STANDARDISATION OF VEGETATIVE PROPAGATION TECHNIQUE IN CASHEW WITH A VIEW TO REDUCE THE POST-SEPARATION MORTALITY OF AIR-LAYERS

By

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THESIS

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DECLARATION

I hereby declare that this thesis entitled "Standardisation of vegetative propagation technique in cashew with a view to reduce the post-separation mortality of air-layers" is a bonafide record of research work done by me during the course of research and the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

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Vellanikkara,
11th September, 1978

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Certified that this thesis is a record of research work done independently by Kumari. P.K.Valsalakumari under my guidance and supervision and that it has not previously formed the basis for the award of any degree, followship or associateship to her.

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INTRODUCTION

Cashew, Anacardium occidentale Linn belonging to the family Anacardiaceae has a long history as a useful plant but only in the present century has it become an important tropical tree crop. It was introduced into India in the 16th century and in spite of the neglected conditions under which it is grown, it has established itself as a major crop on the west and east coasts of India.

Cashewnut is perhaps the most versatile and remarkable of all nuts. It is rich in nutrients, crisp and tasty and is consumed in more than one form. It contains a high percentage of protein and is rich in vitamins and minerals and has a high calorific value. The cashewnut shell liquid, the testa of the kernel and the cashew apple are important by-products which are not fully exploited at present. Cashew apple is a juicy fruit and a rich source of vitamin C which is not lost even after fermentation. The juice has some medicinal properties and has been traditionally used as a diuretic. A popular liquor called 'Feni' is prepared from cashew apple juice in Goa. It has been demonstrated that cashew apple can be used for the preparation of squashes, jams, jellies and chutneys.

Cashew was introduced into India in the 16th century from Brazil, its home country. Now its cultivation is concentrated in the states of Kerala, Tamil Nadu, Mysore,

Andhra Pradesh and Maharashtra. It is also grown in certain areas of Orissa, West Bengal and Assam. In Kerala, where the cultivation and processing of cashewnut are largely concentrated, it occupies a total area of 1,05,940 ha. The processing industry in Kerala gives direct employment to about a lakh and a half persons. The export of cashew kernel and cashew shell liquid earns over 100 crores of rupees in foreign exchange annualy.

However, the production of raw nut within the state is only about 1.17 lakh tonnes, which is sufficient to meet about a third of the requirements of the processing industry. The remaining quantity was hitherto met from the import of raw nut from the African countries at considerable cost. In recent years, this source of supply of raw nuts has also become difficult due to the establishment of large, mechanical processing factories in those countries. Therefore, it has become vitally important to increase the internal production of raw nuts to the level of self sufficiency within the shortest possible time.

In spite of its agricultural, industrial and commercial importance, no attention was paid until recently on the improvement of this crop. Being a crop in which a high degree of cross pollination occurs in nature, cashew trees exhibit a high degree of variability in economic characters such as yield, size of nuts, shelling percentage etc.

A survey conducted in 1961-63 by the Indian Agricultural Research Statistics on the area and production of cashew in Kerala showed that nearly 73 per cent of the cashew trees gave a yield below 3 kg.of nuts, while 2.5 per cent yielded over 14 kg. This large variability in the productivity of the trees in the existing plantations is indicative of the poor genetic stock.

The main reason for the above situation is that the existing plantations were almost entirely raised from seed. Researches carried out in the past 25 years have identified superior genotypes even in the existing population. But there has not been a systematic programme to multiply these types. Some superior hybrids have also been evolved in the research stations; but these also are not available on a large scale due to the lack of an effective programme of multiplication. Identification of better types by selection or breeding and effective method of multiplication of the selected types are the strategy to be adopted in any scheme of cashew improvement.

Standardisation of vegetative methods of propagation has been taken up from the earliest days of cashewnut research in our country. Approach grafting, side grafting, budding and air-layering have been reported to be successful. Trials have also shown that plants raised from layers and grafts come to bearing earlier than seedlings and give significantly higher yields as compared to seedling trees.

With all its limitations, air-layering is regarded as the most satisfactory method of vegetative propagation of cashew at least in Kerala. It has certain advantages over the other methods of vegetative propagation practised in cashew. It is the simplest and the cheapest method and eliminates root-stock influence. But the main draw-back of this method is the high degree of post-separation mortality after planting in the main field. If the post-separation mortality of the air-layers can be reduced, the main draw back pointed out against this method can be overcome. The present studies were undertaken with the main objective of finding out some means of reducing the post-separation mortality of cashew air-layers by adopting suitable techniques like the time of layering in relation to shoot growth, use of plant growth regulators and post-separation management.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Cashew being a highly cross-pollinated crop, a high degree of variability has been noticed in the seedling progenies. Vegetative propagation is an important method of solving this problem and trials to standardise in effective method of vegetative propagation for cashew have attracted the attention of a number of research workers in the past. A brief review of the past work done in this field is given below.

Marked variations among progenies of individual trees, occur in shape, size and weight of nuts, and shape, size, and colour of apple which is to be expected in a heterozygous, cross-pollinated and seed-propagated population. Naik (1949) reported that cashew trees differed in their fruiting behaviour, nut size and shape. Rao and Rao (1953) reported that in one and the same plantation of cashew, wide variations existed among trees in respect of the yield of nuts, ranging from less than ten pounds to as much as 40 pounds, Rao and Hassan (1956) observed wide variations in weight, shelling percentage and some other characters in 100 samples of cashew seeds collected from India and other countries and emphasised the need for ensuring uniformity of planting materials as well as increasing the plantation efficiency by making comprehensive selection of desirable types and building up of

their clonal strains by vegetative propagation methods. Mukherjee (1956) while undertaking a survey of cashew gardens in West Bengal observed that there was wide range of variation in the types that were grown. Plants differed considerably in their nut size and bearing capacity. In a study conducted at the Agricultural Research Station, Nileswar involving 1000 adult seedling trees ranging in age from 25 to 35 years it was found that the trees varied considerably in most of the economic characters viz; yield, apple and nut characters. The colour of apple varied from shades of yellow to pink and their combination; shape ranged from oblong, fusiform to ovate and size, from small, medium and big. Variations in size and shape of nuts were also common. (Aiyadurai and Koyamu, 1957). Northwood (1967) also had reported wide variations in the yield of cashew trees. Damodaran (1977) while studying the variability in the F1 population of four parental combinations in cashew found considerable variation in progenies of each cross with regard to mean yield, weight of 100 nuts, mean weight of apple, shelling percentage, size, colour and shape of apples.

1. <u>Air-layering in Cashew</u>

In cashew air layering had been found to be the easiest and cheapest method of vegetative propagation.

Trials conducted at Kodur (Naik, 1948) showed that layering and inarching gave best results in the propagation of cashew; though side grafting, inarching, patch and shield buddings were also possible. Naik reported even upto 100 per cent success in layering cashew. But at Taliparamba only 45 per cent success could be obtained in the trials conducted (Anon, 1954). Hayes (1957) described air-layering as the best method of vegetative propagation of cashew. Khan (1957) found air-layering to be an easy way of multiplying selected cashew trees and that plants raised by layering came into bearing in twenty months as compared to four years in the case of seedling trees. Rao (1958) in his studies conducted at the cashewnut Research Station, Ullal, obtained 100 per cent success in November, using one year old shoots. There were reports of the cashew layers excelling seedlings in growth, flowering and fruiting (Nair and John, 1958) and having better root and shoot systems as compared with the seedlings of the same age (Damodaran, 1968).

Success in air-layering of cashew was also reported by Aiyadurai (1968), Kurup and Viswanathan (1970) and Muthappa Rai (1970).

1.1. Time of air-layering

Seasonal variations in the percentage of rooting under different climatic conditions in India were reported by Rao (1958) and Aiyadurai (1966). Maximum success in air-layering in Ullal, India was obtained during the hot weather period when the trees were in full flush. The time of separation of layers varied from 51 days in January to 103 days in June. But in Tanzania, the rainy season was best for air layering when the trees were not in flower (Northwood, 1964). Layers made from October to April matured faster and in greater numbers than those made at other times.

However, in both cases best rooting was obtained when the trees were in the peak period of the vegetative growth. Observations in India (Aiyadurai, 1966) showed that nonflowered shoots had significantly higher rooting percentages than flowered shoots. This observation confirmed Argles (1969) hypothesis that the vegetative growth phase and not rainfall or presence or absence of flowers and fruits that determined the success of air-layering. The available information also indicated that vegetative propagation was most successful when temperature ranges were seasonably high and moisture stress was not severe.

1.2. Selection of shoots

The age of the layered shoot as well as the age of the tree on which layering was done were found to have considerable influence on the capacity to root. Rooting decreased with increasing age of the plant from the seed. Such observations had been made by Cheesman and Spencer (1936) as quoted by Rao (1958). The only advantage of having bearing trees for propagation is that there is less opportunity to make mistakes in the identity of the desired varieties. In Cashew, Rao and Rao (1957) observed that the age of the parent tree had some influence on the rooting of air-layers. Eventhough there was no difference in rooting between plants of one year and 10 year of age, the shoots rooted earlier in 10 year old trees than those which were 20 years old. In one year old seedlings, rooting commenced within the shortest period of 22 days rendering it possible to separate the layers from the parent within 35 days. However, 10 years were long enough to judge the performance of a cashew tree and the suggested the choice of six to ten year old trees as scion material in preference to old trees. Regarding the age of the shoot for air-layering, he could obtain a high percentage of success with one year old shoots them with current seasons shoots.

While Rao (1957) and Aiyadurai (1968) recommended pencil thick shoots for air-layering, reports from Kottarakkara showed that thicker shoots produced more vigorous plants during the early years.

1.3. Rooting medium and wrapping material

The rooting medium must provide sufficient moisture and aeration and must be free from disease carrying microbes. The rooting medium has effect on the percentage of rooting and on the nature of roots formed.

