STUDIES ON PROPAGATION THROUGH STEM CUTTINGS AND AIR LAYERING IN FIG (*Ficus carica* L.) CULTIVAR POONA FIG

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PHK 421

DIVISION OF HORTICULTURE
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in

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AFFECTIONATELY DEDICATED

TO

MY BELOVED PARENTS,

BROTHER AND FRIENDS

DIVISION OF HORTICULTURE
UNIVERSITY OF AGRICULTURAL SCIENCES
BANGALORE

CERTIFICATE

This is to certify that the thesis entitled **"Studies on propagation through stem cutting and air layering in Fig (*Ficus carica* .L) cultivar Poona Fig"** submitted by **Mr. DHARSHAN, B.V. (PHK 421)** in partial fulfillment of the requirements for the award degree of ***MASTER OF SCIENCES*** in ***POMOLOGY*** to the University of Agricultural Sciences, Bangalore, is a record of bona fide research work done by him during the period of his study in this University under my guidance and supervision and no part of the thesis has been previously submitted for the award of any degree, diploma, associateship, fellowship or any other similar titles.

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"Great discoveries and improvements invariably involve the co-operation of many minds. I may be given credit for having blazed the trail but when I took at the subsequent developments, I feel credit to others rather than to myself".

- Alexander Graham Bell

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STUDIES ON PROPAGATION THROUGH STEM CUTTING AND AIR LAYERING IN FIG (*Ficus carica* L.) CULTIVAR 'POONA FIG'

DHARSHAN, B.V.

THESIS ABSTRACT

Fig (*Ficus carica* L.) is a deciduous and subtropical fruit crop. It is said to have originated in the east Mediterranean region. Figs are consumed fresh, dried, preserved and canned. Fresh fruits are very delicious and nutritious, and are used as dessert or for making Jam. Fig is a rich source of calcium, iron and sugar. The area under fig is increasing in dry tracts of Karnataka. There is an increased awareness among farmers to cultivate fig. Hence, in view of these development, investigations were conducted to study propagation of Fig (*Ficus carica* L.), cv. Poona Fig, through stem cuttings and air layering.

In propagation through cuttings, the percentage of rooting was higher with basal cuttings in which leaves were retained and cuttings treated with 1000 ppm IBA. Similarly with respect to shoot growth of cuttings, time taken for sprouting of shoot buds was hastened. Number of sprouts per cutting, length of sprouted shoots and number of leaves were more in this treatment. With reference to the root growth, the cuttings which received this treatment rooted early and produced greater number of primary and secondary roots.

In propagation of fig through air layering, higher percentage of rooting was observed in etiolated than non etiolated shoots, sphagnum moss as the media than coir pith, and air layered shoots treated with 1000 ppm IBA than other auxin treatments. Similarly with reference to shoot growth of air layered shoots, IBA at 1000 ppm resulted in early sprouting with higher number of sprouts per cutting, greater shoot length with more number of leaves. With reference to the root growth from the air layered shoots, treatment with IBA 1000 ppm resulted in early rooting with greater number of primary and secondary roots.

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ಅಂಜೂರ (*ಫೈಕಸ್ ಕ್ಯಾರಿಕ ಲಿನ್*) ತಳಿ 'ಪೂನಾ ಅಂಜೂರ' ದಲ್ಲಿ ಕಾಂಡದ ತುಂಡು ಮತ್ತು ಗೂಟಿ ಕಟ್ಟುವ ವಿಧಾನಗಳ ಸಂತಾನವೃದ್ಧಿ ಕ್ರಮಗಳ ಅಧ್ಯಯನ.

ದರ್ಶನ್, ಬಿ.ವಿ.

ಪ್ರಭಂದದ ಸಾರಾಂಶ

ಅಂಜೂರ (*ಫೈಕಸ್ ಕ್ಯಾರಿಕ ಲಿನ್*) ಒಂದು ಎಲೆ ಉದುರುವ ಸಮಶೀತೋಷ್ಣ ವಲಯದ ಪೂರ್ವ ಮೆಡಿಟರೇನಿಯನ್ ಪ್ರಾಂತ್ಯದ ಮೂಲದಿಂದ ಬಂದಂತಹ ಹಣ್ಣಿನ ಬೆಳೆ, ಅಂಜೂರದ ಹಣ್ಣುಗಳನ್ನು ಹಾಗೆಯೇ ತಿನ್ನಲು (ತಾಜಾ ಸ್ಥಿತಿಯಲ್ಲಿ), ಅಲ್ಲದೆ ಒಣಗಿಸಿ, ಸಂಸ್ಕರಿಸಿ ಮತ್ತು ಡಬ್ಬಿಗಳಲ್ಲಿ ಶೇಖರಿಸಿ ಉಪಯೋಗಿಸಬಹುದು. ಕರ್ನಾಟಕದ ಒಣ ಪ್ರದೇಶಗಳ ಒಂದು ಮುಖ್ಯ ಬೆಳೆಯಾಗಿದೆ. ಈ ಪ್ರದೇಶಗಳಲ್ಲಿ ಹೆಚ್ಚಿನ ಪ್ರದೇಶದಲ್ಲಿ ಬೆಳೆಯುವ ಪರಿ ಕಂಕಡುಬರುತ್ತಿದೆ. ಆದುದರಿಂದ, ಅಂಜೂರ ತಳಿಯಲ್ಲಿ ಕಾಂಡದ ತುಂಡು ಮತ್ತು ಗೂಟಿ ಕಟ್ಟುವ ಕ್ರಮಗಳನ್ನು ಅನುಸರಿಸಿ ಸಂತಾನವೃದ್ದಿಗೊಳಿಸುವ ಅಧ್ಯಯನಗಳನ್ನು ಕೈಗೊಳ್ಳಲಾಯಿತು.

ಈ ಪೂನಾ ತಳಿಯ ಬುಡಭಾಗದಿಂದ ಪಡೆದ, ಎಲೆಗಳನ್ನು ಉಳಿಸಿಕೊಂಡಿರುವ ಮತ್ತು 1000 ಪಿ.ಪಿ.ಎಂ, ಐ.ಬಿ.ಎ. ಚೋದಕ ದ್ರಾವಣದಿಂದ ಉಪಚರಿಸಿದ ಕಾಂಡಗಳಿಂದ ಅಧಿಕ ಸಂಖ್ಯೆಯಲ್ಲಿ ಪ್ರಾಥಮಿಕ ಮತ್ತು ತಂತು ಬೇರುಗಳನ್ನು ಬಿಟ್ಟವು, ಹಾಗೆಯೇ ಅಂತಹ ಕಾಂಡಗಳಲ್ಲಿ ಶೀಘ್ರ ಬೇರು ಮೂಡಿಕೆ, ಹೆಚ್ಚಿನ ಸಂಖ್ಯೆಯಲ್ಲಿ ಎಲೆಗಳು, ಕಾಂಡದ ಹೆಚ್ಚಿನ ಬೆಳವಣಿಗೆಯನ್ನು ಪಡೆಯಲಾಯಿತು.

ಗೂಟಿ ಕಟ್ಟುವ ಮುನ್ನ ಕಪ್ಪು ಪಾಲಿಥೀನ್ ಹಾಳೆಯಿಂದ ಮುಚ್ಚಿ, ಬೆಳಕಿಗೆ ಒಡ್ಡದ (Etiolated) ಕಾಂಡಗಳಿಂದ ಹೆಚ್ಚಿನ ಸಂಖ್ಯೆಯಲ್ಲಿ ಬೇರು ಬುಡಿಕೆ ಕಂಡುಬಂದಿತ್ತು. ಗೂಟಿ ಕಟ್ಟಲು ಸ್ಪಗ್ನಮ್ ಮಾಸ್ (ಪಾಚಿ ಸಸ್ಯ) ಬಳಸಿ ಹಾಗೂ 1000 ಪಿ.ಪಿ.ಎಂ. ಸಾಂದ್ರತೆಯ ಐ.ಬಿ.ಎ, ದ್ರಾವಣದಿಂದ ಉಪಚರಿಸಿದ ಕಾಂಡಗಳಲ್ಲಿ ಶೇಕಡ 66.00 ಕಾಂಡಗಳು ಬೇರು ಬಿಟ್ಟವು, ಐ.ಬಿ.ಎ. ದ್ರಾವಣದಿಂದ ಉಪಚರಿಸದ ಕಾಂಡಗಳಲ್ಲಿ ಶೇಕಡ 45.25 ಕಾಂಡಗಳು ಬೇರು ಬಿಟ್ಟವು. ಐ.ಬಿ.ಎ 1000 ಪಿ.ಪಿ.ಎಂ. ದ್ರಾವಣದಿಂದ ಉಪಚರಿಸಿದ ಕಾಂಡ ಶೇಕಡ 81.45 ರಷ್ಟು ಪ್ರಾಥಮಿಕ ಹಾಗೂ 124.91 ರಷ್ಟು ತಂತು ಬೇರು ಬಿಟ್ಟವು. ಹಾಗೆಯೇ ಹೀಗೆ ಉಪಚರಿಸಲ್ಪಟ್ಟ ಕಾಂಡಗಳಲ್ಲಿ ಸರಾಸರಿ 22.52 ಮಿ.ಮಿ ಕಾಂಡದ ಬೆಳವಣಿಗೆ ಹಾಗೂ ಐ.ಬಿ.ಎ. 1000 ಪಿ.ಪಿ.ಎಂ. ದ್ರಾವಣದಿಂದ ಉಪಚರಿಸದ ಕಾಂಡಗಳಲ್ಲಿ ಸರಾಸರಿ 13.71 ಮಿ.ಮಿ ಕಾಂಡದ ಬೆಳವಣಿಗೆ ಕಂಡುಬಂದಿತು.

ತೋಟಗಾರಿಕೆ ವಿಭಾಗ
ಕೃಷಿ ವಿಶ್ವವಿದ್ಯಾಲಯ, ಜಿ.ಕೆ.ವಿ.ಕೆ.
ಬೆಂಗಳೂರು.

(ಬಿ.ಎನ್. ಸತ್ಯನಾರಾಯಣ)
ಪ್ರಧಾನ ಮಾರ್ಗದರ್ಶಕರು

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Introduction

I. INTRODUCTION

Fig (*Ficus carica* L.) is a deciduous and subtropical fruit crop. It is said to be originated in the east Mediterranean region, from where its cultivation expanded to the whole of the Mediterranean region. Along with date palm, *vinifera* grape and olive, the fig was one of the important fruit crops of the ancient civilization of the eastern Mediterranean region and appeared in many songs and legends of historical and mythological background.

Greece is now the leading fig producing country followed by Algeria, Morocco, Syria and Italy in the world. Although wild figs are grown in India for thousands of years, the common fig is not being cultivated commercially, though factors like soil and climate are most suitable for its cultivation in the country.

Fig, though cultivated in an area of about 1000 ha in India, on a commercial scale it is cultivated only in Pune district of Maharastra state. It is also cultivated in small areas in Bangalore, Mysore, Chitradurga and Bellary districts of Karnataka as well as Ananthpur district of Andhra Pradesh. In North India it is cultivated in Uttar Pradesh, Punjab, Bihar and West Bengal in small gardens or in home backyard (Bose and Mitra, 2001).

Morphologically, the fig fruit is called as 'Syconus' which is fleshy receptacle. Figs are consumed fresh, dried, preserved and canned. Fresh fruits are very delicious and nutritious and used as dessert or for making jam. Fig is a rich source of calcium, iron and sugar. Fruits have been prized over centuries for their medicinal and dietary properties (poor source of vitamin C). Fig is valued for its laxative properties and is used in the treatment of skin infection. The fruit helps to maintain acid alkali balance of the body. Latex is useful to coagulate milk.

As fig is gaining greater importance and is preferred in dry land horticulture, perpetuation of the crop needs immediate attention. Although, it is possible to propagate this crop from stem cuttings, by air layering, grafting and by tissue culture, commercially it is propagated through stem cuttings. Reports on systematic investigations into various aspects of propagation of fig from stem cuttings and air layering is scanty. As the soil and climatic conditions are suitable and favourable for cultivation of fig, there is an ever increasing demand for the planting material in South India. This has necessitated investigations into finding an, easier, quicker and a successful method of propagation.

Physiological aspects such as the type of cuttings, aspects of etiolation of shoots in air layering, media and most importantly growth regulators have all known to influence adventitious rooting be it from cuttings or from air layered stems. Discovery of growth regulating substances such as auxins and cytokinins had revolutionized the industry of propagation during mid thirties. The influence of these aspects has to be studied in relation to a particular species in question to evaluate their efficacies in that species. Hence, the present investigation of studying the influence different aspects on propagation of fig through cuttings and air layering was undertaken with the following objectives.

1. Standardization of type of stem cuttings and growth regulators for rooting and establishment of stem cuttings.

2. Study the influence of etiolation, rooting media, and growth regulators for rooting of air layered shoots.

Review of Literature

II. REVIEW OF LITERATURE

Propagation is one of the important aspects of Horticulture. Vegetative propagation methods such as through stem cuttings, air layering, budding and grafting are being widely followed to multiply plants of desired characteristics and to maintain their purity for commercial exploitation in many fruit and ornamental crops.

The art of propagation by vegetative method has gained popularity in the field of horticulture. Many of the horticultural plant species which are found to be difficult to root, are made to root easily by use of root inducing hormones and by providing mist. The relevant studies on propagation by stem cutting and air layering in different horticultural crops in India and elsewhere are briefly reviewed here.

Research work on propagation of fig has not received much attention. Hence, studies reported on other important horticultural plants are reviewed in this chapter under the following headings.

2.1 Stem cuttings

1. Studies on propagation through stem cuttings.
2. Studies on effect of type of stem cuttings and growth regulators.

2.2 Air layering

1. Studies on propagation through air layering.
2. Studies on effect of etiolation and use of growth regulators in air layering.

2.1 Stem Cuttings

Plant stem cutting, also known as striking/cloning, is a technique for vegetatively (asexually) propagating plants in which a piece of the

source plant, containing at least two or three cell is placed at a suitable medium such as moist soil, potting mix, coir or rock wool. The stem cuttings produce adventitious roots at the base and develop into an individual plant.

2.1.1 Effect of type of cuttings

Depending on the species and maturity of the stem types of stem cutting have been described. Normally based on ontogenic maturity of tissues, the stem cuttings are divided into hardwood, semi hard wood and soft wood stem cuttings. Generally herbaceous plants ontogenically matured, the tissue or the wood of the stem remain soft.

In hardwood and semi hardwood stem cuttings of Karna Khatta (*Citrus kamaraj*) showed no significant differences by Singh (1962). But the better results were obtained wit hardwood cuttings of vence (*Cirus liven)* reported by Singh and Singh (1973).

The studies on the rooting ability of woody, semi woody and less woody cuttings of ornamental plants by Bose *et al.* (1975) showed better rooting in semi woody cuttings than those from other types of wood.

The studies on the rooting of *Allamanda cathodica* soft wood cuttings treated with 200 ppm of IBA showed 92.50 per cent rooting compared to semi-hardwood cuttings treated with 3000 ppm IBA (Singh, 1980).

Treating of hardwood cuttings of cinnamon (*Cinnamomum zeylanicum*) with 2500 ppm IBA, resulted in rooting of 45 per cent of cuttings. The application of 5000 ppm NAA induced 22 per cent rooting in semi hardwood cuttings.

In basal cuttings of *Corissa* sp. using 500 ppm of IBA 75 per cent rooting was obtained (Bandopadhyay *et al.* [1982]). A hundred per cent rooting was obtained with forced etiolated shoots of jackfruit treated with 5000 ppm IBA. Similar results were obtained by Dhua *et al.* (1983) using 3000 ppm and 2000 ppm Iron folic acid (Mukherjee and Chatterjee, 1982). They also obtained 100 per cent rooting from guava cuttings treated with IBA 3000 ppm. The cuttings were taken from the shoots sprayed with 50 and 100 ppm Ethephan, seven days before planting.

The basal cuttings of pomegranate treated with 5000 ppm IBA showed highest rooting of 80 per cent when compared to sub-optical cuttings treated with the some concentration (Shekarappa, 1983).

Softwood stem cuttings of the Chinese goose berry cv. Allison which were treated with IBA at 5000 ppm recorded maximum percentage of rooting (90%). The rooting of hardwood and semi hardwood stem cuttings was poorer than softwood stem cuttings with the same treatment (Rathore, 1984).

The 90 per cent of rooting was obtained in hardwood and semi-hardwood stem cuttings of Cocoa (*Theobroma cacao*) when treated with NAA 4000 ppm or 6000 ppm IAA for 60 seconds (Keshvachandran and Nair, 1985).

Purushotham *et al.* (1986) used single node stem cuttings of coffee cv. S. 795, which were taken from etiolated and ringed suckers. After treating with 5000 ppm IBA they recorded 73 per cent rooting. Ramulu and Purushotham (1986) obtained similar results in another cultivar (S.3655) of coffee, using single node sucker stem cuttings.

Application of IBA at 3000 ppm to Damask rose stem cuttings resulted in the highest survival of rooted stem cuttings (48.97%) followed

by 300 ppm NAA (41.11%). The basal woody stem cuttings were found to root better than the middle semi-woody stem cuttings (Shenoy, 1992).

The hardwood stem cuttings of west Indian cherry treated with IBA 1500 ppm showed the maximum survival percentage (Singh and Attri, 2000) followed by Semi-hardwood stem cuttings.

Terminal wood stem cuttings of various lengths of Fig were taken in February and rooted. Root regeneration of C1 stem cuttings was significantly higher than that of C2. Rooting rate of stem cuttings ranged between 95.83 and 100 per cent according to the stem cutting type. The longest root length was obtained from stem cuttings, which had Five nodes with two year old wood at their bases. Lowest values were obtained from stem cuttings, which had Five nodes with two year old wood at their bases. Lowest values were obtained at one year old wood. One year old shoot and intermediate stem cuttings with Five nodes from two years old wood even recorded 100 per cent rooting (Ozeker, 2001).

Rooting was examined by applying various concentrations of IBA to the stem cuttings taken at different periods. One year old hardwoods stem cutting of three fig cultivars were planted in perlite from end of October to end of March. The highest rooting was obtained in the cv. Patlcan (58%) with 100 ppm IBA (Karadeniz, 2003).

The effects of the timeng of stem cuttings collection and IBA application on the rooting of fig cv. Roxo de valinhos were studied under greenhouse conditions. The stem cuttings obtained from one-year-old branches of adult fig trees every fortnight between April and August were treated with IBA (100 mg/l) for 24 hours. The highest percentage (100%) of rooted stem cuttings was obtained with stem cuttings collected during April and May (Chalfun *et al.,* 2003).

Defoliated small stem cuttings (10 cm) from sprouting fig cv. Roxo de Valinhos with or without apical buds were conditions in polypropylene trays containing sand, sand:soil (2:1), sand:soil (1:1) and soil. The small stem cuttings were maintained in a greenhouse under controlled humidity and temperature. After 50 days the rooting and sprouting percentage and the number of leaves, sprouts and roots of each stem cuttings were evaluated. Soil and sand:soil (1:1) promoted increased the rooting and sprouting percentage of the stem cuttings without apical buds (Pio-R *et al.,* 2003).

2.1.2 Effect of growth regulators on rooting

Plant hormones (also known as plant growth regulators (PGRs) and phytohormones) are chemicals that regulate plant growth. Plant hormones are signal molecules produced at specific locations in the plant, and occur in extremely low concentrations. The hormones cause altered processes in target cells locally and at other locations. Plants, unlike animals, lack glands that produce and secrete hormones. Plant hormones shape the plant, affecting seed growth, time of flowering, the sex of flowers, senescence of leaves and fruits. They affect which tissues grow upward and which grow downward, leaf formation and stem growth, fruit development and ripening, plant longevity and even plant death. Hormones are vital to plant growth and, if they were to lack them, plants would be mostly a mass of undifferentiated cells.

Auxins are compounds that positively influence cell enlargement, bud formation and root initiation. They also promote the production of other hormones and in conjunction with cytokinins, they control the growth of stems, roots, flowers and fruits. Auxins were the first class of growth regulators discovered. They affect cell elongation by altering cell wall plasticity. Auxins decrease under condition of light and increase under dark. They stimulate cambium cells to divide and in stems cause

secondary xylem to differentiate. Auxins act to inhibit the growth of buds lower down the stems, affecting a process called apical dominance, and also promote lateral and adventitious root development and growth. Auxins promote flower initiation, converting stems into flowers. When auxins are no longer produced by the growing point of a plant, leaf abscission. Initiated seeds produce auxins, that regulate specific protein synthesis, as they develop within the flower after pollination, causing the flower to develop a fruit to contain the developing seeds. Auxins are toxic to plants at higher concentrations; they are most toxic to dicots and less so to monocots. Because of this property, synthetic auxin herbicides including 2,4-D and 2,4,5-T have been developed and used for weed control. Auxins, especially 1-Naphthaleneacetic acid (NAA) and Indole-3-butyric acid (IBA), are also commonly applied to stimulate root growth when taking stem cuttings of plants. The most common auxin found in plants is indole-acetic acid.

As early as 1925, the Dutch scientist Vandrolock suggested that the formation of hormone in the developing bud and its condition caused rooting in the base. (Thiman and Went,1934) showed the auxins play a vital role in inducing rooting in stem cuttings.

