STANDARDISATION OF PROPAGATION TECHNIQUES IN *Phyllanthus emblica* Linn.

By

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THESIS

submitted in partial fulfilment of
the requirement for the Degree

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Department of Pomology and Floriculture
COLLEGE OF HORTICULTURE
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DECLARATION

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

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CERTIFICATE

Certified that the thesis entitled "Standardisation of propagation techniques in Phyllanthus emblica Linn." is a record of research work done independently by Miss. Pushpalatha, P.B. under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

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We, the undersigned members of the Advisory Committee of Miss. Pushpalatha, P.B., a candidate for the Degree of Master of Science in Horticulture majoring in Pomology and Floriculture agree that the thesis entitled "Standardisation of propagation techniques in *Phyllanthus emblica* Linn." may be submitted by Miss. Pushpalatha, P.B. in partial fulfilment of the requirements for the degree.

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Introduction

INTRODUCTION

Aonla (*Phyllanthus emblica* Linn.) popularly called as 'Nelli' locally is indegenous to India and is widely distributed in tropical and subtropical regions. It grows wild in the evergreen and dry deciduous forests of Western Ghats region of Kerala. The fruit finds diverse uses and its primemost importance is due to its high Vit C content (500-750 mg/100g of pulp). Nelli possess medicinal properties also.

With its wide climatic adaptability 'Nelli' can be grown with ease in the homesteads as well as in the orchards. Propagation of this fruit tree is mainly through seeds and majority of aonla plantations are still of seedling origin. This does not guarantee progenies which are true to variety. The progenies from seedling trees very in size, shape and vitamin content besides yield.

A survey conducted in the Western ghat regions (Aravindakshan *et al*., 1985) has shown that there is considerable scope for selection of high yielding trees with better fruit characters. Lack of standardised method of vegetative propagation has been one of the major set backs in propagating selected types.

Despite the fact that seed is the basal unit of evolution of new varieties either through breeding or through chance seedlings, it is the vegetative method of propagation that guarantees perpetuation of superior clone or cultivar to any length of time. Among the accepted methods of vegetative propagation, cuttings would be the cheapest and easiest, provided suitable methods have been standardised. Rooting potential of different species varies considerably. Some root easily, others root with difficulty and still many species are obstinate and do not root even with the application of synthetic growth substances. Aonla is a 'difficult to root' species. But it is already an established fact that cuttings of many tree species could be stimulated to root with the application of synthetic growth substances. For successful rooting of cuttings in a majority of fruit plants intermittent mist is also beneficial.

Vegetative method of propagation of aonla by inarching has been discouraged, as the grafts prepared are weak in nature (Singh, 1952). Preliminary works on layering has not yielded success so far. Although different methods of budding have been reported to be successful, none of these methods are still employed on a commercial scale, which indicates the necessity for further detailed work on this aspect.

Adventitions buds naturally appear on the roots of certain plant species and they give rise to suckers which can be used for propagation. The regeneration capacity of the roots vary depending upon the season and treatments given to them. Although Aonla produce root suckers in the field, no attempt has been undertaken to study the possibility of its propagation through root cuttings or through suckers.

In the absence of an easy method of vegetative propagation, we can adopt only seed propagation in any crop plant. In the case of aonla, even seed propagation very often do not meet with complete success because of the hard "shell" covering the true seeds. The extraction of the seeds have been found to be useful in obtaining better seed germination (Sreekumar and Aravindakshan, 1985). Seed treatment with growth regulators are employed in enhancing seed germination in many crops. In aonla it was felt necessary to evolve methods in order to enhance seed germination and seedling survival to the maximum extent.

The study reported in the thesis were carried out with the main objectives to standardise methods for maximum seed germination and seedling survival, and to assess the possibilities of vegetative propagation through shoot cuttings, root cutting, suckers, budding or layering.

Review of Literature

REVIEW OF LITERATURE

I. Seed propagation

The growing of seedlings is used in propagating more species and cultivars than any other propagation method (Hartmann and Kester, 1975). When the vegetative methods are not feasible mass production by such a method would be uneconomical and impractical and seed is the only means of propagation in that case. Seedlings are also to be produced extensively to provide rootstocks for budding or grafting. Seed propagation also provide a means for selection of superior types.

2.1. Effect of chemicals on seed germination

The chemical treatment was found to have significant effect on seed germination of various crops and fruit plants and their subsequent seedling growth.

Bhujbal (1975) reported an improved method of seed propagation in *Phyllanthus emblica*. When fruits or stones were sown fresh or dried after soaking in 500 ppm GA for 24 hours, 92.5 per cent germination was obtained. But the tallest seedlings were obtained in the case of untreated dried stones.

Jackfruit seeds when treated with NAA 25 ppm recorded maximum germination, optimum height of seedlings and number of leaves (Sinha and Sinha, 1968). In guava Sinha et al. (1973) obtained better germination of seeds when treated with ethrel 500 ppm, but boiling water was found to have an adverse effect on germination.

Randhawa and Negi (1964) conducted a preliminary study to find out the effect of different chemicals on seed germination and seedling growth in grapes. Kinetin and Thiourea was found to augment seed germination.

Ber seeds when treated with GA at 400 ppm and IAA at 100 ppm improved the seed germination and seedling growth (Shanmugavelu, 1983). Krishnan and Kulasekaran (1984) treated the ber seeds with GA and thiourea alone and also in combination with 5 per cent sucrose. They stated that GA at 200 ppm recorded the highest percentage of germination followed by GA at 200 ppm + 5 per cent sucrose and thiourea 500 ppm. Treating the seeds with GA 200 ppm + 5 per cent sucrose produced maximum shoot length with more number of leaves, where as GA 200 ppm enhanced the length of primary roots while thiourea 500 ppm recorded highest number of lateral roots.

Misra and Verma (1980) studied the effect of ascorbic acid (100-250 ppm), ethrel (100-150 ppm) and GA (50-200 ppm)

on seed germination of kinnow oranges at Himalayas and found that soaking in ascorbic acid at 1000 ppm recorded highest germination (87.3 per cent) and highest survival of plants in the field (73 per cent). Choudhari and Chakrawar (1980) soaked the lime seeds in GA at 10, 20 and 40 ppm, NAA at 10, 20 and 40 ppm, thiourea at 1.0, 1.5 and 2.0 per cent, KNO_3 at 1.0, 1.5 and 2.0 per cent. All treatments of GA, NAA and KNO_3 were found to give the highest germination of 83 to 100 per cent. The seeds of malta orange were also found to respond well to the treatment with GA at 200 ppm for 12 hours (Misra et al., 1982) with respect to germination, plant height, number of leaves and leaf area per plant. Among them best treatment was 100 ppm GA followed by ascorbic acid 50 ppm.

The beneficial effect of nitric acid (0.25%) on increasing the germination (58.5%) of strawberry seeds was reported by Negi and Singh (1972). Where as IAA 100 and 200 ppm considerably lowered the germination percentage (24.5 and 22.0 per cent respectively). Devlin and Karczmarczyk (1975) reported increased germination of cranberry seeds when treated with GA under exposed condition to light.

Sharma and Singh (1979) treated the peach seeds with various chemicals viz., GA_3 (500, 1000 and 2,000 ppm),

Thiourea (2,500, 5,000 and 7,500 ppm) and Kinetin (25, 50 and 100 ppm). Highest germination was recorded with 5,000 ppm thiourea followed by 1,000 ppm kinetin. Bajwa *et al*. (1980) from their trial on plum to find out the effect of chemicals like GA (20-100 ppm) or thiourea (2,500 - 10,000 ppm) or GA (50 ppm) + thiourea (5,000 ppm) observed highest germination for GA at 50 ppm.

In walnut GA at concentrations ranging from 125-250 ppm increased the germination percentage and height of seedlings (Gulur, 1980). This treatment was proved to be better than H_2SO_4 at 10 and 20 per cent concentrations or hand cracking of seeds. Crisosto and Sutter (1985) subjected the olive seeds to chemical scarification with NaOH and H_2SO_4 and stated that H_2SO_4 was more effective than NaOH.

Das and Pattanaik (1971) observed the superiority of GA treatment on increasing the height of okra seedlings when seeds were given a pretreatment with GA. Das and Prusty (1972) recorded increased germination as well as height of plants when seeds were treated with GA. The leaf number, fresh weight of shoots and roots were also found to be increased compared to control.

In onion, seeds treated with IBA and GA resulted in better germination of seeds, number of main roots,

number of fresh and dry weight of leaves compared to NOA on a commercial scale (Srivastava and Adhikari, 1972). They recommended pre-sowing treatment of onion seeds with GA 50 ppm for six hours since it increased the total yield of the crop. Maurya and Lal (1972) recorded a rapid increase in germination of onion seeds when treated with 60 ppm NAA, 20 and 40 ppm GA and 20 ppm IAA. However 40 ppm GA was found to give best results. Prakash et al. (1978) observed inhibitory effect of IAA at all concentrations on germination of lettuce seeds.

Effect of chemicals on seed germination was studied in a number of ornamental plants like Chrysanthemum indicum, Dianthus chinensis and Gaillardia pulchella by Bankar (1980). The seeds of all these species were found to germinate two days earlier than control. Overall percentage of germination was accelerated due to treatment with GA at various concentrations viz. 40 ppm in chrysanthemum, 80 ppm in dianthus and 60 ppm in Gaillardia appeared to improve the germination more than others. Dehgan and Schutzman (1983) reported highest germination of 82.8 per cent in Zinnia furfuraceae when seeds were exposed to H_2SO_4 for 15 minutes. The number of days for germination was reduced to 37.7 in treatment with H_2SO_4 for 30 minutes, followed by GA treatment for 24 hours. Investigations were undertaken by Jana and Das (1984) to find out the effect of chemical treatment on the

germination of annual seeds like Coreopsis tinctoria, Centaurea moschata and Phlox drummondii. Treatment with 100 ppm IAA produced highest percentage of germination of coreopsis seeds followed by GA_3 (100 ppm). In sweet sultan GA_3 100 ppm produced highest per cent of germination and in phlox MH 100 ppm was found to be the best.

2.2. Seed storage

Recent development in seed storage techniques have been led to a new delimitation of storage condition which allows the seeds of a number of species of crop plants to be stored for many years. Controlled conditions can minimise the loss in vigour and viability but cannot prevent it completely. The various parameters known to influence the longivity of seeds in storage are temperature, light, moisture content and oxygen pressure (Owen, 1956; Barton, 1961; James, 1967 and Roberts, 1972). Numerous experiments have been conducted to delineate the parameters that affect the longevity of seeds. The effect of storage material, storage temperature and humidity on seed viability have been defined quantitatively by various workers for most of the crop seeds.

Evans (1950) suggested easy access of free air and low rate of loss of water from seeds as the two conditions to preserve seed viability during storage. Seeds

of many species stored under high temperature and humidity lost viability very rapidly (Delouche et al., 1967). Harrington (1970) demonstrated that storage at low temperature and low humidity in sealed containers prolonged seed viability. These two factors were shown to have independent effect and a combination of both low temperature and moisture is recommended to maintain viability during storage.

Williams and Hanson (1974) recommended speed of germination and dry weight of seedlings as a means of testing the seed vigour and germination capacity. Thus vigour testing in seed storage programme was recommended by him as a means of predicting imminent viability losses.

Bajpai and Trivedi (1961) successfully stored mango stones in charcoal dust with 50 per cent relative humidity for 70 days without lossing the viability. Arumugam and Shanmugavelu (1976) observed that Co-1 and Co-2 papaya seeds stored in paper bags, lost viability after nine months. The germination percentage reduced from 89 per cent to 66 per cent for Co-1 and from 89 per cent to 67.7 per cent for Co-2 after storage. When seeds were stored in open containers early loss of viability was observed.

Barton (1943) reported that 50°C is the ideal temperature for storing of sour orange and rough lemon seeds.

Bajpai et al. (1963) tested the viability of citrus seeds under different storage media viz. charcoal powder, sealed polythene bags, desiccators over $cacl_3$, keeping in open jar and leaving in the fruits itself. Maximum germination was recorded for seeds stored in room temperature and at 50 per cent relative humidity followed by seeds stored in polythene bags. Significant fall in germination was also observed in seeds stored in open air. Elge and Polest (1969) reported that when freshly extracted citrus seeds were stored in sealed polythene bags, remained in good condition for several months. Bhakasut et al. (1976) conducted the germination studies in citrus seeds and observed that viability of seeds was rather low and storage of seeds for long duration resulted in loss of viability. Stored seeds which had no germination capacity contained larger quantities of phenolic compounds to fresh seeds of the same species. Mobayen (1980) discovered that seeds extracted from trifoliate orange fruit required storage at 4.5°C for about 12 weeks before achieving the faster rate and shortest time span of germination. Viability of seeds was fairly high enabling the storage for over three years without much loss of viability.

Chakraverthy (1976) reported loss of viability of corchorus seeds due to the accumulation of inhibitors, during storage. Ultimately the seeds turned to be nonviable.

Bhaumik and Mukherjee (1981) studied the accumulation of growth inhibitors in relation to viability of stored jute seeds. Germination percentage of the seeds stored in open container (kept in cotton bag) gradually decreased and was nil by the next year. The germination percentage of the seeds stored at low temperature (22± 2°C kept in air tight glass jar) remained more or less unchanged. Thus the non-viability of the seeds had been attributed to the increased accumulation of different inhibitors in the seeds during storage. The viability of control seeds was also found to be reduced gradually when they were exposed to ambient conditions of temperature and moisture.

Ramakrishnan *et al.* (1970) conducted seed viability studies on ornamental plants like zinnia, cosmos, gaillardia, tagetus, marigold and thithonia. The seeds of tagetus and cosmos were found to be short lived and life span of these seeds did not exceed 21 and 23 months respectively. But the seeds of thithonia, zinnia and gaillardia remained viable under normal conditions of storage for a period of 28, 30 and 31 months respectively. Tewari and Gupta (1981) stored the sunflower seeds in cold room and ambient room conditions for eight months to compare the retention of viability under both conditions. It was found that germination percentage of ambient stored seeds was 18.2 per cent against

88.8 per cent in cold room. The hypocotyl length of the seeds stored in cold room was also higher than those stored under ambient condition.

II. Rooting of cuttings

Regeneration through cuttings is the most simplest and easy method of plant propagation. This is less expensive, more rapid and does not require special technique as other propagation means.

2.3. Effect of growth regulators and mist on rooting of stem cuttings

The process of root regeneration in cuttings of a wide range of easy and difficult to root plant species can be accelerated with the use of root promoting substances at proper concentrations. However, several plant species fail to root even with treatment of root promoting substances. It has been experienced by several workers that the success in propagation of several difficult to root plant species are possible with a combined effect of intermittent mist and growth regulator treatment. The literature on this aspect is so volumeness and here the review has been restricted to the more recent literature on tree crops in general and perennial fruits in particular.

Rajan and Ram (1982) could obtain rooting in aonla cuttings. They treated the semihard wood cuttings collected

from the middle portion of invigorated shoots of seedling trees with IBA 0.024, 0.049, 0.074 and 0.098 M concentrations and planted in hot bed. All the concentrations of IBA treatment were effective and rooting was noticed on 12th day itself. Treatment with IBA 0.0735 M (15,000 ppm) produced the best results with respect to number of roots (8.45), root length (4.8 cm) and root thickness (1.46 cm) and percentage of rooting was 66.38.

In jackfruit successful rooting (80 per cent) and survival (58 per cent) of cuttings were reported by Mukherjee and Chatterjee (1978). The invigorated shoots of jack were etiolated, ringed and after callus formation base was dipped for 25 - 30 second in IBA 5,000 ppm. Chatterjee and Mukherjee (1980) again tried the rooting of two categories of jackfruit cuttings viz. leafless and leafy cuttings using (IBA 5000 and 10,000 ppm) and mist conditions. Untreated leafless and leafy cuttings failed to root while a rooting of 90 and 60 percentage was noticed for treatment with IBA 5,000 and 10,000 ppm respectively. Hamilton et al. (1982) observed that 95 per cent bread fruit cuttings rooted within ten weeks when they were treated with IBA 2,500 ppm and kept in green house under intermittent mist conditions.

In guava good rooting was observed for NAA 100 ppm (Teaotia and Pandey, 1961). Dhua (1982) reported 100 per cent

rooting of guava cuttings when they were treated with ethephon at 50 or 100 ppm followed by IBA at 3,000 ppm and when kept under mist conditions at 27°C. Treeby (1983) treated the guava cuttings with IBA 500, 2,500 and 5,000 ppm for 1, 5 and 15 minutes and placed under intermittent mist with bottom heat (27°C) for six weeks. Rooting was nil in control while it was highest (30.5 per cent) in cuttings treated with 0-5,000 ppm IBA.

Shafrir (1970) reported that dipping the cuttings of Washington navel orange in IBA solution (1000 or 2000 ppm) for 10 seconds significantly increased the number of roots per cuttings, the proportion of cuttings suitable for transplanting and survival rate after planting out in the main field. Ranvir and Singh (1973) found that hardwood cuttings of sweetlime when treated with 2,000 and 4,000 ppm IBA rooting was increased to 87 per cent. In the case of lemon cuttings IBA failed to produce any effect.

In litchi Bhandary and Shivashankar (1970) noticed a high percentage of rooting with more number and length of roots when treated with IBA 5000 ppm and kept under intermittent mist. Lenka and Das (1985) tried rooting in litchi cuttings taken in different dates between April to October and noted rooting only in cuttings taken during

April and September. Highest rooting (32.8 per cent) was with cuttings taken in April treated with IBA 3,000 ppm.

Ernst (1981) obtained better rooting in avacado when cuttings were treated with IBA at 1.0 per cent. A highest percentage of rooting (75%) was obtained when they were planted in aerated medium after treatment.

Zyl et al. (1971) studied the effect of upto 8,000 ppm IBA on rooting hardwood cuttings of peach and 1000 ppm was found to produce best results. Doud and Carlson (1972) reported good rooting when basal cuttings of peach was treated with IBA 1000 to 1,500 ppm. Robitaille and Yu (1980) reported better rooting of peach hardwood cuttings under mist when base of cuttings were dipped in IBA solution for 10 seconds. In peach excellent rooting was obtained by Erez and Yablowitz (1981) when cuttings were dipped in IBA 0.1 per cent for five seconds. Pandey and Upadhyay (1981) treated the peach cuttings with IBA 2,000, 2,500, 3,000 and 5,000 ppm. The cuttings treated with 2,000 and 2,500 ppm IBA was reported to produce significantly maximum rooting while IBA 2,000 ppm recorded maximum survival. In peach improved rooting was also obtained by Nyomora and Mnzava (1982) by treating the cuttings with 0.1 per cent IBA.

In plum Chauhan and Reddy (1974) reported IBA 1000 ppm to be the best with respect to rooting (25.77%),

number of primary roots, length and diameter of longest roots. IBA also proved superior over NAA or IBA + NAA. Pathak et al. (1975) dipped one year old mature cuttings of plum in IBA at various concentrations ranging from 2,000 to 5,000 ppm. After treatment half of the cuttings were placed in hot bin (21°C) and the rest in open atmosphere. It was found that IBA 2,000 ppm and 2,500 ppm recorded maximum rooting. Higher concentrations beyond this limit were found to have an inhibitory effect. Hartmann (1982) obtained maximum rooting and survival of plum cuttings at IBA 4,000 ppm when cuttings were made from the base of the shoot, at 2,000 ppm for middle part and at 500 ppm for shoot tip.

