effect on sprouting and survival of veneer grafts consisted of three months, 14 months and 26 months old root stocks. The observations on these aspects recorded as in Table 21 and evaluation of which was done after consolidating it as in Table 21a provided the following details.

The sprouting and survival percentages were maximum when 14 months old root stocks were used for grafting (Fig.12). Both sprouting as well as final survival decreased as the age of root stock fluctuated towards either side. In cases where three months old stocks were used the final survival was very low that it never came above 18 per cent. With the 26 month old root stocks the final survival was 44 per cent compared to 62 per cent survival obtained when 14 months old stocks were used from the September grafts. The statistical evaluation through chi-square analysis also confirmed these views. The pair-wise comparison was conducted, the details of which appears in Appendix XV, showed that 14 months old root stocks gave best results among the treatments.

B. Growth parameters

Extension growth of scion

The effect of age of root stocks on the scion extension

Table 21. Effect of age of root stock on sprouting and survival (data for different months of grafting)

Month of grafting	Age of root-stock	Number of grafts prepared	Sprouting percentage	Survival percentage
August	3 month	50	30	16
	14 month	50	82	58
	26 month	50	56	40
September	3 month	50	28	18
	14 month	50	92	62
	26 month	50	80	44
October	3 month	50	24	12
	14 month	50	84	50
	26 month	50	74	36

Table 21a. Effect of age of root stock on sprouting and survival (consolidated data)

Treatments	Number of grafts prepared	Sprouting		Survival	
		Number	Percentage	Number	Percentage
3 month	150	41	27.33	23	15.33
14 month	150	129	86.00	85	56.67
26 month	150	105	70.00	60	40.00
Value of chi-square		116.10**		55.45**	

** Significant at 1% level of probability.

FIG: 12 EFFECT OF DIFFERENT AGE OF ROOT-STOCK ON SPROUTING AND SURVIVAL OF VENEER-GRAFTS

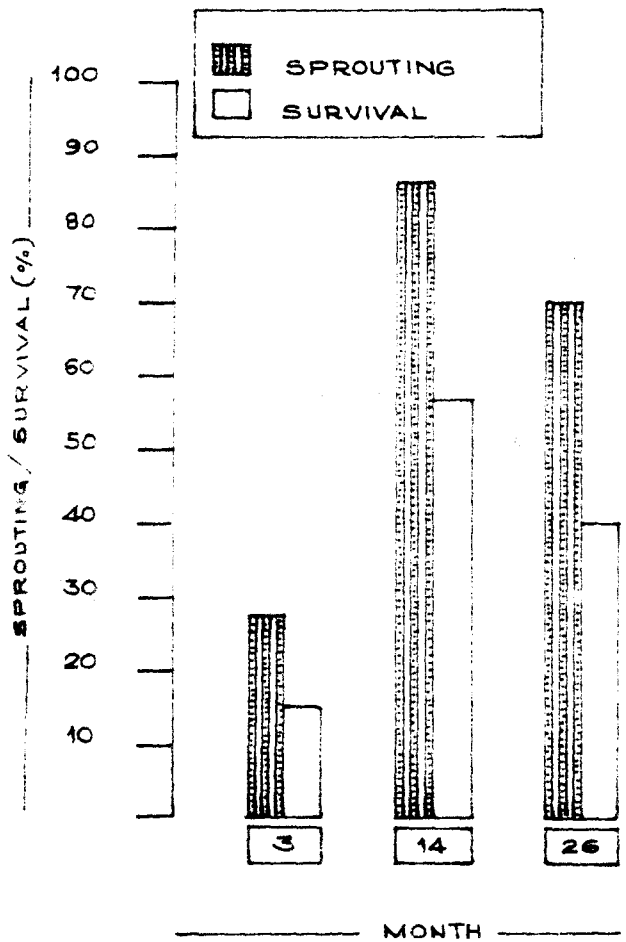
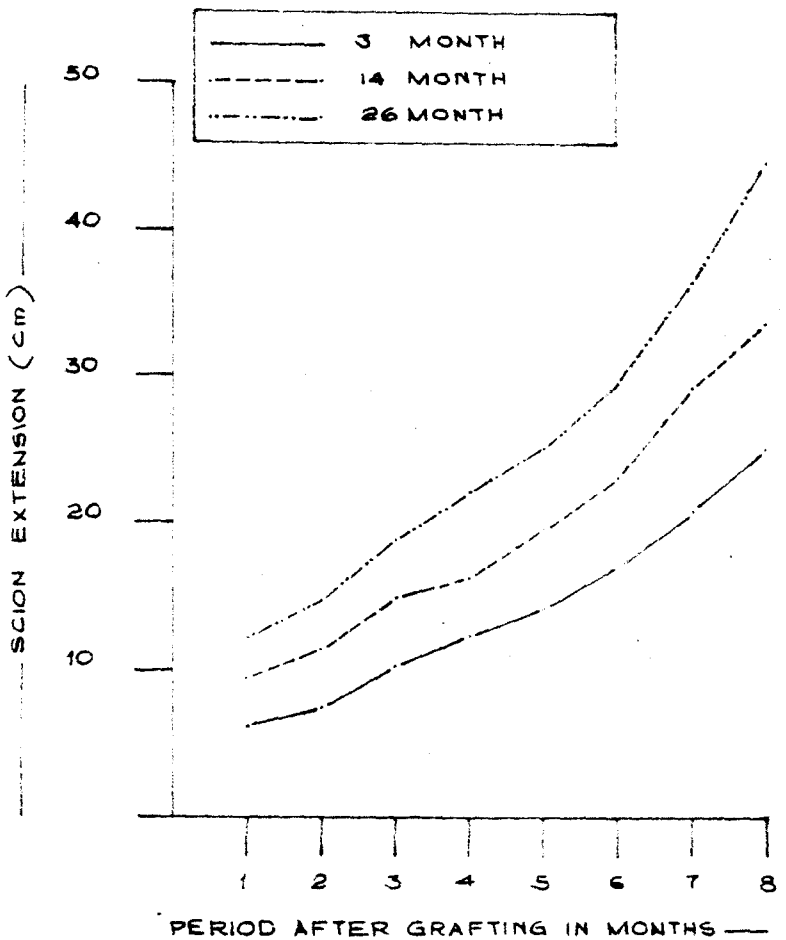


FIG: 13 - EFFECT OF DIFFERENT AGE OF ROOT-STOCK ON SCION GROWTH OF VENEER-GRAFTS



was monitered for a period of eight months after grafting. The data on which aspects have been presented in Table 22 with a graphical representation in Fig.13.

It was observed that the 26 months old root stocks used for grafting resulted in more scion extension growth compared to three months and 14 months old stocks. A maximum elongation measuring to 48.78 cm was observed after eight months on these root stocks on the October grafts, while that on three months old stocks and 14 months old stocks were 27.28 and 39.53 cm in the September grafts (Table 22).

The statistical analysis conducted with the pooled data as in Table 22a adopting the principles of analysis of varience indicated that 26 month old root stock gives better performance interms of scion extension.

The growth rate computed after examining the linearity of the response of scion extension to the age of root stocks, which was proved by the statistical significance of 't' values (Appendix XX), was recorded as 4.39 with 26 months old stocks, 3.41 with 14 months old stocks and 2.6 with three month old stocks. Regression equations were formulated to explain these effects as in (Appendix XIX).

