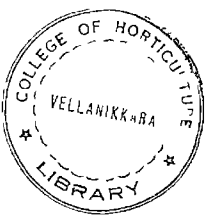
STANDARDISATION OF PROPAGATION TECHNIQUE AND GROWING MEDIA IN REX BEGONIA

[*Begonia rex* (Putz.) Inimitable]



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DECLARATION

I hereby declare that this thesis entitled "standardisation of propagation technique and growing media in Rex begonia (Begonia rex (Putz.) Inimitable)" is a bonnfide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

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Vellayani,
30--7--1988.

CERTIFICATE

Certified that this thesis, entitled "Standardisation of propagation technique and growing media in Rex begonia (Begonia rex (Putz.) Inimitable)" is a record of research work done independently by Smt Chitra, D.V., under my guidance and supervision and that it has not previously formed the basis for the award of any degree/fellowship or associateship to her.

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INTRODUCTION

1. INTRODUCTION

Begonia (Begonia rex (Putz.) Inimitable) is one of the important foliage plant best suited for indoor gardening. It is native of Assam, where it is a half-hardy, herbaceous, subshrubby plant with thick, fleshy rhizomes creeping below and bearing inflorescence in an axillary cyme with pale rose to red flowers. The plants prefer to grow under a moist atmosphere, shady situation and a porous soil (Jindal, 1968).

Rex begonias are usually propagated through leaf cuttings which is easier and economical and provide a large number of plants when compared to other methods of propagation. New plants develop from secondary meristems arising from mature cells at the base of the leaf blade or from the petiole (Hartmann and Kester, 1972). New plantlets are also developed from the secondary meristems, where veins are cut and those are detached and potted separately. Original leaf and petiole gradually disintegrate. Eventhough this is considered as a slow method of propagation, this is successfully practised on a commercial scale in many plants (Gaycon, 1976).

Other methods of propagation include the use of stem cuttings and tubers. However, foliage type of begonias are not propagated by tubers.

Propagation through stem cuttings ultimately ruin the plant, because of their high sensitivity. However, the most suitable method of propagation and the effect of IBA on rooting and growth were not standardised. Hence the present study aims at finding out the most suitable and easy propagation methods using various vegetative parts and different concentrations of rooting hormone (IBA).

Standardisation of potting medium for begonia has been reported with certain specially suited media. Most of the recommendations are based on the results obtained outside the country which could not be adopted as such to our conditions. Hence the present study was taken up to find out the suitability of certain easily available and cheap materials under Kerala conditions as growing media for Rex begonia.

The investigation was undertaken with the following objectives:

1. To standardise the propagation techniques of Rex begonia.
2. To standardise suitable growing medium.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

The review of literature relating to the present study is given under the following titles. Since the references relating to begonia were inadequate, studies on related crops have also been reviewed.

2.1 Propagation with leaves.
2.2 Propagation with stem cuttings.
2.3 Standardisation of growing medium.

The suitability for a particular method of propagation depends upon the kind of plant. Mott (1975) reported propagation of Rex begonia by rhizome pieces and leaf with petiole cuttings. Zanutto (1977) reported the use of leaf cuttings, seeds, tuber segments, stem cuttings and layers for propagation of begonias.

2.1 Propagation with leaves.

Plants propagated vegetatively reproduce all the characters of the parent plant. Many cells in vegetatively propagated plants, even in mature parts are capable of

returning to the meristematic condition and produce the necessary shoot or root system or both.

Wright and Titchmarsh (1981) reported that Begonia rex can be propagated through leaf cuttings. Gayson (1976) described the leaves of Rex begonia as large and firm and hence propagated by flat-leaf cuttings. An important characteristic associated in this case is that one leaf can be forced to put out many tiny plant lets.

2.1.1 Propagation techniques with leaves

Propagation through leaf is adopted in many plants including Begonia rex, Saintpaulia and Sansevieria (Wright and Titchmarsh, 1981). Gayson (1976) reported the propagation of Pelargonium hortorum and Sinningia speciosa by leaves.

According to Hartmann and Kester (1972), new plants develop from the secondary meristems produced from mature cells at the base of leaf blade or from the petiole in leaf cuttings of Begonia rex, Sedum, Saintpaulia, Sansevieria, Crassula and Lilies wherein adventitious root initials form on leaves much more readily than adventitious buds.

Studies were conducted on the histology of adventitious shoot and root formation on leaf-petiole cuttings of Rieger begonia cv. Aphrodite Peach (Mikkelsen and Sink, 1978). The studies revealed that epidermal and sub-epidermal cells formed a callus at the basal portion of the petiole. Roots arose from cells of the internal portion of the callus and from parenchymatous cells of the petiole while shoots arose from cells of the surface of the enlarging callus.

Regenerative ability of leaf depends on the age of the source plant. Garner and Hatcher (1962) concluded that stock plants should be in active vegetative growth and not entering the flowering stage to have the highest regeneration capacity.

The influence of age of the leaf in the process of regeneration is reported by several authors. Studies conducted in Peperonia griseoargentea by Ozeri and Evenari (1979) showed a better rooting response in mature leaves than young leaves. Marynen (1966) subjected leaves of Elatior begonia cvs Exquisite and Rose Queen in a phytotron. Older leaves were preferable to young ones (physiological maturity being more important than size after a certain stage of development).

According to Heide (1965), young, expanding leaves of Begonia cheimantha had a greater ability to form buds than older ones. In a trial with Flatlor begonia cv. Aphrodite, Systema (1977) found that leaves of medium age gave better results than younger or older ones. However, leaf age was not found critical for growth as evident from the experiments of Onofeghara and Commeh (1981) when excised young, mature and old leaves of Bryophyllum pinnatum were cultured on moist filter paper.

Many researchers have conducted experiments on the area and size of the leaf in the process of regeneration of leaf and leaf cuttings. In Peperomia griseoargentea, an increase in leaf area or weight, resulted in a decrease in rooting response per unit area. The rooting response was similar in all leaf cuttings and it was determined by the number and length of the veins and not by the area between the veins (Ozeri and Evenari, 1979).

Prevot (1968) used leaf pieces (1 to 20 cm length) from Begonia rex cvs Rauroiff and President Carnot. The smaller the piece, greater was the number of buds and roots in proportion to length. In a trial with Begonia cheimanthe leaves, the larger the leaf blade (upto 7 cm diameter), greater was the number of roots and shoots formed.

Leaf size had no significant effect on the subsequent development of Begonia hiemalis leaf cuttings as observed by Powell and Bunt (1979). However, when large leaves were trimmed to a size comparable to that of small leaves, rooting was observed to be poor and also such leaves produced hardly few shoots.

Hartmann and Kester (1972) deviced a method for propagating Begonia rex. The large veins when cut on the underside of the mature leaf and laid flat on surface of the propagation medium with upper surface exposed under humid conditions, new plantlets originated at the point where each vein was cut and the old leaf blade gradually disintegrated.

A petiole length of 3cm produced better root and shoot growth in leaves of Elatior begonia cv. Exquisite (Harynen, 1966).

Bigot (1967) reported the results of trials with leaf cuttings of fourteen Begonia rex varieties. Leaf fragments when cultured in 16 h days at 20-22°C, all varieties developed roots and buds after 35 days. Bud formation was more frequent on the upper than on the

lower surface except for var. Reiga. Eleven varieties out of the fourteen tested showed polarity of new growth which was localised at the petiolar face of the fragments.

Reports of Powell and Hunt (1980) showed that leaves of Rieger begonia cv. Schwabenland Red produced about 30 buds per cutting, 13 weeks after insertion in the rooting mixture, of which an average of 8.2 developed into fully grown shoots in long days as against 1.9 in short days.

2.1.2 Effect of growth regulators on leaf propagation

As early in 1934, Went found that auxins such as IAA stimulated the production of adventitious roots in stem and leaf cuttings. Among the synthetic root promoting chemicals, Indole 3-butyric acid and Naphthalene acetic acid are the most widely used in stimulating adventitious root formation in cuttings of which IBA is the best.

Since then, experiments conducted by Plant (1940) revealed that differentiation and behaviour of meristematic tissue is determined in a plant part, by specific concentration of growth substance which influences root and shoot production.

According to Audus (1959), species which normally root with ease will usually respond to auxins with an accelerated rate of initiation of root meristems and an increase in the quantity and quality of roots produced.

IBA is associated with formation of root primordia. Studies conducted in leaves of begonia showed a marked increase in RNA content of the basal tissues during the period of root primordia formation, but no increase in DNA content (Hartmann and Kester, 1972).

Root promoting chemicals are usually helpful in propagation through leaves. Studies on the regenerative capacity of Begonia cheimantha leaves were conducted by Heide (1965). Auxin at high concentrations inhibited bud formation and stimulated root formation while low concentrations promoted bud formation to a lesser extent. Legerstedt (1967) cultured leaf discs of begonia under continuous fluorescent light on filter paper with 3 ml of distilled water as the culture medium. Treatment of discs with IBA at various concentrations caused excellent rooting responses, notably at 100 mg per litre and 500 mg per litre. Concentrations above 100 mg per litre caused greater root initiation, but retarded bud development. Chiyah (1972)

found that when IAA was applied to leaf fragments of Begonia rex under aseptic conditions, bud formation was stimulated at 2.5 x 10^{-5}M while 10^{-6}M resulted in less bud formation than control. Under non-aseptic conditions, IAA had no effect except at a higher dosage (10^{-3}M) when no buds was formed, but roots appeared. Horváth and Horváth (1969) treated petioles of Begonia semperflorens with 1000 mg per litre IAA and rooting was induced in 8 days as against 11 days for control.

In Peperomia caperata leaves, IBA promoted root and shoot formation as reported by Sympson and Chin (1980). Root and bud formation was stimulated in leaves of Streptocarpus cv. Susi at IBA 100 or 500 mg per litre while 1000 mg per litre caused retardation as suggested by Schärer (1986).