In apple Doud and Carlson (1972) recorded best rooting of 21.1 per cent when basal cuttings were treated with IBA 2,000 ppm. IBA 2,500 ppm was found to induce maximum number of roots (Pathak et al., 1977). Randhawa and Nito (1980) reported a high rooting percentage of 90 for Malus prunifolia when treated with IBA 1,250 and 2,500 ppm whereas M-9, M-26 and Starking delicious failed to root because of high content of growth inhibitors (ABA).

Thibault and Hermann (1971) obtained highest percentage of rooting of pear hardwood cuttings when dipped in IBA 5,000 ppm. Ibrahim et al. (1976) reported highest rooting

percentage (48%) when cuttings were treated with IBA 200 ppm during February and kept in glasshouse. Bahlool and Mezelg (1977) stated that in pear the endogenous auxin level in the cuttings was very low and so responded well to IBA treatment. Highest rooting was recorded when these cuttings were treated with IBA 1000 to 4000 ppm.

In mist propagation studies with blue crop, blue berry, corille and stanley blue berries, Hull and Ceorts (1973) observed enhanced rooting when treated with IBA. In sourcherry, cuttings treated with IBA at 100 mg/l recorded 90 per cent rooting (Margolite and Gerdvilite, 1973). Munoz and Solanes (1983) reported maximum rooting of Prunus persica var. nectarina when treated with IBA 1,500 ppm compared to control where rooting was nil.

Nicotra and Cappellini (1972) dipped cuttings of different varieties of apricot in 2,000 and 4,000 ppm IBA and kept in peat over bottom heat for four months. Most of the cultivars failed to root and only 22 of the 84 varieties tested produced roots. Jawanda et al. (1980) treated almond cuttings with IBA at concentrations of 50, 100, 150 and 200 ppm and they observed that cuttings treated with IBA 100 ppm produced highest per cent of rooting. Rooting was found to be decreased with increase in IBA concentrations beyond 100 ppm.

Vadivel et al. (1981) reported maximum percentage of rooting with cinnamon hardwood cuttings when the cuttings were treated with IAA 2,500 ppm. Rajan and Rao (1982) stated that mist condition is highly congenial for regeneration of roots in Patchouli herbaceous cuttings. Excellent rooting of 100 per cent was achieved within 10th day itself with the treatment of growth regulators viz. NAA, IAA and IBA at 5,00 , 1,000, 1,500 and 2,000 ppm under mist condition, as against 83.33 per cent in control. Pannelli et al. (1983) studied the effect of growth regulators and other conditions on rooting of semiwood cuttings of olive. Rooting percentage of 95, 45 and 7 were obtained in untreated cuttings of varieties frantoio, Leccino and Moraiolo under mist. Rooting was further improved by treating the cuttings with growth regulators viz. Germon (NAA), Rhizophon A (IBA) and Rhizophon B (NAA). Generally rooting was found to be high under mist than in heated frames. In Delonix regia Battacharjee and Balakrishna (1983) obtained no rooting when treating with the growth substance or girdling alone was done, whereas application of IBA at 10,000 ppm in lanolin paste to girdled mother shoots three weeks prior to taking cuttings and pre-planting treatment of these cuttings with IBA at 6,000 or 10,000 ppm resulted in 60-66 percentage rooting. In this case survival was also found to be high.

In a detail study conducted by Bose et al. (1970) semihardwood cuttings of 62 species and varieties of trees, shrubs and climbers were treated with NAA and IBA 3,000 ppm and hardwood cuttings with 6,000 ppm and planted under intermittent mist. They obtained a rooting percentage 80-100 with marked increase in the number of roots in 48 species and varieties using IBA and NAA. In 13 species and varieties the above chemicals induced only 50-80 per cent rooting. IBA was found to be most effective than NAA. Bose and Mondal (1972) studied the effect of intermittent mist on root formation of 30 species of perennial ornamental plants. The untreated cuttings of shrubs and climbers showed moderate to high percentage of rooting while those from trees in most cases showed poor rooting. Treatment with IBA was found to enhance rooting and was effective than NAA. They stated that the poor rooting with the trees may be due to the presence of more layers of mechanical tissue especially of schlerenchyma cells.

2.4. Root cuttings

In many plant species (eg. Apple, aonla, breadfruit etc.) rooting of cuttings is very low, and so, if successful the use of root cuttings in the propagation field will be an alternate approach, which can eliminate the need for rootstocks and special skill required for other vegetative methods.

Stoutemyer (1937) and Smith (1959) in apple observed the capacity of root cuttings to regenerate shoots. Tarasenko (1964) reported that propagation of apple by root cuttings would be an alternate approach, since they were capable of giving out shoots. Robinson and Schwabe (1977) studied the regeneration of apple cultivars from root cuttings. These were escavated to a depth of 0.5 cms before removal and the cuttings were taken at a length of 16 cms. They were kept horizontally one centimeter between the surface of vermiculate and kept under cold storage. He found that the root cuttings regenerated shoots in large amount.

Investigations were carried out by Mendilcioglu (1968) on the propagation of important fruit species like almond, plums, mahalebs, apricot, cherries, sour cherries, peaches, trifoliate orange and olive through root cuttings. Root cuttings were taken from trees of less than 4 years old and trees of 10-20 years old and it was observed that root cuttings from young trees regenerated shoots fairly well. The root cuttings of six clones of *Pyrus caucasica* were found to produce large amount of callus when planted after storage at 5-8^{o}C for four months with treatment of NAA at 1.5 or 3.0 g/l or IBA at 2.5 or 5.0 g/l for five seconds (Znajdek *et al.*, 1974). But the cuttings failed to survive inspite of producing leaves and shoots.

Taylor and Murray (1981) lifted the root segments of black berry cultivars Ashton cross and their regeneration under glass house condition was studied. Regeneration of root cuttings was high when they were lifted during winter months and when thicker roots were used. The regeneration was not found to be enhanced by chilling or treating the cuttings with kinetin or IAA and even IAA 100 ppm suppressed the production of adventitious shoots. Bolt (1983) in his trial on Barton pecan, cut the root cuttings into 100, 150 or 200 mm in length with a mean basal diameter of 10-15 mm. They were planted under 50 per cent shade and irrigated weekly. After one year the rooting was observed to be 60, 80 and 100 per cent and the length of new stem 150, 200 and 250 mm in 100, 150 and 200 mm root cuttings respectively.

Out of 150 root cuttings of Pelargonium graveolens which were of 5 cm length and 0.5 cm diameter 64 cuttings (43%) produced sprouts and roots (Swamy and Sundaram, 1963).

Smyk et al. (1982) propagated Potentialla alba, a medicinally important herbaceous plant by root cuttings taken in November. Lyubimov (1984) at Mangyshlak tried to develop an easy technique for the propagation of poplars, Populus euphratica, Populus pruinosa, Populus diversifolia and Populus pruninosa, which were of great use in urban

landscaping by root cuttings. The cuttings were planted in autumn in vertical slits along irrigated furrows and grown for two years. The success rate found to vary from 61 to 63 per cent in Populus ariana and Populus diversifolia and 75 per cent in other species.

III. Budding

Budding has been reported to be successful in several horticultural crops by various workers.

2.5. Method of budding

Budding in aonla was reported as early as 1952 by Singh. He selected aonla seedlings having a girth of one centimeter for shield budding during early June. After three weeks they were headed back and 90 per cent bud take was recorded. Nand (1959) conducted trials on shield budding using one to one and half year old aonla seedlings during second fortnight of September and found that the buds after union remained completely dormant upto January and gradually showed the signs of sprouting from the second week of February. The buds were found to grow very vigorously and they attained a height of 4" to 5" by the next rain. At Basti Teaotia and Asthana (1960) recorded 80 per cent success for patch budding in aonla during July. Srivastava (1964) and Srivastava (1965) also reported

good success for budding in aonla. Five to seven months old aonla seedlings were budded through shield, patch and forket method with buds taken from mature one year old twig, from June to September. June budding was found to initiate early sprouts with maximum success followed by those done in September, August and July. Gangwar et al. (1975) recommended 'T' budding for easy and commercial propagation and also for the rejuvenation of aonla trees. Moti et al. (1976) tried two types of budding viz. shield and patch method in a number of subtropical and tropical fruit plants including aonla and observed that patch budding resulted in 98.8 per cent success in aonla especially during May. Pandey and Prasad (1979) tried patch, chip and 'T' budding in aonla starting from May to October. On an average 66.7, 47.8 and 40.6 per cent bud take was recorded for patch, chip and 'T' budding respectively 90 days after budding. Patch budding in June (91.7 per cent take) was the best followed by May and July (85 and 80 per cent take respectively). July and August was on par and October produced worst result. Patch method was also found to be significantly superior with respect to length of scion.

In jackfruit Teaotia et al. (1963) obtained 100 per cent success for patch budding when done in June. Samadar and Yadav (1970) tried vegetative propagation through

budding in jackfruit and discovered that eventhough but take was there they failed to sprout.

Singh and Singh (1954) recommended patch budding for commercial propagation of mango during June. During July and August forket method of budding was found to produce better results in mango (Gandhi, 1955). Singh and Srivastava (1962) advocated forket method of budding in mango during July where the percentage of success was maximum (100 per cent). In a study on propagation of mango by shield budding, Parasai (1963) reported good success when nine month old seedlings were shield budded during spring when the temperature ranged from 90° and 100°F. Jaginder and Ali (1965) noticed more bud take in nine month old seedlings of mango stocks than in two year old stocks. Patch method of budding was found to be superior than any other method in mango under U.P. condition (Teotia and Maurya, 1970). Moti et al. (1976) conducted two types of budding viz. shield and patch in mango at monthly intervals from April to August with a view to standardise the type of budding and season of operation. Patch budding was found to be superior than shield budding with a success of 80 per cent and June was the best season.

The success of budding in cashew had been tried by various workers from different parts of the country.

Naik (1948) and De Albergaria (1967) recommended patch budding as a successful vegetative propagation method in cashew. Samadar and Yadav (1970) tried budding in a number of fruit plants including cashew and obtained a very high number of bud take (88). Compared to veneer grafting patch budding was found to be superior when done on One year old root stock (Phadnis et al., 1974). Palaniswamy and Hameed (1976) observed very vigorous growth and maximum survival of patch budded cashew plants.

In guava, Srivastava (1962) stressed the superiority of forket method of budding over shield method due to the vigorous growth. Srivastava (1963) repeated the experiment including patch method in guava and again found that forket method is the best owing to better growth performance and field establishment of budded plants followed by patch method. Shield budding was not a success. Superiority of patch budding in guava was found out by Moti et al. (1976) when done during June. Studies conducted by Singh et al. (1978) also revealed that patch budding was superior compared to chip-budding in guava and maximum take was obtained when done in August. Pandey et al. (1979) obtained 90 per cent success for patch budding in guava when one year old seedlings were used as rootstocks.

2.6. Effect of defoliation of scion shoot

To stimulate the terminal and axillary bud activity defoliation of scion shoots prior to detachment from the mother tree is advocated.

Singh and Khan (1943) in their trials on budding in mango, obtained greatest success when defoliated bud wood were used. Jauhari and Singh (1970) reported 50 per cent bud sprout in mango when buds were activated two weeks before budding as against 40 and 30.75 per cent by activating one week and without defoliation before budding respectively. Increased percentage of bud sprouts were noted in mango when two weeks prior defoliation treatment was given (Tenotia and Maurya, 1970).

In guava, Pandey et al. (1979) could obtain a success as high as 90 per cent when fresh swollen buds were used for budding as against the one week earlier defoliated ones (68.3 per cent).

IV. Air layering

The principle advantage of layering is the success with which plants can be rooted by this method. Many clones which will not root easily by cuttings can be propagated by layering enabling the plant to be established on its own roots.

Applying root promoting substances such as Indole butyric acid during layering is some times beneficial as it is with cuttings although the method of application may be somewhat different (Ching et al. 1956; Singh, 1953 and Vieitez, 1953). Applying the material to girdling cuts as a powder in lanolin or as a solution in 50 per cent alcohol can be utilised.

Some preliminary studies were conducted with success of air layering on aonla trees by Teaotia and Srivastava (1959) and Srivastava (1960).

IBA 10,000 ppm when applied in lanolin paste produced 100 per cent success in layering and 91.66 per cent field establishment of layers in jack (Mukherjee and Chatterjee, 1978). Lingarappan (1982) stated that pretreatments like etiolation and girdling together with the growth regulator treatment like IBA + NAA caused successful rooting in jack fruit air layers. Also the number of roots/layers, the length and weight of roots and survival of the layers in the field were also found to be greater.

In mango Singh (1954) obtained better results with NAA. 100 per cent rooting and survival was observed by Srivastava (1960) when 10,000 ppm NAA was applied to the air layers. Layering was found to be good for the clonal

propagation of mango rootstocks (Mukherjee, 1963). A mixture of IAA, IBA, IPA, and NAA each at 0.25 per cent or 0.5 per cent when applied in lanolin paste produced good roots in mango air layers (Rao et al., 1963). Sen and Bose (1967) found the superiority of IBA on rooting of mango air layers. Similarly Chhonkar and Singh (1972) reported the effectiveness of IBA particularly at a higher concentration of 5,000 ppm over NAA in the rooting of air layers in mango. Chatterjee (1982) applied IBA or NAA each at 5,000 and 10,000 ppm in lanolin paste to the mango air layers and the best rooting (75 per cent) and plant survival (55 per cent) was obtained with IBA at 10,000 ppm.

Rao and Hassan (1957) reported better rooting of cashew air layers during June and July when growth regulating substances like Seradix A was applied as against no rooting in control. Chhonkar and Singh (1967) conducted experiment to find out the effect of growth regulators like IBA and IAA in lanolin paste at varying concentrations on air layers in cashew. Mean number of roots produced by layers was found to be high in IBA compared to control and IAA. A positive relation was noticed between the concentrations of IBA and number of roots produced. Acharya and Dash (1972) reported that IBA at 3,000 ppm produced 84.6 per cent success compared to control where the success was 46.2 per cent and the longest

roots in cashew air layers. Trials conducted at the Cashew Research Station, Kottarakkara showed that the application of IAA at 250 ppm in lanolin paste to the layering twigs increased the percentage of rooting and subsequent sprouting of layers after separation.

In sapota 72 per cent rooting was noticed for treatment with IBA + NAA at 1000 ppm as against no rooting in control (Singh et al., 1962). Sulladmath and Kulotgi (1969) tried varying concentrations of NAA, IBA, IAA and IBA+NAA on rooting of sapota air layers. NAA at all concentrations were found to be toxic while IBA and IBA + NAA induced earlier and better rooting. For the combination treatment IBA + NAA 10,000 ppm was found to be the best which produced better root system with larger number of laterals and tertiary roots and when used individually IBA 10,000 ppm was the best.

In guava var. Lucknow 49, Bhujbal (1972) attained 86.6 per cent rooting and 76.6 per cent of field survival by the use of IBA at 3,000 ppm.

Materials and Methods

MATERIALS AND METHODS

The present investigations were carried out in the Department of Pomology and Floriculture, College of Horticulture during 1984-85 with the objective of standardising the propagation techniques in *Phyllanthus emblica* Linn.

The study consisted of two aspects.

(i) Seed propagation

(ii) Vegetative propagation like shoot cuttings, root cuttings, budding and layering.

Expt. 1. Seed propagation

The experiment on seed propagation was carried out to establish suitable methods to increase the germination of stones/seeds, survival of seedlings and their subsequent growth.

3.1. Effect of chemicals and mist

The effect of chemical treatments and mist on the germination of stones and extracted seeds, survival of seedlings and their subsequent growth was studied during the two seasons viz. summer (February 1985 to May 1985) and rainy season (June 1985 to November, 1985).

Number of seeds/stones under each treatment was 20 and the design of the experiment was CRD.

3.1(a) Extraction of seeds

The method adopted was as described by Sreekumar and Aravindakshan, 1985. Fully ripe fruits were collected and they were left in the sun on a floor for two to three days till the fruits dried up completely and split open to release the seeds within the stones. These seeds were collected and subjected to different chemical treatments.

3.1(b) Chemical treatments

The chemical treatments consisted of the following.

GA - 250 ppm, 500 ppm, 1000 ppm

Vit C - 1% , 2% , 5%

Thiourea - 1%, 2% , 5%

Potassium nitrate (KNO_3) - 1%, 2%, 5%

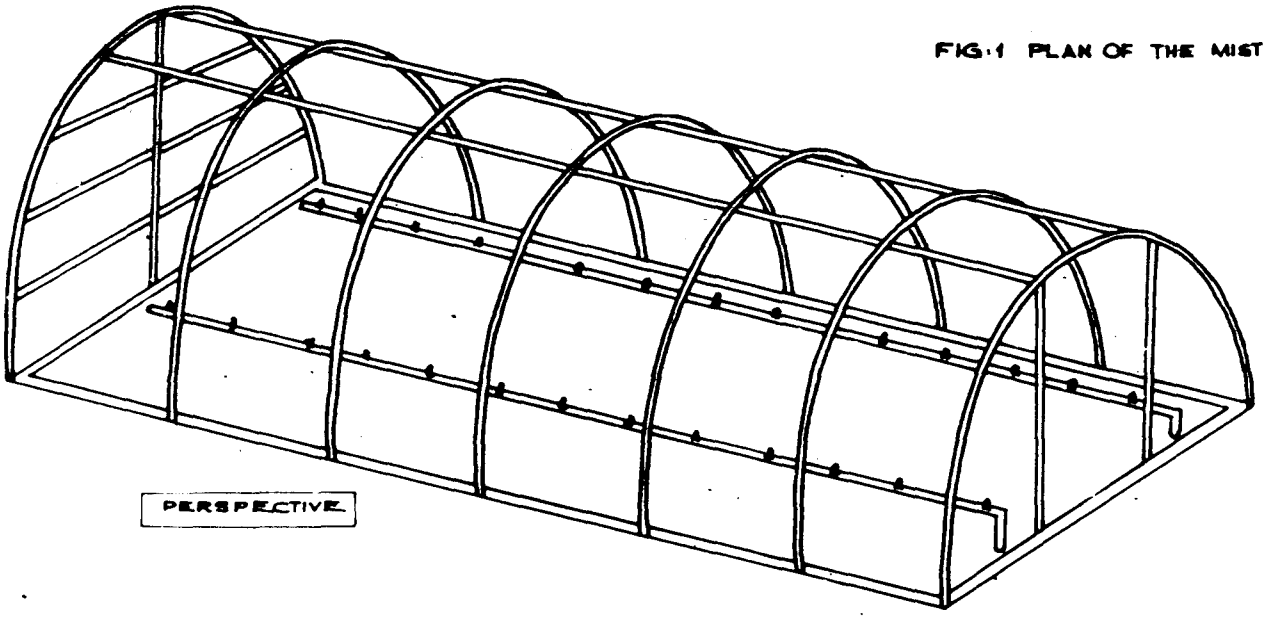
Indole acetic acid (IAA) - 250 ppm, 500 ppm, 1000 ppm

Control

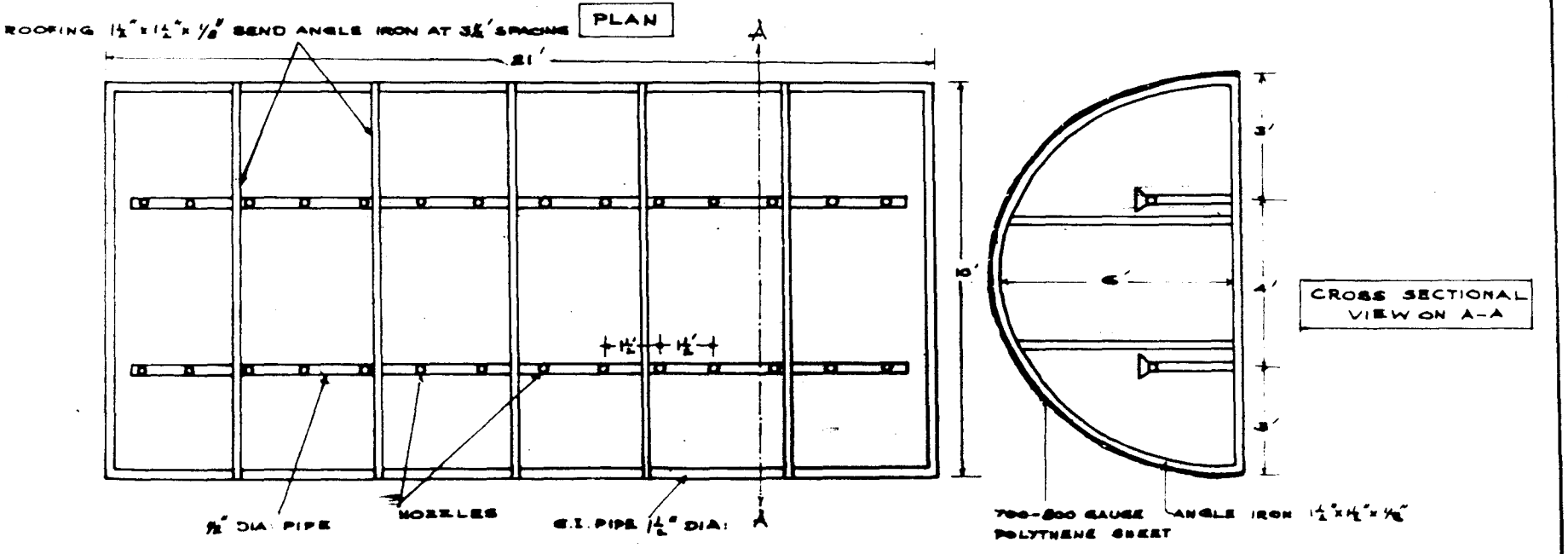
3.1(c) Mist chamber and misting operation

The details of the mist chamber used for the study are given in the figure 1. Misting was done at one hour interval for three minutes, from 8 A.M. to 7 P.M. every day.

