STANDARDISATION OF VEGETATIVE PROPAGATION TECHNIQUES IN JACKFRUIT (*Artocarpus heterophyllus* Lam.)

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Dedicated to

My Beloved Parents

DIVISION OF HORTICULTURE
UNIVERSITY OF AGRICULTURAL SCIENCES
BANGALORE

CERTIFICATE

This is to certify that the thesis entitled "STANDARDISATION OF VEGETATIVE PROPAGATION TECHNIQUES IN JACKFRUIT (*Artocarpus heterophyllus* Lam.) submitted in partial fulfilment of the requirements for the degree of DOCTOR OF PHILOSOPHY in HORTICULTURE to the University of Agricultural Sciences, Bangalore is a record of bonafide research work carried out by Mr. G.S.K. SWAMY under my guidance and supervision and that no part of the thesis has been submitted for the award of any degree, diploma, associateship, fellowship or other similar titles.

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CONTENTS

Chapter		Page

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

INTRODUCTION

I. INTRODUCTION

Jackfruit (Artocarpus heterophyllus Lam.) belongs to the family Moraceae. It is indigenous to India and bears the largest fruit amongst the edible fruits and is quite a heavy yielder. Being a staple food, it is very popular among the poorer classes and house wives for culinary preparations and it is known as the 'Poor Man's food' in the eastern and southern parts of India.

The ripe fruit has high nutritive value and contains minerals, vitamin A and C. It is used for the preparation of pickles, dehydrating leather, thin papads, canned fruits, and nectar from the pulp. The rind is rich in pectin and the pectin extracted could be used for Jelly making. The seed is rich in nutritive values and is used in many culinary preparations. The flour prepared from the seed is used along with wheat flour for the preparation of different products. Immature fruits are used as vegetables. The rind or skin of the fruit and leaves are excellent cattle feed. Jack timber is valuable for making furniture.

Jackfruit tree is widely grown in Southern states viz., Kerala, Tamilnadu, Karnataka and Andhra Pradesh. It is also cultivated in other states like Assam, Bihar, Orissa, Maharastra and West Bengal. The total area under Jackfruit cultivation in India is around 32,660 ha (Shanmugavelu, 1987).

In Karnataka jackfruit is grown in an area of 10,004 ha with an annual production of 2,42,496 tonnes (Anon., 1991). It is rarely grown on plantation scale but preferred very much in homestead gardens. It occupies considerable area in forests, coffee gardens and on roadsides.

Jackfruit trees come up well under humid and warm climate of hill slopes. It is also coming up well in arid and warmer plains of South India. It requires rich, deep and well drained alluvial soil or a open textured loamy or lateritic soil supplied with adequate moisture and plant food. Jackfruit is grown up to 1500 m MSL, but the trees grown above 1200 m MSL produce fruits of inferior quality. It is very sensitive to frost and drought.

Jackfruit is a cross-pollinated crop, and as such highly heterozygous plants are produced if seed propagation is resorted. The most common and the simplest method of raising jackfruit trees is from seed. As trees do not bear true to type, it leads to immense variation in yield and fruit characters such as density of spikes on the rind, bearing capacity, size, shape, quality and period of maturity. At present there are not many standard varieties. Further, the seedling plants take long time to come to fruiting. Therefore, there is a great need to find out a suitable method of vegetative propagation for quick multiplication of selected plants.

The significance of vegetative propagation in maintenance of genetic uniformity and preservation of identity of a clone / cultivar is well recognised in horticultural crops. With the advancement in technical aspects, it is now possible to propagate even those plants once considered as difficult-to-root through vegetative means. Appropriate methods like cuttage, budding, layering and grafting were standardised in various horticultural crops in accordance with their structural peculiarities.

In grafting, approach grafting or inarching has shown greater success, but it is only suitable for small scale propagation and is cumbersome, laborius and costly. Other detached scion methods of grafting like veneer, wedge, side, epicotyl and softwood grafting have been practiced in jack in different growing tracts as followed in case of mango, cashew and other fruit crops with varying degree of success. In budding, chip budding, ring budding, 'T' budding are followed with variable success.

The present day nursery practices involve much cost and risks with respect to raising of seedling rootstocks and their subsequent maintenance till they attain graftable size. Healthy growth of the rootstocks and correct grafting techniques will probably help to attain higher rate of success. Amin (1978a) developed in situ softwood grafting in mango at the Anand campus of the Gujarat Agricultural University and it has given very good success in the drier tracts of Gujarat state. This method of grafting would be useful even in jack if standardised for the rootstocks raised in polythene containers with suitable media. Both grafting and budding could be standardised on these rootstocks of different ages and using scions cured for different duration.

Propagation through cuttings being inexpensive, rapid, simple and not requiring the techniques necessary in other methods needs to be perfected for commercial multiplication of jack.

The air layering of jack with the help of plant growth regulators has been found to be successful by several workers (Singh, 1955; Sen and Bose, 1959; Mukherjee and Chatterjee, 1978). However, this method has not been practiced on a large scale so far. Use of the appropriate growth regulators in accordance with the crop requirement has made a break-through in rooting of cuttings and layers. For better results and to avoid toxicity, these growth regulators are to be used in the optimum concentration which may vary from crop to crop. Selectivity of seasons in relation to rooting in some plant species were found to be related to the environmental factors around the plants as well as to the morphological status of the shoots. Pre-conditioning treatments such as girdling and etiolation clubbed with growth regulator application were found to improve the rooting potentiality in many difficult-to-root plant species. These treatments had a remarkable effect on the internal levels of nutrients and growth promoters as well as inhibiting substances in the tissues.

For standardising vegetative propagation of jack different experiments were conducted with the following objectives:

1. To evaluate better and quicker method of vegetative propagation by grafting, budding, layering and cutting.
2. To study the effects of age of rootstocks on the success of grafting and budding.
3. To study the effect of growth regulators on rooting of air layers and cuttings.
4. To study the impact of season on rooting of air layers and cuttings.

REVIEW OF LITERATURE

II. REVIEW OF LITERATURE

Commercially quite a few fruit crop species are propagated primarily from seeds and are often of poor quality. The importance of vegetative propagation in preserving the identify of a cultivar or a clone is well recognised. Several attempts were made to propagate fruit plants by grafting, budding, air layering, cuttage and stooling. This is also true for jackfruit in which several variations have been found and some of them are worth multiplying. The following review is primarily on the vegetative methods of propagation of the important tropical fruit trees ike jackfruit, mango, cashew and other fruit crops by grafting, budding, cuttings and layering.

2.1 Grafting

2.1.1 Effect of season on grafting

2.1.1.1 Jackfruit

Inarching on Artocarpus hirsuta and on jack seedlings during the month of July recorded 67 per cent success but on Rudrakshi jack seedlings, the success was 80 per cent. Use of Seradix improved the success rate to 72 per cent and 56 per cent success with alpha naphthalene acetic acid (Anon., 1950). Gunjate et al. (1980) reported 50 to 90 per cent success in epicotyl grafting. According to Vijayakumar et al. (1991) about 45 to 50 per cent of successful grafts coulc be obtained within 40 to 50 days after grafting during April - May by following green wood cleft grafting. Jose and Valsalakumari (1991) noted high percentage of sprouting and survival of epicotyl grafts prepared during the month of June compared to May, July and August months. They found that keeping the grafts under mist improved the success rate and survival of grafts. Sumagang et al. (1990) recorded 35 per cent grafting success in Philippines using the common cleft method of grafting during the month of February.

2.1.1.2 Mango

Naik (1947) stated that inarching was the traditional method of vegetative propagation. Asadullah and Khan (1960) reported that inarching in spring gave better success than in autumn season in case of cultivar Langra. Ihra and Tamari (1961) suggested that May - July was the best time for grafting decidous trees and June - August for grafting evergreen trees by softwood grafting. In mango, the percentage of survival of the grafts prepared by inarching was higher when the rootstocks were maintained in pots compared to those maintained in polythene bags, and spring season was better, compared to monsoon season (Majhail and Singh, 1962).

Ahmad (1964) carried out experiments by veneer grafting on nine and twelve month old seedling rootstocks of Langra, Dashehari and Samar Bahishet on four different dates during the spring and autumn season. He found that Samar Bahishet was the best rootstock for grafting when the age of the stock was twelve months. Mukherjee and Majumdar (1964) reported that mango could be successfully veneer grafted during March and also stated that maximum scion growth recorded was found in grafts prepared during March - April. Jagirdar et al. (1968) noted over 90 per cent success following veneer grafting with Sindhri and Dashehari and spring months were the best for preparing the grafts. In the cooler months the success recorded was 80 per cent for Sindhri, Langra and Banganapalli. Gunjate and Limaye (1978) reported that the percentage success of Veneer grafting in mango varied between 68 and 91 for the grafts prepared at intervals from the first week of March to first week of June. However, the highest success rate recorded was for the grafts prepared in the middle of May.

Singh and Srivastava (1982) reported 84 per cent success with inarching and softwood grafting in the month of July, when the scions of Dashehari were grafted on the seedling rootstock of Bappakai variety. Patel and Amir (1981) observed that softwood grafting between the third week of May and third week of August resulted in 90 to 100 per cent graft take, and it was 85 to 90 per cent between February and May.

Iqbal (1982) reported that side grafting under 50 per cent shade was highly successful compared to side grafting under exposed conditions. Under shade the success rate was ranging from 60 to 95 per cent, whereas under exposed condition it was between 1 to 69 per cent.

Ram and Bist (1982) recorded 100 per cent graft take in case of veneer grafts of Dashehari prepared in the months of June, July and August. Singh and Srivastava (1982) reported that softwood grafting was better than veneer grafting with reference to success rate and was found to have better shoot growth when examined in the month of August.

Desai and Patil (1984) observed the highest rate of success in stone grafting (70 %) in July in the greenhouse but under open conditions the success rate was only 40 per cent. Gunjate (1989) reported that stone grafts prepared in June and July survived better and also suggested to use two rootstocks for a single scion, while preparing the grafts.

In a study by Tayde et al. (1988) observed that in situ softwood technique was better compared to veneer and stone grafting tecnhiques and also suggested that from July to September grafts could be prepared successfully. Srivastava (1989) observed that temperature and humidity were the main limiting factors for the success of different grafting methods in mango and June month was having the optimum temperature and humidity. Kulwal and Tayde (1989) noted that August and September months were more suitable for softwood grafting under Akola conditions than other months of the year. Dhungana et al. (1989) recorded the highest rate of success when stone grafting was done during the month of August and the lowest rate of success during the month of May. The highest survival rate was observed if the scions were defoliated ten days prior to stone grafting.

2.1.1.3 Cashew

Phadnis (1971) reported that for successful veneer grafting, early part of the south west monsoon was the best period. Nagabhushanam and Rao (1978) reported that July month was the best month for grafting. Similar observations were reported with veneer grafting by Dasarathi (1979) in Bapatla. In cashew propagation studies carried out in Vittal, it was reported that the maximum success rate recorded was during October and June months (Anon., 1977; Nambiar, 1980;1981).

Nagabhushanam (1983) recorded highest success by following epicotyl grafting. Grafts were prepared with 15 day old stocks between June to August. Sawke (1983) stated that epicotyl grafting in cashew under Konkan conditions, could be done from February to May. During this period on an average the success rate was ranging from 62.4 to 67.7 per cent.

Sawke et al. (1985) recorded highest mean success rate in case of softwood grafting during August (83.66%) and April (83.00%) and the lowest (22.00 to 33.00%) in December under Vengurla conditions. Kumar and Khan (1988) recorded maximum success in *in situ* softwood grafting with plants grafted during May (60.00%) followed by April (55.00%) under Ullal conditions.

Kumar et al. (1989) reported in case of epicotyl grafting a success rate of 39.5 to 86.0 per cent with the maximum success during the month of May (86.0%). Correlations studies on softwood grafting in cashew with weather parameter by Swamy et al. (1990) revealed that the increased rate of success was highly correlated with higher mean minimum temperature and higher relative humidity. Rainy season (June - October) was found to be the best period for commercial multiplication. Mahablaeshwar (1992) obtained more than 80.0 per cent success at the G.K.V.K. campus by following softwood grafting during January month.

2.1.2 Effect of age of the rootstock and scion on grafting

2.1.2.1 Jackfruit

A comparative trial on age of the rootstock was carried out at Taliparamba. The results revealed that six month old jackfruit seedlings, when approach grafted with six month old scions, a maximum of 76.0 per cent success was recorded, but on two year old stocks, the success rate was only 26.0 per cent. The use of younger stocks, resulted in faste propagation and reduced the cost of watering (Anon., 1950).

Desai and Desai (1989) stated that softwood grafting i a simple and rapid method. They recorded success rate fro 33.33 to 80.00 per cent by using 2.5 to 10.0 cm long scion of six month growth. They also said that scion sticks coul be stored up to three days in moist sphagnum moss o polybags, moist gunny cloth or moist news paper. Jose an Valsalakumari (1991) reported that epicotyl grafting on fiv day old stocks with precured scions of three to four month age was found supeior compared to softwood grafting in jack The maximum sccess rate recorded was 83.3 per cent.

A form of approach grafting called "suckle-grafting' practiced in jack plant on a large scale in Thailan (Soepadmo, 1991). Young potted seedling rootstocks of Jack were decapitated and subsequently inserted in twigs of a selected mother tree. The success rate is high and the method could be practised at any time of the year. In Australia according to Acedo (1992), wedge grafting has been found to give very good results. Scions are grafted onto young vigorous rootstocks in an enclosed high-humidity chamber. In Philippines a preliminary study at the Bureau of Plant Industry's Mandaue (Cebu) experiment station, recorded grafting success ranging from 30 to 80 per cent following cleft method. In this study, the scions used were defoliated one to two weeks before the grafting to induce bud activation and small cuts were made at the base of the rootstock to minimise latex accumulation at the point of contact of scion and stock (Acedo, 1992).

2.1.2.2 Mango

Burns and Prayag (1920) suggested that three week old seedlings could be used as rootstock for inarching and the grafts could be separated within three months after grafting. Sen (1941) stated that the best result could be obtained by grafting scions of pencil thickness on three months old seedlings. Torres (1949) recorded a very high rate of success with splice grafting on 3 to 12 months old rootstocks when the stocks were in active state of growth.

Jagirdar and Bhatti (1968) reported that veneer grafting success rate was not affected by the age of the rootstocks but the per cent take was increased by the use of mature wood, compared to immature scion wood. Majumdar et al. (1972) reported that the scions from the non-flowering shoots proved better for veneer grafting. They also found that the success of veneer grafting was not affected by length of scion sticks (2.5 - 10.0 cm), but the subsequent growth was greater with longer scions.

The percentage success of side grafting in mango was raised from 75 to 100 per cent when the scions were defoliated ten days before grafting (Kashyap et al., 1972). Amin (1974) carried out wedge grafting on seedlings aged one or two years, using scion wood defoliated one to two weeks prior to grafting. Amin (1978a) reported that excellent results were obtained when the terminal growth of the rootstock was young and bronze in colour for softwood grafting. He used rootstocks of age more than one year and grown in situ.

Singh and srivastava (1979) obtained 80 per cent success when twelve months old rootstocks were veneer grafted with six months old scions. The scions were defoliated ten days prior to separation, and they observed that white polythene tape was the best tying material. Patil et al. (1984) reported that the best combinations of rootstocks and scions were found between four days old seedling rootstocks and the scions defoliated ten days prior to grafting. But the height of the plants and number of leaves were highest for four days old stocks and scions defoilated seven days prior to separation. Kulwal and Tayde (1989) showed successful mango propagation by softwood grafting on one year old seedling rootstocks with success rate ranging from 72 to 92 per cent.

In a study on effect of rootstocks age on success of softwood grafting in mango, Reddy and Melanta (1988) reported that seven month old rootstocks were best for in situ grafting (90%) followed by eight month old stocks (80%). The graft take by rootstocks of different age groups in polybags did not differ significantly. However, three month old stocks recored a maximum graft union success of 58 per cent followed by six month old stocks with 55 per cent success.

2.1.2.3 Cashew

Phadnis (1971) suggested the use of rootstocks of less than five months age and not more than 50 cm in height with a girth of 4 to 5 mm for veneer grafting. Nagabuhshanam and Rao (1978) observed 35 to 96 per cent graft take with five to six months old rootstocks compared to 20 to 49 per cent graft take with 15 to 20 months old rootstocks. Amin (1978b) recorded 70 per cent success by softwood grafting on rootstocks which were grown in situ for a year. Muniswami (1979) reported 90 per cent success of veneer grafting on 4 to 5 months old seedling rootstocks in a mist chamber. At Vengurla, four to six months old root stock were used for softwood grafting and a maximum success of 94 per cent was recorded during February and March (Anon, 1983).

A comparative study of different methods of vegetative propagations of cashew by Valsalakumari *et al*. (1985 revealed that with wedge grafting, the best results were obtained under mist on eight month old seedling. Yogananda (1989) found better success with four to seven month old seedling for *in situ* grafting in case of cashew. Sarada *et al*. (1991) observed that August, September and January months were suitable for grafting. Per cent success and growth of grafts were better with precured scions than of freshly defoliated ones. Mahabaleshwar (1992) recorded higher success of softwood grafting using one to two months old root stock.

2.2 Budding

2.2.1 Effect of season on budding

2.2.1.1 Jackfruit

At Burliar both flute budding and patch budding o jackfruit seedling rootstocks failed, while shield buddin gave a 10 per cent take in May and June when the stocks wer notches after insertion of bud (Anon., 1952). Teaotia *e al*. (1963) carried out monthly trails on patch budding at th Fruit Research Station, Basti, Uttar Pradesh and obtaine 100 per cent success in June and over 90 per cent in May an July. During these months, rainfall was average and both th stock and scion were in active state of growth. They als observed that the budded plants grow much more vigorousl than seedlings of the same age. Moti et al. (1976) recorded higher percentage of bud take in patch budding compared to shield budding during June month.

Buds from healthy jack tree were patch, chip and T-budded on the seedlings of the same species in the third week of each month between February and September. Patch budding in June and July gave the highest bud take of 90.0 and 81.6 per cent respectively. T-budding was the least successful (Singh et al., 1982). Biswas and Hossain (1984) recorded 80 per cent success in May with ring budding followed by flute budding which recorded 60 and 40 per cent success in May and June respectively. Budding has given very variable results; the most promising method appears to be patch budding (Garner, 1976). Kelaskar et al. (1991) reported that patch buds kept under different light intensities showed no significant differences in sprouting and survival. However, highest sprouting, survival and better growth were observed in the budded plants kept in glasshouse followed by those kept in open sunlight or under partial and complete shades.

2.2.1.2 **Mango**

Singh and Srivastava (1962) did studies on budding in case of mango. Scions of the cultivar Langra and Dashehari were budded by the forkert method on one year old seedlings from July to September at an interval of fifteen days. In both the cultivars 100 per cent success was obtained when budding was done in July.

Ahmad and Ahmad (1960) obtained good success by patch budding on nine month old stocks in May. However, in September, budding on one year old stocks was more successful than on three month old stocks. Teaotia (1963) obtained significantly better success by budding in March compared to May and July months. Bhandary and Chinnappa (1963) stated that October month was suitable for Forkert budding of mango. In U.P. and Punjab, shield budding gave higher percentage success during March - July (Teaotia, 1963; Jauhari and Singh, 1970). Jagirdar and Ali (1965a) obtained greater percentage of sprouting in Sindhri and Langra when budded in late summer.

Rao (1967) opined that August to September and February to June are the suitable periods for shield budding in South India and North India respectively. Jauhari and Singh (1970) obtained the best success in July by activating buds two weeks before budding and cutting back stocks one week after budding. Moti et al. (1976) obtained the highest percentage of bud take in mango with patch budding during June month.

2.2.1.3 Cashew

Ferraz et al. (1974) reported 99.59 per cent take in patch budding on eight month old seedlings when budding operations was carried out during the dry season. Palaniswami and Hammeed (1976) achieved 71 per cent success in July and 50 to 58 per cent in March, April, September and October by patch budding. Nagabhushanam and Rao (1978), on the other hand, observed very poor result in case of patch budding. Chana and Savant (1979) obtained a maximum success of 72 per cent in June followed by 69 and 70 per cent in April and May respectively with forkert budding. They opined that the high percentage success obtained during March - June was due to the vigorous sap flow during the period. Das and Mishra (1978) tried 'T' budding in cashew and obtained 60 per cent success during September.

2.2.2 Effect of age of the rootstock and budsticks on budding

2.2.2.1 Jackfruit

Experience in Malaysia has shown that budding on one year old seedling rootstocks produces strong trees of uniform growth (Anon., 1935). Modified forkert budding has been practised in Sri Lanka using budwood of the previous seasons growth (Richards, 1950). In India, chip budding on one year old jackfruit seedling gave 41 per cent success (Samaddar and Yadav, 1970). It was believed that exudation of latex was the cause for low bud take. Moti et al. (1976) achieved about 40 to 96 per cent success following patch budding on one year old rootstocks. Kelaskar et al. (1990)

obtained 62 per cent success in polythene bags and 80 per cent success *in situ* following patch budding in jackfruit.

2.2.2.2 Mango

In Hawaii, two to five year old rootstocks have been used for shield budding (Higgins, 1910). Hosein (1958) used three to four month old mango seedling successfully for T-budding in Trinidad. Singh and Khan (1943) obained 30 to 40 per cent success in two year old plants while three year old plants recorded 70 per cent success.

Jagirdar and Ali (1965) studied the effect of the age of stock plants on bud take in mango and they reported higher percentage of success on nine month old seedling, compared to that on 3 and 15 month old seedling. Parasai (1963) in a budding experiment removed all the leaves on the selected scion shoots up to a length of six inches from the terminal bud and 10 to 15 days later only plump buds were used for budding. Ismail and Rao (1989) reported 28.3 per cent success by patch budding on six month old rootstocks.

2.2.2.3 Cashew

The official recommendation to the farmers in Mozambique for vegetative propagation of cashew was by budding on 5 to 12 month old seedlings of 1.0 to 1.5 cm dia as rootstock. It was also suggested that the bud woods from hardened parts of current year shoots, after flowering should be used (Anon., 1966). Phadnis (1971) recommended budding on one year old seedlings. Ferraz et al. (1974) reported 99.59 per cent take in case of patch budding on eight month old seedlings when carried out during the dry season.

Bhattee (1979b) from Goa reported 80 per cent success in a nursery trial when two-and-a-half month old seedlings were bud grafted. In another trial at Goa, Bhattee (1979a) recorded a success range from 4 to 64 per cent by bud grafting on two year old plants during the month of September - October. He reported 98 per cent successful establishment when they were planted in the field. Many workers recorded higher success following patch budding in cashew on seedling rootstock (Dhandar, 1985; Palaniswami et al., 1985; Nagabhushanam, 1985; Rao, 1985).

2.3 Effect of chemical constituents on grafting and budding

Fahamy (1952) studied the effect of pre-girdling on the accumulation of carbohydrates and the rate of graft take in case of sapota and macadamia. He observed significant accumulation of starch and carbohydrates in the pre-girdled scions of macadamia, and total sugars, starch and carbohydrates in pregirdled scions of sapota. However, he did not observe any significant difference between pregirdled and ungirdled scions with regard to rate of graft take. Fahamy (1954) found positive correlation for the carbohydrate content and graft union success for sapota and canistel (Lucuma nervosa) plants, but for mango and macadamia he did not get positive correlation.

Fedrov (1961) noted an increase in carbohydrate content at bud swelling stage in wild chinese apple and the content was comparatively higher at the time of bud unions of sweet and sour cherry, plum, apricot and apple and opined that nutrient composition of rootstocks influence bud take. He also observed that hardiness of successfully grafted buds was reduced owing to low reserves of starch and other nutrients of rootstocks.

Reddy and Melanta (1989) studied the effect of different scion varieties of mango on the success of softwood grafting. They observed maximum success of graft take in Dashehari which contains minimum phenol content, while in Alphonso maximum phenol content recorded and graft take was the lowest. Preconditioning helped in the reduction of phenols which in turn helped in better graft union. Nanda (1979) reported that phenols are responsible for the death of cuttings at higher temperature, where the sugar content reduced but phenol content increased due to high rate of respiration.

2.4 Effects of girdling and etiolation on rooting of air layers and cuttings

It has been reported that pretreatments like girdling and etiolation given to the base of cuttings or air layers bring about some physiological and biochemical changes resulting in better rooting (Jauhari and Rahman, 1959; Teaotia and Pandy, 1961). The inhibitory effect of light has been reported by Shapiro (1958). The process of etiolation has long been recognised to be effective in increasing adventitious root formation in stem tissue (Sachs, 1864). Kawase (1965) studied the effect of etiolation on willow and mungbean tissue. He observed retention of higher level of IAA at the site of etiolation during the period of root initiation.

Turekaja and Kof (1965) analysed the tissues of ten days old etiolated bean seedlings and recorded significantly higher amount of auxin with complete absence of growth inhibitor, whereas in controls, reverse was the case.

Stoltz and Hess (1966a) studied the effect of girdling upon root initiation in Hibiscus. According to them the increase in rooting potentiality of girdled shoots might be due to accumulation of rooting substances or their precursors and an increased amount of parenchyma tissue. Girdling helped in accumulation of carbohydrates and free amino acids.

Increase in the concentration of root promoting cofactors especially cofactor No. 4 was observed in girdled and etiolated shoots. In subsequent studies, Stoltz and Hess (1966b) showed that auxin content of girdled shoot decreased with time, because girdling promoted the onset of dormancy. An adaptive auxin oxidising system was stimulated which destroyed the auxin at a greater rate than the rate of accumulation . Basu et al. (1968) suggested that the changed physiological status of ragenerating tissues consequent upon ringing was an important condition in the formation of root in relatively difficult to root mango shoots. They found that ringing and auxin treatments were condusive to protein synthesis and suggested that increased rooting can be correlated with increased protein synthesis. Similar observations were made by Choudhary (1971) also.

Mukherjee and Chatterjee (1978) recorded the highest percentage (100.00) of rooting and establishment (91.66) of Jack layers when the etiolated shoots were treated with 10,000 ppm of Indole Butyric Acid. Etiolated shoots produced significantly more primary roots than non-etiolated shoots. Lingarajappa (1980) observed higher percentage of jackfruit layers with better root characters and survival of the layers in the field when the stems were pregirdled and etiolated and treated with IBA + NAA. He also noticed that juvenile shoots formed roots 30 days earlier than mature shoots. Similar results were observed by Desai and Patil (1984) in jackfruit plant. Nazeem et al. (1984) obtained 81.29 per cent rooting by air layering, using one year old shoots of bearing plants with coconut pith as the medium. Chatterjee and Mukerjee (1982) got best results with etiolated, invigorated jack shoots treated with 5000 ppm IBA. Dhua et al. (1983) obtained 90 per cent rooting in jack cuttings taken from shoots etiolated and ringed for 30 ays and then treated with IBA 3000 ppm in combination with ferulic acid at 2000 ppm. However, in air layers of jack, Dhua and Sen (1984) got 98.30 per cent rooting success with IBA 1000 ppm in combination with ferulic acid 1000 ppm. According to them, etiolation of shoots prior to layering markedly increased rooting and had beneficial effects on root characters but did not exhibit any beneficial effect on survivability of rooted layers.

Mukherjee et al. (1967) studied the effect of etiolation on rooting of mango cuttings and obtained better results in etiolated shoots as compared to non-etiolated ones. Bid and Mukherjee et al. (1969) in an experiment on air layering of mango reported that the etiolated shoots produced more fibrous roots than the non-etiolated ones and application of IBA + NAA further improved the rooting. The same workers (1972) noted better root formation in the cuttings of forced mango shoots and found improved rooting on etiolated shoots.

Rao (1958) obtained 100 per cent rooting in cashew air layers by etiolation and cincturing treatment. Khan (1962) reported moderate degree of rooting of cashew stem cuttings when they were etiolated and treated with 100 ppm IBA for 24 hours. According to Melanta (1982) invigorated-ringed-etiolated cuttings of semihardwood type produced a few roots. Gorgoshidze (1971) obtained 15 per cent increased rooting in Feizoa cuttings by girdling compared to control. Stoltz (1965) also reported the advantage of girdling in rooting of hibiscus cuttings.

Nalwadi and Sulikeri (1972) found that girdling shoots thirty days in advance to layering was optimum in fig cuttings. Hulmani and Reddy (1974) obtained cent per cent rooting in Pumelo marcots ringed and etiolated for two months as against 15 per cent rooting in fresh marcots. Taylor and Odem (1970) noted the beneficial effect of girdling and etiolation than girdling alone. In their studies with pecan (Carya illinoenais), girdled and etiolated shoots produced highly branched and vigorous root system as compared to mere girdled ones and control.