Any loose material which would afford sufficient aeration and room for unrestrained development of rootlets could be used as the rooting medium for cashew air-layering (Rao and Hassan, 1957). Among eight different media tried by them wood shavings, coconut coir husk, coir husk dust and sand proved to be the best; while material like a mixture of red earth and leaf mould which developed a sticky condition proved unsuitable. A mixture of 50 per cent cowdung and 50 per cent sand was found to be the most suitable medium for raising air-layers in Assam. (Aiyadurai, 1966). But at the cashew research Station, Kottarakkara, it was found that the different rooting media viz; sand and saw dust, wood shavings, vermiculite (coarse) and vermiculite (fine) did not have any significant difference in rooting. (Aiyadurai, 1966).

Recent attempts in propagation through air-layering have largely been done using polythene films which are available in different gauges of thickness. Singh (1952) working on litchi and jack had reported a high degree of success in air-layering of shoots by the use of polythene wrapper. Wyman (1953) had mentioned the special properties of polythene such as its inertness, durability, toughness and impearmeability to moisture, and to retain the moisture around the layer, and at the same time allowing free passage of the gases of respiration. Rao (1958) reported that in air-layers of cashew polythene film of 150 gauge as a wrapper was very efficacious and economical as compared to banana sheath which was unsuitable. The use of polythene film eliminated the cumbersome and costly procedure of hand-watering of layered shoots and also assured the maintenance of a continuously moist condition on the treated shoot. Later Rao and Hassan (1957) reported that polythene film of 100 gauge was as effective or even better than 150 gauge film and was more economical also. Aiyadurai (1966) while reviewing the research on spices and cashewnut stated that polythene film of 200 gauge for covering was found to be better for air-layering from the point of better rooting and safety from damage by birds and insects.

2. Establishment of air layers

The problem of establishing layered plants after their separation from the parent trees had been a difficult problem. High mortality of separated cashew air-layers in the nursery had been observed by Rao (1958) in trials conducted at Mangalore though the method was the cheapest and the easiest. Mukherjee and Majumder (1973) and Anon. (1978) stated that due to the mortality of layers after separation from the mother tree and during the process of planting in the main field, air-layers had not found favour with cashew growers.

The low percentage of survival of air-layers in mango was also reported. Ledin and Reuhle (1954) in Florida tried to propagate mango by air-layering but the roots were so brittle that few plants survived after planting. However, Srivastava (1960) could obtain 100 per cent rooting and 100 per cent survival for mango air-layers treated with 10,000 ppm. NAA, IBA and a mixture of NAA and IBA, while the control layers had a few small and thin roots.

Despite accelerated and substantial rooting with the use of a mixture of IBA and NAA at 1000 ppm the final success in the field was only 5 per cent in sapota air-layers (Singh *et. al.*, 1962). The high mortality seemed to be due to inadequate development of root system both in nature and extent.

Observations in India showed that procuring the layered twigs by removing all its leaves about a week before the separation of the twig and transplanting immediately after separation from the parent tree improved plant establishment. Procuring probably helped to activate the growing bud. The observations conformed to the view expressed by Argles (1969) that when the top-root ratio was at its lowest point the trees were in the best condition to survive transplanting, when the terminal buds were just starting to swell preparatory to making a new growth flush.

Nelson (1953) recommended placing of the rooted air-layers under mist for several weeks, followed by gradual hardening of, as the most satisfactory method of reducing mortality. Mist technique for rooting leafy cuttings was reported by Raines (1940), Went (1940), Grossand (1944), Stoutemyer (1945), Bose and Mandal (1972) and Singh and Dhar (1977). Such sprays maintained a film of water on the leaves, which not only resulted in a high relative humidity surrounding the leaf, but also lowered the air and leaf temperature-all factors tending to lower the transpiration rate (Hartmann and Kester, 1972).

3. Effect of Plant growth regulators on rooting and establishment of air-layers

The use of growth regulators has been reported to be helpful in the propagation of some plants which are normally difficult to root. Beneficial effects of growth regulators on the rooting of cashew air-layers have been reported by some workers. Rao and Hassan (1957) reported from Mangalore that the application of growth regulating substances such as seradix A on cashew air-layers resulted in larger number of roots and better rooting in the months of June and July when the rooting was poor without them. Chhonkar (1967) could obtain 88 per cent success with 75 ppm IBA in lanolin paste on cashew air-layers. The average number of roots, their length and diameter were also greater in the treated shoots as compared to that of the un-treated ones. Acharya and Dash (1972) obtained 84.6 per cent success in marcotting with IBA 300 ppm. compared with 46.2 per cent in un-treated marcots, which also gave the longest roots, the greatest number of roots and the shortest period to root emergence. Results with 200 ppm. IBA were statistically good, but NAA was not effective. Trials conducted at the cashew Research Station, Kottarakkara showed that the application of Indole acetic acid in concentration of 250 ppm. in lanolin to the layering twigs

increased the percentage of rooting and the subsequent sprouting of the separated layers. Both the number of roots and length of roots per layer were found to increase as a result of the treatment.

The beneficial effects of plant growth regulators on the rooting and establishment of mango air-layers have been reported by several workers. Singh (1954) obtained better results with NAA on mango air-layers. Srivastava (1960) reported that 10,000 ppm. NAA brought out 100 per cent rooting and survival and was most effective in terms of number and length of roots. Rao et.al. (1963) obtained optimum production of rooted air-layers by the use of a mixture of IAA, IBA, PA and NAA at 0.25 per cent or 0.5 per cent, each in lanolin paste. Sen and Bose (1967) found IBA to have a better effect on rooting of mango air-layers. Chhonkar and Singh (1972) reported IBA 5000 ppm. was markedly more effective than IAA in promoting the rooting and establishment of mango marcots.

Amongst the root promoting chemicals so far tried, IBA was found to be the most effective (Basu et.al., 1977). Regarding the root promoting effects of IBA in air-layering, Sen and Bose (1966) observed that the increase in rooting

under IBA was associated with a greater depletion of sugars from the root promoting region of mango air-layers. Basu et.al.(1967, 1972) suggested that the root promoting effect of IBA was related to the metabolism of carbohydrates and proteins. Bose et.al.(1973) noted that rooting co-factor activity in Bougainvillea and Hibiscus cuttings decreased during root formation and the reduction was more in cuttings treated with IBA. According to Nanda (1975), auxins seemed to play a multifarious role in rooting, those concerned with the division of meristematic cells, in the elongation, in the differentiation of cambial initials into root primordia and most of all in the mobilisation of reserve food materials caused by enhancing the activity of the hydrolyzing enzymes and passing the metabolized sugars to the site of root initiation. Basu et.al.(1977) suggested involvement of phenols, ferulic acid, p-hydroxy benzoic acid, p-coumaric acid and abscisic acid, as noted by their increase during the initial phase of rooting and their fall in the later phases of root formation of the mango air-layers. They observed that the levels of accumulation of the above noted substances, especially abscisic acid and the their extent of utilization were more under IBA which significantly promoted rooting.

4. Growth studies in relation to rooting

In cashew rooting of the layers had been found to be varying in different months of the year. (Rao, 1958, Aiyadurai, 1968). Their observation that the two months of June and July were unsuitable for air-layering was attributed to the fact that the trees were completely inactive during that period. The seasonal behaviour of rooting of air-layers seemed to be related to the growth activity of the trees.

The importance of growth studies in fruit plants for suggesting suitable cultural practices (Zelanki, 1943) and in understanding the problems of flowering and fruiting (Patridge, 1919; Barnard, 1932; Mc Munn, 1939) had been emphasised by various workers. Growth studies in mango and citrus had been made in great detail. In mango, the time of growth was believed to have a profound influence on the extent of flowering and fruiting in the succeeding season. (Sen and Mallik, 1941; Naik and Mohan Rao, 1942). Growth features in mango had also been studied by Nakasone (1955) in Hawaii, Krishnamurthy et.al. (1961) in India and Holdsworth (1963) in Ghana.

Maximum success in air-layering of cashew were reported to be obtained in Ullal, India (Rao, 1958) and in Tanzania (Northwood, 1964) when the trees were in the peak period of

the vegetative growth phase. Observations in India (Aiyadurai, 1966) showed that non flowering shoots had significantly higher rooting percentages than flowering shoots. These observations led Argles (1969) to suggest that the vegetative growth phase, determined the success of air-layering to a great extent.

The pattern of growth of a bearing tree consists of a generative flower flush and a vegetative flush. The vegetative flush consisting of lateral shoots, always develops soon after the main fruit crop has matured. Flowering is terminal and is universally preceeded by the vegetative flush.

Rao (1956) observed two major flower flushes in Cashew, one in November and the other in May. Dasarathi (1958) as quoted by Nambiar (1977) observed two main flushes in December and May and another minor flush in September resulting in off season flowering in some trees. Galang and Lazo (1935) recognized three corresponding flushes, in November, May and July in the Philippines. Generally in a bearing tree, two or three peak periods of growth are usually observed, eventhough under favourable conditions of soil and moisture and other environmental factors, as in parts

of Tanzania, stray shoot growth might occur almost every month (Argles, 1969).

Many instances could be cited of the influence of the time of taking cuttings on rooting in relation to the condition of the tree from which cuttings were taken. This is related to the physiological condition of the tree rather than the calendar date. On the basis of seasonal rooting trials, the plant species were classified as easy-difficult and shy-to-root-types (Nanda et.al., 1968; Nanda, 1970). Stem cuttings of easy to root species like Populus nigra, Hibiscus rosa-sinensis and Ficus infectoria exhibited rhythmical changes in rooting response which were governed by morpho-physiological factors, primarily related to winter dormancy (Nanda, 1970; Nanda and Anand, 1970). During that period the branches were devoid of leaves, the axillary buds were dormant and the cambial cells were at their lowest activity. The scarce and delayed rooting was followed by a phase of vigorous rooting that started with the renovation of growth activity in February to March, coinciding with the period of cambial activity.

