Effect of Growth regulators and Rooting Media on Callusing, Rooting and Survival of Air Layers of Kagzi lime

(Citrus aurantifolia, Swingle)

THESIS

Submitted to the

Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (M. P.)

IN PARTIAL FULFILMENT OF THE REQUIREMENT
FOR THE DEGREE OF

MASTER OF SCIENCE IN AGRICULTURE

(Horticulture)

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1989

C E R T I F I C A T E -I

This is to certify that the thesis entitled, "Effect of growth regulators and rooting media on callusing, rooting and survival of air layers of kagzi lime (Citrus aurantifolia swingle)" submitted in partial fulfilment of the requirement for the degree of "Master of Science in Agriculture" of the Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, is a record of the bonafide research work carried out by Shri Avilok Singh Yadav under my guidance and supervision. The subject of the thesis has been approved by the student's Advisory Committee and the Director of Instructions.

No part of the thesis has been submitted for any other degree or diploma (certificate/awards etc.) or has been published. All the assistance and helps received during the course of the investigation have been duly acknowledge by him.

CHAIRMAN OF THE ADVISORY COMMITTEE.

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C E R T I F I C A T E - II

This is to certify that the thesis entitled "EFFECT OF GROWTH REGULATORS AND ROOTING MEDIA ON CALLUSING, ROOTING AND SURVIVAL OF AIR LAYERS OF KAGZI LIME (CITRUS AURANTIFOLIA, SWINGLE)" submitted by Shri Avilok Singh Yadav to the Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur in partial fulfilment of the requirement for the degree of M.Sc.(Ag.) in the Department of Horticulture, College of Agriculture, Gwalior has after evaluation, been approved by the external examiner and by the students advisory Committee after an oral examination on the same.

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A C K N O W L E D G E M E N T

It is my unique privilege to express my heartful gratitude towards my respectable guide and chairman of the Advisory Committee, and Head of the section of Horticulture for his kind and valuable guidance, helpfull criticism during the course of this investigation and preperation of this manuscript.

I am deeply indebted to Prof. S.N. Tripathi, Shri M.P. Khandekar, Assistant Prof. of statistics, Dr. H.G. Sharma, Soil Chemist, Dr. C.M. Mathur head of the section department of Botany, who are the members of my advisory committee for their valuable guidance and kind help during the course of study.

My Sincere thanks to Dr. M.K. Mishra, Dean College of Agriculture, Gwalior for providing necessary facilities and encouragement during the investigation.

I am short of word to appreciate the cooperation to Shri R.A.S. Sikarwar, Shri D.K. Tripathi, P.C.Patidar, M.A. Rahim, P.Abhyankar and D.P. Joshi, during the investigation.

I also express my heartfull thanks to Shri M.A. Rathore, Shri S.K. Beohar, M.K. Jain, M.S. Rajput, R.S. Rajput, A.K. Agarwal, R.S. Kurmi, S.K. Mishra, A.K. Soni, D.L. Verma and D.C. Gupta for all.

Last but not least, I can not express my heartfull gratitude in words to my loving parents for their constant encouragement.

(AVILOK SINGH YADAV)

C O N T E N T S

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CHAPTER - I

INTRODUCTION

C H A P T E R - I

INTRODUCTION

Since antiquity Citrus aurantifolia swingle (acid lime) and other citrus fruit have been under cultivation in Indochina and sub-Himalyan parts of India. All the citrus fruits, including lime, occupied prominent place among popular and extensively cultivated tropical and subtropical fruits and placed at third order after

Mango and Banana with respect to acreage and production in India. Throughout the world, citrus fruits are regarded for their nutritive value and economic significance as evident by the proverb " an orange a day keeps a doctor away". Lime occupies a major status as it covers 15 percent of the total acreage (2,25,000 acre) under citrus fruits in India, while in M.P. lime capture 3832 acres out of 12,000 acre under citrus fruits.

Lime is a shrub or small tree of straggling habit, with small, stiff, interlocking or drooping thorny branches; thorns small, sharp, numerous, young branches light green, becoming darker with age, leaves small, ellaptic oval, oranges like (hence the name) glossy green; flowers small, axillary in clusters of 3-10, bisexual, faintly pink in the bud, bud fades easily, calyx 4-5, pointed; petals 4-5 fleshy; stamens small 20-25, united into bundles, ovary about 10 - loculed; fruits small, greenish yellow, round to oval, frequently papellate, peel very thin, paper like and auromatic, pulp greenish, acid, juice sacs small, slender, pointed, seeds small, oval, pointed; highly polyembryonic.

Lime is a native of India and South eastern china. It is now widely distributed and naturalised in tropics. It is most important acid fruit of tropics. Outside the tropics and the warmer subtropical regions, lime has never

been successful since it is the tenderest of all the citrus fruits.

Lime cultivation has many merits. Limes are available throughout the year as two crops of enormous weight anf better quality are available, hence have a capacity to capture market almost throughout the year. In a country like India, where hot weather prevails from March to November, it not only provides vitamins, minirels and many other essential substances which are required for human health, but also delicious and refreshing to eat. It is especially important for growing childrens and is important source of vitamin C. Its importance in Indian diet is well proven now. Refreshing drinks like squashes, cordials are prepared from lime and consumed in every home. Lime fruits are also used for pickles and squeed juice, is consumed by adding into dal(cooked pulse).

With the increase in the population, knowledge of nutritional value of fruits for vitamins, minirels, antiseptic property of juice, more area is coming day by day under lime plantation. Therefore pressing demand for undertaking more area under lime plantation is coming before us for the provision of numerous plants in future. Under present circumstances lime is propagated

both by seeds and vegetative method. But they are generally multiplied by seeds, taking the advantage of polyembryoni. Nucellar seedlings are vigorous, homogenous identical to mother plant and is virus free. Viruses are screened by a substance possibly DNA, which impregnates the embryo sac and adjacent tissue at the flowering time, swingle(1948). On the other hand seed propagated plants are much thorny and have a long juevenile period and takes much time to come to bearing, and also identification and distinction of nucellar seedling among the group of seedlings having zygotic seedling too, is very difficult and require technical knowledge. Hence the advantage of polyembryoni can not be commercially utilized by nurserymens.

Vegetative propagation is preferred because it ensures true to the type plants, regular bearing, uniform quality. Various vegetative methods for propagation of kagzi lime are layering, cutting and budding. Vegetative propagation through cutting is unsuccessful, while propagation by budding is very difficult operation, as thorns are present on the plants. In addition to, spines present in leaf axil, renders the budding operation unsuccessful. Thus airlayering of Kagzi lime seems to be a rather certain method for propagation. Further, with the advances in our knowledge in Genetics and allied sciences,

we get the value of vegetative multiplication to obtain uniformity in the progeny of selected plants. Selection and maintenance of nucleus plant for supply of nucleus material for standardization of fruit industry are basic steps in general for improving the production of fruit plants.

Several factors contribute towards success in the propagation of fruit plants. Some of them are stem treatment, water and nutrient supply, etiolation, rooting media, application of root promoting substances, enviromental conditions, age of stock etc. Among these factors rooting media and application of growth regulators contribute much towards successful propagation.

The recent advances regarding the knowledge of use of growth regulators in plant propagation has further improved the scope of their use in vegetative propagation in various fruit crops. Several workers had reported the use of various growth regulators for increased rooting in airlayers. These growth regulators increases percent success by faciliating root formation in plants, which can't easily propagated by vegetative propagation. Many workers have used these growth regulators for vegetative propagation of fruit plants. Auxins particularly IAA, IBA, and NAA are reported to be the main rooting hormones, which induces

rooting in various species of plants with varying success. However, the response of growth regulator treatment varies with different concentration, species, rooting media , date of operation of airlayers i.e. changing environmental conditions. Work done by various workers reported that IBA and NAA are better growth regulators than IAA & others for inducing rooting in airlayers due to their stable nature. IAA, on the other hand is readily destroyed by auxin destroying enzymes.

Sen and Bose (1959) described the effect of different concentration of IAA, IBA and NAA viz. 1000, 5000 and 10,000 ppm in lanolin paste for layering jack fruit tree. Among the above regulators IBA had better root promoting effect than others.

Hartaman and Kestar (1976) are of the opinion that among the most suitable root promoting chemicals, the IBA is best for general use due to its non toxic nature over wide range of concentration and its effectiveness in promoting rooting in variety of species.

Hitchcock and Zimmerman (1939) observed that NAA was superior to IBA for cuttings of some species.

While using growth regulators, use of proper concentration in relation to a species is also important factor for maximum rooting. If growth regulators are used

in excessive concentration, it may result in injury. This may merely inhibit development or it may causes yellowing and dropping of leaves, blackening of the stem, while low concentration of growth regulator when used may inhibit the growth. Growth regulator should be used in this range of action, which is very narrow. Hence for standardization, it is necessary to determine suitable concentration of growth regulator in plant propagation by way of experimentation.

The rooting media used in airlayers should provide enough moisture and oxygen, and should be disease free. Rooting media not necessarily is a source of nutrients for airlayers, until a rooting system is established. Rooting media may affect rooting of airlayers. Various mixtures of soil, sand, leaf mould, Fym, peat and artificial inorganic substances such as vermiculite and perlite have been widely used.

Swingle (1940) quotes and Woycicki and Terpinski (1937) showed that the moisture of a sand medium has a marked effect on rooting. Mukherjee (1967) considered soil as the common medium used for rooting in nursery but newer media have been very effective in root development. Hudson and Hartman (1972) also stated that peat moss as often added to sand in varying proportions mainly to increase

the water holding capacity of the mixture. Mukherjee(1972) reported that medium of peat moss and sand (1:1) was better for rooting than either material alone, vermiculite or soil plus leaf mould.

Therefore, this is a matter of great interest to find out the best concentration of the two growth regulators IBA & NAA which are reportedly much better rooting hormone, best rooting media which can induce better rooting in airlayers & can improve the survivalness of airlayers of kagzi lime after detachment. Keeping in view the potentialities of above chemicals and different rooting media the present experiment "Effect of growth regulators and rooting media on callusing, rooting and survival of airlayers of kagzi lime (citrus aurantifolia swingle)" have been proposed to be carried out during the rainy season of 1988-89 under agroclimatic and soil conditions of northern Madhya Pradesh for the following objectives:

1. To find out the optimum concentration of the growth regulators used in the experiment.
2. To find out the effect of rooting media on rooting and survival of airlayers.
3. To find out the effect of interaction of growth regulators and rooting media for better performance of airlayer.

CHAPTER - II

REVIEW OF LITERATURE

C H A P T E R - II

REVIEW OF LITERATURE.

Many workers have tried growth regulators for propagating the horticultural plant by air layering in order to supply nucleus material for standardization of fruit industry. Some work on these lines already reported but mostly confined to other plant species in different sets of climatic conditions. Moreover, efforts have been made to review the work done so far in India and abroad on propagation of lime and other fruit plants by layering

with the help of rooting media and growth regulators. The observation and results recorded by them are of great importance in context to the present investigation and have been presented under seperate appropriate headings.

Mode of action of Growth regulators :

Research workers have tried to understand the mode of action of plant growth regulators from the time of their discovery in the rooting of plants propagated by cuttings and layerings.

Cooper (1940) presumed that the application of growth substances results in accumulation of certain chemical substances at the base of cutting which stimulate the meristem to divide quickly and form roots.

Burstorm (1942, 1950 and 1952) found that auxin induced acceleration of cell elongation in individual root cells. Elongation of cell is caused by stimulation of the first phase cell stretching. The second phase of cell elongation can only be retarded by auxin. Thus an overall acceleration of elongation can be brought about by addition of auxin only if its concentration is so low

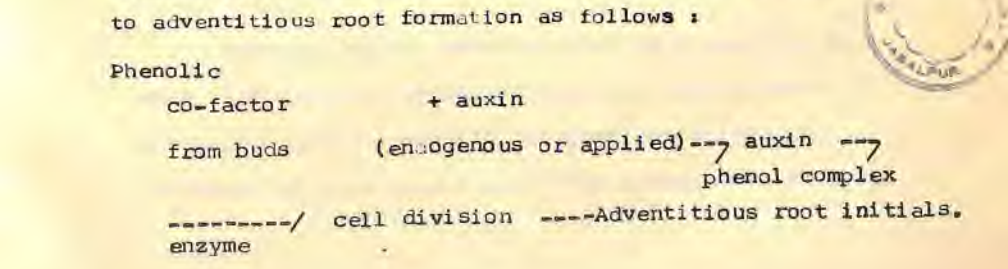
that the acceleration of the first phase of growth is not completely marked by retardation of the second phase.

Skoog (1944) reported that when the ratio of auxin to certain other plant constituents, especially adenine is low, the meristem section tend to form bud and leaf primordia. When the ratio is medium callus is formed and when the auxin content is high root primordia developed.

According to Gardon (1953) almost only living tissue cambium, epidermis, pericycle, endodermis, cortical, parenchyma, pith rays will form root by the interaction of suitable gross nutritional level and raised auxin level. The low concentration of auxin required for root initiation are generally above the level required for cell elongation. Low concentration like wise induced cell division in root cambium or pericycle which form lateral roots. Roots produced following treatment with growth regulator, are similar in origin to those produced naturally. Branch roots generally arise from the larger primary root structure. Root initiation appear first in pericycle, where cell divide to form a growing point with a root cap. The secondary root penetrates through the cortical tissue and epidermis of the roots.

Bouillenne and Bouillenne (1955) proposed that "rhizocline" be considered as a complex of three components (i) a specific factor, translocated from the leaves and characterized chemically as an ortho-dihydroxy-phenol and (ii) a non specific factor (auxin), which is translocated an is found in biologically low concentrations and (iii) a specific enzyme located in cells of certain tissue (Pericycle, phloem, cambium) which is probably of the polyphenol-oxidase type.

They further proposed that the ortho-dehydroxy-phenol reacts with auxin wherever, the enzyme is present, giving rise to the complex, "rhizocline". Applied auxines in high concentrations, are believed to act as accelerators of respiration and cell mitosis. "Rhizocline" may be considered one step ahead in a chain of reactions which ends in the differentiation of tissues and finally in the organization of root structure. Such indole-phenol complex may react at the base of the cutting with a specific enzyme, initiating cell division and leading to adventitious root formation as follows :



Samant rai and Pattanaik (1956) observed three stages of development of roots in cutting treated with growth regulators. The first stage was governed by plant regulators which converted the parenchyma tissue into meristems while the other two stages were the re-organization of meristems into root primordia and the development of factors such as vitamin-'B'.

Audus (1963) viewed that the discovery of the growth regulators and their use in rooting have helped considerably in plant propagation. These are now in common use in many plants. Among these indole butyric acid (IBA), Indole acetic acid (IAA), and nephthelene acetic acid (NAA) are more effective in rooting of cuttings.

Gautheret (1969), Olimen et al, (1971) and Haising (1972) stated that auxin natural or artificially applied is a requirement for initiation of adventitious roots on stem and indeed it has been shown that the division of first root initial cell is dependent upon either applied or endogenous auxin.

Haissing (1971) observed that root initials in stem is apparently dependent upon the native auxin in plant plus auxin synergist together these lead to synthesis of ribonucleus acid (R.N.A.)which is involved

in initiation of the root primordia.

Devlin (1974) stated that action of auxin in root is similar to that in stem, but that the concentration of auxin to stem growth are inhibitory to root growth. In other words roots are much more sensitive to auxin than stem and real stimulation of root elongation may be achieved if low concentrations are used. The application of relatively high concentration of IBA to root not only retards root elongation but a noticeable increase in number of branch roots.

Arslanov (1980) reported that breakdown of sugars & starch with a simultaneous increase in respiration rate & a rise in catalyse & peroxidase activity were noted during callusing & the begining of growth in lemon cutting. An increase starch, sugar & ascorbic acid synthesis was noted during mass rooting & begining of shoot growth.

GROWTH REGULATORS AND THEIR CONCENTRATIONS IN THE PROPAGATION OF CITRUS FRUIT:-

Cooper (1935) obtained quicker and more rooting in the cuttings of Eureka lemon and several other varieties of citrus by treatment with IBA and IAA, as compared to control.

Marques (1938) recorded better rooting by using 100 and 50 ppm IAA and NAA long dip in case of sour orange cuttings.

Hitch Cock and Zimmerman (1939) observed that NAA was superior to IBA for cuttings of some species.

Singh (1955) investigated the effect of number of growth regulators on the rooting of citrus air layers. He obtained good results with hormone mixture of IAA(1%) and IBA (1%) in kagzi lime.

Jauhari and Nigam (1958) reported that 10,000 and 20,000 ppm concentration of IBA and IAA can successfully be utilized for propagation of Karonda by air layering, Alpha NAA and control failed to produce roots.

Singh (1960) conducted a trial with Karna Khatta, sweet lime and Kagzi lime cuttings by treating with IBA by the concentrated dip method. It was found that the

early rooting of cuttings of young nursery plants of Karna Khatta and soft wood cuttings of Kagzi lime had not responded to any concentration of IBA except the semi hard wood cuttings of Karna Khatta which require only 500 ppm for effective rootings. Hard wood cuttings did not show any improvement due to IBA treatment and in all the case the rooting was very poor.