The two most important auxins, i.e. IBA and NAA have been used widely either singly or in combination for induction of rooting in stem cuttings of various crop species (chimel, 1985). Treatment with auxins has been shown to increase the per cent of rooting, hasten initiation and increase the number and quality of roots in a large number of plant species.

The rooting studies on *Ficus mysorensis* stem cuttings by El-Hakim *et al.* (1962), showed the stem cuttings treated with IBA 100 and 200 ppm solution for 12 hours showed highest rooting than IAA.

In the studies conducted by Vijayakumar (1973) on propagation of guava by stem cuttings, 84.5 per cent rooting was obtained by treating the stem cuttings with 5000 ppm IBA and planting in the month of July. IBA treatment increased the number and length of primary roots. Stem cuttings of 'Allahabad Safeda' pretreated with 2000 ppm IBA + NAA + IBA, were found to have maximum rooting.

The studies done by Lenka and Das (1981) on litchi stem cuttings treated with 3000 ppm IBA transplanted in month of April in the medium perlite (0.5-1.0mm) showed highest rooting. Similarly successful rooting in stem cuttings of mango cv. Longra treated with 10000 ppm IBA (Ranjan and Ram,1983).

Arora and Yamadagni (1985) obtained highest rooting with leafy cuttings of lemon treated with 2000 ppm NAA.

Sweet lime stem cuttings treated with 100 ppm IBA showed highest rooting (Sandhu and Singh, 1986).

Singh *et al.* (1986) obtained the best rooting, subsequent sprouting and growth in 25 cm long stem cuttings of sweet lime using 1500 ppm IBA. (Ramsunder and Abdul Khader,1986) reported 40 per cent rooting with etiolated and ringed shoots of sapodilla treated with 2000 ppm IBA.

The relationship between the size and rooting of stem cutting depend on IBA treatment (Singh *et al.,* 1986) and poor results obtained softwood stem cuttings of perlite grapes.

Application of IBA at 5000 ppm resulted in maximum rooting percentage (83.33%) in pomegranate hard, semi-hardwood and soft stem cuttings, when compared with NAA application (Ghose *et al.,* 1988).

According to Reddy and Singh (1988), the non wounded hardwood stem cuttings of guava treated with IBA 2000 ppm showed 87.5 per cent rooting and 62.86 per cent survival. Prasad *et al.* (1988) reported the best rooting (98%) with IBA treatment at 2500 ppm in hardwood stem cuttings of guava.

Guava stem cuttings (Barvipur, Sardar and Haritha) treated with IBA 2000 ppm gave best rooting percentage (83.3%, 73.3% and 73.3%) as reported by Debnath and Maiti (1990).

The apical and medial shoots of kiwifruit cv. "Monty" cuttings treated with 6000 ppm IBA + 3000 ppm NAA in pure sand showed higher percentage of rooting (Nasser *et al.,* 1991).

The effect of different concentrations of IBA (50-400 ppm) on root initiation in semi-hardwood stem cuttings of peach cv. Early Grande found that IBA at 400 ppm resulted in the maximum number of shoots (2), leaves (21.25), roots (4), lowest number of days for sprouting (14) and average shoot length of 7.5 cm and root length of 3.7 cm (Sadiq, 1991).

Oosthuizen (1993), reported that the pecan Cv. Sioux cuttings treated with IBA showed highest rooting percentage (97%). Dunn *et al.* (1996), stated that *Pistachia chinnensis* cuttings treated with a combination of IBA and NAA each at 5000 ppm produced more rooted cuttings than other combination treatments.

Timla fig stem cuttings treated with 5000 ppm IBA showed the highest rooting percentage (76.6%) (Sundaram and Rangaswamy ,1994).

The hybrid grape stem cuttings treated with 1250 ppm IBA showed highest percentage of rooting and mean length of roots (Prataparedddy *et al.,* 1996). According to Ma-Kai *et al.* (1997) softwood stem cuttings of fig

cv. Burnswick with 2-3 leaves taken on 20th September and 13th October found 80-100% rooting when treated with IBA at 1000-4000 mgL^{-1}.

Responses of eight species (including *Flacourtia sp*. olive, bar, fig, peach and carambola) treated with IBA at 500, 1000, 1500, 2000, 2500 and 3000 ppm are described by Bora *et al. (*1998). Rao *et al.* (1988) obtained 52 per cent rooting in cashew stem cuttings treated with 1000 ppm IBA after being ringed for 90 days.

Norberto *et al.* (2001) observed that fig stem cuttings treated with IBA 100 mg/l recorded highest percentage of rooting (95%). Kishore *et al.* (2001) stated that IBA at 3000 ppm is suitable concentration for rooting in hard wood stem cuttings of West Indian cherry.

The smooth and hard wood apical stem cuttings (20 cm) of fig tree were immersed in 2 per cent sucrose solution and also in 0, 100, 200 and 300 mgL^{-1} of IBA for 24 hours. The stem cuttings were then transferred to 26 x 14 cm plastic bags filled with soil and sand at a ratio of 2:1 (v/v) and maintained in a greenhouse under a controlled temperature. Sucrose supported the rooting of the stem cuttings and the growth of the major root. IBA slowed the rooting of the stem cuttings and reduced the number of sprouting and root dry matter. The interaction between sucrose and IBA was not significant (Pio *et al.,* 2003).

Basal stem cuttings may be used for mass multiplication of fig plant. The higher percentage of rooting could be obtained under greenhouse by the application of 4500 ppm each of IBA and NAA (Ganta bhagyalakshmi, 2004).

Apical stem cuttings of fig (20 cm long) were immersed for 5 seconds in solutions containing IBA (0, 1000, 2000, 3000 or 4000 mg/l) with or without sucrose (2%). The stem cuttings were planted in pots

containing soil and sand (2:1 v/v) and transferred to the greenhouse or grown directly in the field on a substrate consisting of soil and cattle manure (3:1, v/v). After 120 days, rooting was observed in stem cuttings treated or untreated with sucrose or IBA was only necessary to increase the rooting percentage (Pio *et al.,* 2004).

2.1.3 Establishment of rooted stem cuttings

While propagating plants, the knowledge about their extent of establishment is important to obtain better productivity.

Gupta (1982), reported a maximum survival of 90 per cent of rooted cuttings in *Lagastreemia lancasteri*, this rooted cuttings had been rooted by using 400 ppm IBA.

Kempe Gowda (1984) reported that in the rose cultivar Mariacallas there was 40 per cent field establishment of hardwood stem cuttings treated with 2000 ppm IBA whereas in Queen Elizabeth semi hardwood stem cuttings treated with 2000 ppm NAA recorded 81.66 per cent establishment.

Semi-hardwood stem cuttings of Kathbael (*Limonia acidisima*) immersed for 24 in 50 to 100 ppm NAA gave good results with respect to rooting and field establishment (Poi and Mazumdar, 1989).

Kaundal and Singh (1989) reported that the higher rooting success in *Pyrus communis* cultivar “Leconte” with 200 ppm IBA treatment and correlated it to high C:N ratio.

The maximum number of survivability and rooting were obtained in fig stem cuttings (Borah and Das, 2000) treated with 3000 ppm IBA.

When the apical and subapical stem cuttings of kiwifruit treated with 5000 ppm IBA (Rana and Jindal, 2001) reported the maximum

rooting in apical type and subapical type showed maximum survivability in field.

2.2 Air layering

Air layering is a simple propagation technique that was perfected in China more than 4,000 years ago to create offspring that are genetically identical to their parent plants.

A method of propagating plants by wounding a stem or branch, applying a hormone to the wound, wrapping the stem or branch with damp sphagnum moss and polyethylene sheet to encourage root formation, and finally removing the rooted stem or branch as an independent plant.

In an experiment conducted in Parbhani, Maharashtra, India from 20 July, 1993 to 20 January, 1994 to determine the effects of climatic seasons and IBA (500 ppm) on air layering of figs (cv. Daulatabad), air layering along with IBA was successful during August and September (wet season).

2.2.1 Effect of girdling and etiolation on rooting

Girdling in relevance to propagation such as air layering is the process of completely removing a strip of bark (consisting of secondary phloem tissue) around a stem or branches. Girdling helps in the accumulation of photosynthates such as CHO's and other metabolites. The accumulation of CHO's helps in the initiation of roots from phloem tissue or the bark tissue at the girdled site.

Etiolation is the process of subjecting a stem of plant towards dark condition. Etiolation normally favours the rooting of cuttings. It is established that increased synthesis and accumulation of auxins takes

place near the tissues which are exposed to dark condition. (Hartmann and Kester, 1976).

The beneficial effects of etiolation on air layering of mango have been demonstrated by Mukherjee and Bid (1965) and Bid (1969). Etiolated shoots produced higher number of primary and secondary roots than non-etiolated shoots after treatment with IBA at 10,000 ppm and NAA at 5,000 ppm.

In case of Langra variety of mango, 100 per cent rooting and establishment of marcots were obtained when the etiolated layers were treated with 1000 ppm IBA and NAA in equal parts (Bid and Mukherjee, 1969). Further, they recorded 90 per cent survival in Chousa variety by treating the etiolated shoots with IBA plus NAA each at 5000 ppm.

In avocado (*Persea americana)* stem cuttings were difficult to root. However, Frolich (1961) obtained good rooting by subjecting them to girdling and etiolation. Girdled and etiolated soft wood pecan (*Carya illinoensis*) stem cuttings produced more highly branched and more vigorous root system than only girdled stem cuttings. Hard and soft wood stem cuttings of pecan did not initiate roots even after girdling (Talyor and Odour, 1970).

The relation between starch content and rooting in *Populus nigra* was studied by Nanda and Anand, 1970. They stated that the delayed rooting shows high starch content and nigrous rooting shows low starch content.

The Basu *et al.* (1972) showed progressive increase in carbohydrates in air layered mango shoots and in layers treated with IBA. Reuveni and Adato (1974) observed higher total carbohydrates

content in easy-to-root offshoots than in difficult-to-root offshoots of datepalm, although the latter contained more reducing sugars.

Dash Chowdhury (1971) obtained higher carbohydrate to nitrogen ratio in the girdled shoots of mango. He observed that this was due to the accumulation of carbohydrates in the girdled shoots.

Rooting earliness of pummelo (*Citrus grandis* Osbeck) air layers was dependent on ringing and etiolation. After four weeks of air-layering 100 per cent rooting was noted in the layers that were ringed and etiolated for two months, as compared to 15 per cent rooting obtained in the control (Hulmani and Reddy, 1974).

Hore and Sen (1997) reported that maximum rooting success of 96.75 and 88.12 % could be achieved in ringed + etiolated shoots than ringed + non-etiolated shoots of pomegranate, respectively with Paclobutrazol at 1000 ppm + IBA at 5000 ppm as against 54.56 and 50.28% rooting in Non-ringed + etiolated than ringed + non-etiolated control.

2.2.2 Effect of growth regulators on rooting in air layers

It was originally shown by Went (1934) that auxin stimulated adventitious root formation in stem cuttings. Hitchcock and Zimmerman (1940) reported that mixtures of equal parts of IBA and NAA were more effective at lower concentrations as they obtained higher percentage of rooting in stem cuttings of bitter sweet (*Cleastura*), arborvitae (*Thuja*) and sequoia (*Sequois).* Further, Hitchcock and Zimmerman (1940) reported that addition of phenolic compounds either to IBA or NAA produced excellent results. According to them addition of phenolic compounds in small amount representing not more than 25 per cent of total concentration of hormones was more effective in producing the root system which was qualitatively better than that obtained by phenolic

compounds alone. Hitchcock and Zimmerman (1942b) observed the combined effect of IBA and NAA in rooting of apple stem cuttings variety "Rhode Island Greening" taken in May. They recorded cent per cent rooting by treating with IBA at 8 mg per g as well as at 3 mg per g whereas IBA at 1 mg per g gave no rooting. They recorded 25 per cent rooting by treating with NAA at 8 mg per g, 4 mg per g and 1 mg per g. IBA and NAA in combination at 2 mg per g gave 80 per cent rooting and that of 4 and 8 mg per g resulted in 50 per cent and 20 per cent rooting, respectively.

While investigating propagation of cacao by marcottage, obtained 66 per cent rooting in 6 weeks by applying IBA at $5mgL^{-1}$ as compared to 16 per cent in untreated ones. The same concentration gave cent per cent rooting in hybrid cinchona whereas none of the untreated marcots rooted (Copper, 1944).

The effect of different growth substances on rooting of loquat (*Eribotrya iaponica* (thumle) Lindi.) air layers (Sing and Sharma, 1954). They reported that there was cent per cent rooting with NAA 3 per cent, 80 per cent with IAA 2 per cent, 90 per cent with IAA 3 per cent with IAA 2 per cent, 90 per cent with IAA 3 per cent as against 20 per cent in control. Jauhari and Amarjit (1960) reported that NAA was the most effective growth substance. They studied the effect of different growth substances on air layering of loquat (variety 'Pale Yellow'). Using NAA at 10000 to 30000 ppm, they obtained 40 to 50 per cent rooting on 15 -year old trees compared to 30 to 40 per cent rooting with IAA at 12000 to 20000 ppm, 20 to 30 per cent with IBA at 20000 to 20000 ppm and none zero per cent in control. They also reported that rooting was obtained only with NAA at 20000 ppm when the air layers were prepared in February.

According to Stoutmyer (1954) some of the chloride substituted phenoxy compounds are highly effective in root formation at low concentrations and their effects are noticeable particularly in mixtures. Avery and Johnson (1947) reported that mixtures of hormones were found to be more effective than equivalent concentrations of a single hormone for stem cuttings of a number of species. Kondo (1948) obtained good results by treating the grapevine stem cuttings with heteroauxin at 300 ppm and NAA at 25 ppm.

Sen and Bose (1959) studied the effects of different growth substances on rooting of jack air layers. IAA, IBA and NAA at 1000, 5000 and 10000 ppm were applied in lanolin paste at the time of ringing in the middle of May and June. A significant increase in the percentage of rooting was obtained due to all the three growth substances and all of them gave better rooting with June treatment. They also reported that IBA gave best results with 5000 ppm concentration and IAA and NAA at 10000 ppm. Muzik (1948) reported 80 per cent rooting due to dipping the branch stem cuttings of tropical breadfruit in 1 per cent IBA solution.

Experiments with Kalipatti variety of Sapota air layers showed that mixture of IBA and NAA combined in equal proportion gave earlier rooting (Chinnappa and Kololgi, 1961). Of the various concentrations tried, concentration of 2000 ppm gave earlier rooting and better root formation with highest percentage of success. The time taken for rooting in case of treated air-layers ranged from 18 to 27 weeks.

The effect of IBA and NAA individually and with equal mixture of both in lanolin paste in the concentration range of 0 to 1000 ppm on sapodilla air-layers was tested by Singh *et al.* (1962). Good results were obtained when the mixture of IBA and NAA in equal proportion was applied compared to the application of individual growth substances in equivalent concentration. Rooting improved with increasing

concentration and was highest (72.6%) with the mixture at 1000 ppm. The macrotting period was greatly reduced by this treatment. The shortest period was 107 days as compared to 5 to 6 months taken by air-layers in the normal course. Further, they reported that IBA was better than NAA.

Kempanna *et al.* (1961) in a trial on propagation of *Glyricidia maculata* by air layering observed that mixtures of NAA and IBA was better for rooting rather than either of the growth substances applied alone. Lingaraj (1960) found that in air-layers of *Althea rosea* treatment with either IBA or NAA at 4000, 3000 and 2000 ppm induced rooting. Further, he noted that lower concentrations were more effective than higher concentrations and that roots appeared 14 days after the treatment.

Hess (1961) conducted mung bean bioassay test to find out the presence of root promoting substances in ivy (*Hedera helix*). He noted four root promoting zones in the extracts of juvenile ivy tissues at R_f 0.1, 0.3, 0.6 and 0.8. Further, he observed the greatest amount of activity of the root promoting substances when stem cuttings were treated with IAA. However, when IAA alone was supplied to the stem cuttings it had little effect on root initiation. Therefore, he concluded that the root promoting substances served as a cofactor of IAA. His opinion was that the degree of difficult-to-root is an expression of the degree to which various components of rooting complex are limiting.

Kailasam *et al.* (1964) reported that the stem cuttings of cacao (*Theobrama cacao*) treated with a mixture of IBA and NAA at 5000 ppm in sand dust medium gave good results. Evans (1951) reported that in cacao early rooting was obtained by treating the stem cuttings with IBA and NAA in combination than treating with individual hormones. Onsom (1952) studied the synergistic effect of IBA and NAA in rooting of bean

stem cuttings. Jauhari and Nigam (1959) induced good rooting in all the treatments of NAA, IAA and IBA at various concentrations in *Morus alba* layers. But concentrations of 5000 to 10,000 ppm gave better results than higher concentrations. There was no rooting at all in control. Jauhari and Nigam (1958) worked on *Carissa carandas* L. and reported 100 per cent rooting in air layers treated with NAA and IBA (mixed in equal proportion) at concentrations of 10000, 7500, 5000 and 2500 ppm after six weeks, but the untreated layers did not root. Further, they noted that there was only 20 to 40 per cent rooting due to higher concentration of IBA and NAA in mixture, i.e. more than 10000 ppm.

Basu *et al.* (1966) reported that there was a greater accumulation of naturally occurring rooting cofactors in the girdled shoots of mango as compared to non-girdled ones. Hess (1966) by adopting chromatography and mung bean bio-assay observed the differences in substances involved in stimulating root initiation from the methanol extracts of juvenile and mature tissues. The highest peak activity was referred to as rooting cofactor-4. This cofactor-4 had synergetic effect with IBA in the stimulation of root initiation. He also noted that there was highest difference in the level of this cofactor between juvenile and matured shoots.

In cashew, Chhonkar and Singh (1967) observed that 88 per cent rooting of air layers treated with 75 ppm IBA. Average number of roots produced, length and diameter were superior in case of IBA treatment to IAA or control. Acharya and Dash (1972) obtained 84.6 per cent rooting in cashew air layers by treating with IBA at 300 ppm compared to 46.23 per cent in untreated marcots.

Thakurta and Dutta (1941) successfully propagated mango from gootee of two and three year old plants by treatment with 3 per cent IAA whereas 1 to 3 per cent NAA was found to be ineffective.

The mixture of IBA, Paclobutrazol and NAA gave better rooting in mango air-layers (Rao *et al.,* 1963). Chhonkar and Singh (1972) reported that IBA at 5000 ppm was more effective than NAA in promoting rooting of mango air-layers. Similar results were obtained by various workers (Mukherjee *et al.,* 1965, Basu *et al.,* 1967 and Sen and Bose, 1967).

The (Basu *et al.,* 1968) showed the rooting activity in mango seed extracts was due to single substances which was neither phenolic nor indolic in nature and was highest at R_f 0.7. Taylor and Odour (1970) located three to four areas of endogenous rooting cofactor activity corresponding to specific R_f values in basal extracts of all stem cuttings by paper chromatography and mung bean bloassy. Likewise, Kawase (1970) extracted root promoting substances from soft wood stem cuttings of *Salix alba* and treated with mung bean stem cuttings. He observed three major root promoting factions in descending order at R_f 0.1, 0.7 to 0.8 and 0.3 to 0.4. The R_f 0.1 had higher rooting activity and its concentration was about seven to eight times higher than control. Ghosh and Ghosh (1971) found high regenerative capacity of acalypha stem cuttings associated with greater quantity of rooting cofactors as compared to poorly rooting ones.

Majumdar and Mukherjee (1968) indicated that guava can be successfully propagated through air-layers by using IBA in lanolin paste.

The IBA and NAA in combination was good for earlier rooting of guava air-layers variety “Lucknow-49”. According to Bhandary and Kololgi, 1960) 10000 ppm and 15000 ppm concentrations were optimum and induced rooting in the shortest period of 5 to 6 weeks. They also reported that 20000 ppm had toxic effect while 5000 ppm was found to be sub-optimal. Mixtures of IBA and NAA each at concentrations of 5000 ppm gave highest number of primary, secondary and tertiary roots in guava variety ‘Lucknow-49’ (Anon, 1961).

More number of primary and secondary roots in mango air-layers were obtained by treating the air-layers with IBA and NAA in combination each with 5,000 ppm concentration (Bid and Mukherjee, 1969). This was attributed to the possible synergistic effect of IBA and NAA in combination Azzous *et al.* (1969) tested the effect of IBA, NAA and their mixtures at concentrations of 0.25 per cent to 1.0 per cent in 'Aromas' variety of mango. They recorded 70 per cent rooting in the layers treated with one per cent IBA against 40 per cent rooting in control layers.

The effect of IBA and NAA in rooting of sapota air-layers (Sulladmath and Kololgi, 1969). They reported that IBA and NAA at 10000 ppm mixed in equal parts was optimum. The combination gave 90 per cent rooting in 16 weeks against 40 per cent rooting in 38 to 40 weeks in untreated control.

Verma *et al.* (1970) reported that the strong synergistic effect of IBA and NAA at 7500 ppm in mango and guava marcots and concluded that IBA was more effective in induction of roots in the air layers of different plants. Bhandary and Mukherjee (1971) proved the synergistic effect of IBA and IAA in rooting of rose apple stem cuttings.