The effectiveness of even exogenously applied auxins changed with the season and were also governed by morpho-

physiological factors related to bud dormancy. Nanda et. al. (1968) and Adarsh Bala et. al. (1969) reported that control cuttings of Dalbergia sissoo and Populus nigra rooted well in May to June when the plants were in an active phase of growth. The level of endogenous auxin was high due to high meristematic activity. Rooting at that time was more or less completely inhibited by higher concentration of all auxins probably because the concentration of endogenous auxin was raised to supra-optimal inhibitory level. The inhibitory effect of higher concentration of auxin on rooting decreased gradually in subsequent plantings. This was attributed to the decreased production of auxin with decreasing temperature, causing a slow down in meristematic activity. At that time the exogenously applied auxin raised the concentration to an optimal level causing profuse rooting (Nanda, 1970).

The rate and magnitude of polar transport of auxin va varied with the season and caused seasonal changes in rooting response of stem cuttings (Nanda, 1975).

The content of starch also exhibited rhythmical pattern coinciding with strong and weak phases of rooting during the annual cycles of growth (Nanda, 1975). The disappearance of starch was closely associted with the activity of hydrolysing enzymes causing mobilization of reserve food materials. The hydrolitic activity was high when rooting was profuse and also in auxin treated cuttings (Adarsh Bala et.al., 1969); Nanda, et.al. (1970).

5. Methods of vegetative propagation other than layering in cashew.

Vegetative propagation methods other than layering had been reported in cashew by various workers. Naik (1948) reported inarching, patch and shield budding to be successful in cashew. Hayes (1957) reported that inarching, side grafting and patch and shield budding were all possible with cashew. Rao and Rao (1957) reported from Mangalore that inarching by the conventional method gave an average success of 60 per cent with a highest percentage in November. They also stated that using rootstocks potted in alkathene wrapping the cost of inarching could be reduced and the season suitable for this work could be extended. The high percentage of casualities in transplanting cashew seedlings (Hassan and Rao, 1957)

was also avoided by this method. Eleven month old seedings were used and the highest percentage of success was obtained from January to May. Rao and Rao (1958) also reported the nurse grafted Y cutting method which was a combination of air-layering and inarching was a success with cashew, if carried out between February and May.

Different methods of grafting with different ages of stocks and scions and also at different times had been reported by various workers.

Phadnis (1971) from Ahammendnagar reported that veneer grafting was successful on seedlings not more than five months old. It seemed that aged seedlings were not ideally suited for veneer grafting and they could be utilized for side grafting (Anon, 1978).

Wedge grafting on 21 days old seedlings using thin procured terminal current season's shoot as scions were reported by Bhandary et. al. (1974) from Bangalore. Bud grafting of cashews in the nursery on seedlings of two and a half month old with a success of 90 per cent was reported by Bhattee (1977) from Goa.

There are reports from other countries of successful grafting of cashews. De Albergaria (1967) had observed that

whip grafting on 5 - 12 months old seedlings with current seasons shoots was a success in Mozambique. Tip grafting (Lefebvere, 1971) on three month old seedlings with a success of over 90 per cent and splice and cleft grafting (Ascenso and Milheiro, 1973) with a success of 100 per cent with stocks and scions of 3 to 5 mm diameter were also reported from Mozambique.

High percentage of success had been reported by veneer grafting and side grafting at Vengurla, Orissa and to a lesser extent at Vridhachalam. Studies at Kerala Agricultural University, Mannuthy showed 60 - 80 per cent success by side grafting in July-August under nursery conditions. Propagational trials conducted at Bapatla, Andhra Pradesh gave encouraging results with veneer grafting. It was found that July and August were quite congenial to take up grafting on six month old seedlings (Anon, 1978).

Chip budding with 88 per cent success was reported from Krishnanagar by Samaddar and Yadav (1970). Phadnis (1971) reported budding in cashew was successful when done from September to November in Ahammednagar. Palaniswamy et. al. (1976) reported 71 per cent success by patch budding in July. In March, April, September and October 50 - 58 per cent success

was achieved at Vridhachalam. In trials conducted at cashew Research Station, Bapatla patch budding done on both tender and aged seedlings in cashew had not given any success (Anon, 1978).

MATERIALS AND METHODS

MATERIALS AND METHODS

The investigations were carried out on four year old cashew trees at the main campus at Vellanikkara of the Kerala Agricultural University. Representative samples were taken for the different studies and the data were collected during the period February 1977 to June 1978. The methods adopted for different investigations are briefly described below.

1. Rooting of air-layers in relation to growth flushes

The studies were initiated on the Ist of February 1977. Five trees were selected and on each of the selected tree, 10 uniform shoots were tagged for air-layering. The selected shoots were about nine months old and were pencil-thick. The shoots were distributed on all sides of the trees and five of them were flowered shoots and the remaining five were non-flowered during that season. This grouping into flowering and non-flowering shoots were done only for the layers prepared in December, January, February and March.

The air-layering method consisted of removing a ring of bark of 1 to 1.5 cm. in width at a point about 15 to 25 cm. from the tip and tying a piece of gunny thread in the centre of the ring to prevent the cut ends of the bark from joining together. A mixture of moistened saw dust and sand in the propagation of 2:1 was placed around the ringed portion in

the form of a ball to serve as the rooting medium. It was then tightly wrapped with a polythene film of 150 guage and 20 cm. x 15 cm. size and the ends were secured tightly with gunny threads. Observations on rooting were recorded at regular intervals. At the time of layering an eye-estimate of the percentage of shoots in flush on the tree was recorded.

The trial was repeated at fortnightly intervals.

Since the time of rooting varied with each batch of operation no definite interval could be determined for the time of separation. When the roots could be felt and some could be seen piercing the polythene film, it was taken as indication for the severence of the air-layered shoot from the parent. In order to lessen the shock of sudden serverence each rooted shoot was given an initial V - shaped cut to a depth of one third thickness of the stem, just below the polythene wrapper. The rooted twigs were separated two weeks after the first cut. About ¾th portion of the leaf laminae of the rooted shoots were cut off, one week before separation, in order to reduce moisture loss by transpiration from the leaf surface and to activate the dormant buds.

2. Establishment of separated layers

The first batch of rooted layers were separated in May, 1977. They were divided into four groups and each group was subjected to the following methods of planting.

The polythene wrappers were removed from the first group of air-layers and the rooting medium was carefully washed away and the layers were kept in beakers containing. nutrient solution (Hewitt, 1963) for a week. The solution was changed everyday. A week later they were planted in polythene bags filled with sand, soil and compost in 1:1:1 proportion. Since the plants wilted and dried up soon, this treatment was not repeated in subsequent batches.

The second group of rooted layers were planted in polythene bags of 20 cm. x 15 cm. size with the ball of rooting medium intact and using the same potting mixture as above. The plants were watered everyday with nutrient solution (Hewitt, 1963) for a week.

The third group of rooted layers were planted in polythene bags with the same medium as mentioned above and regularly watered.

The last group of layered plants were directly planted in the field in small pits with a spacing of 1 M. x 1 M.

Observations were taken at fortnightly intervals for the number of layers sprouted and established.

The separation and planting of air-layers were repeated in every month in order to study the survival percentage in different months of the year. This was not done in December, 1977 since rooted layers were not available then.

Layers prepared on 15.3.1978 were separated on 25.5.78. They were divided into two groups and planted in polythene bags. One group was kept in a closed polythene chamber which was made by spreading polythene film over a wooden frame and tightly sealed the edges of the film to the ground with soil and the other group was kept in the open under shade. Hewitt's nutrient solution was supplied to half of the number of plants in each group. Fine sprays of water were allowed in the polythene chamber thrice a day with a knapsack sprayer.

3. Effect of Growth Regulators on rooting and establishment of air-layers

The effect of some growth regulators on the rooting and establishment of air-layers was studied.

Four plant growth regulators, Viz. IAA, IBA, NAA and Seradix B-2 in different concentrations were tried to find out their effect on rooting and establishment of the layers. The different concentrations were obtained by mixing them with talc.

Mature, pencil thick shoots of nine months to one year old and of uniform size were selected as for the ordinary method of air-layering. The treatments consisted of 250 and 500 ppm. each of IAA, IBA, NAA and Seradix B-2 (a proprietary product of M/S May & Baker). The control treatment consisted

of shoots air-layered without plant growth regulators.

Twenty five shoots were taken under each treatment, made up of five shoots on each tree with five trees thus adopting a randomized block design. The required quantities of plant growth regulators were dissolved in a small quantity of alcohol and thoroughly mixed with the required quantities of talc and dried to room temperature before application. The plant growth regulator in talc and sermidix B-2 were applied at the upper end of the ringed portion after moistening the portion where the material was to be applied. The portion was then covered with the rooting medium and polythene film as for the ordinary method of air-layering.

The rooted shoots were separated in two batches, first on 15.2.1978 and then on 15.3.78. Observations were recorded on the layered plants separated in the first batch for the percentage of rooting, and number and length of primary roots. The second batch was planted in polythene bags. They were divided into two groups and plants in one group were supplied with nutrient solution (Hewitt, 1963) for a week. Observations were recorded on the establishment of layers at fortnightly intervals.

4. <u>Growth cycles in relation to rooting and establishment</u>

The trees on which layering had been done were also

used for studying the growth cycles. On each tree 10 dormant shoots were tagged at random on the 1st of February, 1977. The shoots were selected on all sides of the tree. Thus altogether 50 shoots were selected on the five trees. As far as possible shoots of the same length and size were tagged. Measurements of extension growth made by these shoots were recorded at fortnightly intervals.

The mean extension growth made in each month was found out and from that the percentage of growth were calculated which was then correlated with the percentage of rooting and percentage of establishment in different months to see if there was any relationship between the shoot growth cycles of the parent tree and the rooting and establishment of layered shoots.

5. Wedge grafting

Wedge grafting was tried on eight month old cashew seedlings in February, 1978. The trial was repeated in March.

Seed nuts of the variety Ansur-I were sown in polythene bags filled with a mixture of soil, sand and compost in the ratio of 1:1:1 in May, 1977. The next batch of seed nuts were sown in June. Twenty seedlings of the first batch were wedge grafted in February, 1978. The second batch sown in June was ready for grafting in March.