According to Woszczyn'ska and Borys (1976), when petioles of Saintpaulia ionantha were treated with IBA at 1 to 1000 ppm for 1 to 24 h and raised in distilled water, rooting was stimulated and the effect increased with increasing concentrations of IBA, the maximum rooting being obtained at 1000 ppm. Milinčáí (1974) observed rapid and prolific rooting when Saintpaulia ionantha petioles were kept in 0.03 per cent heteroauxin solution.

Pimpini and Libera (1986) reported that when leaf cuttings of Sansevieria trifasciata were immersed in 100, 500, 1000 and 2000 ppm IBA for 30 minutes and placed in sand, the number of rootlets were found to increase upto the 1000 ppm concentration of IBA. The lowest rate increased rootlet length, bud number and growth and the higher rates significantly reduced the bud numbers.

In an experiment with culturing excised leaves of Bryophyllum pinnatum on moist filter paper at varying concentrations of IAA ranging from 5 to 500 ppm, growth was promoted, but the response varied with leaf age and concentration (Onefeghara and Commeh, 1981).

In Chrysanthemum, mature leaves with petioles kept for 6 h in 100 mg per litre IBA stimulated rooting while IBA at 300 to 500 mg per litre inhibited rooting (Movchan, 1979). Abdulla eva (1973) found that dipping the leaves in heteroauxin at apical end stimulated root and shoot growth in Phlox paniculata.

Use of growth substances other than auxin is also reported. Good bud formation was obtained by applying cytokinin with auxin (Systema, 1977). He concluded the best

treatment for Elatior begonia cv. Aphrodite is to immerse the base of petiole in benzyladenine (10 mg per litre) solution for 24 h followed by a dip in 0.05 per cent NAA in fine talc.

2.2 Propagation with stem cuttings

A wide range of plants can be propagated by stem cuttings including herbaceous, softwood, semihardwood and hardwood plants (Goodley, 1981). Roots were formed before the development of shoots when softwood cuttings were used as observed by Constantinescu et al. (1965).

Propagation of begonia by stem cuttings has been reported by several authors. Mott (1975) reported propagation of Begonia rex by rhizome pieces of 1 to 2 inches length. Thompson (1978) recommended propagation by stem cuttings in Begonia odetelantha. Subsequently, Wright and Titchmarsh (1981) proposed propagation by stem cuttings in fibrous rooted Begonia socotrana and its varieties, namely, John Heal and Gloire de Lorraine. But fewer useful cuttings were produced from pinched out shoots of large flowered pink varieties and dark leaved varieties of Lorraine begonia.

Some of the earlier researchers have obtained a favourable response in rooting by retaining the leaves on the cuttings. According to Fretz et al. (1979), stem cuttings (except hardwood and cane cuttings) should have 3 to 4 leaves for quicker rooting. Softwood or herbaceous cuttings are generally taken with 3 to 5 inches length with leaves retained on the upper portion of the cutting. In an experiment on retention of leaves on terminal cuttings of Pelargonium graveolens, Dass et al. (1983) obtained 66.4 per cent rooting with 6 leaves retained as against 47 per cent in control which did not bear any leaves.

2.2.1 Effect of growth regulators on rooting of stem cuttings

The aims of treating cuttings with auxins are to hasten root initiation, to increase the number and quality of roots produced per cutting, to increase uniformity in rooting and to increase the percentage of rooting. (Hartmann and Kester, 1972). Audus (1959) reported that plants which normally root with ease will usually respond readily to auxins at an accelerated rate. Auxins from buds and leaves accumulate at the basal end of stem cuttings and rooting occurs in the normal case, but when auxin is applied exogenously, it increases the production of roots. Relative

effectiveness of auxins vary with concentrations used and also the plant species tested. For easy-to-root cuttings, weaker concentrations are found better and for difficult-to-root species, stronger concentrations are found to give a better response.

Bala et al. (1970) planted stem cuttings of Bryophyllum tubiflorum after treatment with 100 mg/l IBA and the rooting ability and number and length of roots were improved. In Pelargonium graveolens, Kumar et al.(1980) suggested better rooting effect of IAA than IBA on terminal cuttings. Hein and Schneider (1981) from their experiments on Pelargonium zonale concluded that rooting was best with 200 mg/l IBA in the var. Rubin. Higher rates (300 mg/l IBA) gave poorer rooting and at 400 mg/l IBA, losses due to secondary infection from foot rot occurred. Gabisoniya (1972) successfully achieved the multiplication of Geranium No.24 after treatment of cuttings with a heteroauxin (unspecified) at 0.005 per cent for 3 to 6 h. Stem cuttings of Ipomoea fistulosa dipped in IBA (100 mg/l) + ATP (1 mg/l) for 24 h and planted in 1:1:1 sand:soil:farmyard manure produced the largest number of roots per cutting (Kumar et al., 1984). Shin and Lee (1979) reported that chrysanthemum could be propagated better by dipping the cuttings in solutions of

0.5 to 1 ppm IBA. In Hedera helix, rooting was best in single leaf cuttings taken from juvenile shoots and dipped in a solution of 50 per cent ethanol + 3000 ppm IBA for 15s as concluded by Richardson and Humphries (1982).

Growth substances applied to azalea cuttings before mist propagation gave 96 per cent rooting with 40 ppm IBA for cv. Rose and 92 per cent rooting with 10 ppm IBA for cv. Kirin (Baldi, 1964). Banko (1984) proposed that dipping the cuttings of holly cv. Hellari and azalea cv. Hershey Red in 4000 ppm IBA for 5s was detrimental to rooting in holly. In an experiment by Mohan and Maurya (1978) in Gardenia florida, cuttings treated with 100 ppm IBA proved superior in respect of percentage of rooted cuttings (72.54 per cent) while minimum (30.51 per cent) was recorded in control treated with distilled water. According to Singh (1984), hardwood cuttings of Jasminum sambac cv. Motia kept under intermittent mist and treated with IBA 4000 ppm produced significantly higher rooting. The survival percentage of transplants were 100 per cent at IBA 2000 ppm and 4000 ppm.

Eliasson (1961) reported that application of synthetic auxins to stem cuttings at high concentrations can inhibit bud development, sometimes to the point at which no shoot

growth take place eventhough root formation has been adequate. The concentration of auxin (IAA) which stimulate shoot growth may be inhibitory to root growth as postulated by Saxena and Singh (1982). Studies by Chibbar et al. (1974) revealed that stem cuttings of Ipomoea fistulosa dipped in 10 mg/l or 100 mg/l IBA enhanced rooting, but IBA at 100 mg/l suppressed bud sprouting and inhibited shoot growth.

Application of growth regulator compounds in solutions or aqueous suspension as foliar sprays before collection of cuttings is practised in many species. Audus (1959) obtained good degree of success by spraying leaves of mother plants with dilute solutions of auxins. Stoutemyer and O'Rourke (1945) obtained considerable success with certain evergreen shrub species by spraying mother plants with 2, 4, 5-T (10 to 100 ppm) or its sodium salt. Cuttings taken 9 to 40 days after spraying showed essentially the same rooting response as cuttings treated by other methods. However, Yeates (1947) was unable to get much promising results by spraying Coleus with auxin solution.

Treatment with water is found to have some growth promoting effect. In Dracaena fragrans Ker cv. Lausangeana, initial bud-break was hastened in single stem cane cuttings by soaking the base in water before placement in the propagating medium (Poole et al., 1974).

2.3 Standardisation of growing medium

Most of the recommendations based on the results achieved in foreign countries are not as such applicable to our conditions. For a medium to be useful in propagation, it should be inexpensive and readily available, uniform, easily managed, not waterlogged and able to hold a uniform temperature.

The suitability of a substrate for ornamentals depends on a high water, air and heat economy and an ability to fix nutrients so that they are not lost through leaching but do not accumulate to harmful salt levels (Boodt and Verdonck, 1972). Numerous materials in various combinations are available as potting media which vary from field soil to mixtures of organic and inorganic substances which includes sand, ashes, peat, flu-dust or fly-ash, sawdust, pine, fir and hardwood bark, sphagnum moss, rice hulls, cocoa fibre, vermiculite, perlite, styrofoam, calcined clay, processed wood fibre etc. of which the more common is sand (Fretz et al., 1979). According to Bugbee and Frink (1983), few differences appeared to exist between the quality of general potting soils and those labelled as mixes for cacti or African violets.

Sand is a good rooting medium for some woody ornamentals, but not used for many floriculture crops since it does not hold moisture well (Boodley, 1981). Hartmann and Kester (1972) concluded that sand is the heaviest of all rooting media which contains no nutrients or buffer capacity, has only a low water-holding capacity and need more frequent watering. Cuttings rooted in sand produce long, unbranched, coarse and brittle roots and when rooted in sand + peat moss, produced well-branched, slender and more flexible roots. Addition of peat moss to sand improved rooting of cuttings to a great extent as reported by Hitchcock (1928). Investigations by Brown and Pokorny (1975) showed an increase in bulk density and decrease in percolation rate and Cation exchange capacity as the percentage of sand increased in a medium composed of milled pine bark and sand. Peat can be used as soil conditioner to increase or regulate the organic content of soil. Vermiculite loses its structure with time and gets compressed eventually when used in potting mixtures. Perlite has no Cation exchange capacity or nutrient value and do not get broken down or compressed with prolonged use. Sphagnum moss is sterile, light weight, has high water-holding capacity and has some fungistatic properties.

Various type of bark viz., pine, fir, redwood or hardwood mixtures are used in soil mixes which exhibit a much slower rate of decay. Loam and sandy loam can be included in the soil mixture for container growing of rooted cuttings or young seedlings, but is unsatisfactory if used unamended. It is amended with organic matter such as peat, wood shavings or bark to improve its water-holding capacity (Fretz et al., 1979). Leaf mould or compost can be used as soil amendments. Singh and Singh (1961) suggested that a mixture of sand and leaf mould is the best for ready rooting of cuttings. Addition of leaf mould to sand improved the water-holding capacity and also improved its gaseous exchange capacity. Guistinian and Tesi (1982) found that leaf mould contained most NPK and was suitable for growing many flowering species. Chatterjee and Mukherjee (1980) reported higher water-holding capacity (66.04 per cent) and total nitrogen content (0.52 per cent) for leaf mould.