FIG·1 PLAN OF THE MIST CHAMBER



PERSPECTIVE



3.1(d) Observations

The treated seeds/stones were sown in pots containing potting mixture (Sand: soil: cowdung in the ratio 2:1:1) and were kept under both mist and open conditions. They were observed for percentage of germination and survival of seedlings.

One month after germination the seedlings were taken out of the mist chamber and their growth characters like height, girth and number of leaves produced were observed.

The climatological observations like temperature and humidity were recorded both under open and mist conditions for the period of study.

3.2. Effect of storage treatments on seed viability

This experiment was done to assess the retention of viability of seeds under different storage methods in two conditions viz. Low temperature (4°C and 40% R.H) and room temperature (20-33°C at 92% R.H).

The storage methods consisted of (a) cloth bag (b) polythene bag (c) in open container.

To find out the initial viability of the seeds the seeds were sown immediately after extraction under mist

condition. Then at one month interval 20 seeds were drawn from each container and were sown under the same condition.

Number of seeds germinated were recorded to calculate the germination percentage and this was taken as a measure of viability.

Expt.II. Propagation through shoot and root cuttings

Rooting efficiency of shoot cuttings and the regeneration capacity of both root cuttings and intact roots were included in the study. The trial on shoot and root cuttings were done from July 1984 to October 1984 and on intact roots from January 1985 to November 1985.

3.1. Effect of growth regulators on rooting of shoot cuttings

The following growth regulators at concentrations specified below were tried for rooting of cuttings.

IBA - 250 , 500 , 1000 , 1500 and 2000 ppm

NAA - 250 , 500 , 1000 , 1500 and 2000 ppm

IBA+NAA - 250 , 500 , 1000 , 1500 and 2000 ppm

Number of cuttings under each treatment was 100 and the design of experiment was CRD.

3.1.1. Collection and preparation of shoot cuttings

Uniform shoots of 3 cm thickness were collected from trees maintained at the Instructional Farm, Mannuthy. Cuttings of about 15 cm length were prepared and were bundled to fifty each for growth regulator treatment.

3.1.2. Preparation of growth regulators

A stock solution of 2000 ppm of NAA and IBA were separately prepared after dissolving the growth regulators in minimum quantity of alcohol and were diluted with distilled water to appropriate concentrations. No flocculation was observed in the preparation of stock solution or during dilution.

3.1.3. Treating the cuttings with growth regulators

The basal ends (5 cm) of the cuttings were dipped in the prepared growth regulator solution for three seconds in the case of higher concentrations i.e. 1000 ppm and above and 12 hrs in the case of other lower concentrations.

3.1.4. Planting

The cuttings so treated were planted under three conditions namely in nursery beds under partial shade, pots (filled with potting mixture in the ratio sand:soil: cowdung - 2:1:1) and under mist in a mist chamber.

3.1.4(a) Preparation of nursery beds

Nursery beds of 1 M x 1 M size were prepared and sand was spread evenly over these beds. The cuttings were planted at a spacing of 10 cm x 10 cm.

3.1.5(b). Mist operation

Misting was done at one hour interval for three minutes from 8 A.M. to 7 P.M. every day.

3.1.6. Observations

The cuttings were observed for sprouting (daily). 10 cuttings were removed from each treatment at 10 days interval for observation on rooting. Number of shoots/ cuttings, extension of scion shoots and number of leaves/ sprouted cuttings were also recorded at 10 days interval.

3.2. Effect of growth regulators on regeneration of root cuttings

Since aonla produce suckers from roots, possibility of propagation through root cuttings were also tried with the same concentrations of growth regulator treatment as described earlier for shoot cuttings.

3.2.1. Collection and preparation of root cuttings

The root cuttings were collected from the full grown trees from Valakkavu forest area in Trichur district from five trees. Roots of about 2 to 5 cm in thickness were selected. The distal and proximal ends were marked and brought to the College of Horticulture, Vellanikkara on the same day of collection. Cuttings of 15 cm in length were prepared for various treatments.

3.2.2. Preparation of the field and planting

The nursery beds of 1 M x 1 M size were prepared and the cuttings were planted at 20 cm apart in a slight slanting position with proximal end facing upward.

The cuttings were observed for sprouting.

3.3. Sucker production from intact roots

The trial was conducted to examine whether sucker production can be accelerated by injuring intact roots.

Five full grown trees were selected for this experiment. The soil at the root region was removed so as to expose the roots without causing damage. In each tree the exposed roots were categorised into four groups based on the root thickness namely 3 cm, 5 cm, 7 cm and 10 cm.

Each group consisted of 50 roots. The roots were injured by removing a 'V' shaped portion from the top ¼th of the root and roots were covered with soil.

The observations consisted of the number of roots sprouted and their growth characters like height, girth and number of leaves. These growth parameters were recorded one month after sprouting upto 45 days.

3.3./. Survival of transplanted suckers

The roots were injured 15 cm apart on both sides of the suckers and after 15 days they were separated and planted in pots. The observation on survival was recorded two months after transplanting.

Expt. III Budding

3.1. Effect of the method of budding and defoliation of scion shoot

The experiment was conducted during 1985 to find out the effect of two methods of budding namely patch and 'T' budding and precuring of scion shoots on the final success. The precuring consisted of the following three types of defoliation of scion shoots.

1. No defoliation (control).
2. 3 days after defoliation.
3. 6 days after defoliation.

Twenty seedlings were budded under each of the three defoliation treatments in both the methods. Design of the experiment was CRD.

3.2. Seedlings for rootstock

The seedlings were made available from Chambakad colony area in Idukky district. They were raised from the seeds collected from a single selected parent (Chambakad large) and were of 9 month old and raised in polybags. These seedlings were brought to the College of Horticulture, Vellanikkara and they were repotted in mud pots in a medium consisting of FYM, soil and sand in the ratio 2:1:1 and were kept in partial shade. When they were one year old, healthy and vigorous seedlings (Plate I) were selected and utilised for budding.

3.3. Selection and preparation of scion shoot

The bud woods were selected from a single tree growing in the College orchard. The selected bud woods were defoliated six days and three days prior to budding and labelled properly. In the case of no defoliation the leaf blades were removed on the same day of budding. These three types of scion shoots were severed from the mother tree on the same day of budding.

PLATE I. One year old rootstock for budding.

Plate I

3.4. Budding operation

Two methods of budding patch and 'T' were done on the same day (3.6.85).

3.4(a). 'T' budding

A vertical cut about 2.5 cm was made approximately 2 cm above the collar region of the stock first and then a horizontal cut through the bark about 1/3rd the distance around the stock. The two flaps of the bark was opened with the help of a knife. The buds were then removed from the bud wood and was inserted by pushing it downward under the flaps of the bark and bud union was tied with polythene.

3.4(b). Patch budding

A patch of bark was removed from the stock and in the same manner a patch containing the bud was removed from the bud wood. It was inserted on the stock and the union was wrapped tightly with polythene.

3.5. After care of budlings

When the union was ensured as indicated by the bursting of the buds, the top portion of the rootstocks were clipped off in two stages as described by Srivastava (1963) viz. clipping of the top one-third portion two weeks

after budding and rest two-third portion three weeks after the first cut leaving 3 - 5 cm above the bud. Suckers from the rootstocks were removed as and when they appeared. Weeding and plant protection measures were carried out at regular intervals.

3.6. Observations

The budded plants were examined daily for the sprouting of the buds and the final success was assessed after 40 days of budding. The following growth parameters were recorded at 20 days interval starting from one month after budding.

1. Extension of scion shoot.
2. Girth of the rootstock and scion (measured 1 cm below and 1 cm above the joint respectively).
3. Number of leaves on the scion shoot.

Expt.IV. Air layering

3.1. Effect of growth regulators on rooting

For the experiments in air layering one year old shoots were selected from five trees available in the college orchard. These trees were five year old. The scion shoots so selected were brown in colour and about 5 cm in thickness. The layering was done in June, July and

August at monthly intervals during first week of every month in the year 1984.

The following growth regulators were applied in lanolin paste at concentrations as specified below.

IBA - 250, 500, 1000, 1500, 2000 ppm

NAA - 250, 500, 1000, 1500, 2000 ppm

NAA + IBA 250, 500, 1000, 1500, 2000 ppm

Control

3.1.1. Preparation of growth regulators in lanolin paste

To prepare the above specified concentrations, separately weighed quantity of growth regulators were dissolved in 2 ml of alcohol and were throughly mixed with required amount of lanolin paste.

Twentyfive shoots were selected under each treatment and the design of the experiment was CRD.

3.1.2. Layering operation

A strip of bark about 2.5 cm wide was removed from around the stem at a position of about 25 cm from the tip end of the shoot.

The lanolin paste mixed with appropriate concentrations of growth regulators were applied to the exposed

wound. Moistened sphagnum moss was placed around the stem to enclose the cut surface and a piece of polythene film was wrapped around so as to cover the sphagnum moss and the two ends were tied firmly with twine.

3.1.3. Observations

Five air layers were detached from the mother trees at 15 days intervals for observations on callus formation and rooting.

3.2. Effect of higher concentrations of IBA on root initiation

The above experiment indicated that callus formation was confined to the treatments with the growth regulator IBA during the month of July. Further trials were therefore restricted to treating of the shoots with IBA adding higher concentrations as treatments.

The experiment was carried out on five year old plants at college orchard. The shoots were of one year old and brown in colour. Fourty shoots were selected in each treatment with varying concentrations of IBA as given below.

IBA - 250, 500, 1000, 2000, 3000, 4000 and 5000 ppm.

3.2.1. Observations

The observations on callus formation and rooting was observed at fortnightly intervals by removing five shoots from each treatment at a time.

Statistical analysis

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

The differences among treatments with regard to the qualitative characters such as seed germination, seedling survival, sucker production from roots, sprouting and final survival in budding were tested for significance using chi-square test. Whenever the number of treatments were more than two.

Chi-square was calculated as

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

where χ^2 = chi-square

a is the number of successes under each treatment.

a^1 is the number of failiures under each treatment.

n_1 is the number of successes for all the treatments taken together

n_2 is the number of failures for all the treatments taken together

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

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

where a and c are the number of successes under each treatment. b and d are the number of failiures under each treatment. and $n = a+b+c+d$

The differences among the treatments with respect to quantitative characters viz. height, girth and number of leaves observed as well as the growth of these characters were tested for significance using analysis of variance.

The linear growth rate of 'Y' for each plant was obtained by using the formula,

$$b = \frac{\Sigma xy - \frac{(\Sigma x)\ (\Sigma y)}{n}}{\Sigma x^2 - (\Sigma x)\ (\Sigma x/n)}$$

where b = Linear growth rate of y.

x = Time expressed in days.

n = Total number of observations.

To find out the correlation coefficient (r) between time and seedling growth, sucker growth or scion extension for

various treatments the formula used was

$$r = \frac{\Sigma xy - \frac{(\Sigma x)\ (\Sigma y)}{n}}{\sqrt{(\Sigma x^2 - (\Sigma x)\ (\Sigma x/n))\ (\Sigma y^2 - (\Sigma y)\ (\Sigma y/n))}}$$

The expected value for each character was obtained by using the formula

$$y = a + bx$$

where

y = character for which expected value is obtained.

b = linear growth rate

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

$\bar{y}$ = mean of y

$\bar{x}$ = mean of x

Results

RESULTS

The results of the present studies on standardisation of propagation techniques in *Phyllanthus amblica* Linn. are presented hereunder.

I. Seed propagation

4.1. Effect of chemicals and mist

The results of the experiment conducted to find out the effect of chemical treatment and mist on seed germination, survival of seedlings and their growth behaviours are summarised below.

4.1.1. Effect on germination

The stones irrespective of the treatments failed to germinate and the percentage of germination of the extracted seeds during both the seasons are presented in Table 1.

During summer there was no significant difference among the chemicals on seed germination under mist. However, GA 250 ppm induced maximum germination (80%). On the other hand the treatments differed significantly under open. Thiourea 1 per cent induced maximum germination (30%) and it was on par with GA 250 ppm (25%), GA 500 ppm (20%), GA 1000 ppm (15%), Vit C 1 per cent (10%), Vit C

Table 1. Effect of chemicals and mist on germination of seeds

Treatments		Summer		Rainy	
		Mist (%)	Open (%)	Mist (%)	Open (%)
GA	250 ppm	80	25	70	60
	500 ppm	55	20	60	45
	1000 ppm	40	15	55	40
Vit C	1%	50	10	20	10
	2%	40	5	30	10
	5%	40	10	40	0
Thiourea	1%	50	30	20	10
	2%	40	20	30	10
	5%	60	0	40	20
KNO_3	1%	40	0	30	0
	2%	40	5	30	10
	5%	60	15	20	5
IAA	250 ppm	60	0	45	30
	500 ppm	60	10	40	20
	1000 ppm	50	5	20	0
Control		40	0	20	5
Chi-square value		18.59	52.96**	31.78**	66.72**

** Significant at 1 per cent level of probability

5 per cent (10%), Thiourea 2 per cent (20%), KNO_3 5 per cent (15%) and IAA 500 ppm (10%). Treatments with Thiourea 5 per cent, KNO_3 1 per cent and IAA 250 ppm as that of control failed to induce germination.

During rainy season under both the conditions viz. mist and open the chemical treatments were found to differ significantly. GA 250 ppm produced the maximum germination (70% and 60% respectively) followed by GA 500 ppm (60% and 45% respectively) and GA 1000 ppm (55% and 40% respectively). There was no significant difference between these three levels of GA.

The results of the pooled analysis of the data to find out the effect of chemical treatment for both the seasons are presented in Table 1(a). During summer there was no significant difference between the treatments. However, maximum germination was noted with GA 250 ppm (52.5%) followed by Thiourea 1 per cent (40%) and lowest germination was in KNO_3 2 per cent (17.5%). During rainy season the treatments differed significantly and the maximum percentage of germination was noted for GA 250 ppm (65%) followed by GA 500 ppm (52.5%) and GA 1000 ppm (47.5%). The lowest germination was noted with IAA 1000 ppm (10%) followed by control (12.5%) and KNO_3 5 per cent (12.5%).

Table 1(a). Effect of chemicals on germination

Treatments		Summer (%)	Rainy (%)
GA	250 ppm	52.5	65.0
	500 ppm	37.5	52.5
	1000 ppm	27.5	47.5
Vit C	1%	30.0	15.0
	2%	22.5	22.5
	5%	25.0	25.0
Thiourea	1%	40.0	15.0
	2%	30.0	20.0
	5%	30.0	30.0
KNO_3	1%	20.0	15.0
	2%	17.5	20.0
	5%	37.5	12.5
IAA	250 ppm	30.0	37.5
	500 ppm	35.0	30.0
	1000 ppm	27.5	10.0
Control		20.0	12.5
Chi-square value		22.66	78.84**

** Significant at 1 per cent level of probability

The data presented in Table 1(b) clearly indicated the beneficial effect of mist on seed germination. During both the season mist significantly increased the germination of seeds compared to open condition. Under mist condition the germination percentage was 49.69 during summer and 35.63 during rainy season. While under open condition it was only 10.63 per cent and 17.19 per cent respectively.

Result of the pooled analysis of the data presented in Table 1(c) showed no significant difference between the two seasons on germination of seeds.

The germination percentage and weather parameters like maximum and minimum temperature, relative humidity under mist and open condition are given in Appendix I. It can be seen that a higher percentage of germination was obtained when the temperature fluctuation (especially that of soil) was low and relative humidity was maximum.

4.1.2. Survival of seedlings

The data on the percentage of seedlings survived out of the seeds germinated for both conditions viz. mist and field for the two seasons are presented in Table 2.

Table 1(b). Effect of mist on germination

Treatments	Summer (%)	Rainy (%)
Mist	49.69	35.63
Open	10.63	17.19
Chi-square value	102.69**	25.79*

* Significant at 5 per cent level of probability
** Significant at 1 per cent level of probability

Table 1 (c). Effect of season on germination

Season	Germination (%)
Summer	30.16
Rainy	26.88
Chi-square value	2.22

Table 2. Effect of chemicals and mist on survival of seedlings

Treatments		Summer		Rainy	
		Mist (%)	Open (%)	Mist (%)	Open (%)
GA	250 ppm	87.5	40	95.7	50.0
	500 ppm	100.0	0	83.3	33.3
	1000 ppm	87.5	0	100.0	50.0
Vit C	1%	70.0	0	100.0	0.0
	2%	50.0	0	83.3	33.3
	5%	75.0	0	87.5	0.0
Thiourea	1%	80.0	30	100.0	50.0
	2%	50.0	0	83.3	50.0
	5%	75.0	0	75.0	25.0
KNO_3	1%	50.0	0	100.0	0.0
	2%	66.6	0	100.0	0.0
	5%	66.6	0	100.0	0.0
IAA	250 ppm	41.6	0	88.0	33.3
	500 ppm	33.3	0	87.5	0.0
	1000 ppm	33.3	0	100.0	0.0
Control		50.0	0	100.0	0.0
Chi-square value		30.55*	0	3.63	9.15

*Significant at 5 per cent level of probability

During summer the seedling survival was nil under open condition in the treatments other than GA 250 ppm (40%) and Thiourea 1 per cent (30%). Under mist the treatments had significant influence on survival of seedlings. Maximum survival was noted with GA 500 ppm (100%) followed by GA 250 ppm and 1000 ppm (87.5%). The next best treatments were Thiourea 1 per cent (80%) followed by Thiourea 5 per cent and Vit C 5 per cent (75%). The survival was minimum with the treatments IAA 500 ppm and IAA 1000 ppm (33.3%). During rainy season the treatments had no significant influence on survival of seedlings. The percentage survival ranged from 25 to 50 under open and 75 to 100 under mist.