Eight month old dormant shoots having the same thickness as the seedlings used as the rootstocks were selected as scions. They were procured by removing the leaves 15 days before the grafting operation. At the time of grafting, the scions were having three to four active buds in each and were of seven to eight cm. in length.

Twenty healthy, vigorous and uniform seedlings were selected as rootstocks. The tops were cut off at a height of 8 - 10 cm. from the bottom. The cut stump was split to a depth of 2 - 3 cm. and the split ends were made into the shape of a wedge to permit a smooth contact between the stock and scion. The basal end of the scion was cut into the shape of a wedge fitting exactly into the cut made on the root-stock. The base of the scion was inserted into the split in such a way that both sides of the scion wedge pressed firmly against the stock for their entire length. A strip of polythene 6 - 8 mm. in width was tied tightly over it.

The grafted plants were kept in a closed polythene chamber. Fine sprays of water were allowed in the chamber thrice a day with a knapsack sprayer through a small hole made in the polythene film.

After a month the sprouted grafts were taken out and kept in shade everyday for an hour. The time of exposure was lengthened gradually until they were kept in the open

completely. Observations were made on the number of grafts sprouted and the number of grafts survived after taking out of the polythene chamber.

RESULTS

RESULTS

1. Rooting of air-layers

1.1. Rooting in relation to percentage of shoots in flush.

Layering was done at fortnightly intervals from February 1977 to January 1978. The percentages of rooting obtained in different months and extent of shoots in flush at the time of layering are presented in table 1.

The data show that the highest rooting of 75 per cent is obtained in March followed by 74 per cent in February and 69 per cent in April. However there is no significant difference in the percentages of rooted air-layers during the period January to April and in November. The rooting is below 50 per cent during the remaining months. The lowest percentage of rooting is obtained in July. These months are definitely unsuitable for air-layering.

It may be seen from the data presented in table 1 that the percentage of shoots in flush has some relationship with the percentage of rooting. The percentage of rooting is more or less in conformity with the percentage of shoots in flush. It has been observed that in July the trees are completely dormant and there is no new growth at all. New growth starts from August onwards and it increases gradually during the months of August to April. Maximum number of shoots are in growth in April closely

followed by March and February.

The percentage of shoots in flush at the time of layering and the percentage of rooting of air-layers show a significant positive correlation. It is quite evident from the data presented that the congenial conditions for air-layering is when the tree is in active growth phase.

Table 1. Percentage of rooted air-layers, percentage of shoots in flush at the time of layering, mean number of rooted air-layers and the mean number of shoots in flush in different months.

Month of layering		Percentage of rooted layers.	Percentage of shoots in flush	Mean no. of air-layers (transformed data)	Mean percentage of shoots in flush** (transformed data)
February	1977	74	70.00	3.84	57.19
March	"	75	78.00	3.86	62.05
April	"	69	80.00	3.71	63.47
May	"	48	46.00	2.95	42.65
June	"	37	9.00	2.64	13.67
July	"	27	0.00	2.30	0
August	"	42	31.00	2.88	32.42
September	"	46	35.50	2.97	36.53
October	"	46	26.00	3.01	29.43
November	"	62	60.50	3.51	51.14
December	"	48	23.50	3.09	27.41
January	1978	62	51.50	3.50	45.06
$C.D._{0.05}$				0.52	9.24

*data were transformed for statistical analysis by using the square root.

**data were transformed for statistical analysis by angular transformation.

ROOTING OF CASHEW AIR-LAYERS IN RELATION TO PERCENTAGES OF FLUSH AND SHOOT GROWTH OF THE PARENT TREE AT THE TIME OF LAYERING

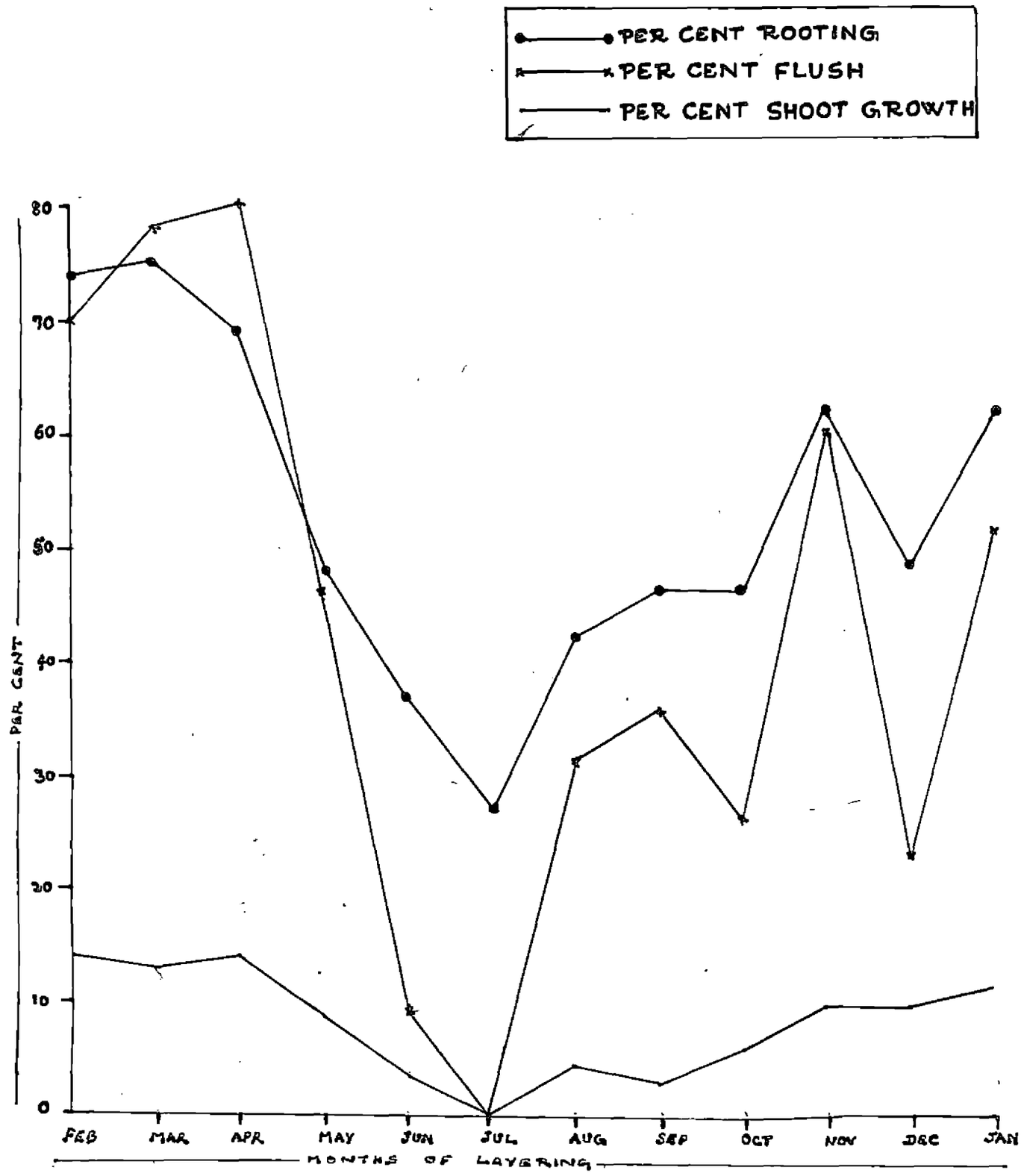


FIG. 1

1.2. Rooting in relation to temperature and rainfall

The relationship between some of the weather factors like rainfall and maximum temperature were studied and the data are presented in table 2.

Table 2. Rooting and Establishment of air-layers under different temperature and rainfall conditions.

Months		Mean maximum temperature °C	Total rainfall mm.	Mean per cent rooting	Per cent establishment under direct planting
February	1977	37.7	8.6	74	
March	"	39.1	7.2	75	
April	"	37.6	64.4	69	
May	"	33.1	294.6	48	42.8
June	"	31.8	586.2	37	79.41
July	"	31.0	721.1	27	78.57
August	"	30.9	194.2	42	50.00
September	"	32.5	162.6	46	44.44
October	"	33.0	389.9	46	40.00
November	"	32.1	440.8	62	31.25
December	"	32.1	0.0	48	-
January	1978	34.3	0.0	62	38.46
February	"	35.4	40.3		33.30
March	"	37.5	5.2		26.70
April	"	38.0	19.9		25.00