Number of leaves

The data pertaining to the number of leaves produced in the experimental material with the treatments under consideration over a period of eight months have been recorded in Table 23

Table 22. Effect of age of root stock on extension growth of scion (data for different months at monthly intervals)

Month of grafting	Age of root-stock	Scion extension in cm							
		1	2	3	4	5	6	7	8
August	3 month	5.35	6.52	9.25	9.63	10.58	11.92	15.41	19.58
	14 month	8.30	9.42	12.82	13.22	14.54	15.92	21.97	23.27
	26 month	13.84	15.98	18.28	22.82	23.51	25.29	31.29	38.17
September	3 month	7.08	8.54	11.31	13.82	15.21	19.23	22.47	27.78
	14 month	10.44	12.41	16.12	17.97	22.10	26.61	31.81	39.53
	26 month	12.00	14.49	18.33	21.55	25.63	30.46	37.35	46.68
October	3 month	6.57	8.00	10.35	13.53	17.07	20.60	24.22	27.65
	14 month	9.47	12.51	15.83	17.52	22.18	26.97	34.28	37.98
	26 month	10.85	13.98	17.63	21.32	25.90	32.49	40.39	48.78

Table 22a. Effect of age of root stock on extension growth of scion (consolidated data after four and eight months of grafting)

Treatments	Scion extension (cm)	
	4 month	8 month
3 month	12.33	25.00
14 month	16.23	33.59
26 month	21.89	44.54
F value	79.063**	187.771**
C.D.	1.541	2.036
SEm.	0.541	0.715

** Significant at 1% level.

Table 23. Effect of age of root stock on number of leaves (data for different months at monthly intervals)

Month of grafting	Age of stock	Leaves in number							
		1	2	3	4	5	6	7	8
August	3 month	3.62	4.50	6.00	6.50	6.75	9.50	13.25	16.17
	14 month	4.50	5.10	7.40	7.83	8.70	12.40	17.00	17.50
	26 month	4.50	5.00	8.80	9.50	9.60	14.50	19.90	22.33
September	3 month	4.71	6.00	8.71	16.67	11.86	16.00	17.71	21.17
	14 month	4.80	7.00	11.10	13.33	17.50	20.90	22.60	27.16
	26 month	5.00	7.20	10.60	14.17	17.00	22.70	25.70	32.17
October	3 month	4.25	5.00	8.25	10.67	14.00	14.95	18.75	20.67
	14 month	4.80	7.80	10.70	12.17	16.90	19.40	23.50	24.50
	26 month	4.30	7.60	11.60	15.83	20.30	23.40	27.10	30.33

Table 23a. Effect of age of root stock on number of leaves (consolidated data after 4 and 8 months of grafting)

Treatments	Number of leaves	
	4 month	8 month
3 month	9.28	19.33
14 month	11.11	23.06
26 month	13.17	28.28
F value	13.310**	40.047**
C.D.	1.519	2.022
SEm.	0.533	0.710

** Significant at 1% level.

with its modified form used for statistical analysis appended as Table 23a.

In general, it was observed that the scion grafted on older stocks produced more number of leaves with the maximum number observed on the 26 month old stocks in this case. The findings were similar to those observed under the scion extension.

Girth of stock and scion

Table 24 shows the recording based on month-war observations on girth parameters of stock and scion when stocks materials of different ages were used. The results obtained kept parity with the results from its effects on scion extension and number of leaves i.e. when the 26 months old stocks were used the girth of stock and scion were higher compared to three and 14 months old stocks. The analysis of these data as in Table 24a also lead to similar conclusion.

Expt. 4. Varietal response

On sprouting and survival

This study was conducted with the intention of observing the varietal response when grafting was done on common mixed root stocks employing scion materials from the available six varieties of mango. The grafting trials conducted with these varieties during June, July and August recorded sprouting and final survival rates as in Table 25. Observing the graphical presentation (Fig.14) of the general trend it was evident that from among the six varieties,

Table 25. Effect of different varieties on sprouting and survival (data for different months)

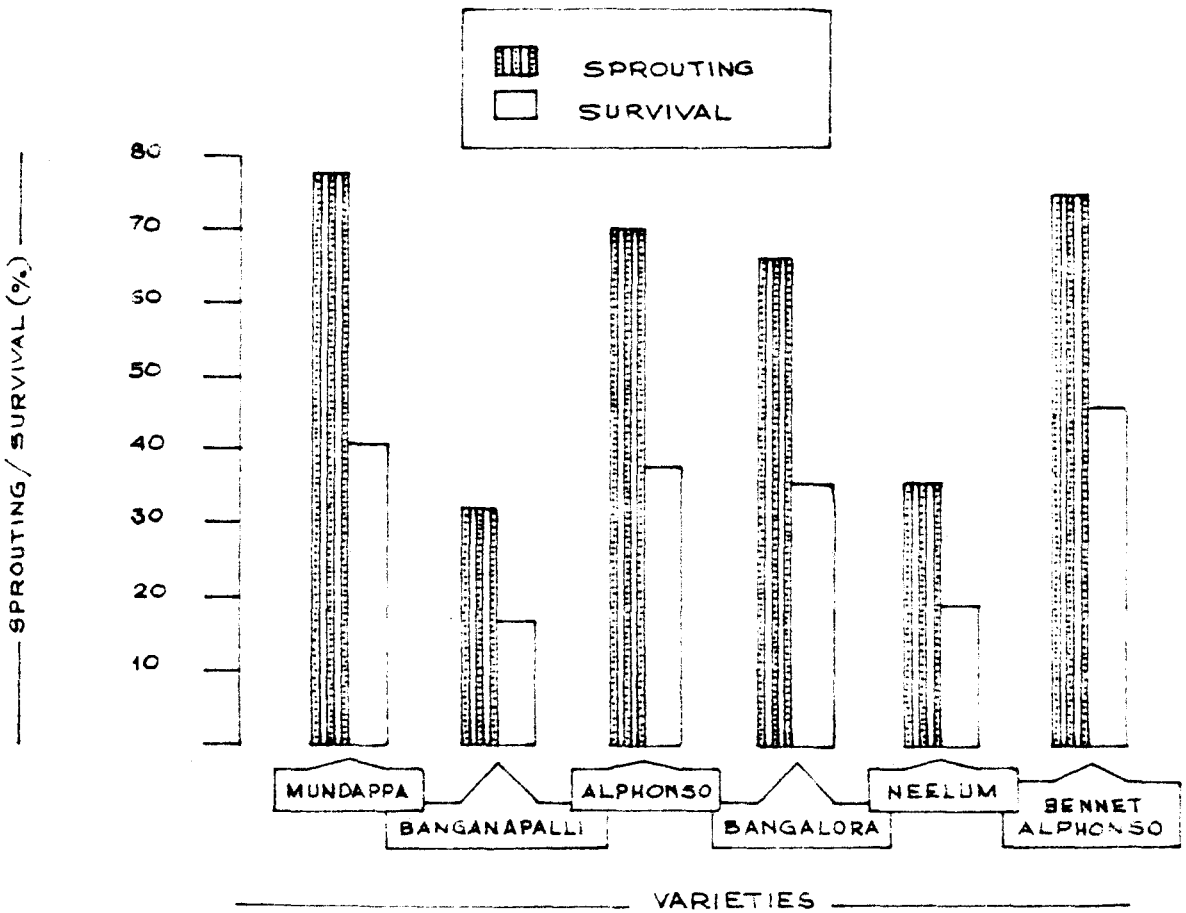
Months	Varieties	Number of grafts prepared	Sprouting percentage	Final survival percentage
June	Mundappa	50	66	30
	Banganapalli	50	22	12
	Alphonso	50	56	26
	Bangalora	50	44	22
	Neelum	50	26	14
	Bennet Alphonso	50	54	24
July	Mundappa	50	78	42
	Banganapalli	50	34	18
	Alphonso	50	76	40
	Bangalora	50	74	36
	Neelum	50	42	20
	Bennet Alphonso	50	80	50
August	Mundappa	50	88	50
	Banganapalli	50	40	20
	Alphonso	50	78	46
	Bangalora	50	80	48
	Neelum	50	38	22
	Bennet Alphonso	50	90	64