The chi-square test based on the consolidated data (Table 2(a)) showed that during summer the seedling survival was significantly affected by various chemical treatments. Maximum survival was noted when seedlings were treated with GA 250 ppm (76.19%) followed by Thiourea 5 per cent (75%) and GA 500 ppm (73.33%). IAA at 500 ppm (28.57%) and Thiourea 2 per cent (33.33%) recorded the minimum percentage of survival. All other treatments were on par. During rainy season the survival percentage did not differ significantly between various treatments.

Table 2(a). Effect of chemicals on survival of seedlings

Treatments		Summer (%)	Rainy (%)
GA	250 ppm	76.19	69.23
	500 ppm	73.33	61.90
	1000 ppm	63.63	78.95
Vit C	1%	58.33	66.66
	2%	44.44	66.66
	5%	60.00	70.00
Thiourea	1%	68.75	83.33
	2%	33.33	75.00
	5%	75.00	58.33
KNO_3	1%	50.00	100.00
	2%	57.14	75.00
	5%	53.33	80.00
IAA	250 ppm	41.66	71.43
	500 ppm	28.57	83.33
	1000 ppm	39.36	100.00
Control		50.00	100.00
Chi-square value		29.62*	10.32

* Significant at 5 per cent level of probability

The data on the percentage survival of the seedlings for two seasons viz. summer and rainy under mist and open conditions are furnished in Table 2(b). Statistical analysis of the data indicated that mist had a very significant influence on seedling survival. Survival was 64.77 per cent under mist while it was only 13.88 per cent under open during summer and during rainy season seedling survival was found to be 90.35 per cent and 39.66 per cent respectively.

The results of the pooled analysis of the data to find out the influence of season is given in Table 2(c). The seasonal influence on the survival rate was evident. Survival percentage was high (73.20%) during rainy season compared to summer (53.38%).

The weather parameters like maximum and minimum temperature, relative humidity and survival percentage of the seedlings are presented in Appendix II. Survival of seedlings got reduced when the variation in temperature especially that of soil was high. Relative humidity and seedling survival was positively related.

4.1.3. Growth behaviour of seedlings

The observations on the growth parameters like height, girth and number of leaves recorded at 20 days

Table 2(b). Effect of mist on survival of seedlings

Treatments	Summer (%)	Rainy (%)
Mist	64.77	90.35
Open	13.88	39.66
Chi-square value	30.76**	50.42**

** Significant at 1 per cent level of probability

Table 2(c). Effect of season on survival of seedlings

Season	Survival (%)
Summer	53.38
Rainy	73.26
Chi-square value	12.63*

* Significant at 5 per cent level of probability

interval commencing from one month after sowing during summer and rainy seasons are as follows.

4.1.3(a). Height of seedlings

The consolidated data on the effect of seed treatment on the height of seedlings and rate of increase in height are given in Table 3 and 4 for the summer and rainy season respectively.

The analysis of the data indicated that the treatments differed significantly (Appendix III and IV). All the three levels of GA, Thiourea and Potassium nitrate significantly increased the height of the seedlings over control both during summer and rainy season. GA in general and especially at a concentration of 250 ppm produced the tallest seedlings. GA 500 ppm and GA 1000 ppm did not show any significant difference. All the three levels of Vit C were found to be inferior especially during summer where the effect was on par with control. A graphical presentation of these aspects are given in Fig.2 and 3.

The different treatments were also compared for rate of increase in height using analysis of variance. During summer maximum rate of increase was noted for GA 1000 ppm (2.7 cm) followed by GA 250 ppm (2.5 cm) and GA 500 ppm (2.4 cm). These three levels of GA did not differ

Table 3. Effect of chemicals on height of seedlings (Summer season)

Treatments		Height (cm)				Rate of increase in height
		20 days	40 days	60 days	80 days	
T_1 GA	250 ppm	6.55	9.23	12.78	13.53	2.50
T_2	500 ppm	5.48	8.40	11.30	12.33	2.40
T_3	1000 ppm	6.03	9.80	11.68	12.63	2.70
T_4 Vit C	1%	1.55	2.20	3.63	4.58	1.10
T_5	2%	1.43	2.15	2.85	4.08	0.72
T_6	5%	1.83	2.18	3.18	3.98	0.75
T_7 Thiourea	1%	4.68	6.08	8.13	8.98	1.50
T_8	2%	3.93	4.95	7.33	8.05	1.50
T_9	5%	4.65	5.35	7.70	8.75	1.40
T_{10} KNO_3	1%	4.40	6.33	8.55	9.43	1.70
T_{11}	2%	5.50	8.38	11.08	11.90	2.20
T_{12}	5%	4.83	7.60	9.28	10.58	1.90
T_{13} IAA	250 ppm	5.20	7.20	9.65	10.30	1.80
T_{14}	500 ppm	2.17	2.88	4.58	5.48	1.20
T_{15}	1000 ppm	4.30	5.40	7.03	9.15	1.60
T_0 Control		1.53	2.20	2.88	3.45	0.65
CD =		0.61	0.97	1.07	1.08	0.30
SEm ±		0.22	0.34	0.38	0.38	0.11

Table 4. Effect of chemicals on height of seedlings (Rainy season)

Treatments		Height (cm)						Rate of increase in height
		20 days	40 days	60 days	80 days	100 days	120 days	
T_1 GA	250 ppm	7.75	18.88	33.23	47.28	59.88	75.05	13.5
T_2	500 ppm	6.98	18.08	29.48	44.98	55.45	70.28	12.7
T_3	1000 ppm	5.65	17.23	29.30	43.15	56.10	71.08	13.1
T_4 Vit C	1%	2.68	8.28	16.25	22.08	32.65	46.00	8.5
T_5	2%	2.23	8.10	14.05	19.05	26.93	35.93	6.6
T_6	5%	2.20	6.78	11.68	14.73	22.40	30.38	5.5
T_7 Thiourea	1%	4.78	16.38	29.13	41.83	54.65	69.80	12.9
T_8	2%	6.28	15.58	24.20	30.98	42.73	55.98	9.6
T_9	5%	4.33	14.45	19.32	24.63	33.08	45.10	7.6
T_{10} KNO_3	1%	5.93	16.38	29.03	42.23	52.95	67.28	12.3
T_{11}	2%	6.28	15.30	26.28	30.95	42.10	55.25	9.4
T_{12}	5%	5.30	15.63	28.40	41.35	52.40	66.00	12.2
T_{13} IAA	250 ppm	3.75	11.63	22.83	34.13	41.32	52.50	9.8
T_{14}	500 ppm	3.83	11.58	19.30	25.43	33.30	41.05	7.4
T_{15}	1000 ppm	3.55	12.05	15.40	19.63	30.00	39.18	6.5
T_0 Control		2.30	6.10	12.05	15.68	21.90	31.65	5.7
CD =		1.23	1.14	2.63	7.85	8.89	8.75	0.87
SEm ±		0.43	0.40	0.93	2.76	3.13	3.08	0.31

FIG. 2 EFFECT OF CHEMICALS ON THE HEIGHT OF SEEDLINGS (SUMMER SEASON)

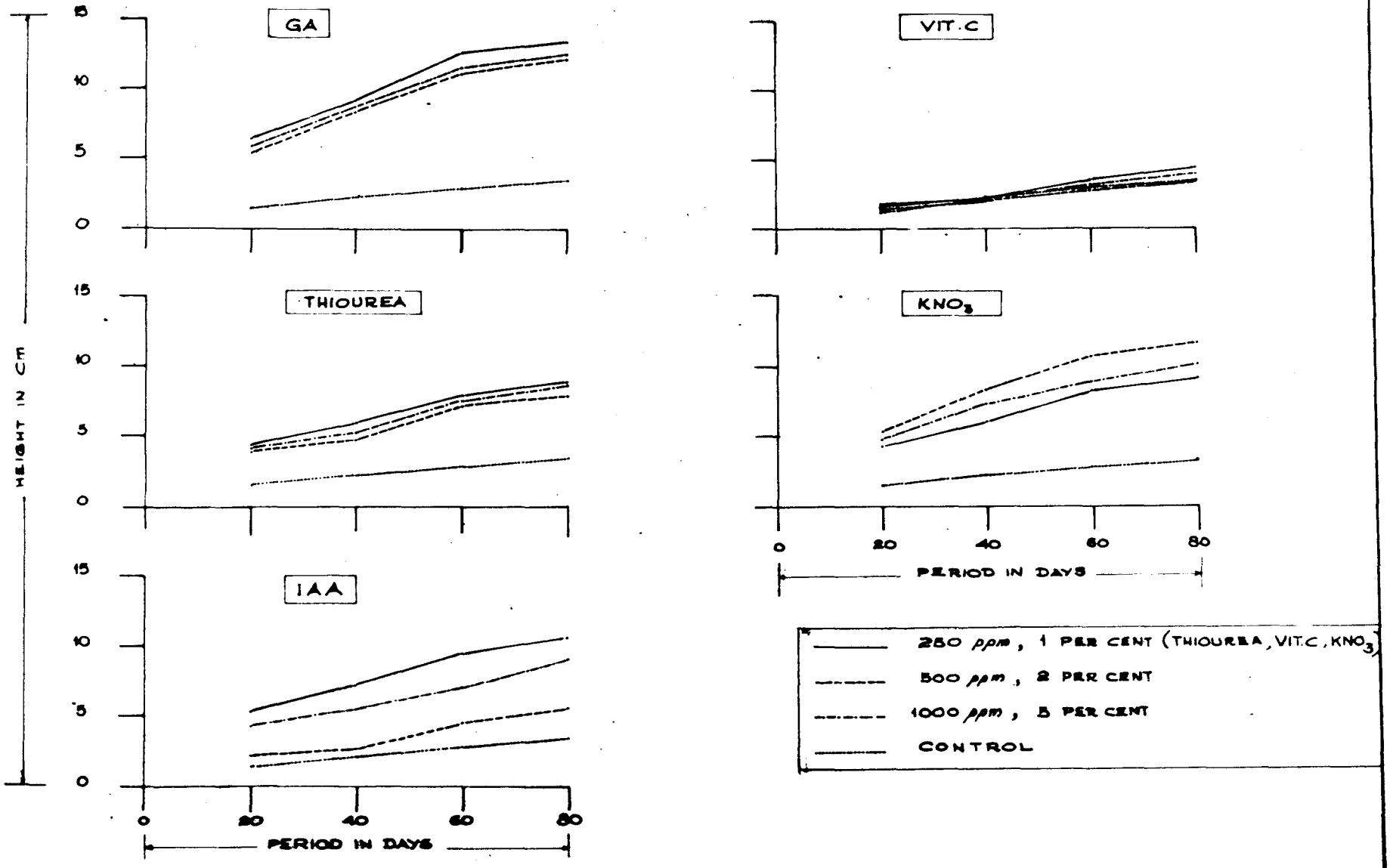
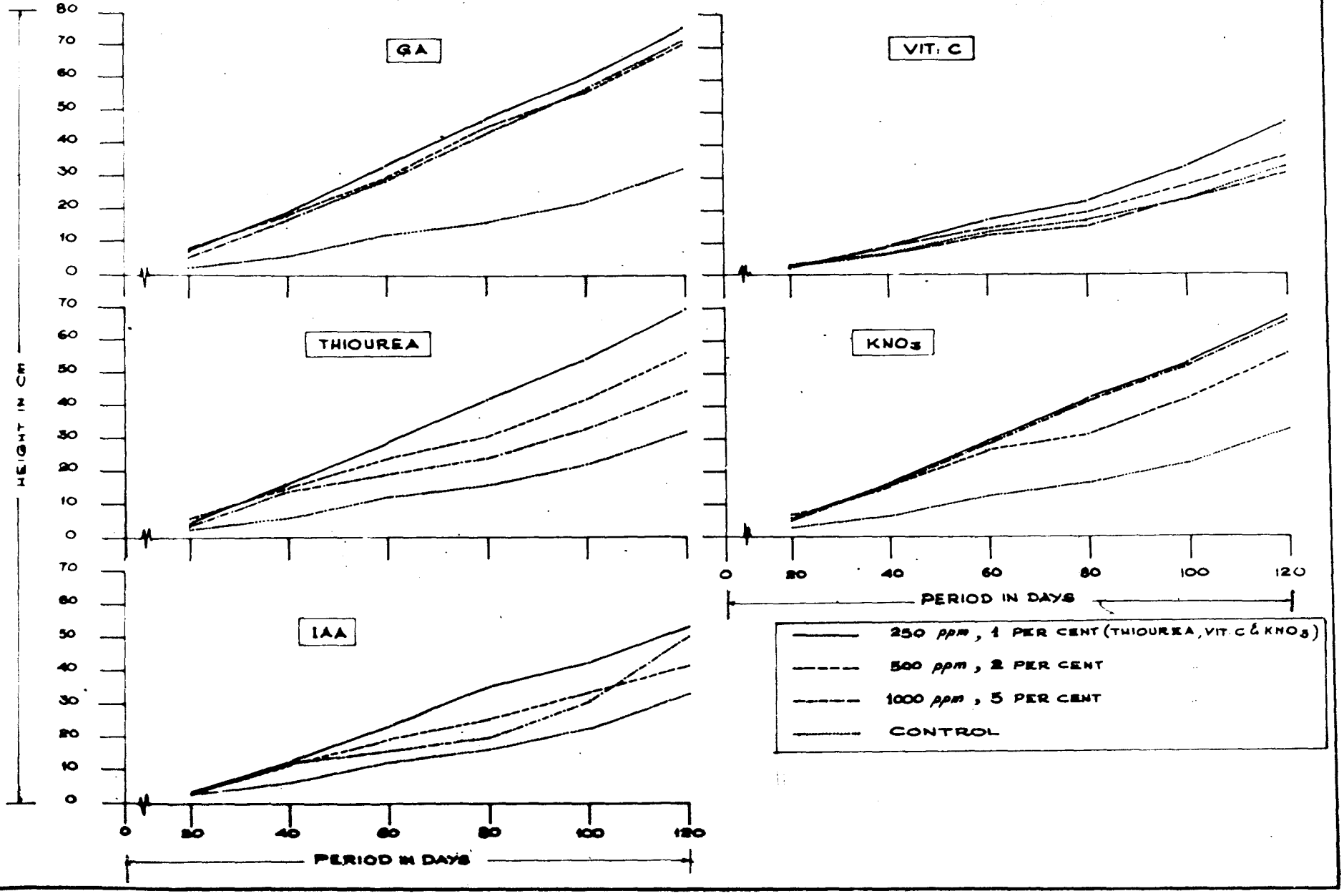


FIG: 3 EFFECT OF CHEMICALS ON HEIGHT OF SEEDLINGS (RAINY SEASON)



significantly. The growth rate was lowest in control (0.65 cm) and was on par with Vit C 2 per cent (0.72 cm) and Vit C 5 per cent (0.75 cm). In rainy season GA 250 ppm (13.5 cm), GA 1000 ppm (13.1 cm), Thiourea 1 per cent (12.9 cm) and GA 500 ppm (12.7 cm) was found to be the most effective treatments and there was no significant difference between them. The treatments, Vit C 2 per cent (6.6 cm), Vit C 5 per cent (5.5 cm) and IAA 1000 ppm (6.5 cm) was on par with control (5.7 cm).

The growth of the seedlings five months after germination (during rainy season) under various treatments can be seen from Plates II to VI.

The linearity of growth rate was tested using correlation coefficient between time and height of seedlings. It was observed that correlation coefficient was significant and linear nature was confirmed. Linear regression equation fitted to get the expected height of seedlings are given in Appendix V.

4.1.3(b). Girth of seedlings

The observations on girth of seedlings produced during summer and rainy seasons and rate of increase in girth are given in Table 5 and 6 respectively.

PLATE II. Effect of GA on growth of seedlings (Five months after germination)

T_0 Control
T_1 GA 250 ppm
T_2 GA 500 ppm
T_3 GA 1000 ppm

PLATE III. Effect of Vit C on growth of seedlings (Five months after germination)

T_0 Control
T_4 Vit C 1%
T_5 Vit C 2%
T_6 Vit C 5%

Plate II

Plate III

PLATE IV. Effect of thiourea on growth of seedlings (Five months after germination)

T_0 Control

T_7 Thiourea 1%

T_8 Thiourea 2%

T_9 Thiourea 5%

PLATE V. Effect of potassium nitrate on growth of seedlings (Five months after germination)

T_0 Control

T_{10} KNO_3 1%

T_{11} KNO_3 2%

T_{12} KNO_3 5%

Plate IV

Plate V

PLATE VI. Effect of IAA on growth of seedlings (Five months after germination)

T_0 Control

T_{13} IAA 250 ppm

T_{14} IAA 500 ppm

T_{15} IAA 1000 ppm

Plate VI

Table 5. Effect of chemicals on girth of seedlings (Summer season)

Treatments		Girth (cm)				Rate of increase in girth
		20 days	40 days	60 days	80 days	
T_1 GA	250 ppm	0.73	1.38	1.65	2.10	0.435
T_2	500 ppm	0.83	1.23	1.53	2.00	0.382
T_3	1000 ppm	0.98	1.30	1.60	2.00	0.338
T_4 Vit C	1%	0.75	1.10	1.40	1.83	0.352
T_5	2%	0.58	0.80	1.10	1.40	0.278
T_6	5%	0.80	1.08	1.35	1.73	0.305
T_7 Thiourea	1%	0.83	1.13	1.48	1.90	0.358
T_8	2%	0.65	0.93	1.30	1.68	0.345
T_9	5%	0.73	0.95	1.30	1.48	0.260
T_{10} KNO_3	1%	0.90	1.33	1.60	2.03	0.365
T_{11}	2%	0.78	1.03	1.38	1.73	0.320
T_{12}	5%	1.02	1.23	1.50	1.93	0.298
T_{13} IAA	250 ppm	0.73	0.95	1.20	1.58	0.280
T_{14}	500 ppm	0.75	1.00	1.35	1.70	0.320
T_{15}	1000 ppm	0.70	0.95	1.25	1.63	0.308
T_0 Control		0.40	0.68	0.93	1.20	0.265
CD =		0.25	0.23	0.23	0.22	0.008
SEm ±		0.09	0.08	0.08	0.08	0.031

Table 6. Effect of chemicals on girth of seedlings (Rainy season)

Treatments	Girth (cm)						Rate of increase in girth
	20 days	40 days	60 days	80 days	100 days	120 days	
T_1 GA 250 ppm	0.80	1.03	1.32	1.38	1.45	1.53	0.141
T_2 500 ppm	0.83	1.00	1.25	1.45	1.50	1.58	0.156
T_3 1000 ppm	0.73	0.88	1.15	1.30	1.35	1.45	0.149
T_4 Vit C 1%	0.73	0.88	1.08	1.28	1.30	1.45	0.146
T_5 2%	0.70	0.80	1.20	1.30	1.28	1.40	0.144
T_6 5%	0.70	0.83	1.08	1.20	1.23	1.30	0.144
T_7 Thiourea 1%	0.75	0.83	1.15	1.23	1.30	1.38	0.132
T_8 2%	0.70	0.83	1.05	1.38	1.45	1.53	0.181
T_9 5%	0.78	0.85	1.05	1.18	1.28	1.38	0.125
T_{10} KNO_3 1%	0.75	0.93	1.10	1.23	1.35	1.45	0.140
T_{11} 2%	0.75	0.80	1.13	1.25	1.28	1.38	0.134
T_{12} 5%	0.75	0.85	1.13	1.23	1.23	1.30	0.113
T_{13} IAA 250 ppm	0.68	0.75	1.08	1.33	1.33	1.40	0.160
T_{14} 500 ppm	0.80	0.95	1.23	1.33	1.35	1.43	0.126
T_{15} 1000 ppm	0.78	0.88	1.20	1.03	1.10	1.20	0.075
T_0 Control	0.65	0.73	0.90	0.95	1.03	1.50	0.095
CD =	0.10	0.13	0.15	0.11	0.11	0.28	0.045
SEm ±	0.37	0.05	0.05	0.04	0.039	0.10	0.012

Treatments were found to differ significantly during summer season (Appendix VI) with respect to girth. In general treatment with GA 250 ppm produced the best response while the untreated seedlings were significantly inferior to other treatments.