Sen, P.K. and Bose, (1962) IBA application promoted root growth in all the 8 lemon and 3 lime varieties as did IAA to a lesser extent. NAA had little effect on any of the lemons except jamberi but produced 100% rooting in cuttings of sweet lime.

Singh (1963) noted a marked improvement in rooting as well as sprouting of sweet lime cuttings (Citrus limettiodes Tan.) by quick dip application of 2,000 ppm IBA.

Armour (1965) got very good success in rooting of many citrus species when treated with IBA with bottom heat arrangement.

Singh (1969) recorded that sweet lime is generally propagated by air layering or from hard wood cuttings. The results are improved by treatment with seradix A or IBA 500 ppm in Assam. Air layering of

Mandarin, sweet lime and musembi give success varying from 90 to 100 per cent.

Verma et al (1971) recorded strong syneregistic of IBA at the level of 7,500 ppm on all characters of mango, guava and citrus marcots. The high rooting success of 100% in citrus, 60% in guava, and 8% in mango was obtained by 7,500 ppm IBA.

Tomar (1979) have also obtained the maximum length of primary roots, number and length of secondary roots in Karonda air layers with IBA 10,000 ppm. Thus IBA has proved superior for root initiation in comparison to other growth regulators.

Tomar (1981) reported that among the four concentrations of IBA, 5,000 ppm proved significantly better for rooting of kagzi lime air layers.

Sharma, S.K. (1981) reported that from the over all performance it can be concluded that NAA 10,000 ppm had significantly affected the various characters followed by NAA 7,500 ppm and IBA 10,000 ppm.

Gurjar (1983) reported that among the three concentrations of IBA, 10,000 ppm was found significantly better for the callusing and rooting success and survivalness of air layers of kagzi lime.

Kushwah (1984) reported that among the different concentrations of regulators IBA 5,000 ppm was found significantly better than rest of the concentrations, while NAA 5000 ppm was placed at second order.

GROWTH REGULATORS AND THEIR CONCENTRATIONS IN THE PROPAGATION OF OTHER FRUITS:-

Sen (1939) reported that effect of IBA in stimulating the rooting of cutting of Litchi chinensis and Justicia gendarusa. He found that the treatment with IBA was more effective than IAA as indicated by callus growth and in all cases 60 ppm when applied for the longest period, produced the best results.

Thakurta and Dutta (1941) noted 90% success in air layers of mango with IBA 1% in lanoline paste.

Singh and Teotia (1951) treated mango air layers with several plant regulators in different concentrations and found 1 per cent and 0.2 per cent NAA, 2 per cent IAA and 1 per cent as the most effective.

Singh et al (1954) studied the effect of the different growth regulators and their treatment on air layers of golden loquate. They obtained 20% rooting in control, 100 per cent in NAA (3%), 50 per cent in

phenyl acetic acid (1%), 80 per cent in IAA (2%), 90 per cent in IBA (3%) and 40 per cent in 2, 4-D (1%).

Singh (1955) compared different plant regulators at different concentrations for jack fruit and obtained 100 per cent success with 1% IBA.

Sen and Bose (1956) obtained great success in air layers of jack fruit with the use of 5,000 ppm and 10,000 ppm NAA.

Sen and Bose (1956) described that effect of IAA, IBA, NAA and MH at concentration of 10,000, 5,000 ppm and 1,000 ppm in lanoline for layering of jack fruit tree (Artocarpus heterophyllus Lamk) by ringing in the middle of May and June. In mango the growth substances IBA showed significantly root promoting effect both under May and June ringing conditions. IBA 5,000 ppm however, gave optimum rooting. IAA and NAA at 1,000 ppm showed significant root promoting effect only when ringing was made in June. MH has an inhibiting effect on rooting.

Jauhari (1960) found that the shoot cuttings of phalsa gave 60% rootings when treated with 100 ppm IBA solution for 24 hours whereas the control did not root.

Jauhari (1960 a) reported vegetative propagation of Zizyphus mauritiana Lamk. from gootee and cuttings. The 12-15 year old trees were treated each with 10,000 ppm mixture. Goottees were covered with wet sphagnum moss and firmly tied with plastic rubber. Air layers exam ned two weeks after treatment demostrated profuse root development with an average of 8 to 6 roots per goottee and the largest root measured 4 to 8 cm. The control had no roots.

Jauhari and Jit (1960) recorded the effectiveness of plant growth regulators on the rooting of air layers with hormones NAA (10,000 to 30,000 ppm), IBA (20,000 to 30,000 ppm) and IAA (10,000 to 20,000 ppm) and have found NAA to be the best.

Godara (1960) have carried out a thesis at I.A.R.I., New Delhi also indicates the usefulness of IBA in air layering of guava. IBA (250 ppm) applied in lanoline improved the rooting significantly over other treatments.

Sinha et al. (1960) attempted marcatting with IBA and NAA, Rooting response was 92.5% and survival (87.6%) as against rooting response of 50% and survival of 40% in the control. NAA was less effective.

Singh et al. (1961) obtained the best rooting response (92.5%) with IBA 250 ppm in golden yellow loquate air layers wheres NAA 250 ppm was found less effective than IBA. The mixture of NAA and IBA gave the same results as those of IBA alone.

Chinnappa (1962) obtained excellent results with IAA and IBA, NAA at 10,000 and 15,000 ppm. Higher concentration gave better results. The main effect is the variable percentage of survival after planting in the nursery.

Jauhari (1962) obtained maximum of 44% rooting in guava with 0.8 per cent OBA under mist.

Rathore (1964) worked on guava layers and found 2% concentration of different hormones to be most effective.

Chinnappa (1966) recorded the effect of plant growth regulators on the rooting of air layers in litchi with 10,000 ppm and 15,000 ppm of IBA and NAA respectively. The results showed that the higher concentrations were more successful.

Sulladnath and Kologi (1969) trated chiku air layers with IBA, NAA, IAA and IBA + NAA at concentration

between 5,000 to 25,000 ppm. The highest rooting i.e. 90% was recorded with the treatment of 10,000 ppm of IBA + NAA.

Mukherjee (1967) tried to propagate litchi and guava by air layering with the help of IBA 5,000 ppm and found that this concentration gave 100% rooting in both the fruit crops.

Mukherjee et al. (1967) reported that the mango cutting may be made to induce roots provided IBA at 5,000 in lanoline paste was applied at the base of cuttings after ringing while they were still attached to the mother trees. The rooting of cuttings of different age was improved from 20 to 25.5 per cent in 10 years old tree to one month seed ling.

Mishra and Jauhari (1970) conducted an experiment to evaluate the potentiality of certain gowth substances on rooting of Morusalba and Zizyphus mauritiana stem. In case the Morus alba, IBA and NAA mixture at 7,500 ppm with Boron proved to be the best for rooting in air layers followed by IBA and IAA mixture of 7,500 ppm without Boron. In case of Zizyphus mauritiana, a mixture of IBA and NAA with Boron at concentration of 7,500 ppm proved to be best followed by the mixture with Boron at concentration of 5,000 ppm. Control layers did not

produce any root.

Shannugavalu (1971) found that the application of IBA either as spray or in lanoline paste to the seedlings of jack fruit increased the root growth.

Bhujbal, (1972) reported that IBA was used at concentration of 1,000 - 4,000 ppm in marcattage experiments on Lucknow 49 guava. The best results were obtained with treatment at 5,000 ppm, which gave 86.6% rooting and 76.6% survival.

Chhonkar and Singh (1972) found IBA at 5,000 ppm to be more effective in propagation of mango by air layering.

Saraswat (1973) observed that 2.5% IBA in the form of lanolin paste increased the rooting in air layers of jack fruit but survival rate was very low.

Quadeer (1974) found that 2% IBA in the form of lanolin paste gave very good results in propagation of jack fruit by air layering. However, a very low survival percentage was recorded.

Nanda, (1975) reported the cuttings of Molus prunifolia treated with IBA 1250 and 2500 ppm

gave 90 per cent rooting. Even IBA 625 ppm gave 70 per cent success.

Hartman and Kestor (1976) stated that synthetic root promoting chemicals have been found most reliable in stimulating adventitions root production in cutting. Although there are other which can also be used. IBA is probably the best chemical for general use because it is non-toxic over wide concentration range and is effective in promoting roots of a large number of plants.

Maiti (1977) obtained minimum success of 32 per cent in the treated air layers of Ixora singaporensis against 22% in control. IBA and NAA (1000, 2000, 3000 ppm) gave better results than IAA. In case of NAA success diminished with the rise of concentration whereas the case was nearly reverse in IBA. By 1,000 ppm NAA cent per cent layers produced root.

Kahlon and Sukhdev Singh (1981) reported that juvenile patharnakh cuttings were synchronised with better root formation and shoot growth potentialities. Moreover IBA at 100 ppm proved to be effective in encouraging rooting and invigorating shoot growth.

Rathore, (1982) reported that among the four concentrations IBA 15,000 ppm proved significantly better for rooting of guava air layers.

Patel (1985) found IBA better than NAA o ver all concentrations & IBA at 3,000 ppm gave highest 100% rooting & 76.6% survival in airlayering of Guava.

Gurjar (1986) reported that growth regulator NAA was found better treatment for callusing, rooting and survival of airlayers then IBA and IAA, in Bougainvillea.

Sharma (1986) observed that in Bougainvillea growth regulator NAA (10,000 ppm) induced better rooting and survival of airlayers as compared to IBA (7,500 ppm).

EFFECT OF ROOTING MEDIA ON THE PROPAGATION OF FRUIT PLANTS :

The rooting madia must provide sufficient moisture and oxygen and must be relatively disease free. It is not necessary that the rooting media be source of nutrients until a root system is established. Many research workers have formulated the essential and desirable qualities of a good medium.

Hitchcock (1928) from his extensive trials with peat moss, peat moss mixture with sand and sand alone

reported that out of 96 varieties (of 46 genera) only 5 failed to root best in misture of equal proportion of peat moss and sand. He stated that the efficiency of the mixture was mainly due to its high moisture retaining capacity, to the presence of growth promoting material furnished by peat moss, to efficient aeration and in some cases to its acid reaction.

Esper and Roof (1931) concluded from his experiment with soft wood cuttings of nine species, that slag and peat together formed a very good medium as the proper balance of pH was obtained in such mixture.

Chadwick (1932) found that sand and peat mixture often resulted in better massing of roots at the base of taxus cuttings. He also found that roots produced in peat were more flexible than those produced in sand.

Long (1933) observed that the difference in characteristics of root produced in sand and peat moss might be due to the difference in the moisture content of the media. Determination of the air and moisture content of peat moss and sand when each was at the point of considered optimum for rooting of cuttings showed that on a volume basis, peat moss contained cover twice as much air and three time as much moisture

as sand. He pointed out further that media had no influence on rooting of easy to root cuttings but it had influenced to a considerable degree on difficult to root cuttings.

Hubert et al. (1939) experimenting with 10 different media found that mixture of peat and sand and peat alone proved best for number of plant species. They concluded that the beneficial effect of peat media might be due to the stimulating substances in the peat.

Swingle (1940) quotes and Woycicki and Terpinaki (1937) showed that the moisture of a sand medium has a marked effect on rooting.

Dobrovitzkaya (1940) worked on lemon cuttings and found that the mixture of peat and sand was better for cuttings. The length and number of rootlets was highest in a mixture of peat and sand or in pure peat.

Grace and Farrar (1941) observed that mixtures of peat and sand were superior to sand alone for Norway Spruce cuttings.

DeBoer (1947) found that for acer cuttings a mixtures of 2 parts peat moss : 1 part sand gave better results over traditional mixtures of high sand content.

Opitz (1951) found that for troyer citrange cuttings, the mixture of sand and peat was satisfactory.

Dickey (1952) observed that among several rooting media tested those containing peat moss and sawdust in combination with each other or with vermiculite were the best.

Puccini (1954) compared vermiculite with sand, soil, leaf mould and sphagnum moss for herbaceous and semi woody and woody ornamental and observed that vermiculite had a better water absorbing and water holding capacity than any of the other materials except sphagnum moss, but in general, was not a good medium.

Ford (1954) reported that among all the media tried soil and sand mixture in the ratio of 3:1 proved superior in the case of citrus cuttings.

Adriance and Brison (1955) have concluded that any medium used should be loose and easily worked to facilitates up rooting of cuttings with little damage to the roots, It should be fairly retentive of moisture, and yet well drained. It should be free fungi and bacterial, which attack cuttings and it should be freely available at reasonable cost.

DeBoer (1955) made another study of various rooting media for soft wood cuttings of different species viz. peat (pH 3.9), river sand (pH 7.2) sand mixture of peat and sand in the proportions 4:1, 3:1, 2:1, 1:1, 1:2, 1:3 and 1:4. She found that most of the plants had optimum root formation in a mixture with high proportion of peat. Ericaceous and some other plants preferred pure peat, while with Daphne and Contomeaster, sand medium was better. She also noted that in sand callus formation was stimulated at the expense of root formation.

Evans (1958) reported that works on the propagation of coffee revealed the facts about suitability of different media for rooting. He recommended vermiculite and river silt 1:1 mixture an ideal medium for the purpose. For practical use a 1:1 mixture of red soil and river sand also was recommended.

Hartmann and Kester (1959) reported that cuttings planted in sand had produced long, unbranched, coarse and brittle roots, but in peat moss roots were well branched, slender and more flexible. The latter type was found to be more desirable than the former type.

Singh (1959) reported that the soft wood cuttings of kagzi lime were quite successful in 50:50 sand and leaf mould mixture.

Singh (1960) observed that of all the media a mixture of sand and leaf mould (1:1) proved quite satisfactory for nursery cuttings of Karna Khatta (Citrus Karna).

Singh and Singh (1961) working on the rooting of Karna Khatta cuttings obtained from young nursery plants and from mature bearing trees found that those taken from nursery plants gave best results in a mixture of sand and leaf mould but cuttings from bearing trees performed better in sand alone, soil alone gave the poorest results.

Pennock and Meldonado (1963) did not obtained any appreciable effect of rooting media on rooting of guava, when cuttings were planted in various media such as coco-peat, firebark, vermiculite, perlite and maxiferm.

Clay (1964) reported that vermiculite was a more suitable rooting medium than coarse sand for rooting of kale cuttings. Similar results were also obtained for avocado cuttings.

Loreti and Hartmann (1964) compared sand, perlite and peat moss in all combinations and in different propagation, 1:1, 2:1, 1:2 and perlite and vermiculite in equal proportion on rooting of alive cuttings. They obtained high percentage of rooting in perlite peat moss mixture (1:2) and perlite vermiculite mixture. The later mixture resulted in about twice the number of roots per cuttings and twice the root length as occurred in other media. Sand, however, was found to be the poorest rooting medium giving the lowest percentage of rooting and smallest number of roots per cutting of all the media used.

Foster (1965) the pH of the rooting medium had a significant effect upon root initiation and very early root growth of muskrelon cuttings. Optimum pH was found to be ranging from 6:5, to 7.0 with a sharp increase in time required for root initiation in the more acid media.

Flores and Kester (1966) observed significantly better rooting of almond cuttings with perlite peat moss mixture than peat vermiculite or vermiculite - perlite mixture. Cutting in media which included peat moss produced longer roots than did those in the vermiculite perlite mixture.

Mukherjee (1967) stated that physical and chemical characteristics of the media are given in Table. It will be seen that total nitrogen and water holding capacity of peat moss in higher than others, but the important aspects is perhaps the pH which is acidic in M_4 and M_5 and this may also account for better success.

Media	pH	Water holding capacity (%)	Sand (%)	Silt (%)	Clay (%)	Total nitrogen (%)
Sand (M_1)	7.6	21.80	-	-	-	0-03
Sand +leaf mould (M_2) (1:1)	6.6	65.78	50	34	15.91	0.51
Vermiculite(M_3)	8.8	596.30	-	-	-	0.01
Peat moss (M_4)	3.5	475.44	-	-	-	1.95
Peat moss + Sand (M_5) (1:1)	4.4	212.62	-	-	-	1.10

Mukherjee (1972) reported that medium of peat moss and sand (1:1) was better for rooting than either material alone, vermiculite or soil plus leaf mould.

Rathore (1982) reported that rooting media soil + sand + leaf mould (R_3) proved significantly superior to all the other rooting media.

Banerjee et al. (1983) shoots of cinnamomum camphora (about 45 cm long and 1 cm in diameter) had a 1.5 cm ring of bark removed. The cut was treated with several phenolic compounds, covered with sphagnum and soil (1:1) and wrapped with plastic. The layers were detached 60 days later and assessed for rooting. Treatment with Mallic acid at 1000 ppm gave 75% rooting as compared with 5% in the control and 10% in shoots treated with tannic acid at 1000 ppm. Results for other variants are tabulated.

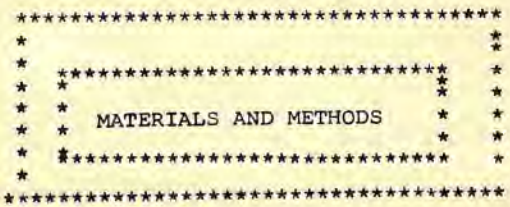
Gurjar (1983) reported that among the five rooting media leaf mould proved significantly better for rooting of kagzi lime layers.