High percentage of rooting in litchi cuttings was recorded by Sen et al. (1967) under intermittent mist treatment with IBA. Litchi cuttings from ringed shoots produced 66 per cent rooting by treatment with IBA under intermittent mist. Ferrulic acid and P-hydroxybenzoic acid synergized with auxins and resulted in better root formation in the treated cuttings (Dhua and Sen, 1982). According to Barauah (1988) in case of custard apple, girdling and etiolation for 40 days before making cuttings or preparing layers was found to be better in respect of rooting. Nair (1989) observed in sapota that pretreatments of shoots increased the number of successful air layers produced. There was reduction in the time for marcooting besides enhancing the number and size of roots. The presence of root promoting cofactors in the tissue samples were also found.

2.5 Effect of growth regulators on rooting of airlayers and cuttings

In jack, Singh et al. (1949) observed sixty per cent rooting when two to three year old shoots were layered in the last week of August or first week of September. Application of growth regulators induced rooting in 72 per cent air layers while 48 per cent shoots rooted under control (Singh, 1951). Treatment with one per cent IBA markedly stimulated rooting in air layers of two to two-and-half year old shoots (Singh, 1955). Use of growth substances produced no improvement in rooting in a trial at the National Botanical Garden, Lucknow in Jack (Singh, 1955). In this trial, apical, semi-hardwood and hardwood cuttings were treated with IPA (Indole Propionic Acid) at 0.01 per cent, NAA at 0.05 per cent and the combinations NAA 0.05 per cent + IAA 0.05 per cent and NAA 0.1 per cent + IAA 0.1 per cent. No rooting was obtained with any of the treatment. Similar results were obtained in jack by Audus (1959). Sen and Bose (1959) reported that application of IAA, IBA and NAA significantly increased the percentage of rooting.

Mukherjee and Chatterjee (1979) reported that forcing, etiolation and IBA treatments are advantageous for rooting of jackfruit cuttings. Chatterjee and Mukherjee (1980) got best results with invigorated, etiolated shoots treated with 5000 ppm IBA. Out of the three media used for planting of cuttings, vermiculite proved to be the best and sand was the next best for rooting. Dhua and Sen (1984) observed maximum rooting success of 98.30 per cent with IBA 1000 ppm in combination with 1000 ppm ferulic acid by air layering in jack. Angeles (1983) obtained very low success with air layering in jack. The highest rooting success was 45 per cent when layering was done in July. Poor rooting (less than 10%) of young and mature stem cuttings of jack had also been noted in the Philippines. Application of NAA or IBA, use of low or high pressure mist propagators and use of different media all failed to improve the rooting ability of the jack cuttings (Angeles, 1983). Morton (1987) reported rooting of young jackfruit woody stem cuttings under mist. *Jack root cuttings were like wise unsuccssful* (Hensleigh and Holaway, 1988).

Rao et al. (1963) observed that the mixture of IAA, IBA and NAA was effective in inducing high percentage of rooting when applied at 0.25 or 0.50 per cent each in mango airlayers. Synergistic effect of IBA and NAA at 7500 ppm in mango air layers were reported by Verma et al. (1970). Sadhu and Bose (1980) recorded success in the rooting of mango cuttings by pre-soaking treatment in ethrel (50 ppm) and acetylene (100 ppm) followed by quick dip in IBA or IAA at 2500 ppm. Patil and Singh(1982) obtained 66.6 per cent rooting with IBA 20,000 ppm plus NAA 5,000 ppm in mango.

Chhonkar and Singh (1967) obtained a slight improved rooting of cashew air layers by treating with IBA at 75 ppm on ringed portion of one year old shoots. Coester and Ohler (1976) opined that semi mature stem cuttings with the application of one per cent IBA in talc, produced better roots in perlite medium. Hanamashetti et al. (1984) reported that application of IAA increased the number of roots and root length in cashew air layers. Many workers have reported good rooting with IBA treated cashew air layers (Sen and Chakraborthy, 1972; Melanta, 1982; Valsalakumari et al., 1985). Palaniswami et al. (1985) reported 40 to 50 per cent rooting in cashew air layers treated with 500 ppm IBA prepared during July - September.

The difference in root promoting effects of different auxins could be due to their differences in initiating hydrolysis of nutritional reserves (Sen et al., 1965). Nanda et al. (1968) observed that enhanced hydrolytic activity in the tissues in the presence of exogenously applied hormone was responsible for increased rooting of auxin treated shoots of some forest tree species.

Bhandary and Kololgi (1960) considered that IBA and NAA in combination was good for earlier rooting of guava (Var. Lucknow-49) air layers. According to them, 10,000 ppm IBA and 15,000 ppm NAA concentration were optimum and induced rooting in shorter period of five to six weeks. Bhandary and Mukherjee (1969) obtained 90 per cent rooting in invigorated shoots treated with IBA at 500 ppm, but observed only 13.3 per cent rooting in non-juvenile shoots of guava. Vijayakumar (1972) reported that treatment of guava cuttings with 5000 ppm of IBA and planting in July resulted in maximum rooting of 84.56 per cent. Wally et al. (1981) in an experiment with hardwood cuttings reported that treatment with IBA at 500 ppm and Alpha-naphthol at 10 ppm recorded 40 per cent rooting, when the cuttings were planted in October. Treatment with P-hydroxybenzoic acid (200ppm) in combination with IBA (5000 ppm) recorded 93.3 per cent rooting of cuttings in comparison with 60 per cent under control in guava (Dhua et al., 1982a). Treatment with ethephon at 50 and 100 ppm on stock plant and application of IBA at 3000 ppm caused 100 per cent rooting of cuttings. But the percentage of root formation was found to decrease with further increase in Ethephon concentration in case of guava (Dhua et al., 1982b). Patel et al. (1989) recorded 100 per cent rooting with IBA at 3000 ppm in guava. Similar results of successful rooting in guava cuttings were reported by Prasad et al. (1988) and Debnath and Maiti (1990).

Ganapathi (1988) opined that tamarind can be propagated by air-layering with the application of IBA at the rate of 2500 ppm during June/July but the cuttings failed to root. However, Swaminath et al. (1990) obtained 52 per cent rooting in stem cuttings of tamarind.

Early rooting of air layers of Sapota cv. Kalipati treated with IBA and NAA combined in equal proportions was reported by Chinnappa and Kololgi (1961). Sulladmath and Kololgi (1959) concluded that IBA and NAA at 10,000 ppm (mixed in equal parts) as optimum dose for the rooting of sapota air layers. Uthaiah (1975) recorded significant increase in number of rooted layers, number of roots per layer and length of roots and early rooting in sapota with IBA and NAA in combination. Chatterjee *et al.* (1989) recorded 91.7 per cent rooting success and 90.9 per cent survival of air layers in sapota when invigorated shoots after etiolation treated with 10,000 ppm IBA.

Baruah (1988) reported that growth regulator concentration of IBA + NAA 20,000 ppm was the most effective in initiating rooting which produced 25.00 per cent rooting in mature shoot cuttings, 22.50 per cent in air layer and 30.00 per cent in invigorated shoot cuttings in custard apple.

Singh *et al.*(1973) indicated that IBA at 2,500 ppm induced early and extensive rooting in litchi air layers and the marcoting period was reduced from 106 days to 69 days in treated ones. According to Chadha (1968) in litchi optimum concentration of IBA and NAA at 250 ppm gave 88.8 per cent and 72.2 per cent rooting respectively as against 37.2 per cent in control. Sharfuddin and Husain (1973) obtained cent per cent rooting in litchi marcots by treating with IBA at 5000 ppm.

Chatterjee and Rao (1978) reported that 10,000 ppm IBA application gave 95 per cent rooting in ber air layers. Ughreja and Chauhan (1983) observed 97.6 per cent rooting of ber layers treated with 15,000 ppm IBA.

2.6 Seasonal variations in rooting

The selection of seasons in relation to rooting of cuttings and layers was observed in some of the plant species. The changes in rooting response with changes in seasons have been attributed to the morpho-physiological status of the shoot. The endogenous levels of nutrients and growth promoting substances are also influenced by environmental conditions such as sunshine, temperature, humidity and rainfall. Some of these factors in turn have effect on the mobilization of reserve food material through hydrolytic enzymes resulting in their convertion into readily available forms to cater to the requirements of rapidly growing cells and tissues. Changes in the cambial activity and tissues content of auxins, inhibitory substances and root promoting co-factors due to seasonal variations also have been observed by several scientists.

Singh (1950) reported that guava gooties rooted better during the rains. He observed good rooting and root development. In sapota, Chinnappa (1960) found that the temperature prevailing in Dharwar conditions did not inhibit rooting of air layers in any part of the year. However, humidity has a role in rooting. Low humidity, when compared to coastal regions was pointed out as one of the factors for limitation of rooting under Dharwar condition. Humidity was high during rainy months and low during winter and other season. Temperature and humidity during the first 12 to 16 weeks after layering seems to be the controlling factor for root initiation. Earlier Sulladmath and Kololgi (1959) recommended first week of October for air layering of sapota under Dharwar condition.

Bose and Mandal (1970) observed that many species of plants which failed to root or showed a low percentage of root formation produced roots under high humidity and low temperature. They found that providing low temperature and high humidity artificially facilitates rooting in hard to root plants. This practice encouraged more number of roots in a much shorter period.

Singh et al.(1957) and Janik (1979) explained the merits of high humidity and low temperature of the atmosphere in terms of reduction in transpirational loss of water. This reduces the desication of the tissues. Hartman and Kester (1986) opined that for good rooting, it is essential that the shoots maintain their turgidity and high leaf water potential. Studies have shown that low water potential (well below −10 bars) often occur and this low level is related to poor rooting. To reduce the transpiration loss, the vapour pressure of the water in the atmosphere surrounding the leaves should be maintained nearly equal to the water vapour pressure in the inter cellular spaces within the leaf. High humidity in the environment and low temperature can reduce loss of water from the leaves. Nanda and Kochar (1985) opined that the efficacy of synthetic auxins to initiate roots in cuttings varied not only with the nature and concentration of auxin and plant species, but also with season.

Nanda et al. (1971) observed that the seasonal changes in rooting response of Hibiscus are closely related to the seasonal changes in starch content and the low rooting capacity corresponding to high starch content and vice versa. Hess and Synder (1957) also found that lowering leaf temperature increased carbohydrate content in shoots.

Jauhari and Mehra (1960) had very meagre success with air layering in February, even with growth substances in jack, while they achieved up to 100 per cent rooting during the rainy season of late August to late October.

Vijayakumar (1972) has reported seasonal variations in root promoting cofactor activity in the invigorated and mature tissues of guava. The root promoting 'cofactor No.3' was found in higher amount in girdled and etiolated shoots taken in July as compared to those of May in three varieties of guava. The higher activity was found associated with higher rooting activity.

Suryanarayan and Rao (1982) obtained highest percentage of successful layers and highest number of roots per air layer in shortest period in mango when air layering was done in August to October months. According to Baruah (1988), monsoon was the best season for making cuttings and air layering of custard apple, where as summer was the best season for stooling. Similar results were obtained by Nair (1989) in sapota Angeles (1983) in jack.

2.7 Biochemical factors affecting rooting of air layers and cuttings

2.7.1 Nutritional status

The rooting capacity of the cuttings has been correlated with nutritional status of cuttings, by many workers (Tukey and Green, 1934; Pearse, 1943; Haun and Cornell, 1951) and they were of the opinion that cuttings with high carbohydrate and low nitrogen contents produced high percentage of rooting, while converse was substantiated by Schrader (1925) and Reid (1924, 1926). Taylor and Odom (1970) recorded higher quantity of nitrogen, total sugars, starch and total carbohydrate in rooted cuttings of Carya illinoensis with girdled and etiolated shoots.

Basu et al. (1967) carried out analytical studies at callusing and root emergence stages of mango air layers treated with IBA and found that they contained relatively greater quantity of carbohydrates in root forming region.

Similar results were obtained in air layers of mango by Basu et al. (1972).

Nanda and Anand (1970) established relationship between starch content and rooting in Populus nigra. The delayed rooting was attributed to high starch content of the cuttings. They further stated that vigorous rooting was associated with low starch content and the poor rooting was caused by low activity of hydrolysing enzyme which affected the hydrolysis of starch into sugars. In similar studies, it was found that there is a close relationship between seasonal changes and starch content. The low rooting corresponded with high starch and vice-versa (Nanda et al., 1971).

According to Sen and Basu (1960) root initiation was found to be directly proportional to carbohydrate/nitrogen ratio, but root development was dependent on a proper balance of carbohydrate and nitrogenous substances. They obtained enhanced rooting in Justicia gendarusa when the cuttings were low in nitrogen and high in total carbohydrates.

Singh (1960) reported that ringed hardwood cuttings of mango treated with IBA showed enhanced metabolic activity with increases in reducing and non-reducing sugars and a favourable C/N ratio compared with unringed cuttings or ringed cuttings not treated with IBA.

Stuart (1938) and Altman and Wareing (1975) observed a mobilisation of carbohydrates towards developing root systems of leafy softwood cutting of Phaseolus vulgaris. Breen and Muraoka (1973) reported initial reductions in carbohydrate reserves in the rooting zone of semihardwood plum cuttings followed by an increase from current photosynthesis. Vietz et al. (1980) found reduction in starch at the base of juvenile chesnut cuttings. Girdling and etiolation of tamarind shoot for 30 days prior to air layering resulted in occumulation of higher percentage of total sugars, less starch and high percentage of total nitrogen according to Gowda (1983). He also reported that girdling and etiolation considerably shortened the time required for root initiation.

2.7.2 Role of nitrogen

A proper ratio between carbohydrates and nitrogen is essential for cuttings and air layers to strike good rooting. Thus, the level of nitrogen is of vital importance in determining the proper balance with carbohydrates.

Bachelard and Stowe (1963) observed that nitrogen compounds alone or together with sucrose appear to play some role in optimal rooting but the effect may not have direct influence on the chemical content. Rooting of stem cuttings of pear showed the mature tissue to contain more soluble and protein nitrogen than in juvenile. But in all the three species that they studied, rooting behaviour bore no relationship to nitrogen fraction (Ali and Westwood, 1966). Haun and Cornell (1951) noticed low level of nitrogen in Geranium sps. resulting in a significantly higher percentage of rooted cuttings than the high levels.

Ali and Nazir (1970) said that auxin treatment led to initial increase in total soluble nitrogen, followed by a steady decline of nitrogen in cuttings of mango. Hosai et al. (1972) noticed that soluble nitrogen content of hardwood cuttings of grape vines gradually decreased in both upper and lower values of the items throughout the rooting period, while insoluble nitrogen content fell markedly only in upper half of the stem. They observed that much of the nitrogen moved from lower to upper parts of the cuttings as root and shoot begain to grow.

Zarkua (1974) reported the direct correlation between protein and nitrogen contents and root regenertion in cuttings of grape vines. Ghosh and Basu (1974) noted that mobilisation of nitrogen from upper parts of the cuttings was more when treated with root promoting auxins. Similar observations were recorded by Stuart (1938), Gregory and Samantarai (1950).

2.7.3 Role of root promoting co-factors

As early as 1938, Went postulated the presence of specific factors other than auxins which he believed were manufactured in the leaves and were essential for root formation. Bouillenne and Bouillenne (1952) in their experiment with mungbean (Phaseolus aureus Roxb.) rooting observed that by increasing the concentration of centrifugal diffusate, there was an increase in number of roots. They attributed this phenomena to the base of the cuttings in sufficient amount. Sengupta and Chattopadhya (1954) reported that failure of rooting in response to auxin application in many cases like Mangifera indica and Eugenia jumbolana may be attributed to the lack of cofactors in the cuttings.

Basu et al. (1966) reported that there was a greater accumulation of rooting cofactors in the girdled seedling shoots of mango when compared to non-girdled ones. Fadal and Hartman (1967) conducted mung bean bioassay test in the extracts of basal section of hard wood cuttings of pear cv. 'Old home' and recorded higher level of promoters during maximum rooting.

Vijayakumar (1972) observed that invigorated tissues of guava (Psidium guajava L.) obtained during the month of July contained all the four rooting co-factors and especially rooting cofactor 4 which is very essential for initiation of root.

Chatterjee and Rao (1985) reported that in jack the net root promoting activity of invigorated shoots was higher than that of the non-invigorated shoots. Etiolation of both the invigorated and non-invigorated shoots induced higher net root promoting effect than of non-etiolated shoots. All the four rooting cofactors were recorded in pregirdled plus etiolated shoots of jack by Lingarajappa (1980) and Shivanna (1983).

According to Baruah (1988), in mature shoots of custard apple, the activity of inhibitors was high and the activities of auxin like substances and root promoting cofactors were low. The juvenile shoots showed higher activities of auxin like substances and root promoting cofactors No.1, 2 and 4, while the activity of inhibitors was negligible. In all the shoot samples, the root promoting cofactor No. 3 was absent. He observed sesonal effect on root promoting cofactors. The root promoting cofactors were higher level in monsoon and inhibitors were more in winter season.

MATERIAL AND METHODS

III. MATERIAL AND METHODS

The studies on vegetative propagation in jackfruit were carried out at the Horticultural Research Station, Gandhi Krishi Vignana Kendra (G.K.V.K), University of Agricultural Sciences, Bangalore, situated at an elevation of 830 m above mean sea level, at 12^{o} 58' north latitude and 77^{o} 35' east latitude. Different experiments were carried out with the main objective of finding out quicker and easier methods among grafting, budding, airlayering and rooting of stem cuttings. For grafting and budding, the rootstocks were raised in polythene bags, for air layering and rooting of stem cutting, the existing trees in the G.K.V.K. campus were utilised. Tissue samples were analysed to find out the possible relation of biochemical constituents to grafting, budding and rooting. The meteorological data for the whole period are presented in Appendix I.

3.1 Collection of jackfruit seeds

Jackfruit seeds were collected from healthy, fully ripened fruits. Large seeds possess better germination potential and can produce more vigorous seedlings (Sonwalkar, 1951). Seeds weighing 5 to 6 g were collected and used for raising seedlings. After extraction, the seeds were thoroughly washed with water to remove their slimy coating and soaked in water for 24 hours to enhance germination. These seeds were sown in polythene bags.

3.1.1 Raising of rootstocks in polythene bags

Polylthene bags of 300 gauge (8" x 6" size) thickenss were used for raising jack rootstocks. Pot mixture of red earth, sand, farm yard manure (FYM) and coir dust (1:1:1:1 V/V) treated with one per cent BHC (Benzene Hexachloride) was used. Selected healthy, large sized seeds were laid flat on the medium with their hilum part facing down. The polythene bags holding the seeds were maintained in the nursery with necessary care.

3.1.2 Care of the rootstocks

Watering was done daily for the seeds sown in the polythene bags. Regular hand weeding was done whenever the weeds appeared. Germination of seeds started 20 days after sowing and continued for 30 to 40 days. The seedlings were watered regularly and general prophylactic plant protection sprays were given with pesticides and fungicides periodically to control the pests and diseases.

3.1.3 Selection of planting material for air-layers and rooting of stem cuttings

For the preparation of air-layers and rooting of stem cuttings, healthy, vigorously growing ten year to fifteen year age trees were selected.

3.1.4 Preparation of growth regulator formulations

Beta-indole-3 butyric acid (IBA) and napthalene acetic acid (NAA) were used in these experiments for treating the air layers and cuttings. Required quantity of IBA or NAA was first dissolved in a small quantity of isopropyl alcohol and further diluted with 50 per cent isopropyl alcohol.

EXPERIMENTAL DETAILS

3.2 Experiment-1: Effect of rootstocks age on grafting success.

Treatment	Age of the rootstock
T_1	3 months
T_2	4 months
T_3	5 months
T_4	6 months
T_5	7 months
T_6	8 months
T_7	9 months
T_8	10 months
T_9	11 months
T_{10}	12 months

Design: Completely Randomised Design (CRD)

Replications: Three

Number of grafts per treatment: 30 (at the rate of 10 grafts per replication)

Total number of grafts: 300

Method of grafting: Softwood grafting.

Date of grafting: Second week of every month starting from November 1990.

3.2.1 Selection of rootstock

Vigorously growing, uniform seedlings of specified age were used in different months of grafting. The rootstocks were selected every month for softwood grafting.

3.2.2 Preparation of scion

The scions from healthy, good and high yielding mother tree were used. One season old (6-8 month) shoots of pencil thickness, free from pest and diseases were selected for the preparation of scions. The terminal tip portion was removed from the selected scion and they were defoliated with a sharp secature, keeping one cm of the petiole attached to the shoot. Defoliation was done fifteen days prior to grafting and these scions were separated on the day of grafting.

3.2.3 Collection of scion

The defoliated scion shoots prepared on the selected jackfruit trees were separated in the morning hours from 7.00 to 9.00 am on the day of grafting. The scion shoots were separated from the selected tree with sharp secature and were wrapped in moist cloth and carried in polythene covers to the site of grafting. The scions collected were kept in water to get rid of the white latex. These scions were dipped in 0.2 per cent Bavistin solution at the time of grafting. The scions separated were grafted on the same day.

3.2.4 Grafting method

3.2.4.1 Softwood grafting

For the softwood grafting method, the top growth on the rootstock was decapitated with a knife. The girth of the stock in that region is almost equal to that of the scion stick. After this, a longitudinal cut of 5 cm length was given on the terminal trimmed rootstock. The top of the rootstock appeared like the letter 'V'. The leaves below the 'V' cut were intact. A scion of about the same thickness as that of the rootstock with a 'V' cut on the rootstock was selected. The length of the scion was about 10 cm. The lower end of the scion was cut into gently sloping wedge of about 5 cm by removing the bark and a little wood from the two opposite sides. Care was taken to retain some bark on the remaining two sides. The wedge shaped scion thus prepared was inserted into the'V' shaped slit of the stock and secured firmly with 1.5 cm wide and 45 cm long, 200 guage white transparent polythene strip. The scions were covered with small transparent bags to avoid desiccation of the scions by creating humidity near and above the graft union region.

3.2.5 Observations recorded

1. Percentage of graft union success was recorded after 30 days and 60 days of grafting.
2. Number of sprouts on the scion after 30, 60, 90 and 120 days of grafting was recorded.

3. Number of leaves on the sprout of scion after 30, 60, 90 and 120 days of grafting was recorded.

4. Sprout length on the scion after 30, 60, 90 and 120 days of grafting was recorded.

3.3 Experiment-II: Effect of curing of scion on softwood grafting success rate.

Age of stock	Duration of scion curing
T_1 - 4 months	20 days
T_2 - 4 months	15 days
T_3 - 4 months	10 days
T_4 - 5 months	20 days
T_5 - 5 months	15 days
T_6 - 5 months	10 days
T_7 - 6 months	20 days
T_8 - 6 months	15 days
T_9 - 6 months	10 days
T_{10} - 7 months	20 days
T_{11} - 7 months	15 days
T_{12} - 7 months	10 days
T_{13} - 8 months	20 days
T_{14} - 8 months	15 days
T_{15} - 8 months	10 days

Design: Completely Randomised Design (CRD)

Replications: Two

Number of grafts per treatment: 20 (at the rate of 10 grafts perreplication)

Total number of grafts: 300

Date of grafting: Third week of every month starting from December, 1990.

3.3.1. Selection of rootstock

Vigorously growing,uniform seedlings of specific age were used for softwood grafting.

3.3.2 Preparation of scion

For this experiment the leaf blades from the selected shoots were removed, keeping 1.00 cm long petioles attached to the scion shoots. The shoots were allowed to remain ~~as~~ such on the tree for 10-20 days. While, preconditioning, separating and grafting care was taken as described in the previous experiment.

3.3.3 Method of grafting

Softwood grafting was done on specified age jack rootstocks. The method followed was as described in the previous experiment.

3.3.4 Observations recorded

1. Percentage of graft union success was recorded after 30 and 60 days of grafting.
2. Number of sprouts on the scion after 30,60,90 and 120 days of grafting was recorded.
3. Number of leaves on the sprout of scion after 30,60,90 and 120 days of grafting was recorded.
4. Sprout length on the scion after 30,60,90 and 120 days of grafting was recorded.

3.3.5 After care of grafts

The grafted plants raised in polythene bags were kept under partial shade. The plants were regularly watered. The transparent polythene covers put on the graft covering the graft union regions were removed when the sprouts emerge on the scions 25 days after grafting. The sprouts appearing on the rootstock below the graft union were removed regularly whenever noticed. Regular prophylactic sprays with insecticides were given to control the attck of pests.

3.4 Experiment-III: Effect of age of rootstock on the success of chip budding

Treatments	Age of rootstocks
T_1	3 months
T_2	4 months
T_3	5 months
T_4	6 months
T_5	7 months
T_6	8 months
T_7	9 months
T_8	10 months
T_9	11 months
T_{10}	12 months

Design: Completely Randomised Design (CRD)

Treatments: 10

Replication: 3

Number of budlings per treatment: 30 (at the rate of 10 budlings per replication)

Total number of budlings: 300

Date of budding: Last week of every month starting from September, 1991.

3.4.1 Selection of rootstock

Vigorously growing, healthy,uniform seedlings of specified age were used for chip budding.

3.4.2 Preparation of buds

The buds were prepared on healthy mother trees. One season old (6 to 8 month) shoots of pencil thickness, free from pest and diseases were selected. The selected shoots were defoliated by removing the leaves with a sharp secature, keeping one cm of the petiole attached to the shoot. Defoliation was done 20 days prior to budding and these bud sticks were separated on the day of budding.

3.4.3 Collection of buds

The defoliated shoots were separated in the morning hours from 7.00 am to 9.00 am on the day of budding. These bud sticks had about four to six usable buds. The bud sticks were separated from the mother tree with sharp secature and were wrapped in moist cloth and carried in polythene covers to the site of budding. These bud sticks were placed in water to leache out latex and then dipped in 0.2 per cent Bavistin solution at the time of budding.

3.4.4 Budding method

3.4.4.1 Chip budding

Chip budding is generally done when the bark does not slip well. A chip of bark about 2.5-3.0 cm long was removed from a smooth place of the internode of the rootstock. Then another chip of the same size and shape and containg a mature bud was collected from the budstick and placed on the rootstock. The bud was then wrapped securelly with 1.0 cm wide and 30.0 cm long, 200 gauge white transparent polythene strip. Then the budlings were kept in polythene chamber to avoid desication and to prevent the buds from drying out by creating humidity.

3.4.5 Observations recorded

1. Percentage success recorded after 30 and 60 days of budding.
2. Number of leaves on the sprout of successful budlings after 30, 60, 90 and 120 days of budding.
3. Sprout length of successful budlings after 30, 60, 90 and 120 days of budding.

3.5 Experiment-IV: Studies on different methods of budding in jackfruit plant.

Treatment	Method of budding
T_1	'T' budding
T_2	Inverted 'T' budding
T_3	Patch budding
T_4	Ring budding
T_5	Chip budding

<u>Design</u>: Completely Randomised Design (CRD)

<u>Replication</u>: Four

<u>Number of budlings per treatment</u>: 40 (at the rate of 10 budlings per replication)

<u>Total number of budlings</u>: 200

<u>Age of the rootstock</u>: six month old

<u>Season</u>: December, 1991

The same experiment was again carried out on 12 month old rootstock during June, 1992.

3.5.1 *Selection of rootstock*

Vigorously growing, uniform seedlings of 6 and 12 months aged were used as rootstocks for different methods of budding.

3.5.2 Selection of buds

Buds from healthy mother tree, preconditioned for 20 days were used for budding. For preconditioning and separation of buds as per the procedures described in the previous experiment were followed.

3.5.3 Method of budding

3.5.3.1 Chip budding

Chip budding method followed is described in the previous experiment.

3.5.3.2 'T' budding

Suitable rootstock was selected for 'T' budding. A T-shaped incision was made through the bark and the two flaps of the bark were loosened with the help of the blade of a budding knife. The shield bud was cut out from the bud stick by passing the blade of the knife, so as to remove a shield - shaped patch of bark with a bud about 2.5 cm long and just slightly wider than the bud. The bud should be as thin as possible and the wood was removed before placing the bud into the stock. The bud was then slipped into the T-cut on the stock and tied with polythene tape leaving the bud and the leaf stalk exposed. Then the budlings were kept in polythene chamber under humid conditions to avoid desication and to prevent the buds from drying out.

3.5.3.3 Inverted 'T' budding

The techniques of inverted T-bud method are same as that of T-budding, except that the incision in the stock has the transeverse cut at the bottom rather than at the top of the vertical cut, and while removing the shield piece from the budstick the knife starts above the bud and cuts downwards. The shield was removed by making the transverse cut 2.5 cm below the bud. The shield piece containing the bud was inserted into the lower part of the incision and pushed upward until the transverse cut of the shield meets the tranverse cut that made in the stock. Then the bud was tied with polythene tape and kept in polythene chamber.

3.5.3.4 Patch budding

Patch budding was done on rootstock which are slightly thicker. The bark containing the bud was cut out in a rectangular form and a patch of bark equal to that of bud patch was removed on the rootstock. The bud was placed on the rootstock where a patch of bark was removed to arrange the bud and then tied with polythene tape and kept in polythene chamber.