Fretz et al. (1979) reported the composition of traditional potting mixes for growing of rooted cuttings as well as seedlings. They observed that a mixture of 1 or 2 parts sand, 1 part loam and 1 part peat is satisfactory for potting young rooted cuttings or seedlings. According to Hartmann and Kester (1972), 1 or 2 parts sand, 1 part loam,

and 1 part peat moss or shredded bark or leaf mould is good for potting rooted cuttings and young seedlings. For container grown nursery stock, 1:2:1 sand:loam:peat moss or shredded bark or leaf mould is good.

Several materials are used alone or in combination as growing media. Soukup (1982) tested 1:1 composted pine or spruce bark and peat mixture for greenhouse plants including begonia, azalea, chrysanthemum, pelargonium, petunia and gerbera and obtained very promising results in these plants. The soil should be very porous for Rex begonia and soil used is 2:1:1 leaf mould:soil:sand as suggested by Bose and Bhattacharjee (1980). Seddon (1982) proposed 4:4:3:2 loam:peat:leaf mould:coarse sand or 2:1 leaf mould:sand as special composts for Begonia. Sphagnum peat moss can be used along with other materials in pot mixes. Mott (1975) reported the use of 2:1:1 sphagnum peat moss, vermiculite or soil, perlite or sand or a mixture of 50 per cent peat for moisture-holding capacity for potting of Rex begonias. In a comparison of 10 potting media for Rieger begonias by Kiplinger et al. (1973) all proved suitable with a mixture of peat and vermiculite giving the best results. Uncomposted pine bark is also proved as one of the best medium for Rieger begonias, gloxinias and Coleus by Prasad (1980).

Höber and Fischer (1980) obtained best results with regard to fresh weight and root length of cutting for Elatior begonia hybrid Mayer's Rote grown from cuttings rooted in perlite. The addition of 20 per cent by volume of perlite to the potting substrate is recommended to provide aeration for Elatior begonia (Scharpf and Grantzau, 1985). The same authors in 1984 used substrates comprising of white peat, black peat, a standard potting compost and 4 bark products mixed with 40 per cent white peat for growing Elatior begonia cv. Aphrodite and obtained bark products as satisfactory substitutes for the conventional methods. Reese et al. (1979) conducted studies on Elatior begonia, Kalanchöe blossfeldiana and chrysanthemum. For herbaceous species, 4:1 ground bark:sand was best as assessed by the number of roots produced. Hill (1979) reported good results with 50:50 white peat:black peat mixture for Elatior begonia and pelargoniums.

Nagamura (1980) used a combination of 4:3:3 soil:sawdust:rice husk, 75:25 sawdust:rice husk and 100 per cent sawdust alone for growing several plants. Begonia was found to produce better root growth in 100 per cent sawdust. Since then, Nagamura (1982) compared the standard

potting mixture (1:1:1 sand:loam:compost) with another potting mixture (75:25 sawdust:rice hull). The growth of begonia was not satisfactory in sawdust + rice hull mixture because of high water retaining properties. The plants grew well in another compost having high air:water ratio. Experiments conducted using fresh bark (Wiśniewska-Grzeszkiewicz and Marcinkowski, 1976) observed its use as a substitute for high peat. This gave satisfactory results in rooting of cuttings of Begonia fuchsioides, Pelargonium hortorum and Peperomia obtusifolia. Schuster et al. (1977) in a study compared 70 per cent hardwood bark + 30 per cent vermiculite, 80 per cent hardwood bark + 20 per cent sand, 35 per cent hardwood bark + 35 per cent peat + 35 per cent vermiculite and 70 per cent pine bark + 30 per cent vermiculite. Most media produced better acceptable plants of Begonia semperflorens cv. Scarletta, Coleus blumei cv. Carefree Scarlet and Impatiens wallerlana cv. Elfin White of which half received a slow-release fertilizer before planting, other supplied with liquid fertilizer during seedling growth. The clay content in growing media had a marked effect on plant growth. In Begonia hiemalis, the more clay the compost contained, the less well the plants grew (Djurhuus and Gislerod, 1985). Mixtures of sawdust and chaff were used for growing Begonia hiemalis, Kalanchoe and Saintpaulia by

Nagamura and Urabe (1973). Media containing 100, 75, 50, 25, or 0 per cent sawdust and balance as chaff proved successful. In an experiment by Marahrens and Toop (1986), Begonia lucerna cuttings were planted in sand:peat media. Roots produced were short and fibrous and shoots were short, but of a good colour. Best root and shoot growth resulted from cuttings planted in peat + vermiculite and peat + perlite amended with superphosphate and calcium nitrate.

McCormick (1961) reported the use of a compost of equal parts of loam, leaf mould, well-rotted manure and silver sand for tuberous begonia. The use of Finnish peat was also reported by several workers. Finnish peat with or without pine litter which contained fertilizers was best for the growth and development of tuberous begonia seedlings according to Maegeman and Van Onsem (1966). The best rooting (75 per cent) was obtained with cuttings of multiflora begonia cv. Hélène Haerens in Finnish peat. De Boodt and Schelstraete (1967) working on multiflora begonias reported best rooting in Finnish peat and perlite and plastic flock amendments improved rooting when added to white peat and conifer litter in ratios of 1:3. They recommended the addition of chalk to rooting media for begonias.

Experiments were also conducted by using easily available potting media for Saintpaulia. Wright and Titchmarsh (1981) reported that new plantlets originate when the stalk of the leaves of African violet was inserted into sandy compost. The highest decorative value for Saintpaulia ionantha plants were obtained by Milinoăi in 1974, when leaf petioles were kept in 0.03 per cent heteroauxin solution and rooted in sand and peat medium. The effect of sawdust on growth of Saintpaulia was also studied. Investigations made by Worrall (1981) reveal that the growth rates of Saintpaulia, Coleus blumei, Peperomia scandens and Pilea cadierei in media containing 50 to 80 per cent composted hardwood sawdust were equivalent to or better than in 50:50 sawdust:sphagnum peat and receiving the same level of liquid or slow-release fertilizer. The leaf area and dry weight of Impatiens walleriana were reduced when sphagnum peat was substituted with sawdust, but there was no significant effect on number of flowers. The growth of Saintpaulia and Pilea were best in 50:50 sawdust:peat. Saintpaulia could be grown in a powdered bark-based medium as reported by Tesi and Paro (1985).

In Pelargonium, Rodríguez and Rivera-López (1976) reported that plants potted in sandy soil amended with dry coffee leaves and sugarcane bagasse gave as good results as

sphagnum peat moss in proportions of 1:1, 1:3 or 3:1. The growth of Pelargonium cv. Königin Wilhelmine was tested in different substrates by Biermann (1974). Rooting of cuttings was stronger where soil or sand was added to a peaty substrate. Mele et al. (1982) reported better plant growth and flowering of Pelargonium zonale planted in an unheated greenhouse in a well-aerated medium of 1:1:1 forest soil:composted pine bark:peat. Altman and Freudenberg (1983) postulated that perlite is an ideal medium for the initiation of roots and new leaves of Pelargonium graveolens stem cuttings. The number of adventitious roots and leaves were equal in perlite and a standard peat:perlite mixture. Dekendorf et al. (1977) inserted cuttings of pelargonium in (1) sharp sand (2) 1:1 peat:perlite (3) hardwood bark (4) 1:1 hardwood bark:sand or (5) 2:1 hardwood bark:sand. Pelargonium rooted well (over 90 per cent) in all media and was best in medium (1).

Seddon (1982) proposed 2:1:1:1 loam:leaf mould:peat: coarse sand as special composts for Peperomia. In gloxinias, 1:1:1 peat:sand:bark mixture produced smaller plants and flowering was also delayed due to low water-holding capacity (Sheehan and Tjia, 1976). Propagation of leaf cuttings of Sansevieria and Echeveria peacooki in sand has been reported by Sundararaj et al. (1970). They observed that new

plants were formed when leaves were cut into 2 to 3 inches long sections and inserted for ½ of their length in sand. In a three year trial with softwood cuttings of thirteen broad-leaved plants rooted in frames under mist in sand, perlite, vermiculite or sand:peat (1:1), Komarov and Šohin (1968) obtained better rooting of Hydrangea paniculata. According to Richardson and Humphries (1982), when single leaf juvenile shoot cuttings of Hedera helix was treated with growth regulators and rooted in a peat:sand mixture or vermiculite, the effect of substrate was slight. Better plants of petunias and marigolds were produced by Goldsberry (1965) by planting in 50:50 sand:sawdust and 75:25 sand:peat than the same ingredients mixed 50:50 with a clayloam soil, especially when they were supplied with adequate fertilizer. When ten ornamental species (mainly foliage plants) were grown in 1:1 or 1:3 sand:macadamia husks, Trochoulas and Burton (1983) obtained greater plant vigour after 51 days.

Several investigators and commercial growers found variable success with rooting plants in different media, indicating that there is no'best medium' for all plants for all conditions. Media has marked influence on root elongation, type of root system, plant survival and success in transplanting (Fretz et al., 1979).

2.3.1 Effect on flower induction

According to Skvortsova (1970), in Begonia tuberhybrida, the first inflorescence was initiated in the axil of the fifth leaf. Zimmer and Krebs in 1980 reported that in Begonia boweri, flowering was induced by the youngest fully expanded leaves at the apex of the main rhizome. Increasing the number of leaves did not affect induction. When two leaves were left on stems, there was a decrease in flowering response, the decrease being related to the age of the leaves and or the distance from the main rhizome apex. Zimmer and Bahnemann (1981) reported the critical leaf area for flower induction after 5 short (9h) days as 20 cm^2 for Begonia boweri and 15 cm^2 for Clone III when leaves were young and near the shoot apex. For older leaves near the base of plant, it was 35 cm^2 for Begonia boweri and 40 cm^2 for Clone III.

MATERIALS AND METHODS

3. MATERIALS AND METHODS

The experiment was carried out in the greenhouse attached to the Department of Horticulture, College of Agriculture, Vellayani during 1986-87.