Tomar (1985) reported that among the six rooting media, sand (R_2) proved significantly better for rooting of kagzi lime airlayers.

Gurjar (1986) reported that in Bougainvillea rooting media M_4 (Soil + Fym) produced better callusing and maximum rooting percent. While survival percent was higher under M_4 as well as in M_3.

Sharma (1986) observed that in Bougainvillea rooting media M_2 (Soil + leaf mould) gave better callusing, rooting percent and survival of airlayers.

C H A P T E R - III



C H A P T E R-III

MATERIALS AND METHODS

The present investigation, " Effect of growth regulators & rooting media on callusing, rooting and survival of airlayers of Kagzi lime, (Citrus aurantifolia Swingle) carried out in the experimental area of department of Horticulture, JNKVV JABALPUR campus, College of Agriculture, Gwalior during rainy season 1988-89 under argoclimatic and soil conditions of northern Madhya Pradesh. The details of methods and techniques followed in the experiment are described and given below :

1. EXPERIMENTAL SITE :-

The experiment was conducted on the Kagzi lime plants planted in year 1965-66, in the plot No. E_{1A} behind hostal No.1, in the orchard of college of Agriculture, Gwalior, which is situtated in the northern Madhya Pradesh at an elevation of 207m from mean sealevel and its location is 26^{0} 14' N latitude and 78^{0}75'east longitude.

Table No.1 Previous history of nursery area.

Sl.No.	Year	Rainy Season	Winter Season	Summar Season
1.	1984-85	Nursery of Rainy season flower.	Nursery of Winter Season flower.	Fallow.
2.	1985-86	Nursery of Rainy season flower.	Nursery of Winter Season flower.	Fallow
3.	1986-87	Nursery of Rainy season Flower.	Nursery of Winter season Flower.	Fallow
4.	1987-88	Nursery of Rainy season flower.	Nursery of Winter Season flower.	Fallow
5.	1988-89	Transplanting of Kagzi lime airlayers.	Continued. (Present Experiment.)	

SOIL OF NURSERY :-

The Soil of the experimental field in nursery is sandy loam and well drained. Before the conduction of the experiment soil sample was taken, upto a depth of 10-15cm from the experimental plots, for mechanical and chemical analysis which is done in the department of Soil chemistry.

Table- 2 a : Mechanical compostion of the soil of the experimental area :-

Sl.No.	Constituents	Percentage
1.	Sand	56.8
2.	Silt	15.4
3.	Clay	27.8

Table No.2b- Chemical composition of the soil of the experimental area :-

Sl.No.	Constituents	Quantity	Method of determination.
1.	Available N (Nitrogen)	82.0	Available nitrogen estimation by Alkaline permagnate method.
2.	Available P_2O_5 (Phosphorus)	26.2	Available phosphorus estimation by olson method.
3.	Available K_2O (Pottash)	375	Available Pottassium estimation by flame photometer.
4.	Organic Carbon	0.41	Organic Carbon estimation by Black and Wakley method.
5.	Electrical Conductivity.	0.8 M. mhos/cm.	E.C. measurement by L.B.H. type conductivity meter.
6.	PH of Soil.	7.3	pH measurement by Blackman PH meter.

2. Climate and Season :-

Gwalior is having typical subtropical climate with rainfall during July to September. The high temperature and hot winds prevails during summer months, however occasional frost in winter months also occurs. This experment

was conducted during rainy season as high temperature with suitable atmosphere humidity 70 to 80 percent prevails, which are favourable and very suitable for propagation by layering.

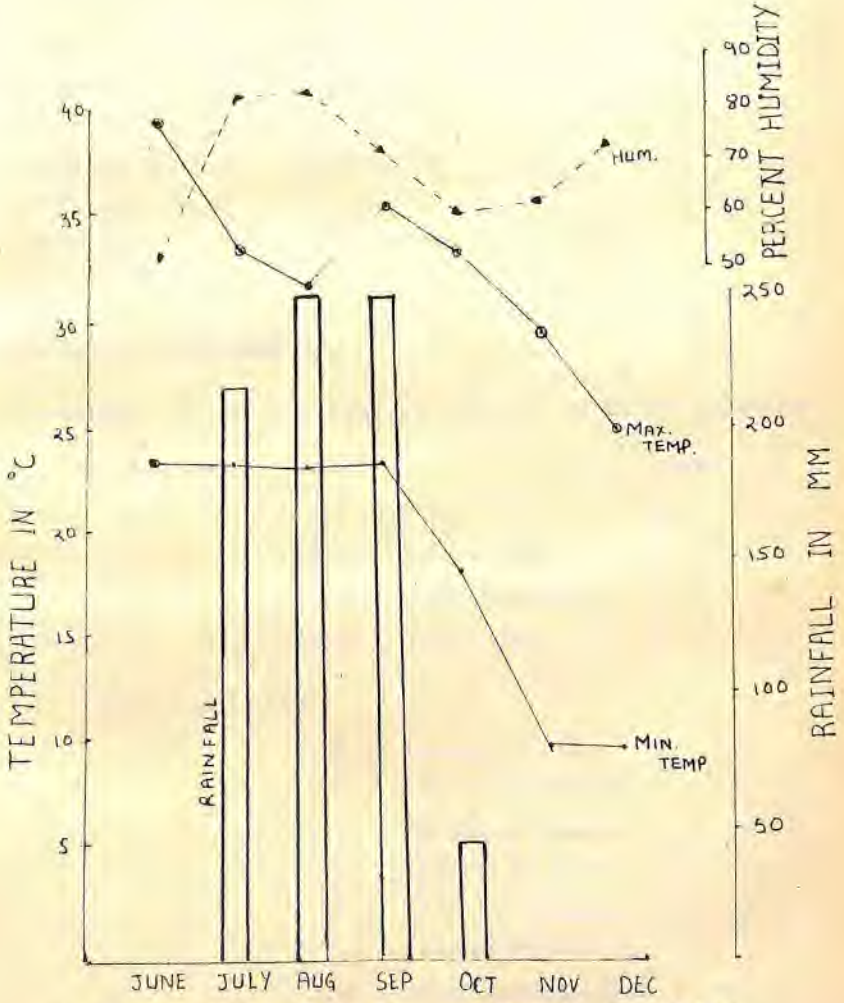
Collecton of Meteorological data :-

The meteorological data regarding minimum and maximum temperature, relative humidity and total rainfall as recorded during July 1988 to December 1988 in the meterological observatory are given in table-3 and depicted graphically in fig. 1.

Table 3: Mean monthly temperature (Minimum and Maximum), relative humidity and rainfall during experimental period.

Month&year	TEMPERATURE in ^{o}c		Relative humidity %	Rainfall (mm)
	Minimum	Maximum		
June, 1988	23.49	39.87	50.73	-
July, 1988	23.45	33.79	81.83	213.9
August, 1988	23.08	32.0	82.16	248.7
September, 88	23.62	35.48	71.26	247.2
October, 88	18.6	33.58	59.70	43
November, 88	10.4	29.86	61.73	-
December, 88	9.2	25.29	72.11	-

FIG. 1



METEOROLOGICAL DATA DURING THE CROP SEASON

3. DETAILS OF EXPERIMENT

Design	-	Randomized block
Number of replications	-	Three
Number of treat-- ments		Twenty
Method of propogation	-	Airlayering

DETAILS OF TREATMENTS :-

Treatment - There are two factors in the experiment

1. Rooting media- Four Symbol.

(i)	Soil	M_1
(ii)	Soil + sand	M_2
(iii)	Soil +Leafmould	M_3
(iv)	Soil + FYM	M_4

2. Growth regulators-

(i)	Control(without growth regulator)	G_o
(ii)	7500 ppm concentration of IBA (INDOLE BUTYRIC ACID)	G_1
(iii)	5000 ppm concentration of IBA	G_2
(iv)	7500 concentration of NAA (NAPTHELENE ACETIC ACID)	G_3
(v)	5000 concentration of NAA	G_4

TABLE -4-

TREATMENTS COMBINATION AND THEIR DETAILS :-

S.No.	Treatments combination	Details of ingredients of treatments
1.	G_0M_1	0 ppm and Soil
2.	G_0M_2	0 ppm & Soil + Sand
3.	G_0M_3	0 ppm and Soil + Leafmould
4.	G_0M_4	0 ppm and Soil + FYM
5.	G_1M_1	7500 ppm IBA and Soil
6.	G_1M_2	7500 ppm IBA and Soil + Sand
7.	G_1M_3	7500 ppm IBA and Soil + Leafmould
8.	G_1M_4	7500 ppm IBA and Soil + FYM
9.	G_2M_1	5000 ppm IBA and Soil
10.	G_2M_2	5000 ppm IBA and Soil + Sand
11.	G_2M_3	5000 ppm IBA and Soil + Leaf mould
12.	G_2M_4	5000 ppm IBA and Soil + FYM
13.	G_3M_1	7500 ppm NAA and Soil
14.	G_3M_2	7500 ppm NAA and Soil + Sand
15.	G_3M_3	7500 ppm NAA and Soil + Leaf mould
16.	G_3M_4	7500 ppm NAA and Soil + FYM
17.	G_4M_1	5000 ppm NAA and Soil
18.	G_4M_2	5000 ppm NAA and Soil + Sand
19.	G_4M_3	5000 ppm NAA and Soil + Leaf mould
20.	G_4M_4	5000 ppm NAA and Soil + FYM

Plot size		4 plants per replication
Number of airlayers per treatment per replication	:	25
Number of airlayers per replication	:	500
Total number of airlayers under experiment	:	1500
Total number of plants	:	12
Year of planting of kagzi lime trees	:	1965-66
Variety	:	Kagzi lime
Date of operation of airlayers	:	5.7.1988
Date of detachment of airlayers	:	20.8.1988

SELECTION OF PLANTS AND THEIR BRANCHES :

For the experiment 12 plants of Kagzi lime of uniform vigour and size were selected. Four plants were taken under each replication& 500 well matured, about 1 or 2 years old healthy branches of pencil's thickness were selected for airlayering. 25 airlayers under each treatment, thus 500 airlayers under each replication and 1500 under whole of the experiment were operated.

PREPARATION OF MIXTURE OF GROWTH HORMONES :-

Lanoline paste was taken as a media for growth regulators, for applying it in airlayers. In the present experiment two concentrations each of IBA and NAA were used. First of all stock solution of 1500 ppm each of IBA and NAA in lanoline paste were prepared. For this 0.75 gm each of IBA and NAA were weighed separately with the help of eletric balance.

These growth regulators were taken in different glass beakers and dissolved in 25 cc. of 95% ethyl alcohol. When regulators were dissolved, 492 5 gm of lanoline paste was added in each beaker and were heated so that whole material will be uniformly mixed. After making stock solution, it was reduced to following strength (on page 43).

TABLE-5

PREPARATION OF STOCK SOLUTION OF IBA AND NAA.

Name of regulator	Quantity of regulator (gm)	Quantity of alcohol (cc.)	Quantity of lanoline paste (gm)	Total quantity of mixture (gm)	Cconcentration stock solution (ppm)
IBA	0.75	25 c.c.	49.25 gm	50 gm	15,000 ppm
NAA	0.75	25 c.c.	49.25 gm	50 gm	15,000 ppm

(1) Solution 7500 ppm of IBA, by mixing 25 gm ordinary lanoline paste in 25 gm of stock solution of IBA..

(2) Solution 5000 ppm of IBA, by mixing 50 gm ordinary lanoline paste in 25 gm of stock solution of IBA.

(3) Solution 7500 ppm of NAA, by mixing 25 gm ordinary lanoline paste in 25 gm of stock solution of NAA.

(4) Solution 5000 ppm of NAA, by mixing 50 gm ordinary lanoline paste in 25 gm stock solution of NAA.

As these substances are very photo-sensitive, hence prepared solutions were kept away from sunshine by covering the containers with black sheet.

PREPARATION OF ROOTING MEDIA :-

In the experiment four rooting media used were prepared as follows :-

(1) Soil -

The soil used for rooting media was taken from garden and sieved so as to remove gravels from it. Soil taken was of sandy loam nature, it was made in the paste form, by adding water and mixing thoroughly to develop a mud. The mechanical and chemical composition is given in table - 2 A and 2 B.

(2) Soil + Sand -

Soil and sand were sieved. These were taken in the ratio of 1:1 by volume and mixed together. Before using, mixture was maintained in the mud form.

(3) Soil + leaf mould -

Soil and well rotted leaf mould manure were sieved separately and mixed in the ratio 1:1 by volume. Water was added to it and than mixed thoroughly to develop a mud.

(4) Soil + FYM -

Soil of garden and well rotted FYM was taken from college dairy having animals, cows and buffalows. These were sieved seperately and mixed in the proportion 1:1 by volume. By adding water and mixing it thoroughly a mud is developed.

METHOD OF TREATMENT :

A ring of bark of about 1 to 2 cm. width was removed from the selected shoots of Kagzi lime trees just below the bud without injuring the underlying woody xylem. Coarse sand was than rubbed over ringed portion in order to remove cambium. Lanoline paste containing growth regulators were applied separately on the upper ring with camel hair brush for each concentration of growth regulator. The treated

cut was than covered with respective rooting media and than wrapped with polythene film (400 guage) with the help of sutli. Control branches were operated without applying any of the regulator.

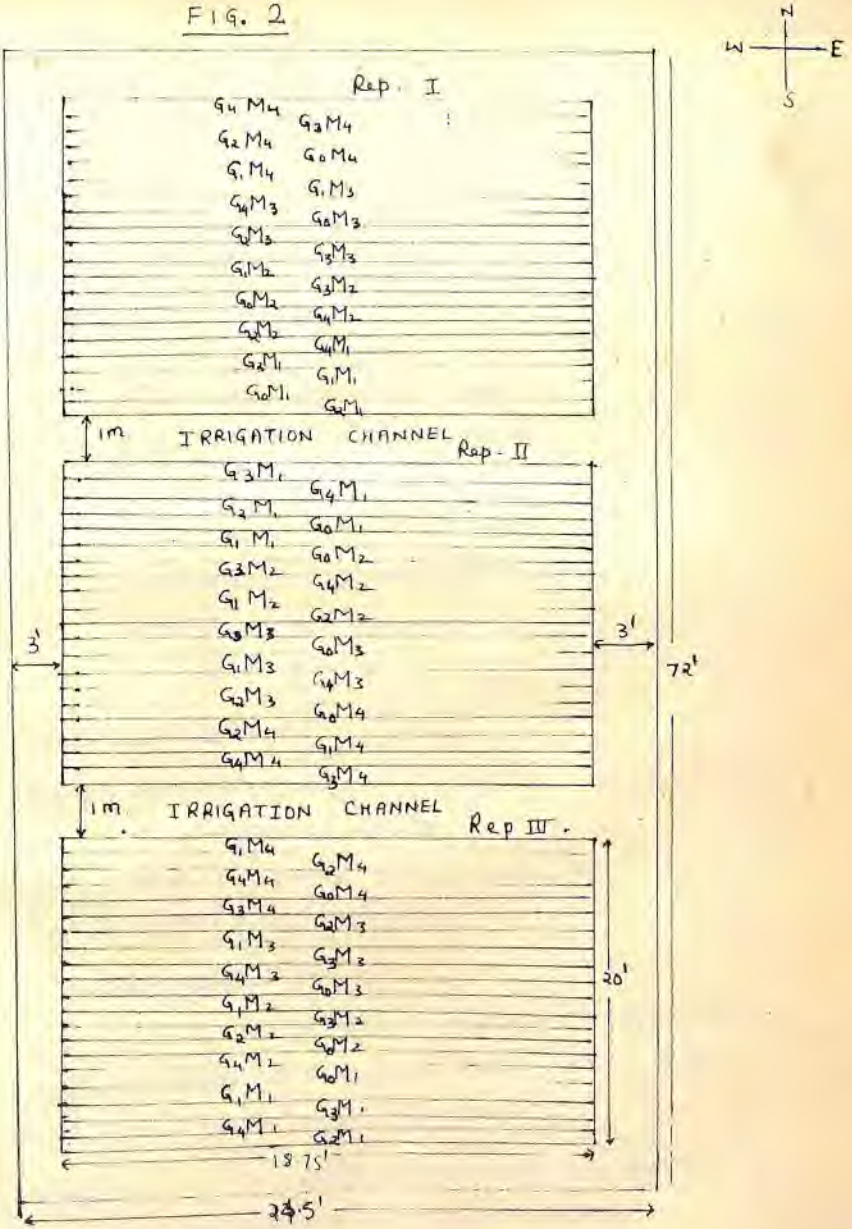
DETACHMENT OF AIRLAYERS.-

The airlayers were detached from the mother plant after 45 days when roots were visible. Cut was made just below the lower end of the ringed surface with the help of secateur. After detachment the airlayers were brought under the shade and their polythene covers were, gently, removed precautiously, without injuring their roots. The successfull airlayers (goottees) after counting and removing leaf area were planted in a well prepared nursery bed laid out statistically. The layout plan in which planting of airlayers was done for the study of their survival is depicted in figure.