Table 25a. Effect of varieties on sprouting and survival (consolidated data)

Treatments	Number of graft prepared	Sprouting		Survival	
		Number	Percentage	Number	Percentage
Mundappa	150	116	77.33	61	40.67
Banganapalli	150	48	32.00	25	16.67
Alphonso	150	105	70.00	56	37.33
Bangalora	150	99	66.00	53	35.33
Neelum	150	53	35.33	28	18.67
Bennet Alphonso	150	112	74.67	69	46.00
Value of chi-square		126.734**		49.44**	

** Significant at 1% level of probability.

FIG. 14. EFFECT OF VARIETIES ON SPROUTING AND SURVIVAL OF VENEER-GRAFTS



Mundappa, Bennet Alphonso, Alphonso and Bangalora gave better results. The performance by Banganapalli and Neelum were very poor.

The chi-square analyses indicated that the varietal response was statistically significant (Table 25a). On an average the variety Mundappa gave a maximum of 77.33 per cent sprouting and 40.67 per cent final survival. The lowest results were obtained from Banganapalli which gave 32 per cent sprouting and 16.67 per cent final survival. Considering the final survival alone, Bennet Alphonso excelled with 46 per cent.

The pair-wise comparisons through chi-square (Appendix XVI) indicated that the performance of Mundappa was significantly better than Banganapalli, Bangalora and Neelum interms of sprouting and Banganapalli and Neelum interms of final survival. Alphonso and Bennet Alphonso were on par with Mundappa.

Expt. 5. Effect of duration of storage of scion sticks

Under this experiment the effect of three storage duration, under two different conditions of storage provided for scion materials with fresh defoliation and to those with ten days prior defoliation, on sprouting and survival of the grafts were studied. Tables 26, 26a, 27 and 27a give the observations recorded under this study. It was observed that storage of any kind done on scion materials with or without

Table 26. Effect of duration of storage of fresh scion sticks on sprouting and survival

Month of grafting	Wrapping materials	Storage duration	Number of grafts prepared	Sprouting percentage	Survival percentage
June	Gunny bag with moss	3 days	50	24	16
		6 days	50	28	16
		9 days	50	22	14
	Polythene with moss	3 days	50	22	12
		6 days	50	18	10
		9 days	50	20	12
July	Gunny bag with moss	3 days	50	32	18
		6 days	50	36	20
		9 days	50	28	16
	Polythene with moss	3 days	50	24	14
		6 days	50	26	14
		9 days	50	22	10
August	Gunny bag with moss	3 days	50	46	26
		6 days	50	52	30
		9 days	50	42	22
	Polythene with moss	3 days	50	32	20
		6 days	50	32	18
		9 days	50	24	14

Table 26a. Effect of duration of storage of fresh scion sticks (data for statistical analysis)

Treatments	June grafting				July grafting				August grafting			
	Gunny bag + moss		Polythene + moss		Gunny bag + moss		Polythene + moss		Gunny bag + moss		Polythene + moss	
	Sprouting No.	Survival No.	Sprouting No.	Survival No.	Sprouting No.	Survival No.	Sprouting No.	Survival No.	Sprouting No.	Survival No.	Sprouting No.	Survival No.
3 days	12	8	11	6	16	9	12	7	23	13	16	10
6 days	14	8	9	5	18	10	13	7	26	15	16	9
9 days	11	7	10	6	14	18	11	5	21	11	12	7
Value of chi-square	0.502	0.103	0.250	0.133	0.735	0.271	0.219	0.482	1.017	0.832	1.029	0.651

which are non significant

Table 27. Effect of duration of storage of prior defoliated scion sticks on sprouting and survival

Month of grafting	Wrapping materials	Storage duration	Number of grafts prepared	Sprouting percentage	Survival percentage
June	Gunny bag with moss	3 days	50	30	16
		6 days	50	26	12
		9 days	50	24	12
	Polythene with moss	3 days	50	24	14
		6 days	50	18	12
		9 days	50	22	10
July	Gunny bag with moss	3 days	50	46	22
		6 days	50	42	22
		9 days	50	32	18
	Polythene with moss	3 days	50	38	18
		6 days	50	32	16
		9 days	50	26	12
August	Gunny bag with moss	3 days	50	66	32
		6 days	50	58	28
		9 days	50	38	20
	Polythene with moss	3 days	50	60	24
		6 days	50	42	20
		9 days	50	34	16

Table 27a. Effect of duration of storage of prior defoliated scion sticks (data for statistical analysis)

Treatments	June grafting				July grafting				August grafting			
	Gunny bag + moss		Polythene + moss		Gunny bag + moss		Polythene + moss		Gunny bag + moss		Polythene + moss	
	Sprouting No.	Survival No.	Sprouting No.	Survival No.	Sprouting No.	Survival No.	Sprouting No.	Survival No.	Sprouting No.	Survival No.	Sprouting No.	Survival No.
3 days	15	8	12	7	23	11	19	9	33	16	30	12
6 days	13	6	9	6	21	11	16	8	29	14	21	10
9 days	12	6	11	5	16	9	13	6	19	10	17	8
Value of chi-square	0.477	0.461	0.556	0.526	2.166	0.325	1.654	0.718	11.018**	1.908	7.155*	1.00

** Significant at 1% level of probability.

* Significant at 5% level of probability.

pre-treatment decreased the sprouting as well as survival percentages compared to what had been obtained under similar circumstances with fresh scion materials earlier. In general the sprouting and survival decreased as the period of storage increased. But statistical analysis proved that the rate of decrease were not significant in most cases excepting for the August season sprouts for prior defoliated scion sticks.

When the two methods of storage i.e. gunny bag with moss and Polythene with moss were compared, irrespective of the type of scion used, it was found that storage in the gunny bag-moss medium was better (Appendix XVII).

Expt. 6. Effect of in situ, polybag and modified trench grafting

Table 28 shows the sprouting and survival percentages recorded under the three treatments conducted over a period of three months. The observations lead to the conclusion that the survival percentage of veneer grafts could be substantially improved by adopting the modified trench method of grafting. When the three treatments were compared it was observed that the differences between them were statistically significant (Table 28a). On an average the veneer grafting conducted in situ gave a final survival rate of 7.33 per cent, while grafting conducted in poly bags gave 21.33 per cent survival and the modified trench method gave 31.33 per cent survival (Fig.15).