The study comprised of three parts:

3.1 Propagation with mature leaves of Rex begonia
3.2 Propagation with stem cuttings of apical shoot
3.3 Standardisation of growing medium

The investigations probed into the study of the effect of area, nutritional status of the leaves, effect of IBA on rooting, growth of leaf as well as stem cuttings and also the effect of various growing medium in relation to establishment and subsequent growth of the plant.

3.1 Propagation with mature leaves

3.1.1 Preparation of leaves

Uniformly mature leaf blade (7 cm diameter) with 3 cm long petiole attached to the leaf blade was taken.

3.1.2 Preparation of IBA stock solution

Indole 3 - butyric acid, at different concentrations was the growth substance employed for the studies. Distilled water treatment was run as a control in addition to a general control (T_1) with no distilled water treatment.

A stock solution of 5000 ppm IBA was prepared by dissolving 5 g of IBA in a small quantity of 50 per cent ethanol and made up the volume to 1000 ml with distilled water. The stock solution was further diluted to the required concentrations and used for the study.

3.1.3 Preparation of containers for rooting

The rooting medium consisted of sand and loam in the proportion of 1:1. Earthenware pots of 18 cm size were provided with drainage facilities at the bottom of the pots and filled with the prepared potting mixture.

3.1.4 Treatments

Sl.No.	Treatment code	Mode of treatment
1	T_1	General control
2	T_2	10 ppm IBA prespray

3	T_3	100 ppm IBA prolong dip (6h)
4	T_4	300 ppm IBA prolong dip (6h)
5	T_5	500 ppm IBA prolong dip (6h)
6	T_6	1000 ppm IBA quick dip (5s)
7	T_7	3000 ppm IBA quick dip (5s)
8	T_8	5000 ppm IBA quick dip (5s)
9	T_9	Distilled water prespray
10	T_{10}	Distilled water prolong dip (6h)
11	T_{11}	Distilled water quick dip (5s)

3.1.5 Experimental design

The experiment was laid out in Completely Randomised Design. The treatments comprised of 7 concentrations of IBA, one control with no distilled water treatment (T_1) and separate prespray, prolong dip and quick dip controls with distilled water treatment (T_9, T_{10} and T_{11} respectively). There were eleven treatments in total and under each treatment, eighty leaves were tested, which was divided into four replications each consisting of twenty leaves.

3.1.6 Treating the leaves with IBA and planting

Mature plants from which leaves were taken were sprayed with 10 ppm IBA, 24 h prior to the collection of cuttings

by using an atomizer in the case of the prespray treatment(T_2). A control (T_9) was sprayed with distilled water (prespray) in a similar manner to that of T_2.

IBA solutions were taken in small pans and leaves were given a fresh cut retaining 3 cm petiole and treated with varying concentrations by prolong dip method for a period of 6 h. A prolong dip control (T_{10}) was given with distilled water.

Leaf blades with 3 cm petiole were dipped in varying concentrations of IBA by quick dip method for a period of 5s. A quick dip treatment was given in a similar manner for control (T_{11}) with distilled water alone.

Leaf blades were cut across the main veins running from the central stem with a sharp razor blade and laid with leaf facing upwards (adaxial side above) on the surface of shallow pot filled with moist rooting media. Petiole was pushed into soil and little pebbles were put on to the leaf to hold it firmly in position and to maintain contact with soil. The treatments were distributed at random. Irrigation was provided carefully by sprinkling water over it with a fine rose can.

The pots were arranged inside the greenhouse, where the entry of direct sunlight was partially prevented.

3.1.7 Observations recorded

i) Leaf area

Leaf area was plotted graphically before planting.

ii) Number of days for emergence of the first sprout

The number of days taken for the appearance of the first adventitious bud in the leaf from the date of planting was recorded.

iii) Number of leaves producing sprouts

Number of leaves producing sprouts were recorded upto 45 days from the date of planting.

iv) Number of sprouts

The total number of sprouts produced in each leaf were recorded at fortnightly intervals.

v) Number of leaves

The total number of leaves produced from new plantlets that originated in each leaf were recorded at fortnightly intervals.

3.1.8 Statistical analysis

The mean values for the different parameters were calculated and data analysed using the analysis of variance technique for CRD. Their significance was tested by F-test (Snedecor and Cochran, 1967).

3.2 Propagation with stem cuttings of apical shoot

The stem cuttings were collected from plants of uniform maturity. The cuttings were treated with IBA at varying concentrations.

3.2.1 Preparation of the cuttings

The mature plants were lifted carefully from pots and all the leaves were removed. The terminal stem portions were then cut into segments bearing 3 to 4 nodes.

3.2.2 Preparation of IBA solution

A stock solution of 5000 ppm IBA was prepared by dissolving 5 g in a little quantity of 50 per cent ethanol and the volume made upto 1000 ml with distilled water. The stock solution was further diluted to the required concentrations.

3.2.3 Treatments

Sl.No.	Treatment code	Mode of treatment
1	T_1	General control
2	T_2	10 ppm IBA prespray
3	T_3	100 ppm IBA prolong dip (6h)
4	T_4	300 ppm IBA prolong dip (6h)
5	T_5	500 ppm IBA prolong dip (6h)
6	T_6	1000 ppm IBA quick dip (5s)
7	T_7	3000 ppm IBA quick dip (5s)
8	T_8	5000 ppm IBA quick dip (5s)
9	T_9	Distilled water prespray
10	T_{10}	Distilled water prolong dip(6h)
11	T_{11}	Distilled water quick dip (5s)

Altogether there were 11 treatments.

3.2.4 Experimental design

The experiment was laid out in Completely Randomised Design. There were 4 replications under each treatment and 20 stem cuttings were used in each replication.

3.2.5 Preparation of rooting medium

The rooting medium consisted of sand and loam at equal proportion.

3.2.6 Preparation of containers

Earthernware pots were provided with drainage facilities and filled with the prepared rooting medium.

3.2.7 Treating with IBA and planting

In the case of prespray treatment with IBA (10 ppm) solution, the mature plants from which stem cuttings were collected were sprayed 24 h prior to the collection of cuttings. A control (T_9) was sprayed with distilled water alone in the same manner.

Cuttings were grouped into bundles of 20 each. The basal portion of the bundles were treated with varying concentrations of IBA by prolong dip method for 6 h (T_3, T_4 and T_5) and in varying concentrations by quick dip method for 5 s (T_6, T_7 and T_8). Similarly prolong dip and quick dip treatments with distilled water (T_{10} and T_{11} respectively) were kept as control. In addition, a general control (T_1) with no distilled water treatment was run.

The stem cuttings were then planted in the pots filled with the potting mixture allocating the different treatments at random.

3.2.8 Observations recorded

Observations were made on the number of cuttings sprouted and established.

3.2.9 Statistical analysis

The statistical analysis was conducted by using the Chi-Square test (Snedecor and Cochran, 1967).

3.3 Standardisation of growing medium

Established plants of uniform size were taken and the effect of different rooting medium on their growth was studied.

3.3.1 Treatments

Sl.No.	Treatment code	Ratio	Components
1	T_1	1:1:1	sand, loam, compost (control)
2	T_2	1:1:1	sand, loam, leaf mould
3	T_3	1:1:1	sand, loam, sawdust
4	T_4	1:1:1	sand, loam, coconut pith
5	T_5	1:1	sand, leaf mould
6	T_6	1:1	sand, sawdust
7	T_7	1:1	sand, coconut pith

3.3.2 Experimental design

The experiment was laid out in Completely Randomised Design. There were 7 treatments and 5 pots in each replication.

3.3.3 Preparation of growing media and planting

The different mixtures of growing media were prepared in the specified proportions.

Coconut pith and sawdust were allowed to decompost well before use.

Earthernware pots of 18 cm size were filled with the prepared medium and the treatments were allocated at random. The pots were watered judiciously, so as to avoid any chance of drenching.

3.3.4 Observations recorded

i) Number of leaves

The total number of leaves produced were counted at fortnightly intervals.

ii) Leaf area

The leaf area of the top, middle and bottom canopies were measured graphically and the average leaf area of each plant was computed 5 months after planting.

iii) Plant height

Height of plants were measured (from the base to the top) 5 months after planting.

iv) Number of flowers produced

The number of flowers were recorded 6 months after planting.

3.3.5 Statistical analysis

Analysis were conducted using the analysis of variance technique for Completely Randomised Design and mean values for the various observations were calculated and significance tested by F-test (Snedecor and Cochran, 1967).

RESULTS

4. RESULTS

The observations recorded in the present study were statistically analysed and the results obtained are presented under the following titles.

4.1 Propagation with mature leaves
4.2 Propagation with stem cuttings (apical shoots)
4.3 Standardisation of growing medium

4.1 Propagation with mature leaves

The data from the 11 treatments were statistically analysed and the results interpreted.

4.1.1 Leaf area before planting and number of days taken for emergence of the first sprout

The mean leaf area of treated leaves were not significantly different from that of the control leaves before planting (Appendix-I).

The effect of treatments on the number of days taken for the emergence of the first sprout was statistically

significant (Appendix-I). Minimum number of days for emergence of the first sprout from the leaf was observed with IBA 100 ppm (T_3) and maximum period for emergence was recorded with IBA 5000 ppm (T_8).

In general, treatment of leaf with IBA resulted in a significant delay in emergence of the first sprout, the only exception being T_3 which gave an average of 15.25 days for the emergence of first sprout as against 25.18 days for T_{10} (Table 1) and 25.56 days for T_1. The effect of prolonged dip of IBA was not significantly different from that of the control which received distilled water treatment (T_{10}) whereas the quick dip and prespray IBA treatments differed significantly from their respective control treatments. Higher concentrations of IBA showed a negative influence on the character studied. As the concentrations varied between 0 ppm to 5000 ppm, the mean number of days taken for the emergence of first sprout varied between 25.56 days to 42.74 days. This effect showed a delaying effect of IBA treatment on the emergence of first sprout. The best treatment which produced early first sprout was IBA (100 ppm) prolong dip evidently T_3.