OBSERVATIONS RECORDED-

For taking observations three airlayers were randomly selected from each treatment in a replication, data with regard to rooting were recorded at 10 days interval after operation. After transplanting of airlayers in nursery three plants under each treatment were selected for further survival studies. Observations with regard to survival had been taken at 15 days interval up to 60 days after transplanting.

FIG. 2



PLAN OF LAYOUT

RANDOMIZED BLOCK DESIGN

ROOTING STUDIES:-

(1) Callus formation

(2) Success in rooting

(3) Total number of primary roots

(4) Average length of primary roots

(5) Diameter of primary roots

(6) Total number of secondary roots

(7) Average length of secondary roots

(8) Diameter of secondary roots

(9) Dry weight of roots.

SURVIVAL STUDIES :-

(1) Survival of plants.

(2) Total number of branches.

(3) Girth of plants.

(4) Average length of shoots.

CULTURAL PRACTICES :-

Irrigation:- Plants in the nursery were irrigated regularly at an interval of 15 days, starting from the date of transplanting of airlayers.

Weeding:- Two weedings were done at a monthly interval precautiously to avoid root injury.

PLANT PROTECTION :-

Blitox @ 2 gm/litre and melathion were dissolved in the water for spraying the lime plants for protecting them from fungus and lemon butterfly attack.

STATISTICAL ANALYSIS :-

Data of rooting of airlayers as recorded at final observation i.e. 45 days after operation, at detachment and data of survival of airlayers were collected 60 days after transplanting and subjected to statistical analysis as per method given by Fisher (1950). The skeleton of analysis of variance table is given below:-

TABLE 6

Skeleton of analysis of variance table

S.No.	Source of variance	D.F.	S.S.	M.S.S.	'F' VALUE
1.	Replication	2			
2.	Rooting Media	3			
3.	Concentration of Growth Regulator	4			
4.	Interaction (GM)	12			
5.	Error	38			
	Total	59			

The 'F' test was performed for judging the significance of treatment. The significance between different means was judged by using critical difference when was calculated as follows.

I. S.E. (m) ± for comparing concentration growth regulators mean

$$\sqrt{\frac{Ems}{4x3}} = \sqrt{\frac{Ems}{12}}$$

C.D. for growth regulators mean= $S.E.(m) \times \sqrt{2} \times t$ Value 5%

II. S.E.(m) ± for rooting media means

$$\sqrt{\frac{Ems}{3x5}} = \sqrt{\frac{Ems}{15}}$$

C.D. for rooting media means= $S.E.(m) \times \sqrt{2} \times t$ Value 5%

III. S.E.(m) ± for interaction of media & concentration of growth regulators means

$$= \sqrt{\frac{Ems}{3}}$$

C.D. for interaction means= $S.E.(m) \times \sqrt{2} \times t$ Value 5%

Where Ems is erron mean sum of square.

t value at 5%, D.F. 38 = 2.025

DETAILS OF CULTURAL OPERATIONS :-

1.	Selection of kagzi lime plants	28.6.88
2.	Preperation of rooting media	3.7.88
3.	Preperation of hormones mixture	4.7.88
4.	Operation of air layers	
	Replication I	5.7.88
	Replication II	6.7.88
	Replication III	7.7.88
5.	Observations	
	Observation Ist	10.7.88
	Observation IInd	20.7.88
	Observation IIIrd	30.7.88
	Observation IVth	10.8.88
6.	Preperation of field	9.8.88
7.	Seperation of airlayers	
	Replication I	20.8.88
	Replication II	21.8.88
	Replication III	22.8.88
8.	Date of planting in the field	23.8.88
9.	Spray of Blitox	18.9.88

10. Observations on growth studies

Observation	Ist	7.9.88
Observation	IInd	22.9.88
Observation	IIIrd	7.10.88
Observation	IVth	22.10.88
Observation	Vth	6.11.88
~~Observation~~	~~VIth~~	~~.10.88~~

CHAPTER - IV

EXPERIMENTAL FINDINGS

CHAPTER IVth

EXPERIMENTAL FINDINGS

This chapter deals with the findings of the experiment "Effect of growth regulators and rooting media on callusing, rooting and survival of airlayers of kagzi lime (*Citrus aurantifolia* Swingle) carried out during rainy season in year 1988-89 in experimental area of the Horticulture section in college of Agriculture, Gwalior.

STUDIES OF ROOTING OF AIR LAYERS:-

Observations on callus formation, root initiation number, length, diameter of primary and secondary roots, and rooting percentage of airlayers was recorded at an interval of 10 days after operation of airlayering for root studies. Data collected during observation of root studies have been depicted by diagram. Data of Last observations were analysed statistically and analysis of variance have been presented in appendix I. The mean values of different characters as affected by the treatments are shown in the appendix II. Findings of the Characters.

CALLUS FORMATION:-

Callus formation is the first apparent symptom of root formation process. Growth regulators help in faster development of callus cells and ultimately roots. In this trial, observations were recorded with the help of vernier callipers, at 10 days interval after operation of airlayers. The Data of the final observation was analysed statistically and analysis of variance is given in appendix I. Mean diameter of

callused cells as affected by different treatment is shown in table 7 and depicted in diagrams.

TABLE 7

Mean diameter of callusing (cm) as affected by different rooting media, growth regulators and their combination.

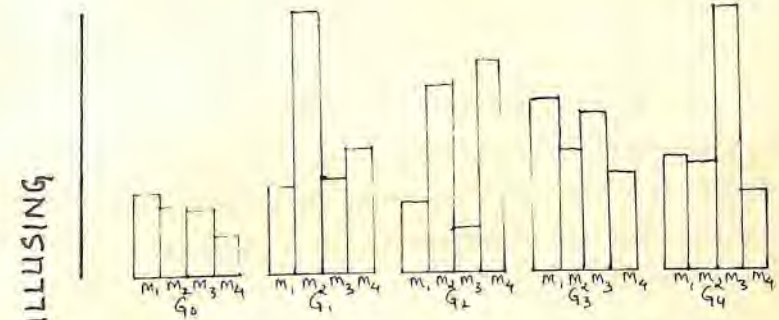
	M_1	M_2	M_3	M_4	Mean
G0	0.15	0.126	0.123	0.075	0.1185
G_1	0.16	0.446	0.17	0.215	0.2477
G_2	0.128	0.323	0.076	0.358	0.2212
G_3	0.299	0.207	0.27	0.170	0.2365
G_4	0.205	0.188	0.446	0.137	0.244
Mean	0.188	0.258	0.217	0.191	

	Rooting media	Growth regulator	Interaction GxM
S.E.$_{(M)}$ ±	0.005736	0.006414	0.01282
C.D. at 5%	0.0164	0.01836	0.0367

Perusal of the data given in appendix I shows that callusing had been affected significantly by rooting media, growth regulator and their interactions.

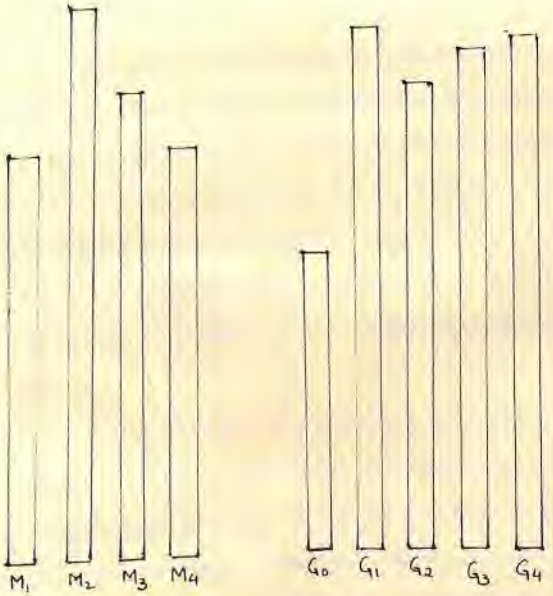
FIG 3

Scale - 0·089 = 1cm



AVERAGE DIAMETER OF CALLUSING

Scale - 1cm = 0·02



EFFECT OF DIFFERENT TREATMENTS ON CALLUSING

It is apparent from table 7 that maximum diameter of callused cells was in treatment M_2 and was significantly superior to rest of the treatments viz. M_3 M_4 & M_1. Treatment M_3 was significantly better than M_4 and M_1 while M_4 was found at par to M_1 with regard to callusing in kagzi lime airlayers.

Different concentrations of growth regulators IBA and NAA caused significant increase in the callusing. Regulator G_1 produced maximum callus and was significantly superior to G_2 and G_0. All the concentrations of growth regulator viz G_1, G_4, G_3, G_2 were significantly superior to G_0(Control). Treatment G_4 and G_3 are found statistically at par to G_1.

Significant improvement was also brought about due to interaction between rooting media and growth regulators. Thickest callusing was noted in the treatment combination G_1 M_2 and G_4 M_3, and both these combinations were observed significantly superior to rest of the combinations . Other

better combinations are $G_2 M_4$, $G_2 M_2$, $G_3 M_1$, and $G_3 M_2$. Thinnest callusing was noted in the combination $G_0 M_1$.

AVERAGE NUMBER OF PRIMARY ROOTS:-

Number of roots is one of the important character on which success or failure of airlayering depends. In the present experiment number of primary roots was recorded subsequently at 10 days interval after operation of airlayers and were depicted in the figure4. Final data of the observation recorded at the time of detachment of airlayers, regarding number of primary roots were subjected to satistical analysis and the mean number of primary roots as affected by different treatments is given in the table 8.

TABLE 8

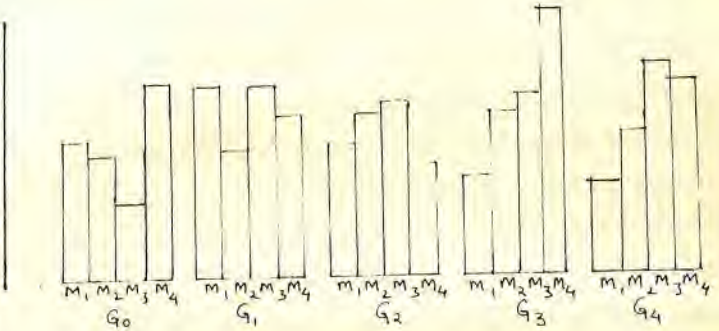
Mean number of primary roots per airlayer as affected by rooting media, growth regulators & their combinations.

	M_1	M_2	M_3	M_4	Mean
G_0	13.66	8.0	12.5	19.5	13.41
G_1	18.75	12.5	19.0	16.5	16.68
G_2	13.0	15.66	17.2	11.33	14.29
G_3	10.33	16.5	17.85	26.0	17.67
G_4	9.8	14.5	21.25	20.0	15.69
Mean	13.10	13.43	17.56	18.66	

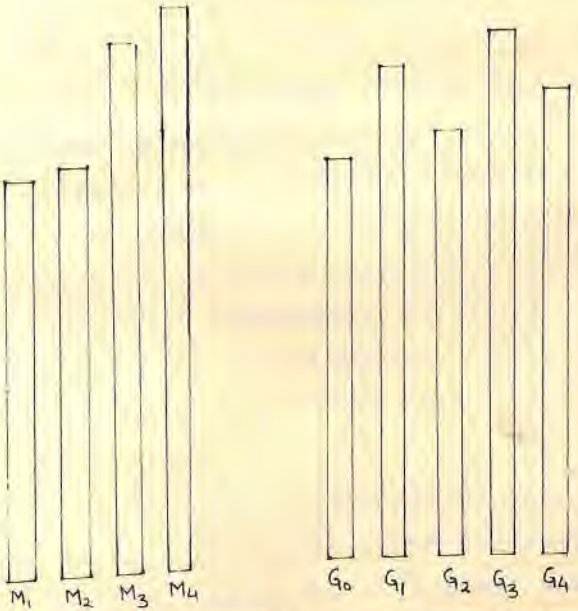
	Rooting Media	Growth Regulator	Interaction GxM
$S.E._{(M)} \pm$	0.1516	0.16953	0.3390
C.D. at 5%	0.434	0.4855	0.9711

From the analysis of variance given in the appedix I it is observed that different rooting media, concentrations of growth regulators and their interaction (Gx M) had produced statistically different number of primary roots.

Scale 1cm = 5·2



AVERAGE NUMBER OF PRIMARY ROOTS



Scale 1cm = 1·75

EFFECT OF DIFFERENT TREATMENTS ON NUMBER OF PRIMARY ROOTS

Different rooting media helped in the production of different number of primary roots in airlayers of kagzi lime and highest number of main roots were counted in the treatment M_4 which was significantly superior to rest of the treatment viz M_3, M_2 and M_1. Treatment M_3 was ranked at second order but also found statistically better than M_2 and M_1. Treatment M_2 and M_1 were proved to be statistically at par.

All the levels of the growth regulators had exhibited significant increase in the number of primary roots as compared to treatment G_0 (Control). Largest number of primary roots was recorded in the treatment G_3, statistically better than G_1, G_4 and G_2 respectively. Treatment G_1 was placed at second position and found statistically better than G_4 and G_2. Treatment G_4 was also observed statistically better than G_2.

Interaction between rooting media and growth regulator had affected number of primary roots of airlayers. Maximum number of primary roots was noted

in the treatment interaction G_3 M_4 and was found significantly superior to rest of the treatments. Second best treatment combination was G_4 M_3 followed by G_4 M_4. Minimum number of primary roots were recorded in the treatment combination G_0 M_2 and was significantly inferior to rest of interaction.

AVERAGE LENGTH OF PRIMARY ROOTS:-

Length of roots is considered to be an important factor from growth point of view. Hence observations were recorded after each 10 days. Final data recorded after detachment of airlayers was analysed statistically and analysis of variance is presented in appendix I. Mean length of primary roots as affected by different treatments is presented table 9 and shown in diagram 5.

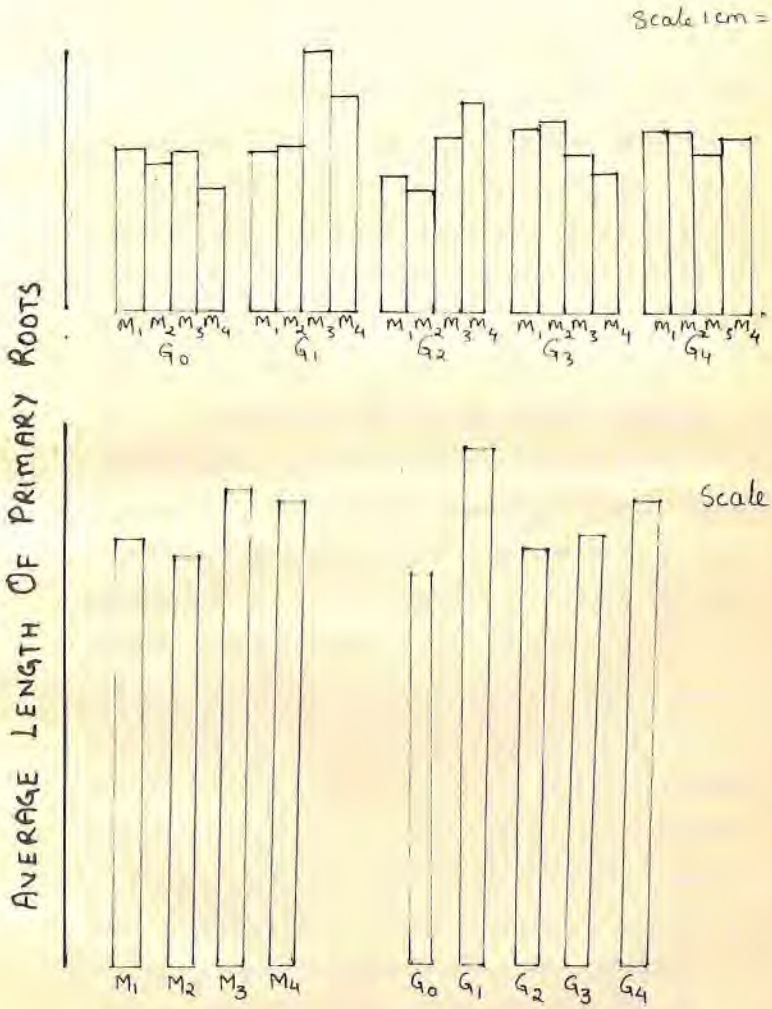
TABLE 9

Mean length of primary roots per airlayers (cm) as affected by different rooting media, growth regulator & their combinations.

	M_1	M_2	M_3	M_4	Mean
G_0	3.575	3.45	3.7	2.962	3.421
G_1	3.62	3.75	5.925	4.9	4.548
G_2	3.025	2.83	3.98	4.78	3.653
G_3	4.04	4.275	3.6	3.3	3.803
G_4	4.26	4.26	3.64	4.137	4.059
Mean	3.70	3.595	4.169	4.0158	

	Rooting Media	Growth Regulator	Interaction G×M
S.E. (M) ±	0.2088	0.2336	0.4672
C.D. at 5%	N.S.	0.669	1.338

It was obvious that growth regulator and interaction between rooting media and growth regulator had affected mean length of primary roots per airlayer significantly. On the other hand different rooting media had not influenced significantly length of primary roots.