During rainy season the treatments had no significant effect on girth during initial stage of observation. However the effect was evident during the later stages and again observed to be nil at the final stage (Appendix VII). GA 250 ppm and 500 ppm gave the best response and they were on par. In general girth was minimum in control.

A comparison of the rate of increase in girth also showed significant effect due to treatments. Rate of increase was maximum in GA 250 ppm (0.435 cm) during summer whereas thiourea 2 per cent (0.181 cm) was found to be the best during rainy season.

The correlation worked out between the girth and age of seedlings was found to be significant thus indicating the linear nature of growth.

4.1.3(c). Number of leaves

Table 7 and 8 shows the number of leaves produced on the seedlings at 20 days interval and rate of leaf production during summer and rainy seasons respectively.

Table 7. Effect of chemicals on leaf production (Summer season)

Treatments		Leaf number				Rate of leaf production
		20 days	40 days	60 days	80 days	
T_1 GA	250 ppm	3.0	6.0	8.0	10.0	2.30
T_2	500 ppm	3.0	6.0	8.0	10.3	2.38
T_3	1000 ppm	3.0	5.3	8.0	10.5	2.53
T_4 Vit C	1%	2.0	5.0	7.0	9.3	2.38
T_5	2%	2.0	5.0	6.0	8.3	1.98
T_6	5%	2.0	5.0	6.0	8.0	1.90
T_7 Thiourea	1%	2.0	5.0	6.5	8.3	2.03
T_8	2%	2.0	5.0	7.0	8.8	2.23
T_9	5%	2.0	5.0	7.3	8.5	2.18
T_{10} KNO_3	1%	2.0	5.3	7.5	8.0	2.33
T_{11}	2%	2.0	5.8	7.5	9.3	2.35
T_{12}	5%	2.0	5.8	7.3	9.3	2.30
T_{13} IAA	250 ppm	2.3	5.5	7.5	9.5	2.38
T_{14}	500 ppm	2.3	5.0	7.0	9.3	2.23
T_{15}	1000 ppm	2.0	5.0	7.0	8.5	2.15
T_0 Control		2.0	3.0	3.5	4.8	1.03
CD =		0.32	0.42	0.52	0.82	0.28
SEm ±		0.11	0.15	0.18	0.29	0.09

Table 8. Effect of chemicals on leaf production (Rainy season)

Treatments		Leaf number						Rate of leaf production
		20 days	40 days	60 days	80 days	100 days	120 days	
T_1 GA	250 ppm	4.25	9.75	19.00	32.75	54.50	73.00	14.10
T_2	500 ppm	6.25	8.50	16.25	27.25	40.00	54.00	10.30
T_3	1000 ppm	4.25	7.50	16.75	28.25	39.75	53.75	9.97
T_4 Vit C	1%	3.20	6.25	10.25	14.75	19.75	30.25	5.32
T_5	2%	2.25	6.75	11.25	16.00	21.25	26.50	4.84
T_6	5%	2.25	6.50	10.25	15.75	22.25	26.25	4.86
T_7 Thiourea	1%	3.00	7.50	15.75	23.50	33.75	48.50	8.97
T_8	2%	2.50	7.50	14.50	23.00	30.25	35.75	6.94
T_9	5%	3.00	7.50	15.50	25.25	32.50	45.75	8.53
T_{10} KNO_3	1%	2.75	7.75	15.25	37.50	50.00	64.50	13.08
T_{11}	2%	2.75	7.25	14.75	31.75	42.00	55.50	11.00
T_{12}	5%	2.75	7.25	17.50	38.50	48.75	61.50	12.55
T_{13} IAA	250 ppm	3.00	6.50	11.00	16.25	20.50	30.75	5.32
T_{14}	500 ppm	2.50	7.25	12.50	18.50	23.75	28.25	5.27
T_{15}	1000 ppm	2.00	6.75	13.50	18.25	23.25	29.00	5.41
T_0 Control		2.00	4.50	9.00	13.75	11.25	18.75	3.11
CD =		0.65	0.99	1.97	2.89	6.93	3.64	0.54
SEm ±		0.23	0.34	0.69	1.02	2.44	1.28	0.18

All the treatments were significantly superior to control during both the seasons (Appendix VIII and IX) with respect to leaf production. Their effect became more evident as the seedlings grew. During summer, the treatment with GA in general was found to be the best and there was no significant difference among the three levels of GA. In the rainy season the best response was not stable with a particular treatment during the initial stages of observation (i.e. upto 80 days). But later GA 250 ppm dominated over other treatments and number of leaves was 73 after 120 days compared to a leaf number of 18.75 in control. The effect of potassium nitrate also became more apparent in the later stages and KNO_3 1 per cent recorded highest number of leaves than all the treatments other than GA 250 ppm.

Rate of leaf production was compared using analysis of variance and it was observed that this character of growth during summer was maximum with GA 1000 ppm (2.53) followed by GA 500 ppm, Vit C 1 per cent and IAA 250 ppm (2.38). It was minimum in control (1.025). During rainy season rate of leaf production was maximum in GA 250 ppm (14.10) followed by KNO_3 1 per cent (13.08), KNO_3 5 per cent (12.55) and KNO_3 2 per cent (11.00). The rate of leaf production was significantly the lowest in control (3.11).

The correlation between number of leaves and age was worked out and the correlation coefficient was found to be significant for both the seasons confirming the linear nature of leaf production.

4.2. Effect of storage treatments on seed viability

The data on the germination percentage of seeds stored under varying treatments are presented in Table 9. It is evident that the storage methods had significant influence only for one month and two months after storage. During these periods, in general maximum germination was noted with the seeds stored in cloth under low temperature but this was on par with the seeds stored in cloth under room temperature. There was no significant difference in viability of seeds stored in polythene and open under both the temperature.

The chi-square analysis showed that there is significant difference between the storage periods with respect to viability. Germination was 20 per cent initially (i.e. immediately after extraction) and reached maximum two months after storage irrespective of storage treatments. The viability was lost seven months after storage (Fig.4).

The pooled data to find out the effect of temperature on storage are presented in Table 9(a). There was no

Table 9. Percentage germination of seeds under different storage treatments (at monthly interval)

Storage treatments		1	2	3	4	5	6	7	
Low temperature (4°C)	Cloth	40	90	50	25	20	10	0	40.28**
	Polythene	30	50	40	20	10	0	0	27.15**
	Open	10	70	60	30	15	0	0	44.82**
Room temperature (22-33°C)	Cloth	30	70	45	20	10	10	5	33.48**
	Polythene	10	40	40	15	10	10	0	18.26**
	Open	0	40	30	15	0	0	0	31.74**
Chi-square value		15*	12.21*	4.22	2.07	4.57	6.32		

* Significant at 5 per cent level of probability

** Significant at 1 per cent level of probability

FIG: 4 EFFECT OF STORAGE TREATMENTS ON GERMINATION OF SEEDS

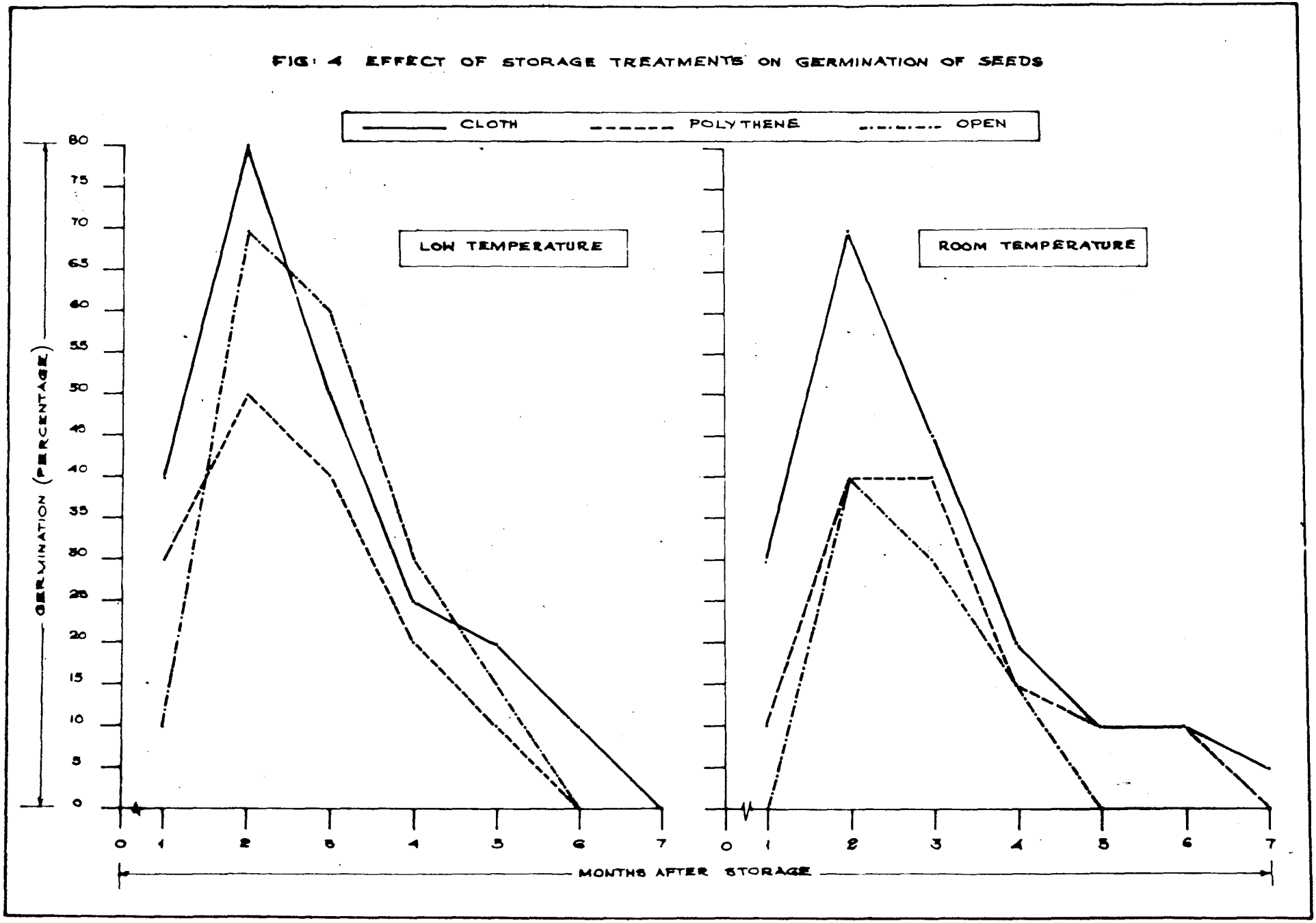


Table 9(a). Percentage germination of seeds under different storage temperature.

Storage temperature	1	2	3	4	5	6	7
Low temperature (4°C)	26.66	66.66	50.00	25.00	15.00	3.30	0.0
Room temperature (22-23°C)	13.33	50.00	38.33	16.67	6.67	6.67	1.6
Chi-square value	3.33	3.43	1.65	1.26	1.38	1.27	

Table 9(b). Percentage germination of seeds stored in different storage materials

Storage materials	1	2	3	4	5	6	7
Cloth	35	75	47.5	22.5	15.0	10	2.5
Polythene	20	45	40.0	17.5	10.0	5	0.0
Open	5	55	45.0	22.3	7.5	0	0.00
Chi-square value	11.25*	3.57	0.47	0.41	1.21	4.21	

* Significant at 5 per cent level of probability

statistical difference in the germination of seeds whether stored in low temperature or room temperature, throughout the periods of storage.

The data were pooled and analysed to find out the effect of storage material on germination (Table 9b). Significant difference was recorded only when the seeds were stored for one month. Maximum germination (35%) was obtained for the seeds stored in cloth followed by those stored in polythene (20%). Viability was least (5%) when the seeds were stored in open container. There was no significant influence for the storage material during the other periods.

II. Propagation through shoot and root cuttings

4.1. Effect of growth regulators on rooting of stem cuttings

All the cuttings invariably under mist and field condition failed to root, although sprouting was obtained when cuttings were kept under mist (Plate VII). The cuttings kept in open condition did not show any sign of sprouting (Plate VIII). The data on the percentage of cuttings sprouted under mist is given in Table 10. It can be seen from the table that maximum percentage of cuttings sprouted (70%) with the treatment IBA 250 ppm (Plate IX) followed by NAA 500 ppm (46%) (Plate X). The sprouting was very low (5%) in control.

PLATE VII Effect of mist on sprouting of cuttings (One month after planting).

PLATE VIII Failure of the cuttings to sprout under open condition.

Plate VII

Plate VIII

Table 10. Effect of growth regulators on sprouting of cuttings

Treatments (ppm)		Number of cuttings planted	Percentage sprouted
NAA	250	100	28
	500	100	46
	1000	100	16
	1500	100	9
	2000	100	30
IBA	250	100	70
	500	100	30
	1000	100	28
	1500	100	24
	2000	100	16
NAA + IBA	250	100	11
	500	100	10
	1000	100	14
	1500	100	22
	2000	100	22
Control		100	5

PLATE IX. Effect of IBA 250 ppm on sprouting of cuttings (One month after planting).

PLATE X. Effect of NAA 500 ppm on sprouting of cuttings (One month after planting).

Plate IX

Plate X

The data recorded one month after planting on the number of shoots, length of shoots and number of leaves per cutting under each treatment (at 10 days interval) are furnished in the Table 11, 12 and 13. Statistical analysis of these growth parameters were not carried out since all the sprouts dried up within three months.

4.2. Effect of growth regulators on regeneration of root cuttings

The observation trial conducted on the regeneration of root cuttings was not successful. Regeneration was nil irrespective of the different treatments given.

4.3. Sucker production from intact roots

Sucker production from the intact roots of grown up trees was noticed during the month of June (i.e. six months after injuring the roots). The percentage of sucker production from intact roots of varying thickness are presented in Table 14.

The analysis of the data showed that there was significant difference for the thickness of roots with respect to regeneration capacity. Maximum percentage of regeneration was noted with roots of 3 cm thickness

Table 11. Effect of growth regulators on number of shoots per cuttings (10 days interval)

Treatments (ppm)		Number of shoots			
		10 days	20 days	30 days	40 days
NAA	250	1.9	2.5	2.8	2.7
	500	2.6	3.5	4.0	3.8
	1000	1.6	2.4	2.8	2.6
	1500	0.0	0.0	0.0	0.0
	2000	2.0	2.5	2.2	2.3
IBA	250	2.5	3.5	3.5	4.4
	500	2.2	3.0	3.0	3.4
	1000	1.7	2.6	2.6	2.8
	1500	1.5	2.6	2.6	2.9
	2000	2.2	3.1	3.1	3.3
NAA + IBA	250	0.0	0.0	0.0	0.0
	500	1.5	2.5	3.1	2.6
	1000	2.0	2.1	2.1	2.5
	1500	2.1	2.3	2.3	0.0
	2000	2.0	2.3	2.3	2.1
Control		1.3	1.6	1.6	1.6

Table 12. Effect of growth regulators on length of shoots/cuttings (10 days interval)

Treatments (ppm)		Shoot length (cm)			
		10 days	20 days	30 days	40 days
NAA	250	3.32	4.39	5.60	5.82
	500	2.49	2.95	3.92	4.22
	1000	2.29	2.67	3.22	3.44
	1500	0.00	0.00	0.00	0.00
	2000	2.26	3.16	3.56	3.75
IBA	250	2.63	3.79	4.72	4.90
	500	3.90	5.43	6.15	6.14
	1000	1.73	2.34	2.76	2.97
	1500	1.89	2.61	2.97	3.26
	2000	2.35	2.99	3.39	3.59
NAA + IBA	250	0.00	0.00	0.00	0.00
	500	1.54	2.03	2.46	2.70
	1000	1.46	1.90	2.31	2.51
	1500	2.10	2.58	3.00	3.24
	2000	2.02	2.52	2.88	0.00
Control		1.27	1.62	2.14	2.28

Table 13. Effect of growth regulators on number of leaves/shoot (10 days interval)

Treatments (ppm)		Leaf number			
		10 days	20 days	30 days	40 days
NAA	250	2.8	5.0	6.1	6.1
	500	2.2	3.2	4.3	4.3
	1000	1.9	2.5	3.3	3.3
	1500	0.0	0.0	0.0	0.0
	2000	1.6	3.3	5.9	3.8
IBA	250	2.3	3.8	5.2	5.0
	500	3.3	5.1	5.8	6.2
	1000	1.2	2.2	3.4	3.3
	1500	1.2	2.1	3.1	3.1
	2000	2.1	2.6	3.7	3.5
NAA + IBA	250	0.0	0.0	0.0	0.0
	500	1.0	1.5	2.2	2.2
	1000	1.0	1.5	2.4	2.3
	1500	1.7	2.3	3.1	3.1
	2000	1.0	2.4	2.9	3.0
Control		1.0	1.9	2.5	2.3

Table 14. Effect of thickness of roots on regeneration

Thickness of roots	Number of roots injured	Number of roots sprouted	Percentage sprouting
3 cm	50	28	56
5 cm	50	17	34
7 cm	50	9	18
10 cm	50	6	12
Chi-square value		27.62**	

** Significant at 1 per cent level of probability

Table 15. Effect of thickness of roots on height of suckers (15 days interval)

Thickness of roots	Height (cm)			Rate of increase in height
	15 days	30 days	45 days	
3 cm	3.32	10.76	14.90	5.40
5 cm	3.14	6.20	10.64	3.75
7 cm	2.68	5.34	8.74	3.03
10 cm	2.24	3.96	6.36	2.06
CD	0.49	0.74	0.58	0.60

followed by roots of 5 cm thickness. Lowest regeneration was noted in 10 cm thick roots. It is evident from the table that the thickness of roots is negatively correlated with regeneration capacity. A graphical presentation of this aspect is given in Fig.5.