Table 28. Effect of in situ, polybag and modified trench grafting on sprouting and survival (data for different months)

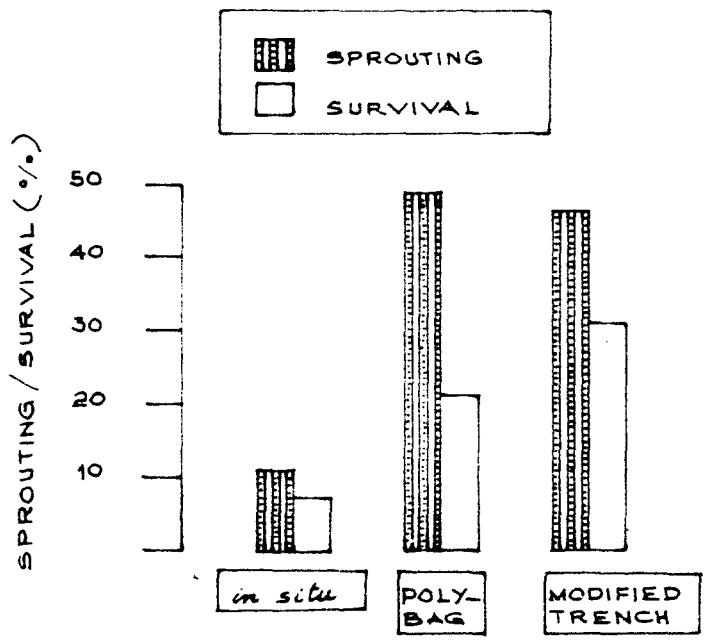
Month of grafting	Method of raising stocks	Number of grafts prepared	Sprouting percentage	Survival percentage
January	in situ	50	6	4
	Polybag	50	46	22
	Modified tecnch	50	48	30
February	in situ	50	10	6
	Polybag	50	40	18
	Modified trench	50	44	30
March	in situ	50	16	12
	Polybag	50	60	24
	Modified trench	50	48	34

Table 28a. Effect in situ, polybag and modified trench grafting on sprouting and survival (consolidated data)

Treatments	Number of grafts prepared	Sprouting		Survival	
		Number	Percentage	Number	Percentage
in situ	150	16	10.67	11	7.33
Polybag	150	73	48.67	32	21.33
Modified trench	150	70	46.67	47	31.33
Value of chi-square		60.047**		27.25**	

** Significant at 1% level of probability.

FIG: 15 - EFFECT OF *in situ* POLY BAG AND MODIFIED TRENCH GRAFTING ON SPROUTING AND SURVIVAL OF VENEER-GRAFTS



When the treatments were compared in a pair-wise manner, it was observed that interms of final survival modified trench method of grafting was significantly superior to both the polybag method as well as the *in situ* method (Appendix XVIII). The poor percentage of success of grafting in this experiment might be due to unprecedented drought that occurred.

Discussion

DISCUSSIONS

Among the fruit crops of India, mango has received major attention of research workers. The varietal wealth of mango in the country is so unparalleled that perhaps no other fruit has such a large number of distinct varieties. Hundreds of these varieties are still being maintained, a marvel which has been made possible through vegetative means of propagation.

Of the several methods of vegetative propagation, the more commonly adopted methods in mango are inarching, side grafting, veneer grafting, stone grafting and budding. Of these, the concepts of stone grafting and veneer grafting have come to the picture only in recent times but have struck with highly promising results.

Inspite of the proven superiority of stone grafting or veneer grafting over other methods, their adoption for commercial production of mango grafts in Kerala has not made any headway. The few isolated attempts on veneer and stone grafting made in mango in Kerala have been sporadic in nature which lacked any systematic approach. The need for a detailed investigation on these two important methods of propagation in mango therefore appeared necessary before any final word could be said on their feasibility under our conditions.

The present series of studies are the first of its kind done in Kerala on the above lines and have yielded valuable

results. The results of the studies are discussed here under.

1. Effect of season and defoliation

The effect of season on the success of vegetative propagation in tropical fruit is well established (Naik, 1941; Singh, 1952; Asadullah and Khan, 1960; Maijhail and Singh, 1962; Ahmad, 1964; Mukherjee and Majumder, 1964; Sukla, 1964; Talukdar and Ahmad, 1965; Bhan et al. 1968; Limaye and Phadnis, 1968; Majumder and Rathore, 1970; Gunjate et al. 1976; Amin, 1978; Damodaran et al. 1979; Mandal, 1979; Pandey et al. 1979; Upadhya and Gupta, 1979; Dengale, 1980; Harmekar, 1980; Nagwekar, 1981; Daulta and Chauhan, 1982 and Gunjate et al. 1982).

The present study lead to the conclusion that the best season for stone grafting was August which was closely followed by July when a success of 69.33 per cent and 56.00 per cent (Table 1a) was obtained respectively. During the months of May and June the percentage of success was as low as 20 to 28 which clearly indicated that the season of operation is highly critical for the ultimate success of stone grafting.

During the four month studies, the mean maximum temperature was lowest (28.9° C) in August. From the results of the study it would appear that a mean maximum temperature of above 30° C is unfavourable for stone grafting. It was also found that the fluctuation in the mean maximum and minimum temperatures was comparatively lesser during the month of August which favoured for better 'take'. Likewise a humidity

lower than 85 per cent reduced the success considerably. The influence of weather parameters like humidity and temperature on the success of stone grafting has been observed by Patel and Amin (1976). In their experiments they found that a range of temperature between 23.15°C and 25.87°C was the most favourable. In studies on the effect of humidity on healing of apple grafts, Shippy (1930) found that air moisture level below the saturation point inhibited callus formation and the cells desicated faster as the humidity dropped.

Veneer grafting although was found feasible all the year round, the most favourable months were August, September and October during which period a success of 43 to 53 per cent (Table 13a) was obtained. The success was significantly correlated with weather parameters like temperature and humidity. A temperature range between 23°C to 31°C appeared to be most congenial for success of veneer grafting. The studies also showed that when the relative humidity fell below 77 per cent the success was considerably reduced. Singh *et al.* (1983) observed that the minimum temperature and rainfall had pronounced effect on the success of veneer grafting in mango. They obtained highest success (75 to 92 per cent) during rainy season in Lucknow.

Stone grafting appeared to be most suitable for Kerala conditions from the point of percentage success in comparison

to veneer grafting. However, the time of operation in stone grafting being highly restricted, veneer grafting has the advantage that it could be done over a longer period of two to three months.