Sen and Chakravarthy (1972) reported that the best results can be obtained by treating the macrots of cashew with 500 ppm IBA. Rajan (1978) obtained highest number of primary and secondary roots in cashew air layers due to treatment with combination of IBA 300 at ppm NAA at 200 ppm and 10 ppm of 2,4-D.

In an investigation on the effect of IBA at concentrations ranging from 1000 to 4000 ppm on air layering of guava variety "Lucknow-49", the best results were obtained with 3000 ppm which gave 86.6 per cent rooting and 76.6 per cent survival(Bhujbal,1972).

The IBA at 250 ppm induced early and extensive rooting in ber air-layers (Singh *et al.,* 1973) and the marcotting period was reduced from 106 days to 69 days in treated ones. Chadha (1968) indicated that the optimum concentration for IBA and NAA was 250 ppm which gave 88.8 per cent and 72.20 per cent rooting, respectively, as against 37.2 per cent in control in litchi air-layers. Sharfuddin Hussain (1973) reported that cent per cent rooting in litichi marcots by treating with IBA at 500 ppm. Jauhari (1960a) reported that 100 per cent rooting in gootee of *Zizyphas mauritiana* when treated with 400 ppm NAA alone.

Vijayakumar and Chauhan (1974) reported that the root promoting cofactors, especially cofactor-4 was present in higher amounts in girdled and etiolated shoots of guava. Reuveni and Adato (1974) assessed the endogenous root promoting and inhibiting activity in datepalm by adopting mung been bioassay. The root promoters were present at R_f 0.1 to 0.2 and R_f 0.3 to 0.5 and root inhibitors at R_f 0.5 to 0.8. Root inhibiting activity of R_f 0.5 to 0.8 was higher in difficult-to-root offshoots than in easy-to-root offshoots. They further concluded that the rooting ability was positively correlated to carbohydrate content.

The propagation of sapota by air-layering reported that the number of rooted layers, the number of roots per layer and total length of the roots in rooted layer were significantly more at higher levels of IBA + NAA in combination. The layers treated with IBA + NAA at 5000 ppm, 10000 ppm and 15000 ppm rooted earlier (Uthaiah, 1975).

Mukherjee and Chatterjee (1978) reported that there was significant increase in the percentage of rooting of jack air-layers by using IBA. They obtained 100 per cent and 91.66 per cent rooting by treating the etiolated shoots with IBA 10000 ppm and 5000 ppm, respectively. The survival in the nursery bed was 91.66 and 74.55 per cent, respectively, after keeping in nursery bed for one year.

Suryanarayana and Venkateswara (1982) obtained the highest percentage of successful layers and highest number of roots per layer in mango due to treatment with IBA at 2000 ppm in august, September and October. Roots also appeared in the shortest time with IBA at 20000 ppm in all the three months of layering.

Highest number of roots per air layer (40.66) was recorded in the gauva layers treated with IBA at 5000 ppm and the lowest number of roots (4.66) in control (Singh and Singh, 1996).

The study conducted by Singh and Singh (1996) revealed that gauva layers treated with IBA at 5000 and 6000 ppm recorded maximum length of roots per layer(1.96 cm) and minimum length of roots (1.23 cm) was recorded in control. Hore and Sen (1997) observed maximum number of roots (14.9) in pomegranate layers treated with ferulic acid (FA) at 1000 ppm + IBA at 5000 ppm treated layers.

Karunakara (1997) observed highest percentage of rooting treated with IBA and NAA at 3000 ppm and the lowest percentage of rooting was recorded in control.

The air layers of pomegranate treated with PHB 1000 ppm + IBA 5000 ppm showed maximum rooting success (Hore and Sen, 1997) of 89.35 per cent and minimum rooting 54.06 per cent in control treatment.

Propagation of custard apple through air layering by using IBA at 10,000 ppm showed the maximum number of secondary roots (20.25) where as the minimum number of secondary roots observed in control (4.66) (Chovatia and Singh, 2000).

According to Sengupta and Thakur (2001), the rooting of jackfruit air layers was maximum (90%) when they were treated with 5000 ppm IBA + NAA.

The more number of primary roots (19.00) and secondary roots per layer (6.01) of jack fruit was recorded in combined treatment of IBA and NAA at 5000 ppm and less number (6.01 and 3.4 respectively) in control. Maximum length of primary roots (11.39 cm) was noticed in the jack fruit layers treated with both IBA + NAA at 5000 ppm and minimum length (3.41 cm) in the control treatment (Sengupta and Thakur, 2001).

Kumar *et al*. (2001) reported that the maximum number of roots were recorded in custard apple layers treated with combination of saw dust + 500 ppm IBA (10.80) and least number of roots in gootee mixture + 500 ppm IBA (7.00).

Dubey and Yadav (2003) reported that the maximum number of primary roots (5.03 cm) was obtained in the sweet orange layers treated with 600 ppm NAA and lowest length was recorded with 200 ppm NAA treatment. They also reported that the highest number of primary roots (6.97) in sweet orange was noticed in NAA (400 ppm) treated layers.

Kunal Kumar and Syamal (2005) observed that the maximum number of primary roots in guava air layers was noticed with the treatment 3000 ppm IBA (14.80) and minimum number in control (2.90).

2.2.3 Establishment of rooted layers.

The 100 per cent rooting in mango marcots using NAA, IBA, NAA + IBA at 2500, 5000 and 10000 ppm (Srivastava, 1963). He recorded 100 per cent survivability after transplanting. Chhonkar and Singh (1972) reported that IBA at 5000 ppm was more effective than NAA in promoting the rooting and establishment of mango marcots.

Bhujbal (1972) found that IBA at 3000 ppm produced 86.6 per cent rooting and resulted in 76.6 per cent survival in air layers of guava.

The highest percentage of establishment of rooted shoots of ber (76%) was obtained with 12000 ppm IBA. Mukherjee and Chatterjee (1978) confirmed that etiolated air layers of jack fruit (*Artocarpus heterophyllus* Lam.) treated with IBA at 10000 ppm and 5000 ppm gave 100 per cent and 91.66 per cent rooting, respectively. Further, they recorded a survival percentage of 91.66 and 74.75, respectively, after keeping in the nursery bed for one year. They also found that jackfruit air layers obtained from invigorated shoots and treated with 5000 ppm IBA gave 86 per cent rooting and 58 per cent survival after one year of planting in nursery bed.

The effect of IBA and NAA each at 250, 500 and 750 ppm either alone or together on air layers of Kaghizi Khalan (a natural hybrid between lime and lemon). Rooting and subsequent field establishment was highest with IBA + NAA each at 500 ppm followed by IBA + NAA each at 750 ppm showed by (Misra and Agarwal, 1975).

Extensive root development which is important for success in vegetative propagation of cashew by air-layering was accomplished by several workers (Singh *et al.,* 1973; Chhonkar and Singh, 1967). Air layers of cashew treated with IBA plus NAA each at 5000 ppm were found to survive better (Anon, 1970). Cheriyan and Kurian (1976) observed that limited number of roots in cashew air layers was one of the important factors responsible for poor establishment of layers which may be further accentuated by rough handling of layers.

The highest rooting success of litchi layers was recorded in between 30 days and 60 days after layering and the highest mortality (52%) was in the first week of layering (Kahlon *et.al.,* 1994).

The guava layers treated with IBA 5000 ppm showed (Singh and Singh, 1996) the highest percentage of rooting success (74.99) and mortality (19.44%) in control.

The Baramasha lemon layers when treated with IBA 2000 ppm + 200 ppm PHA showed maximum (79.87) percentage of survivability (Rakesh kumar and Gill, 1996) and minimum survivability in control (40.27%).

The application of 2000 ppm IBA with 2000 ppm p-Hydroxybenzene acid to the air layered shoots of baramasha lemon was the best treatment for better rooting success (78.86) and least was recorded in control (54.68) (Rakesh kumar and Gill ,1996).

Maximum survival percentage (88.20 %) of pomegranate layers was noticed in the layers treated with PHB 1000+ IBA 2800 ppm (Hore and Sen, 1997). Pomegranate layers treated with1000 ppm PHB +2500 ppm IBA showed maximum percentage of survivability (94.30%) and minimum percentage in ferulic acid 1000 ppm (54.70%).

Chovatia and Singh (2000) observed the maximum percentage of survivability in rooted layers of custard apple with the treatment IBA at 10,000 ppm (77.08 %) and minimum percentage in control (15.62 %).

The jack fruit layers when treated with 500 ppm IBA showed maximum success of (85%) (Sengupta and Thakur, 2001) and minimum (54.22%) in control treatment.

Kumar *et. al.* (2001) reported that the maximum percentage of success in custard apple air layering in the combination treatment of saw dust and IBA at 500 ppm (53.76%) whereas minimum percenatge of success was with standard gootee mixture with-out IBA (22.45%).

Kumar *et al*. (2001) showed the significant effect of IBA on rooting with all three rooting media (44%) viz., saw dust, sphagnum moss and standard gootee mixture. The maximum survival percentage (31 %) was recorded in sawdust in combination with 500 ppm IBA and minimum survival percentage (22%) was recorded in gootee mixture without IBA.

The air layered sweet orange plants treated with NAA at 400 ppm showed highest percentage of success (31.20%).whereas the lowest percentage of success was noticed in layers treated with 600 ppm NAA (20.45%) (Dubey and Yadav, 2003).

The layers of sweet orange treated with NAA 400 ppm showed highest per cent of success (31.20%) and survivability (78.20%) reported by Dubey and Yadav (2003) and lowest was seen in treatment 200 and 600 ppm of NAA respectively.

Dubey and Yadav (2003) reported that highest percentage of survivability of air layers in different verities of sweet orange have been successfully achieved by exogenous application of NAA at 400ppm (78.20) and lowest percentage of survivability of air layers in application of NAA 200ppm (71.10).

Guava plant layers treated with 3000 ppm IBA showed highest percentage of success (93%) where as the lowest percentage (60%) was seen in control (Kunal Kumar and Syamal, 2005).

The survivability studies done by Kunal Kumar and Syamal (2005), showed the guava layers treated with 3000 ppm IBA showed maximum percentage of survivability (75.90%) and minimum percentage with control (40.55%).

Material and Methods

III. MATERIALS AND METHODS

The present investigation was carried out at the Zonal Agricultural Research Station, Hiriyur, University of Agricultural Sciences, Bangalore during the year 2005 – 2006. This location is situated at an elevation of 606.1 meters above the mean sea level and at 13^0 57 minutes 32 seconds North and 70^0 37 minutes 38 seconds East latitude.

3.1 Geographical locations and climate

The annual mean relative humidity of the location is 68.2 per cent. The minimum and maximum temperatures in a year range between 15 – 22^0C and 28 – 37^0C, respectively. The major rainfall is received from the Southwest monsoon between June and September and from North – East monsoon between October and January with little precipitation even during February and May.

Experiment – 1 : Effect of growth regulators on rooting of fig stem cuttings

3.1.1 Source and preparation of the stem cuttings

The matured shoots of past season growth were collected from an orchard near Zonal Agricultural Research Station, located at Hiriyur, Chitradurga (Dist.).

The shoot was divided in two parts i.e. tip and basal stem cuttings of length of 15 – 20 cm length. The basal portion of mature stems were used as basal cutting. Similarly terminal portion of the stem was used as tip cutting. Each cutting type was further divided into two types, *i.e.* leaf retained and leaf not retained. A slant cut was given at the base of the stem cutting and each cutting had about four to five buds.

3.1.2 Preparation of rooting media

Sieved sand was used as the rooting media. Before planting, the sand was thoroughly drenched with copper fungicide at 5 g per litre. It was then filled in polythene bag leaving a gap of two centimetre from the top. The prepared stem cuttings were planted in polythene bags after dipping in growth regulator solutions prepared as per the treatments.

3.1.3 Design and layout of the experiment

Design	:	Factorial Randomized Complete Block Design (FRCBD)
Variety	:	Poona Fig
Number of treatments	:	20
Number of replications	:	3 (Each with 6 stem cuttings)
Number of factors	:	3

Total number of stem cuttings: 6 x 3 x 3 x 20 = 1080 stem cuttings

Method of treatment : Quick dip method

First factor : Growth regulator

1) Control
2) NAA 500 ppm
3) NAA 1000 ppm
4) IBA 500 ppm
5) IBA 1000 ppm

Second factor : Type of cuttings

1) Tip cutting
2) Basal cutting

Third factor : Presence of leaves on the cutting

1) leaf retained
2) Leaf not retained

3.1.4 Treatment details

T_1 - Control (Tip Cutting +Leaf retained +Water)
T_2 - NAA 500ppm+Tip Cutting +Leaf retained
T_3 - NAA 1000ppm+Tip Cutting +Leaf retained
T_4 - IBA 500ppm + Tip Cutting + Leaf retained
T_5 - IBA 1000ppm + Tip Cutting + Leaf retained
T_6 - Control (Tip Cutting +Leaf Not retained +Water)
T_7 - NAA 500ppm+Tip Cutting +Leaf Not retained
T_8 - NAA 1000ppm+Tip Cutting +Leaf Not retained
T_9 - IBA 500ppm + Tip Cutting + Leaf Not retained
T_{10} - IBA 1000ppm + Tip Cutting + Leaf Not retained
T_{11} - Control (Basal Cutting +Leaf retained +Water)
T_{12} - NAA 500ppm+Basal Cutting +Leaf retained
T_{13} - NAA 1000ppm+Basal Cutting +Leaf retained
T_{14} - IBA 500ppm + Basal Cutting + Leaf retained
T_{15} - IBA 1000ppm + Basal Cutting + Leaf retained
T_{16} - Control (Basal Cutting +Leaf Not retained +Water)
T_{17} - NAA 500ppm+Basal Cutting +Leaf Not retained
T_{18} - NAA 1000ppm+Basal Cutting +Leaf Not retained
T_{19} - IBA 500ppm + Basal Cutting + Leaf Not retained
T_{20} - IBA 1000ppm + Basal Cutting + Leaf Not retained

3.1.5 Preparation of growth regulator solutions

The aqueous solution of IBA was prepared by dissolving the required quantity of IBA in a small quantity of acetone and was made up to the required volume by adding distilled water.

Likewise NAA was prepared by dissolving the required quantity of NAA in sodium hydroxide (0.1N) and the required volume was made up by adding distilled water.

3.1.6 Method of treatment and planting of the stem cuttings

The basal portion of the stem cuttings (about 2 cm) was dipped in the growth regulator solution for 60 seconds and then they were planted in polythene bag containing the rooting media with two basal nodes buried inside the medium and kept in open conditions.

3.1.6 After care

To prevent the fungal infection a spray of COC at 2 gl^{-1} was given at fortnightly intervals.

Experiment – 2 : Effect of rooting media, etiolation and growth regulators on rooting of air layers

The investigation was carried out in a fig orchard near Zonal Agricultural Research Station, Hiriyur.

3.1.7 Selection of planting material

For the purpose of air layering, one year old shoots, having the least number of lateral shoots, from ten healthy vigorously growing trees of the same age and size were selected, the shoots were 45-55 cm in length.

3.1.8 Preconditioning treatments

The treatments such as girdling and etiolation were given to the shoots during the last week of October, 2005 (15 days before air layering).

Girdling was done on selected healthy shoots by removing a complete ring of bark below a node. The girdled portion was scraped. The girdled portion was covered with black insulation tape to bring etiolation.

3.1.9 Preparation of growth regulators

Lanolin paste was used as a carrier of growth regulators. The growth regulators were first dissolved in 20 ml alcohol. The solution was mixed with lanolin paste gradually and thorough mixing was done by continuous stirring to ensure uniform mixing of the chemicals with lanolin paste. The paste was dried in dark so that the alcohol got evaporated, without causing denaturation of the growth regulators.

3.2.1 Air layering

Air layering operation was carried out thirty days after preconditioning treatments (first week of December, 2005). Black polythene strips used for etiolation were removed from the shoots. To facilitate easy penetration of the chemical pin puncturing of the shoots above the girdled portion was done. With the help of a fine camlin brush the growth regulators in lanolin paste was smeared to the upper part of the girdled portion of the shoot. In first treatment sphagnum moss and another treatment coirpith was used. Sphagnum moss presoaked in water, was used to cover the girdled portion immediately after application of growth regulators.In case of control, no growth regulator was smeared.

3.2.2 Design and layout of the experiment

Design	:	Factorial Randomized Complete Block Design (FRCBD)
Variety	:	Poona Fig
Number of treatments	:	20
Number of replications	:	3
Number of layers per replication	:	5
Number of factors	:	3

Total number of layers = 20 x 3 x 3 x 5 =900

First factor : Growth regulators

1) Control
2) NAA 500 ppm
3) NAA 1000 ppm
4) IBA 500 ppm
5) IBA 1000 ppm

Second factor : Media

1) Coconut pith
2) Sphagnum moss

Third factor : Conditioning (Etiolation)

1) Etiolated
2) Not Etiolated

3.2.3 Treatment details

T_1 - Control (Non Etiolated +Sphagnum Moss + Water)
T_2 - NAA 500ppm + Non Etiolated + Sphagnum Moss
T_3 - NAA 1000ppm + Non Etiolated + Sphagnum moss
T_4 - IBA 500ppm + Non Etiolated + Sphagnum Moss
T_5 - IBA 1000ppm + Non Etiolated + Sphagnum moss
T_6 - Control (Non Etiolated +Coir pith + Water)
T_7 - NAA 500ppm + Non Etiolated + Coir pith
T_8 - NAA 1000ppm + Non Etiolated + Coir pith
T_9 - IBA 500ppm + Non Etiolated + Coir pith
T_{10} - IBA 1000ppm + Non Etiolated + Coir pith
T_{11} - Control (Etiolated +Sphagnum Moss + Water)
T_{12} - NAA 500ppm + Etiolated + Sphagnum Moss
T_{13} - NAA 1000ppm + Etiolated + Sphagnum moss
T_{14} - IBA 500ppm + Etiolated + Sphagnum Moss
T_{15} - IBA 1000ppm + Etiolated + Sphagnum moss
T_{16} - Control (Etiolated +Coir pith + Water)
T_{17} - NAA 500ppm + Etiolated + Coir pith

T_{18} - NAA 1000ppm + Etiolated + Coir pith
T_{19} - IBA 500ppm + Etiolated + Coir pith
T_{20} - IBA 1000ppm + Etiolated + Coir pith

3.2.4 After care of layers

The layered trees were kept under constant observation to prevent the mechanical damage. If any occurrence of intermittent showers made the weather favourable for the retention of moisture in sphagnum moss / coir pith. Polythene tubings were replaced whenever they were found damaged by birds.

When there was a long break in rains, the moss or coir was moistened by injecting water through the polythene tubing by some means of a wash bottle.

3.2.5 Observations

A) Percentage of success in different treatments

1) Percentage of cuttings rooted
2) Percentage of air layered shoots rooted

B) Growth parameters of aerial parts

1) Days taken for first sprouting.
2) Number of buds sprouted
3) Sprout length at 30 and 60 days after treatment
4) Number of leaves per plant

C) Growth parameters of roots

1) Days taken for root initiation
2) Number of primary roots at 30 and 60 days after treatment
3) Number of secondary roots
4) Length of primary roots

Experimental Results

IV. EXPERIMENTAL RESULTS

4.1 Experiment 1: PROPAGATION OF FIG THROUGH STEM CUTTINGS

The results of the experiments carried out to study the propagation of fig through stem cuttings with the use of different rooting media and growth regulators are presented in this chapter.

4.1.1 Percentage of success in rooting of cuttings

Differences in percentage of rooting among different types of stem cuttings and also among stem cuttings treated with different growth regulators and the interaction effect of type of stem cutting and growth regulators were significant (Table-1).

The percentage of rooting was significantly higher (63.20%) with basal stem cuttings, whereas, it was minimum (51.90%) with tip cuttings. The percentage of success was significantly more in cuttings in which leaves were retained (59.20%), compared to that of shoots in which leaves were not retained (56.20%). The stem cuttings treated with 1000 ppm IBA showed significantly highest percentage of rooting (66%), and least percentage (45.25%) was noticed in control.

With reference to the combinations of type of stem cutting and leaf retained or leaf not retained, the percentage of success was significantly highest in basal stem cutting with leaf retained (65.80%) and the lowest (51.20%) was in stem cuttings with leaf not retained.

Regarding interaction between growth regulator and leaf retained or leaf not retained, the percentage of success was significantly higher in stem cuttings with leaf retained, treated with 1000 ppm IBA (67%),

Table 1: Influence of type of stem cuttings, retention of leaves and growth regulators on percentage of rooting in cutting.