3.4.3.5 Ring budding

A ring of bark 1.25 to 2.50 cm long and containing a good bud was loosened from the scion wood and slipped off from one end of the branch. The stock having the same diameter as that of the scion budstick was cut back to a height where budding to be done. Then a portion of the bark was peeled off and the ring of bark containing the bud was slipped down over the stock and tied with polythene tape and kept in polythene chambers to avoid desication. The polythene chambers maintaines high humidity.

3.5.4 Observations recorded

1. Percentage of budding success after 30 and 60 days of budding.

2. Number of budlings survived after 60 days.

3. Number of budlings dead.

3.5.5 After care of budlings

The budlings were kept in polythene chamber. The plants were regularly watered. The sprouts appearing on the rootstock below the bud union were removed regularly whenever noticed. Once the bud union was formed, the tape was removed and the top of the root stock was cut back. Regular prophylactic plant protection sprays were given to control the attack of pests and diseases.

3.6 Experiment-V: Effect of growth regulators on rooting of air layers of jackfruit.

Treatments	Concentration of growth regulators (ppm)
T_1	Control
T_2	IBA 10000
T_3	IBA 7500
T_4	IBA 5000
T_5	IBA 2500
T_6	IBA 1000
T_7	NAA 10000
T_8	NAA 7500
T_9	NAA 5000
T_{10}	NAA 2500
T_{11}	NAA 1000

Design: Completely Randomised Design (CRD)

Replication: Three

Number of air layers per treatment: 30 (at the rate of 10 layers per replication

Total number of air layers: 330

The experiment was carried out in three seasons i.e., winter (October), summer (February) and rainy (July).

3.6.1 Selection of materials

Healthy, vigorously growing, one season old shoots with stem thickness ranging from 1.0 to 1.2 cm from 15 year old plants were selected for air layering.

3.6.2 Preparation of air layers

Shoots of 50 to 60 cm length were selected for the experiment. A ring of bark measuring 2.5 cm length was made by carefully removing the bark just below the node and the wood exposed was rubbed with fingers to remove the cambium tissue. Growth regulator (IBA and NAA) was smeared to a length of 2.5 cm from the exposed shoot over the bark above the upper end of the ring. The exposed portion of the control shoots are treated with water. The treated shoots were then covered with moist spagnum moss (which was treated with 0.2 % Captan) and wrapped with polythene sheet by tieing both the ends with gunny thread.

3.6.3 Observations recorded

1. Number of air layers rooted
2. Number of roots on rooted air layer
3. Length of the longest root
4. Length of the shortest root
5. Number of layers survived

3.7 Experiment-VI: Effect of girdling + etiolation on rooting of air layers of jackfruit.

Treatments	Concentration of growth regulators (ppm)
T_1	Control (No girdling + etiolation)
T_2	Girdling + etiolation + IBA 10000
T_3	Girdling + etiolation + IBA 7500
T_4	Girdling + etiolation + IBA 5000
T_5	Girdling + etiolation + IBA 2500
T_6	Girdling + etiolation + IBA 1000

T_7	Girdling + etiolation + NAA 10000
T_8	Girdling + etiolation + NAA 7500
T_9	Girdling + etiolation + NAA 5000
T_{10}	Girdling + etiolation + NAA 2500
T_{11}	Girdling + etiolation + NAA 1000

Design: Completely Randomised Design (CRD)

Replication: Three

Number of air layers per treatment: 30 (at the rate of 10 layers per replication)

Total number of air layers: 330

The experiment was carried out in three seasons i.e., winter (October), summer (February) and rainy (July).

3.7.1 Selection of materials

Healthy, vigorously growing one season old shoots with stem thickness ranging from 1.0 to 1.2 cm from 15 year old plants were selected for air layering.

3.7.2 Preparation of air layers

3.7.2.1 Pregirdling and etiolation

Shoots of 50 to 60 cm length were selected for the experiment. The shoots were girdled by removing a ring of bark measuring about 2.5 cm length. Girdling was done from the portion just below the node. The exposed wood was rubbed with finger to remove cambium tissues. Then a black polythene film was covered around the shoots, covering the ring of bark removed, up to a length of 5.0 cm from the upper cut end of the ring. Thirty days after girdling and etiolation, layering was done as described in the previous experiment. For control girdling and etilation treatments were not given.

3.7.3 Observations recorded

1. Number of layers survived
2. Number of layers rooted
3. Number of roots on rooted air layer
4. Length of the longest root
5. Length of the shortest root

3.7.4 After care of air layers

The layered trees were kept under constant observation for mechanical damage. Polythene wrappers were replaced whenever they were found damaged by birds or squirrels.

3.7.5 Sampling

The shoot samples were collected from the preconditioned and control shoots for estimation of nitrogen, reducing sugars, non-reducing sugars, total sugars, protein and rooting cofactor studies at the time of air layering. The samples were collected from the upper edge of the ring or the corresponding region of all the non-ringed shoots.

3.8 Experiment VII: Effect of growth regulators on rooting of stem cuttings.

Treatments	Concentration of growth regulators (ppm)
T_1	Control
T_2	IBA 10000

T_3	IBA 7500
T_4	IBA 5000
T_5	IBA 2500
T_6	IBA 1000
T_7	NAA 10000
T_8	NAA 7500
T_9	NAA 5000
T_{10}	NAA 2500
T_{11}	NAA 1000

Design: Completely randomised design (CRD)

Replication: Three

Number of cuttings/treatment: 30 (at the rate of 10 per replication)

Total number of cutting: 330

Type of cuttings: Hardwood.

Season: Winter (October); Summer (March); Rainy (June)

3.8.1 Selection of plant material

Current season shoots having good, healthy and uniform thickness (1.0 to 1.2 cm) were selected for hardwood cuttings.

3.8.2 Preparation and treatment of cuttings

Hardwood cuttings were separated from the mother tree and the tender terminal green wood portion of cutting were cut off. Cutting of 15 to 20 cm length were collected before 10 a.m. All the cuttings werewrapped in moist paper and taken to the mist unit. The cuttings were trimmed to about 15 to 20 cm length. On each cutting, four vertical incisions of 2.5 cm length were made at the base. Solution of IBA and NAA was prepared in 50 per cent isopropyl alcohol. The basal 2 cm part of cuttings was dipped for 30 seconds in solution of IBA and NAA depending upon the respective treatments. Suusequently the cuttings were planted when the solution dried up. The medium used. was. sand.

3.8.3 Planting of cutting

The cuttings were planted in pots filled with washed sand as a rooting medium and kept under intermittant mist in a mist chamber. Care was taken to ensure that regular intermittant mist was given for 10 seconds with an interval of fifteen minutes from 8.00 a.m. to 6.00 p.m.

3.8.4 After care

To prevent the attack of fungal infection and other pathogenic damage, regular spray with a mixture of 'Bavistin' and 'Rogor' was given at fortnightly intervals.

3.8.5 Observations recorded

1. Number of cuttings survived
2. Number of cuttings with callus formation.
3. Number of roots formed per cuttings.

3.9 Experiment-VIII: Effect of girdling and etiolation on rooting of stem cuttings.

Treatments	Concentration of growth regulators (ppm)
T_1	Control (No girdling + etiolation)
T_2	Girdling + etiolation + IBA 10000
T_3	Girdling + etiolation + IBA 7500
T_4	Girdling + etiolation + IBA 5000
T_5	Girdling + etiolation + IBA 2500
T_6	Girdling + etiolation + IBA 1000
T_7	Girdling + etiolation + NAA 10000
T_8	Girdling + etiolation + NAA 7500
T_9	Girdling + etiolation + NAA 5000
T_{10}	Girdling + etiolation + NAA 2500
T_{11}	Girdling + etiolation + NAA 1000

Design: Completely Randomised Design (CRD)

Replication: Three

Number of cuttings per treatment: 30 (at the rate of 10 per replication)

Total number of cuttings: 330

Type of cuttings: Hardwood

Season: Winter (October): Summer (March): and Rainy (June).

3.9.1 Selection of material

Healthy, vigorously growing current season shoots of Uniform thickness (1.0 to 1.2 cm) were selected.

3.9.2 Preparation and treatment of cuttings

3.9.2 Girdling and etiolation

Current season's shoots having good, healthy and uniform thickness were selected and were girdled by removing a ring of bark of 2.5 cm width from the portion just below a node at a distance of 30 cm from the tip of the shoot. The exposed wood was rubbed with finger to remove the cambium tissue. The girdled portion was etiolated by black polythene sheet. Thirty days after girdling and etiolation, the cuttings were prepared as described in the previous experiment. For control, the cuttings were not girdled or etiolated.

3.9.3 Observations recorded

1. Number of cuttings survived
2. Number of cuttings with callus formation
3. Number of roots per cuttings

3.9.4 Sampling

The shoot samples were collected from the girdled and etiolated shoots and also from the shoots which were not girdled and etiolated. The tissue samples were used for the estimation of nitrogen, sugar, starch and rooting co-factors at the time of planting the cuttings. The samples were collected from the upper edge of the ring from the girdled and etiolated shoots and from the corresponding region of the non-girdled and non-etiolated shoots in case of control.

3.10 Chemical analysis

Rootstocks of different age and scions cured for 10, 15 and 20 days were analysed. Shoots of jackfruit used for the preparation of air-layers and stem cuttings allowed to root were also analysed. The tissue samples were analysed for the following constituents.

1. Dry matter percentage
2. Reducing sugars
3. Non-reducing sugars
4. Total sugars and starch
5. Total carbohydrates
6. Total nitrogen
7. Protein
8. Carbohydrate / nitrogen ratio

Fresh samples of nonjuvenile, girdled and non-girdled shoots of jackfruit were analysed for rooting cofactors.

3.10.1 Dry matter percentage

A known quantity of fresh material was dried in an oven at temperature ranging between 60 and 70 ^{o}C for 48 hours. Drying was completed at a temperature of 100 ^{o}C for two to three hours till two consecutive weight were constant. The dry matter percentage was calculated by the formula.

$$\frac{\text{Total dry weight of the sample}}{\text{Total fresh weight of the sample}} \times 100$$

3.10.2 Determination of sugars

Extraction of the samples for the determination of sugars was done according to the modified procedure of Asana and Saini (1962).

3.10.2.1 Estimation of total sugars

To an aliquot (5 ml) of the clarified extract, 0.5N HCl (2.5 ml) was added and then heated on a water bath for 30 minutes. After cooling, the excess acid was neutralised with 0.5 N NaoH using a drop of phenoptheleir as an indicator. The contents were made slightly acidic by adding a drop of 0.1 N oxalic acid and then made to a known volume (100 ml) by adding distilled water. From this an aliquot (0.5 ml) was taken and total sugars were determined as in the case of reducing sugars.

A standard curve for glucose was plotted and the amount of reducing sugars and total sugars were estimated with reference to the standard curve. The amount of non-reducing sugars was calculated by the difference between total sugars and reducing sugars.

3.10.2.2 Estimation of reducing sugars

The reducing sugar estimation was carried out by Nelson-Somogi Micro Copper Method (1944). To an aliquot (1ml) of the clarified extract, copper reagent (1 ml) was added and heated in a boiling water bath for 12 minutes. After cooling under tap water, arsenomolybdate reagent (1 ml) was added and the volume was made to 10 ml by adding distilled water. The colour intensity was measured at 530 nm.

3.10.3 Estimation of starch

The residual plant material remaining after extraction of sugars with ethyl alcohol was dried at 80 °C and the weight was recorded. A sample of the dried residue (50 mg) was suspended in water (5 ml) with five to seven drops of 10N HCl and boiled for half-an-hour on a water bath to hydrolyse starch. This was then cooled under running tap water and centrifuged, and the supernatent liquid decanted. This was made up to a known volume (100 ml).

The starch content was estimated as per the procedure adopted for reducing sugars with Somogy's method. In this procedure glucose was used as a standard. The amount of glucose equivalent obtained was multiplied by 0.9 to get starch content.

3.10.4 Total carbohydrates

Total carbohydrates content was calculated by adding together the values for total sugars and starch content.

3.10.5 Estimation of total nitrogen

The dried and powdered samples were used for the estimation of nitrogen. Nitrogen was determined by following micro-kjeldhal method as outlined in A.O.A.C. (1970). The results were expressed as percentage.

3.10.6 Estimation of carbohydrates/nitrogen ratio

The value of total carbohydrates present in the plant samples was divided by that of total nitrogen to get the carbohydrates/nitrogen ratio.

3.10.7 Protein

The protein content was obtained by multiplying the percentage nitrogen with the factor 6.25 i.e., % N x 6.25.

3.10.8 Bioassay of rooting co-factors

The rooting co-factors in the cuttings and air-layers of jackfruit shoots were assayed by using mung bean bioassay technique as followed by Hess (1961). Fresh shoot samples collected were thoroughly washed by using distilled water. The excess water was removed by pressing them gently in between two blotting papers. The shoots were chopped into small pieces and 100g of the sample was used for the bioassay purpose. The samples were macerated with ice-cold methanol. The macerated material was submerged in excess of the methanol and allowed to stand at -15^{o}C for eight hours. At the end of extraction period the clear supernatent liquid was decanted. The plant material was again submerged in methanol after thorough mixing and the supernatent was decanted after eight hours. After two more such extractions the residue was washed with fresh methanol. All the decantations and the washings were combined and filtered. The filterate was evaporated to dryness in a flash evaporator under reduced pressure at 35 to 40 °C. The dry residue was dissolved in methanol (10 ml) and was used for bioassay.

Whatman No. 3 chromatographic paper was streaked with 100 μl aliquot. The chromatograms was developed by descending chromatographic technique by using Isopropanol and water (8:2 V/V) proportion. When the front was advanced 30 cm, chromatograms were taken out from the chamber and dried in forced air for 30 minute. Chromatograms were cut into 3 cm sections. Blank strip developed in the same solvent served as control. Each section was placed in a vial containing 4 ml solution of 5×10^{-6} M of IAA. Ten mung bean cuttings containing primary leaves, epicotyl and 3 cm hypocotyl tissue were placed in each vial. The vials were placed in a growth chamber. The chamber was illuminated for 16 hours a day with a light intensity of approximately 2000 foot candles and temperature of 20 °C. The IAA present in the vials and the substances leached from the chromatogram sections were taken up by the cuttings within 12 hours. Glass distilled water was added to the level of the cotyledonary node and maintained throughout the period of assay. At the end of sixth day, the cuttings were removed and number of roots per cutting was counted. The mung bean rooting bioassay test for all the samples was done in duplicate and the average values worked out. *Histograms were prepared to show the places of* promotion and inhibition of roots.

According to Hess (1961), the approximate *Rf* values of four rooting co-factors separated by using solvent system Isopropanol and water (8:2 V/V) as mentioned below were used for identifying the presence of the various co-factors on the chromatograms of the different shoot extracts studied.

Rooting co-factors	Rf-values
1	0.1
2	0.3
3	0.6
4	0.8

3.11 *Statistical interpretation of* data

Statistical interpretation of the data of all the experiments were done by following Fisher's analysis of variance technique as given by Panse and Sukhatme (1967).

EXPERIMENTAL RESULTS

IV. EXPERIMENTAL RESULTS

The results of different experiments carried out are presented in this chapter. The experiments were carried out to standardise the vegetative propagation techniques in jack. Propagation techniques like grafting, budding, air layering and from cuttings were carried out. Effect of age of rootstocks on success of softwood grafting, budding and the effect of scion curing on softwood grafting were also studied. Effect of growth regulators and season on rooting of air layers and cuttings were also studied. The data on various constituents like dry matter percentage, nitrogen, sugars, starch and rooting cofactors are also presented in this chapter.

4.1 Effect of rootstock age on grafting success in jack

This experiment was carried out to find out the optimum age of rootstock for carrying out softwood grafting in jack.The grafting operation was carried out at monthly intervals on three month to twelve month old rootstocks. Pre-cured scion sticks were used for grafting purpose.

4.1.1 Per cent graft union success

The data on the per cent graft union success on 30 th day and 60 th day after grafting are presented in Table 1 and Fig. 1. (Plate I).

The per cent graft union success on the 30 th day and 60 th day after grafting showed significant differences among the treatments.

Table 1: Effect of rootstock age on graft union success in Jack

Treatments (Age of rootstock)	Graft union success (per cent)	
	30 DAG	60 DAG
T_1 - 3 month	10.00 (18.43)	10.00 (18.43)
T_2 - 4 month	10.00 (18.43)	10.00 (18.43)
T_3 - 5 month	23.33 (28.78)	16.67 (23.36)
T_4 - 6 month	40.00 (39.23)	36.67 (37.22)
T_5 - 7 month	33.33 (35.21)	30.00 (33.00)
T_6 - 8 month	23.33 (28.07)	20.00 (25.36)
T_7 - 9 month	23.33 (28.07)	15.00 (22.59)
T_8 - 10 month	25.00 (29.92)	20.00 (26.56)
T_9 - 11 month	10.00 (18.43)	10.00 (18.43)
T_{10} - 12 month	15.00 (22.59)	15.00 (22.59)
C.D at 5%	11.39 (7.94)	13.34 (9.33)
S.Em $\pm$	3.87 (2.70)	4.53 (3.17)
C.V. (%)	31.94 (17.64)	42.83 (22.34)

DAG = Days after grafting.

Values in the parentheses indicate angular transformed ones

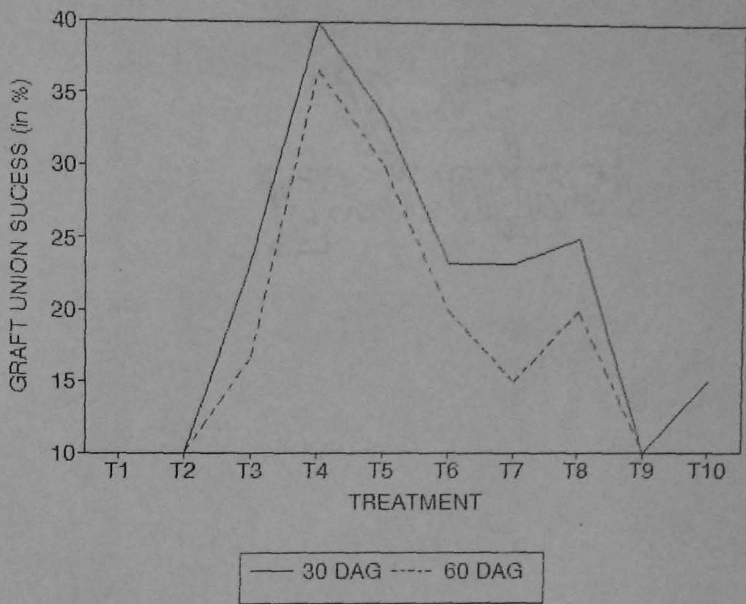


FIG. 1 : EFFECT OF ROOTSTOCKS AGE ON GRAFT UNION SUCCESS

Plate I : Successful softwood grafts of jack

PLATE - I

On the 30 th day after grafting, the maximum graft union success was recorded in six month old rootstock (40.00 %). The lowest success was in case of eleven month old rootstock (10.00 %) however, it was on par with three month old, four month old and twelve month old rootstocks. On the 60 th day after grafting, six month old rootstock has given maximum success (36.67 %) followed by seven month old rootstock (30.00 %) but these two treatments were on par. The least success was recorded by three, four and eleven month old rootstock (10.00 %) which were on par with ten, five, eight, nine and twelve month old rootstocks .

4.1.2 Effect of age of rootstocks on average number of leaves per graft

The data on average number of leaves on 30th, 60th, 90th and 120th day after grafting are presented in Tabel 2 and Fig. 2. The average number of leaves per graft on 30th, 60th, 90th and 120th day after grafting were significantly different among the treatments.

On the 30th day, a maximum number of leaves per graft was in eight month old rootstock (7.83) followed by six month old rootstock (6.40) but these two treatments were on par. The least number of leaves recorded was 1.00 In ten month old rootstock which was on par with eleven month old rootstock which had an average leaf number of 1.66.

Table 2: Effect of rootstock age on average number of leaves per graft in Jack

Treatments (Age of rootstock)		Average number of leaves			
		30 DAG	60 DAG	90 DAG	120 DAG
T_1 -	3 month	3.50 (1.99)	5.50 (2.44)	11.00 (3.38)	13.50 (3.74)
T_2 -	4 month	3.00 (1.85)	6.00 (2.54)	11.50 (3.46)	15.50 (3.99)
T_3 -	5 month	4.33 (2.18)	6.60 (2.64)	8.20 (2.89)	10.66 (3.31)
T_4 -	6 month	6.40 (2.60)	14.40 (3.85)	16.33 (4.10)	19.83 (4.50)
T_5 -	7 month	4.93 (2.32)	10.33 (3.26)	13.63 (3.74)	14.56 (3.86)
T_6 -	8 month	7.83 (2.86)	11.83 (3.50)	16.23 (4.09)	19.16 (4.43)
T_7 -	9 month	3.50 (1.99)	4.00 (2.11)	7.66 (2.85)	9.75 (3.20)
T_8 -	10 month	1.00 (1.22)	5.50 (2.44)	9.75 (3.20)	14.25 (3.84)
T_9 -	11 month	1.66 (1.46)	2.76 (1.80)	4.10 (2.13)	5.43 (2.40)
T_{10} -	12 month	2.66 (1.78)	5.10 (2.36)	10.25 (3.27)	14.50 (3.87)
C.D at 5%		1.96 (0.41)	2.89 (0.47)	3.13 (0.51)	3.25 (0.48)
S.Em. ±		0.66 (0.14)	0.98 (0.16)	1.06 (0.17)	1.10 (0.16)
C.V. (%)		29.78(11.94)	23.64(10.38)	16.99 (9.09)	13.97 (7.61)

DAG = Days after grafting.

Values in the parentheses indicate square root transformed ones

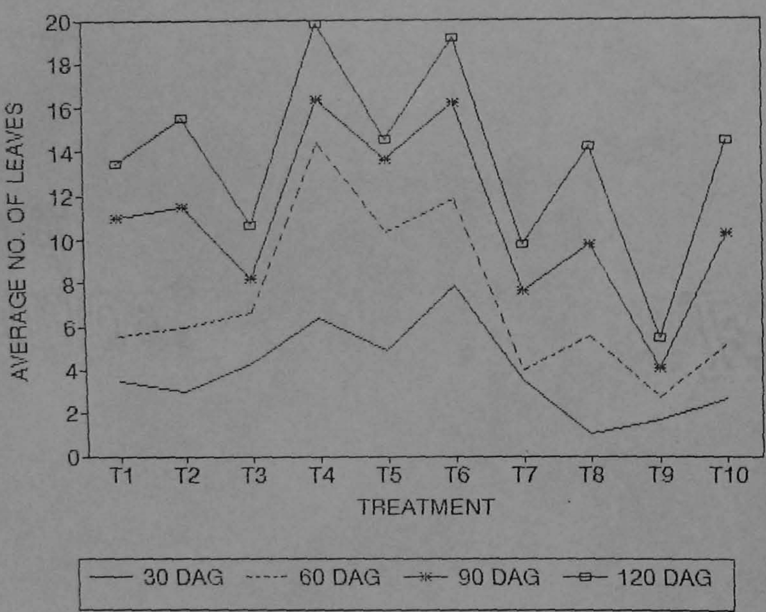


FIG. 2: INFLUENCE OF ROOTSTOCK AGE ON AVERAGE NUMBER OF LEAVES PER GRAFT

On the 60th day after grafting, the maximum average number of leaves recorded was 14.40 in six month old rootstock followed by eight month old rootstock (11.83). However, these two were on par. The lowest number of leaves recorded was in eleven month old rootstock (2.76). However, it was on par with three, nine, ten and twelve month old rootstocks.

On the 90th day after grafting, six month old rootstock recorded maximum number of leaves (16.33) followed by eight month old rootstock (16.23), but these two were on par. Least number of leaves was recorded in eleven month old rootstock (5.43).

On the 120th day after grafting, maximum average number of leaves per graft was in six month old rootstock (19.83) followed by eight month old rootstock (19.16), but were on par. Least number of leaves recorded was 5.43 in eleven month old rootstocks.

At all stages of growth six month and eight month old rootstocks have produced maximum number of leaves.

4.1.3 Effect of age of rootstocks on number of sprouts per graft

The data on average number of sprouts on 30th, 60th, 90th and 120th day after grafting are presented in Table 3 and Fig. 3. The difference for average number of sprouts on scion portion of the graft on 30th, 60th, 90th and 120th day after grafting were significant among the treatments.

Table 3: Effect of rootstock age on average number of sprouts per graft in Jac

Treatments (Age of rootstock)		Average number of leaves		
	30 DAG	60 DAG	90 DAG	120 DAG
T_1 - 3 month	1.00 (1.22)	2.00 (1.58)	2.00 (1.58)	2.00 (1.58)
T_2 - 4 month	1.50 (1.40)	2.50 (1.72)	2.50 (1.72)	2.16 (1.62)
T_3 - 5 month	1.50 (1.40)	1.66 (1.46)	1.86 (1.53)	2.20 (1.63)
T_4 - 6 month	2.75 (1.78)	2.93 (1.84)	3.00 (1.86)	3.16 (1.91)
T_5 - 7 month	2.33 (1.68)	2.76 (1.80)	2.90 (1.83)	2.90 (1.83)
T_6 - 8 month	4.11 (2.14)	4.06 (2.11)	4.16 (2.14)	4.16 (2.14)
T_7 - 9 month	1.50 (1.40)	1.50 (1.40)	2.25 (1.65)	2.25 (1.65)
T_8 - 10 month	1.00 (1.22)	2.00 (1.58)	2.00 (1.58)	2.00 (1.58)
T_9 - 11 month	1.00 (1.22)	0.76 (1.11)	0.76 (1.11)	0.76 (1.11)
T_{10} - 12 month	1.75 (1.48)	1.50 (1.40)	1.50 (1.40)	1.50 (1.40)
C.D at 5%	1.16 (0.31)	1.22 (0.33)	1.11 (0.29)	1.18 (0.31)
S.Em. ±	0.39 (0.10)	0.41 (0.11)	0.37 (0.10)	0.39 (0.10)
C.V. (%)	37.25(12.56)	33.22(12.35)	28.61(10.57)	29.96(11.35)

DAG = Days after grafting.
Values in the parentheses indicate square root transformed ones

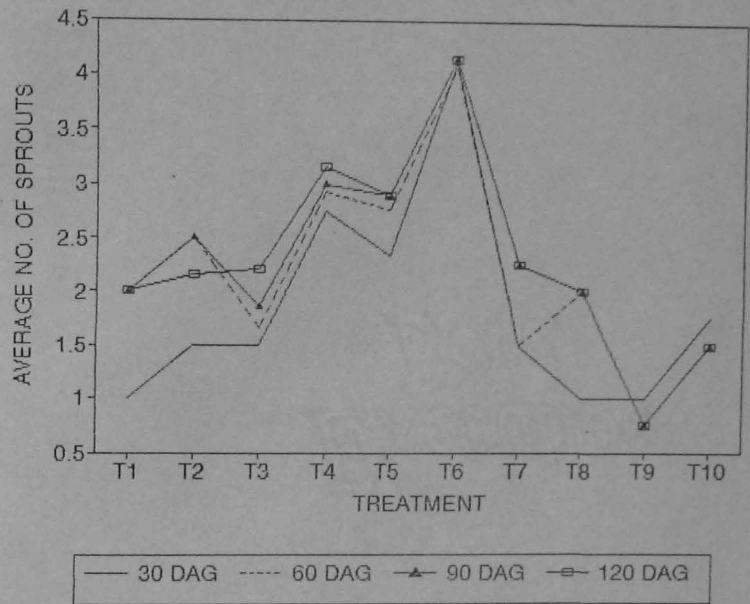


FIG.3 : INFLUENCE OF ROOTSTOCK AGE ON AVERAGE NUMBER OF OF SPROUTS PER GRAFT

On the 30th day after grafting, the maximum number of sprouts recorded was 4.11 in eight month old rootstock. The minimum number of sprouts recorded was 1.00 in eleven month old rootstock but on par with three, four, five, nine, ten and twelve month old rootstocks.

On the 60th day after grafting, eight month old rootstock recorded maximum number of sprouts (4.06) followed by six month old rootstock (2.93), but these two were on par. Least number of sprouts was in eleven month old rootstock (0.76). However, it was on par with five, nine and twelve month old rootstocks.

On the 90th day after grafting the maximum number of sprouts was in eight month old rootstocks (4.16). The lowest number of sprouts recorded was on eleven month old rootstock (0.76), but it was on par with five month old and twelve month old rootstocks.

On the 120th day after grafting, the maximum number of sprouts recorded was 4.16 in eight month old rootstock followed by six month old rootstock (3.16), however, these two treatments were on par. The lowest number of sprouts recorded was in eleven month old rootstock (0.76), but on par with twelve month old rootstocks.

4.1.4 Effect of age of rootstocks on sprout length on scion.

The data pertaining to the average sprout length on 30th, 60th, 90th and 120th day after grafting are given in Table 4 and Fig. 4.