Precuring of scion materials by way of defoliation prior to grafting proved to be a definitely advantageous over the fresh scion materials in both stone and veneer grafting. In both these cases defoliation 10-15 days ahead of grafting significantly increased the ultimate success (Table 1b and 13b; Fig.2 and 9). In the defoliation treatments, viz. 10 days and 15 days the success ranged from 47.50 to 49.50 per cent and 34.83 to 37.83 for stone and veneer grafting respectively. In case where scion were used fresh without precuring the success limited to 33.50 per cent for stone grafting and 18.83 per cent for veneer grafting. It was possible to conclude from the above results that grafting using precured scions during the most favourable season ultimately decided the success. Many workers who have found similar effects for the defoliation treatments have reasoned this phenomenon to the increased meristimatic activity in the axillary and terminal bud regions (Munch, 1930; Singh and Khan, 1943; Zimmerman, 1958b, Jindal, 1968; Teotia and Mayurya, 1970; Rajput and Haribabu, 1971; Kashyap et al. 1972; Persai, 1974; Singh and Srivastava, 1979; Maiti and Biswas 1980; Singh and Srivastava, 1981 and Nagabhusanam, 1982). According to Mukherjee and Majumder (1964) similar effects could be obtained when scion

materials with swollen buds were used for grafting. The findings of the present study further confirmed the beneficial effects of defoliation especially towards activation of buds. In tropics like Kerala where humidity and warm temperature prevail through out the year, mango seldom remains in an inactive condition. The possibility of obtaining the scion materials with naturally activated axillary buds do not therefore exist and thus a treatment which could lead to forced activation of the buds could be advantageous. According to Ram and Bist (1982) predefoliated scions also suffer less from desication than the freshly defoliated scions.

Precuring of scions although profoundly influenced the ultimate success of grafting, the use of fresh scions without precuring also resulted in some degrees of success. The success of 33.50 per cent in stone grafting and 18.83 per cent in veneer grafting indicates that under situation where precuring cannot be carried out, fresh scions will be useful materials for grafting in mango. When scions have to be collected from distant places, especially from isolated grown up trees, precuring becomes an impracticable proposition. Between stone grafting and veneer grafting, stone grafting is more preferable in such a situation.

The evaluation of season and defoliation treatments were carried out further by judging the growth rate of scion after grafting. In the case of stone grafts the comparative

superiority of grafts produced in August (53.19 cm after 12 month of grafting) over other months was evident in this respect (Table 2a). A better growth rate was observed for the veneer grafts grafted between August and March (14.47 to 18.77 cm after three month of grafting) although the summer months were most unfavourable from the point of view of success. The period between December and March coincides with the emergence of flushes in mango, and probably the scions collected during this period might have contributed towards the higher growth rate of the grafts. The period which gives a maximum 'take' with satisfactory growth is the one to be reckoned in judging the suitability of any method of propagation. Judged from the points the period between August and October would be the most suitable for veneer grafting under humid high rainfall conditions of Kerala.

Defoliation also favoured the growth rate of scions in stone grafts (Table 2b). This might be due to the fact that the scion materials with already activated buds loose no time in putting forth growth, whereas in the case of the undefoliated scion materials this time lag is comparatively more.

2. Effect of age of scion and stocks

The age of scion and stock was also found to be one of the determining factors for the success of both stone and veneer grafts. It was observed from the present study that in the case of stone grafting the four months old scion on five days

old root stocks to be the best i.e. 61.33 per cent (Table 5a and Fig.4). In stone grafts four months old scions attained more or less the same thickness of the root stocks at the time of grafting. The similarity in the thickness of stock and scion might be one of the favourable factors for the proper fitting of root stock and scion at the time of operation. According to Rajput and Haribabu (1971) for the success in stone grafting in mango the scion and the stock should be plump, vigrous and preferably of similar thickness. Singh and Srivastava (1981) also pointed out that the higher success in stone grafting obtained with four months old scions could perhaps be attributed to the ready to use reserves available with the sprouting root stocks.

In the case of veneer grafting a combination of 14 months old stock and six months old scion yielded best survival rate of 45.33 per cent (Table 17a and Fig.10). As in the case of stone grafting, the scion and stocks come to the same thickness during this period. The tight fitting of both stock and scion perhaps would have contributed a better success in this case. Singh and Srivastava (1979) also indicated that scion should fit tightly with stock, which activated the cambial activity resulting in better union.

An evaluation of the growth rate of grafts based on the scions of different age groups also yielded interesting conclusions. In stone grafting between the different age

groups of scion, two month old scion proved to be superior (Table 6a, Fig.5). Maximum extension of 40.53 cm was observed after nine months of grafting. Similarly younger the root-stocks the better was the scion growth (Table 10a and Fig.7). The best growth of 35.17 cm was obtained with five days old stocks compared to older stocks. An evaluation based on the growth of grafts alone may lead to a faulty conclusions. For commercial adoption of a practice the percentage of success forms a basic consideration. An optimum sized (35-40 cm) grafts (Plate IX) will be preferable to large sized onces which possess problems of handling. From these points stone grafting on five days stock with four months scion in August would be the most preferable.

In the case of veneer grafting the best growth of scion (44.54 cm after eight months of grafting) was obtained when 26 months old stock was grafted with six months old scions (Table 22a and Fig.13). However, on an over all analysis of the factors like percentage of success, age of stocks and scions and the extension growth of scion, the choice falls on six months old scion veneer grafted on 14 month old stocks, which resulted 39.53 cm (Table 22 and Plate XXI) in eight months. Many authors have attributed the increased growth rate observed when very young scion shoots and older root stock materials are used, to the higher meristimatic activity in the former and the established root system in the latter (Uradya, 1976; Prasad et al. 1973; Gunjate et al. 1976; Dhakal, 1979).

3. Varietal response

The adaptability of a particular method of grafting on a wider scale in mango depends upon its suitability in a wide range of varieties. Varietal response to grafting in mango has been noted in the several experiments conducted earlier (Ahmad, 1964; Kukherjee and Majumder, 1964; Talukdar and Ahmad, 1965; Jagirdar et al. 1968; Dhakal, 1979; Maiti and Biswas, 1980; Singh and Srivastava, 1981).

In the present study scion materials from six different varieties when veneer grafted showed that the resultant success ranged from 16 to 46 per cent (Table 25a). This would mean that all other factors being favourable a wrong variety can upset the success of the method. The differential response of varieties might have some relationship with the growing habit or other genetic factors of the tree. Mukherjee and Majumder (1964) observed that the success in veneer grafting in mango depended upon the active growing phase of the mother trees. Maiti and Biswas (1980) found varietal variation in epicotyl grafts also.

From the results of the present study it would be stated that veneer grafting is suitable for varieties like Mundappa, Bennet Alphonso, Bangalora and Alphonso under Kerala conditions. However, a detailed evaluation by further experiments with a large number of varieties will be of considerable interest.

4. Effect of storage of scion

The storage trials conducted during this experiment showed that the scions of mango cannot be stored successfully with any of the storage condition tried for more than nine days. Even within three days under the best storage condition (gunny bag moss medium) the percentage of success was reduced to 26 to 32 (Tables 26 and 27) in comparison to 45 per cent (Table 13a) in the case of fresh scions. The advantages of using the gunny bags for storing scion sticks as observed in the present study were also reported by Ram and Bist (1982) when scion sticks have to be transported from long distances, short time storage will become necessary and under such conditions storing in gunny bags will be the most useful method. The storage trials on scion materials conducted by earlier workers (Srivastava, 1962; Majumder et al. 1972; Uradya, 1976; Singh and Srivastava, 1978 and Kanwar and Singh, 1981) had also showed varying degree of success with stored scion sticks.

5. Effect of in situ, poly bag and modified trench grafting

Gunjate and Limaye (1978) reported that the modified trench method as a cheaper and effective means to improve grafts 'take' in veneer grafts. The results of the present study using root stocks raised in situ (bed), poly bag and modified trench method also confirmed that keeping the seedlings raised in poly bags, in trenches increased the graft take.