	Treatment	Type of Stem cuttings		
		Tip cutting (%)	Basal cutting (%)	Mean
Leaf Retained	Control	42.00	51.00	46.50
	NAA500ppm	51.00	64.00	57.50
	NAA1000ppm	55.00	70.00	62.50
	IBA500ppm	55.00	70.00	62.50
	IBA1000ppm	60.00	74.00	62.50
Mean		52.60	65.80	59.20
Leaf Not Retained	Control	40.00	48.00	44.01
	NAA500ppm	48.00	60.00	54.00
	NAA1000ppm	53.00	64.00	58.50
	IBA500ppm	55.00	64.00	59.50
	IBA1000ppm	60.00	70.00	65.00
Mean		51.20	61.20	56.20
Growth Regulators	Control	41.00	49.50	45.25
	NAA500ppm	49.05	62.00	55.75
	NAA1000ppm	54.00	67.00	60.50
	IBA500ppm	55.00	67.00	61.00
	IBA1000ppm	60.00	72.00	66.00
Mean		51.90	63.20	-----

Source	F test	S.Em ±	CD @ 5%
A (Tip/Basal)	*	0.07	0.10
B(LR/LNR)	*	0.07	0.10
C (Growth regulators)	*	0.11	0.15
Interaction between AxB	*	0.10	0.14
AxC	*	0.15	0.22
BxC	*	0.15	0.22
AxBxC	*	0.39	0.67

* Significant at 5%

Fig. 1. Influence of types of stem cutting, retention of leaves and growth regulators on percentage of rooting in shoot cuttings

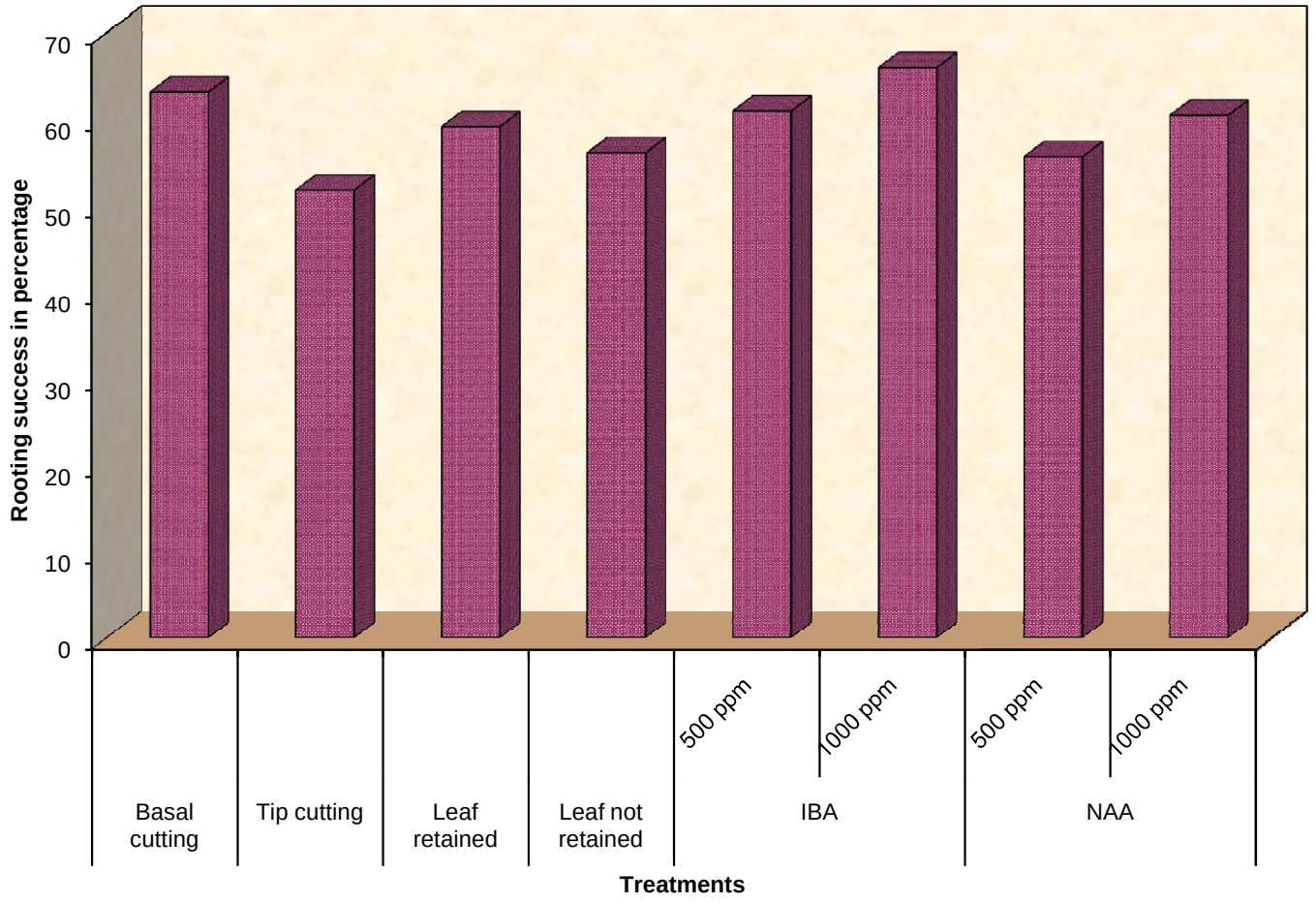


Plate 1 : A Photograph showing rooting of fig stem cuttings at 30 and 60 days interval after planting

whereas it was less (44%) in leaf not retained stem cuttings in control (no growth regulator).

Interaction effect between type of stem cuttings and growth regulator treatment showed that the higher percentage of success (72%) was in basal stem cuttings treated with 1000 ppm IBA, whereas the lower percentage (41%) was seen in tip cuttings with control treatment.

Three way interactions have shown that the highest percentage of success (74%) was recorded in basal stem cuttings with leaf retained and treated with 1000 ppm IBA and a minimum (40%) success in tip cuttings with leaf not retained with control.

4.1.2 Growth parameters of shoots in cuttings

4.1.3 Days taken for sprouting in stem cuttings

Differences in number of days taken for sprouting among different types of stem cuttings and also among stem cuttings treated with different growth regulators and interaction effect of different types of stem cuttings and different concentration of growth regulators are given in table 2.

The days taken for sprouting was significantly early (17.49 days) in basal stem cutting, whereas in tip cuttings it took (19.68 days). Similarly the stem cuttings with leaf retained showed significantly early sprouting (18.36 days), compared to stem cuttings with leaf not retained (19.81 days).

Doubling the concentration of IBA from 500ppm to 1000ppm did not show any changes in number of days taken for sprouting of stem cuttings. It was about 18days for both concentrations.

Table 2: Influence of type of stem cuttings, retention of leaves and growth regulators on days taken for sprouting of shoots in cuttings

	Treatment	Type of stem cuttings		
		Tip cutting	**Basal cutting**	**Mean**
Leaf Retained	Control	21.93	19.36	20.65
	NAA500ppm	19.70	16.96	18.33
	NAA1000ppm	18.73	17.30	18.01
	IBA500ppm	18.80	17.26	18.03
	IBA1000ppm	18.20	15.36	16.78
Mean		19.47	17.25	18.36
Leaf Not Retained	Control	22.96	18.73	20.85
	NAA500ppm	20.36	18.80	19.58
	NAA1000ppm	19.13	16.86	18.00
	IBA500ppm	18.83	17.03	17.93
	IBA1000ppm	18.13	17.23	17.68
Mean		19.88	17.73	18.81
Growth Regulators	Control	22.45	19.05	20.75
	NAA500ppm	20.03	17.88	18.95
	NAA1000ppm	18.93	17.08	18.00
	IBA500ppm	18.81	17.15	17.98
	IBA1000ppm	18.16	16.03	17.23
Mean		19.68	17.49	----

Source	**F test**	**S.Em ±**	**CD @ 5%**
A (Tip/Basal)	*	0.13	0.38
B (LR/LNR)	*	0.13	0.38
C (Growth regulators)	*	0.21	0.60
Interaction between AXB	NS	0.18	0.54
AXC	*	0.29	0.85
BXC	NS	0.29	0.85
AXBXC	NS	0.73	1.21

* Significant at p=0.03
NS: Non Significant

Plate 2 : A Photograph showing shoot buds sprouted on a layered shoot

With reference to combinations of basal stem cuttings with IBA 1000 ppm produced early sprouting (16.30 days) and the tip cuttings with no growth regulators treatment took more days to sprout (22.45 days), whereas remaining all interaction combinations produced no differences in number of days taken to first sprout.

4.1.4 Number of buds sprouted

Differences in number of buds sprouted per stem cutting as influenced by type of stem cutting and growth regulators at different concentrations showed significant differences (Table 3).

The number of buds seen were maximum in basal stem cuttings (3.09) and were minimum (2.17) in tip stem cuttings. Similarly, the stem cuttings with leaf retained recorded more number of buds (2.82), when compared to stem cuttings with leaf not retained (2.53). Among the growth regulator treatments, the stem cuttings treated with 1000 ppm produced more number of buds (3.40). In stem cuttings not treated with growth regulators, the number of buds seen were less (1.85).

With reference to combinations of basal stem cuttings with leaf retained produced significantly a more number of sprouts (3.34) and significantly least number of buds were sprouted in tip cuttings with leaf retained (2.23). while in the remaining interaction combinations seen no significant differences.

4.1.5 Sprout length

4.1.6 Sprout length at 30 DAP (Days after planting)

Differences among sprout length were significantly recorded at 30 days after sprouting (Table 4).

Table 3: Influence of type of stem cuttings, retention of leaves and growth regulators on number of shoot buds sprouted in cuttings

	Treatment	Type of cutting		
		Tip cutting	Basal cutting	Mean
Leaf Retained	Control	1.70	2.13	1.91
	NAA500ppm	2.06	2.86	2.46
	NAA1000ppm	2.43	3.60	3.01
	IBA500ppm	2.46	3.63	3.05
	IBA1000ppm	2.83	4.50	3.66
Mean		2.30	3.34	2.82
Leaf Not Retained	Control	1.53	2.06	1.80
	NAA500ppm	2.06	3.10	2.58
	NAA1000ppm	2.10	2.76	2.43
	IBA500ppm	2.76	2.70	2.73
	IBA1000ppm	2.70	3.56	3.13
Mean		2.23	2.84	2.53
Growth Regulators	Control	1.61	2.10	1.85
	NAA500ppm	2.06	2.98	2.52
	NAA1000ppm	2.26	3.18	2.72
	IBA500ppm	2.61	3.16	2.89
	IBA1000ppm	2.76	4.03	3.40
Mean		2.17	3.09	-----

Source	F test	S.Em ±	CD @ 5%
A (Tip/Basal)	*	0.08	0.24
B(LR/LNR)	*	0.08	0.24
C (Growth regulator Concentrations)	*	0.13	0.38
Interaction between AXB	*	0.11	0.34
AXC	NS	0.18	0.54
BXC	NS	0.18	0.54
AXBXC	NS	0.46	0.76

* Significant at 5%
NS: Non Significant

Table 4: Influence of types of stem cutting, retention of leaves and growth regulators on length of sprouted shoots in fig cuttings at 30 and 60 days after planting.

	Treatment	Type of cuttings (30 days)			Type of cuttings (60 days)		
		Tip	**Basal**	**Mean**	**Tip**	**Basal**	**Mean**
Leaf Retained	Control	10.76	12.86	11.81	13.76	16.10	14.93
	NAA500ppm	15.80	15.76	15.78	19.76	19.83	19.80
	NAA1000ppm	14.83	15.70	16.26	18.60	19.96	19.28
	IBA500ppm	14.93	15.46	15.20	18.90	19.73	19.31
	IBA1000ppm	15.23	15.16	15.70	18.96	20.16	19.56
Mean		14..31	15.19	14.75	18.00	19.16	18.58
Leaf Not Retained	Control	10.53	11.23	10.88	13.76	14.36	14.06
	NAA500ppm	15.76	15.10	15.40	19.73	19.36	19.55
	NAA1000ppm	14.46	15.40	14.93	18.60	19.53	19.06
	IBA500ppm	14.98	15.36	15.15	18.93	19.96	19.45
	IBA1000ppm	15.23	16.03	15.63	19.33	20.43	19.88
Mean		14.18	14.62	14.40	18.07	18.73	18.40
Growth Regulators	Control	10.65	12.05	11.35	13.76	15.23	14.50
	NAA500ppm	15.78	15.43	15.60	19.75	19.60	19.67
	NAA1000ppm	14.65	15.55	15.10	18.60	19.75	19.17
	IBA500ppm	14.93	15.41	15.17	18.91	19.85	19.38
	IBA1000ppm	15.23	16.10	15.66	19.15	20.30	19.72
Mean		14.25	14.91	-----	18.03	18.94	----

Source	**After 30 days**			**After 60 days**		
	F test	**S.Em ±**	**CD @ 5%**	**F test**	**S.Em ±**	**CD @ 5%**
A (Tip/Basal)	*	0.14	0.40	*	0.13	0.38
B(LR/LNR)	*	0.14	0.40	NS	0.13	0.38
C (Growth regulators)	*	0.22	0.64	*	0.21	0.30
Interaction between AXB	NS	0.20	0.57	NS	0.19	0.26
AXC	NS	0.31	0.90	NS	0.30	0.42
BXC	NS	0.31	0.90	NS	0.30	0.42
AXBXC	NS	0.7	1.28	NS	0.74	1.22

* Significant at 5%
NS: Non Significant

The Maximum sprout length (14.91 mm) was significantly recorded in basal stem cutting when compared to tip stem cuttings. Similarly in stem cuttings without leaves didn't produced any significant difference. The stem cuttings treated 1000 ppm IBA showed significantly highest sprout length (15.66 mm) but the minimum was noticed in control (11.35 mm)(no growth regulators).

Among the interaction between the different types of stem cuttings and growth regulators showed no much differences with respect to sprout length at 30 days after sprouting. Among interaction between different type of stem cuttings with leaf retained and leaf not retained, the maximum sprout length was recorded in basal stem cutting with leaf not retained (14.62 mm) and minimum sprout length was recorded in basal stem cutting with leaf retained (14.18mm).

With reference to combinations with leaf retained, leaf not retained and different growth regulator treatment, the maximum sprout length of (15.70 mm) was recorded with leaf retained and 1000 ppm IBA. Similarly the stem cuttings with leaf not retained and without growth regulator treatment recorded maximum sprout length (10.88 mm).

4.1.7 Sprout length at 60 DAP

Differences in length of sprout among stem cuttings and also among stem cuttings treated with different growth regulators and the interaction effect of type of stem cutting and growth regulator were significantly different (Table 4).

Significantly maximum length of sprout was recorded in the basal stem cutting (18.94 mm) compared to tip stem cuttings (18.03 mm). But the leaf retained and leaf not retained did not produced any significant difference with respect to sprout length, but the leaf retained on stem

cutting produced the higher sprout length (18.58 mm) when compared to leaf not retained (18.40 mm).

Treatment with growth regulators produced significant difference. The stem cuttings treated with 1000 ppm IBA recorded the maximum length of sprout (19.72mm) whereas the less sprout length (14.50) was seen in control.

All the interaction combinations recorded no significant difference with respect to sprout length at 60 DAP. Whereas the basal stem cutting with leaf not retained recorded the maximum sprout length (18.73 mm) and the tip stem cutting with leaf retained produced the minimum sprout length (18.00 mm).

The basal stem cutting with leaf not retained and treated with 1000 ppm IBA recorded the maximum sprout length (20.43 mm) and the tip stem cutting with leaf retained and leaf not retained without growth regulators treatment recorded the minimum (13.76 mm) sprout length.

4.1.8 Number of leaves per plant

Differences were significantly in number of leaves per plant among different type of stem cuttings and also among stem cutting treated with different growth regulators and the interaction effect of type of stem cuttings and growth regulators (Table 5).

The significantly more number of leaves were recorded in basal stem cuttings (4.92).when compared to tip stem cuttings (4.11).

Similarly significantly more number of leaves were recorded in the stem cuttings with leaf retained (4.67), when compared to stem cuttings with leaf not retained (4.36).

Table 5: Influence of type of stem cuttings, retention of leaves and growth regulators on number of leaves in stem cuttings at 30 and 60 days after planting of cuttings.

	Treatment	Type of cutting (30 days)			Type of cutting (60 days)		
		Tip	Basal	Mean	Tip	Basal	Mean
Leaf Retained	Control	1.83	2.13	1.98	2.83	3.13	2.98
	NAA500ppm	4.10	5.43	4.76	5.26	6.16	5.71
	NAA1000ppm	5.06	5.93	5.50	6.20	6.70	6.45
	IBA500ppm	4.80	5.80	5.30	5.93	6.90	6.41
	IBA1000ppm	5.16	6.43	5.80	6.26	7.43	6.85
Mean		4.19	5.14	4.67	5.30	6.06	5.68
Leaf Not Retained	Control	1.23	1.76	1.50	2.36	2.50	2.43
	NAA500ppm	3.93	5.13	4.53	4.93	5.86	5.40
	NAA1000ppm	4.56	5.20	4.88	5.56	6.30	5.93
	IBA500ppm	5.20	5.60	5.40	6.20	6.70	6.45
	IBA1000ppm	5.23	5.80	5.51	6.23	6.53	6.38
Mean		4.03	4.70	4.36	5.06	5.58	5.32
Growth Regulators	Control	1.53	1.95	1.74	2.60	2.81	2.70
	NAA500ppm	4.01	5.28	4.65	5.10	6.01	5.55
	NAA1000ppm	4.81	5.56	5.19	5.88	6.50	6.19
	IBA500ppm	5.00	5.70	5.35	6.06	6.80	6.43
	IBA1000ppm	5.20	6.11	5.65	6.25	6.98	6.61
Mean		4.11	4.92	----	5.18	5.82	-----

Source	After 30 days			After 60 days		
	F test	S.Em ±	CD @ 5%	F test	S.Em ±	CD @ 5%
A (Tip/Basal)	*	0.10	0.30	*	0.09	0.28
B(LR/LNR)	*	0.10	0.30	*	0.09	0.28
C (Growth regulators)	*	0.16	0.48	*	0.15	0.44
Interaction between AXB	NS	0.15	0.43	NS	0.13	0.39
AXC	NS	0.23	0.67	NS	0.21	0.62
BXC	NS	0.23	0.67	NS	0.21	0.62
AXBXC	NS	0.58	0.96	NS	0.53	0.88

* Significant at 5%level
NS: Non Significant

Fig. 2. Influence of type of stem cutting, retention of leaves on number of leaves at 30 and 60 days after planting in cuttings

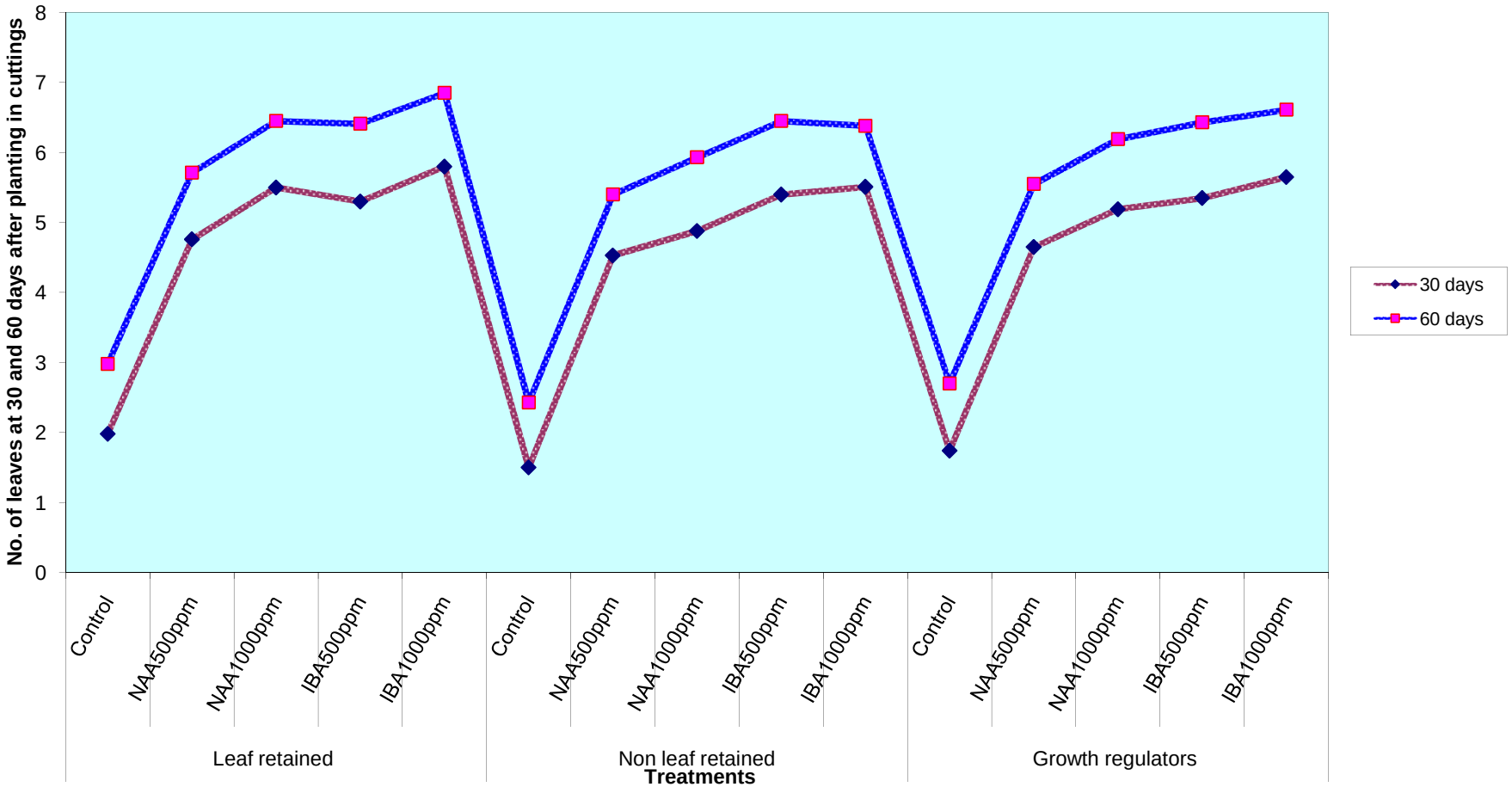


Plate 3 : A Photograph showing profused number of leaves from basal cuttings with leaves and treated with 1000ppm of IBA (60 days after planting of cutting)

Effect of growth regulators showed a significant difference with respect to number of leaves. The stem cuttings treated with 1000 ppm IBA recorded the maximum number of leaves (5.65) when compared to control (1.74).