Table 4: Effect of rootstock age on average number of sprout length of graft in jack

Treatments (Age of rootstock)		Average sprout length (cm)			
		30 DAG	60 DAG	90 DAG	120 DAG
T_1 -	3 month	5.50 (2.44)	7.50 (2.82)	9.50 (3.16)	12.00 (3.53
T_2 -	4 month	5.00 (2.33)	7.50 (2.82)	9.50 (3.15)	12.50 (3.60
T_3 -	5 month	3.53 (1.98)	4.20 (2.13)	7.46 (2.75)	9.50 (3.08
T_4 -	6 month	4.96 (2.29)	7.55 (2.82)	10.45 (3.30)	12.54 (3.60
T_5 -	7 month	2.56 (1.74)	5.85 (2.51)	7.56 (2.83)	10.15 (3.25
T_6 -	8 month	2.87 (1.82)	4.66 (2.26)	7.87 (2.88)	8.16 (2.93
T_7 -	9 month	1.50 (1.40)	2.43 (1.70)	6.25 (2.59)	9.00 (3.08
T_8 -	10 month	1.00 (1.21)	5.00 (2.33)	6.25 (2.58)	7.50 (2.81
T_9 -	11 month	1.38 (1.36)	2.16 (1.56)	2.76 (1.68)	3.66 (1.84
T_{10} -	12 month	1.00 (1.21)	3.33 (1.95)	5.50 (2.44)	7.75 (2.87
C.D at 5%		1.82 (0.46)	2.41 (0.55)	3.33 (0.68)	4.25 (0.81
S.Em. ±		0.61 (0.15)	0.82 (0.18)	1.13 (0.23)	1.44 (0.27)
C.V. (%)		36.57(15.35)	28.28(14.17)	26.85(14.77)	27.01(15.69)

DAG = Days after grafting.
Values in the parentheses indicate square root transformed ones

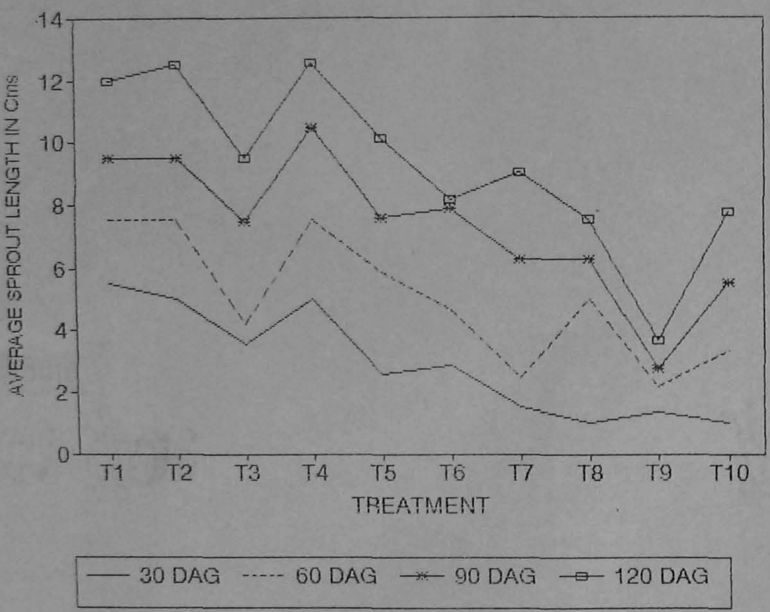


FIG. 4: INFLUENCE OF ROOTSTOCK AGE ON AVERAGE SPROUT LENGTH OF GRAFT

The length of sprout on scion after 30th, 60th, 90th and 120th day of grafting recorded significant differnce among the treatments.

On the 30th day after grafting, three month old rootstocks recorded heighest sprout length (5.50 cm) followed by four month old rootstock (5.00 cm) and six month old rootstock (4.96 cm). However, these treatments were on par. The lowest sprout length was in case of twelve month old stocks (1.00 cm).

On the 60th day after grafting, the maximum sprout length was found in six month old rootstocks (7.55cm). However, it was on par with three, four and seven month old rootstocks. Lowest sprout length was in case of eleven month old rootstocks (2.16 cm).

On the 90th day after grafting, the maximum sprout length was in case of six month old rootstock (10.45cm). However, it was on par with three, four, five, seven and eight month old rootstock. The sprout length of (2.76 cm) was the minimum in eleven month old rootstocks.

On the 120th day, the average sprout length of 12.54 cm was maximum in six month old rootstocks. However, it was on par with three, four, five, seven and nine month old rootstocks. The least sprout length was recorded in elven month old rootstocks (3.66 cm).

4.2 Effect of curing of scion on softwood grafting success rate

This experiment was conducted to know the influence of duration of curing of scion on the success rate of softwood grafting in jack on rootstocks of different age. The scions were cured for 10, 15 and 20 days prior to grafting and grafted on four months to eight months old rootstocks at monthly interval.

4.2.1 Per cent graft union success

The per cent graft union success on 30th and 60th day after grafting are presented in Table 5.

The rate of graft union success on 30th and 60th day after grafting recorded significant differences among the treatments.

On the 30th day after grafting, the maximum graft union success was recorded in five month old rootstocks with scions cured for 15 days (50.00 %), followed by eight month old rootstock (45.00 %) and five month old rootstock (40.00 %) with scions cured for ten days. However, these treatemtns were on par. The lowest graft union success of 10.00 per cent was recorded with six month old rootstock and scions cured for ten days, seven month old rootstocks with 20 days cured scions and five month old rootstocks with 20 days cured scions.

Table 5: Effect of age of rootstocks and curing of scion for different days on graft Union success

Treatments (Age of rootstock)	Graft union success (per cent) 30 DAG	60 DAG
T_1 - 4 month + 20 days	20.00	20.00
T_2 - 4 month + 15 days	15.00	15.00
T_3 - 4 month + 10 days	20.00	20.00
T_4 - 5 month + 20 days	10.00	10.00
T_5 - 5 month + 15 days	50.00	45.00
T_6 - 5 month + 10 days	40.00	40.00
T_7 - 6 month + 20 days	10.00	10.00
T_8 - 6 month + 15 days	25.00	15.00
T_9 - 6 month + 10 days	10.00	5.00
T_{10} - 7 month + 20 days	30.00	15.00
T_{11} - 7 month + 15 days	25.00	15.00
T_{12} - 7 month + 10 days	15.00	10.00
T_{13} - 8 month + 20 days	15.00	10.00
T_{14} - 8 month + 15 days	25.00	25.00
T_{15} - 8 month + 10 days	45.00	45.00
C.D at 5%	12.89	13.47
S.Em. ±	4.28	4.47
C.V. (%)	25.58	31.62

DAG = Days after grafting.

On the 60th day after grafting, five months old rootstocks grafted with scions cured for 15 days recorded maximum graft union success of 45.00 per cent and on eight month old rootstock grafted with scions cured for 10 days (45.00 %). The minimum graft union success of 5.00 per cent was obtained in six month old rootstock with scions cured for 10 days.

4.2.2 Effect of curing of scion on average number of leaves per graft

The data on average number of leaves of the grafts on 30th, 60th 90th and 120th day after grafting are presented in Table 6.

The average number of leaves per grafts on the 30th, 60th, 90th and 120th day after grafting did not differ significantly among the different treatments.

When observed on the 30th day after grafting, the maximum average number of leaves of 10.57 was recorded in case of four month old rootstocks with scions cured for 10 days followed by 8.25 in case of five month old rootstocks with scions cured for 10 days. The minimum average number of leaves of 1.50 was recorded by seven month old rootstock with scions cured for 10 days.

On the 60th day after grafting seven month old rootstock with 20 days cured scion produced maximum number of leaves of 16.75 followed by four month old rootstocks with

Table 6: Effect of age of rootstocks and scions cured for different days on the number of leaves produced per graft

Treatments (Age of rootstock)			Average number of leaves			
			30 DAG	60 DAG	90 DAG	120 DAG
T_1 -	4 month	+ 20 days	6.50	8.75	11.25	15.50
T_2 -	4 month	+ 15 days	7.00	10.50	13.50	20.50
T_3 -	4 month	+ 10 days	10.50	13.50	17.75	22.50
T_4 -	5 month	+ 20 days	7.00	9.50	13.50	15.50
T_5 -	5 month	+ 15 days	5.50	9.05	12.55	17.40
T_6 -	5 month	+ 10 days	8.25	10.35	12.50	16.85
T_7 -	6 month	+ 20 days	5.50	10.00	10.50	12.00
T_8 -	6 month	+ 15 days	4.00	8.00	10.00	12.00
T_9 -	6 month	+ 10 days	1.50	5.00	5.00	6.50
T_{10} -	7 month	+ 20 days	3.50	16.75	18.00	18.25
T_{11} -	7 month	+ 15 days	4.00	11.25	13.25	13.60
T_{12} -	7 month	+ 10 days	1.50	9.50	11.50	13.00
T_{13} -	8 month	+ 20 days	3.00	10.00	13.00	14.50
T_{14} -	8 month	+ 15 days	6.90	8.00	10.00	10.05
T_{15} -	8 month	+ 10 days	7.60	9.50	11.30	14.25
C.D at 5%			NS	NS	NS	NS

DAG = Days after grafting.
NS = Non-significant

10 days cured scions which recorded 13.50 average number of leaves. The minimum average number of leaves of 5.0 was recorded by six month old rootstocks with 10 days cured scions.

On the 90th day after grafting, the maximum average number of leaves of 18.00 was recorded in seven month old rootstock with scions cured for 20 days followed by 17.75 in four month old rootstock with scions cured for 10 days. The minimum average number of leaves of 5.50 was recorded in six month old rootstock with 10 days scion curing.

On the 120th day after grafting , the maximum average number of leaves was recorded in four months old rootstocks with scions cured for 10 days (22.50). It was followed by four months old rootstock with scions cured for 15 days (20.50). The minimum average number of leaves recorded was with six month old rootstocks when grafted with scions cured for 10 days (6.50).

4.2.3 Effect of curing of scion on average number of sprouts developed per graft

The data on the average number of sprouts developed per graft on the 30th, 60th, 90th and 120th day after grafting are presented in Table 7.

The average number of sprouts developed per graft on the 30th, 60th, 90th and 120th day after grafting did not differ significantly among the treatments.

Table 7: Effect of age of rootstocks and scions cured for different days on the number of sprouts developed per graft

Treatments (Age of rootstock)		Average number of sprouts			
		30 DAG	60 DAG	90 DAG	120 DAG
T_1 -	4 month + 20 days	2.50	3.00	3.50	3.50
T_2 -	4 month + 15 days	3.50	4.00	6.00	6.00
T_3 -	4 month + 10 days	4.25	4.25	5.25	5.25
T_4 -	5 month + 20 days	2.00	2.50	2.50	2.50
T_5 -	5 month + 15 days	2.50	2.60	3.25	3.35
T_6 -	5 month + 10 days	2.20	3.10	3.20	3.20
T_7 -	6 month + 20 days	2.00	2.50	2.50	3.00
T_8 -	6 month + 15 days	2.50	3.50	3.50	3.50
T_9 -	6 month + 10 days	1.50	1.50	1.50	1.50
T_{10} -	7 month + 20 days	3.25	3.50	3.50	3.50
T_{11} -	7 month + 15 days	1.65	2.50	2.50	2.50
T_{12} -	7 month + 10 days	0.50	2.50	2.50	2.50
T_{13} -	8 month + 20 days	1.75	3.00	3.00	3.00
T_{14} -	8 month + 15 days	2.30	2.30	2.30	3.00
T_{15} -	8 month + 10 days	3.25	3.05	3.25	3.35
C.D at 5%		NS	NS	NS	NS

DAG = Days after grafting.
NS = Non-significant

On the 30th day after grafting, the maximum average number of sprouts produced per graft was 4.25 in four month old rootstocks grafted with scions cured for 10 days. It was followed by the scions cured for 15 days and grafted on four month old rootstocks (3.50). The minimum average number of sprouts recorded was in seven month old rootstocks grafted with scions cured for 10 days (0.50).

On the 60th day after grafting, grafts on four month old rootstocks with scions cured for 10 days recorded maximum average number of sprouts (4.25) followed by the grafts with scions cured for 15 days and grafted on four month old rootstocks (4.00). The lowest average number of sprouts of 1.50 was recorded with six month old rootstocks grafted with scions cured for 10 days.

On the 90th day after grafting, the maximum average number of sprouts of 6.00 was recorded when the scions cured for 15 days were grafted on four month old rootstocks. It was followed by the scions cured for 10 days when grafted on four month old rootstocks (5.26). The minimum number of sprouts of 1.50 was recorded when the scions cured for 10 days were grafted on six month old rootstocks.

On the 120th day after grafting, the maximum average number of sprouts was recorded on grafts prepared with 15 days cured scions grafted on four months old rootstock (6.00).

It was followed by the grafts prepared with scions cured for 10 days and grafted on four month old rootstocks (5.26). The lowest average number of sprouts of 1.50 was recorded with the grafts prepared with scions cured for 10 days and grafted on six month old rootstocks.

4.2.4 Effect of curing of scion on average length of sprout

The data pertaining to the average sprout length of the grafts on the 30th, 60th, 90th and 120th day after grafting are given in Table 8.

The length of sprout of the scion after grafting on the 30th day differ significantly among treatments. However, on 60th, 90th and 120th day after grafting the differences were not significant among the different treatments.

The maximum average length of sprout on 30th day after grafting was recorded with scions cured for 15 days and grafted on five month old rootstock (7.25 cm) followed by the scions cured for 20 days and grafted on five month old rootstocks (7.00 cm). The minimum average sprout length was recorded on grafts prepared with scions cured for 10 days when grafted on seven month old rootstocks (1.00 cm).

On the 60th day after grafting, higher sprout length of 9.50 cm was recorded with the scions cured for 20 days and grafted on five month old rootstock. It was followed by the scions cured for 15 days and grated on five month old

Table 8: Effect of age of rootstocks and scions cured for different days on the sprout length

Treatments (Age of rootstock)				Average sprout length (cm)			
				30 DAG	60 DAG	90 DAG	120 DAG
T_1 -	4 month	+	20 days	4.25	6.25	7.25	9.25
T_2 -	4 month	+	15 days	3.25	4.00	5.50	8.75
T_3 -	4 month	+	10 days	5.12	6.75	7.50	9.10
T_4 -	5 month	+	20 days	7.00	9.50	12.25	13.00
T_5 -	5 month	+	15 days	7.25	8.84	10.85	14.50
T_6 -	5 month	+	10 days	4.81	6.64	8.65	12.37
T_7 -	6 month	+	20 days	6.00	8.76	10.00	12.50
T_8 -	6 month	+	15 days	3.00	4.00	4.50	6.00
T_9 -	6 month	+	10 days	2.00	3.75	4.50	5.50
T_{10} -	7 month	+	20 days	2.83	8.50	10.00	11.00
T_{11} -	7 month	+	15 days	2.35	6.65	9.29	10.50
T_{12} -	7 month	+	10 days	1.00	4.50	7.25	8.50
T_{13} -	8 month	+	20 days	1.75	8.00	8.25	10.50
T_{14} -	8 month	+	15 days	3.33	7.12	7.62	8.65
T_{15} -	8 month	+	10 days	4.72	7.85	9.95	11.10
C.D at 5%				2.81	NS	NS	NS
S.Em. ±				0.93			
C.V. (%)				33.73			

DAG = Days after grafting.
NS = Non-significant

rootstocks (8.84 cm). The lowest sprout length of 3.75 cm was recorded on six month old rootstock grafted with scions cured for 10 days.

On the 90th day after grafting, the maximum sprout length was recorded with grafts prpeared on five month old rootstock and the scions cured for 20 days (12.25 cm). It was followed by the scions cured for 15 days and grafted on five month old rootstocks (10. 85 cm). Six month old rootstocks grafted with scions cured for 10 days recorded a minimum sprout length of 4.5 cm.

On the 120th day after grafting five month old rootstocks grafted with scions cured for 15 days recorded maximum average sprout length (14.50 cm). It was followed by the scions cured for 20 days and grafted on five month old rootstocks (13.00cm). The minimum average sprout length of 5.50 cm was recorded when the grafts prepared with scions cured for 10 days and grafted on six month old rootstocks.

4.3 Effect of age of rootstock on success of budding

This experiment was carried out to find out the optimum age of rootstock for chip budding in jack. Budding was carried out at monthly intervals starting with three month old rootstock to twelve month old rootstock. Pre-cured buds were used for budding purpose.

4.3.1 Per cent bud union success

The data on the per cent bud union success on 30th day and 60th day after budding are presented in Table 9 (Plate II).

The per cent bud union success on 30th day and 60th day after budding showed significant differences among the treatments.

On the 30th day after budding, eight month old rootstock has given maximum success (15.00 %). All other treatments recorded a success rate of 10.00 per cent except three month old rootstock which totally failed to form bud union.

On the 60th day after budding, the maximum bud union success was recorded with eight month old rootstock (15.00 %) but, on par with all other treatments. But three month old rootstocks recorded zero per cent bud union.

4.3.2 Effect of age of rootstocks on average number of leaves per budding

The data on average number of leaves on 30th, 60th, 90th and 120th day after budding are presented in Table 10 and Fig. 5.

The average number of leaves on the budlings on 30th, 60th, 90th and 120th day after budding were significantly different among the treatments. Three month old rootstock totally failed to form bud union. Hence, no data on leaf number were recorded.

Table 9: Effect of age of rootstock on per cent success of budding

Treatments (Age of rootstock)	Bud take 30 DAB	Bud take 60 DAB
T_1 - 3 month	0.00 (00.00)	0.00 (00.00)
T_2 - 4 month	10.00 (18.43)	10.00 (18.43)
T_3 - 5 month	10.00 (18.43)	10.00 (18.43)
T_4 - 6 month	10.00 (18.43)	10.00 (18.43)
T_5 - 7 month	10.00 (18.43)	10.00 (18.43)
T_6 - 8 month	15.00 (22.59)	15.00 (22.59)
T_7 - 9 month	10.00 (18.43)	13.33 (21.14)
T_8 - 10 month	10.00 (18.43)	13.33 (21.14)
T_9 - 11 month	10.00 (18.43)	10.00 (18.43)
T_{10} - 12 month	10.00 (18.43)	10.00 (18.43)
C.D at 5%	2.68 (2.18)	5.14 (4.18)
S.Em. ±	0.91 (0.74)	1.74 (1.42)
C.V. (%)	16.64 (7.56)	29.78(14.02)

DAB = Days after budding

Values in the parentheses indicate angular transformed ones

Plate II: Successful chip budlings of jack

PLATE II

Table 10: Effect of rootstock age on average number of leaves recorded on on the budded plant

Treatments (Age of rootstock)		Average number of leaves		
	30 DAB	60 DAB	90 DAB	120 DAB
T_1 - 3 month	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)
T_2 - 4 month	0.66 (1.05)	1.66 (1.44)	3.00 (1.72)	4.00 (1.89)
T_3 - 5 month	1.00 (1.22)	1.33 (1.34)	2.33 (1.59)	3.33 (1.78)
T_4 - 6 month	1.33 (1.34)	1.66 (1.44)	2.33 (1.59)	3.33 (1.78)
T_5 - 7 month	2.50 (1.72)	4.50 (2.23)	7.00 (2.73)	10.50 (3.31)
T_6 - 8 month	2.58 (1.75)	5.00 (2.33)	7.00 (2.73)	9.00 (3.08)
T_7 - 9 month	2.66 (1.73)	5.00 (2.31)	8.00 (2.90)	9.66 (3.18)
T_8 - 10 month	3.00 (1.85)	4.66 (2.25)	8.33 (2.95)	11.00 (3.37)
T_9 - 11 month	1.66 (1.46)	2.00 (1.52)	3.00 (1.72)	3.66 (1.84)
T_{10} - 12 month	1.66 (1.46)	2.33 (1.59)	3.33 (1.78)	4.33 (1.94)
C.D at 5%	1.20 (0.39)	2.33 (0.62)	4.17 (1.01)	6.02 (1.34)
S.Em. ±	0.41 (0.13)	0.73 (0.21)	1.41 (0.34)	2.04 (0.45)
C.V. (%)	41.64(16.15)	48.83(21.56)	55.40(29.29)	60.31(34.48)

DAB = Days after budding.
Values in the parentheses indicate square root transformed ones

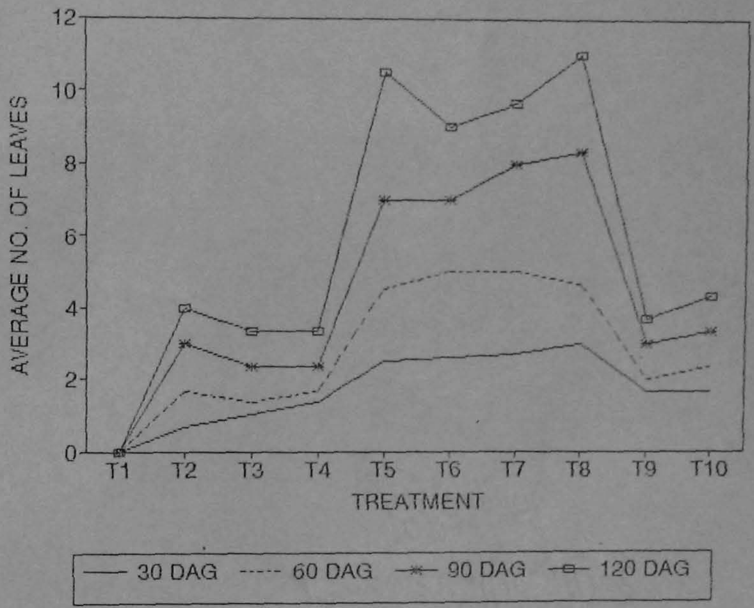


FIG. 5: INFLUENCE OF ROOTSTOCKS AGE ON AVERAGE NUMBER OF LEAVES PER BUDLING

On the 30th day after budding, the maximum average number of leaves recorded was 3.00 on ten month old rootstock followed by nine month (2.66), eight month (2.58) and seven month old rootstocks (2.50). However, these treatments were on par. The lowest number of leaves recorded was on four month old rootstocks (0.66).

On the 60th day after budding, a maximum number of leaves per budling recorded was in eight month old rootstock (5.00) followed by seven month (4.50), nine month (5.00) and ten month old rrootstocks (4.66). But these treatments were on par. The least number of leaves recorded was 1.33 on four month old rootstocks.

On the 90th day after budding, ten month old rootstock recorded maximum number of leaves (8.33) followed by nine month (8.00), seven month (7.00) and eight month old rootstocks (7.00). However, these treatments were on par. The least number of leaves recorded was on five month (2.33) and six month old rootstocks (2.33).

On the 120th day after budding, the maximum average number of leaves per budling recorded was on ten month old rootstock (11.00) followed by seven month (10.50), nine month (9.66) and eight month (9.00) old rootstocks. However, these treatments were on par. The least number of leaves recorded was 3.33 in both five month and six month old rootstocks.

4.3.3 Effect of age of rootstocks on sprout length

The data pertaining to the average sprout length on 30th, 60th, 90th and 120th day after budding are given in Table 11 and Fig. 6.

The length of sprout recorded after 30th, 60th, 90th and 120th day of budding showed significant differences among the treatments. Budding on three month old rootstock was complete failure. Hence, the length of sprout was not recorded.

On the 30th day after budding, the maximum sprout growth was found both in eight month old and ten month old rootstocks (3.00 cm) followed by seven month old rootstocks (2.00cm). However, these treatments were on par. The lowest sprout growth recorded was with five month old rootstocks (0.46 cm).

On the 60th day after budding, eight month old rootstock recorded the heighest sprout growth (5.50 cm) followed by ten month old rootstocks (4.16 cm). But these two were on par. The lowest sprout growth was recorded in case of five month old rootstocks (0.83 cm).

On the 90th day after budding, the maximum sprout growth was recorded in case of eight month old rootstocks (8.00 cm) followed by ten month old rootstocks (6.16 cm). However, these two treatments were on par. The sprout length of 1.66 cm was minimum in case of budlings prepared on five month old rootstocks.

Table 11: Effect of rootstock age on average sprout length recorded on the budded plant

Treatments (Age of rootstock)		Average sprout length (cm)		
	30 DAB	60 DAB	90 DAB	120 DAB
T_1 - 3 month	0.00 (0.70)	0.00 (0.70)	0.00 (0.70)	0.00 (0.70)
T_2 - 4 month	0.66 (1.07)	1.00 (1.17)	1.83 (1.48)	3.16 (1.81)
T_3 - 5 month	0.46 (0.98)	0.83 (1.13)	1.66 (1.44)	2.16 (1.56)
T_4 - 6 month	1.06 (1.21)	1.50 (1.39)	1.83 (1.48)	2.66 (1.66)
T_5 - 7 month	2.00 (1.57)	3.50 (1.99)	5.50 (2.44)	7.66 (2.85)
T_6 - 8 month	3.00 (1.85)	5.50 (2.44)	8.00 (2.91)	10.16 (3.26)
T_7 - 9 month	1.83 (1.48)	3.50 (1.97)	5.33 (2.40)	7.06 (2.74)
T_8 - 10 month	3.00 (1.86)	4.16 (2.15)	6.16 (2.57)	8.33 (2.95)
T_9 - 11 month	0.83 (1.14)	1.50 (1.39)	2.00 (1.52)	2.83 (1.69)
T_{10} - 12 month	0.66 (1.07)	1.83 (1.48)	2.50 (1.63)	3.26 (1.77)
C.D at 5%	1.09 (0.38)	1.54 (0.49)	2.36 (0.65)	3.91 (0.97)
S.Em. ±	0.37 (0.12)	0.52 (0.16)	0.80 (0.22)	1.33 (0.32)
C.V. (%)	47.60(17.26)	38.92(18.18)	40.00(20.67)	48.71(27.14)

DAB = Days after budding
Values in the parentheses indicate square root transformed ones

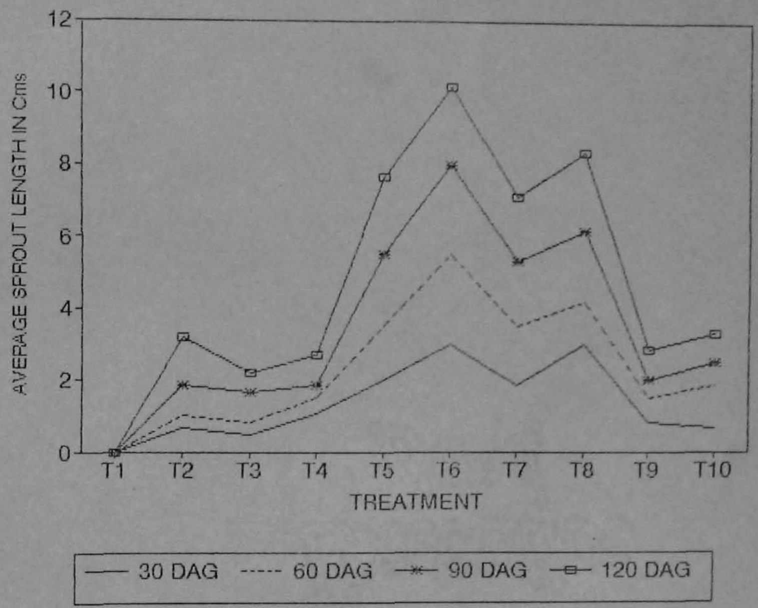


FIG.6: INFLUENCE OF ROOTSTOCKS AGE ON AVERAGE SPROUT LENGTH OF BUD

On the 120th day after budding, the average sprout length of 10.16 cm was maximum with eight month old rootstocks. However, it was on par with ten month (8.33 cm), seven month (7.66 cm) and nine month old (7.07 cm) rootstocks. The least sprout growth was recorded on five month old rootstocks (2.16 cm).

4.4 Studies on different methods of budding in jack

In this experiment, effect of different methods of budding on two different aged rootstock i.e., six month and tweleve month old rootstocks were studied. The data are presented in Table 12.

Out of 200 budlings prepared by following different methods, 19 budlings remained green when observed on the 45th day and only 9 buds sprouted after 60 days of budding on six month old rootstocks. Among the different methods, chip budding proved to be better followed by patch budding. None of the buds in inverted 'T' budding and Ring budding sprouted even after 60 days.

Out of the 200 budlings prepared by different methods on twelve month old rootstocks, only 26 buds were green for over 45 days and only 15 buds sprouted after 60 days of budding. Here also chip budding recorded higher number of sprouts compared to other methods of budding. In case of chip budding out of the 40 budlings prepared, eight budlings

Table 12: Success rate of different methods of budding on rootstocks of different age

Treatments (methods of budding)	Number of budlings prepared	6 month old root stock		12 month old root stock	
		Green stage at 45 days	Number of sprouted budlings after 60 days	Green stage at 45 days	Number of sprouted budlings after 60 days
'T' budding	40	2	1	3	2
Inverted 'T' budding	40	2	0	3	0
Patch budding	40	5	3	6	4
Ring budding	40	2	0	4	1
Chip budding	40	8	5	10	8
Total	200	19	9	26	15

were successful. They showed the growth of the sprouts from the buds.