Table 1. Leaf area before planting and the number of days taken for emergence of first sprout

Treatments		Leaf area (cm^2)	Days for first sprout
T_1	- General control	138.69	25.56
T_2	- IBA 10 ppm prespray	137.91	27.54
T_3	- IBA 100 ppm prolong dip	137.19	15.25
T_4	- IBA 300 ppm prolong dip	139.73	29.87
T_5	- IBA 500 ppm prolong dip	137.19	32.74
T_6	- IBA 1000 ppm quick dip	136.09	36.87
T_7	- IBA 3000 ppm quick dip	139.08	39.55
T_8	- IBA 5000 ppm quick dip	138.72	42.74
T_9	- Prespray control	137.35	25.35
T_{10}	- Prolong dip control	136.19	25.18
T_{11}	- Quick dip control	139.18	26
	CD(0.05)	1.625	1.348

4.1.2 Effect of treatments on percentage of leaves producing sprouts at fortnightly intervals

Significant difference was observed among the treatments on number of leaves producing sprouts in the first fortnight.

Among all the treatments tested, only T_3 (IBA 100 ppm prolong dip) produced sprouts during the first fortnight to the extent of 45 per cent of the leaves producing sprouts. Treatment with IBA 100 ppm (T_3) caused earliness in sprouting of leaves.

The percentage of leaves producing sprouts was significantly lesser in the case of leaves treated with IBA than those in the relevant control cuttings with the exception of T_3 both in the second and third fortnights (Appendix-II). The quick dip treatments with IBA (T_5, T_6, T_7) differed significantly from the corresponding control treatment (T_{11}) in second and third fortnights. Effect of prolong dip IBA treatments (T_3, T_4, T_5) were significant when compared to their respective control treatment (T_{10}) in third fortnight, whereas the prespray treatment (T_2) was significantly different from that of the distilled water control (T_9) in the second fortnight. However, the different concentrations of IBA showed significant difference and the lower concentrations recorded higher percentage of success.

In the second fortnight, T_3 recorded maximum percentage of sprouts produced from the leaves which was followed by T_{10} and T_9. None of the leaves treated with the two higher

6ncentrations of IBA were found to produce sprouts in the second fortnight, while the lower concentrations caused the production of more number of sprouts from the leaves than the higher concentrations (Table 2).

In the third fortnight, sprouting was completed in all the leaves except those treated with the two higher concentrations of IBA (IBA 3000 ppm and 5000 ppm). Sprouting was delayed with higher concentrations and the maximum delay was observed in T_8.

Table 2. Effect of treatments on percentage of leaves producing sprouts upto and including second and third fortnights

Treatments	2nd	3rd
T_1 - General control	61.05 (51.37)	100
T_2 - IBA 10 ppm prespray	52.57 (46.45)	100
T_3 - IBA 100 ppm prolong dip	100 (90)	100
T_4 - IBA 300 ppm prolong dip	40 (39.20)	100
T_5 - IBA 500 ppm prolong dip	25 (29.93)	100
T_6 - IBA 1000 ppm quick dip	6.25 (14.29)	100
T_7 - IBA 3000 ppm quick dip	0 (0)	78.92
T_8 - IBA 5000 ppm quick dip	0 (0)	63.11
T_9 - Irespray control	63.11 (52.58)	100
T_{10} - Prolong dip control	66.62 (54.69)	100
T_{11} - Quick dip control	61.05 (51.37)	100
CD (0.05)	2.215	

Figures given in parentheses are the values obtained using angular transformation.

4.1.3 Effect of treatments on number of sprouts

There was significant difference between the effect of treatments on the number of sprouts produced in the first fortnight. Treatment of leaves with IBA 100 ppm (T_3) alone produced sprouts in the first fortnight with about 36 sprouts out of a total of 80 leaves (av: 0.45)(Table 3).

Table 3. Effect of treatments on number of sprouts in first fortnight

Treatment code	1st
T_1	0
T_2	0
T_3	0.45
T_4	0
T_5	0
T_6	0
T_7	0
T_8	0
T_9	0
T_{10}	0
T_{11}	0

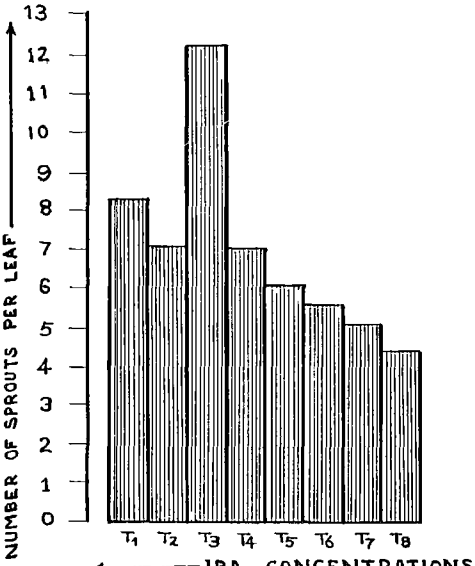
The effect of treatments on the number of sprouts produced during different fortnights (second till eighth) was statistically significant (Appendix - III).

In general, the control treatments had a better performance than IBA treatments. However, T_5 was adjudged as the best treatment since it produced the maximum number of sprouts in all the fortnights from second till eighth. Statistical analysis revealed the superiority of this treatment over all other treatments during the entire period of experiment (Table 4). Average number of sprouts produced per leaf treated with IBA 100 ppm upto the eighth fortnight was found to be 12.17 as against 8.15 for prolonged dip with distilled water(T_{10}) and 8.18 for T_1. T_3 was followed by T_9, T_{10} and T_{11} which were on par with T_1 in all fortnights (Fig.1).

The effect of quick dip treatments with IBA (T_6,T_7,T_8) over its corresponding distilled water control was statistically significant in all fortnights. T_{11} (quick dip control) produced more number of sprouts per leaf than the IBA quick dip concentrations (Plate-1).

The average effect of prolonged dip IBA treatment (T_3,T_4,T_5) over T_{10} was also statistically significant except in the third, sixth and eighth fortnights. T_{10} recorded significantly higher number of sprouts per leaf than in leaves treated with IBA 300 ppm and 500 ppm in second, fourth, fifth and seventh fortnights (Plate-2).

FIG.1 EFFECT OF IBA CONCENTRATIONS ON NUMBER OF SPROUTS PER LEAF.



T_1 General control	T_5 IBA 500 ppm
T_2 IBA 10 ppm	T_6 IBA 1000 ppm
T_3 IBA 100 ppm	T_7 IBA 3000 ppm
T_4 IBA 300 ppm	T_8 IBA 5000 ppm

T_2 differed significantly from the corresponding control treatment (T_9) during all fortnights except in the second fortnight when T_9 produced significantly higher number of sprouts per leaf than T_2 (Plate-3).

T_8 produced the minimum number of sprouts per leaf during all fortnights, the effect was decreasing with increasing quick dip concentrations (T_6,T_7 and T_8 respectively) at third, sixth, seventh and eighth fortnights. There was no significant difference between the effects of T_6, T_7 and T_8 in second, fourth and fifth fortnights.

Significant difference was seen among the effect of T_3, T_4 and T_5 during all fortnights. IBA 100 ppm was found to be the best treatment and the number of sprouts per leaf decreased when the concentration of IBA correspondingly increased. However, IBA 300 ppm was on par with IBA 500 ppm in third and fourth fortnights.

Table 4 Effect of treatments on cumulative number of sprouts from second till eighth fortnights

Treatments	2nd	3rd	4th	5th	6th	7th	8th
T_1 - General control	0.68(1.30)	3.62(1.90)	4.63(2.15)	6.72(2.59)	7.01(2.65)	8.00(2.83)	8.18(2.86)
T_2 - IBA 10 ppm prospray	0.56(1.25)	2.23(1.49)	3.21(1.79)	5.14(2.27)	6.06(2.46)	6.50(2.55)	7.02(2.65)
T_3 - IBA 100 ppm prolong dip	2.42(1.85)	5.74(2.40)	7.20(2.68)	9.52(3.09)	10.51(3.24)	11.15(3.34)	12.17(3.49)
T_4 - IBA 300 ppm prolong dip	0.46(1.21)	2.18(1.47)	3.01(1.73)	4.10(2.03)	5.77(2.40)	6.35(2.52)	6.94(2.63)
T_5 - IBA 500 ppm prolong dip	0.30(1.14)	2.08(1.44)	2.62(1.62)	3.68(1.92)	4.92(2.22)	5.56(2.36)	6.00(2.45)
T_6 - IBA 1000 ppm quick dip	0.06(1.03)	1.77(1.35)	2.41(1.55)	3.35(1.83)	4.75(2.18)	5.14(2.27)	5.52(2.35)
T_7 - IBA 3000 ppm quick dip	0 (1)	0.84(0.92)	2.23(1.49)	3.15(1.77)	4.28(2.07)	4.76(2.18)	5.08(2.25)
T_8 - IBA 5000 ppm quick dip	0 (1)	0.68(0.83)	2.07(1.44)	2.91(1.71)	3.63(1.91)	4.14(2.03)	4.35(2.09)
T_9 - Prespray control	0.68(1.30)	3.82(1.95)	4.92(2.22)	6.52(2.55)	7.08(2.66)	8.02(2.83)	8.16(2.86)
T_{10} - Prolong dip control	0.69(1.30)	3.52(1.88)	4.63(2.15)	6.52(2.55)	7.01(2.65)	7.98(2.82)	8.15(2.85)
T_{11} - Quick dip control	0.67(1.29)	3.74(1.93)	4.75(2.18)	6.76(2.60)	7.11(2.67)	8.10(2.85)	8.17(2.86)
CD(0.05)	0.048	0.138	0.136	0.107	0.086	0.062	0.027

Figures given in parantheses are those obtained by using $\sqrt{x+1}$ transformation for the second fortnight and $\sqrt{x}$ transformation for third till eight fortnights

Plate - 1 Comparative effect of IBA concentrations on the number of sprouts and growth from the leaves (quick dip)

Plate - 2 Comparative effect of IBA concentrations on the number of sprouts and growth from the leaves (prolong dip)

Plate - 3 Comparative effect of IBA (prespray) on the growth and development of plants from the leaves

4.1.4 Effect of treatments on number of leaves

The effect of treatments on number of leaves produced in the first fortnight was not significant whereas in the second fortnight, there was significant difference for the effect of treatments. T_3 alone produced about 210 leaves from new plantlets out of 80 leaves used in propagation (av: 2.63) in the second fortnight. This showed an early and increased emergence of leaves by this treatment (Table 5).