Different interaction combinations showed no significant difference in number of leaves per stem cutting, but the basal stem cutting with leaf retained induced more number of leaves (5.14), whereas tip stem cuttings with leaf not retained recorded minimum number of leaves (4.03).

The stem cuttings with leaf retained and 1000 ppm IBA recorded the maximum number of leaves per stem cutting (5.80), whereas the stem cuttings with leaf not retained and with no growth regulator treatment recorded minimum (1.50) number of leaves per stem cuttings.

Among the interactions of three factors the basal stem cuttings with leaf retained and with 1000 ppm IBA recorded maximum (6.43) number of leaves. Whereas the tip stem cuttings with leaf not retained and without growth regulator treatment recorded the minimum number of leaves (1.23).

The differences on number of leaves per plant at 60 DAP as influenced by different types of stem cuttings and growth regulators is furnished in table 5.

The basal stem cuttings showed significantly more number of leaves (5.82) when compared to tip stem cuttings (5.18).

The stem cuttings with leaf retained showed significantly more number of leaves per plant (5.68) when compared to stem cuttings with leaf not retained (5.32).

Whereas the stem cuttings treated with 1000 ppm IBA recorded significantly more number of leaves (6.61) and minimum number of leaves per plant was recorded in control (2.70).

All the interaction combinations showed non significant differences with respect to number of leaves per plant at 60 DAP.

The basal stem cuttings with leaf retained showed higher number of leaves (6.06) and the tip stem cuttings with leaf not retained showed minimum number of leaves (5.06).

The stem cuttings with leaf retained and treated with 1000 ppm IBA showed higher (6.85) number of leaves. Whereas the stem cuttings with leaf not retained and treated without growth regulators showed minimum number of leaves (2.43).

Similarly the basal stem cuttings treated with 1000 ppm IBA showed more number of leaves (6.98) and the tip stem cuttings without growth regulators showed minimum number of leaves (2.60).

4.2 Growth parameters of roots

4.2.1 Days taken for root initiation

Differences in days taken for root initiation among type of stem cuttings and also among growth regulators and the interaction effect were significantly different (Table 6).

The basal stem cuttings produced roots significantly early (15.49 days) when compared to tip stem cuttings (17.79 days). The stem cuttings with leaf retained showed significantly early initiation of roots (16.37 days) when compared to stem cuttings with leaf not retained (16.91 days). Among the different growth regulator treatments the stem cuttings treated with 1000 ppm IBA showed significantly early initiation

of roots (15.15 days) followed by 500 ppm IBA (15.97 days), NAA 1000 ppm (16.19 days) and the stem cuttings treated with no growth regulators took significantly maximum days for initiation of roots (18.84 days).

Among the interaction combination Basal stem cuttings with 1000 ppm IBA treatment showed significantly early initiation in roots (14.13 days), and tip stem cuttings with no growth regulator treatment showed significantly delayed initiation of roots (20.43 days). The basal stem cuttings with leaf retained and 1000 ppm IBA treatment showed significantly early initiation of roots (13.03 days), while the treatment of tip stem cuttings with leaf not retained and no growth regulator treatment took significantly maximum (20.93 days) for initiation of roots. While the remaining interaction combinations showed non significant differences.

4.2.2 Numbers of primary roots at 30 DAP

Differences in number of primary roots influenced by type of stem cuttings and growth regulators (Table 6).

The number of primary roots were significantly higher (69.60) in basal stem cuttings, while it was minimum (64.16) in tip stem cuttings.

The stem cuttings in which leaves were retained recorded significantly higher (67.95) number of primary roots, whereas the stem cuttings with leaf not retained recorded minimum number (65.82) of primary roots.

Similarly the stem cuttings treated with 1000 ppm IBA recorded significantly higher (72.20) number of primary roots while the stem cuttings with no growth regulator treatment recorded minimum (53.16) number of primary roots.

Plate 4 : A Photograph showing a profused root growth from basal stem cuttings with leaves retained and treated with 1000ppm IBA (60 days after planting of cutting)

Table 6: Influence of types of stem cuttings, retention of leaves and growth regulators on number of days taken for root initiation in stem cuttings.

	Treatment	Type of cuttings		
		Tip cutting	Basal cutting	Mean
Leaf Retained	Control	19.93	17.76	18.85
	NAA500ppm	17.73	15.00	16.36
	NAA1000ppm	16.76	15.30	16.03
	IBA500ppm	16.83	15.20	16.01
	IBA1000ppm	16.20	13.03	14.61
Mean		17.49	15.26	16.37
Leaf Not Retained	Control	20.93	16.73	18.83
	NAA500ppm	18.73	16.80	17.76
	NAA1000ppm	17.83	14.86	16.35
	IBA500ppm	16.83	15.03	15.93
	IBA1000ppm	16.13	15.23	15.68
Growth Regulators		18.09	15.73	16.91
	Control	20.43	17.25	18.84
	NAA500ppm	18.23	15.90	17.06
	NAA1000ppm	17.30	15.08	16.19
	IBA500ppm	16.83	15.11	15.97
	IBA1000ppm	16.16	14.13	15.15
Mean		17.79	16.91	-----

Source	F test	S.Em ±	CD @ 5%
A (Tip/Basal)	*	0.13	0.38
B(LR/LNR)	*	0.13	0.38
C (Growth regulators)	*	0.21	0.61
Interaction between AXB	NS	0.19	0.55
AXC	*	0.30	0.86
BXC	NS	0.30	0.86
AXBXC	*	0.74	1.23

* Significant at 5%level
NS: Non Significant

All the interaction combinations show non significant difference with respect to number of primary roots per stem cutting.

The basal stem cuttings with leaf retained recorded maximum number of primary roots (70.85), whereas the tip stem cuttings with leaf not retained recorded minimum number of leaves per stem cutting (63.28). The stem cuttings with leaf retained and treated with 1000 ppm IBA recorded maximum number of primary roots (72.70) per stem cutting, stem cuttings where leaf not retained and treated with no growth regulators recorded the minimum number of primary roots (51.40).

Similarly, the basal stem cuttings treated with 1000 ppm IBA recorded maximum number of roots (74.68) per stem cutting, while the tip stem cuttings treated with no growth regulators recorded minimum number of primary roots (50.26).

The basal stem cutting with leaf retained and treated with 1000 ppm IBA recorded maximum number of roots (75.36), while the tip stem cutting with leaf not retained and treated with no growth regulators recorded minimum (48.73) number of primary roots per stem cutting at 30 days after planting.

4.2.3 Numbers of primary roots at 60 DAP

Differences in number of primary roots per stem cutting after 60 days after planting (Table 7)

The basal stem cuttings recorded significantly maximum (72.51) number of roots compared to tip stem cuttings (66.93).

While the stem cuttings with leaf retained recorded significantly maximum number of leaves (70.68) and it was minimum (68.77) in stem cuttings with leaf not retained. Similarly the stem cuttings treated with

Table 7: Influence of types of stem cuttings, retention of leaves and growth regulators on number of primary roots at 30 and 60 days after planting of cuttings.

	Treatment	Type of cuttings (30 days)			Type of cuttings (60 days)		
		Tip	Basal	Mean	Tip	Basal	Mean
Leaf Retained	Control	51.80	58.06	54.93	59.00	51.66	55.33
	NAA500ppm	65.16	72.00	68.58	68.00	75.66	71.83
	NAA1000ppm	69.16	74.06	71.61	72.66	72.00	72.33
	IBA500ppm	69.06	74.76	71.91	73.66	78.00	75.83
	IBA1000ppm	70.03	75.36	72.70	76.00	80.66	78.33
Mean		65.04	70.85	67.95	69.86	71.60	70.73
Leaf Not Retained	Control	48.73	54.06	51.40	58.00	59.66	58.83
	NAA500ppm	63.03	70.13	66.58	72.33	74.00	73.16
	NAA1000ppm	67.13	72.13	69.63	70.33	81.00	75.66
	IBA500ppm	68.10	71.43	69.76	72.33	75.33	73.83
	IBA1000ppm	69.43	74.00	71.71	79.00	82.00	80.50
Mean		63.28	68.35	65.82	70.40	74.40	72.40
Growth Regulators	Control	50.26	56.06	53.16	58.50	55.66	57.08
	NAA500ppm	64.10	71.06	67.58	70.16	74.83	72.50
	NAA1000ppm	68.15	73.10	70.62	71.50	76.50	74.00
	IBA500ppm	68.58	73.10	70.84	73.00	76.66	74.83
	IBA1000ppm	69.73	74.68	72.20	77.50	81.33	79.41
Mean		64.95	69.60	-----	70.13	73.33	-----

Source	After 30 days			After 60 days		
	F test	S.Em ±	CD @ 5%	F test	S.Em ±	CD @ 5%
A (Tip/Basal)	*	0.21	0.60	*	0.72	2.08
B (LR/LNR)	*	0.21	0.60	NS	0.72	2.08
C (Growth regulators)	*	0.33	0.95	*	1.15	3.20
Interaction between AXB	NS	0.29	0.85	NS	1.03	2.90
AXC	NS	0.47	1.35	NS	1.63	4.60
BXC	NS	0.47	1.35	NS	1.63	4.60
AXBXC	NS	1.16	1.92	*	3.99	6.60

* Significant at 5%
NS: Non Significant

Fig. 3. Influence of type of stem cutting, retention of leaves and growth regulators on no. of primary roots in shoot cuttings at 60 days after planting.

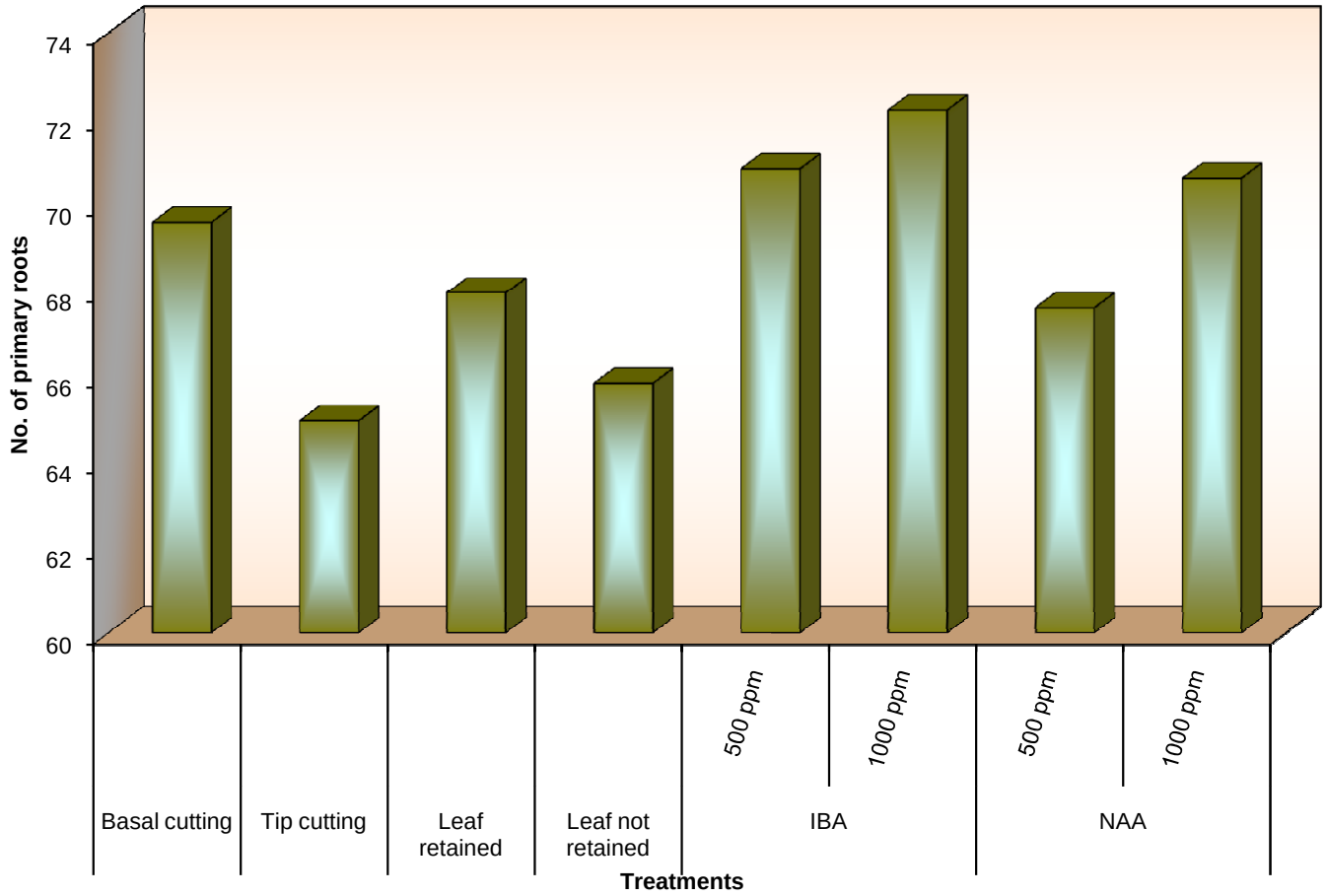


Plate 5 : A Photograph showing the rooting of cuttings (basal cutting treated with 1000ppm of IBA)

1000 ppm IBA recorded significantly maximum (75.40) number of roots per stem cuttings. While it was minimum (55.02) in control.

All the treatment interaction combinations recorded non significant differences with respect to number of primary roots at 60 days after planting.

The basal stem cuttings with leaf retained recorded maximum number of roots (73.70) and minimum (66.21) was recorded in the tip stem cuttings with leaf not retained. The leaf retained stem cuttings treated with 1000 ppm IBA recorded maximum (75.78) number of roots, while the stem cuttings with leaf not retained and treated with no growth regulators recorded (53.45) minimum number of leaves per stem cutting. The basal stem cuttings treated with 1000 ppm IBA recorded maximum number (77.88) of primary roots and it was minimum in tip stem cuttings treated with no growth regulators (51.96).

The basal stem cuttings with leaf retained and treated with 1000 ppm IBA recorded more number of roots (78.50). While it was minimum in tip stem cuttings with leaf not retained and treated with no growth regulators (50.66).

4.2.4 Numbers of secondary roots after 60 DAP

Differences in number of secondary roots among stem cuttings and also among stem cuttings treated with different growth regulators and the interaction effect of type of stem cutting and growth regulators were significantly different (Table 8).

The basal stem cuttings recorded significantly higher number of (115.83) secondary roots when compared to tip stem cuttings (108.20). The stem cuttings retained with leaf recorded significantly maximum number of secondary roots (113.50) when compared to stem cuttings

Table 8: Influence of type of cuttings, retention of leaves and growth regulators on number of secondary roots at 60 days after planting of cuttings of fig.

	Treatment	Type of cutting		
		Tip cutting	Basal cutting	Mean
Leaf Retained	Control	94.00	97.66	95.83
	NAA500ppm	107.66	118.00	112.83
	NAA1000ppm	114.33	122.00	118.16
	IBA500ppm	113.66	124.00	118.83
	IBA1000ppm	115.66	128.00	121.83
Mean		109.06	117.93	113.50
Leaf Not Retained	Control	90.66	96.66	93.66
	NAA500ppm	107.00	114.66	110.83
	NAA1000ppm	111.66	119.66	115.66
	IBA500ppm	111.66	117.00	114.33
	IBA1000ppm	115.66	120.66	118.16
Mean		107.33	113.73	110.53
Growth Regulators	Control	92.33	97.16	94.75
	NAA500ppm	107.33	116.33	111.83
	NAA1000ppm	113.00	120.83	116.91
	IBA500ppm	112.66	120.50	116.58
	IBA1000ppm	115.66	124.33	120.00
Mean		108.20	115.83	----

Source	F test	S.Em ±	CD @ 5%
A (Tip/Basal)	*	0.60	1.74
B(LR/LNR)	*	0.60	1.74
C (Growth regulator Concentrations)	*	0.96	2.75
Interaction between AXB	NS	0.86	2.46
AXC	NS	1.36	3.89
BXC	NS	1.36	3.89
AXBXC	NS	3.33	5.50

* Significant at 5%
NS: Non Significant

with leaf not retained (110.53). The maximum number of secondary roots were recorded in stem cuttings (120) treated with 1000 ppm IBA while it was minimum in control (94.75).

There were non significant differences with respect to secondary roots in all the interaction treatment combinations.

The basal stem cuttings with leaf retained recorded maximum (117.93) number of secondary roots. While the tip stem cuttings with leaf not retained recorded minimum (107.33) number of roots per stem cuttings. The stem cuttings with leaf retained and treated with 1000 ppm IBA recorded maximum number of (121.83) secondary roots while the stem cuttings with leaf not retained and treated with no growth regulators recorded minimum (93.66) number of secondary roots. Similarly the basal stem cuttings treated with 1000 ppm IBA recorded maximum (124.33) number of secondary roots while it was minimum in tip stem cuttings (92.33) treated with no growth regulators.

The basal stem cuttings with leaf retained and treated with 1000 ppm IBA recorded maximum (128.00) number of secondary roots and it was minimum in tip stem cuttings with leaf not retained and treated with no growth regulators (90.66).

4.2.5 Length of primary roots at 30 days after propagation in stem cuttings

Differences in length of primary roots after 30 days after propagation among stem cuttings and also among stem cuttings treated with different growth regulators and the interaction effect of type of stem cutting and growth regulators were significantly different (Table 9).

Significantly maximum length (9.45 mm) of primary roots were recorded is hard wood stem cutting, when compared to (7.16 mm) tip

stem cuttings. The significantly higher root length (8.66 mm) was recorded in stem cuttings with leaf retained and minimum (7.95 mm) was noticed in stem cuttings with leaf not retained. Similarly the stem cuttings treated with 1000 ppm IBA recorded significantly higher (9.87 mm) root length and it was least in (4.78 mm) stem cuttings treated with no growth regulators.

The significant differences were seen in all the interaction combinations. The basal stem cuttings with leaf retained recorded significantly higher root length (9.90 mm), whereas the tip stem cuttings with leaf not retained recorded minimum (6.90 mm) root length. The presence of leaf on stem cutting and treated with 1000 ppm IBA recorded significantly maximum root length (10.00 mm) and it was minimum (4.00 mm) in stem cuttings with leaf not retained and treated with no growth regulators. Similarly the basal stem cuttings treated with 1000 ppm IBA recorded significantly maximum (10.75 mm) root length and it was minimum (3.06 mm) in tip stem cuttings treated with no growth regulators.

Finally the basal stem cuttings with leaf retained and treated with IBA 1000 ppm recorded significantly maximum primary root length (10.75 mm) and it was minimum in tip stem cuttings with leaf not retained and treated with no growth regulators (3.06 mm).

4.2.7 Length of primary roots at 60 days after propagation in stem cuttings

Differences in length primary roots among stem cuttings and also among stem cutting and treated with different growth regulators and the interaction effect of type of stem cuttings and growth regulators were significantly different (Table 9) after 60 days after propagation.

Table 9: Influence of types of stem cuttings, retention of leaves and growth regulators on length of primary roots in stem cuttings at 30 and 60 days after planting of cuttings.