4.5 Effect of growth regulators on rooting of air layers of jack

There were two experiments under this group, tried in three different seasons i.e., rainy season (June - July), winter season (September - October) and summer season (February - March).

Experiment 1: In this experiment, effects of IBA and NAA on rooting of air layers with girdling and etiolation pretreatment for 30 days were studied. The data are presented in Table 13.

Out of 330 air layers prepared during winter season under different treatments, only 169 air layers survived over 80 days. Though none of the layers rooted, 127 layers developed callus. Layers treated with NAA 10,000 ppm showed comparatively better results wherein, out of 30 layers prepared 24 layers survived and 18 layers developed callus. In control only 5 layers formed callus.

During the summer season, out of 330 layers prepared, 155 layers survived over 80 days and only 55 layers produced callus in different treatments, but none of the layers produced roots. There was no callus formation or root formation in control treatment.

Table 13: Effect of girdling and etiolation with growth regulators on rooting of air layers in jack during different seasons

Treatments (conc. of growth regulators)	Number of air layers prepared	Winter (October)		Summer (March)	
		No. of air layers survived	Callus formed	No. of air layers survived	Callus formed
T_1 - Control	30	12	5	10	-
T_2 - IBA 10000 ppm	30	20	16	16	6
T_3 - IBA 7500 ppm	30	18	12	20	8
T_4 - IBA 5000 ppm	30	18	10	18	6
T_5 - IBA 2500 ppm	30	15	10	15	4
T_6 - IBA 1000 ppm	30	10	8	11	4
T_7 - NAA 10000 ppm	30	24	18	18	10
T_8 - NAA 7500 ppm	30	18	16	15	8
T_9 - NAA 5000 ppm	30	14	14	12	4
T_{10} - NAA 2500 ppm	30	12	10	10	3
T_{11} - NAA 1000 ppm	30	8	8	10	2
Total	330	169	127	155	55

Experiment II: In this experiment, the effect of IBA and NAA on rooting of air layers (without prior girdling or etiolation) were studied during three seasons i.e., rainy, winter and summer seasons. The data are presented in Table 14.

During the winter season, out of the 330 layers prepared, 137 layers survived and 63 layers formed callus. None of the layers produced root. Layers treated with NAA 10,000 ppm showed better results compared to other treatments.

In the summer season out of the 330 layers prepared under various treatments, 83 layers survived for 80 days. None of the layers produced roots and they failed to form callus.

One hundered seventy four layers out of 330 layers survived over 80 days after layering and 79 layers produced callus in different treatments during rainy season. None of the layers produced roots.

The number of layers survived and callus formed were more during rainy and winter season compared to the summer season when compared to all the three seasons.

4.5.1 Effect of girdling and etiolation on rooting of air layers of jack during rainy season

In this experiment jack shoots were girdled and etiolated for 30 days. After 30 days they were treated with

Table 14: Effect of growth regulators on rooting of air layers in jack during different seasons

Treatments (conc. of growth regulators)	Number of air layers prepared	Winter (October)		Summer (March)		Rainy (July)	
		No. of air layers survived	Callus formed	No. of air layers survived	Callus formed	No. of air layers survived	Callus formed
T_1 - Control	30	8	2	-	-	6	1
T_2 - IBA 10000 ppm	30	15	8	10	-	20	10
T_3 - IBA 7500 ppm	30	15	7	8	-	18	8
T_4 - IBA 5000 ppm	30	12	6	6	-	16	6
T_5 - IBA 2500 ppm	30	10	4	6	-	16	4
T_6 - IBA 1000 ppm	30	8	3	5	-	14	4
T_7 - NAA 10000 ppm	30	18	10	14	-	19	12
T_8 - NAA 7500 ppm	30	16	9	12	-	18	10
T_9 - NAA 5000 ppm	30	13	7	9	-	16	10
T_{10} - NAA 2500 ppm	30	12	5	7	-	17	8
T_{11} - NAA 1000 ppm	30	10	2	6	-	14	6
Total	330	137	63	83	-	174	79

different concentrations of IBA or NAA and girdled portions the were wrapped with sphagnum moss. Rooted air layers were separated 80 days later.

4.5.1.1 Rate of rooting

The data on per cent rooting of air layers with different concentrations of IBA and NAA are presented in Table 15 (Plate III, IV andV).

There was significant difference among the treatments for rooting percentage. Among the different treatments NAA 10,000 ppm recorded maximum rooting percentage (40.00%) followed by NAA 7500 (33.33 %). However, these two were on par. The lowest rooting per cent recorded was in control (6.66 %). Among the IBA concentrations both IBA 10,000 ppm and IBA 7500 ppm recorded 26.66 rooting percentage.

4.5.1.2 Average number of roots

The data on the average number of roots per rooted air layer as influenced by IBA and NAA concentrations are presented in Table 16 and Fig. 7.

There was significant difference among the treatments, with respect to number of roots per layer. The highest number of roots (25.00) were produced in NAA 10,000 ppm, followed by 7,500 ppm NAA (13.00). The lowest number of roots recorded was in control (1.00). Among the IBA concentrations except IBA 1000 ppm, all other concentrations are on par.

Table 15: Effect of girdling and etiolation with growth regulators on rooting of air layers of jack during rainy season

Treatments (Conc. of growth regulators)	Number of air layers prepared	Number of air layers rooted	Rooting percentage
T_1 - Control	30	2	6.66
T_2 - IBA 10000 ppm	30	6	20.00
T_3 - IBA 7500 ppm	30	8	26.66
T_4 - IBA 5000 ppm	30	8	26.66
T_5 - IBA 2500 ppm	30	6	20.00
T_6 - IBA 1000 ppm	30	3	10.00
T_7 - NAA 10000 ppm	30	12	40.00
T_8 - NAA 7500 ppm	30	10	33.33
T_9 - NAA 5000 ppm	30	6	20.00
T_{10} - NAA 2500 ppm	30	6	20.00
T_{11} - NAA 1000 ppm	30	3	10.00
C.D at 5%			12.82

Plate III: Rooting of air layers with girdling, etiolation and IBA

T_1 - Control

T_2 - IBA 10000 ppm

T_3 - IBA 7500 ppm

T_4 - IBA 5000 ppm

T_5 - IBA 2500 ppm

T_6 - IBA 1000 ppm

Plate IV: Rooting of air layers with girdling, etiolation and NAA

T_7 - NAA 10000 ppm

T_8 - NAA 7500 ppm

T_9 - NAA 5000 ppm

T_{10} - NAA 2500 ppm

T_{11} - NAA 1000 ppm

Plate V: Plate III and Plate IV

PLATE III

PLATE IV

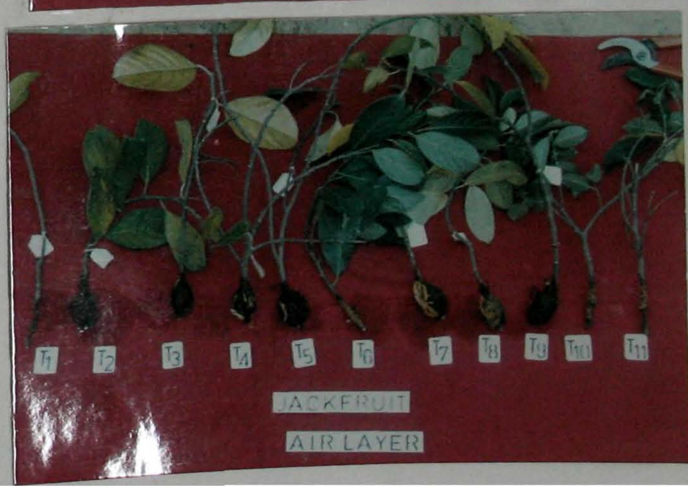


PLATE V

Table 16: Effect of girdling, etiolation and treatment with growth regulators on number of roots and length of roots per layer

Treatments (Conc. of growth regulators)	Average root number	Average root length (cm)
T_1 - Control	1.00	1.50
T_2 - IBA 10000 ppm	5.00	4.00
T_3 - IBA 7500 ppm	7.00	6.00
T_4 - IBA 5000 ppm	8.00	7.00
T_5 - IBA 2500 ppm	5.00	4.00
T_6 - IBA 1000 ppm	3.00	2.00
T_7 - NAA 10000 ppm	25.00	10.00
T_8 - NAA 7500 ppm	13.00	11.00
T_9 - NAA 5000 ppm	4.00	8.00
T_{10} - NAA 2500 ppm	3.00	5.00
T_{11} - NAA 1000 ppm	2.00	2.00
C.D at 5%	4.29	3.71
S.Em ±	1.46	1.27
C.V.(%)	36.77	40.00

4.5.1.3 Length of longest root

The data on the average length of longest root per layer treated with different concentration of IBA and NAA are presented in Table 16 and Fig.7.

Different concentrations of IBA and NAA had the significant influence on the length of longest root per layer. Among the different treatments, NAA 7500 ppm recorded maximum length of root (11.0 cm) followed by NAA 10,000 ppm (10.00 cm) and NAA 5,000 ppm (8.00 cm). However, these treatments were on par. The shortest length of root per layer recorded was in control (1.50 cm). But this was on par with NAA 1,000 ppm, IBA 1,000, 2,500 and 10,000 ppm and NAA 2,500 ppm.

4.6 Effect of growth regulators on rooting of jack stem cuttings with girdling and etiolation pretreatment

In this experiment, effects of IBA and NAA on rooting of girdled and etiolated hard wood stem cuttings of jack under mist were studied in three seasons, i.e. rainy (June), winter (October) and summer (March). The data are presented in Table 17.

During the winter season, out of 330 cuttings planted, 80 cuttings survived and 51 cuttings developed callus at the cut ends. None of the cuttings produced roots. Among different treatments higher concentrations of IBA and NAA showed better results compared to lower concentrations. In control the callus formation was nil.

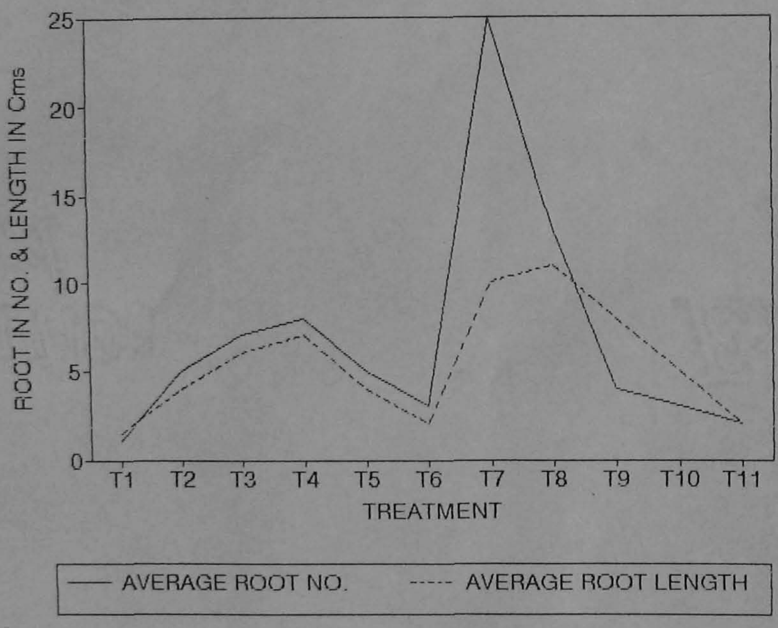


FIG. 7: EFFECT OF GIRDLING AND ETIOLATION WITH GROWTH REGULATORS ON ROOT CHARACTERS

Table 17: Effect of girdling, etiolation and growth regulators on rooting of stem cuttings of jack during different seasons under mist

Treatments (conc. of growth regulators)	Number of cuttings planted	Winter (October)		Summer (March)		Rainy (June)	
		No. of cuttings survived	Callus formed	No. of cuttings survived	Callus formed	No. of cuttings survived	Callus formed
T_1 - Control	30	6	0	8	4	8	4
T_2 - IBA 10000 ppm	30	10	8	16	10	18	12
T_3 - IBA 7500 ppm	30	8	5	18	10	16	10
T_4 - IBA 5000 ppm	30	6	4	12	8	15	8
T_5 - IBA 2500 ppm	30	4	2	12	6	12	6
T_6 - IBA 1000 ppm	30	4	2	10	6	10	5
T_7 - NAA 10000 ppm	30	12	9	18	8	20	10
T_8 - NAA 7500 ppm	30	10	8	16	8	18	8
T_9 - NAA 5000 ppm	30	8	5	16	6	16	6
T_{10} - NAA 2500 ppm	30	6	4	10	6	14	4
T_{11} - NAA 1000 ppm	30	6	4	8	4	9	4
Total	330	80	51	144	76	155	77

During the summer season, out of 330 cuttings planted only 144 cuttings survived over 75 days, though none of the cuttings produced roots. Of the surviving cuttings, only 76 developed callus at the cut ends.

Out of 330 cuttings planted during rainy season, only 135 cuttings survived over 75 days. Though none of the cuttings rooted, 77 cuttings developed callus in different treatments.

4.7 Effect of growth regulators on rooting of jack stem cuttings without girdling and etiolation

In this experiment, effects of different concentrations of IBA and NAA on rooting of jack hardwood cuttings (without girdling and etiolation) under mist were studied in three different seasons i.e., winter (October), Summer (March) and rainy (June). The data are presented in Table 18.

Sixty two cuttings out of 330 cuttings survived over 75 days after planting and 26 cuttings produced callus at the cut ends during winter season under differ¤nt treatments. None of the cuttings produced roots. In control none of the cuttings were survived.

Out of 330 cuttings planted during summer season, only 42 cuttings survived after 75 days. Though none of the cuttings rooted, 21 cuttings formed callus in different treatments. In control none of the cuttings planted

Table 18: Effect of growth regulators on rooting of stem cuttings of jack during different seasons under mist

Treatments (conc. of growth regulators)	Number of cuttings planted	Winter (October)		Summer (March)		Rainy (June)	
		No. of cuttings survived	Callus formed	No. of cuttings survived	Callus formed	No. of cuttings survived	Callus formed
T_1 - Control	30	-	-	-	-	4	-
T_2 - IBA 10000 ppm	30	8	4	6	3	15	4
T_3 - IBA 7500 ppm	30	6	3	6	2	10	5
T_4 - IBA 5000 ppm	30	6	2	4	2	8	3
T_5 - IBA 2500 ppm	30	6	2	4	1	6	2
T_6 - IBA 1000 ppm	30	4	1	2	3	4	1
T_7 - NAA 10000 ppm	30	10	5	6	4	13	6
T_8 - NAA 7500 ppm	30	8	4	6	3	12	4
T_9 - NAA 5000 ppm	30	6	3	4	2	10	3
T_{10} - NAA 2500 ppm	30	5	2	2	1	5	2
T_{11} - NAA 1000 ppm	30	3	-	2	-	5	1
Total	330	62	26	42	21	92	31

survived. Compared to the winter season, the number of cuttings survived during summer season were less.

During rainy season, out of 330 cuttings planted, 92 cuttings survived and 31 cuttings developed callus at the cut ends. None of the cuttings produced roots. In control none of the cuttings developed callus. Compared to the winter and summer seasons, the number of cuttings survived was more during the rainy season.

4.8 Biochemical studies

The data pertaining to biochemical constituents like total sugars, reducing sugars, non-reducing sugars, starch, total carbohydrates, nitrogen, protein, carbohydrate to nitrogen ratio and dry matter in rootstocks and scions of jack are presented on percentage dry weight basis in Table 19 and 20 respectively.

4.8.1 Rootstocks

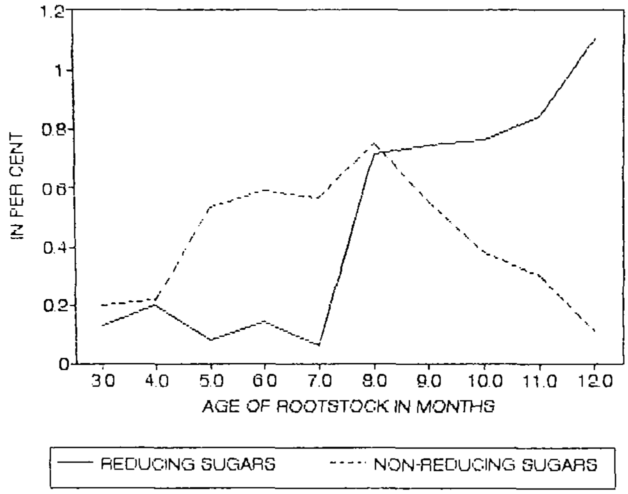
4.8.1.1 *Total sugars, reducing sugars and non-reducing sugars*

Total sugar content varied from 0.33 to 1.46 per cent, the highest being in eight month old rootstock (1.46 %) and the lowest in case of three month old rootstocks (0.33 %) (*Fig. 8*).

Reducing sugar content varied from 0.06 to 1.10 per cent among rootstocks of different age. The highest reducing sugar percentage of 1.10 was recorded in 12 month old rootstocks, and the lowest reducing sugar (0.06 %) was found in seven month old rootstock (Fig. 8).

Table 19: Chemical constituents of rootstocks of different age (per cent dry weight basis)

Particulars (stock age)	Total sugars	Reducing sugars	Non-reducing sugars	Starch	Total carbo-hydrates	Total nitrogen	Protein	C/N ratio	Dry matter
3 months	0.33	0.13	0.20	13.53	13.86	1.96	12.25	7.07	34.06
4 months	0.42	0.20	0.22	12.10	12.52	1.35	8.44	9.27	40.76
5 months	0.61	0.08	0.53	10.66	11.27	1.22	7.63	9.24	38.98
6 months	0.73	0.14	0.59	10.66	11.39	0.71	4.44	16.04	38.09
7 months	0.62	0.06	0.56	10.66	12.28	1.37	8.56	8.23	40.54
8 months	1.46	0.71	0.75	4.76	6.22	1.58	9.88	3.94	40.00
9 months	1.29	0.74	0.55	5.70	6.99	0.92	5.75	7.59	41.21
10 months	1.14	0.76	0.38	6.71	7.85	1.05	6.56	7.48	42.16
11 months	1.14	0.84	0.30	5.30	6.44	1.45	9.06	4.44	40.00
12 months	1.20	1.10	0.11	4.76	5.96	0.99	6.19	6.02	41.48



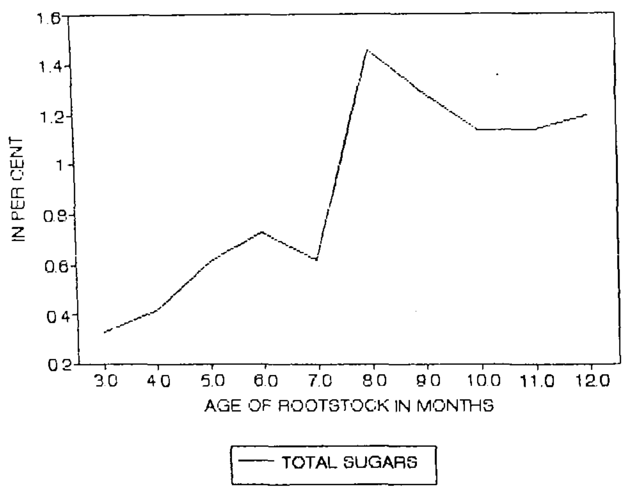


FIG. 8: REDUCING SUGARS, NON-REDUCING SUGARS AND TOTAL SUGARS CONTENT IN ROOTSTOCKS OF DIFFERNT AGE

Non-reducing sugar content varied from 0.11 to 0.75 per cent and the highest being in eight month old rootstock (0.75 %) and lowest in twelve month old rootstocks (0.11 %). Non-reducing sugar content was comparatively higher than reducing sugars in rootstocks of all groups except in nine, ten, eleven and twelve month old rootstocks (Fig. 8).

4.8.1.2 Starch and total carbohydrates

Starch content varied from 4.76 to 13.53 per cent and highest content was in three month old rootstocks and the lowest starch content was in eight and twelve month old rootstocks (Fig. 9).

Regarding total carbohydrates, highest carbohydrates content was observed in three month old rootstocks (13.86 %) and the least was in twelve month old rootstock (5.96 %) (Fig. 9).

4.8.1.3 Nitrogen and protein

The highest nitrogen content was recorded in three month old rootstocks (1.96 %) and the lowest nitrogen content was observed in case of six month old rootstocks (0.71 %). The protein content varied from 4.44 to 12.25 per cent and highest content was in three month old rootstock and the least protein content was in six month old (Fig. 9).

4.8.1.4 Carbohydrate/nitrogen ratio

The carbohydrate to nitrogen ratio was highest in six month old rootstock (16.04) and lowest in eight month old rootstocks(3.94) (Fig.10).

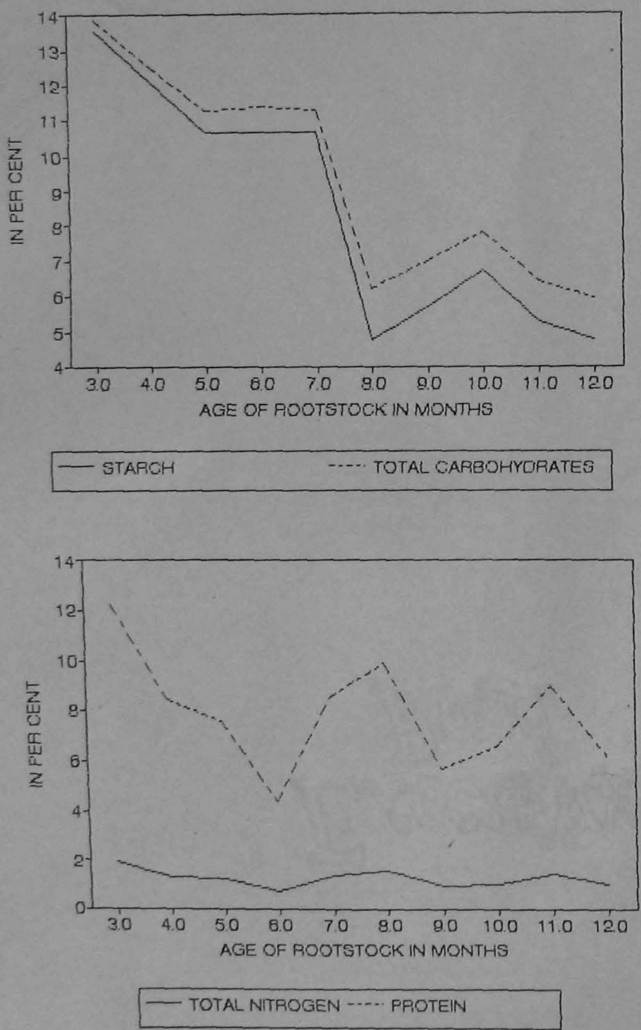


FIG. 9: STARCH, TOTAL CARBOHYDRATES, TOTAL NITROGEN AND PROTEIN CONTENT IN ROOTSTOCKS OF DIFFERENT AGE

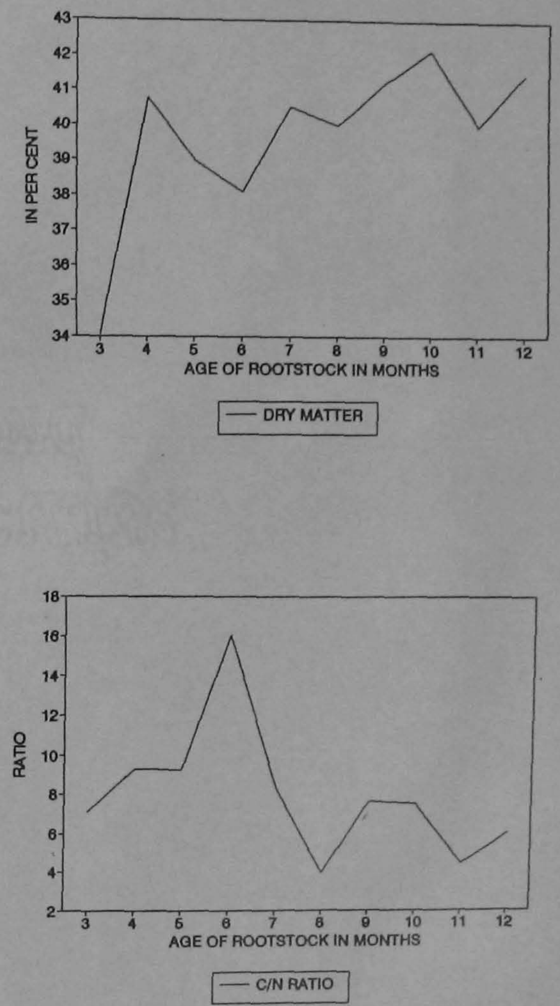


FIG. 10: DRY MATTER AND C/N RATIO IN ROOTSTOCKS OF DIFFERENT AGE

4.8.1.5 Dry matter

The dry matter content was highest in ten month old rootstocks (42.16 %) and the lowest in three month old rootstocks (34.06 %) (Fig. 10).

4.8.2 Scions

4.8.2.1 Total, reducing and non-reducing sugars

Total sugar content was highest in scions cured for ten days (1.25%) whereas the lowest content of 0.60 per cent was recorded in scions cured for 15 days. The total sugar content was 0.74 per cent in scions cured for 20 days (Table 20).

The highest reducing sugar content of 0.64 per cent was recorded in scions cured for 10 days followed by 0.57 per cent in scions cured for 20 days. The least reducing sugar content was observed in scions cured for 15 days (Table 20).

The scions cured for ten days recorded highest non-reducing sugars (0.61%) followed by the scions cured for 20 days (0.17%). The lowest non-reducing sugar content of 0.07 per cent was recorded in scions cured for15 days (Table 20).

4.8.2.2 Starch and total carbohydrates

The highest starch content of 5.85 per cent was noticed in scions cured for 10 days and lowest starch content of 4.76 per cent was observed in scions cured for 15 days. The starch content in scions cured for 20 days was 5.58 per cent (Table 20).

Table 20: Chemical constituents of scions cured for different days (per cent dry weight basis)

Chemical constituents	Duration of scion curing		
	10 days	15 days	20 days
Total sugars	1.25	0.60	0.74
Reducing sugars	0.64	0.53	0.57
Non-reducing sugars	0.61	0.07	0.17
Starch	5.85	4.76	5.58
Total carbohydrates	7.10	5.36	6.32
Total nitrogen	1.98	1.45	1.05
Protein	12.38	9.04	6.56
C/N ratio	3.59	3.69	6.02
Dry matter	50.00	52.38	51.85

Total carbohydrate content was highest in scions cured for 10 days (7.10 %) followed by the scions cured for 20 days (6.32 %). The lowest total carbohydrate content was recorded in case of scions cured for 15 days (5.36 %) (Table 20).

4.8.2.3 Total nitrogen and protein

The total nitrogen content of 1.98 per cent was highest in scions cured for 10 days followed by scions cured for 15 days (1.45 %). The lowest nitrogen content was recorded in scions cured for 20 days (1.05 %). The highest protein content of 12.38 per cent was noticed in scions cured for 10 days followed by the scions cured for 15 days (9.04 %). The lowest protein content of 6.56 was observed in scions cured for 20 days (Table 20).

4.8.2.4 Carbohydrate/nitrogen ratio

The carbohydrate to nitrogen ratio was highest in scions cured for 20 days (6.02 %). The lowest ratio was recorded in scions cured for 10 days (3.59 %). The scions cured for 15 days recorded 3.69 per cent carbohydrate to nitrogen ratio (Table 20).

4.8.2.5 Dry matter

The highest dry matter content of 52.38 per cent was observed in scions cured for 15 days followed by the scions curd for 20 days (51.85 %). The least dry matter content of 50.00 per cent was noticed in case of scions cured for 10 days (Table 20).

4.8.3 Chemical constituents in jack shoots used for cuttings and layering

The data pertaining to chemical constituents in pretreated (girdled and etiolated) and non-pretreated shoots of jack are presented in Table 21.

4.8.3.1 Total, reducing and non-reducing surars

The higher amount of total sugars (0.67 %) and reducing sugars (0.34 %) were recorded in pretreated shoots compared to non-pretreated shoots. However, non-pretreated shoots recorded higher amount of non-reducing sugars (0.45%) (Table 21).

4.8.3.2 Starch and total carbohydrates

Pretreated shoots recorded higher amount of starch (4.76 %) and total carbohydrates (5.43 %) content over non-pretreated shoots (Table 21).

4.8.3.3 Total nitrogen and protein

A higher amount of total nitrogen (1.64 %) and protein (10.25 %) were recorded by non-pretreated over pretreated shoots (Table 21).

4.8.3.4 Carbohydrate / nitrogen ratio

The carbohydrate/nitrogen ratio of 5.90 was higher in pretreated shoots over non-pretreated shoots (Table 21).