The initial success evaluated 35 days after grafting showed no significant difference between poly bag and modified trench method 48.67 and 46.67 per cent respectively at the time of sprouting (Table 28a). The final percentage of survival however, was more in the case of modified trench method (31.33 per cent) compared to seedlings raised in poly bag alone (21.33 per cent) which indicated that post sprouting mortality was considerably reduced when the grafts in poly bags were kept in trenches. In the case of root stocks raised in situ the grafting was done in the open which obviously reduced the final success to 7.3 per cent compared to other two methods.

The above results perhaps indicate that by providing appropriate environmental conditions and modifying the method of raising root stocks, veneer grafting could be done with higher degree of success even in summer months. A uniformly controlled conditions such as mist chamber or green house may provide a suitable environment for veneer grafting on commercial basis all the year round.

The preceeding results arrived from the series of experiments as explained hitherto lead one to the conclusion that both stone grafting and veneer grafting could be adopted successfully for propagation of mango in Kerala. The factors like season/environmental conditions especially in terms of

the optimum temperature and humidity, precuring of scions, stage of growth of scion and stock, varieties and method of raising root stocks are the critical factors which decide the ultimate success. Unlike in the case of approach grafting, which could be done with a higher degree of success even by a novice, stone grafting and veneer grafting are delicate operations to be conducted by experienced hands under proper technical supervision. Observation made on the grafts have indicated that pests and diseases (Plate X) can also become serious problems during the course of the growth of grafts especially in the early stages. This aspect needs detailed investigation. A suitable control measure may increase the percentage of success further. Similarly field establishment studies will be necessary for deciding the performance of stone/veneer grafts.

Summary

SUMMARY

A series of experiments on stone grafting and veneer grafting in mango were under taken at the Department of Pomology and Floriculture, College of Horticulture, Vellanikkara from May 1982 to June 1984, to standardise these techniques under Kerala conditions. The findings obtained during the course of studies are summarised below.

1. Stone grafting was conducted during the months (May-August) and within this narrow span of time, August was found to be the best month for this operation in mango. Grafting during this month gave a maximum survival of 69.33 per cent. Survival was minimum when stone grafting was done during May (20.66 per cent). Veneer grafting also revealed significant influence of the season on this aspect. The maximum 'take' (53.33 per cent) was recorded during September grafting and the minimum survival (17.33 per cent) was noted during February. However, veneer grafting could be commercially practiced from July to November during which period success ranged from 35 to 53.33 per cent. Unlike in the case of stone grafting, success in veneer grafting was found to be related with weather parameters. It was observed that a significant negative correlation existed between survival percentage and mean maximum temperatures while relative humidity,

rainfall and number of rainy days exhibited positive correlation.

2. Prior defoliation of scion shoots was found beneficial for stone grafting as well as for veneer grafting. Maximum percentage of survival (49.50) was observed when scions were defoliated prior to 10 days of stone grafting compared to 15 days prior defoliation (47.50 per cent) or without prior defoliation (33.50 per cent). In veneer grafting, survival was minimum when shoots were not defoliated while the corresponding figures with 10 days and 15 days prior defoliation were 37.83 and 34.83 per cent. However, in both the techniques of grafting when the difference among the two defoliated treatment, viz. 10 and 15 days were compared, no statistical significance was observed.

3. In stone grafting, four months old scion materials were proved superior to others. The highest (61.33 per cent) and the lowest (38.00 per cent) survival of stone grafts was obtained when four and two months old scions were used, respectively. In the three age groups of scions, viz. two month, six month and 12 month, the final survival judged after 90 days of veneer grafting was to the tune of 21.33, 45.33 and 34.67 per cent respectively.

4. There was a negative relationship between the age of stock and survival percentage of stone grafts. A maximum

survival rate of 58.00 per cent was observed with five days old stocks. The survival rate decreased to 50.00 and 32.00 per cent respectively when the age of stock increased from five to 10 days and from 10 to 15 days.

5. For the factors such as season of grafting, age of scion and age of stock, the linear growth rate of scion was different for different treatments. In all the treatments, it was observed that correlation coefficients between the time and scion extension were significant even at one per cent level, confirming the linear nature. The students 't' test conducted to compare the treatments also indicated statistical significance in the growth rates.

6. The success in veneer grafting was 40.67, 16.67, 37.33, 35.33, 18.67 and 46.00 per cent in Mundappa, Banganapalli, Alphonso, Bangalora, Neelum and Bennet Alphonso scion varieties respectively. This indicated that scion varieties had profound influence on the final success of veneer grafting in mango. However, detailed studies with large number of varieties will be necessary to arrive at definite conclusions.

7. It was observed that scion sticks (with or without pre-treatment) wrapped in gunny bag moss medium and stored in room temperature remained in graftable condition for about nine days although the percentage of success was reduced to 22 to 32 in comparison to 45.3 per cent for the corresponding period (August) using defoliated fresh scions.

8. Modified trench method of veneer grafting was significantly superior to polybag and *in situ* methods. The survival rates were recorded as 31.33, 21.33 and 7.33 per cent respectively.

9. On an overall analysis it would be possible to conclude that both stone grafting and veneer grafting are successful methods of grafting in mango under Kerala conditions. Between these two methods, stone grafting appears to be better from the point of view of survival. However, the time of graft production in stone grafting has to be restricted to only July-August. Veneer grafting has the advantage that it could be done for an extended period, viz. July-November, although the most suitable time is August-September.

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Appendices

APPENDIX I

Chi-square values for comparisons between pair of months with regard to the number of sprouting and survival of stone grafts

Months	May	June	July	August
May		1.085 (2.607)	19.505** (41.119**)	50.933** (66.399**)
June			12.377** (25.30**)	39.699** (46.545**)
July				9.683** (3.162)

** Significant at 1 per cent level of probability.
(..) Chi-square value for survival rate.

APPENDIX II

Chi-square values for comparison of different period of precuring with regard to the number of sprouting and survival of stone grafts.

Comparisons	Value of Chi-square
Without vs 10 days	38.104** (14.203**)
Without vs 15 days	43.809** (11.392**)
10 days vs 15 days	0.358 (0.09)

** Significant at 1% level of probability.
(..) Chi-square value for survival rate.

APPENDIX III

Monthly weather data with per cent sprouting and surval of stone grafts

Month of grafting	Sprouting (%)	Survival (%)	Temperature °C		Mean Relative humidity (%)	Rainfall	
			Mean maximum	Mean Minimum		Quantity (mm)	Number of rainy days
May, 1982	50.66	20.66	33.81	24.50	80.00	172.6	8
June, 1982	56.00	28.00	30.60	23.10	80.00	657.6	26
July, 1982	74.67	56.00	29.10	22.90	87.50	600.9	26
August, 1982	88.00	69.33	28.90	24.30	85.00	675.4	27

APPENDIX IV

Correlation coefficients between weather parameter, sprouting and survival percentages of stone grafts.