ROOTING OF CASHEW AIR-LAYERS IN RELATION TO TEMPERATURE AND RAINFALL

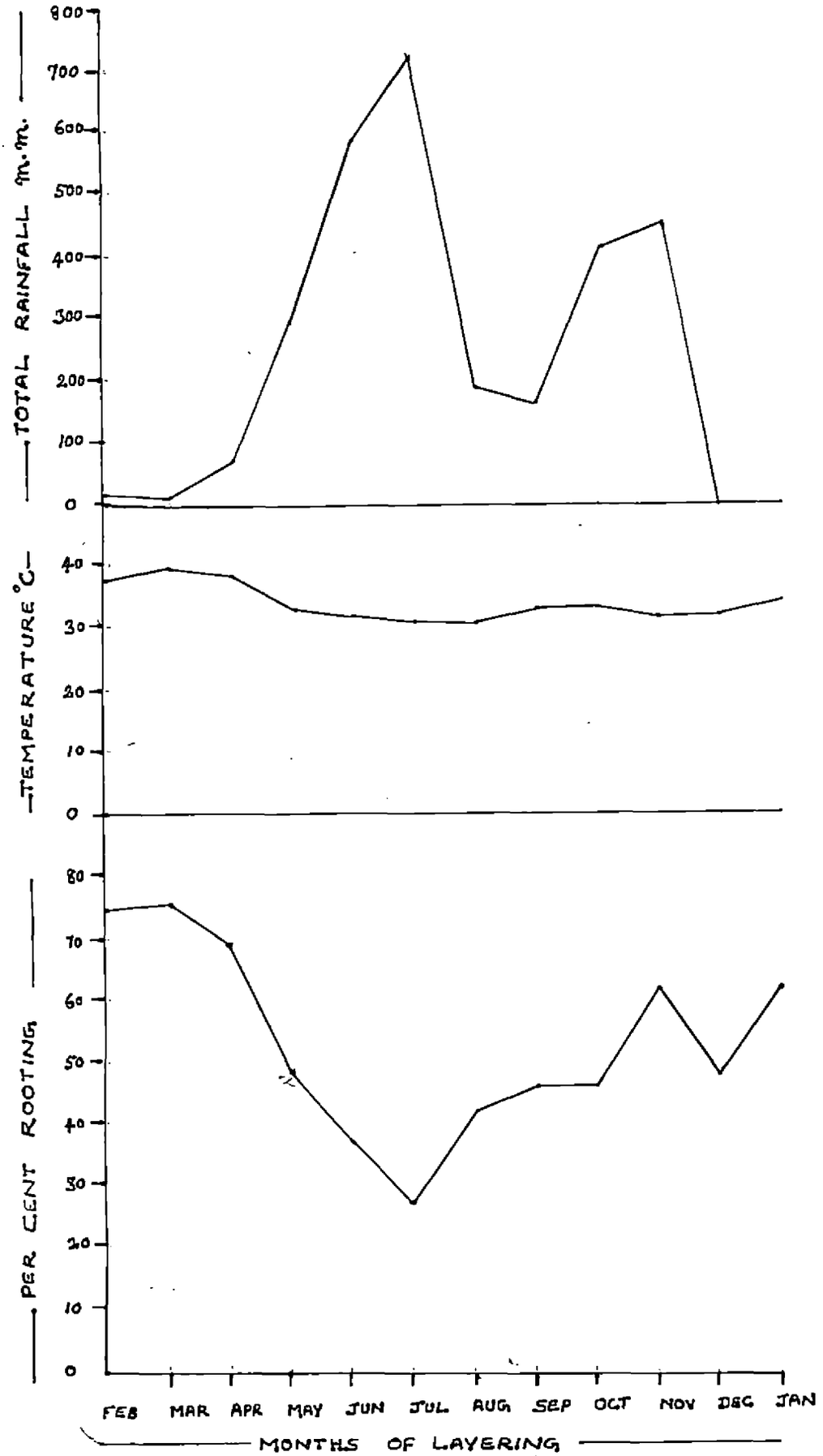


FIG. 2

ESTABLISHMENT OF CASHEW AIR-LAYERS IN RELATION TO RAINFALL

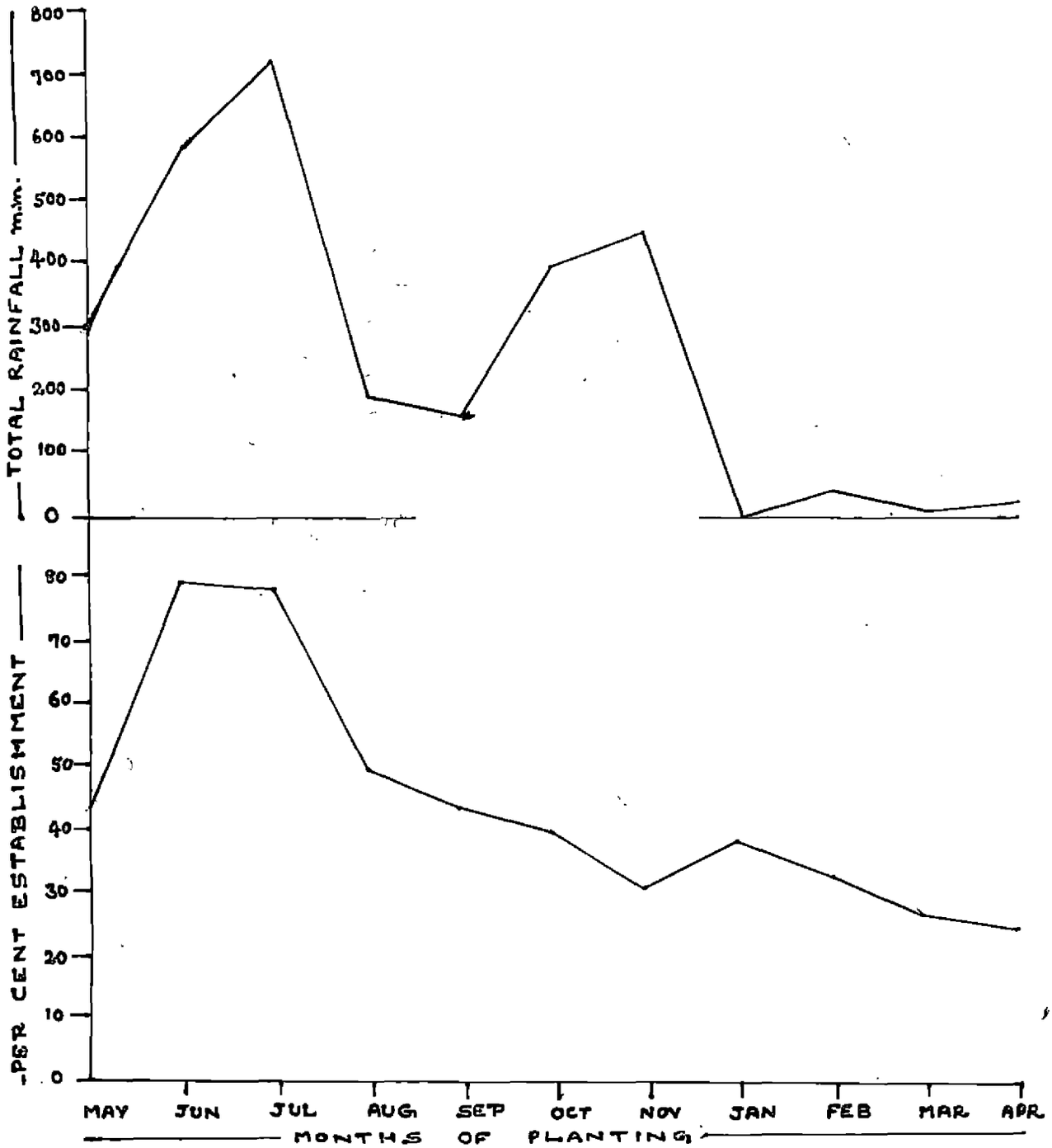


FIG. 3

The percentage of rooting of air-layers in the 12 months of the operation, starting from February, 1977 to January 1978 show that the higher temperature during the months of February-April is more favourable for rooting as compared to the remaining months of the year. This result is also established statistically by the presence of a significant positive correlation between temperature and rooting. Regarding rainfall, the drier months are more favourable for rooting than the rainy months. There is significant negative correlation between the rainfall and the percentage of rooting of layers.

In respect of establishment of the layers, the high rainfall conditions that obtained during the months June and July has given a higher percentage of success as compared to the remaining months. The percentage establishment of layers in different months is significantly and positively correlated with the total rainfall in the respective months.

2. Establishment of air-layers

2.1. Establishment under different treatments.

The rooted air-layers were subjected to four different treatments after separation from the trees, viz;(1) keeping in nutrient solution (2) planting in prepared soil medium

soaked with nutrient solution (3) planting in prepared soil in polythene bags and (4) direct planting in the field. Separated layers kept in the nutrient solution without any medium started wilting within 24 hours. Therefore the above treatment was not continued in the case of layers separated subsequently. The percentage of survival under the remaining treatments are presented in table 3.

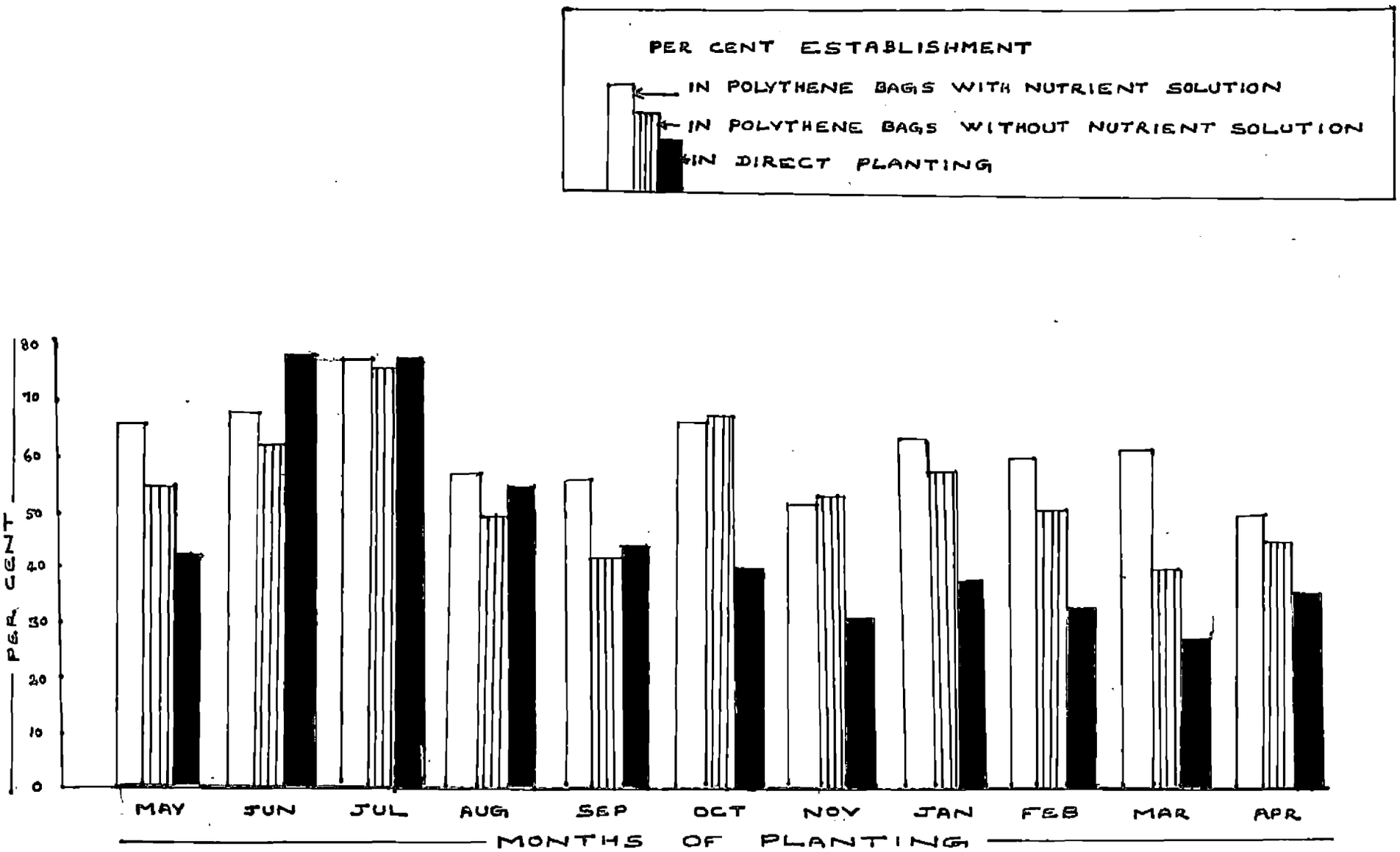
Table 3. Details of establishment of separated layers under different conditions.