4.8.3.5 Dry matter content

The dry matter accumulation was higher in pretreated shoots (41.66 %) over non-pretreated shoots (40.00 %) (Table 21).

Table 21: Chemical constituents in pretreated and non-pretreated shoots of jack (per cent dry weight basis)

Chemical constituents	Pre-treated (Girdling + etiolation)	Non-pretreated (no girdling + no etiolation)
Total sugars	0.67	0.64
Reducing sugars	0.34	0.19
Non-reducing sugars	0.33	0.45
Starch	4.76	4.49
Total carbohydrates	5.43	5.13
Total nitrogen	0.92	1.64
Protein	5.75	10.25
C/N ratio	5.90	3.10
Dry matter	41.66	40.00

In general, except non-reducing sugar, total nitrogen and protein content all the remaining chemical constituents were higher in pretreated shoots compared to non-pretreated shoot of jack (Table 21).

4.8.4 Rooting cofactors

The data on the activity of rooting cofactors as measured in terms of rooting as revealed by mungbean bioassay are presented in the form of histograms (Table 22 and Fig.11 to 16).

The horizontal line indicates control. The columns above the control line indicate the level of promoters and below that of inhibitors.

The girdled and etiolated shoots extract showed the root promoting activity at Rf. 0.1, 0.6 and 0.7. The rooting cofactors 1 and 3 were found to be present in smaller quantities. The rooting cofactor 4 was totally absent (Fig. 11) during winter season.

In case of shoots without girdling and etiolation the root promoting activity was observed only in the region of Rf 0.9. There were no rooting cofactors present (Fig. 12).

During summer season in case of girdled and etiolated shoots the extracts showed the root promoting activity at the region of Rf 0.1, 0.4, 0.8 and 0.9. The rooting cofactors 1 and 4 were present in smaller quantities (Fig. 13). In case

Table 22: Presence of rooting co-factors found in different tissue samples estimated by *mung* bean bioassay during different seasons

Type of shoots	Winter		Summer		Rainy	
	Rf. values for promoters	Co-factors present	Rf. values for promoters	Co-factors present	Rf. values for promoters	Co-factors present
Girdled + *etiolated*	0.1	1	0.1	1	0.9	1
	0.6	3	0.4	-	0.4	-
	0.7	-	0.8	4	0.8	4
	-	-	0.9	-	0.9	-
Non-girdled + non-etiolated	0.9	-	1.0	-	0.2	-
	-	-	-	-	0.4	-
	-	-	-	-	0.7	-
	-	-	-	-	0.9	-

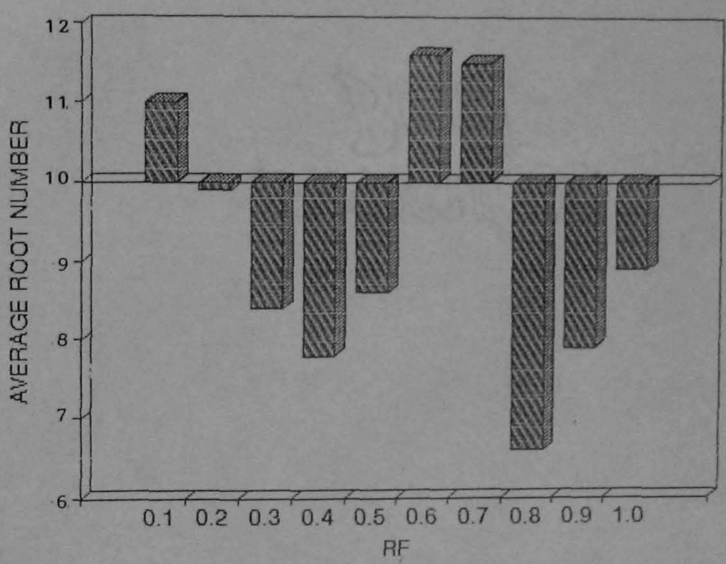


FIG. 11: HISTOGRAM SHOWING THE BIOLOGICAL ACTIVITY OF ROOT PROMOTING CO-FACTORS EXTRACTED FROM GIRDLED AND ETIOLATED SHOOTS OF JACK COLLECTED DURING WINTER SEASON (OCTOBER) IN MUNG BEAN BIOASSAY

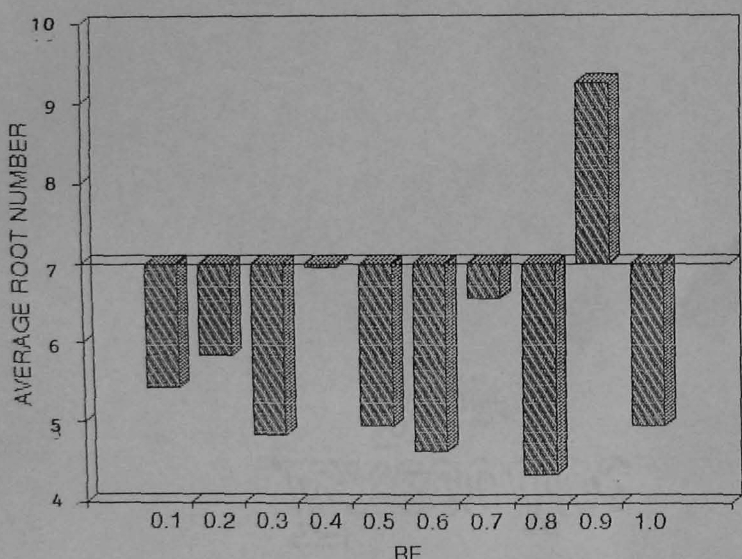


FIG. 12 : HISTOGRAM SHOWING THE BIOLOGICAL ACTIVITY OF ROOT PROMOTING CO-FACTORS EXTRACTED FROM NON-GIRDLED AND NON-ETIOLATED SHOOTS OF JACK COLLECTED DURING WINTER SEASON (OCTOBER) IN MUNG BEAN BIOASSAY

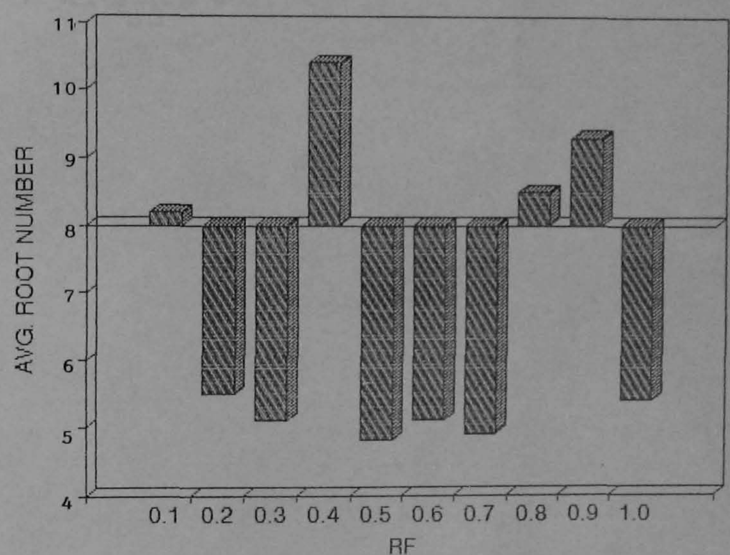


FIG. 13: HISTOGRAM SHOWING THE BIOLOGICAL ACTIVITY OF ROOT PROMOTING CO-FACTORS EXTRACTED FROM GIRDLED AND ETIOLATED SHOOTS OF JACK COLLECTED DURING SUMMER SEASON (MARCH) IN MUNG BEAN BIOASSAY

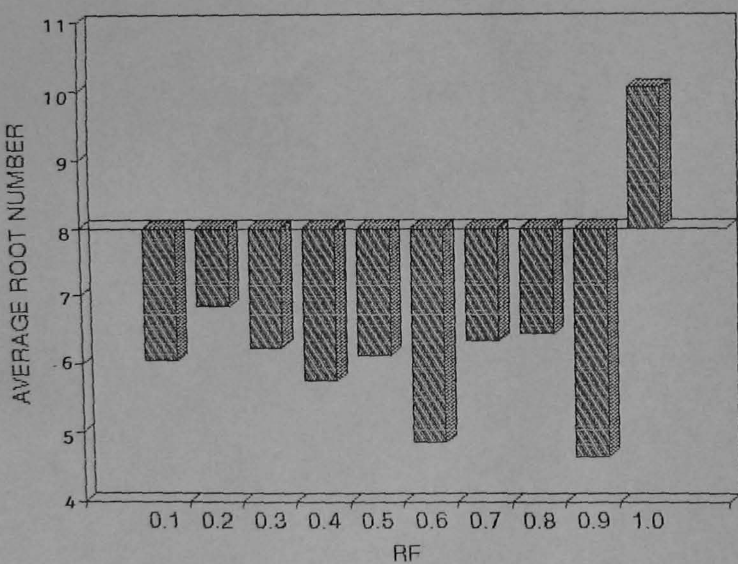


FIG. 14 : HISTOGRAM SHOWING THE BIOLOGICAL ACTIVITY OF ROOT PROMOTING CO-FACTORS EXTRACTED FROM NON-GIRDLED AD NON-ETIOLATED SHOOTS OF JACK COLLECTED DURING SUMMER SEASON (MARCH) IN MUNG BEAN BIOASSAY

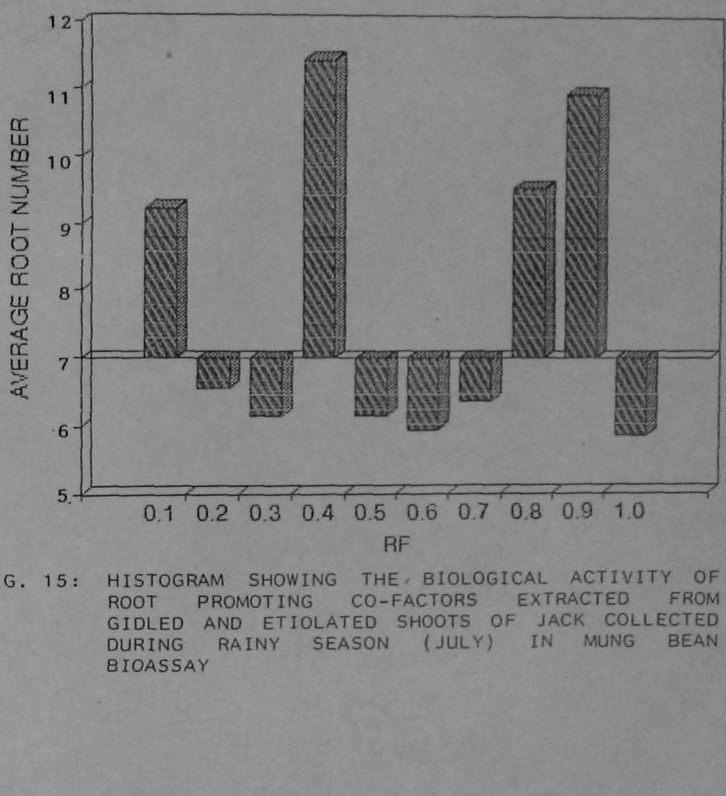


FIG. 15: HISTOGRAM SHOWING THE BIOLOGICAL ACTIVITY OF ROOT PROMOTING CO-FACTORS EXTRACTED FROM GIDLED AND ETIOLATED SHOOTS OF JACK COLLECTED DURING RAINY SEASON (JULY) IN MUNG BEAN BIOASSAY

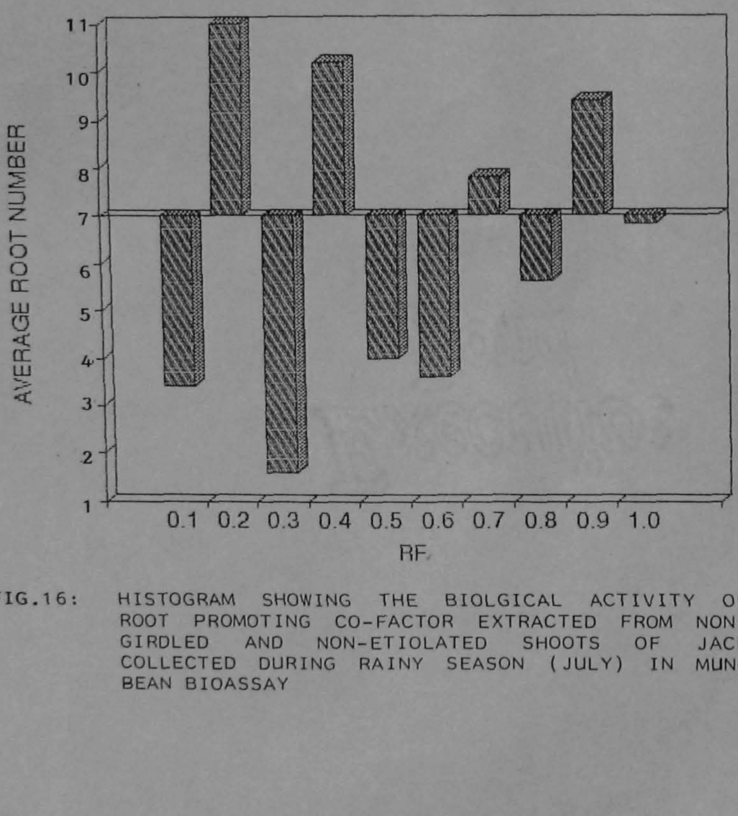


FIG.16: HISTOGRAM SHOWING THE BIOLGICAL ACTIVITY OF ROOT PROMOTING CO-FACTOR EXTRACTED FROM NON-GIRDLED AND NON-ETIOLATED SHOOTS OF JACK COLLECTED DURING RAINY SEASON (JULY) IN MUNG BEAN BIOASSAY

of shoots which were not girdled and etiolated the rooting cofactors were totally absent (Fig. 14).

During rainy season the extracts from the shoots which were girdled and etiolated showed the root promoting activity at the region of Rf 0.1, 0.4, 0.8 and 0.9 correspond' to the presence of rooting cofactors 1 and 4 (at Rf. 0.1 and 0.8 respectively) which are responsible for rooting according to Hess (1966) (Fig. 15). In case of extracts from shoots without girdling and etiolation there was root promoting activity at the region of Rf 0.2, 0.4, 0.7 and 0.9. But there were no rooting cofactors which are responsible for rooting are present (Fig. 16).

DISCUSSION

V. DISCUSSION

Jackfruit is an important tropical fruit crop. The fruit is nutritive and very popular in the tropical regions. In India, it is growtn in most of the southern and north-eastern states. It is generally grown in the backyards and in the coffee and cardamom plantations as shade trees. It has not received much attention towards crop improvement and standardisation of cultural practices. Standardisation of vegetative propagation methods will serve as one of the important tools for boosting up the production and quality of crop, particularly in cross-pollinated crops like jack. Although various vegetative propagation methods have been developed by various workers, still seed propagation has been popularly followed. There are no standard varieties in jack. However, there are good number of trees which are superior in yield and fruit characters. Vegetative propagation of such selected trees assumes greater importance to ensure uniformity of planting material and for enhancing production.

Any vegetative propagation method developed should be easy to adopt and need to help in easy multiplication. Various methods like grafting, budding, layering and propagation from cuttings were tried in jack with varying degree of success. Though, many grafting and budding methods are available, there is a need for improvement in the raising

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Any vegetative propagation method developed should be easy to adopt and need to help in easy multiplication. Various methods like grafting, budding, layering and propagation from cuttings were tried in jack with varying degree of success. Though, many grafting and budding methods are available, there is a need for improvement in the raising of grafts and budlings on container grown rootstocks. Grafts and budlings prepared on rootstock of optimum age will be healthy and easy to maintain if raised on rootstocks maintained in containers.

Softwood grafting studies were conducted to find out the optimum age of rootstock and optimum period for curring of scions. Different budding techniques were also carried out on rootstocks of different ages maintained in polythene bags. Jack is a difficult to root species. For large scale multiplication of any plant/crop, cuttings and air layers are seems to be rapid and viable techniques. But the attempts being made by the various workers in this direction so far are not encouraging. Therefore, a series of experiments were undertaken on air layering and propagation from cuttings to investigate the possibilities and the limitations, if any. In such studies, various growth regulators, seasons and pre-treatments like girdling and etiolation effects were studied. Attempts have also been made to study the chemical constituents of rootstocks, scions and shoots of cutting and layers in relation to graft/bud union and rooting success.

5.1 Effect of age of rootstocks on the success of softwood grafting

This experiment was conducted to find out the optimum age of the rootstock to get the highest success rate of softwood grafting.

5.1.1 Per cent graft union success

The rate of graft union success recorded on 30th and 60th day after grafting revealed significant differences among the rootstocks of different age groups. On 30th day after grafting, grafts on six month old rootstock gave higher rate of success (40%) followed by seven month old rootstock (33.33%) (Table 1). Sixty days after grafting, the highest success rate recorded was 36.67 per cent by six month old rootstock followed by 30.00 per cent in seven month old rootstock, but these two were on par. The success rate ranged from 10.00 to 36.67 per cent with rootstocks of different age groups. There was decrease in the graft union success on the 60th day after grafting due to the failure of some grafts to remain alive.

In general the lower percentage of success in grafting could be attributed to the lack of an intimate contact of a cambial region of both stock and scion and due to interference of exudation of latex (Hartman and Kester, 1986). Six month old rootstocks appeared to be the best. Grafting in February month may be favourable for the graft union success.

In jack, the highest success was observed when approach grafting was done with six month old seedlings and six month old scion as compared to two year old seedling (Anon., 1950). Reddy and Melanta (1988) reported that three month old rootstocks recorded a maximum graft union success followed by six month old rootstock in mango. Phadnis (1971) in cashew recorded a maximum success in veneer grafting with rootstocks of less than five months age. Similar results were recorded in cashew by Nagabhushanam and Rao (1978) and Muniswami (1979). At Vengurla, four to six months old rootstock recorded maximum success during February and March in cashew (Anon., 1983), while Yogananda (1989) found the best use of four to seven month old seedlings for in situ grafting of cashew.

The grafts in polythene bags recorded higher success rate. It might be due to the better moisture availability and better growing conditions created for the grafts. Following grafting higher meristematic activity is possible in the grafts raised in containers with better moisture availability. Amin (1974) obtained higher success rate with wedge grafting (98.5%) in the nursery field compared to main field (76.0%) in case of mango. Similar observations were made by Iqbal (1982) for side grafting and Desai and Patil (1984) for stone grafting in mango under greenhouse. It appears that the efficient management of the grafts influence the success rate.

5.1.2 Effect of age of rootstock on number of leaves, number of sprouts and length of sprouts on graft

5.1.2.1 Number of leaves on sprouts of graft

The average number of leaves produced per graft were significantly influenced by rootstocks of different ages when observed on the 30th, 60th, 90th and 120th day after grafting.

On the 30th day after grafting the number of leaves per graft were maximum (7.83) on eight month old rootstock followed by six month old rootstock (6.46), but these two treatments were on par (Table 2). However, after 60th, 90th and 120th day after grafting, maximum number of leaves were produced on six month old rootstocks followed by eight month old rootstocks. On the 120th day after grafting six month old rootstocks produced 19.83 leaves and eight month old rootstocks produced 19.16 leaves per graft. Leaf number for the grafts on six and eight month old rootstocks were on par.

5.1.2.2 Number of sprouts per graft

Number of sprouts per graft were significant among the different age groups of rootstocks during the entire growth period of grafts. Eight month old rootstocks recorded maxmimum sprouts (4.16) followed by six month old rootstocks (3.16) but these two were on par (Table 3).

5.1.2.3 Sprout length on graft

The average sprout length on graft after 30th, 60th, 90th and 120th day of grafting, exhibited no definite pattern of growth among different age group of rootstocks. However, six month old rootstocks produced highest length of sprout after 60th to 120th day of grafting (Table 4).

The vigour of the grafts were expressed by their successful graft union and growth characters. Srivastava

(1989) observed that temperature and humidity were the main limiting factors for the success of different grafting methods in mango and June month was the best period for grafting. Singh and Srivastava (1982) reported that softwood grafts exhibited better growth performance compared to veneer grafts and the graft union success rate was high if the grafts were prepared in the month of August. Patel and Amin (1981) reported 90 to 100 per cent graft take between May and August and 85 t0 90 per cent graft union success between February and May. Reddy and Melanta (1988) opined that higher graft union success on seven month old rootstock might be due to low temperature and higher relative humidity prevailing during the month of grafting. It was reported that February to April month was the best period for grafting. In the present study , the higher success obtained during February to April and holds good with earlier works.

5.2 Effect of duration of curring of scions and age of rootstocks on success ot softwood grafting

This study was conducted to find out the optimum duration of curing of scions for softwood grafting on rootstocks of different age groups.

5.2.2 Rate of graft union success

There were significant differences among the scions cured for different days with reference to graft union success.

Scions cured for 15 days recorded *higher rate of* success (50.00 %) on five month old rootstock when observed on the 30th day after grafting. Though there was a reduction in graft take from 30 days to 60 days after grafting, still scions cured for 15 days recorded higher graft union success (45.00%) on five month old rootstock and eight month old rootstock (45.00%). It was followed by five month old rootstock (40.00%) with 10 days cured scions (Table 5).

In general, the graft union success was more with scions cured for 15 days. Desai and Desai (1989) reported that softwood grafting success rate ranging from 33.33 to 80.00 per cent when 2.5 to 10.00 cm long scions were used on six month old in jack. Jose and Valsalakumari (1991) noted high percentage of sprouting and survival by the grafts prepared in the month of June by following epicotyl grafting. Th scions of three to four months in age were precured for 10 days and were grafted on the five day old rootstocks. Similar observations were reported from the *Bureau of Plant Industries Mandaue* (Cebu) Experiment Station, Philippines.They attained a grafting success of 30 to 80 per cent by the cleft method. The scions were defoliated one to two weeks before grafting to activate the buds and small cuts were made at the base of the rootstock to minimize latex accumulation at the point of contact of scion and stock (Acedo, 1992). The importance of curing of scion was reported by many workers in mango (Mukherjee and Majumdar, 1964; Kashyap et al., 1972; Amin, 1974; Singh and Srivastava, 1979; Ram and Bist, 1982; Dhungana et al., 1989) and in cashew (Sarada et al., 1991). Reddy and Melanta (1989) recorded maximum rate of graft take with the scions cured for 10 days on seven month old rootstock while following in situ softwood grafting in mango.

The better union of defoliated scion shoots over undefoliated scion shoots might be due to the fact that defoliation causes an immediate rise in sucrose content of phloem sap of the shoots. This helps in movement of solutes towards the apex of the shoots and thereby resulting in initiation of higher meristematic activity at the bud level. This condition helps in better sap flow and good callus formation due to stimulation of cambium division, favouring better graft union(Maiti and Biswas, 1980).

5.2.2 Effect of duration of curing of scions and age of the rootstocks on number of leaves on sprouts, number of sprouts and sprout length

5.2.2.1 Number of leaves on sprouts of graft

The duration of curing did not influence the number of leaves produced per graft. The average number of leaves on 30th, 60th, 90th and 120th day after grafting, exhibiting no definite pattern among the different age groups of rootstocks and also duration of curing of scions. The maximum number of leaves was recorded in four month old rootstock with 10 days curing of scions (22.50) followed by four months old rootstock with 15 days curing of scion (20.50) (Table 6).

5.2.2.2 Number of sprouts on graft

There was no definite pattern and influence of duration of curing on number of sprout when grafted on rootstocks of different age. The highest number of sprouts developed on grafts prepared on four month old rootstock (6.00) with the scions cured for 15 days, followed by those scions cured for 10 days (5.25) (Table 7). In general 10 to 15 days curing showed higher number of sprouts on four month old rootstocks.

5.2.2.3 Sprout length on graft

Though there was significant differences among the different age groups of rootstocks for graft union success, they did not influence later on sprout length. Scions cured for 15 days recorded highest sprout length on five month old rootstock (14.50 cm) followed by the scions cured for 20 days (13.00 cm) (Table 8).

In general, younger rootstocks were influenced by curing of scions compared to older rootstocks. Patil et al. (1984) noted that in epicotyl grafting of mango, the height of plant and number of leaves were the maximum on grafts prepared on four days old rootstocks with the scions cured for seven days compared to those grafts prepared without curing of scions. Sarada et al. (1991) in cashew observed on softwood grafts better plant growth when preconditioned scions were used compared to those where preconditioning of scions was not followed. Further, girth of scion and girth of rootstock were higher in grafts prepared with precured scions. Such observations were also recorded by Reddy and Melanta (1989) in mango.

5.3 Effect of age of rootstock on success of budding

This experiment was conducted to find out the optimum age of seedling rootstocks for chip budding to obtain highest success.

5.3.1 Per cent bud union success

The rate of bud union success recorded on the 30th day and 60th day after budding showed significant differences among the rootstocks of different age groups. On the 30th day after budding, eight month old rootstock recorded maximum bud take (15.00 %) whereas on three month old rootstock the bud take was complete failure. On the 60th day after budding there was slight increase in bud take on some treatments. The highest bud take was recorded by eight month old rootstock (15.00%) and here also there was complete failure in three month old rootstocks (Table 9).

In general, the success of chip budding was poor. Budding success was better with older rootstocks i.e., eight, nine and 10 month old rootstocks compared to younger rootstocks. Similar findings were obtained by many workers in jack. At Burliar, flute budding and patch budding on jack seedling rootstocks both failed, while shield budding on the seedling stocks recorded 10 per cent success in May and June months (Anon., 1952). Samaddar and Yadav (1970) recorded 41 per cent success by chip budding on one year old jack seedlings. They suggested that exudation of latex was the cause for low bud take. In cashew, farmers at Mozambique used five to twelve month old seedlings of 1.0 to 1.5 cm diameter as rootstocks and the budwoods collected from hardened parts of current year shoots after flowering were used (Anon., 1966).

Jagirdar and Ali (1965) studied the effect of age of stock plants on the bud take in mango and they reported higher percentage of success on nine month old seedling, compared to that on three and 15 month old seedlings. Bhattee (1979a) from Goa, reported a success rate ranging from four to sixtyfour per cent by bud grafting on two year old cashew plants during the month of September - October.

The low percentage of success of budding obtained in the present study could be attributed to high temperature and low humidity during the period of budding and presence of latex which might have prevented the callus formation and subsequent bud union. Structures which create high humidity may help to increase the success rate .

5.3.2 Effect of age of rootstock on number of leaves and length of sprouts on buds

5.3.2.1 Number of leaves on sprouts of buds

Average number of leaves produced per budding were significantly influenced by the rootstocks of different age when observed on the 30th, 60th, 90th and 120th day after budding. There was increase from 30th day to 120th day after budding for the number of leaves. The maximum number of leaves recorded was 11.00 on ten month old rootstock. The number of leaves were higher in age groups of seven month to ten month old rootstocks compared to three to six month old rootstocks (Table 10).

5.3.2.2 Sprout length on bud

The average sprout length of a budded plant on 30th, 60th, 90th and 120th day after budding was significantly influenced by the age of rootstocks. There is increase in sprout length from 30th to 120th day after budding. The maximum sprout length of 10.16 cm was recorded by eight month old rootstock followed by 8.33 cm by ten month old rootstock (Table 11). Here also the rootstock of seven month to ten month age exhibited higher sprout length.

The budlings were prepared from September to June and higher success with reference to bud union and growth were recorded during January to April months on seven month to ten months old rootstocks. In general, the percentage success of budding is very poor and the main reason might be due to presence of latex as reported by Samaddar and Yadav (1970). Kelaskar et al. (1991) observed highest sprouting, survival and better growth of bud grafts of jack which were kept in glass house followed by those kept in open sunlight or under partial or complete shades. Kelaskar et al. (1990) noted that there was a linear increse in success and growth of the bud grafts with an increase in the size of the polythene bags, which may be attributed to better root growth. Ferraz et al. (1974) reported that in cashew 99.59 per cent bud take by patch budding on eight month old seedlings when budding was carried out during the dry season. Palaniswami and Hammeed (1976) achieved 71 per cent success in the month of July and only 50 to 58 per cent success in March, April, September and October with patch budding.

5.4 Success of different methods of budding

This experiment was carried out to find out the best technique of budding to obtain highest success. The experiment was conducted during the month of December on six month old rootstock and in June on 12 month old rootstocks. The results of the present study showed that budding performance was very poor (Table 12). In general, the success in all the methods of budding was poor. However, chip budding success was comparatively better than all the other methods on both six month old and twelve month old seedling rootstocks. Chip budding produced five and eight successful budlings out of fourty on six month and twelve months old rootstock respectively. Patch budding was the next best method which produced three and four successful budlings out of fourty budlings prepared on six month and twelve month old rootstocks respectively. There was complete failure of inverted 'T' budding method. Many workers tried different methods of budding in jack and got varying degree of success (Teaotia et al., 1963; Moti et al., 1976; Singh et al., 1982; Biswass and Hossain, 1984). The low bud take might be due to the exudation of latex as suggested by Samaddar and Yadav (1970). The weather conditions prevailing during the period (Appendix-1) may also affect on budding success. High humidity is helpful in the healing of unions of buds with the rootstocks.