Table 5 Effect of treatments on cumulative number of leaves in second fortnight

Treatment code	2nd
T_1	0
T_2	0
T_3	2.63
T_4	0
T_5	0
T_6	0
T_7	0
T_8	0
T_9	0
T_{10}	0
T_{11}	0

The effect of treatments on the number of leaves produced from new plantlets that originated in each leaf was statistically significant during the different fortnights (Appendix IV). The control treatments had a better performance than IBA treatments, the only exception being T_3 (IBA 100 ppm) as it produced the maximum number of leaves during all fortnights. Treatment of leaves with IBA 100 ppm were superior to all other treatments during the entire period of study which gave an average of 33.48 leaves per leaf from new plantlets that originated, as against 24.12 leaves for T_{10} and 24.03 leaves for T_1. T_3 was followed by the four control treatments (T_1,T_9,T_{10},T_{11}) during all fortnights from third till eighth (Table 6).

T_{11} was found to produce more number of leaves from plantlets produced per leaf than leaves treated with IBA at higher concentrations by the quick dip method (T_6, T_7, T_8) at all fortnights.

The effect of IBA at lower concentrations by the prolonged dip method (T_3, T_4, T_5) differed significantly from their corresponding control treatment (T_{10}) except in the third and fourth fortnights. T_{10} was found to produce more number of leaves from plantlets that originated per leaf than leaves treated with IBA 300 ppm and 500 ppm.

Table 6 Effect of treatments on cumulative number of leaves from third till eighth fortnights

Treatments	3rd	4th	5th	6th	7th	8th
T_1 - General control	3.44(2.11)	6.45(2.54)	10.10(3.18)	14.98(3.87)	20.81(4.56)	24.03(4.90)
T_2 - IBA 10 ppm prespray	3.01(2.00)	5.28(2.30)	9.19(3.03)	13.43(3.66)	16.21(4.03)	20.43(4.52)
T_3 - IBA 100 ppm prolong dip	7.54(2.92)	11.59(3.40)	15.98(4.00)	24.66(4.97)	29.43(5.42)	33.48(5.79)
T_4 - IBA 300 ppm prolong dip	1.91(1.71)	4.63(2.15)	7.79(2.79)	12.28(3.50)	15.10(3.89)	19.14(4.37)
T_5 - IBA 500 ppm prolong dip	1.41(1.55)	3.22(1.80)	5.14(2.27)	9.34(3.06)	12.29(3.51)	15.82(3.98)
T_6 - IBA 1000 ppm quick dip	1.08(1.44)	3.14(1.77)	5.08(2.25)	9.07(3.01)	11.94(3.46)	13.68(3.70)
T_7 - IBA 3000 ppm quick dip	0 (1)	1.74(1.32)	4.14(2.03)	7.52(2.74)	9.27(3.05)	11.29(3.36)
T_8 - IBA 5000 ppm quick dip	0 (1)	1.35(1.16)	3.16(1.78)	5.73(2.40)	7.34(2.71)	9.18(3.03)
T_9 - Prespray control	3.63(2.15)	6.81(2.61)	10.93(3.31)	15.17(3.89)	19.68(4.44)	24.10(4.91)
T_{10} - Prolong dip control	3.43(2.11)	6.52(2.55)	10.06(3.17)	15.56(3.94)	21.81(4.67)	24.12(4.91)
T_{11} - Quick dip control	3.35(2.09)	6.46(2.54)	10.29(3.21)	14.98(3.87)	19.98(4.47)	24.29(4.93)
CD (0.05)	0.115	0.136	0.092	0.094	0.112	0.090

Figures given in parentheses are those obtained by using $\sqrt{x+1}$ transformation for the 3rd fortnight and $\sqrt{x}$ transformation for fourth till eighth fortnights

The prespray with distilled water (control) was found to produce more number of leaves per leaf than T_2 at all fortnights.

There was significant difference for the effect of T_3, T_4 and T_5. Significant difference was also observed for the effect of T_6, T_7 and T_8. T_3 and T_6 produced more number of leaves than their higher concentrations at all fortnights. The production of leaves were low with higher concentrations and minimum number of leaves was recorded in T_8.

4.1.5 Correlation studies

Correlations were worked out between leaf area before planting, number of days for emergence of first sprout and total number of sprouts produced.

The correlation co-efficient (r) between leaf area before planting and number of days for emergence of first sprout was found to be 0.21, which was not statistically significant. The correlation co-efficient between leaf area and total number of sprouts produced was also not significant ($r = -0.17$).

A high correlation was found to exist between number of days for emergence of first sprout and total number of sprouts produced ($r = -0.96^{**}$). Earliness in sprouting of the first sprout was found to be associated with an increase in the total number of sprouts produced.

4.2 Propagation with stem cuttings

Stem cuttings treated with IBA at concentrations above 100 ppm did not survive. Treatment with IBA by the prolong dip method at low concentrations of 300 ppm and 500 ppm (T_4 and T_5 respectively) and at high concentrations of 1000 ppm, 3000 ppm and 5000 ppm (T_6, T_7 and T_8 respectively) also did not survive.

Some of the cuttings perished after sprouting and some had rooted and were alive. In each treatment where stem cuttings had survived, some of the stem cuttings sprouted and perished in due time while the remaining ones established as new plants. The data were statistically analysed using Chi-Square test to know the significance of the difference between sprouted and established plants.

4.2.1 Effect of treatments on sprouting of stem cuttings

The effect of treatments on number of sprouted stem cuttings was statistically significant. Treatment of stem cuttings with prolong dip of IBA 100 ppm (T_3) gave a significantly higher response followed by prespray treatment of mother plants with IBA 10 ppm (T_2). The various controls employed in this experiment namely T_{10}, T_9, T_{11} and T_1 were statistically on par and significantly inferior to T_3 and T_2(Table 7a).

Table 7A Effect of treatments on sprouting of stem cuttings

Treatments	Sprouted	Not sprouted	Total
T_1 - General control	16	64	80
T_2 - IBA 10 ppm prespray	34	46	80
T_3 - IBA 100 ppm prolong dip	47	33	80
T_9 - Prespray control	19	61	80
T_{10}- Prolong dip control	22	58	80
T_{11}- Quick dip control	17	63	80
Chi-Square			42.96**

Table 7b Chi-Square values for comparison of pairs of treatments

	T_1	T_2	T_3	T_9	T_{10}	T_{11}
T_1		9.43**	25.16**	0.33	1.24	0.04
T_2			4.23*	6.35*	3.96*	8.32**
T_3				20.22**	15.93**	23.44**
T_9					0.30	0.14
T_{10}						0.85
T_{11}						

* Significant at 5 per cent level
** Significant at 1 per cent level
Conclusion: T_3 T_2 T_{10} T_9 T_{11} T_1

4.2.2 Effect of treatments on establishment of stem cuttings

Significant difference was noticed between the treatments on the number of established stem cuttings. Stem cuttings treated with IBA 100 ppm (T_3) produced the maximum number of established plants (33) followed by T_2 (21). The four control treatments were statistically on par and significantly inferior to T_3 and T_2 (Table 8a and Plates - 4 & 5).

Table 8a Effect of treatments on establishment of stem cuttings

Treatments	Established	Not established	Total
T_1 - General control	8	72	80
T_2 - IBA 10 ppm prespray	21	59	80
T_3 - IBA 100 ppm prolong dip	33	47	80
T_9 - Prespray control	9	71	80
T_{10} - Prolong dip control	11	69	80
T_{11} - Quick dip control	8	72	80
Chi-Square			41.85**

Table 8b Chi-Square values for comparison of pairs of treatments

	T_1	T_2	T_3	T_9	T_{10}	T_{11}
T_1		7.12**	20.5**	0.07	0.54	0
T_2			4.03*	5.91*	3.91*	7.12**
T_3				18.6**	15.17**	20.5**
T_9					0.23	0.07
T_{10}						0.54
T_{11}						

* Significant at 5 per cent level
** Significant at 1 per cent level
Conclusion: T_3 T_2 $\overline{T_{10}\ T_9\ T_{11}\ T_1}$

Plate - 4 Comparative effect of IBA treatment on stem cuttings (prolong dip)

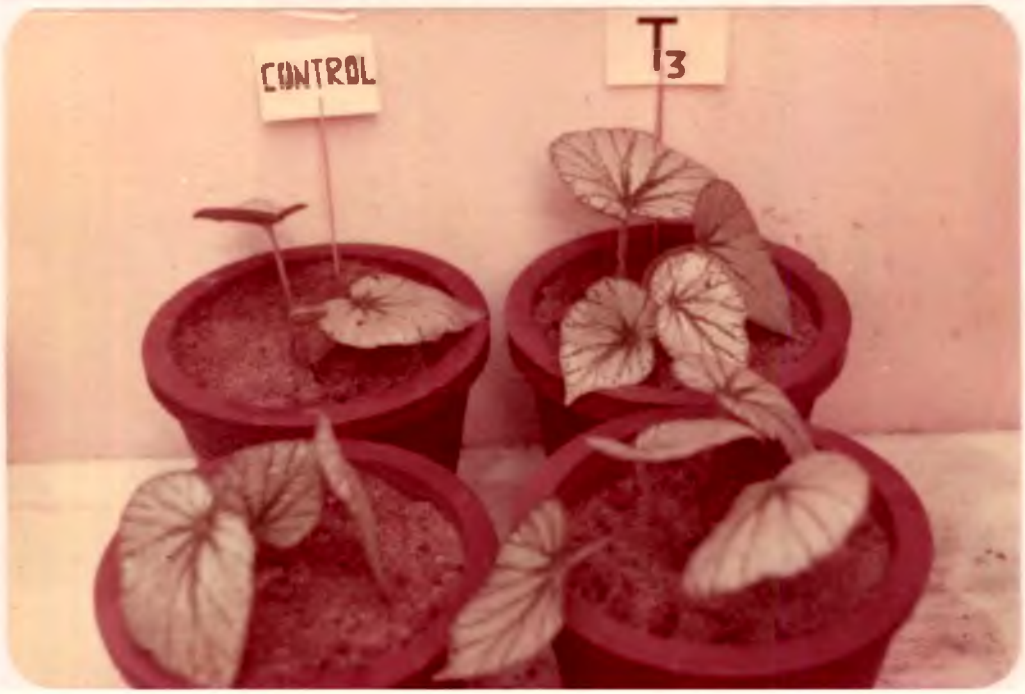


Plate - 5 Comparative effect of IBA (prespray) on the growth and development of sprouts from stem cuttings

4.3 Standardisation of growing medium

The data obtained from the different treatments were analysed statistically and the results interpreted.