EFFECT OF DIFFERENT TREATMENTS ON LENGTH OF PRIMARY ROOTS

Different rooting media did not show any significant effect with regard to length of primary roots. However rooting media M_3 and M_4 gave the maximum length of primary roots but none of them could show any significant effect on length of primary roots and minimum was recorded in the treatment M_1.

Different growth regulators produced significantly longer length of primary roots and the treatment G_1 gave maximum length of primary roots which was found statistically higher than to G_3, G_2 and G_0. G_4 was second best regulator and was significantly superior over control.

Significant differences had been noted due to interaction of rooting media and growth regulator with respect of length of primary roots, and maximum length of primary roots was recorded in G_1 M_3 which was found significantly higher to rest of the other treatments except G_1 M_4 and G_2 M_4. Minimum length of primary roots was recorded in the treatment G_2 M_2 significantly inferior to

remaining treatments except $G_0 M_4$ and $G_2 M_1$.

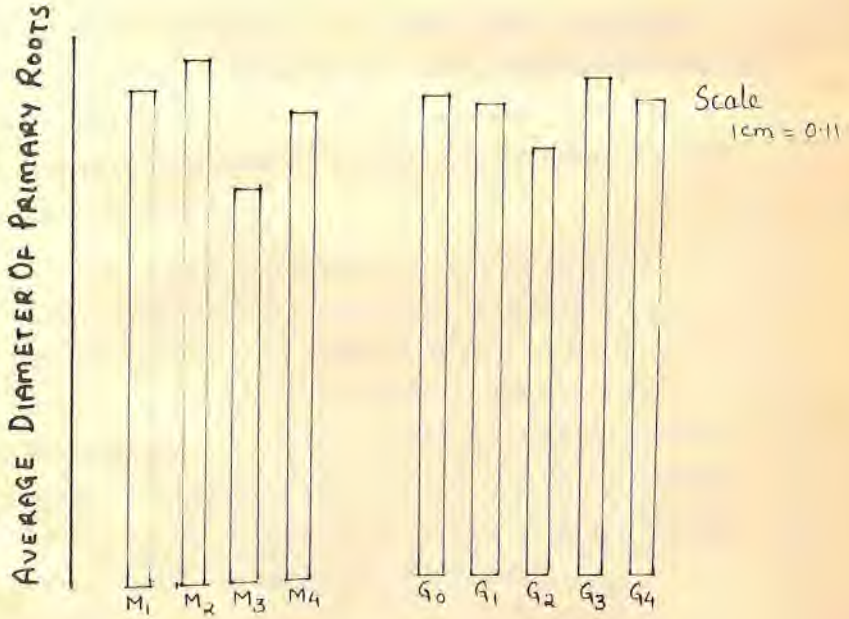
AVERAGE DIAMETER OF PRIMARY ROOTS PER AIRLAYER:-

Diameter of primary root is also an important factor for successful propagation by airlayering besides it's length and number. Hence observations were recorded on the usual observation days and are depicted by diagram 6. The data recorded during final observation had been analysed statistically and mean diameter of primary roots per airlayer as affected by different treatment is shown in the table 10.

TABLE 10

Mean diameter (mm) of primary roots per airlayer as affected by different rooting media, growth regulators & their combinations.

	M_1	M_2	M_3	M_4	Mean
G_0	1.037	1.025	1.08	0.95	1.023
G_1	0.875	1.355	0.837	0.975	1.0105
G_2	1.15	1.036	0.413	1.05	0.91225
G_3	1.20	1.15	0.89	0.993	1.058
G_4	0.968	0.985	0.985	1.13	1.017
Mean	1.046	1.1102	0.841	1.019	



EFFECT OF DIFFERENT TREATMENTS ON DIAMETER OF PRIMARY ROOTS

	Rooting Media	Growth Regulator	Interaction GxM
S.E.$_{(M)}$ ±	0·1264	0·1414	0·2828
C.D. at 5%	N.S.	N.S.	N.S.

Perusal of the data presented in the appendix I indicate that there was no significant influence of rooting media, growth regulator and their interaction on diameter of primary roots.

Different rooting media under experiment did not affect diameter of primary roots significantly. However maximum diameter had been recorded in M_2 followed by M_1 and M_4 respectively. Minimum diameter was recorded in M_3.

Data presented in the table revealed that there was statistical insignificant effect of growth regulator on diameter of primary roots of airlayers as statistical similar diameter were recorded under different growth regulators. Maximum diameter of primary root was recorded in G_2 followed by G_1, G_4 and G_0 respectively. Treatment G_3 produced while minimum diameter of primary roots.

Treatment combinations between rooting media and growth regulator did not differ significantly with respect to diameter of primary roots and however maximum girth of primary root was noted in treatment $G_1 M_2$ and minimum girth of primary root was recorded in treatment $G_2 M_3$.

AVERAGE NUMBER OF SECONDARY ROOTS PER AIRLAYER:-

The formation and number of secondary roots is also an important factor for successful establishment of plant, propagated by airlayering. Therefore data regarding number of secondary roots were recorded at an interval of 10 days and are depicted in figure7. Data recorded at the last observation, at the time of detachment of airlayer, were analysed statistically and were presented in the table 11.

TABLE 11

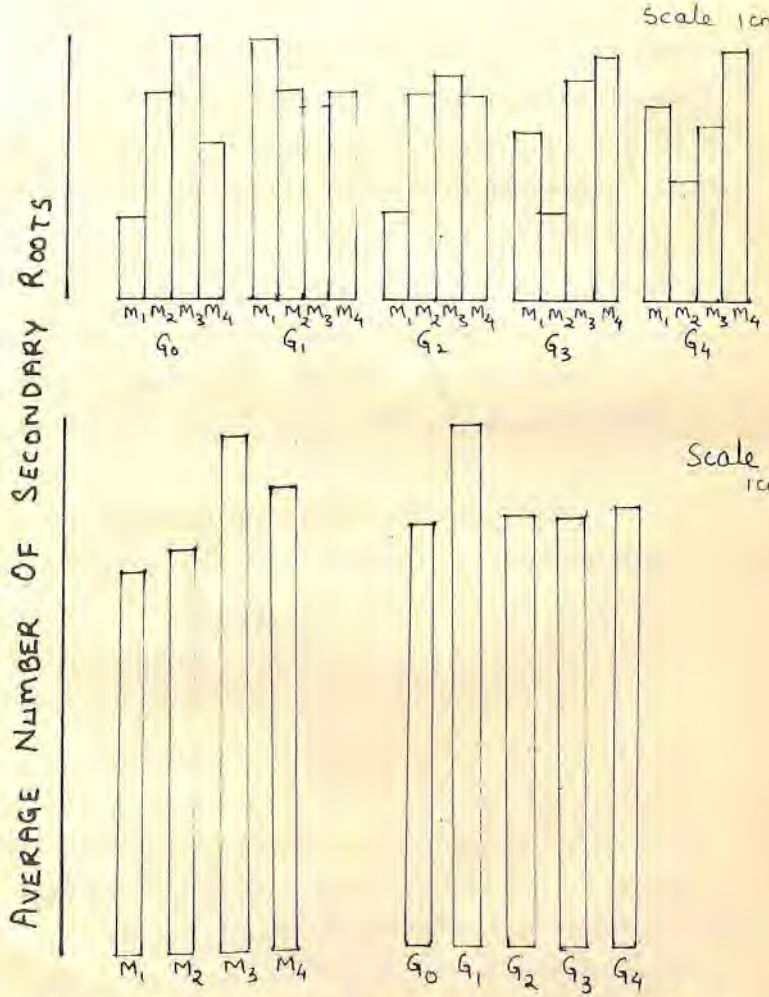
Mean number of secondary roots per airlayer as affected by different rooting media, growth regulators & their combinations.

	M_1	M_2	M_3	M_4	Mean
G_0	26.0	61.75	77.0	48.66	53.55
G_1	77.0	64.0	58.8	64.0	65.95
G_2	26.33	62.66	69.0	61.66	54.91
G_3	52.0	27.33	66.42	73.4	54.78
G_4	59.0	35.8	52.75	75.5	55.76
Mean	48.06	50.30	64.79	64.64	

	Rooting Media	Growth Regulator	Interaction GxM
S.E.$_{(M)}$ ±	1.4526	1.623	3.247
C.D. at 5%	4.6	4.65	9.30

The data presented in appendix I clearly indicated that rooting media, growth regulator and their interaction had affected mean number of secondary roots of air layers significantly.

Study of table 11 showed that rooting media had significantly affected number of secondary roots



EFFECT OF DIFFERENT TREATMENTS ON NUMBER OF SECONDARY ROOTS

and the maximum number of secondry roots were recorded under treatment M_3 which was statistically similar to M_4 and both of them were significantly superior to M_2 and M_1. Minimum number of secondry roots were recorded in treatment M_1 which was found at par with M_2.

Different concentrations of growth regulators exercised their influence on the number of secondry roots significantly which is revealed from the appendix-I. Growth regulator G_1 produced maximum number of secondary roots in airlayer and was proved significantly superior to remaining growth regulator viz G_4, G_3, G_2, G_o. Treatment G_o produced minimum number of secondary root. Treatments G_o, G_3, G_2, G_4, are statistically similar with respect to number of secondary roots per airlayer.

Significant differences was noted due to interaction between rooting media and growth regulator with respect to number of secondary roots. Treatment combinations G_1M_1 and G_oM_3 produced maximum number of secondary roots per airlayer and were found significantly superior to remaining treatment combinations except G_4M_4, G_2M_3, G_3M_4 which are statistically similar. Minimum

number of secondary roots were recorded under treatment combination G_0M_1 which was significantly inferior to rest of the interactions except G_2M_1 and G_3M_2 which are found at par.

AVERAGE LENGTH OF SECONDARY ROOTS PER AIRLAYER.

Average length of secondary roots is also an important factor, therefore data regarding it, were recorded subsequently at an interval of 10 days, which are depicted in figure 8. Final data recorded at the time of detachment of airlayer were analysed statistically as shown in appendix.I. Mean length of secondary roots as affected by different treatments is presented in Table-12.

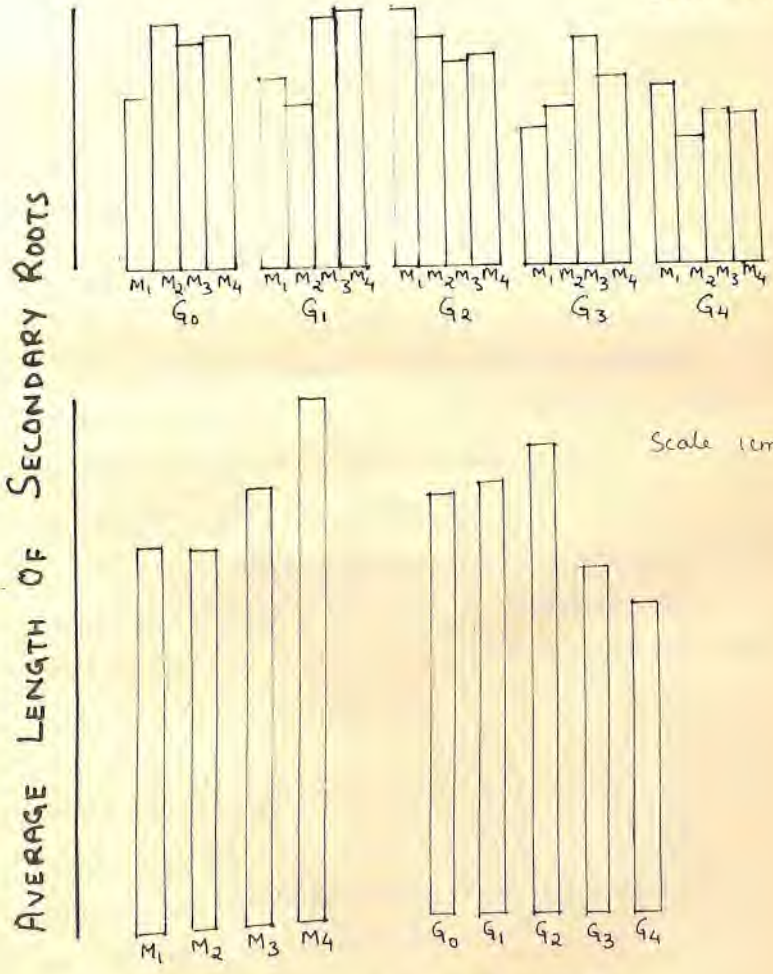
TABLE No.12

Mean length of secondary roots per airlayer as affected by different rooting media, growth regulator & their combinations. (cm)

	M_1	M_2	M_3	M_4	Mean
G_0	1.5875	2.45	2.15	2.233	2.105
G_1	1.90	1.65	2.516	2.6	2.1665
G_2	2.666	2.35	2.116	2.175	2.3267
G_3	1.35	1.587	2.3	1.7498	1.746
G_4	1.82	1.25	1.575	1.555	1.55
Mean	1.864	1.8574	2.1314	2.062	

	Rooting media	Growth regulator	Interaction(GxM)
S.E.(m)±	0.0953	0.1068	0.2137
C.D.at 5%	N.S.	0.306	0.6121

Analysis of variance presented in appendix-I clearly indicate that rooting media did not influence statistically the mean length of secondary roots of airlayers, while growth regulators and interactions between rooting media and growth regulator had affected length of



EFFECT OF DIFFERENT TREATMENTS ON LENGTH OF SECONDARY ROOTS

secondary root significantly.

It is obvious from the table 12 that different rooting media did not influence the mean length of secondary roots significantly. However maximum length of secondary root was recorded in M_3 and minimum in M_2.

It is clear from the Table-12 that growth regulator exert statistical influence on length of secondary roots. Treatments G_2, G_1, G_0 (control) produced maximum length of roots and were found statistically superior to G_3 in this regard. G_2, G_1 and G_0 (control) were statistically similar and also G_3 and G_4 are found statistically at par.

Interaction between rooting media and growth regulator affected mean length of secondary root significantly as shown in the appendix-I. Maximum mean length of secondary roots were noted in G_2 M_1 which was significantly superior to rest of the treatment combination, except G_1M_4, G_1M_3, G_0M_2, G_3M_3, G_0M_4, G_2M_4 G_0M_3, G_2M_3, which are found statistically similar. Minimum mean number of secondary roots was recorded in the treatment combination G_4M_2.

AVERAGE DIAMETER OF SECONDARY ROOTS PER AIRLAYER.

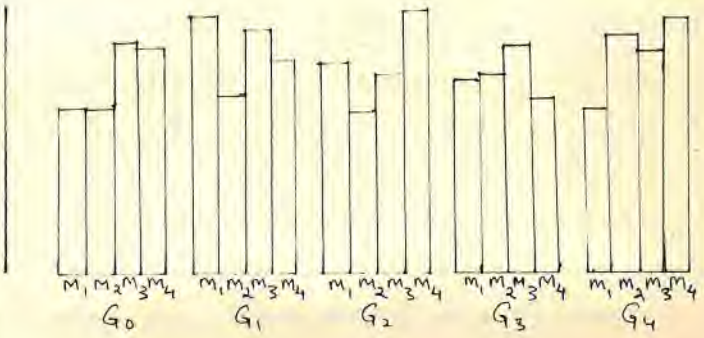
Besides number and length, diameter of secondary roots is also of great importance for successful propagation by airlayers. Hence data on this espect were recorded at 10 days interval and are depicted in figure3. The data recorded 45 days after operation of airlayers was analysed statistically and presented in appendix-I. Mean diameter of secondary roots as affected by different treatments is shown in Table-13.

TABLE-13

Mean diameter (mm) of secondary roots per airlayer as affected by different rooting media, growth regulators and their combinations.

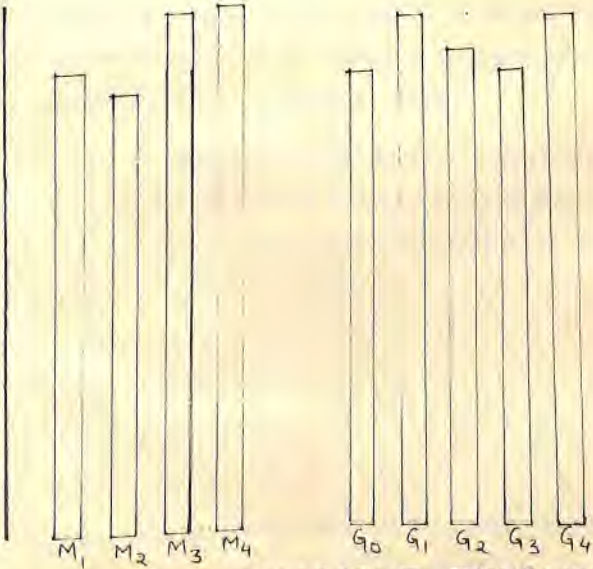
	M 1	M 2	M 3	M 4	Mean
G_0	0.35	0.35	0.5037	0.4916	0.4238
G_1	0.5583	0.385	0.525	0.45	0.4795
G_2	0.4483	0.3575	0.423	0.5587	0.4467
G_3	0.4125	0.425	0.483	0.3812	0.4248
G_4	0.35	0.5133	0.48	0.5487	0.4729
Mean	0.4238	0.4057	0.4829	0.4860	.