Budding has given very variable result in jack and the most promising method appears to be patch budding. This method, apparently so far tried only in North India, still needs to be tried out under other conditions (Garner, 1976). In the present investigation chip budding recorded higher bud take compared to patch budding.

Many workers obtained good success by following different budding techniques during different months Teaotia (1963), Jauhari and Singh (1970) and Moti et al. (1976) in mango, Nagabhushanam and Rao (1978), Chana and Savant (1979) and Nambiar (1980; 1981) in cashew. According to Nambiar (1980) the success obtained in cashew budding at Vengurla and Bhubaneswar Research Station was poor alround the year. The above studies showed that success in budding of cashew is greatly influenced by regional weather conditions. This also holds good for jack and other crops.

5.5 Chemical constituents of rootstock and scions on grafting and budding success

Physiological and biochemical differences between the stock and scion are important features responsible for incompatibility. In the present investigation, the role of various chemical constituents on the success or failure of grafting and budding was studied. Muhanin (1964) stated that the biochemical differnces among the different age groups of rootstocks of different species were responsible for incompatibility.

5.5.1 Rootstocks

There was no definite trend in many chemical constituents of rootstocks of different age groups (Table 19). The total sugar content increased from three months to twelve months old rootstock and eight month stock recorded maximum content. In case of reducing sugars the maximum content was recorded by twelve month old rootstock and there was gradual increase from three to twelve month old rootstocks. Regarding non-reducing sugars, there is no definite trend and maximum content was recorded by eight month old rootstocks. The starch and total carbohydrate content decreased from three to twelve month old rootstock and maximum content was recorded in three month old rootstock. Highest nitrogen and protein content were recorded by three month old rootstocks. However, carbohydrate to nitrogen ratio (C/N) was higher in six month old rootstocks.

In the present study, though grafting and budding on rootstocks of all the groups did not give fair success, the highest success was obtained on five to ten month old rootstocks. There is not much difference in the chemical constituent of rootstocks.

Fahamy (1954) reported that there was no positive relationship between the carbohydrate content of rootstock and scion in graft union success for mango. However, Muhanin (1964) noted that nutrient composition of rootstocks had a definite role in influencing bud take in sweet cherry, sour cherry, plum, apricot and apple. Reddy (1986) in mango found differences in the chemical composition of rootstock of different ages. He obtained higher success of softwood grafting with three to four month old rootstocks raised in polythene bags.

5.5.2 Precured scions

The physiological and biochemical changes during the period of curing of scions plays an important role in the success of grafting. There is difference between scions cured for different days. The scions cured for ten days recorded higher total sugars, reducing sugars, non-reducing sugars, starch, total carbohydrates, total nitrogen and protein . However, the carbohydrate / nitrogen ratio and dry matter content was lower in ten days cured scions. In the present investigation scions cured for ten days and 15 days recorded higher grafting success compared to twenty days cured scions. It might be due to the accumulation of the sugars, starch, and carbohydrates which might have helped in better callus formation.

Fahamy (1952) observed the accumulation of carbohydrates and starch in the pregirdled scions of Mecadamia and Sapodilla for sugars, starch and carbohydrates. However, significant differences were not found between the pregirdled and ungirdled scions for graft take. Fedrov (1961) noted an increase in carbohydrate content at bud swelling stage in wild Chinese apple and the content was comparatively higher at the time of bud burst. Reddy and Melanta (1989) observed the reduction of phenol content with preconditioning which inturn helped in better graft union.

5.6 Propagation of jack by air layers

In the present investigation, one of the objective was to study the effect of various growth regulators in different concentration with pretreatments like girdling and etiolation and without pretreatments in the production of successful air layers in jack under Bangalore condition.

5.6.1 Effect of pretreatments on the success of air layer.

During winter season out of 330 air layers prepared only 169 layers were survived over 75 days. In summer season only 127 layers out of 330 layers survived for 75 days (Table 13). None of the layers produced roots. Better results obtained with NAA 10,000 ppm compared to other treatments. However, during rainy season NAA 10,000 ppm produced maximum rooting (40.00 %) followed by NAA, 7500 ppm (33.33%), when observed 75 days after air layering (Table 15). The layers treated with NAA 10,000 ppm recorded significantly higher number of roots (25) and maximum root length (10.00 cm) followed by NAA 7500 ppm, which recorded (13.00) number of roots and rootlength of 11.0 cm (Table 16).

5.6.2 Layers prepared without pretreatment

The air layers prepared without pretreatment like girdling and etiolation failed to produce roots even with different concentration of growth regulators IBA and NAA during differnt seasons. Compared to three seasons rainy season (July) recorded more number of layers survived over 75 days. Some layers produced callus but failed to produce root (Table 14).

Preconditioning treatments such as girdling and etiolation prior to layering were found to enhance rooting potentiality of several horticultural crops. Girdling around the stem blocked the downward movement of carbohydrates and root promoting substances resulting their accumulation above the girdled portion (Stoltz and Hess, 1966a). Etiolation increased the auxin content (Kawase, 1965) and decreased the level of endogenous growth inhibitors (Turekaja and Kof, 1965). Thus these types of preconditioning treatment create a congenial condition inside the plant body for intitation and development of adventitious roots in air layers.

Advantages of girdling and etiolation on enhancement of rooting and improvements in root characters were reported by Sulladmath and Kololgi (1959), Chinnappa and Kololgi (1961), Nair (1989) in sapota, Nalwadi and Sulikeri (1972) in fig, Vijayakumar (1972) in guava, Melanta (1982) in cashew, Baruah (1988) in custard apple, Mukherjee and Chatterjee (1978), Lingarajappa (1980), Desai and Patil (1984) and Nazeem et al. (1984) in jack.

Better results were obtained by girdling and etiolation along with growth regulators used by many workers in jack (Dhua and Sen, 1984), in cashew (Sen and Chakrabarthy, 1972; Melanta, 1982), in litchi (Sharfuddin and Hussain, 1973) and in ber (Chatterjee and Rao, 1978). This may be attributed to the combined action between endogenous rooting cofactors and externally applied growth regulators. Angeles (1983) obtained very low success with air layering of jack when air layering was done in July. Singh et al. (1949) attributed the failure of younger shoots to produce roots to the fact that they were growing too actively and were therefore not accumulating enough carbohydrates. However, most workers suggests that the jack shoots for air layering should be of two to three years age and brownish in colour (Jauhari and Mehra, 1960; Singh et al., 1949; Singh, 1951; Singh 1955).

5.7 Propagation of jack from stem cutting under mist

Studies were carried out to know the effect of growth regulators in different concentrations on rooting stem cuttings. Effect of pretreatments like girdling and etiolation on rooting ability of jack under mist were also studied.

5.7.1 Effect of pretreatment on successful rooting of cuttings

The cuttings prepared after pretreatments like girdling and etiolation remained alive for over 60 days though they did not root at all. It was observed that growth regulators IBA and NAA at different concentration also failed to strike root. Out of 330 cuttings planted in each season, 80 cuttings survived for 60 days during winter (October) and 144 during summer (March). The number of cuttings survived are 155 during rainy season (June) though few had produced callus (Table 17).

5.7.2 Cuttings prepared without pretreatment

The cuttings prepared without pretreatment like girdling and etiolation kept under mist during three season i.e., rainy, winter and summer failed to root even with different concentration of IBA and NAA. Among the three seasons, rainy season recorded better survival of cuttings for over 60 days and also produced callus (Table 18). However, the number of cuttings survived are less compared to those cuttings prepared with pretreatments.

In general, the rooting was complete failure in jack by cuttings under mist in all the seasons with all kinds of treatments tried. In a trial at the National Botanical Garden, Lucknow by Singh (1955) apical, semihardwood or hardwood cuttings did not root, even when treated with root-promoting growth regulators. Poor rooting (less than 10%) of young and mature stem cuttings has also been noted in the Philippines (Angeles, 1983). Application of NAA or IBA, use of low or high pressure mist propagator and use of different media all failed to improve the rooting ability of the cuttings. Cuttings from roots are also failed to root in jack as observed by Hensleigh and Holaway (1988). It was stated that, the presence of latex makes it a comparatively difficult material to root (Audus, 1959).

Many workers on the other hand successfully obtained higher rooting percentage in jack. Mukherjee and Chatterjee (1978) recorded the highest percentage (100) of rooting and establishment (91.66) when the etiolated shoots were treated with 10,000 ppm IBA during September. The same workers (1979) obtained 84 per cent rooting and 75 per cent survival from invigorated and etiolated shoots treated with 5,000 ppm IBA under mist. Similar results on jack were obtained by Chatterjee and Mukherjee (1982). Dhua et al. (1983) recorded maximum rooting success (90.0 %) in cuttings taken from shoots etiolated and ringed for 30 days and then treated with IBA at 3000 ppm plus ferulic acid at 2,000 ppm. In other crops rooting of cutting was observed by many workers in guava (Dhua et al., 1982; Prasad et al., 1988; Debnath and Maiti, 1990), in tamarind (Swaminath et al., 1990), in mango (Sadhu and Bose, 1980; Bid and Mukherjee, 1972) and in cashew. (Khan, 1962; Coester and Ohler, 1976).

5.8 Influence of season on rooting of airlayer and cuttings in jack

The selectivity of seasons in relation to rooting of cuttings and layers was observed in some of the plant species. The changes in rooting response with changes in seasons have been attributed to the morpho-physiological status of the shoot. The endogenous levels of nutrients and growth promoting substances are also influenced by environmental conditions such as sunshine, temperature, humidity and rainfall. Some of these factors in turn have effect on the mobilization of reserve food material through hydrolytic enzymes, resulting in their convertion into readily availale forms to cater to the requirements of rapidly growing cells and tissues, changes in the cambial activity and tissue content of auxins, inhibitory substances and root promoting cofactors.

In the present investigation though there was complete failure of rooting by hardwood cuttings in all the seasons, rooting of air-layering during the rainy season was satisfactory. This shows that rainy season is more congenial for preparation of air layers. Many scientists obtained higher rooting during rainy season in mango (Surayanarayanan and Rao, 1982) and in sapota (Sulladmath and Koloigi, 1959; Nair, 1989). Jauhari and Mehra (1960) had very meagre success in jack with air layering in the month of February.

But they achieved up to 100 per cent rooting during the rainy season of late August to late October. According to Baruah (1988), the monsoon was the best season for making cuttings and air layers of custard apple.

The variation seems to be related to the climatic factors such as temperature, humidity and rainfall. The weather data given in Apendix show seasonal fluctuation in the above mentioned climatic factors. It is presumed that the congenial atmospheric condition during the callus formation and root initiation periods might have contributed to the better performance of the shoots layered during rainy season. Bose and Mandal (1970) found that high humidity and low temperature enhanced rooting in many plant species. The artificial provision of these factors resulted in more number of roots in a much shorter period. Yet another role of humidity and temperature in rooting is maintenance of turgidity of the tissue and prevention of desiccation. According to Singh et al. (1957), Janik (1979) and Hartman and Kester (1986), high humidity and low temperature decreased transpiration loss of water and desiccation of tissues and helped the shoots to maintain turgidity and high leaf water potential, thus making condition condusive for rooting. The above works thus support the fact that climatic factors have a role in the induction of rooting in jack air layers as observed in the current studies.

5.9 Chemical constituents of jack shoots

The studies on the biochemical constituents revealed slight differences in the different chemical constituents between girdled and etiolated shoots and non-girdled and etiolated shoots. Girdled + etiolated shoots recorded comparatively higher amount of total sugars, reducing sugars, starch, total carbohydrates, carbohydrate to nitrogen ratio and dry matter content over non-girdled and non-etiolated shoots. This indicates that higher carbohydrates content favours the rooting in air layers during rainy season. Nitrogen content was less in pre-girdled and etiolated shoots. Similar observations recorded by Basu *et al*. (1967, 1972) in mango. Hess (1961) suggested that, when other factors for rooting were present, carbohydrate and nitrogenous substances should have promotive effect on rooting. It is possible that these factors may contribute to some extent to better rooting. Sen and Basu (1960) attributed some significance to carbohydrate to nitrogen ratio, but it did not improve rooting of the invigorated cuttings. Nanda and Anand (1970) observed better rooting in *Populus nigra* due to auxin application when the nutritional status of the cutting was satisfactory. They stressed the importance of proper balance between auxin and nutritional status of the stem cuttings.

5.10 Role of root promoting cofactors on rooting of jack

Studies on the rooting cofactors of girdled and etiolated shoots revealed that pretreatments like girdling and etiolation has shown presence of rooting cofactors though the levels were very low. The shoots in the rainy season recorded much higher level of cofactors 1 and 4 compared to shoots of winter and summer season (Table 22 and Figs. 11 to 16).

Hess (1966) indicated that rooting cofactor 4 was quite essential for root initiation. In the present study, though there was complete failure of rooting by cuttings, where as air layers rooted only during rainy season with pretreatments like girdling and etiolation. The poor rooting could be attributed to high level of inhibitors compared to promoters. Sengupta and Chattopadhya (1954) reported that failure of rooting in response to auxin application in many plant species like Mangifera indica and Eugenia jambolana may be atrributed to the lack of cofactors in the cuttings. Basu et al. (1966) observed that greater accumulation of rooting cofactors in the girdled seedling shoots of mango compared to non-girdled ones. Vijayakumar (1972) observed that invigorated tissues of guava obtained during the month of July contained all the four rooting cofactors. The cofactor-4 is very essential for initiation of root was present in the highest amount. Melanta (1982) in cashew observed two important root promoting substances in invigorated and invigorated-ringed, etiolated tissues. Lingarajappa (1982) in jack recorded all the four rooting cofactors in pre-girdled plus etiolated shoots. Similar results were obtained by Shivanna (1983). Chatterjee and Rao (1985) noted that etiolated condition of both the invigorated and non-invigorated shoots induced higher net root promoting effects. According to Baruah (1988), the mature shoots of custard apples contained higher activity of inhibitors and low root promoting cofactors. Juvenile shoots of custard apple showed higher root promoting cofactors 1, 2 and 4. He also noted seasonal effect on root promoting cofactors. The root promoting cofactors were higher level in monsoon and inhibitors were more in winter season.

SUMMARY

VI. SUMMARY

The present investigations on the standardisation of vegetative propagation techniques in jack were carried out in the Horticultural Research Station, Gandhi Krishi Vignana Kendra (G.K.V.K), University of Agricultural Sciences, Bangalore during the year 1990-1992. The studies were conducted to find out quicker, easier and cheaper method of vegetative propagation following techniques of grafting, budding, layering and use of cuttage. The optimum age of rootstocks for the higher success rate and growth of grafts and budlings were studied. The optimum duration for curing of scions on the success of softwood grafting was also studied. Different budding techniques were taken up to find out suitable method. Effect of growth regulators and season on rooting of jack cuttings and air layers were studied. Influence of pretreatements like girdling and etiolation on rooting of cuttings and layers were also studied.

Biochemical analysis of rootstocks, scions and jack shoots were done to know the influence of these on success of grafting, budding and on rooting of cuttings and layers. The salient findings of these studies were summarised as below.

6.1 Grafting

Among the different age groups of rootstocks tried for softwood grafting, six month aged rootstocks recorded the highest rate of graft union success (36.67%) followed by seven month aged rootstock (30.00%).

The maximum number of leaves (19.83) and longer sprouts (12.54 cm) were produced by the grafts on six month aged rootstock and the maximum number of sprouts (4.16) were recorded by grafts on eight month aged rootstocks.

For the softwood grafts, scions cured for fifteen days recorded the maximum rate of graft union success (45.0%) on five month aged rootstock and by ten days cured scions on eight month aged rootstock (45.0 %).

The highest number of leaves (22.00) were produced by the grafts on four month aged rootstock with ten days' curing of scions. The maximum number of sprouts (6.00) were recorded on four month aged rootstock grafted with scions cured for fifteen days. Longer sprout length (14.5 cm) was recorded on five month old rootstocks grafted with scions cured for fifteen days.

6.2 Budding

The success of chip budding was poor. The highest success of 15.00 per cent was recorded on eight month old rootstock.

Budding on ten month aged rootstocks produced higher number of leaves (11.00) and the longer sprouts (10.16 cm) were produced by the budding on eight month old rootstocks.

Among the different methods of budding, chip budding recorded higher number of successful budlings followed by patch budding both on six and twelve month old rootstocks.

The chemical analysis of different age groups of rootstocks did not show much difference in chemical constituents. The total sugar and reducing sugars content increased from three month to twelve month aged rootstock. The starch and total carbohydrate content decreased from three to twelve month aged rootstocks. There was no definite trend in other constituents among different age groups of rootstocks.

Among the scions cured for different days, there was not much difference in chemical constituents. The scions cured for ten days recorded higher total sugars, reducing sugars, non-reducing sugars, starch, total carbohydrates, nitrogen and protein contents.

6.3 Air layering

Jack air-layers failed to produce roots without pretreatments like girdling and etiolation and treatments with different concentration of IBA and NAA. This was observed in all the three seasons i.e., rainy, winter and summer. However, with pretreatments of girdling and etiolation and growth regulators the layers rooted during rainy season but failed to produce root in summer and winter season.

The maximum percentage of rooting (40.00 %) was recorded by the application of NAA 10,000 ppm followed by NAA 7,500 ppm (33.33 %). The highest number of roots per layer (25) were produced by the layers treated with NAA 10,000 ppm followed by NAA 7,500 ppm (13.00). Longer roots (11 cm) were recorded by the layers treated with NAA 7,500 ppm followed by NAA 10,000 ppm (10 cm).

6.4 Stem cuttings

Hardwood stem cuttings of jack failed to strike roots with different concentration of IBA and NAA during all the seasons with pretreatments and without pretreatments. Many of the cuttings survived for 60 days and some produced callus. Among the three seasons, rainy season recorded better survival of cuttings of both pretreated and without pretreated cuttings.

6.5 Rooting cofactors

The jack shoots showed differences for the presence of rooting cofactors. The differences was found between girdlec and etiolated and non-girdled and non-etiolated shoots Pretreatments like girdling and etiolation showed presence o rooting cofactors, though the levels were low. The shoot in the rainy season recorded much higher levels of cofactor 1 and 4 compared to shoots of winter and summer season.

The results of the present investigation revealed that softwood grafting could be adopted for large scale multiplication of jack with cured scions. Chip budding also can be taken up. Air layering would give better success if done during rainy season. The treatments with higher concentrations of NAA is helpful while preparing air layers.

REFERENCES

VII. REFERENCES

Acedo, A.L., 1992, Jackfruit biology, production, use, and Philippine Research. Monograph Number 1. Multipurpose Tree species, Network Research Series. pp. 30-33.

Ahmed, S., 1964, Propagation of mango by veneer grafting. W. Pakistan J. Agric. Res., 2: 32-44.

Ahmed, S. and Ahmed, R., 1960, Mango budding in nursery stages. Punjab Fruit J., 23: 77-79.

*Ali, N. and Nazir, M., 1970, Effect of auxins on carbohydrate and nitrogen contents of mango cuttings. Pakistan J. Sci., 22: 12-21.

Ali, N. and Westood, N.N., 1966, Rooting of Pea cuttings as related to carbohydrates, nitrogen and rest period. Proc. Amer. Soc. Hort. Sci., 88: 145-150.

Altman, A. and Wareing, P.F., 1975, The effect of IAA on sugar accumulation and basipetal transport of 14C-labelled assimilates in relation to root formation in Phaseolus vulgaris cuttings.Physiol. Plant., 35: 32-38.

Amin, R.S., 1974, A study on the establishment of mango orchard with wedge graft on in situ grown seedlings in dry regions of the Gujarat State. Haryana J. Hort. Sci., 3: 160-167.

Amin, R.S., 1978a, In situ softwood grafting in mango. Indian Hort., 23: 7 - 10.

Amin, R.S., 1978b, Soft wood grafting - a new technique for hard wood plants. Curr. Sci., 12: 468-469.

Angeles, D.O., 1983, Cashew and jackfruit research. Research Terminal Report. Laguna, Philippines: Department of Hort., University of the Philippines at Los Banos (UPLB).

Anonymous, 1935, Malayan fruits. Malay. Agric. J., 23: 110-133.

*Anonymous, 1950, Rep. Agric. Stat. Madras Pres.

*Anonymous, 1952, Rep. Agric. Stat. Madras Pres.

*Anonymous, 1966, Cashew budding. Gazeta Agric. Mozamb., 18: 126-127.

Anonymous, 1977, Annual Progress Report. Central Plantation Crops Research Institute, Kasaragodu.

Anonymous, 1983, Annual Progress Report. Central Plantation Crops Reserch. Institute. Kasaragodu.

Anonymous, 1991, Horticulture Technical Guide. Govt. of Karnataka, Department of Horticulture.

A.O.A.C., 1970, Official Methods of Analysis of Association of Official Analytical Chemists, 11th Edn., Association of Analytical Chemicals. Washington.

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

Asana, R.D. and Saini, A. D., 1962, Studies in physiological analysis of yield. Indian J. Pl. Physiol., 5:128-171.

Audus,L.J., 1959, Plant Growth Substance. Leonard Hill, London, pp. 426-427.

Bachelard,E.P. and Stowe, B.B., 1963, Rooting of cuttings of Acer rubrum L. and Eucalyptus camaldulensis Dechn., Aust. J. Biol. Sci., 16: 751-767.

Baruah, S., 1988, Physiology of rooting in custard apple (Annona squamosa L.). Ph.D. Thesis. Univ. Agric. Sci., Bangalore.

Basu, R.N., Ghosh, B. and Sen, P.K., 1968, Naturally occurring rooting cofactors in mango (Mangifera indica L.). Indian Agric., 12: 194-195.

Basu, R.N., Lahiri, B. and Sen, P.K., 1967, Biochemical changes during regeneration of roots in air layers of mango (.Mangifera indica L.) Curr. Sci., 15: 413-415.

Basu, R.N., Roychoudhary, N., Bose, I.K. and Sen, P.K., 1966, Rooting of mango cuttings. Indian Agric., 10: 147-151.

Basu, R.N., Roychoudhary, N., Lahiri, B. and Sen, P.K., 1972, Biochemical changes during root formation in Mangifera indica L. air layers. Acta Hortic ., 24: 64-71.

Bhandary, K.R. and Chinnappa, K.S., 1963, Mango (Mangifera indica L.). The Lal-Baugh, 8: 4-17.

Bhandary, K.R. and Kololgi, S.D., 1960, Studies on the seasonal effect of plant regulators in combination on the rooting of air layers of guava (Psidium guajava L.) var. Lucknow-49. The Lal-Baugh, 5: 8 - 10.

Bhandary, K.R. and Mukherjee, S.K., 1969, Relation between invigoration and rooting of guava (Psidium guajava L.) stem cuttings. Curr. Sci., 38: 197-198.

Bhattee, S.S., 1979a, The cashew in Goa. Cashew Causerie., 1: 2-7.

Bhattee, S.S., 1979b, Vegetative propagation of cashew by grafting of young nursery seedlings. Cashew Causerie., 1: 13-14.

Bid, N.N. and Mukherjee, S.K., 1969, Varietal response to etiolation and growth regulator treatment in air-layering of mango (Mangifera indica L.). Indian J. Agric. Sci., 39: 1013-1019.

Bid, N.N. and Mukherjee, S.K., 1972, Studies into the effect of forced shoot etiolation and different media on the rootage of Mangifera indica L. cuttings. Acta Hortic., 24: 77-81.

Biswas, M.M. and Hossain, A.K.M.A., 1984, Successful methods of vegetative propagation of jackfruit. Bangladesh J. Agric. Res., 9: 145-146.

Bose, T.K. and Mandal, D.P., 1970, Propagation of ornamental trees from cuttings under mist. Sci. Cult., 36: 665-666.

*Bouillene, R. and Bouillene, W.M., 1952, Experiments on the root formation: Non-polar transport of rhizocaline in the epicotyl of Impatiens balsamina and Phaseolus vulgaris. C.R. REsh. I.R.S., IA., No.6. Trav. Centre. Rech. Hormones. Veg., 95-111.

Breen, P.J. and Murakova, T., 1973, Effect of indole butyric acid on distribution of 14C - photosynthate in soft wood cuttings of 'Mariana 2624' Plum. J. Amer. Soc. Hort. Sci., 98: 436-439.

Burns, W. and Prayag, S.H., 1920, The book of the mango. Bull. Bombay Dept. Agric., 103.

Chadha, K.L., 1968, Litchi cultivation in India. Indian Hort., 12: 13-16 and 36.

Chana, S.S. and Savant, P.V., 1979, Bud grafting of cashew in Goa. Indian Fmg., 28: 21-24.

Chatterjee, B.K. and Mukherjee, S.K., 1980, A note on the effect of leafy and non-leafy cuttings rooting of jackfruit (Artocarpus heterophyllus Lam.). Prog. Hort., 11: 49-51.

Chatterjee, B.K. and Mukherjee, S.K., 1982, Studies on the efficacy of rates and methods of application of indole butyric acid (IBA) on the rooting of cuttings of jack fruit (Artocarpus heterophyllus Lam.). Sci. Cult., 48: 74-75.

Chatterjee, B.K. and Rao, D.P., 1978, Propagation of Jujube (Zizyphus jujube) by air layering. Indian Agric., 22: 185-187.

Chatterjee, B.K. and Rao, D.P., 1985, Bioassay of cuttings of jackfruit (Artocarpus heterophyllus Lam.) under invigoration and etiolation treatment. Orissa J. Hort., 13: 35-42.

Chatterjee, B.K., Rao, D.P., Chakladar, B.P. and Mukherjee, S.K. 1989, Effect of different concentrations of growth regulators, etiolation and invigoration on the rooting of air-layers of sapota (Achras sapota Linn.). Indian J. Hort., 46: 426-429.

Chhonkar, V.S. and Singh, R., 1967, Effect of plant gowth regulators on air layering in cashew nut. Indian J. Hort., 24: 26-29.

Chinnappa, K.S., 1960, Studies on seasonal effects of plant growth regulators in combination on the rooting of air layers of chicku (Achras sapota L.) var. Kalipatti. M.Sc. Thesis, Karnataka Univ. Dharwar.

Chinnappa, K.S. and Kololgi, S.D., 1961, Effect of plant regulators on cell wall constituents of bark of chiku (Acharas sapota L.). above the gootee girdle. The Lal-Baugh, 6: 29-32.

Choudhury, R.N., 1971, Aminoacid metabolism during regeneration of roots in mango (Mangifera indica L.) seedling cuttings. Indian Agric., 15: 95-102.

Coester, W.A. and Ohler, J.G., 1976, Cashew propagation by cuttings. Trop. Agric., 53: 353-358.

Das, R.C. and Mishra, S.N., 1978, Studies on the vegetative propagation of cashew. J. Res.,99:26-29.

Dasarathi, T.B., 1979, Cashew research Station, Bapatla. Cashew Causerie., 1: 22-23.

Debnath, G.C. and Maiti, S.C., 1990, Effect of growth regulators on rooting of softwood cuttings of guava (Psidium guajava L.) under mist. Haryana J. Hort. Sci., 19: 79-85.

Desai, J.B. and Patil, V.K., 1984, Success of stone grafting in mango in glasshouse and in open. Punjab Hort. J., 24: 7-10.

Desai, J.B. and Patil, V.K., 1984, Studies on the air layering in jackfruit. Indian J. Forestry, 77: 177-181.

Desai, S.A. and Desai, A.G., 1989, Effect of age, length, defoliation and storage of scion sticks on success of softwood grafting in jackfruit (Artocarpus heterophyllus Lam.). Proc. Indian Acad. Sci., (Plant Sci.) 99: 585-591.

Dhandar, D.G., 1985, Increase cashew production adopting vegetative propagation. Acta Hortic., 108: 285-186.

Dhua, R.S., Mitra, S.K. and Sen, S.K., 1982a, Proceedings of National Seminar on Plant Propagation. Bidhan Chandra Krishiviswavidyalaya, West Bengal. India.pp. 36.

Dhua, R.S., Mitra, S.K., Sen, S.K. and Bose, T.K., 1982b, Effect of ethephon and IBA on rooting of guava. Sci. Cult., 48: 444-445.

Dhua, R.S. and Sen, S.K., 1982, Root regeneration in litchi (Litchi chinensis Sonn.) stem cuttings with auxin and auxin synergists under intermittent mist. South Indian Hort., 30: 188-191.

Dhua, R.S., Sen, S.K. and Bose, T.K., 1983, Propagation of jackfruit (Artocarpus heterophyllus Lam.) by stem cuttings. Punjab Hort. J., 23 84-97.

Dhua, R.S. and Sen, S.K., 1984, Role of etiolation, auxinic and non-auxinic chemicals on root initiation of air layers of jack fruit. Indian J. Hort., 41: 116-119.