	Treatment	Type of cuttings (30 days)			Type of cuttings (60 days)		
		Tip	Basal	Mean	Tip	Basal	Mean
Leaf Retained	Control	3.63	7.50	5.56	58.63	62.50	60.56
	NAA500ppm	7.50	10.00	8.75	62.50	65.00	63.75
	NAA1000ppm	8.50	10.50	9.50	63.50	65.50	64.50
	IBA500ppm	8.50	10.50	9.50	63.50	65.50	64.50
	IBA1000ppm	9.00	11.00	10.00	64.00	66.00	65.00
Mean		7.42	9.90	8.66	62.42	65.90	63.66
Leaf Not Retained	Control	2.50	5.50	4.00	57.50	60.50	59.00
	NAA500ppm	6.50	9.00	7.75	61.50	64.00	62.75
	NAA1000ppm	8.00	10.00	9.00	63.00	65.00	64.00
	IBA500ppm	8.50	10.00	9.25	63.50	65.00	64.25
	IBA1000ppm	9.00	10.50	9.75	64.00	65.50	64.75
Mean		6.90	9.00	7.95	61.90	64.00	62.95
Growth Regulators	Control	3.06	6.50	4.78	58.06	61.50	59.78
	NAA500ppm	7.00	9.50	8.25	62.00	64.50	63.25
	NAA1000ppm	8.25	10.25	9.25	63.25	65.25	64.25
	IBA500ppm	8.50	10.25	9.37	63.50	65.25	64.37
	IBA1000ppm	9.00	10.75	9.87	64.00	65.75	64.87
Mean		7.16	9.45	----	62.16	64.45	----

Source	After 30 days			After 60 days		
	F test	S.Em ±	CD @ 5%	F test	S.Em ±	CD @ 5%
A (Tip/Basal)	*	0.009	0.049	*	0.010	0.030
B(LR/LNR)	*	0.009	0.049	*	0.010	0.030
C (Growth regulators)	*	0.015	0.078	*	0.017	0.047
Interaction between AXB	*	0.013	0.070	*	0.015	0.042
AXC	*	0.021	0.110	*	0.023	0.067
BXC	*	0.021	0.110	*	0.023	0.067
AXBXC	*	0.05	0.09	*	0.06	0.09

* Significant at 5%

Plate 6 : A view of fig cuttings planted in the polybags for rooting

Significantly maximum length (64.45 mm) of primary roots were recorded in hard wood stem cutting,when compared to tip stem cuttings(62.16 mm). A significantly maximum root length (63.66 mm) was recorded in stem cuttings with leaf retained and minimum (62.95 mm) was noticed in stem cuttings with leaf not retained. Similarly, the stem cuttings treated with 1000 ppm IBA recorded significantly maximum (64.87 mm) root length and was minimum in (59.78 mm) stem cuttings treated with no growth regulators.

Among the interaction combinations the basal stem cuttings with leaf retained recorded significantly higher root length (64.90 mm), whereas the tip stem cuttings with leaf not retained recorded minimum (61.90 mm) root length. The presence of leaf on stem cutting and treated with 1000 ppm IBA recorded significantly maximum root length (65.00 mm) and it was minimum (59.00 mm) in stem cuttings with leaf not retained and treated with no growth regulators. Similarly the basal stem cuttings treated with 1000 ppm IBA recorded significantly maximum (65.75 mm) root length and it was minimum (58.06 mm) in tip stem cuttings treated with no growth regulators.

Finally the basal stem cuttings with leaf retained and treated with 1000 ppm IBA recorded significantly maximum primary root length (66.75 mm) and it was minimum in tip stem cuttings with leaf not retained and treated with no growth regulators (58.63 mm).

4.3 Experiment – 2: Propagation of fig through layering

The results of the experiment carried out to study the propagation of fig through air layering with the use of different rooting media, etiolation and growth regulators are presented here under.

Plate 7 : A Photograph showing Air layers made

4.3.1 Percentage of success in rooting of shoots in air layering

Differences in percentage of rooting in layers and also among layers treated with different rooting media, etiolation, growth regulators and the interaction effect of etiolation, rooting media and growth regulators were significantly different (Table 10).

The data shows the significant difference in all the factors and interaction combinations.

Etiolated layers showed significantly maximum (73.96) percentage of success and minimum (62.16) was noticed in non etiolated layers. Layers with sphagnum moss as a rooting media showed significantly maximum (69.86) percentage of success whereas coir pith used layers showed minimum percentage (66.26) of success. The use of 1000 ppm IBA recorded significantly maximum (76.75) percentage of success. While minimum (56.00) was noticed with no growth regulator.

Among the interactions, the etiolated layers with sphagnum moss recorded significantly maximum (76.60) percentage of success. Whereas non etiolated layers with coir pith recorded minimum (61.20) percentage of success.

The use of sphagnum moss with 1000 ppm IBA recorded significantly (78.00) maximum percentage of success, whereas the coir pith with no growth regulators treated layers recorded minimum (54.00) percentage of success.

The etiolated layers with use of 1000 ppm IBA recorded maximum percentage of success (83.50), while the minimum (52.50) percentage of success was recorded in non etiolated layers with no growth regulator treatment.

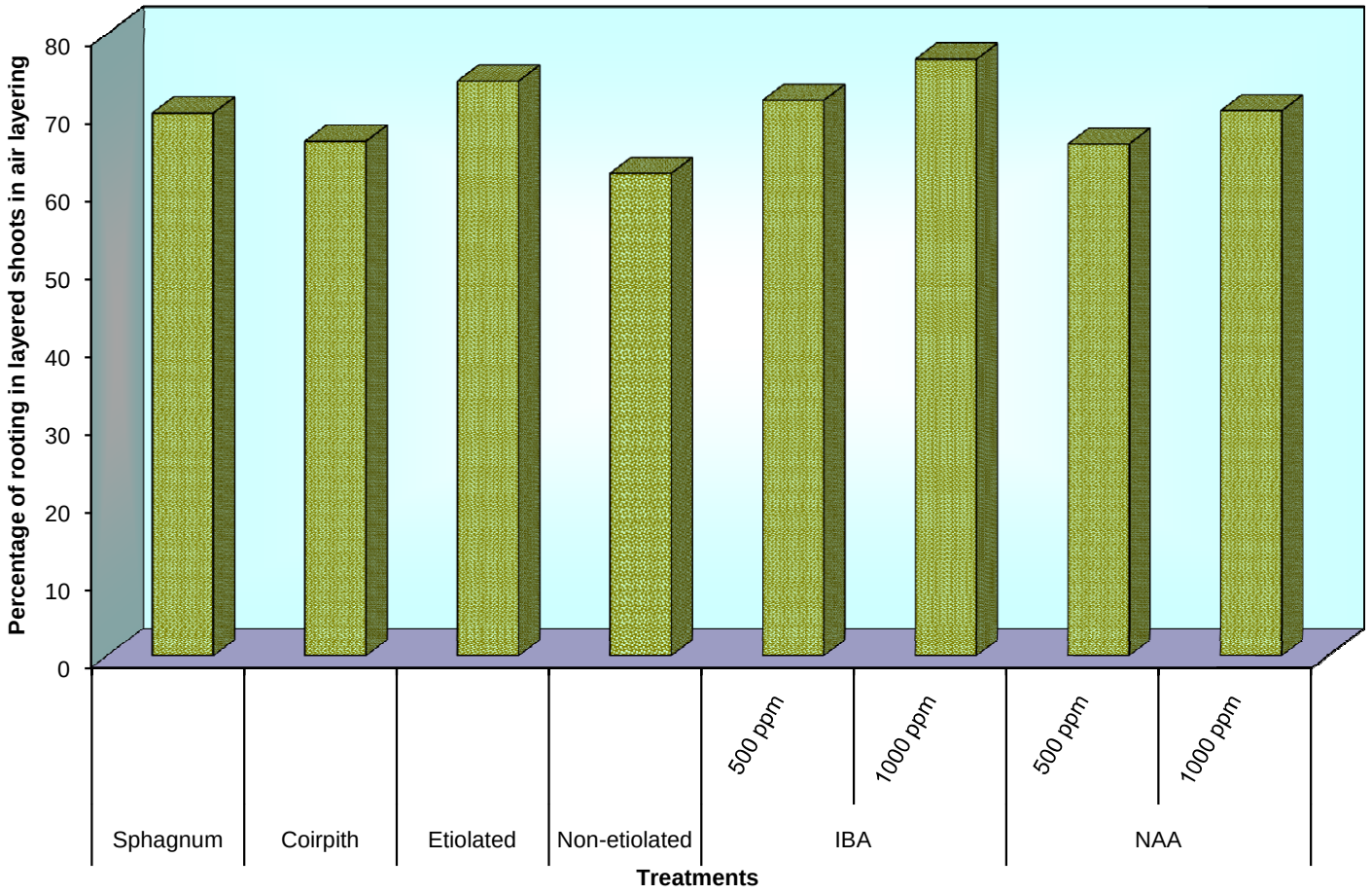
Table 10: Influence of etiolation, media and growth regulators on percentage of air layered shoots rooted.

	Treatment	Condition		
		Non Etiolated	**Etiolated**	**Mean**
Sphagnum moss	Control	55.00	61.00	58.00
	NAA500ppm	60.66	74.00	67.33
	NAA1000ppm	65.00	81.00	73.00
	IBA500ppm	65.00	81.00	73.00
	IBA1000ppm	70.00	86.00	78.00
Mean		63.13	76.00	69.86
Coir pith	Control	50.00	58.00	54.00
	NAA500ppm	58.00	71.00	64.50
	NAA1000ppm	65.00	71.66	67.33
	IBA500ppm	65.00	75.00	70.00
	IBA1000ppm	70.00	81.00	75.50
Mean		61.00	71.33	66.26
Growth Regulators	Control	52.50	59.50	56.00
	NAA500ppm	59.33	72.50	65.91
	NAA1000ppm	64.00	76.33	70.16
	IBA500ppm	65.00	78.00	71.50
	IBA1000ppm	70.00	83.50	76.75
Mean		62.16	73.96	----

Source	**F test**	**S.Em ±**	**CD @ 5%**
A (Etiolated/Non etiolated)	*	0.23	0.68
B (Media)	*	0.23	0.68
C (Growth regulator)	*	0.37	1.07
Interaction between AXB	*	0.33	0.96
AXC	*	0.53	1.52
BXC	*	0.53	1.52
AXBXC	*	1.30	2.15

* Significant at 5%

Fig. 4. Influence of etiolation, media and growth regulators on percentage of rooting in the air layered shoots in layering.



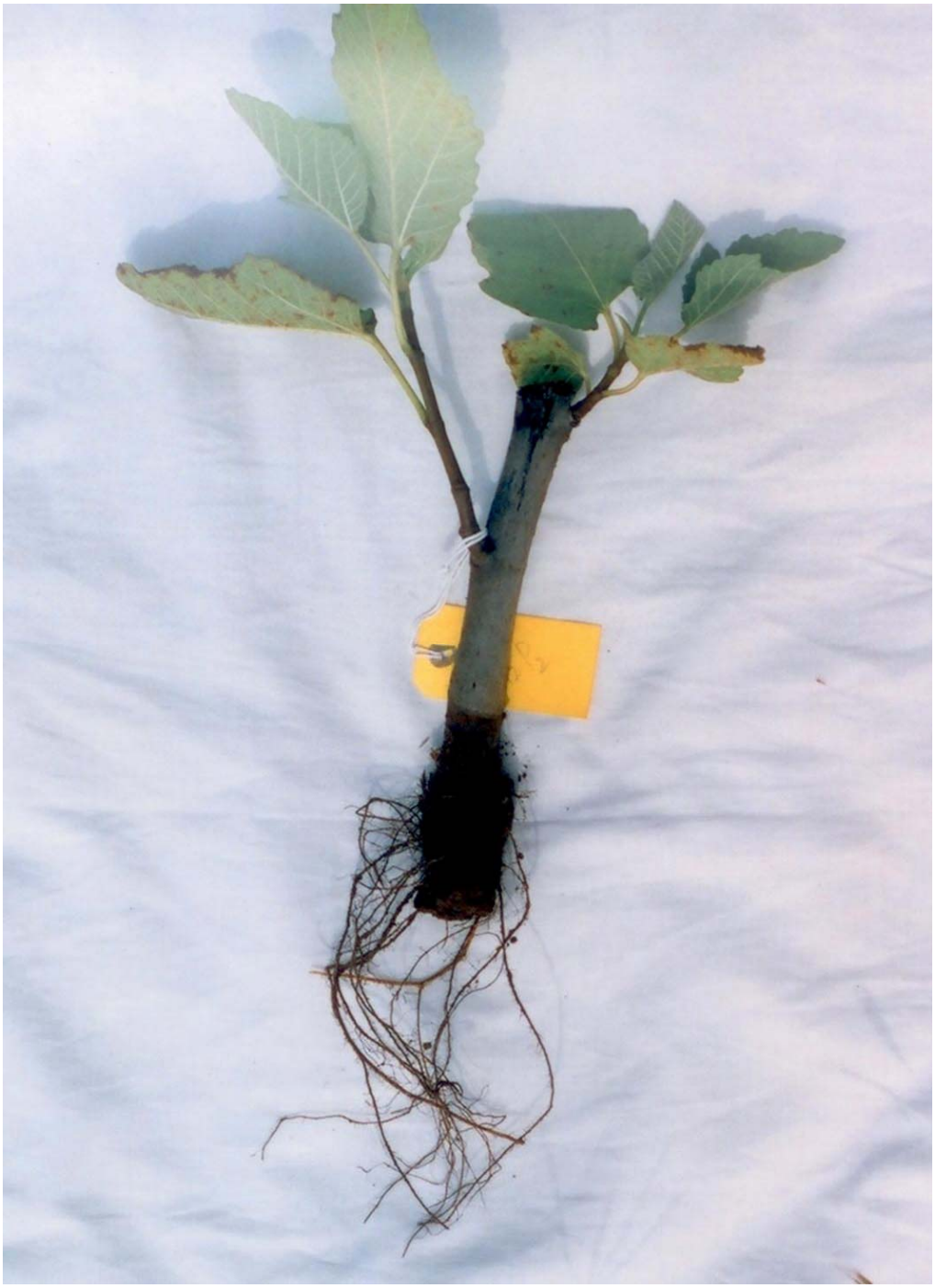


Plate 8 : A Photograph showing profusely rooted air layers (receiving treatment of etiolation, sphagnum moss, media and 1000ppm of IBA)

The etiolated layers with sphagnum moss and use of 1000 ppm IBA recorded significantly maximum percentage (86.00) of success when compared to all the interaction combinations. While minimum (50) was noticed in layers with no etiolation, no growth regulator treatment and layered by use of coirpith.

4.3.2 Days taken for sprouting in layering

Difference in days taken for sprouting in layers and also among layers treated with different growth regulators, rooting media and the interaction effect of type of layers, rooting media and growth regulators were significantly different (Table 11).

The etiolated layers showed significantly early sprouting (15.60 days) when compared to non etiolated layers (17.77). While the layers with sphagnum moss as a rooting media showed significantly early sprouting (16.35 days) when compared to layers with coir pith as a rooting media (17.02 days). Similarly growth regulator treatment of 1000 ppm IBA recorded significantly early sprouting (15.16 days) and the layers treated with no growth regulator took significantly maximum days (18.75 days) for sprouting.

Among the interaction combinations the etiolated layers treated with 1000 ppm IBA sprouting significantly early (14.15 days) and while the non etiolated layers with no growth regulators took maximum days for sprouting (22.45 days). Similarly etiolated layers with sphagnum moss plus 1000 ppm IBA treated layers took significantly minimum days to sprout (13.06 days), while the non etiolated layers with coir pith plus no growth regulator treated layers too significantly maximum days to sprout (81.00). While remaining all the interaction combination showed non significant difference.

Table 11: Influence of etiolation, media and growth regulators on number of days taken for sprouting of shoots in air layered shoots

	Treatment	Condition		
		Non Etiolated	**Etiolated**	**Mean**
Sphagnum Moss	Control	19.93	17.36	18.65
	NAA500ppm	17.76	14.96	16.36
	NAA1000ppm	16.76	15.30	16.03
	IBA500ppm	16.83	15.26	16.05
	IBA1000ppm	16.23	13.06	14.65
Mean		17.05	15.19	16.35
Coir pith	Control	21.00	16.73	18.86
	NAA500ppm	18.36	16.80	17.58
	NAA1000ppm	17.80	16.23	17.01
	IBA500ppm	16.86	15.03	15.95
	IBA1000ppm	16.13	15.23	15.68
Mean		18.03	16.00	17.02
Growth Regulators	Control	20.46	17.05	18.75
	NAA500ppm	18.06	15.83	16.97
	NAA1000ppm	17.28	15.76	16.25
	IBA500ppm	16.85	15.15	16.00
	IBA1000ppm	16.18	14.15	15.16
Mean		17.77	15.60	----

Source	**F test**	**S.Em ±**	**CD @ 5%**
A (Etiolated/Non etiolated)	*	0.14	0.40
B (Media)	*	0.14	0.40
C (Growth regulator Concentrations)	*	0.22	0.63
Interaction between AXB	NS	0.19	0.56
AXC	*	0.31	0.89
BXC	NS	0.31	0.89
AXBXC	*	0.77	1.26

* Significant at 5%
NS: Non Significant

4.3.3 Number of buds sprouted

Differences in number of buds sprouted among Layers and also among layers treated with different rooting media, growth regulators and the interaction effect of etiolation, growth regulators and rooting media were significantly different (Table 12).

The etiolated layers showed significantly maximum number of buds sprouted (4.08), when compared to non etiolated layers (3.22). Similarly sphagnum moss used layers recorded significantly maximum number of sprouted buds (3.82) and significantly minimum number of sprouted buds recorded in coir pith used layers. Among the different growth regulator treatment IBA 1000 ppm recorded maximum number of buds sprouted and significantly minimum (9.87). Number of sprouted buds recorded in layers treated with no growth regulators.

Among the interaction combinations etiolated layers with sphagnum moss recorded significantly maximum number (4.39) of sprouted buds, and significantly minimum number of sprouted buds (3.18) were recorded in non etiolated layers with coir pith used as a rooting media. While remaining all the interaction combinations showed non significant difference.

4.3.4 Sprout length at 30 DAP

Differences in length of sprout among different layers after 30 DAP (Table 13).

The etiolated layers showed significantly maximum length of buds sprouted (17.96 mm), whereas it was minimum (17.31 mm) in the non etiolated layers. The rooting media in layers did not showed any difference in sprout length in layers. While the use of 1000 ppm IBA

Table 12: Influence of etiolation, media and growth regulators on number of shoot buds sprouted on the layered shoot

	Treatment	Condition		
		Non Etiolated	**Etiolated**	**Mean**
Sphagnum Moss	Control	2.70	3.13	2.91
	NAA500ppm	3.06	3.86	3.46
	NAA1000ppm	3.10	4.60	3.85
	IBA500ppm	3.53	4.96	4.25
	IBA1000ppm	3.86	5.40	4.63
Mean		3.25	4.39	3.82
Coir pith	Control	2.60	3.06	2.83
	NAA500ppm	3.06	3.80	3.43
	NAA1000ppm	2.76	3.76	3.26
	IBA500ppm	3.76	3.70	3.73
	IBA1000ppm	3.73	4.53	4.13
Mean		3.18	3.77	3.48
Growth Regulators	Control	2.65	3.10	2.87
	NAA500ppm	3.06	3.83	3.45
	NAA1000ppm	2.93	4.18	3.55
	IBA500ppm	3.65	4.33	3.99
	IBA1000ppm	3.80	4.96	4.38
Mean		3.22	4.08	-----

Source	**F test**	**S.Em ±**	**CD @ 5%**
A (Etiolated/Non etiolated)	*	0.08	0.25
B (Media)	*	0.08	0.25
C (Growth regulator Concentrations)	*	0.13	0.39
Interaction between AXB	*	0.12	0.35
AXC	NS	0.19	0.56
BXC	NS	0.19	0.56
AXBXC	NS	0.48	0.80

* Significant at 5%

NS: Non Significant

Plate 9 : Photograph showing Air layered stem

showed significantly maximum sprout length (18.73 mm). when compared to control (14.36 mm).

All the interaction treatment combination showed no significant differences with respect to sprout length at 30 DAP.

The etiolated layers with sphagnum moss as a media recorded maximum sprout length (18.22 mm) and it was least in non etiolated and coir pith used layers (17.28 mm). The layers with sphagnum moss and treated with NAA 500 ppm recorded maximum (18.81 mm) sprout length and it was minimum in coir pith and no growth regulator used layers (13.91 mm). Similarly the etiolated and 1000 ppm IBA treated layers recorded maximum sprout length (19.15 mm) and non etiolated and no growth regulator used layers recorded minimum (13.71 mm) sprout length.

Finally the etiolated, sphagnum moss used and 1000 ppm IBA treated layers recorded maximum (19.23 mm) sprout length.

4.3.5 Sprout length at 60 DAP

Differences in sprout length among different types of layers after 60 days after propagation (Table 13).

The etiolated layers recorded significantly maximum (22.12 mm) sprout length as compared to non etiolated layers (21.07 mm). There were no significant differences in sprout length due to rooting media. The use of 1000 ppm IBA recorded significantly maximum sprout length (22.52 mm) and it was minimum (18.45) with no growth regulator.

The interaction treatment combinations recorded non significant with respect to sprout length at 60 days after propagation.

Table 13: Influence of etiolation, media and growth regulators on length of sprouted shoots in air layered shoots at 30 and 60 days after Air layering.