Scale 1cm = 0.11



Scale 1cm = 0.048

AVERAGE DIAMETER OF SECONDARY ROOTS



EFFECT OF DIFFERENT TREAMENTS ON DIAMETER OF SECONDARY ROOTS

	Rooting media	Growth regulator	Interaction(Gxm)
S.E.(m)±	0.01731	0.01934	0.0387
C.D.at 5%	0.0496	N.S.	0.1109

It is obvious from the analysis of variance presented in appendix-I that different rooting media and interaction between rooting media and growth regulator had affected significantly the mean diameter of secondary roots, while different concentration of growth regulator did not produce any significant affect on diameter of the secondary roots.

It is clearly indicated in the appendix-I that rooting media exert it's influence on diameter of secondary roots of airlayers. Maximum mean diameter of secondary roots was recorded in treatment M_4 and M_3 which were found at par to each other and both were prove significantly superior to M_1 and M_2. Treatment M_2 gave minimum diameter of secondary roots which was statistically similar to M_1.

Different concentration of growth regulator failed to affect the mean diameter of secondary roots

significantly. However maximum mean diameter of secondary root was produced in treatment G_1 and minimum under control.

Interaction between rooting media and growth regulators significantly affected mean diameter of secondary roots as shown in appendix-I. Maximum mean diameter of secondary roots was recorded in the treatment combinations G_2M_4 which was found statistically similar to G_1M_1, G_4M_4, G_1M_3, G_4M_2, G_0M_3 and was found superior to rest of the treatment combinations. Minimum diameter of secondary root was noted in G_0M_2 and G_0M_1, which were found statistically similar to G_4M_1, and are statistically inferior to the treatments mentioned above.

AVERAGE ROOTING PERCENTAGE:-

Rooting of airlayer in one of the most important factor for successful propagation by airlayering. Commercial adoption of any propagation method depends upon the success of practice used. Therefore data recorded after each 10 days interval and is depicted in the figure10. Final data at the time of detachment of airlayers had been subjected to statistical analysis

and is shown in the appendix-I. Mean rooting percentage as affected by different treatments are presented in the Table-14.

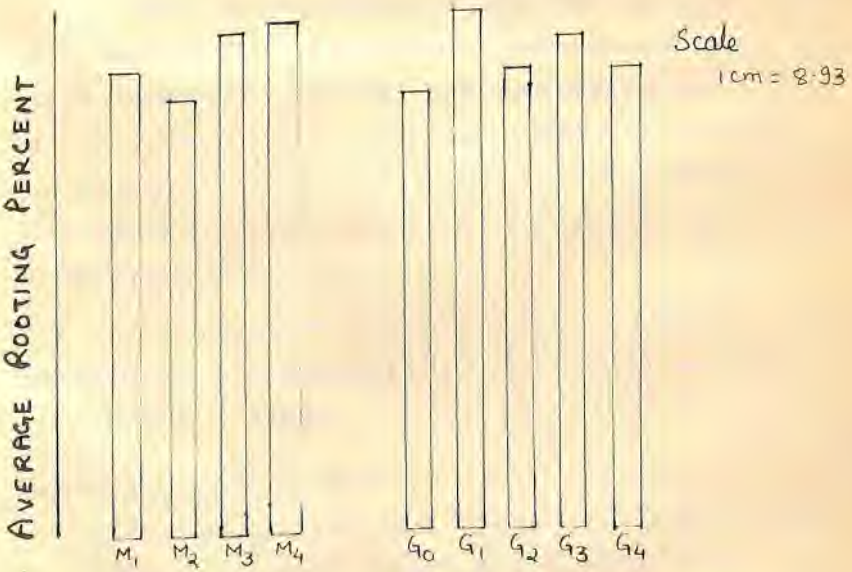
Table No.14

Mean rooting percentage as affected by different rooting media, growth regulator & their combinations.

	M_1	M_2	M_3	M_4	Mean
G_0	72.3	68.9	79.3	81.4	75.47
G_1	88.2	82.4	92.1	94.6	89.32
G_2	75.6	72.3	83.2	85.8	79.22
G_3	84.3	79.4	86.8	89.4	84.97
G_4	75.8	71.4	85.7	85.2	79.52
Mean	79.24	74.88	85.42	87.28	

	Rooting media	Growth regulator	Interaction (Gxm)
S.E.(m)±	0.7797	0.8719	1.7438
C.D.at 5%	2.233	2.497	N.S.

Perusal of the analysis of variance (appendix-I) showed that rooting media and growth regulator significantly affected the rooting percentage of airlayers, while their



EFFECT OF DIFFERERENT TREATMENTS ON PERCENT SUCCESS OF ROOTING

interaction (GXM) did not produce any statistical influence on rooting percentage.

Different rooting media affected the mean rooting percentage of air layers as indicated in appendix I. Treatment M_4 gave maximum rooting percentage which was found at par with M_3. Both M_4 and M_3 are statistically superior to M_1 and M_2 with regard to mean rooting percentage. However treatment M_1 were found statistically superior to M_2.

Mean rooting percentage of airlayers was also significantly affected by different concentraction of growth regulators. Treatment G_1 had maximum rooting percentage, statistically superior to remaining treatments. All treatments were statistically superior over control with regard to rooting percentage. Treatment G_3 was significantly better than G_4.

Interactions between rooting media and growth regulator did not produce significant affect on rooting percentage of airlayers.

Average dry weight of roots:

Dry weight of root is a important factor for survival of airlayers, as survival depends upon the total underground biomass i.e. roots. Hence data regarding the dry weight of roots were taken at an interval of 10 days, commencing from 10 days after operation of airlayers. Data of the final

observation were subjected to statistical analysis and the analysis of variance was presented in the appendix-I. Mean dry weight of roots as affected by different treatments and their interaction are presented in the table-15.

Table-15

Mean dry weight of roots per airlayers as affected by rooting media, growth regulator and their interaction.

	M_1	M_2	M_3	M_4	Mean
G_o	0.41	0.31	0.47	0.49	0.42
G_1	2.4	2.3	2.58	2.6	2.47
G_2	0.82	0.62	1.30	1.41	1.037
G_3	0.51	0.49	0.64	0.66	0.575
G_4	1.59	1.48	2.30	2.38	1.937
Mean	1.146	1.04	1.458	1.508	

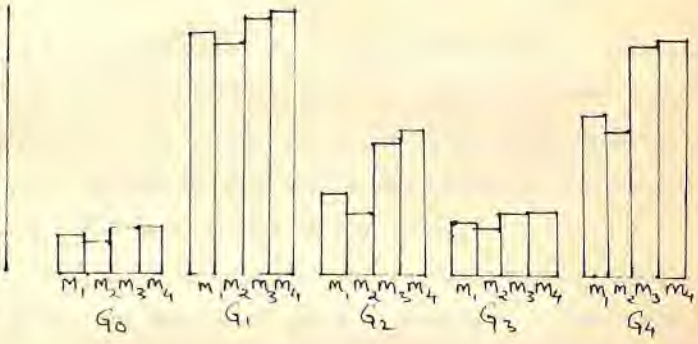
	Growth Regulator	Rooting Media	Interaction
S.E.(M) ±	0.0624	0.0558	0.124
C.D. at 5%	0.178	0.16	0.357

Perusal of the analysis of variance presented in the appendix-I clearly indicated that different rooting media, concentrations of growth regulator and their combination significantly affected dry weight of roots.

Different rooting media had significantly affected mean dry weight of roots. Highest dry weight of roots was

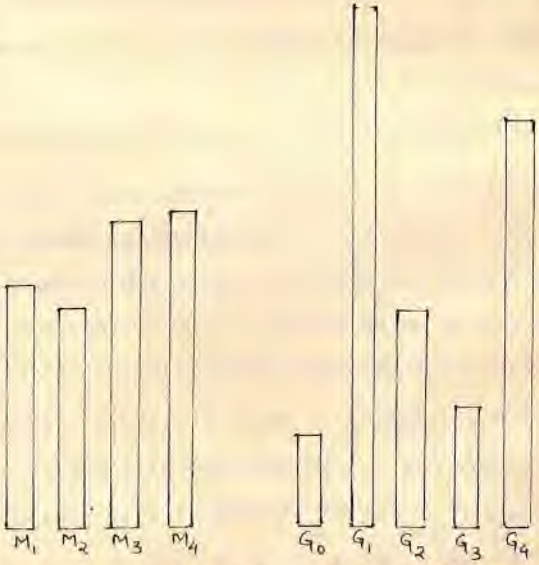
Fig. II

Scale 1cm = 0·4192



AVERAGE DRY WEIGHT OF ROOTS

Scale 1cm = 0·217



EFFECT OF DIFFERENT TREATMENTS ON DRY WEIGHT OF ROOTS

observed in the treatment M_4 and was significantly superior to rest of the treatments, except M_3 which was found statistically at par to M_4. Treatment M_3 was also significantly superior to M_2, minimum dry weight was noted in treatment M_2, which was found statistical at par to M_1.

Different concentrations of growth regulators also affected the dry weight of roots significantly. Treatment G_1 was found statistically best to all other treatments. Treatment G_4 was significantly superior to G_2, G_3 and G_o with respect to dry weight. Minimum dry weight of roots was noted in the treatments G_o and G_3, which were found statistically at par, and therewere significantly inferior to remaining treatments.

Interaction between rooting media and concentration of growth regulator significantly influenced the dry weight of roots. Maximum dry weight of roots was observed in the treatment combination $G_1 M_4$ and was found statistically better than remaining treatment combinations except $G_1 M_3$, $G_4 M_4$, $G_4 M_3$, $G_1 M_1$ and $G_1 M_2$. Minimum dry weight of root was observed in the interaction $G_o M_2$ and significantly inferior to remaining treatments except $G_o M_1$, $G_o M_3$, $G_o M_4$, $G_2 M_2$, $G_3 M_1$, $G_3 M_2$, $G_3 M_3$, and $G_3 M_4$.

AVERAGE SURVIVAL PERCENTAGE :-

The observations on growth studies had been recorded up to 60 days after transplanting at an interval of 15 days, subsequent observations recorded were represented in figure 12. Data of the final observation were subjected to statistical analysis and presented in appendix-I. The mean survival percentage as affected by different treatments in given in table-16.

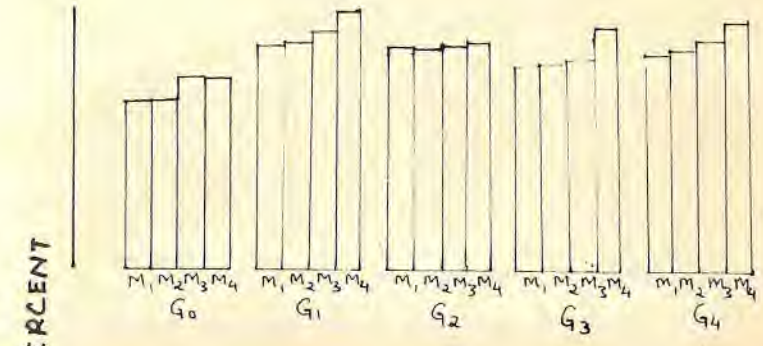
TABLE-16

Mean survival percentage as affected by different rooting media, growth regulators & their combinations.

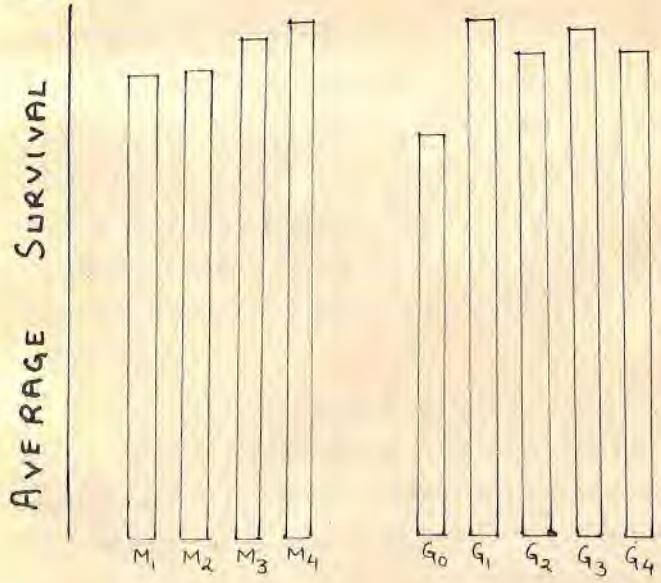
	M_1	M_2	M_3	M_4	Mean
G_0	60.01	59.82	67.51	66.29	63.40
G_1	78.32	78.80	82.21	89.38	82.30
G_2	74.81	77.32	78.49	79.21	77.45
G_3	73.12	71.82	82.01	85.13	78.02
G_4	76.80	77.2	82.17	87.43	80.9
Mean	72.71	72.99	78.47	81.48	

FIG 12

Scale
1cm = 17·87



Scale
1cm = 8·23



EFFECT OF DIFFERENT TREATMENTS
ON SURVIVAL PERCENT

	Rooting media	Growth regulator	Interaction (Gxm)
S.E.(m)	± 0.692	0.7741	1.5482
C.D. at	5% 1.9817	2.2168	4.433

From the analysis of variance (Appendix-I) it is evident that rooting media, growth regulators and their interactions had significantly affected mean survival percentage of airlayers.

It is obvious from the table-16 that maximum mean survival percentage was in treatment M_4 which was significantly superior to remaining treatments. Treatment M_3 was also significantly superior to M_2 and M_1. Treatment M_1 gave minimum survival percentage and was inferior to remaining treatments except M_2 which was found statistically at par.

Different concentrations of growth regulator exert their affect on survival percentage of airlayers. G_1 had maximum survival percentage which was found statistically at par with G_4 and both of them were significantly superior to rest of growth regulators

viz. G_3, G_2 and G_0. All treatments were statistically superior over control with respect to survival percentage. Treatment G_2 was found statistically at par with G_3.

Interaction between rooting media and growth regulators also significantly affected mean survival percentage of airlayers. Maximum mean survival percentage of airlayer was noted in the interaction G_1M_4 and was significantly superior to remaining interactions except G_4M_4 and G_3M_4. Minimum mean survival percentage was noted in G_0M_2 and was significantly inferior to rest of the treatment combinations except G_0M_1 which was found at par.

AVERAGE NUMBER OF BRANCHES :-

The observations on average number of branches had been recorded up to 60 days after transplanting of airlayers in the nursery at an interval of 15 days. The subsequent observations was depicted in the figure13. Data of the final observations had been subjected to statistical analysis and was presented in the appendix-I. Mean number of branches had been whown in the table-17.

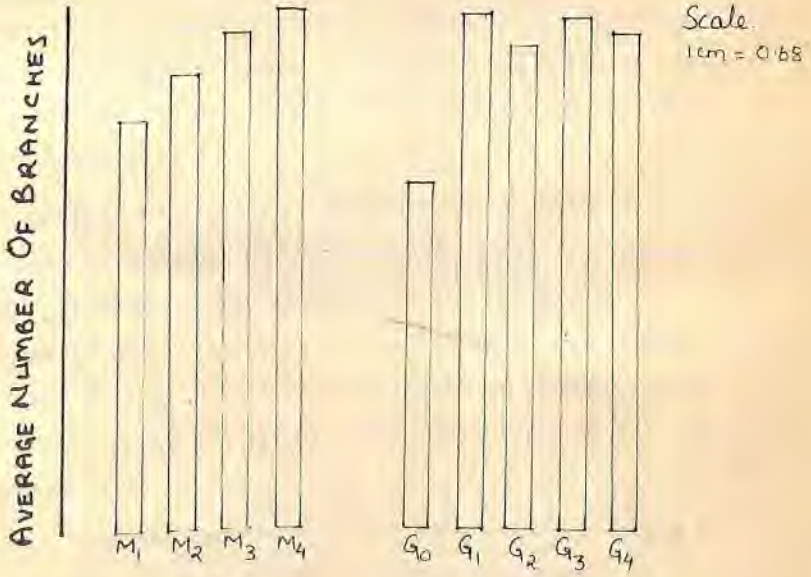
TABLE NO. 17

Mean number of branches per plant as affected by different rooting media, growth regulator & their combinations.

	M_1	M_2	M_3	M_4	Mean
G_0	3.8	4.3	4.8	5.2	4.52
G_1	6.4	6.3	7.0	7.3	6.75
G_2	5.8	6.0	6.6	6.8	6.3
G_3	6.0	6.2	6.8	7.0	6.5
G_4	6.8	6.9	7.2	7.8	6.67
Mean	5.36	5.94	6.48	6.82	

	Rooting media	Growth regulator	Interaction (Gxm)
S.E.(m) ±	0.1957	0.2188	0.4377
C.D.at 5%	0.5606	0.6268	N.S.