4.3.1 Effect of treatments on number of leaves

The observations were recorded for 9 fortnights from the date of planting and results analysed. There was no significant difference between the effect of treatments on the number of leaves in all the fortnights ((Appendix-V). All the 7 different type of growing media produced similar effects on the production of leaves.

4.3.2 Effect of treatments on plant height, leaf area and number of flowers

There were significant differences between the effect of treatments on plant height, leaf area and number of flowers produced (Table 9a and Appendix-VI). T_5 (1:1 sand:leaf mould) was found to be significantly superior to all other treatments with regard to plant height (21.45 cm). The shortest plants were observed with the medium containing 1:1:1 sand:loam:sawdust (9.68 cm) (Fig.2).

Maximum leaf area (113.67 cm^2) and maximum number of flowers (7.50) were recorded with T_5. This treatment was on par with the treatments T_6 (1:1 sand:sawdust) T_7 (1:1 sand:coconut pith) and T_1 (1:1:1 sand:loam:compost).

The treatment T_3 (1:1:1 sand:loam:sawdust) recorded the minimum leaf area (43.79 cm^2) and the minimum number of flowers (0.33).

Table 9a Effect of treatments on plant height, leaf area and number of flowers

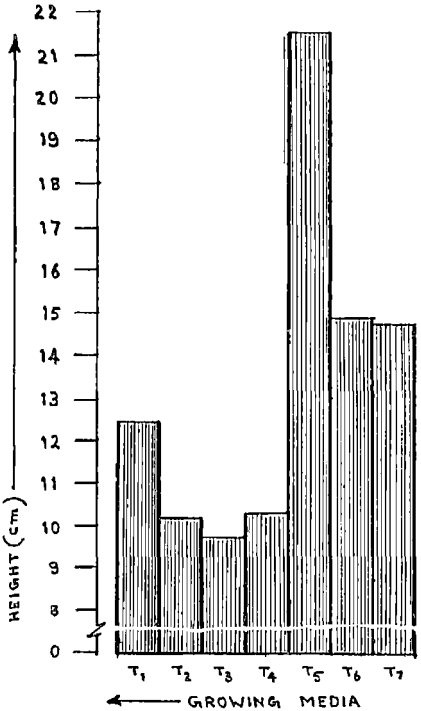
Treatments		5 months after planting		6 months after planting
		Plant height (cm)	Leaf area (cm^2)	Number of flowers
T_1 - 1:1:1	sand:loam:compost (control)	12.36	79.16	3.50
T_2 - 1:1:1	sand:loam:leaf mould	10.10	45.65	1.25
T_3 - 1:1:1	sand:loam:sawdust	9.68	43.79	0.33
T_4 - 1:1:1	sand:loam:coconut pith	10.24	57.04	2.25
T_5 - 1:1	sand:leaf mould	21.45	113.67	7.50
T_6 - 1:1	sand:sawdust	14.80	98.56	5.13
T_7 - 1:1	sand:coconut pith	14.70	94.60	5.88

Table 9b Different values of critical differences for comparing pairs of means

		T_1	T_2	T_3	T_4	T_5	T_6	T_7
Plant height	T_1							
	T_2	7.410						
	T_3	6.628	7.410					
	T_4	6.200	7.030	6.200				
	T_5	6.200*	7.030*	6.200*	5.740*			
	T_6	6.628	7.410	6.628*	6.200	6.200*		
	T_7	6.200	7.030	6.200	5.740	5.740*	6.200	
Leaf area	T_1							
	T_2	42.604						
	T_3	38.107	42.604					
	T_4	35.645	40.418	35.645				
	T_5	35.645	40.418*	35.645*	33.001*			
	T_6	38.107	42.604*	38.107*	35.645*	35.645		
	T_7	35.645	40.418*	35.645*	33.001*	33.001	35.645	
Number of flowers	T_1							
	T_2	5.511						
	T_3	4.929	5.511					
	T_4	4.611	5.229	4.611				
	T_5	4.611	5.229*	4.611*	4.269*			
	T_6	4.929	5.511	4.929	4.611	4.611		
	T_7	4.611	5.229	4.611*	4.269	4.269	4.611	

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

FIG.2 EFFECT OF GROWING MEDIA ON PLANT HEIGHT.



T_1 – 1:1:1 Sand, loam, compost.
T_2 – 1:1:1 Sand, loam, leaf mould.
T_3 – 1:1:1 Sand, loam, Sawdust.
T_4 – 1:1:1 Sand, loam, coconut pith.
T_5 – 1:1 Sand, leaf mould.
T_6 – 1:1 Sand, Sawdust.
T_7 – 1:1 Sand, Coconut pith

DISCUSSION

5. DISCUSSION

The present investigation was carried out to standardise the propagation techniques and a suitable growing medium for leafy begonias. The results obtained in the present investigation are discussed in this chapter.

5.1 Propagation with mature leaves

Propagation with leaf is generally attempted in Rex begonia as this method is less expensive and easier when compared to other methods. The plants and the leaves were treated with Indole 3-butyric acid at different concentrations.

The number of days taken for the emergence of the first sprout per leaf was found to be lesser in the case of leaves treated with Indole 3-butyric acid at 100 ppm (prolonged dip) for 6 h. High concentrations of IBA markedly delayed the sprouting of leaves. In general, treatment of leaves with IBA caused delay in emergence of sprout, with the exception of IBA 100 ppm. Treatment of leaves with IBA 100 ppm caused more percentage of leaves to sprout earlier. The maximum delay in sprouting was with 3000 ppm and 5000 ppm IBA.

The number of sprouts and leaves produced per leaf was more when the leaves were given prolong dip treatment with 100 ppm IBA for 6 h. Treatment with lower and higher concentrations of IBA recorded lesser number of sprouts and leaves per leaf. Minimum number of sprouts and leaves were obtained in the case of treatment with 5000 ppm IBA. Several authors have observed similar delay in sprouting with high concentrations of IBA. Experiments conducted by Lagerstedt (1967) in begonia revealed that leaf discs treated with IBA concentrations of above 100 mg per litre retarded bud development. Similar results are reported in Streptocarpus cv. Susi by Scharer (1986) where he obtained stimulated bud formation with IBA 100 mg per litre, while IBA 1000 mg per litre caused retardation. This again is in agreement with the studies in Sansevieria trifasciata by Pimpini et al. (1986) which showed an increased bud number and growth when leaves were treated with IBA 100 ppm, with higher rates significantly reducing bud numbers. The increased vigour exhibited by the leaves treated with IBA 100 ppm in this experiment may be attributed to the activation of bud formation at low concentrations of the auxin (IBA). This is in agreement with the report of Heide (1965) where he observed a similar effect of IBA on Begonia cheimantha.

The leaf area before planting did not show any beneficial effect on induction of sprouts from the leaf. The number of days taken for the emergence of the first sprout and number of sprouts per leaf were not associated with the leaf area. The results obtained by Powell and Bunt in 1979 also show a similar trend in the development of sprouts from leaves of Begonia hiemalis. Similarly in Peperonia griseoargentea, Ozeri and Evenari (1979) reported that the rooting response was determined by the number and length of the veins and not by the area between the veins in leaf. However, with earliness in sprouting, more number of sprouts per leaf could be produced.

5.2 Propagation with stem cuttings

Propagation of stem cuttings with IBA enhances the rooting ability. In the present study, the number of sprouted cuttings and established cuttings was more when stem cuttings were given prolong dip treatment with IBA 100 ppm for 6 h. This is in agreement with the findings of Bala et al. (1970) where he obtained improved rooting ability of cuttings of Bryophyllum tubiflorum when treated with IBA 100 mg per litre. Similar results have been

reported in Gardenia florida by Mohan and Maurya (1978). Prespray treatment of mother plants with IBA 10 ppm could not favourably influence the sprouting and establishment of stem cuttings. Audus (1959) had obtained some success by spraying dilute solutions of auxins to mother plants before removal of cuttings. This may be presumably due to the foliar absorption and translocation of IBA to the cut ends.

Attempts to propagate begonia stem cuttings by treatment with IBA at 300 ppm and 500 ppm by prolong dip method for 6 h and also by 1000 ppm, 3000 ppm and 5000 ppm IBA by quick dip method for 5s was not much fruitful. This may be due to the toxic effect induced by IBA at high concentrations. Hein and Schneider (1981) from their work on Pelargonium zonale concluded that 200 mg per litre IBA was best for cv. Rubin. Treatment of cuttings with 300 mg per litre gave poor rooting and loses from foot rot occured at 400 mg per litre IBA. Also, IBA at 300 mg per litre caused damage to cuttings of cv. Stadt Bern in February. The detrimental effects of high concentrations of IBA has also been reported by Danko (1984) in holly and azalea. Audus (1959) explained that weaker concentrations are best for easy-to-root cuttings while toxic effect results above a

particular concentration which produces optimum rooting effect. Similarly Ellasson (1961) reported that auxins at higher concentration can inhibit bud development.

From the present investigation it is found that some of the cuttings that sprouted had perished during the course of study. This may be due to the reason that leaves were not retained on cuttings. The effect of leaves on rooting of softwood or herbaceous stem cuttings has been explained by Fretz et al. (1979). Similar results has been reported by Dass et al. (1963) in Pelargonium graveolens where leafy cuttings had a beneficial effect on root development.