4.3.1. Growth behaviour of suckers

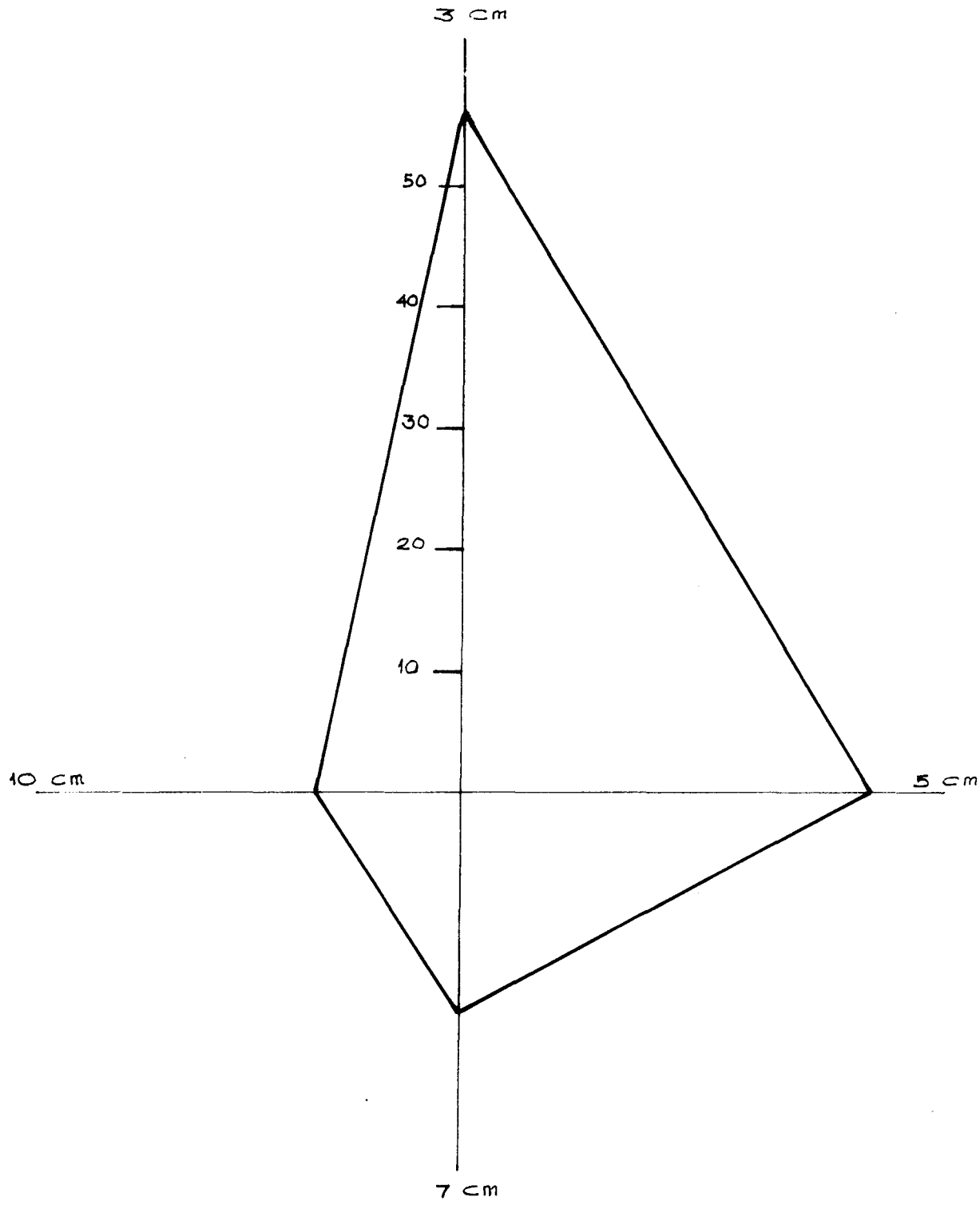
The data on the different growth parameters like height, girth and number of leaves per sucker recorded at 15 days interval commencing from one month after sprouting were analysed and the salient results are summarised below.

4.3.1(a). Height of suckers

It can be seen (Table 15) that the suckers produced from 3 cm thick roots recorded maximum height (14.9 cm), 2½ months after sprouting. The height of the suckers showed a decreasing trend as the thickness of roots increased and the shortest suckers were those produced from 10 cm thick roots. The analysis of variance on the effect of thickness of roots on height of suckers indicated that the treatments were statistically significant throughout the study (Appendix X).

The linearity of the growth rate was tested using the correlation coefficient between time and height

FIG: 5. EFFECT OF THICKNESS OF ROOTS ON PERCENTAGE OF SPROUTING



of suckers and it was above 0.95 in all cases confirming the linear nature. Linear regression equation was fitted to get the expected height of suckers based on this (Appendix XI). The statistical analysis to compare the various treatments with respect to their effect on rate of increase in height also confirmed the significant difference between them and the superiority of 3 cm thick roots over others.

4.3.1(b). Girth of suckers

Table 16 furnishes the girth of sprouts and rate of increase in girth as influenced by the varying thickness of roots. Girth was maximum with the suckers originated from 3 cm thick roots and lowest girth was with the suckers originated from 10 cm thick roots. The analysis of variance on the effect of thickness of roots on girth of suckers confirmed the significant difference of the treatments (Appendix XII) 5 cm and 7 cm thick roots were on par.

The correlation coefficient worked out between time and girth was found to be above 0.86 in all cases indicating the linearity of rate of increase in girth. Analysis of variance to compare the various treatments on rate of increase in girth showed significant difference among them and the superiority of 3 cm thick roots and the reverse nature of 10 cm thick roots.

Table 16. Effect of thickness of roots on girth of suckers (15 days interval)

Thickness of roots	Girth (cm)			Rate of increase in girth
	15 days	30 days	45 days	
3 cm	0.70	1.02	1.26	0.28
5 cm	0.56	0.76	0.92	0.18
7 cm	0.58	0.74	0.94	0.18
10 cm	0.54	0.66	0.78	0.12
CD	0.09	0.10	0.11	0.06

Table 17. Effect of thickness of roots on number of leaves produced on the suckers (15 days interval)

Thickness of roots	Leaf number			Rate of leaf production
	15 days	30 days	45 days	
3 cm	2.8	5.4	9.4	3.3
5 cm	1.8	3.6	8.0	3.1
7 cm	2.2	3.8	7.6	2.7
10 cm	1.6	3.6	7.4	2.9
CD	0.79	0.85	0.65	0.8

4.3.1(c). Number of leaves

The observations on the number of leaves produced on suckers developed from different types of roots are given in Table 17. The statistical analysis of this data clearly indicated that the treatments differed significantly (Appendix XIII). Maximum number of leaves (9.4) were seen on the suckers developed from 3 cm thick roots and lowest in suckers developed from 10 cm thick roots. Other treatments viz. 5 cm and 7 cm did not show any significant difference.

It was observed that correlation coefficient was significant confirming the linear nature of leaf production. A comparison of the rate of leaf production using analysis of variance also led to the conclusion that the performance of 3 cm thick roots are the best.

4.3.2. Survival of transplanted suckers

The details of the suckers transplanted and their survival under each treatment are given in Table 18. Significant difference was noted among the roots of varying thickness and survival was maximum (64.29 per cent) in 3 cm thick roots. As the

Table 18. Effect of thickness of roots on survival of transplanted suckers

Thickness of roots	Number of suckers transplanted	Number of suckers survived	Percentage survival
3 cm	28	18	64.29
5 cm	17	6	35.29
7 cm	9	2	22.22
10 cm	6	0	0.00
Chi-square value		11.67**	

** Significant at 1 per cent level of probability

thickness increased the survival also decreased steadily and became nil in 10 cm thick roots.

III. Budding

4.1. Effect of method of budding and defoliation of scion shoot

Effect of the method of budding and defoliation of scion shoot was analysed based on the sprouting of the buds, survival of buddlings and their growth behaviour.

4.1.1. Effect on sprouting and survival

Table 19 presents the percentage of sprouting and final survival of the budded plants along with the details of precuring and method of budding.

All the treatments were found to differ significantly with respect to sprouting and final survival of buddlings. It is clear from the table that period of precuring had a positive relation with sprouting and survival in 'T' budding. Maximum sprouting (60%) and survival (25%) was noted with six days precuring treatment in this case. Survival was nil when no defoliation and three days defoliation treatments were given.

In the case of patch budding the results indicated that defoliation of scion prior to budding resulted in

Table 19. Effect of method of budding and defoliation of scion shoot on sprouting and survival of budded plants

Method	Precuring period	Number of plants budded	Percentage sprouting	Percentage survival
'T' budding	Without	20	20	0
	3 days	20	30	0
	6 days	20	60	25
Patch budding	Without	20	40	20
	3 days	20	80	40
	6 days	20	80	30
Chi-square value			26.29**	17.05*

* Significant at 5 per cent level of probability

** Significant at 1 per cent level of probability

better success. There was significant difference between the three defoliation treatments with respect to sprouting. The difference between the treatments viz. defoliation three days and six days prior to budding was not significant (Appendix XIV) but were superior to no defoliation. None of the treatments had any significant influence on the final survival.

The results (Table 19(a)) indicated that method of budding had pronounced influence on the sprouting of buds and final survival of buddlings. It was observed that patch budding gave higher sprouting (66.67 per cent) and survival (30 per cent) compared to 'T' budding where the success and survival was 36.67 per cent and 8.33 per cent respectively. These results are also illustrated in Fig.6. The effect of the three defoliation treatments on patch budding with respect to sprouting and survival are given in Fig.7.

4.1.2. Growth behaviour of buddlings

The growth characters like extension of scion, girth of stock and scion and number of leaves produced were recorded at 20 days interval commencing from one month after budding for a period of 100 days and the results are given below. Since the survival was nil in the case of 'T' budding when no defoliation and three days

Table 19(a). Effect of method of budding

Method	Number of plants budded	Sprouting		Survival	
		Number	Percentage	Number	Percentage
'T' budding	60	22	36.67	5	8.33
Patch budding	60	40	66.67	18	30.00
Chi-square value		10.88**		9.09**	

** Significant at 1 per cent level of probability

FIG: 6. EFFECT OF METHODS OF BUDDING ON SPROUTING AND SURVIVAL

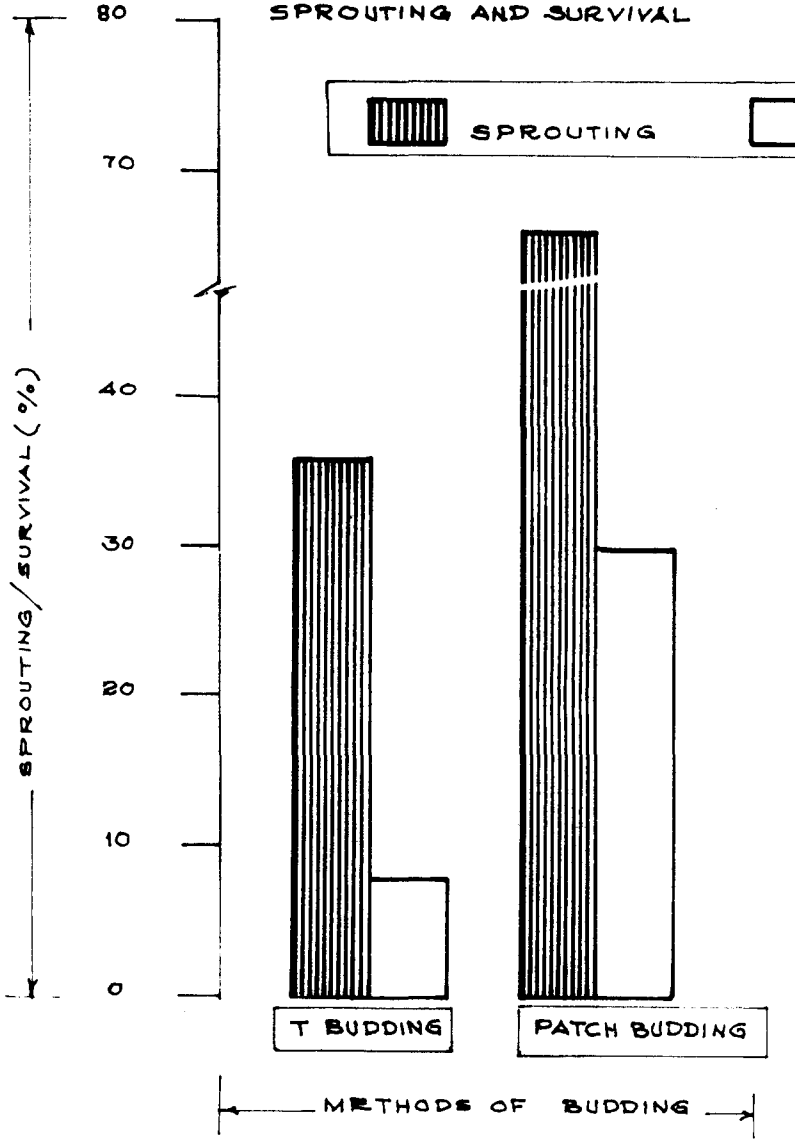
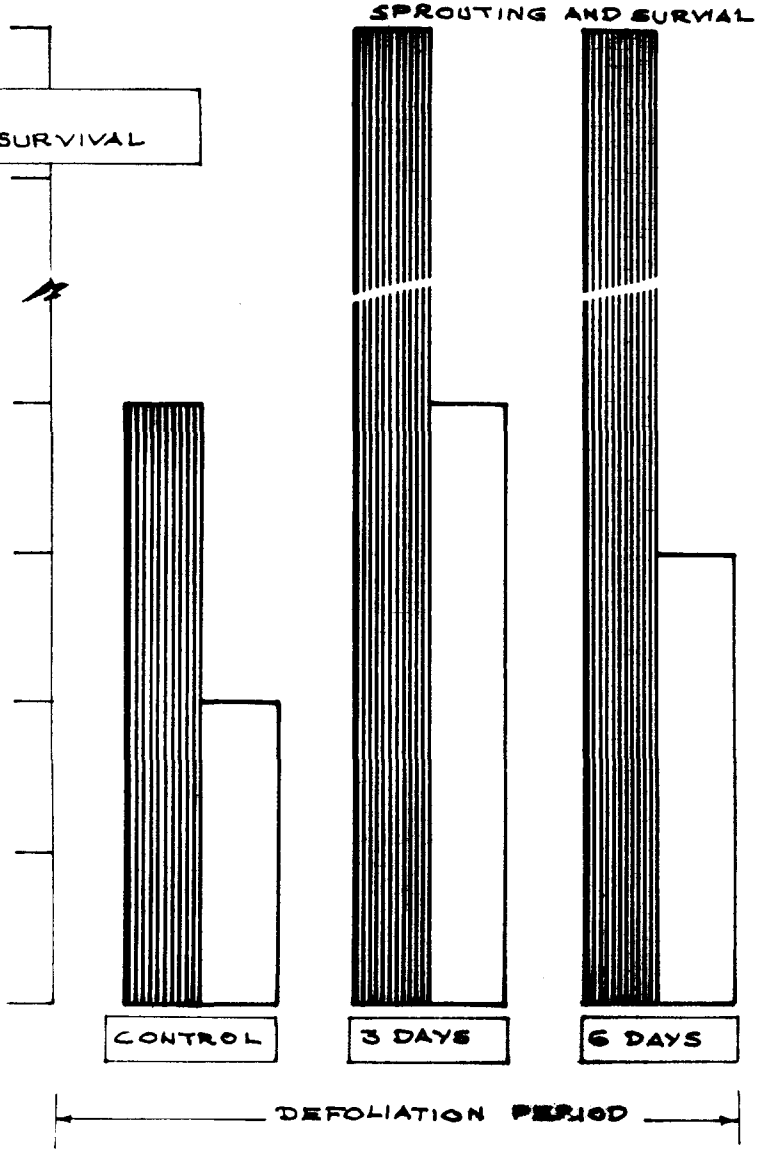


FIG: 9. EFFECT OF DEFOLIATION OF SCION ON SPROUTING AND SURVIAL



defoliation treatments were given, these two treatments were not included in the further analysis.

4.1.2(a). Extension growth of scion

Table 20 furnishes the extension growth of scion and rate of extension under various treatments.

It is obvious from the table that the four treatments differed significantly (Appendix XV) with respect to this character. The scion extension was very low in 'T' budded plants with six days defoliation treatment and it was significantly inferior to all the three defoliation treatments of patch budding. Hence when method of budding alone is considered it is possible to interpret that patch budding is the best compared to 'T' budding.

Among the precuring treatments of patch budding, three days precuring treatment resulted in maximum growth of scion (Plate XI and XII) followed by six days precuring treatment (Plate XIII and XIV). When fresh scion material was used for budding the growth of scion showed a decreasing trend.

The rate of extension was also compared using analysis of variance. The significant influence of the treatments were obvious and three days precuring treatment

Table 20. Effect of method of budding and defoliation of scion shoot on extension growth of scion (20 days interval)

Treatments		Scion extension (cm)					Extension rate
Method	Precuring period	20 days	40 days	60 days	80 days	100 days	
'T' budding	Without	0.00	0.00	0.00	0.00	0.00	0.000
	3 days	0.00	0.00	0.00	0.00	0.00	0.000
	6 days	2.63	3.55	4.55	5.45	6.95	1.055
Patch budding	Without	6.38	12.73	17.80	22.70	27.80	5.283
	3 days	9.73	16.95	22.40	29.50	35.70	6.450
	6 days	8.18	14.68	19.30	25.53	29.88	5.425
	CD =	1.07	1.57	1.49	1.64	1.92	0.543
	SEm ±	0.35	0.51	0.48	0.53	0.62	0.186

PLATE XI. Effect of three days defoliation on scion extension of patch budded plants (one month after budding).

PLATE XII. Effect of three days defoliation on scion extension of patch budded plants (four months after budding).

Plate XI

Plate XII

PLATE XIII. Effect of six days defoliation on scion extension of patch budded plants (one month after budding).

PLATE XIV. Effect of six days defoliation on scion extension of patch budded plants (four months after budding).