Perusal of the data presented in the appendix-I clearly indicated that rooting media, growth regulator had a significant affect on mean number of branches per airlayer.



EFFECT OF DIFFERENT TREATMENTS ON NUMBER OF BRANCHES

while interaction between rooting media and growth regulator did not exhibit any significant affect on mean number of branches.

It is clear from the appendix-I that different rooting media affected mean number of branches significantly. It is obvious from the table-17 that treatment M_4 produced maximum number of branches and was found significantly superior to M_2 and M_1. However treatment M_3 was found at par to M_4. Minimum number of branches was noted in the treatment M_1 and was significantly inferior to all other treatments.

Different growth regulator also significantly affected mean number of branches per airlayer. Maximum number of branches was reported in the treatment G_1. All treatments viz. G_1, G_3, G_4 and G_2 were significantly superior over G_0 (control) with regard to mean number of branches. Treatment G_3, G_4 and G_2 were found at par with treatment G_1.

As mentioned above interaction between rooting media and growth regulator did not affected mean number of branches significantly.

AVERAGE GIRTH OF SHOOT :-

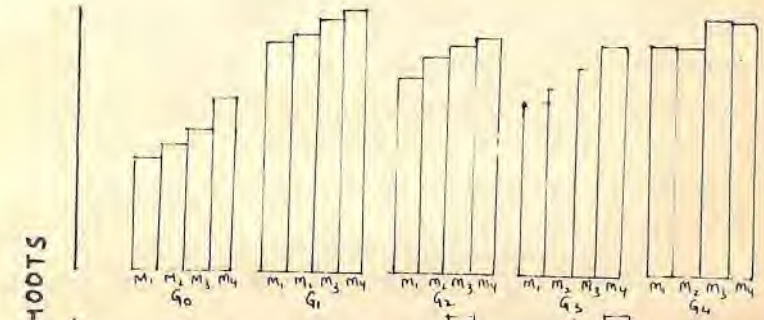
Average girth of shoot is also an important factor for proper establishment of airlayer. Therefore observations regarding mean girth of shoot had been recorded at an interval of each 15 days. Subsequent datas were presented in the figure14. Data of the final observation had been subjected to statistical analysis and was presented in the appendix. Mean girth of shoot as affected by different treatments were shown in the table-18.

TABLE NO. 18

Mean girth of shoot per plant as affected by different rooting media, growth regulator and their combinations (cm)

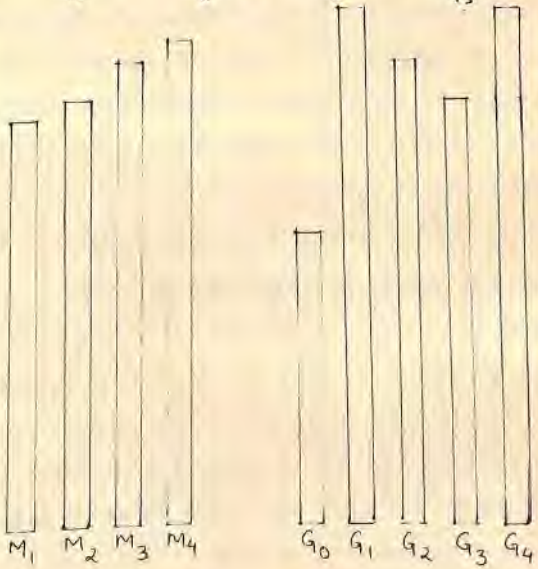
	M_1	M_2	M_3	M_4	Mean
G_0	0.193	0.208	0.243	0.291	0.2337
G_1	0.381	0.391	0.418	0.429	0.4047
G_2	0.320	0.365	0.373	0.391	0.3630
G_3	0.291	0.310	0.351	0.389	0.3352
G_4	0.391	0.387	0.421	0.413	0.403
Mean	0.3152	0.3322	0.3612	0.3826	

Scale 1 cm = 0.085



AVERAGE GIRTH OF SHOOTS

Scale
1 cm = 0.04



EFFECT OF DIFFERENT TREATMENTS ON GIRTH OF SHOOTS

	Rooting media	Growth regulator	Interaction(Gxm)
S.E.(m) ±	0.002731	0.003053	0.006107
C.D.at 5%	0.00782	0.008745	0.01749

Different rooting media significantly affected mean girth of shoot as shown in the appendix-I. It was obvious from the table-18 that maximum mean girth of shoot was noted in the treatment M_4 and which was significantly higher than in other treatments. Treatment M_3 was ranked at second position regarding mean girth of shoot and which was also significantly superior to treatment M_2 and M_1. Minimum mean girth of shoot was noted in the treatment M_1 and which was significantly inferior to rest of the treatments.

Different concentrations of growth regulator also affected mean girth of shoot significantly as obvious in the appendix-I. It is clear from the table-18 that statistical significant differences occour among all the different treatments regarding mean girth of shoots. Maximum mean girth of shoot was observed in the treatment G_1 which was significantly superior to rest of the treatments. Treatment G_4 was ranked at second place and was also significantly superior to remaining treatments with regard

to mean girth of shoot. Minimum mean girth of shoot was noted under control and which was significantly inferior to remaining treatments. Treatment G_2 was superior to G_3 with respect to mean girth of shoot.

Interaction between rooting media and growth regulator affected mean girth of shoot significantly. Maximum mean girth of shoot was observed under the treatment G_1M_4 and which was significantly superior to rest of the treatment combinations second best treatment combination was G_4M_3. Minimum mean girth of shoot was noted in the treatment combination G_0M_1 which was significantly inferior to remaining treatments except G_0M_2. G_0M_2 was found at par with interaction G_0M_1.

AVERAGE LENGTH OF SHOOT :-

Average length of shoot is also a factor affecting successful establishment of airlayers. Therefore, observations were recorded at an interval of 15 days after transplanting of airlayers in nursery, up to 60 days. Subsequent observations were depicted in the diagrams. Data of final observations were subjected to statistical analysis and analysis of variance which

were presented in appendix. Mean length of shoot as affected by different treatments are shown in the table-19.

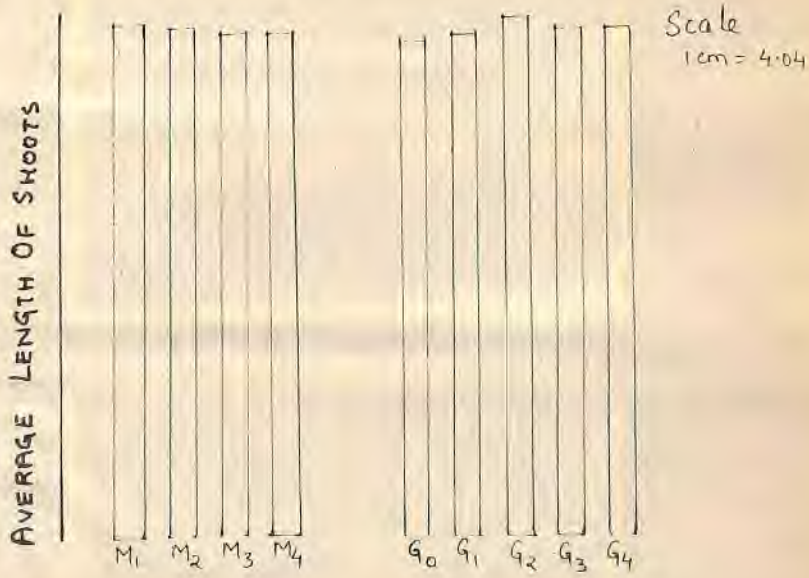
TABLE NO. 19

Mean length of shoot as affected by different rooting media, growth regulator & their combinations.

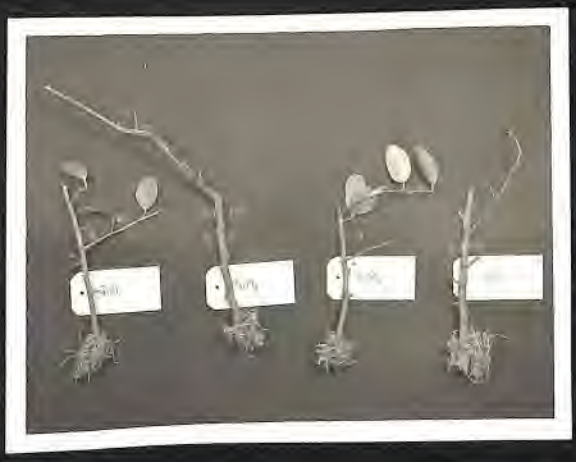
	M_1	M_2	M_3	M_4	Mean
G_0	38.05	38.41	39.28	39.14	38.72
G_1	39.45	38.73	40.07	39.13	39.34
G_2	42.80	38.57	39.83	40.4	40.40
G_3	39.62	41.50	39.40	38.47	39.75
G_4	41.15	39.50	38.79	39.52	39.74
Mean	40.214	39.342	39.474	39.332	

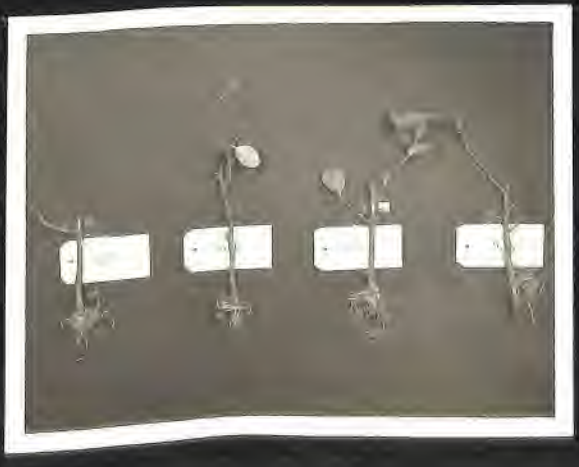
	rooting media	Growth regulator	Interaction (Gxm)
S.E.(m) ±	0.736	0.822	1.64
C.D.at 5%	N.S.	N.S.	N.S.

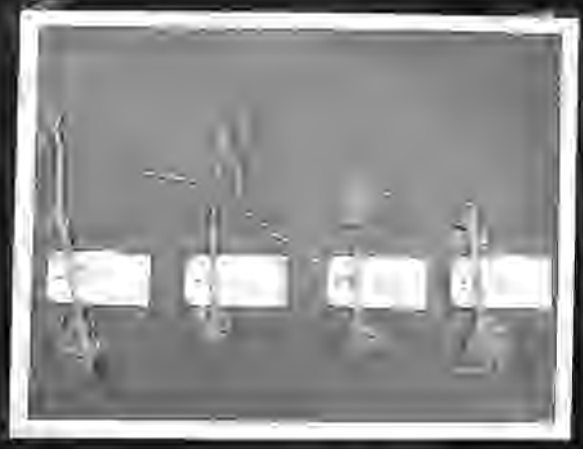
Perusal of the analysis of variance given in the appendix-I had clearly indicated that rooting media, growth regulators and their interactions did not impart any significant affect on the mean length of shoot.



EFFECT OF DIFFERENT TREATMENTS ON LENGTH OF SHOOTS







CHAPTER - V

CHAPTER-V

DISCUSSION

Finding of the present experiment "Effect of growth regulators and rooting media on callusing, rooting and survival of airlayers of Kagzi lime" given in the preceding chapter have been discussed here critically under suitable heads in the light of the literature pertaining to the findings of emminent scientists of India and abroad to elucidate the possible reasons of the variation due to treatment differences in this trial.

EFFECT OF ROOTING MEDIA

During the course of this investigation four rooting media were tried viz Soil (M_1), Soil + Sand (M_2), Soil + leaf mould (M_3) and Soil + FYM (M_4). While going through the preceding chapter it was observed that different rooting media had significantly affected callusing, rooting percent, number of primary & secondary roots, diameter of secondary roots, dry weight of roots, survival percent, number of branches and girth of shoots.

While length of primary roots, diameter of primary roots, length of secondary roots and length of shoots were not affected significantly by different rooting media.

Maximum rooting percent, length of secondary roots, diameter of secondary roots, dry weight of roots, survival percent, number of branches and girth of shoots were recorded statistically better than M_3, M_2 & M_1 due to rooting media Soil + FYM (M_4). Treatment rooting media Soil + leaf mould (M_3) was ranked at second place for most of the characters, while rooting media M_1 (Soil) and sand + Soil (M_2) were similar for most of the characters. However, maximum number of primary roots, length of secondary

roots & primary roots were recorded in the treatment rooting media M_3 (Soil + leaf mould), statistically similar to M_4, whereas these two treatments were proved statistically superior to M_2 and M1. Maximum diameter of callusing was observed in the treatment M_2 (Soil + Sand) which was statistically superior to remaining treatments. Rooting media Soil + leaf mould (M_3) was placed at second position and M_4 & M_1 are statistically similar in this aspect.

Development of callus cells was dependent upon the level of carbohydrates and nitrogen in plant part used for airlayers. When there is high carbohydrate: nitrogen ratio in the airlayered branch, callusing and healing is also improved. The process of callusing is further affected by application of rooting media. Different rooting media used in the experiment possessed different physical and chemical composition, hence showed a varying effect on callusing. Porosity of rooting media seems to be most important factor for callusing. On the other hand water retention capacity of media is not of much importance for callusing. As callusing occurs within few days after operation, rooting media like sand having low water holding capacity, too gives better results only when if it is porous. Hence, porosity seems to be most

important factor for better callusing.

De Beor (1955) also reported that sand medium was better. She also reported that in sand, callus formation was stimulated at the expense of root formation.

Ford (1954) reported that among all media tried, soil and sand mixture proved superior in case of citrus cuttings.

Differences in root attributing parameters were mainly due to wide differences in the rooting media. A wider difference exist in soil and their combination with FYM and leaf mould. These differences created physiological conditions having wide differences in the contents of air, moisture in surroundings of the parts of branches operated for airlayers. When organic matter in the form of FYM and leaf mould was added to the soil, overall organic matter content of the rooting media increases, due to which water retention capacity of media, porosity, soil air increases in the rooting media. On the other hand when sand was added to the soil only porosity of media increases. It is evident from the experiments conducted by several workers that due to addition of organic matter in the soil, higher

content of air and moisture and suitable pH of media achieved, which creates conditions favourable for new growth, leading from callusing to root primordia development, from root primordia development to primary root formation and further promotes development of branch roots. On the other hand organic matter content of FYM is higher than leaf mould, hence due to which media M_4 (Soil + FYM) proved better than M_3.

During the process of root development callusing is subsequently followed by appearance of root primordia, formation of primary roots and its branching..It seems when there was more number of primary roots and higher rooting percent, it ultimately results in higher number of secondary roots, length of secondary roots, diameter of secondary roots and finally more dry weight of roots.

On the other hand growth attributing parameters viz. number of branches of airlayer, girth of shoots and survival percentage, were completely governed by the root attributing characters. Hence, when there was a good root growth, growth of the airlayer after detachment and planting in the nursery was also better.

In this agroclimatic zone soil was sandy loam occurs, percentage of sand in this soil was more and hence

further addition of sand in the soil did not improve the conditions of rooting media for airlayering in lime.

Peat found in the humid areas having more rainfall had affect similar to FYM & leaf mould in this region, improving porosity, water retention capacity of soil and reducing pH.

Findings of Chadwick (1932), long (1933), Hubert et al (1939), Grace and Farror (1941), Deboer (1947), Opitz (1951), Dickey (1952), Puccini (1954), Ford (1954), Adriance and Brisen (1955), Hartamann and Kestar (1959), Singh (1959), Singh (1960), Singh and Singh (1961), Clay (1964), Foster (1965), Florer and Kester (1966), Mukherjee (1967), Mukherjee (1972), Rathore (1982), Benerjee et al (1983), Gurjar (1983), Tomar (1985), Gurjar (1986) also found the efficiency of organic matter was due to better aeration and their acid reaction. These reports are similar to the results recorded in the present trial.

EFFECT OF CONCENTRATION OF GROWTH REGULATOR.

In this experiment five concentrations of growth regulators were used viz., Control (Go) IBA 7500 ppm (G_1) IBA 5000 ppm (G_2), 7500 ppm NAA (G_3) and 5000 ppm NAA(G_4)

These concentrations of growth regulators significantly affected diameter of callusing, rooting percent, number of primary roots, length of primary roots, number and length of secondary roots, dry weight of roots, survival percent, number of branches and girth of shoot. On the other hand, diameter of primary and secondary roots, and length of shoot were not affected by different concentrations of growth regulators.

Findings presented in the preceding chapter showed that maximum extent of callusing, rooting percent, length of primary roots, number of secondary roots, diameter of secondary roots, dry weight of roots, survival percent, number of branches and girth of shoots were recorded under the treatment growth regulator (G_1) IBA 7500 ppm while treatment G_4 (NAA 5000 ppm) was placed at second position with respect to all above characters, except length of secondary roots. Control (Go) was infeior to remaining treatments in respect of all characters except in length of secondary roots. The treatment growth regulator NAA 7500 ppm (G_3) proved to be significantly better than others with respect to rooting percent and ranked second with regard to number of primary roots.