Hence it could be elucidated that IBA at 100 ppm gave more number of sprouts and produced better establishment of the sprouted plants.

5.3 Standardisation of growing medium

In the present investigation, the 7 different type of growing media had a similar effect in the production of leaves. There was no significant difference between the number of leaves produced in all the media used for the study. Fretz et al. (1979) concluded that there is

no 'best medium' for all plants for all conditions based on the findings of several investigators and commercial growers. The quality of general potting soils does not differ much from those labelled as mixes for African violets as reported by Bugbee and Frink (1983).

Plant height were more in growing medium comprising of sand and leaf mould in the proportion of 1:1. The plants grown in this medium had more leaf area and more number of flowers. The influence of media on plant survival has been reported by Fretz et al. (1979). Similarly the suitability of substrate with high air:water ratio to different plants has been outlined by Boodt and Verdonck (1972). The beneficial effects of leaf mould in the present study may be due to the higher water-holding capacity and nitrogen content as reported by Chatterjee and Mukherjee (1980). Tesi (1982) also had reported higher NPK for leaf mould. ~~Singh and Singh (1961) concluded a mixture of sand and leaf mould.~~ Singh and Singh (1961) concluded a mixture of sand and leaf mould as best medium for ready rooting cuttings wherein the water-holding capacity and gaseous exchange capacity were improved with the addition of leaf mould to sand. Seddon (1982) proposed a medium comprising of 4:4:3:2 loam:peat:leaf mould:coarse sand or 2:1 leaf mould:sand as special composts for Begonia.

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SUMMARY

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The investigation was carried out at the Department of Horticulture, College of Agriculture, Vellayani during 1986-'87 to standardise the most suitable method of vegetative propagation and growing medium of Rex begonia. Trials were conducted on propagation with leaves as well as stem cuttings and using different potting mixtures. The effect of IBA on the success of different methods of vegetative propagation were also studied. The salient findings of the investigation are summarised below:

1. IBA had a significant influence on the time taken for the emergence of the first sprout in the leaf. Earlier sprouting (15.25 days) was recorded from treatment of leaves with IBA 100 ppm. Sprouting was delayed at higher concentrations of IBA.

2. Among the different concentrations of IBA tried, the prolong dip treatment at 100 ppm for 6 h induced the maximum number of sprouts (12.17) on leaves. This treatment also produced earliness in sprouting of leaves while the higher concentrations delayed sprouting.

3. Treatment of leaves with IBA 100 ppm produced the maximum number of leaves (33.48) on plantlets that originated from leaf propagules. The control treatments were also equally effective with regard to the leaf production on new plantlets.

4. There was no significant association between leaf area before planting and number of days for emergence of first sprout and also with the total number of sprouts produced.

5. The total number of sprouts per leaf increased with earliness in sprouting.

6. Among the different concentrations of IBA tried on stem cuttings, maximum establishment of the sprouted plantlets was obtained with IBA (100 ppm).

7. Stem cuttings treated with IBA (prolong dip) at concentrations 300 ppm and 500 ppm for 6 h and quick dip at concentrations 1000 ppm, 3000 ppm and 5000 ppm for 5s did not survive.

8. The different types of growing media produced more or less similar effects on the production of leaves up-till ninth fortnight.

9. Plant height recorded after 5 months of planting was more in a medium comprising of 1:1 sand: leaf mould.

10. The maximum leaf area (113.67 cm^2) was recorded after 5 months from plants grown in a medium comprising of sand and leaf mould in equal proportions.

11. The number of flowers produced after 6 months of planting was maximum on plants grown in a 1:1 sand:leaf mould medium.

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* - Originals not seen

APPENDICES

APPENDIX I

ANALYSES OF VARIANCE OF LEAF AREA BEFORE PLANTING AND DAYS TAKEN FOR EMERGENCE OF FIRST SPROUT

Source	df	Mean squares	
		Leaf area	Days for first sprout
Treatments	10	6.06**	244.45**
IBA vs General control	1	1.69	148.67**
IBA Quick dip vs Quick dip control	1	4.47	564.67**
IBA Prolong dip vs Prolong dip control	1	10.22**	1.78
IBA Prespray vs Prespray control	1	0.63	9.54**
Between concentrations of IBA Quick dip	2	10.66**	34.47**
Between concentrations of IBA Prolong dip	2	8.59**	351.67**
Error	33	1.27	0.87

** Significant at 1 per cent level

* Significant at 5 per cent level

APPENDIX II

ANALYSES OF VARIANCE FOR PERCENTAGE OF LEAVES PRODUCING SPROUTS UPTO AND INCLUDING SECOND AND THIRD FORTNIGHT @

Source	df	Mean squares	
		2nd	3rd
Treatments	10	2851.00**	3228.30**
IBA vs General control	1	1393.60**	1711.05**
IBA Quick dip vs Quick dip control	1	6515.34**	1398.54**
IBA Prolong dip vs Prolong dip control	1	8.09	2700.00**
IBA Prespray vs Prespray control	1	75.09**	0
Between concentrations of IBA Quick dip	2	272.41**	1499.85**
Between concentrations of IBA Prolong dip	2	4183.12**	10800.00**
Error	33	2.36	0.12

@ Angular transformation was used for the analysis

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

APPENDIX III

ANALYSES OF VARIANCE FOR NUMBER OF SPROUTS IN SECOND TILL EIGHTH FORTNIGHS@

Source	df	Mean squares						
		2nd	3rd	4th	5th	6th	7th	8th
Treatments	10	0.22**	0.91**	0.61**	0.79**	0.55**	0.58**	0.59**
IBA vs General control	1	0.03**	0.86**	0.54**	0.89**	0.30**	0.46**	0.32**
IBA Quick dip vs Quick dip control	1	0.24**	2.52**	1.40**	2.07**	1.13**	1.41**	1.19**
IBA Prolong dip vs Prolong dip control	1	0.03**	0.03	0.06*	0.13**	0.002	0.02**	0.00003
IBA Prespray vs Prespray control	1	0.004	0.42**	0.36**	0.16**	0.08**	0.16**	0.09**
Between concentrations of IBA Quick dip	2	0.001	0.31**	0.01	0.02	0.08**	0.06**	0.07**
Between concentrations of IBA Prolong dip	2	0.61**	1.18**	1.36**	1.67**	1.19**	1.11**	1.23**
Error	33	0.001	0.01	0.01	0.01	0.004	0.002	0.003

@ Data were transformed by using square root transformation in all fortnights except in the 2nd in which $\sqrt{x+1}$ transformation was applied

** Significant at 1 per cent level

* Significant at 5 per cent level

APPENDIX IV

ANALYSIS OF VARIANCE FOR NUMBER OF LEAVES IN THIRD TILL EIGHTH FORTNIGHTS @

Source	df	Mean squares					
		3rd	4th	5th	6th	7th	8th
Treatments	10	1.27**	1.67**	1.76**	2.00**	2.53**	2.65**
IBA vs General control	1	0.70**	1.07**	1.20**	1.00**	2.47**	2.21**
IBA Quick dip vs Quick dip control	1	2.64**	3.79**	4.22**	3.97**	5.88**	7.35**
IBA Prolong dip vs Prolong dip control	1	0.01	0.03	0.07**	0.03*	0.47**	0.12**
IBA Prespray vs Prespray control	1	0.04*	0.20**	0.15**	0.11**	0.34**	0.30**
Between concentrations of IBA Quick dip	2	0.26**	0.40**	0.23**	0.37**	0.56**	0.45**
Between concentrations of IBA Prolong dip	2	2.25**	2.86**	3.15**	4.00**	4.13**	3.62**
Error	33	0.01	0.01	0.004	0.004	0.01**	0.004

@ Data were transformed by using square root transformation in all the fortnights except in the 3rd in which $\sqrt{x+1}$ transformation was applied

** Significant at 1 per cent level

* Significant at 5 per cent level

APPENDIX V

ANALYSES OF VARIANCE FOR NUMBER OF LEAVES IN FIRST TILL NINTH FORTNIGHTS

Source	df	Mean squares								
		1st	2nd	3rd	4th	5th	6th	7th	8th	9th
Treatments	6	0.40	0.40	0.24	0.77	0.87	1.53	3.24	2.83	1.96
Error	16	0.16	0.33	0.27	0.52	0.87	1.00	1.19	1.15	1.44

APPENDIX VI

ANALYSES OF VARIANCE OF SOME BIOMETRIC CHARACTERS

Source	df	Mean square		
		Plant height	Leaf area	Number of flowers
Treatments	6	62.59**	2467.00**	22.55*
Error	16	14.66	484.64	8.11

STANDARDISATION OF PROPAGATION TECHNIQUE AND GROWING MEDIA IN REX BEGONIA

[*Begonia rex* (Putz.) Inimitable]

By
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ABSTRACT OF THE THESIS
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ABSTRACT

Investigations were carried out at the Department of Horticulture, College of Agriculture, Vellayani during 1986-'87 to standardise the most suitable method of vegetative propagation and growing medium of Rex begonia. The experiment was conducted in Completely Randomised Design with leaves and stem cuttings to find the influence of IBA in enhancing the success with each of these methods and also to find out the influence of different types of growing medium on the growth of the plants.

From the investigations it was found that leaves were the most reliable and successful propagules compared to stem cuttings. In general, the control treatments had a better performance than IBA treatments, the only exception being IBA 100 ppm prolong dip treatment for 6 h. Treatment of leaves with IBA 100 ppm were found to give more success in percentage of sprouting and the total number of sprouts produced per leaf. Earlier sprouting and faster growth of the sprouts were also recorded. The total number of leaves produced from new plantlets that originated from the leaf were also more in leaves treated with IBA 100 ppm.

Propagation with stem cuttings was also found to be successful. IBA 10 ppm and 100 ppm had a positive effect on sprouting and establishment of cuttings with maximum number of sprouted and established plants in the case of treatment with IBA 100 ppm prolong dip for 6 h.

The medium comprising of 1:1 sand:leaf mould were the most reliable growing medium producing plants with maximum height, leaf area and flowers.