Month of planting		Percentage of establishment			Mean	C.D. 0.05
		in polythene bags with nutrient solution	in polythene bags without nutrient solution	under direct planting		
May	1977	66.6(54.70)	55.20(47.98)	42.8(40.86)	42.35(46.95)	9.12
June	"	68.75(56.04)	62.50(62.50)	79.41(52.24)	70.41(43.67)	
July	"	78.57(62.44)	77.14(61.41)	78.59(62.44)	76.92(40.66)	
August	"	57.14(49.08)	44.40(41.78)	50.00(45.00)	50.00(42.55)	
September	"	57.10(49.08)	41.70(40.22)	44.44(41.78)	45.71(47.85)	
October	"	63.6 (52.89)	66.70(54.76)	40.00(39.23)	58.33(56.93)	
November	"	52.40(46.38)	53.30(46.89)	31.25(33.02)	46.15(62.10)	
December		-	-	-	-	
January	1978	64.10(53.19)	57.50(49.31)	38.46(38.35)	56.12(45.29)	
February	"	60.00(50.77	50.00(45.00)	33.30(35.24)	48.78(43.69)	
March	"	61.54(51.65)	40.00(39.23)	26.70(31.11)	45.45(48.96)	
April	"	59.09(50.24)	54.20(47.41)	25.00(30.00)	48.39(42.10)	
Mean		63.06(52.41)	54.79(47.87)	47.40(41.82)		
C.D. 0.05		4.76	4.76			

Transformed data are given in brackets.

It may be seen from table 3 that the highest percentage of establishment has been obtained in the case of layers planted in polythene bags with the soil medium supplied with nutrient solution. However the difference is not significant as compared with layers planted in polythene bags and supplied with water only. In the heavy monsoon months of June and July the percentage of establishment are 79.41 per cent and 78.57 per cent respectively of the layers planted directly in the field as compared to 62.5 per cent and 77.14 per cent respectively in the case of layers planted in polythene bags. The difference between treatments 1 and 2 is not significant statistically. In the case of treatment No.3, viz, direct planting in the field, the highest percentage of success is obtained in June and July. Direct planting during the remaining months has not been as successful as in those two months, presumably due to moisture stress.

ESTABLISHMENT OF CASHEW AIR-LAYERS



2.2. Establishment in mist chamber.

The details of establishment of air-layers kept in mist chamber and in open condition in May, 1978 is given in table 4. The observations were taken a month after planting.

Table 4. Details of establishment of air-layers kept in mist chamber.

No. of layers planted		No. of layers established		Percentage of layers established	
in mist chamber	in open condition	in mist chamber	in open condition	in mist chamber	in open condition
20	20	15	11	75	55

The observations show that keeping the layers in mist chamber has given better establishment of layers than keeping them in the open condition. While 75 per cent of layers kept under humid chamber conditions have established the corresponding figure under open condition is only 55 per cent.

3. Effect of plant growth regulators on the rooting and establishment of air-layers

3.1. Effect on rooting.

The effect of plant growth regulators on the percentage of rooting, mean number and length of roots produced per layer are given in table 5.

The data show that IBA 250 ppm. and NAA 500 ppm. are significantly superior to all the other treatments in respect of the percentage of rooted layers, each recording a success of 72 per cent.

Treatment with IBA 250 ppm. has produced the longest roots with an average length of 4.35 cm. and is significantly superior to all the other treatments. Control treatment has produced roots with an average length of 2.50 cm. only.

With regard to the number of roots produced per layer, it may be seen from the data in table 5 that the treatment with IBA 500 ppm. has produced the largest number of roots per layer with an average of 15.22 followed by IAA 500 ppm. and NAA 250 ppm. with an average of 13.66 and 11.43 roots per layer respectively.

Table 5. Effect of plant growth regulators in improving the rooting of air-layers.

Plant growth regulator and concentration.	Per cent of rooted air-layers	Mean no.of rooted air-layers* (transformed data)	Mean no.of roots per layer (original data)	Mean No.of roots per layer* (transformed data)	Mean length of roots per layer cm.
IAA 250 ppm.	48	7.69	11.43	3.37	2.64
IAA 500 ppm.	64	8.71	13.66	3.69	2.85
IBA 250 ppm.	72	9.43	8.49	2.90	4.35
IBA 500 ppm.	36	6.55	15.22	3.96	2.24
NAA 250 ppm.	36	6.44	8.37	2.89	2.45
NAA 500 ppm.	72	9.46	8.49	2.90	2.45
Seradix B-2	48	7.69	7.43	2.72	2.53
Control	36	6.64	7.8	2.79	2.50
$C.D._{0.05}$		0.35		0.71	0.57

*data were transformed for statistical analysis by using the square root.transformation.

Plate-I. Air-layers treated with IAA 250 ppm.

Plate-II. Air-layers treated with IAA 500 ppm.

Plate III. Air-layers treated with IBA 250 ppm.

Plate III. Air-layers treated with IBA 250 ppm.

Plate-IV. Air-layers treated with IBA 500 ppm.

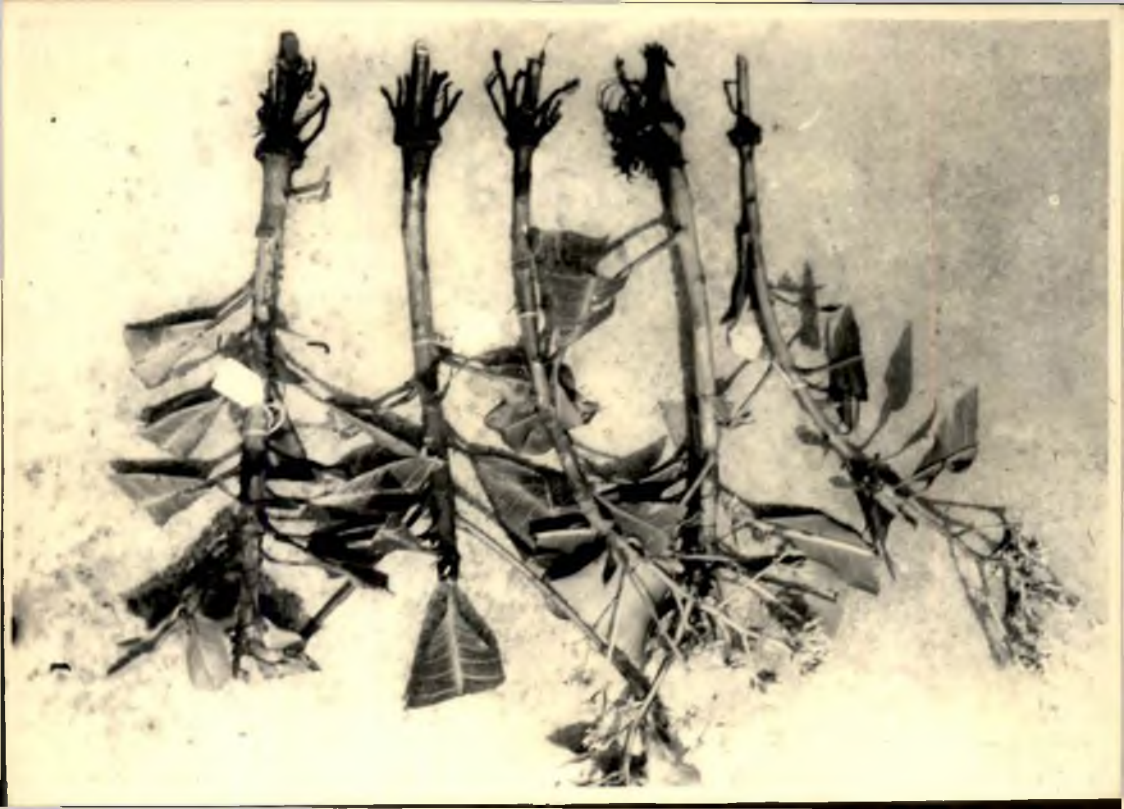


Plate-V. Air-layers treated with NAA 250 ppm.

Plate-VI. Air-layers treated with NAA 500 ppm.

Plate-VII. Air-layers treated with seradix B-2.

Plate-VIII. Control air-layers

3.2. Effect on establishment.

The layers separated from the previous trial were planted in polythene bags with and without adding nutrient solution to the soil medium to find out the whether the treatment with plant regulator at the time of layering had any effect on the establishment of the layers in the field. The data are presented in table 6.