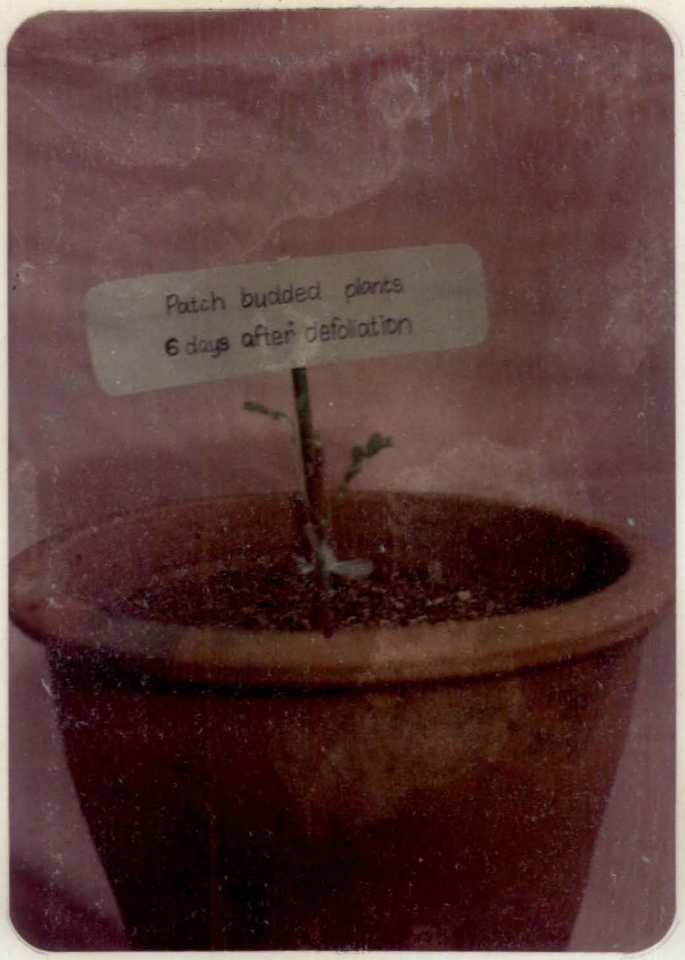


Plate XIII

Plate XIV

of patch budding was found to induce maximum rate of extension (6.450 cm). Without defoliation and six days defoliation of patch budding was not significantly different. 'T' budding with six days defoliation proved to be significantly inferior from all other treatments.

The correlation coefficient was above 0.98 in all cases confirming the linear nature of growth. Regression equation to get the expected length of scion is given in Appendix XVI.

4.1.2(b). Girth of stock and scion

The observations on girth of stock and scion with the details of treatments given and rate of increase in girth are given in Table 21. The treatments were found to differ significantly with respect to girth of stock as well as scion (Appendix XVII).

Girth of stock was found to be significantly high in patch budded plants with scion procured six days prior to budding and the lowest girth of stock was noted for 'T' budded plants with six days procuring treatment. Thus when method of budding alone was compared taking the same procuring treatment of both the cases led to the conclusion that patch budding is the best. This was true when the girth of scion was also considered.

Table 21. Effect of method of budding and defoliation of scion shoot on girth of stock and scion (20 days interval)

Method	Precuring period	Girth (cm)										Rate of increase in girth	
		20 days		40 days		60 days		80 days		100 days			
		Stock	Scion	Stock	Scion	Stock	Scion	Stock	Scion	Stock	Scion	Stock	Scion
'T' budding	Without	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.000
	3 days	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.000
	6 days	1.00	0.50	1.13	0.68	1.25	0.60	1.35	1.10	1.63	1.28	0.148	0.198
Patch budding	Without	1.10	0.70	1.40	0.98	1.63	1.10	2.10	1.30	2.40	1.38	0.326	0.168
	3 days	1.08	0.60	1.45	0.75	1.90	0.90	2.30	1.10	2.60	1.23	0.390	0.160
	6 days	1.45	0.80	1.85	0.95	2.33	1.10	2.70	1.38	2.90	1.55	0.375	0.193
	CD =	0.16	0.13	0.17	0.10	0.09	0.15	0.15	0.13	0.17	0.15	0.047	0.038
	SEm ±	0.05	0.04	0.06	0.03	0.03	0.05	0.05	0.04	0.04	0.05	0.012	0.012

A comparison of the precuring treatments given to patch budding indicated that six days defoliation treatment excelled for stock girth. There was no significant difference between without and six days defoliation treatments when girth of scion was considered except at 100 days observation stage, where the later was found to be superior.

The rate of increase in girth of stock was also found to be differing significantly and the maximum was noted in patch budding with scion given three days precuring treatment (0.390 cm) followed by six days precuring (0.375 cm). These two treatments were not differing significantly. 'T' budded plants were inferior with respect to this character also. There was no significant difference among the four treatments when rate of increase in girth of scion was considered.

4.1.2(c). Number of leaves

The observations recorded on the number of leaves produced and rate of leaf production for various treatments are presented in Table 22. There was significant difference (Appendix XVIII) among the four treatments.

Method of budding was compared taking the six days precuring treatment of both the cases and patch

Table 22. Effect of method of budding and defoliation of scion shoot on leaf production

Method	Procuring period	Leaf number					Rate of leaf production
		20 days	40 days	60 days	80 days	100 days	
'T' budding	Without	0.00	0.00	0.00	0.00	0.00	0.00
	3 days	0.00	0.00	0.00	0.00	0.00	0.00
	6 days	2.00	4.00	6.25	9.75	12.50	2.68
Patch budding	Without	5.00	6.50	8.25	8.75	11.75	1.58
	3 days	4.75	6.75	9.75	12.25	15.00	2.60
	6 days	3.25	6.50	9.25	11.50	13.75	2.60
	CD =	1.22	1.16	1.33	1.18	1.80	0.53
	S$\bar{x}$ ±	0.40	0.38	0.43	0.38	0.59	0.17

budding was found to be superior except at 100 days observation stage.

The three defoliation treatments given to patch budding alone was compared to find out the optimum period of precuring. It can be seen from the table that the number of leaves produced was more in the two defoliation treatments viz. three days and six days defoliation, except in the initial stage of observation. There was no statistical difference between these two defoliation treatments. When no defoliation was provided, it resulted in significant reduction in the number of leaves, when the later stages of growth was observed (i.e. at 80 days and 100 days observation stage).

When rate of leaf production was compared statistically, 'T' budding with six days defoliation was on par with the two defoliation treatments of patch budding viz. three days and six days defoliation. No defoliation treatment given to patch budding was inferior.

IV Air layering

4.1. Effect of growth regulators on rooting

Number of shoots on which callus formation noticed out of five samples drawn at 15 days interval are presented in Table 23.

Table 23. Effect of growth regulators on callus formation in air layered shoots (15 days interval)

Treatments (ppm)		Number of callus formed shoots			
		15 days	30 days	45 days	60 days
IBA	250	2	3	2	1
	500	2	3	2	2
	1000	1	2	1	1
	1500	2	1	3	2
	2000	1	0	1	1
NAA	250	0	0	0	0
	500	0	0	0	0
	1000	0	0	0	0
	1500	0	0	0	0
	2000	0	0	0	0
NAA + IBA	250	0	0	0	0
	500	0	0	0	0
	1000	0	0	0	0
	1500	0	0	0	0
	2000	0	0	0	0
Control		0	0	0	0

Observations were made on five air layers at each time

The results showed that none of the treatments succeeded in rooting of layers. However observation on callus production indicated that IBA at all concentrations induced callus to an appreciable extent. The callus produced started to disintegrate after 60 days indicating that there was no further effect of chemical on root production.

4.2. Effect of higher concentrations of IBA on root initiation

Further trial was carried out to study the effect of IBA alone at concentrations varying from 250 to 5000 ppm and the data are presented in Table 24. The result indicated that callus production could not be enhanced even with concentrations of IBA higher than 2000 ppm. In fact higher concentrations resulted in lower callus production and earlier disintegration of callus produced. The callus produced under varying concentrations of IBA can be seen from Plate XV and XVI.

Table 24. Effect of IBA on callus formation in air layered shoots (15 days interval)

Treatments (ppm)		Number of callus formed shoots					
		15 days	30 days	45 days	60 days	75 days	90 days
IBA -	250	0	4	5	3	4	3
	500	1	5	4	4	3	2
	1000	0	3	3	2	3	3
	2000	1	3	3	3	2	1
	3000	0	2	2	2	2	1
	4000	0	1	2	2	0	0
	5000	0	1	2	2	1	0
Control		0	3	3	0	0	0

Observations were made on five air layers at each time.

PLATE XV. Effect of IBA on callus formation of air layered shoots (upto 2000 ppm) (one month after layering).

T_0 Control

T_1 IBA 250 ppm

T_2 IBA 500 ppm

T_3 IBA 1000 ppm

T_4 IBA 2000 ppm

PLATE XVI. Effect of IBA on callus formation of air layered shoots (Above 2000 ppm) (one month after layering).

T_5 IBA 3000 ppm

T_6 IBA 4000 ppm

T_7 IBA 5000 ppm

Plate XV

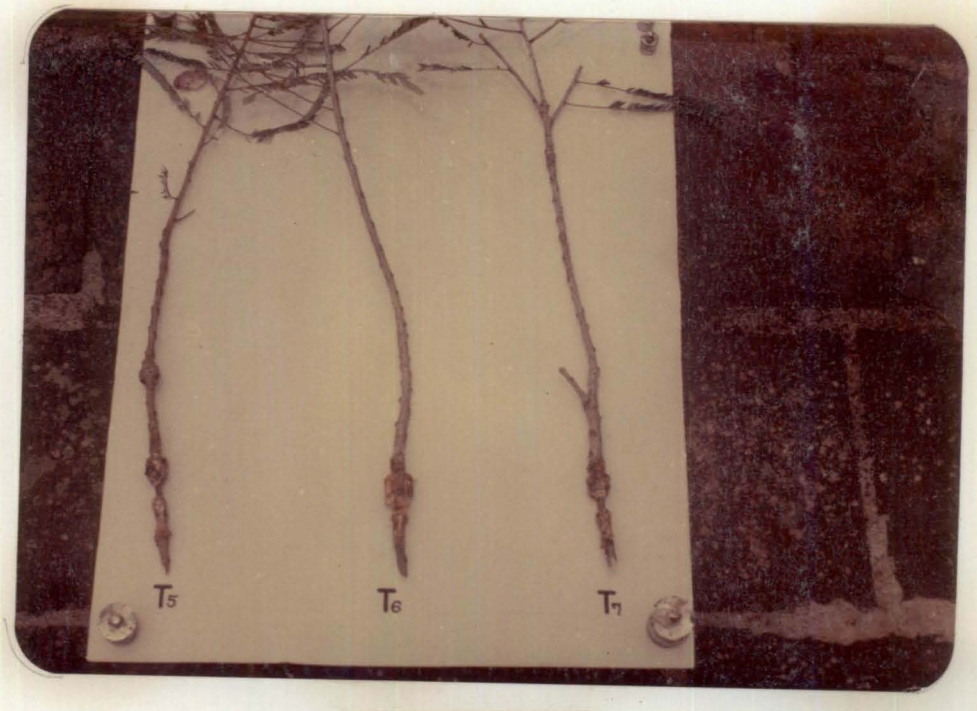


Plate XVI

Discussion

DISCUSSION

Phyllanthus emblica Linn. which is indegenous to India is widely distributed in the evergreen as well as dry deciduous forests of Western Ghats. Being one of the richest sources of Vit C and minerals and adapted to wide range of climatic and soil conditions, this tree fruit has a great potential for growing in the homesteads of Kerala. A detailed survey conducted by Aravindakshan *et al.* (1984) in the dry deciduous forests of Idukky district of Kerala has revealed that there is a great possibility of selecting certain superior types for bigger fruits and higher Vit.C content. The absence of a successful method of vegetative propagation has been the greatest impediment in the large scale easy multiplication of selected types by clonal means. The seed propagation also has limitations since in majority of cases high percentage of germination of the seeds are not obtained through usual means.

The investigations reported in the thesis were mainly directed to standardise methods of seed as well as vegetative propagations, in order to obtain higher degrees of success than reported hitherto.

Seed propagation

The results of the present studies have indicated that the stones if sown as such will not germinate irrespective of the chemical or other treatments given before sowing. The hard 'shell' covering the seeds acted as a great barrier for seed germination. The seed germination could be enhanced if the seeds are extracted and then sown in the nursery. The method standardised by Sreekumar and Aravindakshan (1985) to split open the stones by sundrying so as to extract the seeds was adopted for seed germination studies. The seeds so extracted when sown in the nursery resulted in a germination of 10.63 per cent during summer and 17.19 per cent during rainy season which was increased to 49.69 per cent and 35.63 per cent respectively in the two seasons under mist (Table 1b). Seed germination and seedling survival was also better under mist condition. Higher germination of seeds under mist has also been reported by Singh (1983). A comparative analysis of the weather conditions like temperature and relative humidity inside and outside the mist chamber indicated the effect of environmental conditions on germination of seeds in emblica. The fluctuations in temperature was more in the open especially in summer than inside the mist chamber, which would have lowered the germination outside. The results

probably indicate that higher per cent of seed germination could be obtained at an ambient temperature between 23°C to 27°C and soil temperature 20°C to 23°C and high relative humidity (98%).

The fluctuations in soil temperature has also apparently influenced the seed germination. The soil temperature varied from 28.45°C to 53.11°C under open and 22°C to 23°C under mist during March and in June the corresponding figures were 25.57°C to 30.28°C and 20°C to 22°C respectively. So also the soil temperature fluctuation was low during rainy season when also higher percentage of germination was obtained under open compared to summer (Table 1b).

The survival of the seedlings also followed more or less a similar trend as in the case of germination of seeds. The seeds as well as the seedlings being very delicate have possibly failed to withstand these wide fluctuations causing poor germination and eventual death of seedlings.

Even under the most favourable conditions the seed germination did not attain its maximum obviously due to the internal conditions namely physiological or biochemical factors. The use of growth substances has become a handy tool in order to overcome causes controlled by chemical or

physiological factors (Negi and Singh, 1972; Srivastava and Adhikari, 1972; Sinha *et al*., 1973; Chauhan and Dhillon, 1976; Sharma and Singh, 1979; Choudhari and Chakrawar, 1980). The results of the present study amply justify the use of gibberellic acid (GA) in enhancing seed germination in aonla. When the seeds were soaked in GA solution at a concentration of 250 ppm, 52.5 and 65.0 per cent seed germination was obtained during summer and rainy season respectively (Table 1a). The seedling survival (Table 2a) and subsequent growth of seedlings were also enhanced due to the treatment with GA (Table 3, 4 and 5). The remarkable effect of GA on seed germination especially in breaking seed dormancy has been well established by several earlier workers (Mathew, 1979; Sharma and Singh, 1979; Bajwa *et al*., 1980; Bankar, 1980; Guar, 1980; Misra *et al*., 1982).

The seeds of 'nelli' although cannot be classified as dormant, GA has helped to increase the percentage probably due to its effect to bring about a favourable internal condition for maximum germination. Break down of starch to sugars by enzymatic action preceeds seed germination. GA enables the embryo to germinate by overcoming the restraint imposed by the starchy endosperm or other surrounding structures as pointed out by Monin (1967)

or by increasing the supplies of solute from the endosperm to the embryo. The latter process allows the embryo for higher water uptake thus overcoming mechanical restrain imposed by the surrounding tissues (Chen, 1970). GA also induces the production of more hydrolytic enzymes. Thus the acceleration of germination process can be attributed to the increased activity of enzyme mechanism of germinating seeds. It also enhances the activity of RNA and protein synthesis (Bradbeer and Pinfield, 1967), which stimulate germination.

The treatment of seeds with GA was not only helpful in increasing the germination but also in enhancing vigour and growth of seedlings. The continuous action of GA beyond seed germination noted in the present study is interesting. Increased growth of seedlings due to GA treatment has also been reported by several workers (Elson *et al.*, 1954; Khan *et al.*, 1957; Wittver and Bukovac, 1957; Das and Pattanaik, 1971; Das and Prusty, 1972; Guar, 1980 and Misra *et al.*, 1982) in various plant species. This effect of GA is brought up by cell elongation (Yeou-Der *et al.*, 1962; Shanmugavelu, 1969). The cell elongation is attributed to increased auxin content. It may also be possible that ultimate effect of GA is indirectly lowering the activity of IAA - Oxidase

reaction and to increase the auxin levels in plants (Brain, 1959). The increase in thickness of stem as in the case of plant height is a reflection of stimulation of cambium and its immediate cell progeny as observed by Das and Pattanaik (1971) and scurfield and Moor (1958).

Seed storage

The viability of seeds under different treatments was assessed by their capacity for germination at monthly intervals as adopted by Williams and Hanson (1974). Out of the three methods of storage viz., cloth bag, polythene bag and open, cloth bag proved to be superior in terms of percentage germination and viability compared to control. The lowest germination was noticed when seeds were stored in open. The reduction in viability of seeds stored under open condition has been reported by Bajpai et al. (1963) and Arumugam and Shanmugavelu (1976). The storage temperature and humidity are the two major environmental factors influencing viability of stored seeds. Evans (1950) also stressed the importance of these two factors to preserve viability. In the sealed polythene bag, a higher humidity that accumulated would have contributed to earlier deterioration of viability. The cloth bag on the other hand allows free passage of air without increasing the humidity inside as

was observed by Evans (1950). The rapid loss of viability under open storage could be attributed to the drying effect of air. Bajpai et al. (1963) and Arumugam and Shanmugavelu (1976) were of the opinion that the drying effect of air caused the protoplasm of the embryo to undergo partial desiccation and eventual death of seeds. Storing the seeds either in polythene or cloth bag in cold condition was not helpful to retain a higher viability compared to outside.

The viability of the seeds was lost seven months after storage. The loss of viability in storage might also be due to the accumulation of toxic products caused due to increased respiration under adverse conditions (Harrington, 1970). Bhakasut et al. (1976) showed that loss of viability of citrus seeds was associated with the increased accumulation of phenolic compounds. Chakravarthy (1976) attributed the loss of viability of cotton seeds to the accumulation of growth inhibitors under stored condition which ultimately turned the seeds into a non-viable condition.

An interesting observation made in the study was that the viability of seeds was as low as 20 per cent immediately after extraction which steadily increased attaining the maximum in two months period irrespective of the storage conditions. This possibly indicates that

the seeds may require a period of after ripening or they may contain some inhibitory factors in early stages after extraction as reported by several workers in various plant species (Tukey and Carlson, 1945; Scott and Ink, 1950; Bringurst and Voth, 1957; Randhawa and Negi, 1964; Negi and Singh, 1973). In 'nelli' the theory of after ripening does not appear to hold good since in some earlier studies higher percentage of germination was obtained even immediately after extraction (Sreekumar and Aravindakshan, 1985). Alternatively the presence of some inhibitory factors in the seeds immediately after extraction appears to have been responsible for lowering the germination. This substances probably might have got eliminated in the course of storage under natural conditions.

The result of the storage studies and effect of chemical treatment on seed germination when considered together further showed that GA replaced the requirement of after ripening period or eliminated the inhibitory factors responsible for lowering the germination of seeds. Seeds treated with GA 250 ppm recorded 80 per cent and 70 per cent germination during summer and rainy season respectively immediately after extraction (Table 1) which was comparable to the 80 per cent germination attained after two months of storage (Table 9). The effect of GA in

breaking the dormancy and eliminating the inhibitory factors have been amply demonstrated in several seed storage and germination studies (Black and Wareing, 1955; Donoho and Walker, 1957; Gray, 1958; Frankland, 1961; Randhawa and Negi, 1964; Bradbeer, 1968).

VEGETATIVE PROPAGATION

Propagation through shoot and root cuttings

The most commonly adopted vegetative propagation methods of tree crops are through cuttage or through budding, grafting or layering. Propagation through cuttings has its own advantage since the method is easy and inexpensive.

In the present study on 'nelli' attempts to propagate through shoot cuttings did not succeed although the cuttings sprouted and grew to some extent for about two months. None of them rooted with the treatments provided in the experiment. The only available report on successful rooting of cuttings of *Phyllanthus emblica* is that of Rajan and Ram (1982) under U.P. conditions. Even with the sophisticated techniques of propagation methods cuttings of several species remain as 'difficult to root' ones posing real challenge to horticulturists. Ranvir and Singh (1973) also did not get rooting in lemon cuttings eventhough treated with IBA and kept under intermittent mist.