	Sprouting	Survival	Mean minimum tempera-ture	Mean maximum tempera-ture	Mean Relative humidity	Mean Rainfall
Sprouting	1.0000**					
Survival	0.9966**	1.0000**				
Mean minimum temperature	-0.0002	-0.0617	1.0000**	0.4940		
Mean maximum temperature	-0.8517	-0.8693	-	1.0000**		
Mean Relative humidity	0.8185	0.8620	-0.3266	-0.7753	1.0000**	
Mean Rainfall	0.6542	0.6592	-0.5691	-0.9257	0.4856	1.0000**
Rainy days	0.6773	0.6902	-0.6138	-0.9511**	0.5629	0.9944**

** Significant at 1% level of probability.

APPENDIX V

Chi-square values for comparisons of different age of scion shoot with regard to the number of sprouting and survival of stone grafts

Comparisons	Value of chi-square
2 month vs 4 month	30.538** (17.280**)
2 month vs 6 month	5.074* (2.31)
4 month vs 6 month	10.428** (6.488*)

** Significant at 1% level of probability.
* Significant at 5% level of probability.
(..) Chi-square value for survival rate.

APPENDIX VI

Chi-square values for comparison of different age of root stock with regard to the number of sprouting and survival of stone grafts

Comparison	Value of chi-square
5 days vs 10 days	2.767 (1.532)
5 days vs 15 days	34.064** (19.448**)
10 days vs 15 days	17.218** (8.890**)

** Significant at 1% level of probability.
(..) Chi-square value for survival rate.

APPENDIX VII

Linear growth rate, correlation coefficient and regression equation for describing growth behaviour of scion with regard to the different factors affecting the growth of stone grafts

Factors	Treatments	Correlation coefficient	Linear growth rate	Regression equation
Season of grafting	May	0.995**	2.58	Y = 4.35 + 2.58 X
	June	0.989**	2.51	Y = 2.86 + 2.51 X
	July	0.996**	2.54	Y = 6.82 + 2.54 X
	August	0.997**	3.50	Y = 9.99 + 3.50 X
Age of scion	2 month	0.996**	3.56	Y = 7.30 + 3.56 X
	4 month	0.996**	2.72	Y = 5.37 + 2.72 X
	6 month	0.998**	2.48	Y = 2.87 + 2.48 X
Age of stock	5 days	0.997**	3.14	Y = 5.60 + 3.14 X
	10 days	0.998**	2.51	Y = 4.06 + 2.51 X
	15 days	0.997**	2.29	Y = 0.84 + 2.29 X

** Significant at 1% level of probability.

APPENDIX VIII

Students 't' values for comparisons of growth rate of scion between pair of treatments with regard to different factors affecting growth of stone grafts

Factors	Treatments comparison	Students 't' value
Season of grafting	May vs June	1.25
	May vs July	0.952
	May vs August	-22.51**
	June vs July	-0.545
	June vs August	-18.39**
	July vs August	-24.69**
Scion age	2 month vs 4 month	17.87**
	2 month vs 6 month	26.34**
	4 month vs 6 month	5.85**
Stock age	5 days vs 10 days	16.58**
	5 days vs 15 days	20.73**
	10 days vs 15 days	5.789**

** Significant at 1% level.

APPENDIX IX

Ratio of the girth of the stock to the girth of the scion as affected by season of stone grafting (data at monthly intervals)

Treatment	1	2	3	4	5	6	7	8	9	10	11	12
May	1.048	1.063	1.067	1.090	1.085	1.100	1.092	1.098	1.104	1.107	1.113	1.109
June	1.038	1.073	1.061	1.090	1.077	1.100	1.085	1.082	1.096	1.107	1.105	1.109
July	1.044	1.061	1.081	1.094	1.110	1.090	1.086	1.082	1.103	1.101	1.108	1.105
August	1.039	1.071	1.084	1.084	1.085	1.112	1.201	1.126	1.118	1.115	1.121	1.132
F value	0.4271	0.5027	1.348	0.2797	1.044	0.9145	3.805*	3.444*	1.798	0.5022	0.8861	1.717
C.D.	0.021	0.022	0.026	0.023	0.039	0.026	0.083	0.031	0.019	0.024	0.022	0.026
SEm.	0.007	0.008	0.009	0.008	0.014	0.009	0.029	0.011	0.007	0.009	0.008	0.009

* Significant at 1% critical value of the distribution of F.

APPENDIX X

Chi-square values for comparisons between pairs of months with regard to the number of sprouting and survival of veneer grafts

	Feb.	Mar.	April	May	June	July	August	September	October	November	December
Jan.	0 (0)	27.251 (0.759)	5.986* (0.022)	4.919* (0.529)	8.618** (7.889**)	30.787** (12.426**)	39.174** (27.173**)	57.813** (42.361**)	36.248** (23.845**)	36.248** (14.114**)	5.440* (2.828)
Feb.		11.312** (1.047)	6.582* (0.092)	5.462* (0.779)	15.469** (8.762**)	32.065** (13.471**)	40.593** (28.64**)	59.478** (47.816**)	37.620** (25.237**)	37.620** (15.22**)	6.009* (3.365)
March			0.481 (0.337)	0.868 (0)	0.489 (4.398*)	6.198* (7.945**)	10.464** (20.535**)	21.770** (34.208**)	8.905* (17.612**)	8.905* (9.322**)	0.654 (0.913)
April				0.013 (0.534)	2.268 (7.910*)	10.803** (12.426**)	16.197** (27.173**)	29.542** (42.361**)	14.262** (23.845**)	14.262** (14.113**)	0 (2.828)
May					3.014 (5.006*)	12.343** (8.746**)	18.051** (21.769**)	31.959** (35.75**)	16.012** (18.765**)	16.012** (10.188**)	0.053 (1.204)
June						3.66 (0.735)	7.091** (6.824**)	16.871** (15.784**)	5.810* (5.143*)	5.810* (1.203)	1.930 (1.05)
July							0.778 (3.545)	5.567* (10.589**)	0.392 (2.360)	0.392 (0.130)	10.021** (3.091)
August								2.607 (2.253)	0.016 (0.542)	0.016 (1.984)	15.212** (12.269**)
September									2.56 (2.616)	2.56 (7.757**)	36.09** (23.482**)
October										0.016 (1.125)	13.346** (9.994**)
November											13.347** (3.989*)

** Significant at 1% level of probability.
* Significant at 5% level of probability.
(..) Chi-square value for survival rate.

APPENDIX XI

Chi-square values for comparisons of different period of precuring with regard to the number of sprouting and survival of veneer grafts

Comparisons	Value of chi-square
Without vs 10 days	210.01** (50.93**)
Without vs 15 days	227.19** (37.73**)
10 days vs 15 days	0.500 (0.93)

** Significant at 1% level of probability.
(..) Chi-square value for survival rate.

APPENDIX XII

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

Month of grafting	Sprouting (%)	Survival (%)	Temperature °C		Mean Relative humidity (%)	Rainfall	
			Mean Maximum	Mean Minimum		Quantity (mm)	Number of rainy days
January 1984	36.67	18.00	32.40	23.30	58	0	0
February 1984	36.00	17.33	34.30	24.20	56	27.0	4
March 1984	54.67	21.33	35.20	24.30	67	18.9	2
April 1983	50.00	18.00	36.20	25.80	66	0	0
May 1983	48.67	20.67	35.10	25.50	69	37.4	3
June 1983	58.00	31.33	31.90	24.50	79	387.2	19
July 1983	68.00	35.33	29.70	23.70	87	580.6	21
August 1983	72.00	45.33	29.10	23.80	87	754.7	26
September 1983	79.33	53.33	29.50	23.40	84	496.4	24
October 1983	70.67	43.33	31.20	23.1	77	149.8	6
November 1983	70.67	36.67	31.80	22.30	71	60.2	3
December 1983	49.33	25.33	31.20	23.90	63	24.4	3

APPENDIX XIII

Correlation coefficients between weather parameters, sprouting and survival percentages of veneer grafts.