	Treatment	Condition(30 days)			Condition(60 days)		
		Non Etiolated	Etiolated	Mean	Non Etiolated	Etiolated	Mean
Sphagnum moss	Control	13.86	15.66	14.76	16.86	19.16	18.01
	NAA500ppm	18.80	18.83	18.81	22.80	22.90	22.85
	NAA1000ppm	17.90	18.83	18.36	21.66	22.93	22.30
	IBA500ppm	17.93	18.56	18.25	21.93	22.80	22.36
	IBA1000ppm	18.20	19.23	18.71	22.00	22.40	22.20
Mean		17.34	18.22	17.78	21.05	22.04	21.54
Coir pith	Control	13.56	14.26	13.91	18.13	19.66	18.90
	NAA500ppm	18.93	18.23	18.58	21.53	22.33	21.93
	NAA1000ppm	17.46	18.53	18.00	21.63	22.60	22.11
	IBA500ppm	18.00	18.40	18.20	21.93	23.00	22.46
	IBA1000ppm	18.43	19.06	18.75	22.26	23.43	22.85
Mean		17.28	17.70	17.49	21.10	22.20	21.65
Growth Regulators	Control	13.71	14.96	14.34	17.50	19.41	18.45
	NAA500ppm	18.86	18.53	18.70	22.16	22.61	22.93
	NAA1000ppm	17.68	18.68	18.18	21.65	22.76	22.20
	IBA500ppm	17.96	18.48	18.22	21.93	22.90	22.41
	IBA1000ppm	18.31	19.15	18.73	22.13	22.91	22.52
Mean		17.37	17.96	----	21.07	22.12	----

Source	After 30 days			After 60 days		
	F test	S.Em ±	CD @ 5%	F test	S.Em ±	CD @ 5%
A (Etiolated/Non etiolated)	*	0.19	0.40	*	0.24	0.34
B (Media)	NS	0.19	0.40	NS	0.24	0.34
C (Growth regulator)	*	0.31	0.63	*	0.38	0.53
Interaction between AXB	NS	0.28	0.56	NS	0.34	0.48
AXC	NS	0.44	0.89	NS	0.53	0.76
BXC	NS	0.44	0.89	NS	0.53	0.76
AXBXC	NS	0.77	1.27	NS	1.32	6.10

* Significant at 5%
NS: Non Significant

The etiolated and coir pith used Layers recorded maximum (22.20 mm) sprout length and it was minimum (21.05 mm) in non etiolated and sphagnum moss used layers. The sphagnum moss and use of 1000 ppm IBA treatment recorded maximum sprout length (22.85 mm) and it was minimum in coir pith used with no growth regulator treatment (18.01 mm). Similarly the etiolated and 1000 ppm IBA used layers recorded maximum (22.91 mm) sprout length. Whereas the non etiolated and no growth regulator treated layers recorded minimum (17.50 mm) sprout length.

4.3.6 Number of leaves at 30 DAP

Differences in number of leaves among layers and also among layers treated with different growth regulator, rooting media and the interaction effect after 30 DAP (Table 15).

The etiolated layers recorded significantly higher number of leaves (7.00), when compared to non etiolated layers (6.12). The use of sphagnum moss as a rooting media had recorded significantly maximum number of leaves (6.71) when compared to coir pith (6.41). The use of 1000 ppm IBA had recorded higher number of leaves (7.65) in the layers and it was found minimum (3.78) without growth regulator.

The interaction treatment combinations showed non significant difference with respect to number of leaves at 30 days after propagation.

The use of sphagnum moss in etiolated layers recorded maximum number of leaves (7.20) and it was minimum in non etiolated layers with coir pith (6.02). The use of sphagnum moss with 1000 ppm IBA recorded higher number of leaves (7.83) and it was minimum (3.51) when coir pith was used with no growth regulators. Similarly the number of leaves were maximum (8.13) in etiolated layers treated with 1000 ppm IBA and it was

minimum (3.56) in non etiolated layers treated with no growth regulators.

Finally in etiolated layers with the use of sphagnum moss and 1000 ppm IBA has recorded maximum number of leaves (8.43) and it was minimum (3.23) in non etiolated layers with coir pith and no growth regulator used layers.

4.3.7 Number of leaves after 60 days after propagation

Difference in number of leaves among layers treated with growth regulators, rooting media and interaction effect after 60 DAP (Table 15).

The etiolated layers recorded significantly maximum (8.85) number of leaves, when compared to non etiolated layers (8.12). There were no significant difference in number of leaves as influenced by different rooting media. The use of 1000 ppm IBA recorded significantly maximum number of leaves (9.65) and it was minimum (5.76) with no growth regulator.

All the interaction treatment combinations recorded non significant differences with respect to number of leaves.

The etiolated and sphagnum moss used layers recorded more number of leaves (9.08) and it was minimum (8.10) in non etiolated coir pith used layers. The use of sphagnum moss with 1000 ppm IBA recorded maximum number of leaves (9.85) and it was minimum in coir pith and no growth regulator used layers (5.46). Similarly the etiolated layers with 1000 ppm IBA treatment recorded maximum number of leaves (10.03), while it was minimum (5.68) in non etiolated layers when treated with no growth regulators.

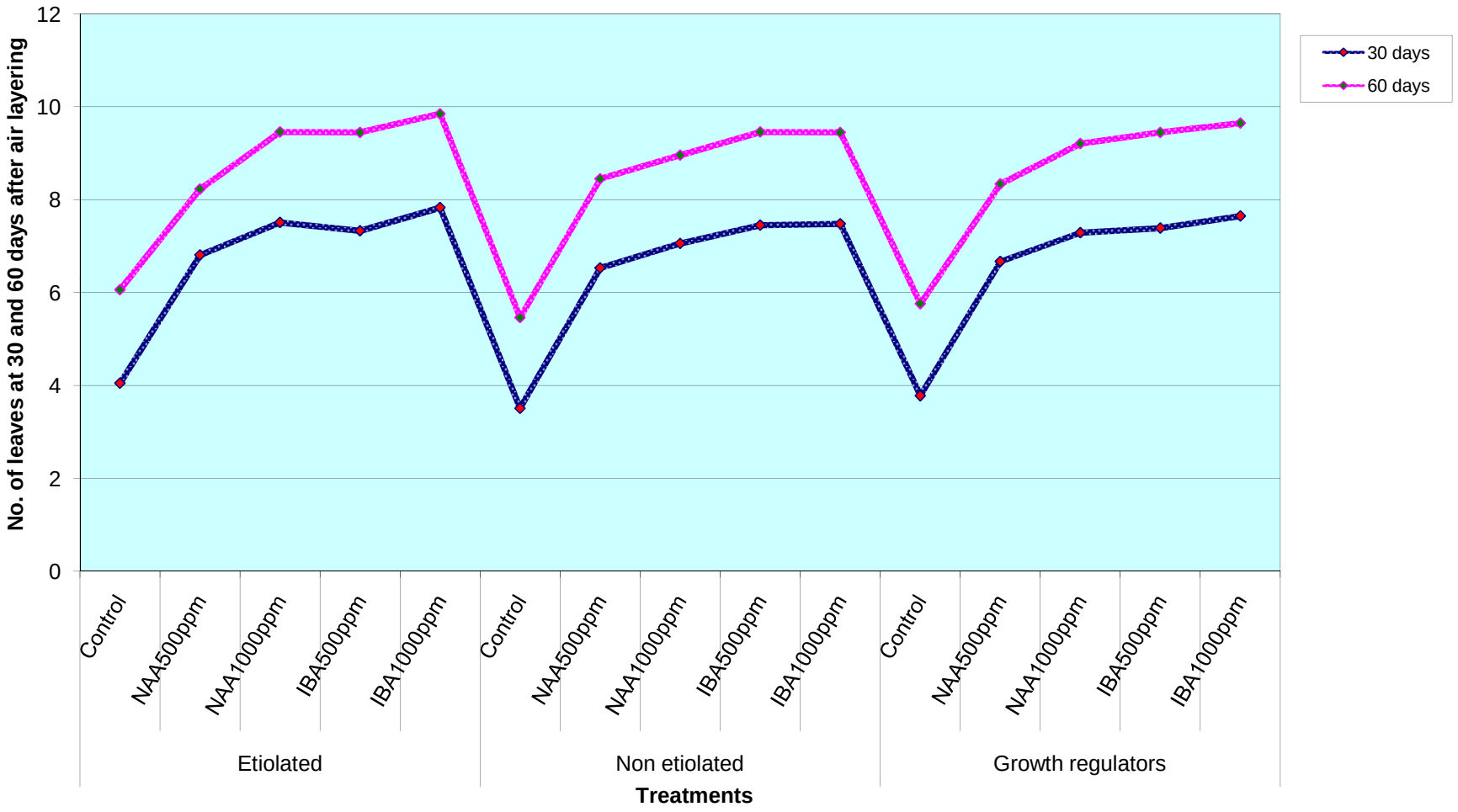
Table 14: Influence of etiolation, media and growth regulators on number of days taken for root initiation in air layered shoots.

	Treatment	Condition		
		Non Etiolated	**Etiolated**	**Mean**
Sphagnum Moss	Control	17.93	15.36	16.65
	NAA500ppm	15.76	12.96	14.36
	NAA1000ppm	14.76	13.30	14.03
	IBA500ppm	14.83	13.26	14.05
	IBA1000ppm	14.23	11.06	12.65
Mean		15.05	13.19	14.35
Coir pith	Control	19.00	14.73	16.86
	NAA500ppm	16.36	14.80	15.58
	NAA1000ppm	15.80	14.23	15.01
	IBA500ppm	14.86	13.03	13.95
	IBA1000ppm	14.13	13.23	13.68
Mean		16.03	14.00	15.02
Growth Regulators	Control	18.46	15.05	16.75
	NAA500ppm	16.06	13.88	14.97
	NAA1000ppm	15.28	13.76	14.52
	IBA500ppm	14.85	13.15	14.00
	IBA1000ppm	14.18	12.15	13.16
Mean		15.77	13.60	----

Source	**F test**	**S.Em ±**	**CD @ 5%**
A (Etiolated/Non etiolated)	*	0.12	0.35
B (Media)	*	0.12	0.35
C (Growth regulator)	*	0.19	0.55
Interaction between AXB	NS	0.17	0.49
AXC	*	0.27	0.78
BXC	NS	0.27	0.78
AXBXC	*	0.67	1.11

* Significant at 5%
NS: Non Significant

Fig. 5. Influence of etiolation, media and growth regulators on no. of leaves at 30 and 60 days after air layering.



Finally the number of leaves were maximum (10.43) in etiolated layers with sphagnum moss and use of 1000 ppm IBA. While it was minimum (5.53) in non etiolated layers with coir pith and no growth regulator treatment.

4.4.1 Growth parameters of roots

4.4.2 Days taken for root initiation

Differences in days taken for root interaction among layers and also among layers treated with different growth regulators rooting media, etiolation and the interaction effect of etiolation, growth regulators rooting media were significantly different (Table 14).

The etiolated layers took significantly minimum days (13.60) for initiation of roots when compared to non etiolated layers (15.77 days). Similarly sphagnum moss used layers took significantly minimum days for initiation of roots (14.35 days) when compared to coir pith used layers (15.02 days). Among the different growth regulator, the layers treated with 1000 ppm IBA took significantly minimum days to sprout (13.16 days) and the layers treated with no growth regulators took maximum days (16.75) for root initiation.

Among the interaction combinations etiolated layers treated with 1000 ppm IBA recorded significantly minimum days (18.15) for root initiation and non etiolated layers with no growth regulator treatment took maximum days for (18.46) root initiation. Similarly etiolated layers with sphagnum moss plus 1000 ppm IBA treated layers took minimum days (11.06) for initiation of roots. While the non etiolated layers with coir pith and treated with no growth regulator took significantly maximum (19.00) days for initiation of roots. Remaining all the interaction combination showed non significant difference.

Table 15: Influence of types of air layering, media and growth regulators on number of leaves on the air layered shoot at 30 and 60 days after layering.

	Treatment	Condition(30 days)			Condition(60 days)		
		Non Etiolated	Etiolated	Mean	Non Etiolated	Etiolated	Mean
Sphagnum moss	Control	3.90	4.20	4.05	5.96	6.16	6.06
	NAA500ppm	6.10	7.53	6.81	7.30	9.16	8.23
	NAA1000ppm	7.06	7.96	7.51	9.20	9.73	9.46
	IBA500ppm	6.80	7.86	7.33	8.96	9.93	9.45
	IBA1000ppm	7.23	8.43	7.83	9.26	10.43	9.85
Mean		6.22	7.20	6.71	8.14	9.08	8.61
Coir pith	Control	3.23	3.80	3.51	5.40	5.53	5.46
	NAA500ppm	5.93	7.13	6.53	8.00	8.90	8.45
	NAA1000ppm	6.56	7.56	7.06	8.63	9.30	8.96
	IBA500ppm	7.23	7.66	7.45	9.23	9.70	9.46
	IBA1000ppm	7.13	7.83	7.48	9.26	9.63	9.45
Mean		6.02	6.80	6.41	8.10	8.61	8.36
Growth Regulators	Control	3.56	4.00	3.78	5.68	5.46	5.76
	NAA500ppm	6.01	7.33	6.67	7.65	8.45	8.34
	NAA1000ppm	6.81	7.76	7.29	8.91	8.96	9.21
	IBA500ppm	7.01	7.76	7.39	9.10	9.46	9.45
	IBA1000ppm	7.18	8.13	7.65	9.26	9.45	9.65
Mean		6.12	7.00	-----	8.12	8.85	-----

Source	After 30 days			After 60 days		
	F test	S.Em ±	CD @ 5%	F test	S.Em ±	CD @ 5%
A Etiolated/Non etiolated)	*	0.09	0.28	*	0.16	0.33
B (Media)	*	0.09	0.28	*	0.11	0.33
C (Growth regulator)	*	0.15	0.44	*	0.18	0.52
Interaction between AXB	NS	0.14	0.40	NS	0.16	0.46
AXC	NS	0.22	0.63	NS	0.25	0.74
BXC	NS	0.22	0.63	NS	0.25	0.74
AXBXC	NS	0.34	0.89	NS	0.63	1.05

* Significant at 5%
NS: Non Significant

Plate 10 : A Photograph showing air layered stem in which root initiation was seen at the earliest (receiving treatments of etiolation, sphagnum moss, media and 1000ppm of IBA)

4.4.3 Number of primary roots at 30 DAP

Difference in number of primary roots among layers and also among layers treated with different growth regulators, rooting media and the interaction effect of etiolation and growth regulators were significantly different (Table 16).

The etiolated layers recorded significantly higher (74.53) number of primary roots when compared to non etiolated layers (69.21). The use of sphagnum moss recorded significantly maximum (72.99) number of primary roots when compared to coir pith (70.75) used layers. The use of 1000 ppm IBA recorded the maximum number of primary roots (77.42) and it was minimum (58.28) without growth regulators.

The interaction treatment combination showed non significant differences with respect to number of primary roots. The etiolated and sphagnum moss used layers recorded more number of primary roots (86.00) and minimum were noticed in non etiolated and coir pith used layers (68.44). The use of sphagnum moss and 1000 ppm IBA recorded maximum number of primary roots (78.00), while minimum (56.60) was noticed in coir pith and no growth regulator used layers. Similarly etiolated layers with 1000 ppm IBA recorded maximum number of primary roots (80.08) while it was minimum (55.60) in no etiolated and no growth regulator treated layers.

Finally the etiolated, sphagnum moss used and treating with 1000 ppm IBA recorded more number of primary roots (81.10) and minimum (54.06) was noticed in non etiolated, coir pith used and without growth regulator used layers.

4.4.4 Number of primary roots at 60 DAP

Differences in number of primary roots among layers and also among layers treated with different rooting media, growth regulators and

Table 16: Influence of etiolation, media and growth regulators on number of primary roots in air layered shoots at 30 and 60 days after layering.

	Treatment	Condition(30 days)			Condition(60 days)		
		Non Etiolated	Etiolated	Mean	Non Etiolated	Etiolated	Mean
Sphagnum moss	Control	57.13	62.80	59.96	59.26	66.70	62.98
	NAA500ppm	69.50	77.10	73.30	73.93	81.40	77.66
	NAA1000ppm	74.13	79.23	76.68	77.93	83.23	80.58
	IBA500ppm	74.10	79.80	76.95	78.20	83.76	80.98
	IBA1000ppm	75.03	81.10	78.06	79.16	84.73	81.95
Mean		69.98	76.00	72.99	73.70	79.96	76.83
Coir pith	Control	54.06	59.13	56.60	60.02	62.30	61.25
	NAA500ppm	68.40	73.46	70.93	72.30	79.26	75.78
	NAA1000ppm	72.13	77.13	74.63	76.13	81.36	78.75
	IBA500ppm	73.10	76.53	74.81	77.26	80.63	78.95
	IBA1000ppm	74.50	79.06	76.78	78.53	83.36	80.95
Mean		68.44	73.06	70.75	72.88	77.38	75.13
Growth Regulators	Control	55.60	60.96	58.28	59.73	64.50	62.11
	NAA500ppm	68.95	75.28	72.11	73.11	80.33	76.72
	NAA1000ppm	73.13	78.18	75.65	77.03	82.30	79.66
	IBA500ppm	73.60	78.16	75.88	77.73	82.20	79.96
	IBA1000ppm	74.76	80.06	77.42	78.85	84.05	81.45
Mean		69.21	74.53	----	73.29	78.67	---

Source	After 30 days			After 60 days		
	F test	S.Em ±	CD @ 5%	F test	S.Em ±	CD @ 5%
A (Etiolated/Non etiolated)	*	0.22	0.63	*	0.35	1.01
B (Media)	*	0.22	0.63	*	0.35	1.01
C (Growth regulator)	*	0.35	1.00	*	0.56	1.60
Interaction between AXB	*	0.31	0.90	NS	0.50	1.13
AXC	NS	0.49	1.42	NS	0.79	2.26
BXC	NS	0.49	1.42	NS	0.79	2.26
AXBXC	NS	1.22	2.01	NS	1.94	3.20

* Significant at 5%
NS: Non Significant

Fig. 6. Influence of etiolation, media and growth regulators on no. of primary roots in air layered shoots at 60 days after planting.

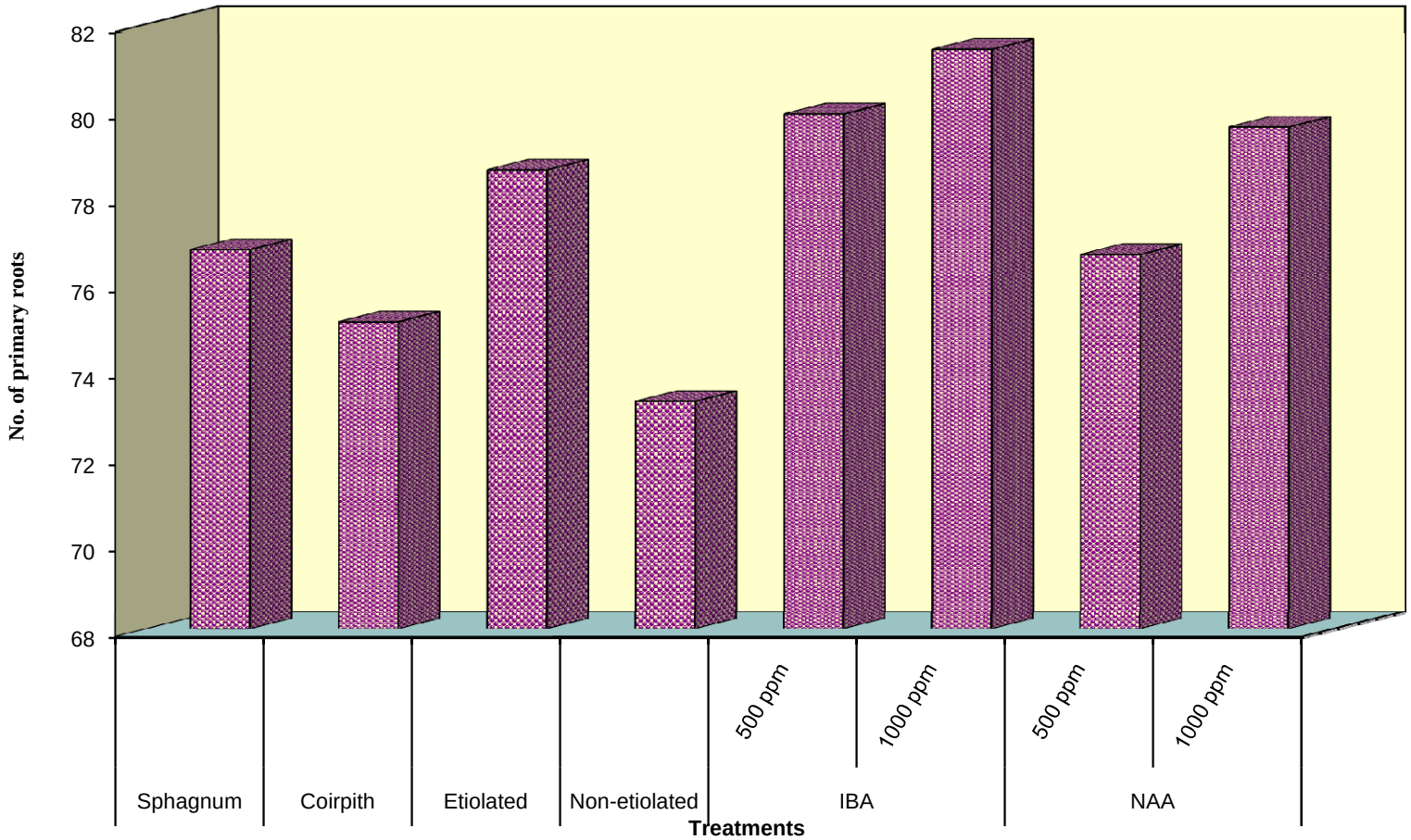


Plate 11 : Rooted air layers at 30 and 60 days after layering was done (reciving treatments of etiolation, sphagnum moss, media and 1000ppm of IBA)

the interactions effect of type of layers and growth regulators were significantly different (Table 16).

