# MORPHOLOGICAL STUDIES OF DIFFERENT TYPES OF *Hibiscus rosasinensis* L. AND STANDARDISATION OF PROPAGATION TECHNIQUES

BY

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## THESIS

submitted in partial fulfilment of
the requirements for the degree of

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Department of Horticulture
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1984

## DECLARATION

I hereby declare that this thesis entitled "Morphological studies of different types of *Hibiscus rosasinensis* L. and standardisation of propagation techniques" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

Vellanikkara,
26-12-1984.

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## CERTIFICATE

Certified that this thesis entitled "Morphological studies of different types of *Hibiscus rosasinensis* L. and standardisation of propagation techniques" is a record of research work done independently by Sri. C.A. Verghese, under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

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We, the undersigned, members of the Advisory Committee of Sri. Verghese, C.A., a candidate for the degree of Master of Science in Horticulture with major in Horticulture, agree that the thesis entitled "Morphological studies of different types of *Hibiscus rosasinensis* L. and standardisation of propagation techniques" may be submitted by Sri. Verghese, C.A., in partial fulfilment of the requirement for the degree.

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# INTRODUCTION

# INTRODUCTION

The genus *Hibiscus* belongs to the Malvaceae comprising nearly thousand species of plants. Out of these, 105 species are commonly found in India. Important species of *Hibiscus* are *H. trionium*, *H. esculentum*, *H. sabdariffa*, *H. cannabinus*, *H. militaris*, *H. schizopetalous*, *H. syriacus*, *H. mutabilis* and *H. rosasinensis* of which *H. rosasinensis*, *H. syriacus*, *H. schizopetalous* and *H. mutabilis* have ornamental values in tropical and sub tropical regions. *H. rosasinensis* L. popularly known as 'China rose' or 'Shoe flower' is the most common ornamental species of *Hibiscus* grown. Its flowers are white, red, yellow, pink, orange, magneta and terracota. Hardiness, ease of cultivation and adaptability to wide range of soil and climatic conditions contribute much to the popularity of this ornamental shrub in Kerala.

Hibiscus is one of the most widely grown ornamental plants in the homesteads of Kerala. This is mostly valued for the attractive flowers. Vigorous and evergreen nature of the plant, year around availability of flowers and freedom from serious pests and diseases make hibiscus very popular.

*H. rosasinensis*, having both ornamental and medicinal importance is one of the ornamental plant species in Kerala, usually grown with little attention. A large number of hibiscus types is grown in Kerala. Most of the types are hardy and tolerent to adverse climatic conditions compared to Hawaiian varieties. While most of the Hawaiian varieties are shy bearers, the types in Kerala flower profusely throughout the year. A comprehensive morphological description of the varieties and studies on flower production potential would help to select desirable types in the breeding programme. Collection and detailed morphological descriptions of the local types are the first steps to be undertaken in the absence of any systematic attempt in this regard.

Propagation through cuttings is the most common and widely accepted practice in hibiscus. But most of the types, especially hybrids, do not respond to ordinary methods of vegetative propagation through cuttings. Therefore, standardisation of vegetative propagation technique would help to propagate the different types including hybrids. The present studies were undertaken with the following objectives.

A. To collect and maintain a minimum of fifty types or varieties of hibiscus.

B. To make detailed description of the types of varieties.

C. To study pollen viability in ten types of hibiscus.

D. To standardise methods of vegetative propagation techniques in ten types of hibiscus using the following three methods.

1. rooting of cuttings with and without leaves.
2. rooting of cuttings by treating the cuttings with different concentrations of growth regulators indoleacetic acid (IAA), indolebutyric acid (IBA) and naphthaleneacetic acid (NAA).
3. air layering.

# REVIEW OF LITERATURE

## REVIEW OF LITERATURE

Malvaceae, the family to which hibiscus belongs comprises of 50 genera. The larger genera are Hibiscus (over 200 species), Sida (200 species), Abuliton (100 species) and Malva (40 species) (Bailey, 1949). Some of the ornamental plants of this family are shoe flower (H.rosasinensis), H.mutabilis, chinese lantern (Achania malvaviscus) and hollyhock (Althea rosea). The genus Hibiscus contains herbs, shrubs and trees native to tropical and temperate regions of the world. A few genera like Abelmoschus and Gossypium yield food and fibre respectively. In the genus Hibiscus, twenty species were reported to be of ornamental value (Bailey, 1949, Anon, 1959, Vasishta, 1972, Bhat, 1976 and Srivastava, 1982). Among these H.rosasinensis is the most common flowering plant held with high esteem in gardens.

### A. Morphological description

The genus Hibiscus was described by Bailey (1949), Anon (1959), Rendle (1971), Vasishta (1972), Bhatnagar (1976), Swamy and Rao (1976) and Shukla and Misra (1979). Brief descriptions of H.rosasinensis, H.mutabilis, H.schizopetalous and H.syriacus were given by Bailey (1949). Though Hooker, as quoted by Sukhla and Misra (1979), had given a species status for H.schizopetalous, Vilasini et al. (1966) considered this as a variety of shoe flower because of close resemblence with shoe flower.