Dhungana, D.B., Aravindakshen, M. and Gopikumar, K., 1989, Standardization of stone grafting in mango. Acta Hortic ., 231: 170 - 174.

Fadl, M.S. and Hartman, H.T., 1967, Isolation, purification and characterisation of an endogenous root promoting factor obtained from basal sections of pear hardwood cuttings. Pl. Physiol., 42: 542 - 549.

Fahamy, A., 1952, Grafting studies on mecadamia and sapodilla in relation to carbohydrates using pregirdled scions. Proc. Fla. State. Hort. Sci., pp. 190-192.

Fahamy, A., 1954, A study on the relation between carbohydrate content and graft union in certain tropical fruit trees and the diffusable auxin content of the scions. Diss. Abstr., 14: 748.

Fedrov, N.L., 1961, Carbohydrates metabolism in wild chinese apple trees during the post planting period and importance for subsequent growth. Fitzol. Rast., 8: 117-119. (Hort. Abstr., 31: 3947).

*Ferraz, L., D'Souza, M.M., Dantas, A.P., Wanderley, M., De and Pedrosa, A.C., 1974, Bull Jecinic do inst. de Pesquisas Agronomicas, 69: 17.

Ganapathi, T., 1988, Studies on clonal propagation in tamarind. M.Sc. (Hort.) Thesis, Univ. Agric. Sci., Bangalore.

Garner, R.J. and Chaudhri, A.S., 1976, Artocarpus heterophyllus - Jackfruit in: The propagation of tropical fruit trees, CAB pp. 269-290.

Ghosh, S.K. and Basu, R.N., 1974, Metabolic changes during the regeneration of roots on cuttings. Indian J. Exp. Biol., 12: 166 - 168.

*Gorgoshidze, O.M., 1971, Rooting of feijoa cuttings in relation to biochemical characteristics of the shoots. Sub-tropic. Kultury, 4: 116-123.

Gowda, N., 1983, Studies on vegetative propagation of Tamarind by air-layering. M.Sc. (Ag.) Hort. Thesis, Univ. Agric. Sci., Bangalore.

Gregory, F.G. and Samantarai, B.,1950, Factors concerned in the rooting responses of isolated leaves. J. Expt. Bot., 1: 159-193.

Gunjate, R.T., 1989, Standardisation of stone grafting for the Konkan region. Acta Hortic ., 231: 164-167

Gunjate, R. T., Kolekar, D.T. and Limaye, V.O., 1980, Epicotyl grafting in jackfruit. Curr. Sci., 49: 667.

Gunjate, R.T. and Limaye, V.P., 1978, Veneer grafting on mango seedlings raised in earthern pots. J. Maharashtra Agric. Univ., 3: 61-62.

Hanamashetti, S.I., Khan, M.M., Hegde, M. and Nagaraju, A.P., 1984, Preliminary studies on the use of growth regulators for inducing rooting in 3/108 Gubbi, Karnataka a difficult to root cashew selection. South Indian Hort., 32: 371-372.

Hartman, H.T. and Kester, D.E., 1986, Plant Propagation: Principles and Practices. Printice Hall of India, P. Ltd., New Delhi., 2nd Edn., pp. 197-252.

Haun, J.R. and Cornell, P.W., 1951, Rooting response of geranium (Pelergonium hortorum Bailey var. Ricard) cuttings as influenced by nitrogen, phosphours and potassium nutrition of the stock plant. Proc. Amer. Soc. Hort. Sci., 58: 317-323.

Hensleigh, T.E. and Holaway, B.K., 1988, Agroforestry Species for the Philippines. pp. 45-49. Manila. AJA Printers.

Hess, C.E., 1961, The physiology of root initiation in easy and difficult to root cuttings. Paper No. 1843. Agr. Expt. Sta. Purdue Univ., 3 -·6.

Hess, C.E., 1966, Root initiation and juvenility - a possible implication of terpane compounds. Proc. 17th Int. Hort. Congr., 3: 443-470.

Hess, C.E. and Synder, W.E.,1957, A physiological comparison of the use of mist with other propagation techniques used in the rooting of cuttings. Report of the 14th Int. Hort. Cong., Schlveningern, 2: 1130-1139.

Higgins, J.E., 1910, Shield budding in mango. Bull. Hawaii Agric. Exp. Stat., 20: 1910.

*Hosai, T., Machida, H. and Yoshida, R., 1972, Changes in nitrogen and carbohydrate contents in hardwood cuttings of grape vines. J. Jap. Soc. Hort. Sci., 41: 127-132.

Hosein, I., 1958, Mango propagation by a 'T' graft method. Trop. Agric. Trinidad, 35: 181-189.

Hulmani, N.C. and Reddy, P.N., 1974, Studies on layerage by pregirdling and etiolation in pummelo (Citrus grandis Osbeck). Curr. Res., 33 106.

Ihara, Y. and Tamari, K., 1961, Studies on softwood grafting of horticultural plants. I. The possibility of suitable season for softwood grafting in certain fruit and ornamental trees. J. Jap. Soc. Hort. Sci., 30 : 253-258.

Iqbal, M., 1982, Review of mango research and production in Fizi. Fizi Agric. J., 44:22-26.

Ismail, S. and Rao, S.N., 1989, Studies on propagation time and method of operation for mango cv. Benganapally. Acta Hortic., 231 : 203-206.

*Jagirdar, S.A.P. and Ali, Z., 1965, Effect of age and variety of stock plants on the bud take in mango. Agric. Pakistan, 16: 461-466.

*Jagirdar, S.A.P. and Bhatti, M.S., 1968, Effect of type of scions wood and age of stock on the success of veneer grafting in mango. W. Pakistan J. Agric. Res., 6: 88-97.

*Jagirdar, S.A.P., Nizameni, M.H. and Shaikh, M.A., 1968, Varietal response of veneer grafting in mango. W. Pakistan J. Agric. Res., 6: 86-89. (Hort. Abstr. 39: 7571).

Janick, J., 1979, Horticultural Science, Purdue University. W.H. Freeman and Company, San Francisco.

Jauhari, O.S. and Mehra, R.C., 1960, Air-layering in Artocarpus heterophyllus Lam. and Psidium guajava L. by treatment with growth regulators. Allahabad Fmr., 34: 137-147.

Jauhari, O.S. and Rahaman, S.F., 1959, Further investigation on rooting in cuttings of Sweet lime (Citrus limettoides Tanaka.) Sci. Cult., 24: 432-439.

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

Jose, M. and Vaisalakumari, P.K., 1991, Standardisation of the technique of epicotyl and softwood grafting in jack (Artocarpus heterophyllus Lam.). South Indian Hort., 39: 264-267.

Kashyap, R., Jyotishi, R.P. and Sharma, A.B., 1972, Techniques of side grafting in mango. Acta Hortic ., 24: 99-100.

Kawase, M., 1965, Etiolation and rooting in cuttings. Physiol. Plant., 18: 1066 - 1076.

Kelaskar, A.J., Desai, A.G. and Salvi, M.J., 1990, Effect of container size and _In situ_ budding on success and growth of patch bud grafts in jackfruit (_Artocarpus heterophyllus_ Lam.). _Indian J. Agric. Sci._, 60: 265-267.

Kelaskar, A.J., Desai, A.G. and Salvi, M.J., 1991, Effect of rootstock, Leaf retention, shade and tying material on patch bud grafts of jackfruit. _Indian J. Plant Physio._, 34: 58-62.

Khan, K.F., 1962, _Fruit Nursery Practices in India._ Ministry of Food and Agriculture, New Delhi.

Kulwal, L.V. and Tayde, G.S., 1989, Studies on propagation of mango varieties by softwood grafting under Akola conditions. _Acta Hortic._, 231; 256-258.

Kumar, D.P. and Khan, M.M., 1988, _In situ_ soft wood grafting in cashew. _The cashew_, 2: 3 - 4.

Kumar, D.P., Subbrayappa, A. and Khan, M.M., 1989, Softwood grafting - A successful method of clonal propagation in cashew. _The cashew_, 3: 3 - 5.

Lingarajappa, V.G., 1980, Studies on the effects of pre-treatments and growth regulators on rooting of jack (_Artocarpus heterophyllus_ Lam.) air layers. M.Sc., Thesis. Univ. Agric. Sci., Bangalore.

Mahabaleshwara, H.L., 1992, Standardisation of vegetative propagation techniques in cashew (_Anacardium occidentale_ L.). M.Sc., Thesis. Univ. Agric. Sci., Bangalore.

Maiti, S.C. and Biswas, P., 1980, Effect of scion variety and type of scion shoots on success of epicotyl grafting of mango. _Punjab Hort. J._, 20: 152-155.

Majhail, H.S. and Singh, K.K., 1962, Inarching in mango 1. The effect of alkathene wrapper, time of inarching and size of stock seedling. _Punjab Hort. J._, 2: 33-43.

Majumdar, P.K., Mukherjee, S.K. and Rathore, D.S., 1972, Further researches on propagation techniques in mango. Acta Hortic ., 24: 72-76.

Melanta, K.R., 1982, Studies on propagation of cashew (Anacardium occidentale L.) by cuttings. Ph.D. Thesis, Univ. Agric. Sci., Bangalore.

Morton, J.F., 1987, Fruits of warm climates. Winterville, North Carolina, USA, pp. 58-64.

Moti, Dhar, L. and Chaturvedi, O.P., 1976, Propagating some sub-tropical and tropical fruits by budding. Punjab Hort. J., 16: 33-38.

*Muhanin, V.G., 1964, Bud take on rootstocks of sour cherry and other fruit species with early and normal budding dates. Micurina, 10: 47-52. (Hort. Abstr. 37: 266).

Mukherjee, S.K. and Chatterjee, B.K., 1978, Effect of etiolation and growth regulators on air layering of jackfruit (Artocarpus heterophyllus Lam.). Indian J. Hort., 35: 1 - 4.

Mukherjee, S.K. and Chatterjee, B.K., 1979, Effects of forcing, etiolation and Indole Butyric Acid on rooting of cuttings of Artocarpus heterophyllus Lam. Sci. Hort., 10: 295-300.

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

Mukherjee, S.K., Majumdar, P.K., Bid, N.N. and Goswami, A.M., 1967, Standardisation of rootstocks of mango (Mangifera indica L.). II. Studies on the source, invigoration and etiolation on rooting of mango cuttings. J. Hort. Sci., 42: 82-87.

Muniswami, K.P., 1979, Cashew grafts under mist conditions. Cashew Causerie, 1: 18-20.

Nagabhushanam, S., 1983, A study on epicotyl grafting in cashew (Anacardium occidentale L.). Indian Cashew J., 1: 13-16.

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

Nagabhushanam, S. and Rao, P. V., 1978, Propagation trials in cashew (Anacardium occidentale L.). Indian Cashew J., 11: 9 - 11.

Naik, K.C., 1947, Mango propagation methods at fruit research station, Kodur. Indian Fmg., 8: 22-25.

Nair, C.S.J., 1989, Physiological and anatomical studies on rooting of sapota [Manilkara achras (Mill.) Fosbeg] air layers. Ph.D. Thesis, Univ. Agric. Sci., Bangalore.

Nalwadi, U.G. and Sulikeri, G.S., 1972, Effect of time of pregirdling and position of girdled cane on rooting of fig (Ficus carica L.) cuttings. Indian J. Hort.,29 : 283-285.

Nambiar, M.C., 1980, Annual report. All India Co-ordinated spices and cashew improvement project, 1978-79. Central Plantation Crops Research Institute, Kasaragod.

Nambiar, M.C., 1981, Annual report. All India Co-ordinated spices and cashew improvement project, 1979-80. Central Plantation Crops Research Institute, Kasaragod.

Nanda, K.K., 1979, Some studies on the physiology of adventitious root formation. Abstr No. 45. International Cashew Symposium, Cochin, .

Nanda, K.K. and Anand, V.K., 1970, Seasonal changes in auxin effects on rooting of stem cuttings of Populus nigra and its relationship with mobilization of starch. Physiol. Plant., 23: 99 - 101.

Nanda, K.K., Anand, V.K., Kochar, V.K. and Jain, M.K., 1971, Studies on physiology of rooting of stem cuttings. Indian Agric., 15: 49-57.

Nanda, K.K. and Kochar, V.K., 1985, Vegetative Propagation of Plants. Kalyani Publishers, New Delhi. pp. 124-125 and 162.

Nanda, K.K., Purohit, A.N., Bala, A. and Anand, V.K., 1968, Seasonal rooting response of stem cuttings of some forest tree species to auxins. Indian Forester, 94: 154-162.

Nazeem, P.A., Gopikumar, K. and Kumaran, K., 1984, Vegetative propagation in jack. Agric. Res. J. Kerala. 22: 149-154.

Nelson, N. and Somogyi, 1944, A photoelectric adoption of the Somogyi method for the determination of glucose. J. Biol. Chem., 163: 376.

Palaniswami, P.J., Hameed, A.S. and Vijayakumar, M., 1985, Vegetative propagation in cashew-work done at Virindhachalm. In cashew; Reseacch-Development. (ed. Rao E.V.V.B and Khan, H.H). Indian Soc. Plant. Crop. p 66-70.

Palaniswami, V. and Hammeed, A.S., 1976, Study of propagation of cashew (Anacardium occidentale L.) by patch budding. South Indian Hort., 23: 24-25.

Panse, V.G. and Sukhatme, P.V., 1967, Statistical Methods for Agricultural Workers, I.C.A.R., New Delhi.

Parasai, R.S., 1963, Propagation by side grafting and shield budding. Punjab Hort. J., 3: 180-184.

Patel, B.M. and Amin, R.S., 1981, Investigation into the best period for softwood grafting of mango in situ. South Indian Hort., 29: 90-94.

Patel, R.M., Patel, R.B. and Patel, M.P., 1989, Effect of growth regulators and polythene wrappers on rooting of air layers of guava. Bharatiya Krishi Anusandhan Patrika, 4: 145-148.

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

Patil, R.M. and Singh, M.P., 1982, Effect of growth regulators on rooting in air layering of mango. J.N.K.V.V. Res. J., 16:351-352.

Pearse, H.L., 1943, The effect of nutrition and phytohormones on the rooting of vine cuttings. Ann. Bot. (N.S.)., 7: 123-132.

Phadnis, N.A., 1971, Studies on the raising of cashew (Anacardium occidentale L.) clonal material in situ. Indian Cashew J. 8: 7-13.

Prasad, J., Rabbani, A. and Ram, R.A., 1988, Rooting of hardwood cuttings of guava (Psidium guajava L.) through bottom heat. Prog. Hort., 20: 20-23.

Ram, S. and Bist, L.D., 1982,, Studies on veneer grafting of mango in Tarai, Punjab Hort. J., 22: 64-71.

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

Rao, S.N., Swamy, G.S. and Sreeramulu, P., 1963, Growth regualtors in propagation of mango by air layering. Punjab Hort. J., 3: 175-179.

Rao, V.N.M., 1958, Studies on the vegetative propagation of cashew. I. Air-layering by cincturing, etiolation of shoots. Indian J. Agric. Sci., 28: 181-187.

Rao, V.N.M., 1967, Propagation practices. In: The Mango Handbook, I.C.A.R pp 32-69.

Reddy, C.V., 1986, Studies on propagation of mango (Mangifera indica L.) by softwood grafting. M.Sc. Thesis, Univ. Agric. Sci., Bangalore.

Reddy, C.V. and Melanta, K.R., 1988, Effect of age of rootstocks on the success of softwood grafting of mango in containers and in situ. South Indian Hort., 36: 143-145.

Reddy, C.V. and Melanta, K.R., 1989, Effect of different scion varieties on the success of softwood grafting mango in relation to phenols content. Mysore J. Agric. Sci., 23: 341-343.

Reid, M.E., 1924, Relation of kind of food reserves to regeneration of tomato plants. Bot. Gaz., 77: 103-120.

Reid, M.E.,1926, Growth of tomato cuttings in relation to stored carbohydrates and nitrogenous compounds. Amer. J. Bot., 44: 289-294.

Richards, A.V., 1950, A note on the cultivation of Singapore jack. Trop. Agric. Ceylon, 106 : 12-13.

*Sachs, J., 1864, Ueber die Neubildug von. advantivwurzelin dunch Dunkelheit, Verhandlingen des naturhistorischen vereines der precussischen Rheilande und westphalens, pp 110-111. Abst. in Bull. Soc. Bot. de. France, 12: Part 2, pp 221.

Sadhu, M.K. and Bose, S., 1980, Note on promotion of rooting in difficult to root fruit -tree cuttings with 2 -chloroethyl phosphonic acid and acetylene in the presence of auxins. Indian J. Agric. Sci., 50: 448-450.

Samaddar, H.N. and Yadav, P.S., 1970, A note on the vegetative propagation of cashewnut, avocado, Jackfruit and custard apple. South Indian Hort., 18: 47-49.

Sarada, C., Prabhakar Rao, V., Ravisankar, C. and Subba Rao, N., 1991, Studies on soft wood grafting in cashew. South Indian Hort., 39: 119-123.

Sawke, D.P., 1983, Effect of season and age of stock on success in epicotyl grafting in cashew. Cashew Causerie., 5: 18-19.

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

Schrader, A.L., 1925, The relation of chemical composition of regeneration of roots and tops in tomato cuttings. Proc. Amer. Soc. Hort. Sci., 21:187-194.

Sen, P.K., 1941, Annual Reports of fruit research station, Sabour, Bihar from 1939 to 40. Bihar, Patna.

Sen, P.K. and Basu, R.N., 1960, Effect of growth substances on root formation in cuttings of Justicia gendarussa L. as influenced by varying levels of nitrogen nutrition of stock plants. Indian J. Pl. Physiol., 3: 72-83.

Sen, P.K. Basu, R.N., Bose T.K. and Roychaudhuri, N., 1967, Conf. Trop. Fruit Propagation in the Far East, New Delhi.

Sen, P.K. and Bose, P.K., 1959, Effect of growth substances on rooting of jack fruit (Artocarpus heterophyllus Lam.) layers. Indian Agric., 3: 43-47.

Sen, P.K. and Chakraborty, S.P., 1972, Effect of growth regulators on airlayering of cashew. 3rd Int. Symp. Subtropical and Tropic. Hort. Soc., India.

Sen, P.K., Sen, S. and Basu, R.N., 1965, Studies on rooting of cuttings. V. Effects of auxin and organic nutrietns on rooting of cuttings of Justicia gendarussa L. taken from stock plant grown under various levels of nitrogen. Indian J. Pl. Physiol., 8: 36-39.

Sengupta, J.C. and Chattopadhyay, S.K., 1954, Hormones and rooting in intact plants and cuttings. Curr. Sci., 23: 294-295.

Shanmugavelu, K.G., 1987, Jackfruit In: Production Technology of Fruit Crops. SBA Pub. Calcutta. pp.411-418.

Shapiro, S., 1958, The role of light in the growth of root primordia in the stem of the Lombardy Poplar. In : The Physiology of Forest Trees ed. K.V. Thimann, Ronald Press. New York, pp. 445-465.

Sharfuddin, A. F.M. and Hussain, A., 1973, Effect of growth regulators and wrapping materials on the success of air layering in Litchi. Bangladesh Hort., 1: 45-51.

Shivanna, H., 1983, Studies on the effects of pretreatment and growth regulators on rooting of Jack (Artocarpus heterophyllus Lam.) by stem cuttings. M.Sc., Thesis, Univ. Agric. Sci., Bangalore.

Singh, J.R. and Srivastava, R.P., 1962, Studies in budding of mango. Indian J. Hort., 19: 130- 134.

Singh, L. and Khan, A.A., 1943, Mango budding in situ. Indian Fmg., 4: 199-200.

Singh, L.B., 1951, Propagating jackfruit, Artocarpus heterophyllus Lam. by air layering with hormones. Curr. Sci., 20: 102-103.

Singh, N.P. and Srivastava, R.P., 1979, Practical hints on veneer grafting in mango. Indian Hort., 23: 6 - 8.

Singh, N,P. and Srivastava, R.P. 1980, A new approach towards double grafting in mango. Curr. Sci., 49: 678-679.

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

Singh, P., Bajwa, M.S. and Singh, R., 1973, Propagation of ber (*Zizyphus mauritiana* Lam.) I. Effect of rooting and IBA on the stooling. *Plant Sci.*, 5: 137-139.

Singh, R.N., 1960, Studies in the differentiation and development of fruit buds in mango (*Mangifera indica* L.) IV. Periodical changes in the chemical composition of shoots and their relation with fruit bud differentiation. *Hort. Adv.*, 4: 48-80.

Singh, R.N., Rao, O.P. and Gorakh Singh, 1986, Modified veneer grafting in Langra mango. *Indian Hort.*, 31: 11-18.

Singh, S.M., Garner, R.J. and Hatcher, E.S.J., 1957, The influence of source and environment on the performance of apple leaf bud cuttings. *J. Hort. Sci.* 32: 248-253.

Singh, S.N., 1950, Effect of some hormones on the rootage of guava (*Psidium guajava* L.). *Sci. Cult.*, 16: 198-202.

Singh, S.N., 1955, Studies on the rootage of fruit plants in relation to hormones IV. *Artocarpus heterophyllus* Lam. *Sci. Cult.*, 20: 393-395.

Singh, S.N., Fozdar, B.S. and Singh, M., 1949, Vegetative reproduction of jack fruit. *Allahabad Fmr.*, 23: 93-97.

Singh, U.R., Pandey, J.C., Upadhyay, N.P. and Prasad, R.S., 1982, Propagation of jackfruit by budding. *Punjab Hort. J.*, 22: 103 -105.

Soepadmo, E., 1991, *Artocarpus heterophyllus* Lam. In:*Plant Resources of Southeast Asia No.2. Edible Fruits and Nuts*, E.W.M. Verheij and R.E. Coronel, eds., 86-91. Wageningen, The Netherlands.

Sonwalkar, M.S., 1951, A study of jackfruit seeds. *Indian J. Hort.*, 8: 27-30.

Srivastava, R.P., 1989, Propagation of mango by newer techniques. Acta Hortic ., 231: 266-267.

Stoltz, L.P., 1965, Physiological study of the effect of girdling in rooting. Dis. Abstr., 26: 1739-1740.

Stoltz, L.P. and Hess, C.E., 1966a, The effect of girdling upon root initiation I. Carbohydrates and amino acids. Proc. Amer. Soc. Hort. Sci., 89: 734-743.

Stoltz, L.P. and Hess, C.E., 1966b, The effect of girdling upon root initiation II. Auxin and rooting cofactors. Proc. Amer. Soc. Hort. Sci., 89:744-751.

Stuart, N.W., 1938, Nitrogen and carbohydrate metabolism of kidney bean cuttings as affected by treatment with Indole acetic acid. Bot. Gaz., 100: 298-311.

Sulladamath, U.V. and Kololgi, S.D., 1959, Synergistic influence of IBA and NAA on rooting of air layers of chiku var. Kalipatti. South Indian Hort., 17: 14 - 17.

*Sumagang, M.G., Gloria. R.P. and De Guzman, R.A., 1990, The influence of varied rootstock/scion strains on the performance of grafted jackfruit. Paper presented at the second DA-BAR National Research Symposium. July 23-24,. 1990.

Suryanarayana, V. and Rao, K.V., 1982, Effect of growth regulators in air layering of mango, lemon and ber. Proc. Natl. Seminar on Pl. Propagation. B.C.K.V., Kalyani. pp. 69-70.

Swaminath, M.H., Ravindran, D.S. and Mumtaz, J, 1990, Propagation of Tamarindus indica through stem cutting. Myforest, 26: 207-208.

Swamy, K.R.M., Singh, R. and Mohan, E., 1990, Correlation of success in soft wood grafting of cashew with weather parameters. South Indian Hort.,388: 297-300.

Tayde, G.S., Kulwal, L.V. and Das, P.R., 1988, Studies on in situ grafting of mango by different methods under Akola conditions. PKV Res. J., 12: 31-36.

Taylor, G.G. and Odom, R.E., 1970, Some biochemical compounds associated with rooting of Carya illinoensis stem cutting. J. Amer. Soc. Hort. Sci., 95: 146-151.

Teaotia, S.S., 1963, Budding in mango. Kanpur Agric. Coll. J., 23: 49-50.

Teaotia, S.S., Dayal, K. and Asthana, M.P., 1963, Propagation of jackfruit by budding. Sci. Cult., 29: 46-47.

Teaotia, S.S. and Pandey, I.C., 1961, Effect of growth substances on rooting of guava stem cuttings. Sci. Cult., 27: 442 - 444.

Torres, J.P., 1949, Splice grafting of mango. Phil. J. Agric. 14: 247-255.

Tukey, H.B. and Green, E.L., 1934, Gradient composition of rose shoots from tip to base. Pl. Physiol., 9: 157-164.

*Tureckaja, R.H. and Kof, E.M., 1965, Dynamic changes in the content of auxin and inhibitors in green and etiolated bean cuttings during the process of root formation. Doklady, Akad. Nauk, Arm. S.S.S.R., 164: 219-222.

Ughreja, P.P. and Chauhan, K.S., 1983, Effect of growth regulators on rooting in air-layering of Ber. Haryana J. Hort. Sci., 12: 162-164.

Uthaiah, B.C., 1975, Studies on propagation of sapota (Achras sapota L.) by air layering. M.Sc., Thesis. Univ. Agric. Sci., Bangalore.

Valsalakumari, P.K., Vidyachandran, K.K. and Damaodaran, V.K., 1985, A comparative study of different methods of vegetative propagation of cashew. Acta Hortic., 108: 289.

Verma, A.N., Srivastava, D.C.,Ram, K. and Sharma, R.K., 1970, Effect of plant regulator on air layering in mango, guava, and Kagzilime. Allahabad Fmr., 44: 139-142.

Vietez, A.M., Ballester, A., Garcia, M.T. and Vietez, E., 1980, Starch depletion and anatomical changes during the rooting of Castanea sativa Mill. Cuttings. Sci. Cult., 13: 261-266.

Vijayakumar, N., 1972, Studies on the propagation of guava (Psidium guajava L.) by cuttings. Ph.D. Thesis., Univ. Udaipur.

Vijayakumar, N., Shivashankar, G. and Nache Gowda, V., 1991, Propagation of jack (Artocarpus heterophyllus Lam.) by green wood cleft grafting. Crop Res., 4: 169-170.

*Wally, Y.A., El-Hamady, M.M., Boulos, S.T. and Atu-Amara, N.M., 1981, Rooting experiments on guava using hardwood stem cuttings. Egypt J. Hort., 8: 77-86.

Went, F.W., 1938, Specific factors other than auxin affecting growth and root formation. Plant Physiol., 13 55-80.

Yogananda, B.D., 1989, Studies on propagation of cashew (Anacardium occidentale L.) in situ soft wood grafting. M.Sc., Thesis. Univ.Agric. Sci., Bangalore.

*Zakura, D.A., 1974, Changes in some physiological processes in relation to the regeneration of grape vine cuttings. Viprosy introduktssi Rast Izelen Strva. 8: 187-192.

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* Original not seen

APPENDIX

APPENDIX I

Meteorological data as recorded at the Horticultural Research Station, G.K.V.K., University of Agricultural Sciences, Bangalore, for the period from January 1990 to December 1992

Month	Mean Temperature (°C)						Sunshine (hr/day)			Mean R.H. (%)			Total Rainfall (mm)		
	1990		1991		1992										
	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	1990	1991	1992	1990	1991	1992	1990	1991	1992
January	27.8	12.1	28.4	15.4	25.8	12.4	8.9	9.4	8.3	65	63	61	1.4	1.0	6.2
February	30.3	14.2	30.2	15.7	29.2	16.4	10.4	10.5	9.5	63	53	62	-	-	-
March	31.9	18.0	33.3	19.6	33.2	16.2	8.6	7.7	10.3	55	50	39	5.8	3.6	-
April	34.6	20.5	33.2	20.8	34.0	19.6	8.9	8.9	9.3	51	55	50	2.6	8.8	10.0
May	30.8	19.2	33.5	20.5	32.2	20.3	6.9	9.3	6.1	64	60	64	116.6	89.6	167.7
June	28.9	17.4	28.0	18.1	25.7	19.6	5.3	4.3	5.7	67	71	76	48.0	212.9	167.6
July	28.0	17.1	27.3	17.0	26.9	18.8	4.7	3.9	4.5	69	72	77	32.2	21.1	135.8
August	26.5	17.2	25.9	18.0	27.1	18.9	4.3	3.5	5.3	75	77	75	79.7	152.2	98.6
September	28.1	19.4	28.7	19.0	27.2	18.6	5.6	8.1	5.1	68	70	74	92.6	60.0	94.2
October	27.4	20.2	26.7	17.1	27.3	18.3	5.0	6.3	5.9	74	77	72	111.9	540.9	107.6
November	26.0	17.7	25.5	16.9	26.5	17.5	6.3	5.4	6.1	67	77	71	32.2	152.2	70.8
December	26.1	14.8	26.7	13.1	26.2	17.1	8.5	5.1	6.1	64	69	64	4.8	-	-