The data show that the treatment with IBA 500 ppm. has given the highest percentage of establishment followed by IAA 250 ppm. and IAA 500 ppm. However, in the case of rooting, IBA at 500 ppm. has given only 36 per cent rooting, as compared to 72 per cent in the case of IBA 250 ppm. In respect of the mean number of roots per layer, IBA 500 ppm. ranks first. Therefore further studies are necessary to arrive at a definite conclusion regarding the most effective concentration of IBA for rooting and establishment of the layers.

Table 6. Details of establishment of air-layers treated with plant growth regulators

Plant growth regulators and concentration	No.of layers planted		No.of layers established		Percentage of establishment	
	In polythene bags in nutrient solution.	In polythene bags without nutrient solution	In polythene bags with nutrient solution	In polythene bags without nutrient solution	In polythene bags with nutrient solution	In polythene bags without nutrient solution
IAA 250 ppm.	4	4	3	2	75.00	50.00
IAA 500 ppm.	6	6	4	3	66.67	50.00
IBA 250 ppm.	4	4	2	2	50.00	50.00
IBA 500 ppm.	3	3	2	2	66.67	66.67
NAA 250 ppm.	2	2	0	1	0	50.00
NAA 500 ppm.	3	3	2	0	66.67	0
Seradix B-2	3	3	1	1	33.33	33.33
Control	2	2	1	1	50.00	50.00
Total ::	27	27	15	12	55.56	44.44

4. Shoot growth in relation to rooting and establishment of air-layers.

The percentage of shoots in growth in the different months, the percentage of extension growth of 50 tagged shoots and the mean per cent of rooting of layers are given in table 7.

The data show that in respect of the total percentage of shoots putting forth new growth as well as the rate of growth as represented by the percentage of growth of tagged shoots, the trees are most active from February-April, the maximum being in April. This period represent the optimum period for layering as indicated by the percentage of rooting obtained during these months. However, the difference in shoot growth during the above months are not statistically significant.

Significant positive correlation is obtained between the percentage of shoot extension growth and the percentages of rooting, the correlation coefficient being 0.91. Establishment of layers did not have a significant correlation with shoot extension growth.

Table 7. Number of shoot growth cycles and its effect on rooting and establishment of air-layers.

Month	Mean per cent of shoots growing (original data)	Mean per cent of shoots growing* (transformed data)	Shoot growth expressed as mean percentage	Mean per cent of shoot growth* (transformed data)	Mean per cent of rooting.	Mean per cent of establishment
February	74	60.00	14.24	22.14	74	48.78
March	90	73.62	13.79	21.89	75	45.45
April	92	77.31	14.40	22.38	69	48.39
May	56	48.51	9.09	17.66	48	42.35
June	12	15.94	3.75	11.23	37	70.41
July	0	0	0	0	27	76.92
August	30	26.95	4.49	12.20	42	50.00
September	38	38.03	3.19	10.36	46	45.71
October	20	21.00	5.70	13.92	46	58.33
November	66	54.51	9.91	18.44	62	46.15
December	16	15.69	9.76	18.28	48	-
January	52	43.15	11.68	19.64	62	56.12
$C.D._{0.05}$		18.85		7.94		

*data were transformed for statistical analysis by using angular transformation.

Wedge grafting

As an alternative method for air-layering, wedge grafting using procured shoots and 8 months old seedling stocks, was tried as an observational trial. The grafted plants were kept under humid chamber and the observations taken are presented in table 8.

Table 8. Particulars of successful grafts obtained by wedge grafting under humid chamber conditions.

Month of grafting	No. of seedlings grafted	Percentage of grafts sprouted.	Percentage of grafts dried after initial sprouting.	Percentage of grafts obtained after hardening.
February	20	90	20	70
March	20	80	15	75

In February, 90 per cent of the 20 grafts prepared have sprouted, but after hardening, only 14 grafts are obtained recording a percentage success of 70. In March though 80 per cent of the grafts have sprouted, one of them has dried up during the course of hardening and only 15 successful grafts are obtained in March. This works out to 75 per cent success.

Plate-IX. Mist chamber

Plate-X. Wedge grafted cashew seedlings

inside the mist chamber

DISCUSSION

DISCUSSION

Standardisation of an effective method of vegetative propagation of cashew has drawn the attention of a number of scientists from the earliest days of cashew research in our country. Among the different methods of vegetative propagation tried in cashew, air-layering has been found to be the simplest and effective method of vegetative propagation under Kerala conditions. However, this method has not found favour with many growers, due to the high degree of mortality when the air-layers are planted in the field. The present studies were under-taken to find out the factors responsible for the post-separation mortality of the cashew air-layers and to improve the technique further.

The results of the present studies indicated that the best period for air-layering in cashew was from February to April under Kerala conditions, and to a lesser extent in January. Eventhough 62 per cent rooting was obtained in November, it was not suitable from the point of view of planting in the field as dry months followed this period. June and July were definitely unsuitable for layering, as the rooting obtained in those months were only 37 and 27 per cent respectively. The favourable response to rooting commenced with the month of August and lasted till May. These results generally conformed to the findings of Rao (1958)

who suggested the best season for air-layering in cashew from August to April on the West Coast. Aiyadurai (1968) also recommended the period from October to April for air-layering.

The data also showed that the percentage of shoots in flush were also maximum during the period from February to April. The low percentage of rooting in June and July might be due to the fact that the trees were in an inactive phase during those months. The production of new flush in April marked the beginning of the successful phase of rooting. The degree of success in rooting increased with the development of the active phase of growth. In November, 60 per cent of the shoots were in flush and the percentage of rooting increased to 62 per cent from 46 per cent in the previous month. From February, the plants were in the peak period of growth as evidenced by the percentage of shoots in flush. These results find support from Rao (1958), Aiyadurai (1966) and Northwood (1964) who have reported similar results. In all these cases best results were obtained when the trees were in the peak period of vegetative growth.

The suitability of the months of February to April for layering is further enhanced by the fact that the layers prepared in these months, especially in March and April will

be ready for separation and planting in June and July which are the heavy rainfall months in Kerala.

It was observed in the present studies that there was positive correlations between the mean maximum monthly temperature and the percentage of rooting of air-layers in the respective months. Rao (1958) obtained maximum success in air-layering at Ullal during the hot weather period. The effect of temperature on rooting was explained by Adarsh Bala et al, (1969, 1970) as due to the mobilisation of starch and other food materials present in the shoot. The activity of starch hydrolysing enzymes was depressed by low temperature, causing inadequate supply of food materials for rooting (Nanda 1975). Poor rooting was observed when the temperature was low (Nanda, 1975).

The Percentage of rooting was found to be negatively correlated with the total monthly rainfall. The unsuitability of rainy months for air-layering in cashew was reported by Rao (1958). This may be due to the fact that the trees were more or less in an inactive phase in June and July, the months of heavy rainfall in Kerala. The effect of rainfall seemed to be indirect considering the results reported by Northwood (1964) who obtained best results in air-layering of cashew in Tanzania during the rainy season when the trees were in flush. During the hot weather period in Kerala the trees

were in active growth and the rooting was maximum. This suggested that the physiological conditions of the layered shoots determined the success of rooting of the air-layers. The effect of temperature on rooting might be determined by the extent to which it activated the growth cycles of the shoots.

Plant growth regulators have been extensively used for rooting of air-layers and cuttings in many plants. In the present studies also, trials on this aspect were under-taken. Against 36 per cent success in control, air-layers treated with 250 ppm IBA and 500 ppm NAA recorded a success of 72 per cent. In respect of the mean length of roots, treatment with IBA 250 ppm was the best, while IBA 500 ppm produced maximum number of roots per layer. Further studies are required to determine the most effective concentration of IBA for rooting of cashew air-layers. These results find support from the work of Rao and Hassan (1957) who obtained better success in air-layering of cashew with Seradix-A (containing IBA) than control and Chonkar (1967) and Acharya and Dash (1972) who obtained better results with IBA, both in the percentage of success and in the number of roots. Further, the beneficial effects of IBA on the rooting of mango air-layers had been reported by several workers. (Sen and Bose, 1969; Chonkar *et. al.*, 1972;

and Basu et al, 1977).

The increased percentage of success obtained by treating with NAA conformed with the reports of increased rooting of mango air-layers as reported by Singh, (1954) and Srivastava, (1960).

Auxins in general are concerned in the division of meristematic cells, in their elongation, in the differentiation of cambium initials into root primordia and most of all in the mobilization of reserve food materials caused by enhancing the activity of hydrolyzing enzymes and passing the metabolized sugars to the site of action. The increase in rooting under IBA was explained by several workers due to a greater depletion of sugars from the root forming region (Sen and Bose, 1966) and was associated with the metabolism of carbohydrates and protein (Basu et al, 1966; 1972). However, as the changes in carbohydrates and nitrogen substances are closely associated with the rooting of air-layers the increased root generating capacity of the IBA treated layers should be considered in terms of interaction between nutritional, hormonal, non-hormonal and possibly other as yet un-identified factors.

The concentration and time of application of plant growth regulators are also important factors. They stimulate rooting because the endogenous auxin produced by the plant

is inadequate and exogenously applied auxin raise it to a higher stimulatory level. The production of endogenous auxins change with the season. When the plants are in an active phase of growth the level of endogenous auxin is found to be high due to high meristematic activity (Adarsh Bala, 1969; Nanda, 1970). At that time there is no need of endogenous application of auxin which sometimes, may cause inhibition to rooting by raising the level of auxin to supra-optimal inhibitory level. In the present study the application of plant growth regulators to cashew air-layers was taken up in December when the trees were yet to enter into a very active phase of growth. Considerable increase in rooting and better development of root system were obtained by some of the treatments as mentioned already.

The highest percentage of establishment of air-layers was recorded in layers treated with IBA 500 ppm. This might be due to the fact that the maximum number of roots per layer was produced by this treatment. IAA treatments followed IBA 500 ppm in the percentage of establishment. Treatment with IAA 500 ppm ranked next to IBA 500 ppm in the case of the number of roots produced per layer. There seemd to be a positive correlation between the number of roots and the percentage of survival. The average length of roots per layer did not show such an effect on establishment. Based on

the above observation, it appeared that one of the reasons for the low percentage of survival of cashew air-layers might be the inadequacy of the development of root system of the layers.