Gautheret (1969), Olimen et al (1971) and Haising (1972) stated that auxin naturally or artificially applied is a requirement for initiation of adventitious roots on stem and indeed, it has been shown that the division of first root initiating, cell is dependent upon applied an endogenous auxins. Haising (1971) observed that root initials in stem is apparently dependent upon the native auxin in plant plus its synergist.

During the process of rooting, callusing occurs first and root primordia forms after wards. For prompt callusing proper concentration of carbohydrates in the branches, used for airlayering, is essential. Layering is usually done during rainy season, because during summer, growth is checked. Hence, syntnesized food material, including carbohydrate gets accumulated in the plants, so that it encourages quick healing and better callusing.

Further, during the process of rooting, application of exogenous auxin also helps to a greater extent.

Findings of Cooper (1940) presumed that the application of growth substances results in accumulation of certain chemical substances at the base of cuttings which stimulates the meristem to divide quickly and form roots. Whereas flevox and Kavaton (1952) was of the opinion

that plant regulators loosen the basal cells and admit more oxygen which induces root initiation, root formation and cell elongation.

Scoog (1964) stated that when the ratio of auxin to certain other plant constituents especially adenine is medium, callus is formed and when it is high root primordia develops.

From the internal physiology of plant, it was seen that root initials were present in different cells of plant parts and with the proliferation of tissue (root primordia), they got chance to come up out side to give visible growth to roots during operational mechanical injury given just below the node; treatment of airlayer with growth regulator to increase the concentration of root inducing hormones (auxin) and then placing in the rooting media. Thus allowing them to take advantage of existing enviromental conditions to become fit for the process of callusing and rooting. These advantages differ comparetively due to differences in chemical nature of growth hormones used in the trial.

It was observed that all concentrations of IBA and NAA improved root inducing parameters. Results of this experiment are in close proximity with the findings

of Cooper (1935), Marques (1938), Hitch cock and Zimmerman (1939), Jauhari and Nigam (1958), Singh (1963), Armour (1965), Singh (1969), Verma (1971), Tomar (1979), Tomar (1981), Gurjar (1983), Rathore (1982), Kushwah (1984), and Gurjar (1986). Hence, our results are justified.

As indicated in the preceding chapter better rooting and growth parameters were observed in the higher concentration of IBA (7500 ppm) followed by NAA (5000 ppm). It seems that NAA as a strong auxin improving rooting at lower concentrations in comparison to IBA. It is well known fact that secondary roots play an important role in plant survival. Secondary roots are induced more by NAA, Secondary roots give rise to root hairs and this helps in better establishment of plants. Root hairs are the agency to receive nutrients and water from soil. Higher number of root hairs will help in greater nutritional uptake and better growth of plants.

While going through the results of this experiment the treatment IBA 7500 was observed to be the best treatment and is similar to the findings of the workers like Verma (1971), Jauhari (1961), Jauhari (1962).

Besides this number of workers had also reported that IBA at 5000 ppm or 10,000 ppm was best for rooting. (Jauhari and Nigam 1958 ; Tomar 1979; Tomar 1981; Mukherjee 1967; Gurjar 1983; Kushwah 1984; Bhujbal 1972; Chonkar and Singh 1972; Rathore 1982). This variation is due to the fact that they had not taken 7500 ppm IBA in their trial or they might have conducted their experiments on different plants species, under different soil & climatic conditions. However, some workers had shown that growth regulator NAA was better than IBA, which are Hitch cock & Zimmerman (1939), Sharma (1981), Jauhari and Jit (1960), Gurjar (1986). Where as in this experiment IBA 7500 ppm was found better than NAA and this variation in results is perhaps due to the fact that above workers might have conducted their trial under different sets of enviromental conditions, different varieites, rooting media and mechanical injury. Hence the results of the present experiment are justified.

Observations recorded under rooting phase indicated that various root character played an important role in the survival and growth of airlayers after planting in the nursery.With regard to root attributing characters, NAA 5000 ppm was placed at second order, hence, growth and survival of airlayers after planting vary accordingly.

The findings of Armour (1965) in citrus, Singh (1965) Sen and Bose (1962) in Karonda, Gurjar (1983) in Kagzi lime showed better survival percentage due to IBA.

EFFECT OF INTERACTION BETWEEN ROOTING MEDIA AND CONCENTRATION OF GROWTH REGULATOR.

Treatment combinations between different rooting media and concentrations of growth regulator differed significantly with respect to callusing, number of primary roots, length of primary roots, number of secondary roots, length of secondary roots, diameter of secondary roots, dry weight of roots, survival percent and girth of shoots.

It is evident from the findings given in the preceding chapter-IV that maximum extent of callusing was observed in the treatment combination $G_1 M_2$ and G_4M_1 and both these were found significantly superior to remaining treatment combinations. Highest number of primary roots were noted in the treatment combination G_3M_1 which was proved significantly better than rest of the combination. Combination G_1M_3 was found significantly superior to remaining treatment combinations except G_1M_4 and G_2M_4 with respect to length of primary roots. Treatment combination G_1M_1 and G_0M_3 were observed

significantly better than rest of combinations except G_4M_4, G_2M_3, G_3M_4 with respect to number of secondary roots. However treatment combination G_2M_1 was proved significantly better than remaining treatments except G_4M_2 with respect to length of secondary roots. Treatment combination G_2M_4 was observed statistically better than remaining treatments except G_1M_1, G_4M_4, G_1M_3, G_4M_2 and G_0M_3. Treatment combination G_1M_4 possesses maximum dry weight of roots significantly better than rest of the combination except G_1M_3, G_4M_4, G_4M_3 and G_1M_2. However maximum survival percentage was recorded in the treatment combination G_1M_4 statistically better than remaining treatments, except G_4M_4 and G_3M_4. Treatment combination G_1M_4 was found significantly superior to remaining treatments with respect to girth of shoots of airlayers after planting in the nursery.

C H A P T E R - VI

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SUMMARY, CONCLUSION AND SUGGESTION

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CHAPTER - VI

SUMMARY, CONCLUSION AND SUGGESTIONS

The experiment "Effect of growth regulators and rooting media on callusing rooting and survival of airlayers of kagzi lime (Citrus aurantifolia swingle)" was conducted during rainy reason of year 1988-89 in the experimental area of department of Horticulture, J.N.K.V.V. Jabalpur campus college of Agriculture, Gwalior in order to find out the best rooting media & optimum concentration of growth regulator for successfull propagation kagzi lime by air layers. Randomized block design with three replication used for experiment.

For experimental trial twelve kagzi lime plants of uniform size and vigour were selected. On these plants well matured and healthy branches of pencils thickness were selected. 25 branches were airlayered in each treatment and 500 branches under each replication. Thus total number of branches layered were1500 in all the three replication. Four rooting media were tried in the experiment viz. M_1(soil), M_2(soil+Sand), M_3 (soil+leaf mould), M_4(soil+FYM), and five concentrations of growth regulator tried were G_0(Control), G_1(7500 ppm IBA), G_2(5000 ppm IBA), G_3(7500 ppm NAA) and G_4(5000 ppm NAA).

Observation regarding root studies were recorded each after 10 days interval and of growth studies at fortnight interval in nursery after transplanting. Air layers were detached from respective mother plants 45 days after operation and were transplanted in the nursery. Data of the Final observations of rooting studies and growth (60 days after transplanting) were statistically analysed and the analysis of variance is presented in Appendix I.

The observations on the following characters were recorded.

1. Callus formation
2. Success rooting
3. Number of primary root
4. Diameter of primary root
5. Dry length of primary root
6. Number of secondary root
7. Diameter of secondary root
8. Length of secondary root
9. Dry weight of root
10. Survival percentage
11. Number of branches
12. Girth of shoots
13. Length of shoots

Effect of Rooting Media :-

1. Maximum callusing was noted in the treatment M_2 significantly better than rest of the rooting media.

2. Highest number of primary roots were recorded under the treatment M_4, significantly superior to M_3, M_2, and M_1. While minimum number was noted in the treatment M_1 and M_2.

3. Statistical Similar length and diameter of primary roots, length of secondary roots & length of shoots were found under all the rooting media.

4. Maximum number of secondary roots were counted in the treatment M_3 & M_4 which were found statistically superior to M_2 & M_1.

5. Maximum diameter of secondary roots, Rooting percent and dry weight of roots were observed in, two statistically similar treatments M_4 & M_3 while minimum were recorded in treatment M_2.

6. Maximum survival percentage and girth of shoot was recorded under the treatment M_4, significantly superior over rest of the treatments.

7. Treatment M_4 & M_3 were similar with respect to number of branches and were superior to rest of the treatments, minimum was noted in M_1.

Effect of Concentration of growth regulators :-

1. Maximum callusing was noted in treatment G_1 statistically similar to G_4 & G_3 but significantly superior to G_2.

2. Maximum number of primary root was counted under the treatment G_3, which was proved significantly superior to others. All concentrations are proved

significantly superior to G_0.

3. Similar observations was noted with respect diameter of primary roots, length of secondary roots and length of shoots under various concentrations of growth regulators.

4. Maximum length of primary root was noted in the treatment G_1 significantly superior to rest of the treatments except G_4.

5. Highest number of secondary roots was counted in the treatment G_1, significantly superior over remaining treatments. All treatments are statistically superior to G_0 (Control).

6. Maximum length of secondary roots was observed in treatment G_2, significantly superior over others.

7. Highest rooting percent, dry weight of roots, and girth of shoots were noted in the treatment G_1 and significantly superior to rest of the treatments. All treatments were found statistically better to control except with respect to root weight.

8. Maximum survival percentage was recorded under treatment G_1 and was significantly superior over

rest of the treatments except G_4. All treatments were also found superior over G_0(Control).

9. Similar number of branches was observed in all treatments except control and were found statistically superior to G_0 (Control).

Effect of interaction :-

1. Maximum callusing was observed in the treatment interaction $G_1 M_2$ and $G_4 M_3$, and were proved significantly superior over remaining treatment combinations.

2. Highest number of primary roots was counted in the interaction $G_3 M_1$ and was found significantly superior over rest of the combinations.

3. Maximum length of primary root was noted in the interaction $G_1 M_3$, which was found significantly superior over remaining interactions except $G_1 M_4$ & $G_2 M_4$.

4. Diameter of primary roots, rooting percentage, number of branches and length of shoots were found statistically similar in various treatment combinations.

5. Maximum number of secondary roots was observed

in interactions $G_1 M_1$ and $G_0 M_3$ were found statistically superior over rest of the instructions except $G_4 M_4$, $G_2 M_3$ and $G_3 M_4$.

6. Highest length of secondary roots was observed in the treatment combination $G_2 M_1$ & was proved significantly superior over remaining treatments except $G_4 M_2$.

7. Highest diameter of secondary roots was noted under interaction $G_2 M_4$ & was found significantly better to rest of the interactions except $G_1 M_1$, $G_4 M_4$, $G_1 M_3$, $G_4 M_2$ and $G_0 M_3$.

8. Maximum dry weight of roots was recorded in the interaction $G_1 M_4$ which was found statistically superior over remaining interactions except $G_1 M_3$, $G_4 M_4$, $G_4 M_3$, $G_1 M_1$ and $G_1 M_2$.

9. Highest survival percentage of airlayers was observed in the interaction $G_1 M_4$ & was found significantly better over $G_4 M_4$ and $G_3 M_4$.

10. Maximum girth of shoot was recorded under the interaction $G_1 M_4$ which was found statistically superior over rest of the interaction.

Conclusion:-

1. Among the four rooting media, M_3 (Soil+leaf mould) and M_4(Soil+FYM) proved significantly better for rooting of kagzi lime airlayers.

2. With respect to different concentrations of growth regulators, G_1 (IBA 7500) proved significantly better for the characters under study.

3. The interaction between G_1 (IBA 7500 ppm) and rooting media M_4(soil+FYM) was found significantly better to all treatment combinations.

Suggestions for further work :-

1. Since it was the first year of the trial, it is suggested that this experiment should be repeated next year for the confirmation of the results of the present investigation.

2. Some other rooting media & few other concentration of growth regulators should also be tried.

3. Mixtures of different concentration of IBA and NAA should also be tried.

4. Different concentration of growth regulator and rooting media should be tried with different dates of layering.

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APPENDIX-I

ANALYSIS OF VARIANCE

Mean sum of square of Callusing, Rooting and survival of airlayering of Kagzi Lime.

Source of variation	D.F.	Diameter of callusing	No.of Primary roots	Length of primary roots	Diameter of Primary roots	No.of secondary roots	Length of secondary roots	Diameter of secondary roots
1. Replication	2	0.00177	25.81	19.21	4.935	21.24	12.16	0.0239
2. Rooting media	3	0.01567**	120.59**	1.134	0.199	1218.8**	0.2897	0.02518**
3. Growth regulator	4	0.03517**	37.54**	2.36*	0.285	312.54**	9.229**	0.0082
4. Interaction (G x M)	12	0.04187**	50.72**	1.638*	0.098	883**	0.3998**	0.01578**
5. Error	38	0.000493	0.345	0.655	0.24	31.66	0.137	0.0045
TOTAL								

Source of variation	Rooting percentage	Dry weight of roots	Survival percentage	No. of branches	Length of shoots	Girth of shoot	Tabulated 'F' value 5%	1%
1. Replication	2.018	0.067	12.36	1.237	41.25	0.00179		
2. Rooting media	487.69**	0.797	277.02**	6.13**	2.673	0.01348**	2.85	4.35
3. Growth regulator	355.41**	9.43**	682.99**	10.26**	3.992	0.05897**	2.62	3.868
4. Interaction (G x M)	6.225	0.099*	15.447*	0.533	4.342	0.00075**	2.018	2.69
5. Error	9.124	0.0468	7.191	0.5749	8.125			

* Significant at 5% level.

** Significant at 1% level.

NS (Non significant).

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Appendix - ii

MEAN VALUE OF THE VARIOUS ROOTING MEDIA AND CONCENTRATION OF GROWTH REGULATOR

Treatments	Callus formation in (Cm.)	Rooting percent	Number of primary roots.	Length of primary roots.	Diameter of primary roots.	Number of secondary roots.
			ROOTING MEDIA			
M_1	0.188	79.24	13.10	3.70	1.046	48.06
M_2	0.258	74.88	13.43	3.595	1.1102	50.30
M_3	0.217	85.42	17.56	4.169	0.841	64.79
M_4	0.191	87.28	18.66	4.015	1.019	64.64
S.E.(m) ±	0.0057	0.7797	0.516	0.2088	0.1264	1.4526
C.D. at 5%	0.0164	2.233	0.434	N.S.	N.S.	4.6
			CONCENTRATIONS OF GROWTH REGULATOR			
G_0	0.1185	75,47	13.41	3.421	1.023	53.55
G_1	0.2477	89.32	16.68	4.548	1.0105	65.95
G_2	0.2212	79.22	14.29	3.653	0.9122	54.91
G_3	0.2365	84.97	17.67	3.803	1.058	54.78
G_4	0.244	79.52	15.69	4.059	1.017	55.76
S.E.(m) ±	0.006414	0.8719	0.1695	0.2336	0.1414	1.623
C.D. at 5%	0.01836	2.497	0.485	0.669	N.S.	4.69
S.E.(m) ±	0.0128	1.7438	0.339	0.4672	0.2828	3.247
C.D. at 5%	0.0367	N.S.	0.971	1.338	N.S.	9.30

MEAN VALUE OF THE VARIOUS ROOTING MEDIA AND CONCENTRATION OF GROWTH REGULATOR

Treatments	Length of Secondary roots	Diameter of Secondary roots	Dry Weight of roots	Survival percent	Number of branches	Girth of Shoot	Length of shoot
			ROOTING MEDIA				
M_1	1.864	0.4829	1.146	72.71	5.36	0.315	40.214
M_2	1.8574	0.4057	1.04	72.99	5.94	0.332	39.342
M_3	2.1314	0.4238	1.458	78.47	6.48	0.361	39.475
M_4	2.578	0.4860	1.508	81.48	6.82	0.382	39.33
S.E.(m) ±	0.953	0.01731	0.0558	0.692	0.195	0.0027	0.736
C.D.at 5%	N.S.	0.0496	0.16	1.98	0.5606	0.00782	N.S.
			CONCENTRATIONS OF GROWTH REGULATOR				
G_0	2.105	0.4238	0.42	63.4	4.52	0.235	38.72
G_1	2.1665	0.4795	2.47	82.3	6.75	0.4047	39.39
G_2	2.326	0.4467	1.037	77.45	6.3	0.363	40.40
G_3	1.74	0.4248	0.575	78.02	6.5	0.335	39.74
G_4	1.55	0.4729	1.937	80.9	6.67	0.403	39.74
S.E.(m) ±	0.1068	0.01934	0.0624	0.774	0.218	0.00305	0.822
C.D.at5%	0.306	N.S.	0.178	2.216	0.626	0.00874	N.S.
			INTERACTION (GxM)				
S.E.(m) ±	0.2137	0.0387	0.124	1.548	0.437	0.00610	1.64
C.D. at 5%	0.6121	0.1109	0.357	4.433	N.S.	0.01749	N.S.

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