	Sprouting	Survival	Mean maximum tempera-ture	Mean minimum tempera-ture	Mean Relative humidity	Mean Rainfall
Sprouting	1.0000**					
Survival	0.9351**	1.0000**				
Mean maximum temperature	-0.6752*	-0.8220**	1.0000**			
Mean minimum temperature	-0.4516	-0.5520	0.6689*	1.0000**		
Mean relative humidity	0.8799**	0.8360**	-0.6993*	-0.2011	1.0000**	
Mean Rainfall	0.6814*	0.7405**	-0.7726**	-0.1930	0.5965**	1.0000**
Rainy days	0.6771*	0.7587**	-0.7622**	-0.1796	0.8777**	0.9766**

** Significant at 1% level.

* Significant at 5% level.

APPENDIX XIV

Chi-square velue for comparison of different age of scion shoot with regard to the number of sprouting and survival of stone grafts

Comparisons	Value of chi-square
2 month vs 6 month	43.94** (20.53**)
2 month vs 12 month	12.03** (7.29**)
6 month vs 12 month	10.05** (3.125)

** Significant at 1% level of probability.
(..) Value of chi-square for survival rate.

APPENDIX XV

Chi-square values for comparisons of different age of root stocks with regard to the number of sprouting and survival of veneer grafts

Comparisons	Value of chi-square
3 month vs 14 month	107.52** (57.42**)
3 month vs 26 month	56.37** (24.05**)
14 month vs 26 month	10.27** (7.69**)

** Significant at 1% level of probability.
(..) Chi-square value for survival rate.

APPENDIX XVI

Chi-square values for comparison between pairs of varieties with regard to the number of sprouting and survival of veneer grafts

Varieties	Bangana-palli	Alphonso	Bangalora	Neelum	Benet Alphonso
Mundappa	60.379** (19.97**)	1.718 (2.25)	4.202* (0.69)	52.089** (16.36**)	0.164 (1.09)
Bangana-palli		44.871** (17.32**)	36.068** (14.57**)	0.537 (0.37)	56.585** (31.37**)
Alphonso			0.383 (0.057)	34.779** (12.05**)	1.066 (2.688)
Bangalora				27.005** (9.74**)	3.131 (3.992**)
Neelum					48.484** (26.87**)

** Significant at 1% level of probability.
* Significant at 5% level of probability.
(..) Value of chi-square for survival rate.

APPENDIX XVII

Chi-square for comparisons of wrapping materials with regard to the number of sprouting and survival of veneer grafts during storage of scion sticks

Type of scion used for sterage	Gunny bag with moss vs Polythene with moss
Freshly defoliated scion	4.972* (5.379*)
Prior defoliated scion	4.905* (2.717)

* Significant at 5% level of probability.
(..) Chi-square value for survival rate.

APPENDIX XVIII

Chi-square values for comparisons of different methods of raising root stocks with regard to the number of sprouting and survival of veneer grafts

Comparisons	Value of chi-square
in situ vs Poly bag grafting	53.741** (13.139**)
in situ vs modified trench grafting	49.31** (29.260**)
Poly bag vs modified trench grafting	0.053 (4.399*)

** Significant at 1% level of probability.
** Significant at 5% level of probability.
(..) Chi-square value for survival rate.

APPENDIX XIX

Linear growth rate, correlation coefficient and regression equation for describing growth behaviour of scion with regard to the different ages of stock and scion affecting the growth of veneer grafts

Factors	Treatments	Correlation coefficient	Linear growth rate	Regression equation
Age of scion	2 month	0.985**	2.70	Y = 5.13 + 2.7 X
	6 month	0.984**	2.25	Y = 2.10 + 2.25 X
	12 month	0.996**	1.905	Y = 1.69 + 1.905 X
Age of stock	3 month	0.988**	2.60	Y = 2.53 + 2.60 X
	14 month	0.981**	3.41	Y = 4.37 + 3.41 X
	26 month	0.978**	4.39	Y = 5.6 + 4.39 X

** Significant at 1% level.

APPENDIX XX

Students 't' value for comparison of growth rate of scion between pairs of treatments with regard to different ages of stock and scion affecting the growth of veneer grafts

Factors	Treatments Comparisons	Students 't' value
Age of scion	2 month vs 6 month	4.79**
	2 month vs 12 month	10.81**
	6 month vs 12 month	3.723**
Age of stock	3 month vs 14 month	-7.94**
	3 month vs 26 month	-16.89**
	14 month vs 26 month	-8.448**

** Significant at 1% level.

STANDARDISATION OF METHODS OF VEGETATIVE PROPAGATION IN MANGO

By

DHUNGANA. D. B.

ABSTRACT OF A THESIS

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the requirements for the degree of

Master of Science in Horticulture

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ABSTRACT

The studies on the vegetative propagation of mango were carried out at the Department of Pomology and Floriculture, College of Horticulture, Vellanikkara during the period from May 1982 to June 1984.

The studies consisted of two techniques of grafting, viz. stone grafting and veneer grafting. It was possible to standardise these techniques under Kerala conditions for the first time after the detail studies of the factors like season of grafting, effect of precuring of scions, effect of age of stock and scion, varietal response, effect of duration of storage of scion sticks and methods of raising rootstocks.

The results indicated that the survival of the stone grafts was best when the grafting was done during August. In case of veneer grafting, no significant difference in the survival of graft was observed during August, September and October although September was most congeneal month for grafting. Both the techniques of grafting revealed, the superiority of 10 days and 15 days prior defoliation of scions over no defoliation treatment. But the difference in the survival of grafts between the treatments with the defoliation 10 days and 15 days prior to grafting was not significant.

In another experiment, the best result was achieved when four month scion was stone grafted on five days old stock material. However, the use of five days and 10 days old stock did not reveal any significant difference in the ultimate survival of the grafts. Similarly, the comparison of different age of stock and scions with regard to their effects on survival of veneer grafts proved, grafting with six month old scion using rootstocks 14 months old would give best results. On examining the extension growth of scion its linear nature was confirmed. The linear growth rate was found to be different for different treatments in the present study.

The scion varieties responded differently in the final success in veneer grafting. The promising effect on the graft take was noticed when the varieties, viz. Mundappa, Alphonso, Bangalora and Bennet Alphonso were adopted for veneer grafting. In varieties like Neelum and Banganapalli veneer grafting did not appear to be satisfactory in mango under Kerala conditions.

Any kind of scion stick i.e. prior defoliated or freshly defoliated when stored for a period of nine days at room temperature, did not prove significant difference in the survival of veneer grafts. However, gunny bag moss medium as wrapping material for scion shoots was found better than

polythene moss medium. The modified trench method of grafting substantially improved the survival rate of polybagged veneer grafts.