There was no significant difference in the percentage of establishment obtained in the case of layers planted in polythene bags with the soil medium supplied with nutrient solution and layers planted in polythene bags with the soil medium supplied with water only. However the percentage of establishment was slightly higher in the former case. In the case of direct planting in the field, the establishment was significantly high when plantings were done in June and July. Observations during the remaining months were not comparable because, the atmospheric humidity, which was vital for survival of the separated layers was very low during those periods. In June and July layers planted in polythene bags recorded a lower percentage of establishment than those planted in the field. Rao (1958) recommended direct planting in the field in June and July since layers planted in hill grass containers resulted in progressive casualities which are particularly severe in the dry weather period. High mortality of cashew air-layers in the field had been reported by various workers (Rao, 1958; Mukherjee and Nanjumder, 1973; and Anon, 1978).

One of the causes for the layered cashew plants not enduring transplanting might be the inadequate development of root system. Visual observations revealed that the root system consisted mainly of a few short and thick roots, devoid of proper proliferation. But layers prepared in March and April when the trees were in full flush had a better developed root system with more secondary and tertiary roots. Since those layers were planted in June and July, there was better establishment in those months.

In the present studies, procuring of the layers were done by removing three fourth portion of the leaves a week before separation. The results obtained showed that further steps to reduce transpiration may be taken up since layers kept in mist chamber have given a better percentage of establishment as compared to layers kept in the open condition. The works of Bose and Mandal (1972) and Singh and Dhar (1977) supported this result. The fine sprays of water allowed inside the chamber resulted in a high relative humidity surrounding the leaf and also lowered the air temperature along with the leaf temperature, lowering the transpiration rate.

In cashew, an active phase of shoot growth alternated with a dormant phase. There had been an active phase of growth from January onwards. The number of shoots growing

and the percentage of growth were maximum in March and April. The dormant phase could be said to have started in May marked by a reduced percentage of extension growth of the shoots. Against 14.40 per cent of extension growth in April, it was only 9.09 per cent in May. The number of shoots growing reduced to 96 per cent in May from 92 per cent in April. The dormant phase continued in June and the growth was practically nil in July. New growth started again in August (4.49 per cent) and continued till April.

In the present study, no definite cycles of growth was observed in oneshow. The growth seemed to be continuous from August to May as observed by Rao (1958) on the west coast. This may be due to the fact that the trees included in these studies were only about 4 years old and continuous growth was a feature of such juvenile trees. In grown up trees of over 20 years in age, definite growth cycles of shoots are seen. Observation on shoot extension growth in individual shoots show that the terminal buds of individual shoots show definite growth cycles, a period of growth alternating with a period of no growth. Similar observations have been made in mango by Nakasone (1956) in Hawaii and Holdsworth (1963). But though the individual terminal buds have shown definite periods of growth and cessation of growth, it was observed

in the present study that the time of active growth phase and cessation of growth were different in individual shoots. But the tree as a whole had no definite periods of growth and dormancy. Apart from the two or three peak periods of growth, stray shoot growth had been reported to occur in almost every month under favourable conditions in Tanzania (Argles, 1969).

The percentage of shoot growth and rooting in different months was found to be positively and significantly correlated. The results obtained showed that rooting was governed by physiological factors inherent in the layered shoots. This found support from Argles (1969) view that active growth phase determined the success of layering.

Rooting is related to the mobilisation of starch (Adarsh Bala et.al, 1969; 1970). The starch content of the shoots exhibited variation in conformity with the growth cycles (Nanda, 1975). The disappearance of starch was closely related to the activity of hydrolyzing enzymes causing mobilisation of reserve food materials. Thus the hydrolytic activity was high when rooting was profuse causing more mobilisation of food materials. This also could explain the profuse rooting of air-layers when the trees were in active growth.

Among the different propagation methods reported, it is evident that only air-layering and approach grafting have been subjected to detailed investigations so far. Various methods of grafting and budding have been reported to be effective and economic methods of propagation. But, these methods are yet to prove successful on a field scale. Economic exploitation of these methods, therefore deserve further studies. With this objective, wedge grafting was tried in the months of February and March under humid chamber conditions. In March, 75 per cent success was obtained while in February 70 per cent success was recorded. Wedge grafting had been reported to be successful by Bhandary et.al. (1974) on 21 days old cashew seedlings in Bangalore. However, this method has to be further standardised to adopt it in large scale multiplication.

It is obvious from the above discussions that the main reasons for the high mortality of cashew air-layers are the inadequate development of the roots in the layered twigs at the time of separation and the physiological condition of the twigs at the time of layering as well as at the time of separation. The results indicated that the rooting was much better when the trees were in active growth. There are also indications that the rooting and establishment of the layers can be improved by using plant growth regulators

(IBA 250 ppm and NAA 500 ppm) at the time of layering. The optimum time of layering was from February to April and that for separation and planting in June-July. Further studies are necessary to standardise wedge grafting as an effective method of propagation for cashew.

SUMMARY

SUMMARY

Studies on air-layering of cashew with the main objective of reducing their post-separation mortality were undertaken on four year old cashew trees at the main campus at Vellanikkara of the Kerala Agricultural University. Wedge grafting was also tried as an alternative method for air-layering. The results of these studies are summarised below.

The best period for air-layering in cashew was from February to April under Kerala conditions, which coincided with the period of maximum number of shoots in flush on the trees. These months of layering had the added advantage that the layers will be ready for planting out in the field in June and July which are the most suitable months for planting. The lowest percentage of rooting was obtained in July. Percentage of rooting was significantly and positively correlated with the number of shoots in flush on the tree at the time of layering.

Rooting was positively correlated with mean maximum temperature and negatively correlated with total rainfall.

The application of nutrient solution to the planting medium in polythene had some beneficial effects in the establishment separated layers, but the differences were

not significant. The establishment of layers was higher in the case of layers planted directly in the field during the high rainfall months of June and July. A significant positive correlation existed between the percentage of establishment of air-layers and the rainfall.

Layers kept in mist chamber showed better establishment than layers kept in the open condition.

Treatment with IBA 250 ppm and NAA 500 ppm produced the maximum number of rooted air-layers. Treatment with IBA 250 ppm was the best treatment in respect of the mean length of roots while IBA 500 ppm produced the maximum number of roots per layer. The highest percentage of establishment was recorded by layers treated with IBA 500 ppm.

In cashew, an active phase of shoot growth alternated with a dormant phase in individual shoots. An active phase of growth in February to April was followed by a dormant phase in June and July. Renewed shoot growth commenced in August and continued till May with variation in the intensity of growth.

Wedge grafting on eight month old cashew seedlings gave 70-75 per cent success in February-March under humid chamber conditions. The method needed further standardisation for adoption on large scale multiplication.

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*Original not referred.

APPENDIX I

Analysis of variance for rooting of air-layers, percentages of flush, shoots growing and shoot growth.

MEAN SQUARE VALUES

Source	df	Rooting of air-layers	Per cent flush	Per cent shoots growing	Per cent shoot growth
Replication	4	1.42	125.46	350.63	5.38
Months	11	1.22**	1860.49**	2962.78**	336.26**
Error	44	0.17	52.65	218.91	38.81
C.D.(P=0.05)		0.52	9.24	18.85	7.94

**significant at 1% level

APPENDIX II

Analysis of variance for establishment of air-layers.

MEAN SQUARE VALUES

Source	df	Establishment of air-layer	C.D. (P=0.05)
Months	10	132.307*	9.12
Treatment	2	310.11*	4.76
Error	20	28.70	

*significant at 5% level

APPENDIX III

Analysis of variance for plant growth regulator treatment

MEAN SQUARE VALUES

Source	df	Per cent rooting	Mean No. of roots	Mean length of roots
Replication	4	0.01	0.08	0.25
Treatment	7	0.30**	1.07*	2.37*
Error	28	0.07	0.30	0.21
C.D. (P=0.05)		0.35	0.71	0.57

* Significant at 5% level

** Significant at 1% level

APPENDIX - IV

Correlation between weather factors and the rooting and establishment of layers

Weather parameters	Rooting of layers	Establishment of layers
Rainfall	−0.7246**	−0.7956**
Mean maximum temperature	0.6824*	

* Significant at 5% level

** Significant at 1% level

STANDARDISATION OF VEGETATIVE PROPAGATION TECHNIQUE IN CASHEW WITH A VIEW TO REDUCE THE POST - SEPARATION MORTALITY OF AIR-LAYERS

By

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ABSTRACT OF A THESIS

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ABSTRACT

Investigations on the different aspects of the post separation mortality of air-layers were carried out on four year old cashew trees at the main campus at Vellanikkara of the Kerala Agricultural University during the period of February 1977 to June 1978. Air-layering was done at fortnightly intervals and observations on the shoot growth were recorded to find out whether there is any correlation between rooting of air-layers and the shoot growth cycles. Wedge grafting was also tried as an alternative method for air-layering.

The best time for air-layering in cashew was from February to April at which time the trees were in active growth phase as indicated by the maximum percentage of shoot extension growth. Percentage of rooting in different months was positively correlated with the percentage of shoots in flush and the rate of shoot extension growth in the respective months. Rooting was positively correlated with maximum temperature in the respective months and negatively correlated with total rainfall.

Establishment was better in layers planted in polythene bags with the medium supplied with nutrient solution as compared with plants not supplied with nutrient solution;

but the differences were not significant. June and July which are the heavy rainfall months in Kerala were the best months for planting out air-layers directly in the field. Establishment was improved by keeping the layers in mist chamber.

Treatment with IBA 250 ppm and NAA 500 ppm produced the maximum number of rooted air-layers. Treatment with IBA 250 ppm was the best in respect of the mean length of roots while IBA 500 ppm produced maximum number of roots per layers. The highest percentage of establishment of air-layers was recorded by layers treated with IBA 500 ppm.

Wedge grafting on eight month old cashew seedlings, though needed further standardisation, gave a better success in March compared to February.