Similarly Randhawa and Mito (1980) reported failure of M-9, M-26 and Starking Delicious varieties of apple to root. Nandha and Anand (1970) reported poor rooting of Populus nigra cuttings due to the slow mobilization of reserve food materials especially starch and sugars necessary for initiation and development of roots. Singh (1983) opined that different plant species behave differently under a similar set of conditions due to physiological, anatomical and genetic differences. The fact that the cuttings did not even form callus, inspite of shoot growth, shows that further detailed investigation will be necessary before we can arrive at a conclusion on the possibility of using shoot cuttings for propagation of Phyllanthus emblica.

Similarly the study to assess the regeneration capacity of root cuttings did not yield fruitful result. On the other hand when the 'intact roots' were escavated large number of adventitious buds arose from the roots. The tendency to sucker is a character possessed by certain plants. The ability of a plant to sucker and to grow from root cuttings are closely related as reported by Hartmann and Kester (1975). With necessary manipulations, it might be possible to successfully regenerate root cuttings in aonla and this is an aspect requiring detailed investigation. The successful sprouting due to injuring the intact roots

and survival after transplanting to the field indicate that induction of sprouts from the intact roots and subsequent separation and planting provide a useful and easy method of propagation.

In the present study roots of about 3 cm thickness sprouted maximum compared to thicker roots (Table 14). Bolt (1983) obtained higher rooting with 10-15 mm thick pear roots than with more thickened roots. The influence of juvelinity in regeneration capacity of pear cuttings have been reported by Zmajdek et al. (1974). They observed that as the age of the tree increased the root cuttings failed to regenerate.

Budding

In the budding experiments patch budding proved to be superior over 'T' budding. The superiority of patch budding over other methods have been brought out by Teaotia and Asthana (1960); Srivastava (1964); Srivastava (1965); Moti et al. (1976) and Pandey and Prasad (1979). Patch budding is widely and successfully used in thick barked species, like walnuts, pecans and various other tropical species such as the rubber, where 'T' budding gives poor results, presumably due to the poor fit around the margins of the bud resulting in unsuccessful healing (Hartmann and Kester, 1975).

Precuring the scion by defoliation prior to budding proved to be definitely advantageous over the fresh scion material both with 'T' budding and patch budding.

In 'T' budding the precuring period was observed to have a positive relation with sprouting and survival. Maximum sprouting (60%) and survival (25%) was obtained when six days precured scion was used. This probably indicates the possibility of obtaining better success when the precuring period is further extended.

In patch budding defoliation three days and six days prior to budding increased the sprouting and survival. The success was 40 per cent with three days defoliation while it was 30 per cent and 20 per cent in six days and without any defoliation respectively. The scion extension was maximum in three days defoliation treatment. There was no significant difference among the two defoliation treatments viz. three days and six days with respect to leaf production, eventhough girth of scion was high when six days precuring was provided. Hence from the present study it can be concluded that the patch budding using defoliated scion will serve as a successful method of vegetative propagation in Phyllanthus emblica. However, three days precuring prior to budding can be suggested since it will avoid time lag.

Singh and Khan (1943) obtained greatest success for budding in mango when defoliated bud wood was used. Jauhari and Singh (1970) obtained 50 per cent bud sprout in mango by activating the buds two week before budding. Teaotia and Maurya (1970) also opined that two week prior defoliation of scion shoot is the best for mango budding. Dhungana (1984) obtained high percentage of success for stone grafting in mango when 10 days procured scion was used. Many workers who have found similar effects for defoliation treatments have reasoned this phenomenon to the increased meristematic activity in the axillary and terminal bud region (Parsai, 1974; Singh and Srivastava, 1979; Maiti and Biswas, 1980 and Nagabushanam, 1982).

Layering

Experiments on layering using IBA, NAA, NAA + IBA in different concentrations did not succeed in both the years of investigations. However, there was formation of callus in IBA treatments which could not be enhanced with higher concentrations. Panday and Phogat (1978) observed profuse callusing in olive air layers without any rooting during April. The failure of the air layers could be traced to the lack of differentiation of callus to roots. The callus formation perhaps suggests the possibility of root induction

by proper manipulations like the use of auxins, kinetins, vitamins etc. Detailed investigation on this aspect perhaps may yield fruitful results. Also experiments on tissue culture might provide a clue for the inhibitory substances responsible for non differentiation of callus.

Summary

SUMMARY

The present investigations on seed and vegetative propagation of *Phyllanthus emblica* Linn. were carried out in the Department of Pomology and Floriculture, College of Horticulture, Vellanikkara during the period from 1984-'85 with the objectives

(a) To standardise methods for effective germination of seeds.

(b) To standardise an easy method of vegetative propagation through stem cuttings, root cuttings, budding or layering.

(c) To find out the effect of growth regulators on rooting of stem and root cuttings.

The conclusions drawn from the present investigations are summarised hereunder.

1. The stones did not germinate when sown as such even after treating with chemicals like GA, vit C, Thiourea, KNO_3 and IAA.

2. Pooled data to find out the effect of chemical treatments revealed that treating the seeds with

GA 250 ppm recorded maximum percentage of germination during summer (52.75%) and rainy season (65.00%) compared to control where the germination percentage was 20.00 and 12.50 respectively.

3. Under intermittent mist condition a germination percentage of 40 and 20 could be obtained during summer and rainy season respectively without any chemical treatment compared to no germination during summer and only five per cent germination during rainy season.

4. The germination percentage attained a maximum of 80 and 70 during summer and rainy season respectively when the seeds were given a presoaking treatment with GA 250 ppm and sown under intermittent mist. Thus the above two factors in combination provided the most congenial condition for seed germination than their individual effect.

5. Treating the seeds with GA 250 ppm and thiourea one per cent resulted in a seedling survival of 40 and 30 per cent respectively during summer. The chemicals did not affect the survival of seedlings during rainy season.

6. Under intermittent mist condition seedling survival was found to be 50 and 100 per cent during summer and rainy season respectively without any chemical treatment.

7. The combined effect of mist and chemicals were clearly evident during summer where cent per cent survival was obtained when the seeds were treated with GA 500 ppm and sown under mist condition.

8. An atmospheric temperature 23 to 27°C and soil temperature 20 to 23°C with very high relative humidity (98 per cent) were found to be the most ideal condition for seed germination and seedling survival.

9. The growth behaviour of seedlings was analysed based on the height, girth and number of leaves produced. GA in general and GA 250 ppm in particular proved to be the best treatment during both seasons for better growth.

10. The experiments on seed storage revealed that temperature did not influence the viability of seeds. Maximum germination was obtained two months after storage which gradually declined as the storage time

elapsed and it was completely lost after seven months. Out of three methods of storage viz. cloth, polythene and open maximum retention of viability was noted in seeds stored in cloth bag.

11. The stem cuttings failed to root inspite of treating with growth substances or by providing intermittent mist.

12. Root cuttings also failed to regenerate inspite of the various treatments given.

13. The intact roots when partially exposed and injured exhibited regeneration. Maximum percentage (56) of sprouting occurred in the roots which were of 3 cm thick. The vigour and survival percentage of the suckers were also maximum in the above case. The survival percentage and the thickness of roots were negatively correlated and survival was zero in the case of 10 cm thick roots.

14. The success of two methods of budding, viz. 'T' and patch analysed in terms of sprouting and survival showed that patch budding was the best. Sprouting and survival was 66.67 per cent and 30.00 per cent respectively in patch budding as against 36.67 and 8.33 per cent respectively in 'T'budding. The growth

characters like extension of scion, girth of scion and number of leaves were also high in patch budded plants.

15. Prior defoliation of scion was found to be beneficial both for 'T' budding as well as for patch budding. Survival was zero per cent when no defoliation and three days defoliation treatments were given while it was 25 per cent with six days defoliated scions. Thus for 'T' budding period of precuring and success was positively related. In the case of patch budding when three days, six days and without defoliation treatments were provided a survival of 40, 30 and 20 per cent were obtained respectively.

16. The extension growth of scion was high when the scion shoots were defoliated three days prior to budding. There was no significant difference among the two precuring treatments viz. three days and six days for leaf production.

17. Air layering studies conducted during June, July and August revealed that none of the treatments succeeded

in rooting eventhough callus formation was fairly high when treated with IBA during the month of July. In another experiment laid out during July 1986 using IBA ranging from 250 ppm to 5000 ppm indicated that rooting could not be obtained even with higher concentration and even callus formation could not be enhanced.

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* Originals not seen

Appendices

APPENDIX I

Weather data and percentage germination of seeds

Month		Germination (%)	Ambient temperature		Soil temperature		Relative humidity (%)
			Maximum (°C)	Minimum (°C)	Maximum (°C)	Minimum (°C)	
March							
	Open	10.63	36.04	24.64	53.11	28.45	62
	Mist	49.69	27.00	23.30	23.00	22.00	98
June							
	Open	17.19	28.14	23.00	30.28	25.57	87
	Mist	35.63	26.00	23.00	22.00	20.00	98

APPENDIX II

Weather data and percentage survival of seedlings

Month		Survival (%)	Ambient temperature		Soil temperature		Relative humidity (%)
			Maximum (°C)	Minimum (°C)	Maximum (°C)	Minimum (°C)	
March							
	Open	13.88	36.04	24.64	53.11	28.45	62
	Mist	64.77	27.00	23.30	23.00	22.00	98
June							
	Open	39.66	28.14	23.00	30.28	25.57	87
	Mist	90.35	26.00	23.00	22.00	20.00	98

APPENDIX III

Analysis of variance table for height of seedlings (summer) (20 days interval)

Source	df	Mean squares			
		20 days	40 days	60 days	80 days
Treatment	15	12.03**	26.90**	44.53**	44.75**
Error	48	18.54	46.69	56.79	57.99
Total	63	-	-	-	-

**Significant at 1 per cent level of probability

APPENDIX IV

Analysis of variance table for height of seedlings (Rainy season) (20 days interval)

Source	df	Mean squares				
		20 days	40 days	60 days	80 days	100 days
Treatment	15	11.09**	70.61**	20.17**	47.75**	39**
Error	48	0.75	0.65	34.30	30.48	
Total	63	-	-	-	-	

** Significant at 5 per cent level of probabiliy

APPENDIX V

Regression equation for describing growth behaviour of seedlings with regard to the different treatments

Treatments		Regression equation	Treatments		Regression equation
GA	250 ppm	$y = 2.5x + 4.27^1$	KNO_3	1%	$y = 1.7x + 2.98^1$
		$y = 13.5x + 26.77^2$			$y = 12.3x + 22.7^2$
	500 ppm	$y = 2.4x + 3.37^1$		2%	$y = 2.2x + 3.72^1$
		$y = 12.7x + 24.56^2$			$y = 9.4x + 20.54^2$
	1000 ppm	$y = 2.7x + 3.31^1$		5%	$y = 1.9x + 3.32^1$
		$y = 13.1x + 22.88^2$			$y = 12.2x + 21.77^2$
Vit C	1%	$y = 1.1x + 0.24^1$	IAA	250 ppm	$y = 1.8x + 3.59^1$
		$y = 8.5x + 10.74^2$			$y = 9.8x + 17.04^2$
	2%	$y = 0.72x + 0.83^1$		500 ppm	$y = 1.2x + 0.78$
		$y = 6.6x + 10.07^2$			$y = 7.4x + 15.12^2$
	5%	$y = 0.75x + 0.91^1$		1000 ppm	$y = 1.6x + 2.47^1$
		$y = 5.5x + 8.29^2$			$y = 6.5x + 13.70^2$
Thiourea	1%	$y = 1.5x + 3.22^1$	Control		$y = 0.65x + 0.89^1$
		$y = 12.9x + 21.89^2$			$y = 5.7x + 8.17^2$
	2%	$y = 1.5x + 2.32^1$			
		$y = 9.6x + 19.94^2$			
	5%	$y = 1.4x + 3.11^1$			
		$y = 7.6x + 16.23^2$			

^{1}Summer season

^{2}Rainy season

APPENDIX VI

Analysis of variance table for the girth of seedlings (Summer) (20 days interval)

Source	df	Mean squares			
		20 days	40 days	60 days	80 days
Treatment	15	0.088*	0.149**	0.149**	0.255**
Error	48	0.0311	0.027	0.0269	0.024
Total	63	-	-	-	-

*Significant at 5 per cent level of probability
**Significant at 1 per cent level of probability

APPENDIX VII

Analysis of variance table for girth of seedlings (Rainy season) (20 days interval)

Source	df	Mean squares					
		20 days	40 days	60 days	80 days	100 days	120 days
Treatment	15	0.009	0.027**	0.039**	0.063**	0.059**	0.075
Error	48	0.005	0.008	0.010	0.006	0.006	0.040
Total	63	-	-	-	-	-	-

** Significant at 1 per cent level of probability

APPENDIX VIII

Analysis of variance table for leaf number (summer)
(20 days interval)

Source	df	Mean squares			
		20 days	40 days	60 days	80 days
Treatment	15	0.750**	1.83**	4.88**	6.783**
Error	48	0.052	0.09	0.14	0.333
Total	63	-	-	-	-

** Significant at 1 per cent level of probability

APPENDIX IX

Analysis of variance table for leaf number (Rainy season)
(20 days interval)

Source	df	Mean squares					
		20 days	40 days	60 days	80 days	100 days	120 days
Treatment	15	1.93**	6.66**	34.53**	268.28**	728.15**	1078.49**
Error	48	0.26	0.46	1.94	4.16	-	6.57
Total	63	-	-	-	-	-	-

** Significant at 1 per cent level of probability

APPENDIX X

Analysis of variance table for thickness of roots on height of suckers (15 days interval)

Source	df	Mean squares		
		15 days	30 days	45 days
Treatment	3	3.17**	43.36**	65.26**
Error	16	0.132	0.307	0.688
Total	19	-	-	-

** Significant at 1 per cent level of probability

APPENDIX XI

Regression equation for describing growth behaviour of suckers under various treatments

Treatments	Regression equation
3 cm	5.40x + -1.14
5 cm	3.75x + -0.84
7 cm	3.03x + -0.47
10 cm	2.06x + 0.06

APPENDIX XII

Analysis of variance table for thickness of roots on girth of suckers (15 days interval)

Source	df	Mean squares		
		15 days	30 days	45 days
Treatment	3	0.026**	0.12**	0.206**
Error	16	0.005	0.01	0.006
Total	19	-	-	-

** Significant at 1 per cent level of probability

APPENDIX XIII

Analysis of variance table for thickness of roots on number of leaves produced on suckers (15 days interval)

Source	df	Mean squares		
		15 days	30 days	45 days
Treatment	3	1.4**	3.8**	7.93**
Error	16	0.4	0.4	0.76
Total	9	-	-	-

** Significant at 1 per cent level of probability

APPENDIX XIV

Chi-square value for comparison of different period of precuring with regard to the number of sprouting and survival of buddlings

Comparison	Value of chi-square
Without Vs 3 days	6.66* (1.90)
Without Vs 6 days	6.66* (0.53)
3 days Vs 6 days	0 (0.43)

* Significant at 5 per cent level of probability

(---) Chi-square for survival rate

APPENDIX XV

Analysis of variance table for method of budding and defoliation of scion shoot on extension growth of scion (20 days interval)

Source	df	Mean squares				
		20 days	40 days	60 days	80 days	100 days
Treatment	3	37.38**	138.11**	248.26**	450.24**	629.16**
Error	12	0.49	1.03	0.93	1.13	1.55
Total	15	-	-	-	-	-

** Significant at 1 per cent level of probability

APPENDIX XVI

Regression equation for describing the growth behaviour of scion under various treatments

Method	Precuring period	Regression equation
T budding	6 days	y = 1.05x + 1.46
Patch budding	Without	y = 5.28x + 1.632
	3 days	y = 6.45x + 3.06
	6 days	y = 5.43x + 3.23

APPENDIX XVII

Analysis of variance table for method of budding and defoliation of scion shoot on girth of stock and scion (20 days interval)

Source	df	Mean squares				
		20 days	40 days	60 days	80 days	100 days
Treatment	13	0.157** (0.066)**	0.357** (0.087)**	0.822** (0.109)**	1.280** (0.078)**	1.190** (0.082)**
Error	12	0.010 (0.006)	0.012 (0.004)	0.004 (0.009)	0.009 (0.007)	0.006 (0.009)
Total	15	-	-	-	-	-

** Significant at 1 per cent level of probability
(---) Values of mean squares for scion

APPENDIX XVIII

Analysis of variance table for method of budding and defoliation of scion shoot on number of leaves (20 days interval)

Source	df	Mean squares				
		20 days	40 days	60 days	80 days	100 days
Treatment	3	7.83**	6.73**	9.58**	10.91**	8.16**
Error	12	0.63	0.56	0.75	0.58	1.38
Total	15	-	-	-	-	-

** Significant at 1 per cent level of probability

STANDARDISATION OF PROPAGATION TECHNIQUES IN *Phyllanthus emblica* Linn.

By

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ABSTRACT OF A THESIS

submitted in partial fulfilment of
the requirement for the Degree

Master of Science in Horticulture

Faculty of Agriculture
Kerala Agricultural University

Department of Pomology and Floriculture
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Vellanikkara - Trichur

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ABSTRACT

The studies on propagation techniques in *Phyllanthus emblica* Linn. were carried out in the Department of Pomology and Floriculture, College of Horticulture, Vellanikkara during the year 1984 to '85.

The studies were carried out on seed as well as vegetative propagation. The present series of studies are the first of its kind done in Kerala on the above lines and have yielded valuable results.

The stones did not germinate with any growth regulator treatment tried. The hard 'shell' covering the seeds acted as a great barrier for seed germination. The seeds are to be extracted and sown to get germination. GA 250 ppm was found to induce the maximum germination of seeds. The growth characters analysed based on the height of seedlings, girth of seedlings and number of leaves produced also revealed the superiority of GA 250 ppm.

The seed germination and seedling survival was always high under mist. The conditions prevailed under the mist i.e. an ambient temperature of 23 to 27°C, soil temperature 20 to 23°C and high relative humidity 98 per cent was found to be the most congenial condition for both seed germination and seedling survival. The

germination and survival was enhanced to the maximum when the effect of GA 250 ppm and mist were combined. The seasonal influence on seed germination was negligible while the seedling survival was highest during rainy season.

The experiment on seed storage showed that the viability increased after extraction and attained maximum two months after storage. The viability decreased there after and was lost completely seven months after storage. Cloth was found to be a useful material for storing the seeds.

Vegetative propagation through shoot cuttings, root cuttings, intact roots, budding and layering were tried. Shoot cuttings failed to root irrespective of the various chemical treatments and conditions provided for rooting. Similarly root cuttings also did not regenerate. But the sucker production from the intact roots could be accelerated by injuring the roots. Out of the four types of roots viz. 3 cm, 5 cm, 7 cm and 10 cm thick roots, 3 cm thick roots proved to be superior in terms of percentage sprouting, vigour and growth. The survival of the sucker after transplanting was also maximum in 3 cm thick roots.

Out of the two methods of budding viz. patch and 'T' budding, patch budding was found to be significantly superior in terms of sprouting, survival and subsequent growth. Defoliation prior to budding was found to be beneficial for sprouting and growth of buddlings.

The experiment on air layering indicated that callus formation was confined to the treatment with IBA especially at lower concentrations. The callus so formed, however, did not differentiate into roots.