The etiolated layers recorded significantly higher number of primary roots (78.67), when compared to non etiolated layers (73.29). The sphagnum moss used layers recorded significantly higher number of primary roots (76.83), when compared to coir pith (75.13). Similarly use of 1000 ppm IBA recorded significantly higher number (81.45) of primary roots and minimum (62.11) was noticed without growth regulator treated layers.

The interaction treatment combination shows non significant difference at 60 DAP with respect to number of primary roots.

The etiolated layers with sphagnum moss recorded maximum number of (79.96) primary roots, while it was minimum in (72.88) non etiolated, coir pith used layers. The use of sphagnum moss and 1000 ppm IBA recorded significantly higher number of primary roots (81.95) and minimum number (61.25) of primary roots were recorded when coir pith was used without growth regulators. Similarly the etiolated layers with 1000 ppm IBA recorded more number of primary roots (84.05) and it was minimum (59.73) in non etiolated layers with out any growth regulators.

The etiolated, sphagnum moss and 1000 ppm IBA used layers recorded maximum (84.73) number of roots and minimum was noticed in non etiolated coir pith used and no growth regulators used layers.

4.4.5 Number of secondary roots at 60 DAP

Differences in number of secondary roots among layers and also among Layers treated with different growth regulators, rooting media and

Table 17: Influence of etiolation, media and growth regulators on number of secondary roots in air layered shoots at 60 days after planting in layering.

	Treatment	Condition		
		Non Etiolated	Etiolated	Mean
Sphagnum moss	Control	96.33	103.66	100.00
	NAA500ppm	112.33	123.00	117.66
	NAA1000ppm	119.00	127.33	123.16
	IBA500ppm	118.66	128.33	123.50
	IBA1000ppm	120.00	133.33	126.66
Mean		113.26	123.13	118.20
Coir pith	Control	95.66	101.33	98.50
	NAA500ppm	112.00	119.66	115.83
	NAA1000ppm	117.33	124.00	120.66
	IBA500ppm	117.33	122.66	120.00
	IBA1000ppm	120.66	125.66	123.16
Mean		112.60	118.66	115.63
Growth Regulators	Control	96.00	102.50	99.25
	NAA500ppm	112.16	121.33	116.75
	NAA1000ppm	118.16	125.66	121.91
	IBA500ppm	118.00	125.50	121.75
	IBA1000ppm	120.33	129.50	124.91
Mean		112.93	120.90	----

Source	F test	S.Em ±	CD @ 5%
A (Etiolated/Non etiolated)	*	0.64	1.84
B (Media)	*	0.64	1.84
C (Growth regulator Concentrations)	*	1.09	2.91
Interaction between AXB	*	0.91	2.60
AXC	NS	1.44	4.12
BXC	NS	1.44	4.12
AXBXC	NS	3.53	5.83

* Significant at 5%
NS: Non Significant

Plate 12 : A view of air layers made on the stem of poona fig plant

the interaction effect of etiolation, rooting media and growth regulators were significantly different (Table 17).

The etiolated layers recorded significantly differences were number of roots (20.90) compared to non etiolated layers (112.93). Use of sphagnum moss significantly increased in more number (118.20) of secondary roots compared to coir pith (115.63). Use of 1000 ppm IBA recorded significantly higher number (124.91) of secondary roots and minimum (99.25) was noticed without growth regulator treatment.

The etiolated layers with sphagnum moss recorded significantly higher number of roots (123.13) and minimum (112.60) was noticed in non etiolated coir pith used layers and the remaining all the interaction treatment combinations shows non significant difference.

4.4.6 Length of primary roots at 30 days after propagation in layers

Differences in length of primary roots at among different types of Layers then interaction effect after 30 DAP (Table 18).

The data shows the significant difference in all the factors and interaction combinations.

The etiolated layers shows significantly maximum root length (12.47 mm) when compared to (10.16 mm) non etiolated layers. The sphagnum moss used layers showed significantly maximum (11.66 mm) root length, when compared to (10.97) coir pith used layers. Similarly use of 1000 ppm IBA recorded significantly maximum root length (12.87 mm), and it was minimum (7.78 mm) in control

Among the interaction combinations the etiolated layers with sphagnum moss recorded significantly maximum root length (12.90 mm) and it was minimum in non etiolated layers with coir pith (9.90 mm).

The use of sphagnum moss with 1000 ppm IBA recorded significantly maximum (13.00 mm) root length and it was minimum in coir pith used layers with no growth regulators (7.00 mm). Similarly etiolated layers with 1000 ppm IBA recorded significantly maximum root length (13.75 mm) and it was minimum in (6.06 mm) in non etiolated layers with no growth regulator treatments.

Finally the etiolated layers with sphagnum moss and treated with 1000 ppm IBA recorded significantly higher root length (14.00 mm), whereas it was minimum (5.50 mm) in non etiolated layers with coir pith and with no growth regulators.

4.4.7 Length of primary roots at 60 days after propagation in layers

Differences in length of primary roots among layers and also among layers treated with different growth regulators, rooting media and the interaction effect of type of Layers, rooting media and growth regulators were significant (Table 18).

The data shows the significant difference in all factors and interaction combinations.

The etiolated layers showed significantly maximum root length (76.4 mm) when compared to (74.16 mm) non etiolated layers. The sphagnum moss used layers showed significantly maximum (175.63 mm) root length when compared to (74.95 mm) coir pith used layers. Similarly use of 1000 ppm IBA recorded significantly maximum root length (76.87 mm) and it was minimum (71.78 mm) with no growth regulator treatment.

Among the interaction combinations the etiolated layers with sphagnum moss recorded significantly maximum root length (76.83 mm) and it was minimum in non etiolated layers with coir pith (73.90 mm).

Table 18: Influence of etiolation, media and growth regulators on length of primary roots in air layered shoots at 30 and 60 days after layering

	Treatment	Condition(30 days)			Condition(60 days)		
		Non Etiolated	Etiolated	Mean	Non Etiolated	Etiolated	Mean
Sphagnum moss	Control	6.63	10.50	8.56	70.63	74.50	72.50
	NAA500ppm	10.50	13.00	11.75	74.50	76.66	75.58
	NAA1000ppm	11.50	13.50	12.50	75.50	77.50	76.50
	IBA500ppm	11.50	13.50	12.50	75.50	77.50	76.50
	IBA1000ppm	12.00	14.00	13.00	76.60	78.00	77.00
Mean		10.42	12.90	11.66	74.42	76.83	75.63
Coir pith	Control	5.50	8.50	7.00	69.50	72.50	71.00
	NAA500ppm	9.50	12.00	10.75	73.70	76.00	74.75
	NAA1000ppm	11.00	13.00	12.00	75.00	77.00	76.00
	IBA500ppm	11.50	13.20	12.35	75.50	77.00	76.25
	IBA1000ppm	12.00	13.50	12.75	76.00	77.50	70.75
Mean		9.90	12.04	10.97	73.90	76.00	74.95
Growth Regulators	Control	6.06	9.50	7.78	70.06	73.50	71.78
	NAA500ppm	10.00	12.50	11.25	74.00	76.33	75.16
	NAA1000ppm	11.25	13.25	12.25	75.25	77.25	76.25
	IBA500ppm	11.50	13.35	12.42	75.50	77.25	76.37
	IBA1000ppm	12.00	13.75	12.87	76.00	77.75	76.87
Mean		10.16	12.47	----	74.16	76.41	----

Source	F test	S.Em ±	CD @ 5%	F test	S.Em ±	CD @ 5%
A (Etiolated/Non etiolated)	*	0.017	0.049	*	0.026	0.075
B (Media)	*	0.017	0.049	*	0.026	0.075
C (Growth regulator)	*	0.024	0.078	*	0.041	0.118
Interaction between AXB	*	0.024	0.070	*	0.037	0.106
AXC	*	0.039	0.110	*	0.059	0.168
BXC	*	0.039	0.110	*	0.059	0.168
AXBXC	*	0.09	0.16	*	0.14	0.24

* Significant at 5%

Plate 13 : A Photograph showing soots in which layers were made (Because of the limitations of plant material the layering was done on different places of the same stem, care was taken to see that layers made on the same stem received the same treatment

The use of sphagnum moss with 1000 ppm IBA recorded significantly maximum (77.00 mm) root length and it was minimum in coir pith used layers with no growth regulators (71.00 mm). Similarly etiolated layers with 1000 ppm IBA recorded significantly maximum root length (77.75 mm) and it was minimum (70.06 mm) in non etiolated layers with no growth regulator treatment.

Finally the layers with sphagnum moss and 1000 ppm IBA growth regulator treatment recorded significantly higher root length (78.00 mm), where it was minimum (69.50) in non etiolated layers with coir pith and with no growth regulator treatment.

Discussion

V. DISCUSSION

Propagation is widely followed to multiply plants of desired constitution and maintain their purity for commercial exploitation in many fruit and ornamental crops. The art of propagation by vegetative method has gained popularity in the field of horticulture in recent years. Many of horticultural plants species which are found to be difficult to root, are made to root easily by using root inducing hormones and providing humid condition. Among the methods of vegetative propagation, cuttings and layering are importance practices.

Fig is grown in India since the time immemorial. However, when compared to other major fruit crops, fig has not progressed on popularity as well as commercially. In recent times, owing to increased interest among farmers to produce fig on a larger scale, availability of elite planting material is a requirement to aid enhanced production of planting material. Hence the results of present investigation would help the increased production of fig. The results obtained in the present investigation are discussed here.

5.1.1 Propagation of fig through cuttings

5.1.2 Percentage of success

Different types of cuttings were used to compare their efficacy in terms of percentage of success in rooting. Basal cuttings rooted well when compared with tip cuttings. The percentage of success was highest in basal cuttings (63.50%). Cuttings in which leaves were retained rooted well, in that the rooting percentage was significantly more (59.30) than from the cuttings in which leaves had been removed.

Cuttings which were treated with 1000 ppm of IBA showed significant success in rooting (66.00%). All these factors when combined,

the maximum percentage of cuttings rooted were those from basal cutting with leaves and treated with 1000 ppm IBA (74.00%). It is a well established fact the stored food material in a cutting plays an important role in adventitious rooting. Hence, the basal cuttings have shown increased percentage of rooting. Possible flow of photosynthates from the leaves to the base of the stem may have contributed to the increased percentage of rooting with cutting where leaves had been retained, though leaves were intact on the stem for a couple of days after cuttings were made. It is also documented that the leaves on the stem exert a positive influence by inducing rooting, as some rooting cofactors produced in the leaves flow back to the base of the stem. The role of auxins in inducing rooting and IBA as the best auxin for root induction is also well documented (Hartman and Kester, 2007). Hence, the leaves retained on the cuttings, though fell off with in a couple of days may have had contributed to the increased percentage of rooting by way of flow of synthates to the base of the cuttings. Similar results have also been reported in crops such as pomegranate (Hore and Sen,1997), Ficus Carica (Raghupathi and Prasana kumar), Fig. cv Poona Fig. (Ghanta Bhagyalakshmi, 2004), Tewari and Dhar (1997) in Indian butter tree (*Aesendra butyracea*.Roxb), reported better sprouting with optimal auxins treatment, Moore and Ink (1964) in blue berry, Bhat and Todaria (1993) in *Bauhinia retusa*, Purohit and Shekarappa (1985) in Pome granate, Arya *et al.*, (1993) in Prosopis, Cineraria Dhyani and Khali (1993) in Fiscus sp.

5.1.3 Shoot growth parameters

Sprouting was significantly early in basal cuttings (17.49 days), basal cuttings with leaf (18.36) and basal cuttings with leaf and treated with 1000ppm of IBA (16.30 days).

Number of buds sprouted was also more with basal cuttings(2.53), basal cuttings with leaf retained (2.82) and basal cuttings with leaf and treated with 1000ppm of IBA (3.09).

Significant increase in the length of leaves as recorded at 30 and 60 days after planting of cuttings was observed with basal cuttings (14.91 & 18.90 mm) basal cuttings with leaf (14.75 and 18.58) and basal cuttings with leaf and treated with 1000ppm of IBA (15.66 and 19.72)

Increased number of leaves were recorded at 30 and 60 days after planting of cuttings, with basal cuttings (4.92 & 5.82), basal cuttings with leaves retained (4.67 & 56.8), basal cuttings with leaves and treated with 1000 ppm IBA (5.65 & 6.61)

Shoot growth parameters are largely influenced by photosynthates and also growth promoting substances. Shoot growth promoting substances such as cytokinins, auxins and also gibberellins play a role. In the present study basal cuttings with leaves retained and treated with 1000 ppm of IBA have shown significant responses as enumerated earlier. Definitely stored food material in cuttings and growth regulating substances as influenced by retention of leaves have played a significant role in early sprouting and number of sprouts recorded. However increase in length of shoots and number of leaves must have been influenced by absorption of nutrients as facilitated by good roots obtained in the basal cuttings with leaves retained and treated with 1000 ppm of IBA. Similar findings have also been reported in studies conducted in crops such as Indian butter tree (*Aesendra butyracea.*Roxb), Blue berry. These results are similar to the findings of Tewari and Dhar (1997) in Indian butter tree, Moore and Ink (1964) in blue berry crop, Arya *et al.,* (1993) in *Prosopis cineraria a* wild edible fruit species.

5.1.4 Growth parameters of roots

Basal cuttings with leaves and treated with 1000 ppm of IBA rooted early (14.13 days). The observation were similar for parameters such as number of primary roots (72.0 and 75.40 as on 30 and 60 days after planting of cuttings), number of secondary roots (120), length of primary roots(9.87 and 64.87 mm at 30 and 60 days, respectively).

The better growth and development of roots observed are probably due to sufficient stored carbohydrates and internal factors including carbohydrate metabolism leading to cell enlargement and hence, triggering the growth of meristematic tissue. The initial stored material of basal cuttings and stimulation from retained leaves and a supplement of auxin (IBA) resulting in early initiation of roots may have contributed towards increased root growth parameters observed at 30 days and 60 days after planting of cuttings. Similarly, incremental shoot parameter such as more number of leaves consequently higher photosynthate production may have also contributed towards increased root parameters, Similar findings have been reported in forestry species *Martinus nijhoff* by Bonga and Durzer (1982), Hareesh et al., (2000) in *Oxgenia oojenensis* crop. Camaron and Rock (1974) in radiala pine species.

5.2.1 Propagation of Fig through Air layering

5.2.2 Percentage of success

The percentage of success in rooting was significantly high in etiolated layers (73.96%) and in treatment where sphagnum moss was used as media (69.86%), similarly in layers treated with 1000 ppm IBA (76.50%). The treatment combination of etiolation, sphagnum moss and treatment with 1000ppm IBA showed a maximum percentage of success in terms of rooting of air layered shoots.

Etiolation, a practice of exposing the plant tissue to dark condition is known to cause accumulation of growth promoting substances, particularly of use to rooting process is also well documented (Hartman and Kester, 1984) Good moisture level at the rooting zone is a necessary factor for good rooting of air layered shoots or to trigger the cellular activity leading towards induction of root initials. This factor has been taken care of using sphagnum moss as the media. Sphagnum moss has more water holding capacity than coir pith owing to the nature of substrate. Sphagnum moss is rich in water holding cells. The role of auxin and particularly IBA as rooting hormone is well documented. The above points of discussion holds good for the increased success in rooting of layers observed in the present study. Studies have also indicated higher amount of total carbohydrate, C:N ratio and rooting co-factors than the non etiolated layers as observed with etiolated layers of Siamese rough bush crop.The results of the present study are also in conformity with the results reported by Roy et al., (1973), Singh and Singh (1973) in Sweet lime, Blazich Acedo (1989) in *Osmanthas heterophylless* and Simily (1995) in *Cinnamon zylanicum,* Guo et al., (1986) in Fig, Poi and Mazumdar (1989) in Bael plant and Osthesigen (1993) in *Pecan sps.*

5.2.2 Shoot growth parameters

The early sprouting, increased number of buds, increased length of sprouts and number of leaves have been recorded in layers which were etilolated, and were made using sphagnum moss as media, and 1000ppm of IBA as auxin source.

The sprout length was significantly high in etiolated layers and similarly in layers treated with 1000 ppm IBA.

The number, of leaves were significantly high with etiolated layers, sphagnum moss used as media and in layers treated with 1000ppm IBA.

Enhanced growth parameters of shoot observed, could be attributed to high starch content of etiolated layers compared to non etiolated layers. The increase in shoot parameters may have been complimented due to better utilization of stored carbohydrates, nitrogen and other factors with the aid of accumulated auxins at the etiolated site in addition to exogenously applied auxin(IBA at 1000ppm). These findings are similar to the findings of Curir et al. (1992), as observed in *Genista monosperma* Lam.

5.2.3 Root growth parameters

The early occurrence of root initiation, increased number of primary roots, secondary roots and length of primary roots was found in etiolated layers with sphagnum moss as the media and receiving 1000ppm of IBA, could be attributed to benefits of etiolation, sphahnum moss and auxin such as IBA, as discussed in the earlier pages of this chapter especially in reference to the percentage of success in rooting, holds good for these root growth parameters also. De Hweiler (1942) also opined that the application of growth regulators leads to high metabolic activity and mobilization of sugars and nitrogen substances present in stem and leaves which help in the intiation of root primordia in layers. Better root promoting activity of IBA could be attributed to its property of slow movement and its relatively slow destruction by auxin degrading enzyme system. Similar findings have been reported by Poulsen and Anderson (1980) in *Hedera helix,* Bhujbal and Kale (1973) in Rose, Bahuguna et al. (1988) in *Woodfordia fruticosa* Kurz, Daoud *et al* (1989); Simily (1994) and Sengupta and Thakur (2001) in jack fruit, Singh and Singh (1996) in guava, Chovatia and Singh (2000) in custard apple and Kumar and Gill (1996) in Baramashi lemon.

Summary

VI SUMMARY

Investigations were conducted to study propagation of Fig (Ficus carica L.), Cv. Poona Fig, through the methods of stem cuttings and air layering.

6.1 Propagation through stem cuttings

In propagation through cuttings, to obtain, increased percentage of cuttings rooted, and cuttings with better root and shoot growth, different factors such as choosing cuttings from basal and tip portion of the mother plant, retention and non-retention of leaves on the cuttings and treating the base of cuttings with auxins suchas IBA and NAA at concentrations 500 and 1000ppm were studied.

6.1.1 The percentage of cuttings rooted was higher with:

- Basal than tip cuttings,
- Cuttings in which the leaves were retained when cuttings were made, and
- Cuttings treated with 1000ppm IBA
- The interaction effect showed a maximum percentage of rooting from basal cuttings with leaves retained and treated with 1000 ppm of IBA.

6.1.2 Similarly, with reference to shoot growth of cuttings:

- Time taken for sprouting of shoots from cuttings after they were planted was hastened,
- Mean number of sprouts per cutting were more,
- The length of sprouted shoots were high,
- The number of leaves from cuttings was more,

In basal cuttings with leaves retained and treated with 1000ppm of IBA.

6.1.3 With reference to the root growth:

- Time taken for rooting from cuttings after they were planted in the media
- Mean number of primary roots were high,
- Mean number of secondary roots were high,
- Length of primary roots were high,

In basal cuttings with leaves retained and treated with 1000ppm of IBA.

6.2 Propagation of fig through Air layering

In propagation through air layering, to obtain, increased percentage of air layers rooted, and layered stem to produce better roots and good shoot growth, different practices such as etiolation, media such as sphagnum moss and coir pith, and auxins suchas IBA and NAA at 500 and 1000ppm were studied.

6.2.1 The percentage of layered stem rooted was higher with:

- Etiolated than non-etiolated shoots,
- Sphagnum moss as the media of air layering than coir pith
- Air layered shoot treated with 1000ppm IBA
- The interaction effect also showed a maximum percentage of air layers shoots etiolated, with sphagnum moss as the media and when IBA, at a concentration of 1000ppm was provided at girdled area.

6.2.2 Similarly, with reference to shoot growth of air layered shoots:

- Time taken for sprouting of shoots from air layered shoots was hastened,
- Mean number of sprouts per air layered shoots were high,
- The length of sprouted shoots were high,
- The number of leaves from air layered shoots were more,

In air layered shoots etiolated, with sphagnum moss as the media and air layered shoots were treated with IBA at a concentration of 1000ppm.

6.2.3 With reference to the root growth from the air layered shoots:

- Time taken for rooting from air layered shoots were hastened,
- Mean number of primary roots were high,
- Mean number of secondary roots were high,
- Length of primary roots were high,

In air layered shoots etiolated, with sphagnum moss as the media and air layered shoots were treated with IBA at a concentration of 1000ppm.

6.3 Conclusions

The results obtained from the present studies have indicated that, in propagation from cuttings of Fig Cv. Poona fig,

- A high rooting percentage of rooting, good growth of roots and shoots from cuttings could be achieved when basal cuttings were selected with leaves retained and treated with IBA at 1000ppm concentration.

In propagation from air layering,

- A good success in rooting of air layered shoots could be achieved from etiolated shoots with sphagnum moss as the medium and girdled shoots were treated with 1000 ppm of IBA.

6.4 Future line of work

The present investigation was carried out under open condition. Hence there is a need to conduct studies under greenhouse conditions including mist facility.

The studies on establishment, further growth and their yield in the field from plants obtained from either cuttings or air layers have not been carried out. Hence, there is a need to pursue further studies on this aspect.

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