Crosses of highly polymorphic cross compatible groups of hibiscus yielded promising hybrids in Hawaii and Florida (Gast, 1971). Mc Fadden (1955) described certain hibiscus seedlings derived from the variety "Red Glory".

Certain fascinating Hawaiian hibiscus varieties like 'Mumtaz', 'Peace', 'Kalway', 'Enchantress', 'Princess Margarete' and 'Ivory Gem' suited for Indian gardens were narrated by Jindal (1957). Sharma (1962) compiled descriptions of sixteen hybrid hibiscus introduced from Hawaii. Descriptions of four hybrid seedlings of hibiscus from Lal Baugh gardens, Bangalore were made by Devaiah (1968). Devaiah and Marigowda (1970) narrated one hibiscus variety "Dr.B.P.Pal" from Lal Baugh Gardens. Bhat (1979) described fourteen promising hybrids developed at the Indian Institute of Horticultural Research, Bangalore. They were 'Arunodaya', 'Basant', 'Benazeer', 'Geetanjali', 'Jogan', 'Nartaki', 'Nazneen', 'Pakeezah', 'Priya', 'Red Gold', 'Shanti', 'Smt. Indira Gandhi', 'Smt. Kamala Nehru' and 'Tribal Queen'. The cultivars namely 'Cromwell', 'Debby Ann', 'Nijalingappa', 'Rachiah', 'Rashtrapathi', 'Ruffle', 'H.S.(red)', 'H.S.123', 'H.S.182', 'H.S.203', 'H.S.381', 'I.I.H.R-H-1' and 'I.I.H.R-H-2' were used in different parental combinations to evolve the above fourteen hybrids. Morphological descriptions of six recently released hybrid seedlings 'Akita', 'Bharat Sundari', 'Chitralekha', 'Dilruba', 'Phulkari', and 'Queen of Hassarghatta' were made by Bhat and Verma (1980). At Tamil Nadu Agricultural University, Coimbatore one hybrid variety, 'Thilagam' and one improved selection 'Punnagai' were released. Descriptions of thirty six types of hibiscus maintained at College of Horticulture, Kerala Agricultural University, Trichur were made by Markose (1984).

B. Pollen viability

Zirkle (1937) described a method of staining the pollen grains with acetocarmine. Balasubramaniam (1959) in guava, Nath and Randhawa (1959) in pomegranate, Singh (1961) in mango and Vilasini et al. (1966) in hibiscus followed this technique for testing pollen viability. Viets (1952) found that the use of 2, 3, 5 triphenyl tetrazolium chloride provided a quick and reliable method for determining the viability of maize pollen. However, Oberle and Watson (1953) found that this technique was not effective in peach, apple, pear and grape pollen. Jacopini (1954) recommended sodium biselenite as a rapid indicator of pollen viability. A viability test based on peroxide reaction on agar medium was described by King (1960) for Irish potato. A fluorescence technique in which the viable grains produced bright fluorescence was described by Heslop-Harrison and Heslop-Harrison (1970) for members of graminae and compositae. Stanley and Linskens (1974) stated that the use of stains was not sufficiently accurate when compared to germination tests because of immature and aborted pollen grains also contained certain levels of chemical constituents which would yield positive results to stain tests.

Markose (1984) used acetocarmine method for testing viability of pollen in hibiscus. The pollen viability of thirty six types/varieties/species studied varied from 4.6 per cent to 97.4 per cent.

C. Vegetative propagation

The function of the leaves on root formation in Hibiscus rosasinensis cuttings was studied by Van Overbeek et al. (1946). They concluded that leaves were ordinarily essential to the rooting of cuttings and contributed sucrose and nitrogenous substances required for rooting. The leaves, however, did not produce the hypothetical hormone 'rhizocaline'. The roots were initiated in the secondary phloem in ray parenchyma. The amount of leaf area left on a cutting was reported to determine the extent and amount of root production in hibiscus (Dubrovickaja, 1949).

Virupaksha (1961) tried the effect of different rooting media on air layering in hibiscus. He compared vermiculate, leaf mould, compost, leaf mould plus farm yard manure and farm yard manure with earth and sand as rooting media. He concluded that the quickest rooting of air layers took place in compost as rooting medium. Kennedy (1966) reported little or no rooting is soft tip cuttings and basal cuttings of thick woody stems which became dessicated in the cultivar 'Ohio' in hibiscus, but obtained 80 to 90 per cent rooting within a month using soft tip and basal cuttings from which all, but one or two leaves had been removed.

1. Effect of growth regulators on rooting of cuttings

Considerable amount of work has been done on the influence of growth regulators on the rooting of cuttings of different ornamental woody perennials including hibiscus. The responses to growth regulators vary with the species and physiological state of the cuttings.

Monceu (1758) explained the formation of adventitious roots on stems on the basis of the downward movement of sap. In extending this concept, Sachs (1882) postulated the existence of a specific root forming substance manufactured in the leaves which moved downward to the base of the stem where it promoted root formation. It was shown by Van der Lek (1925) that strongly sprouting buds promoted the development of adventitious roots. The existence of a specific root forming factor was first determined by Went (1929) when he found that if leaf extracts from acalypha plants were applied to acalypha tissue, they would induce root formation. Indole-3 acetic acid (IAA) was identified by Kogl et al. (1934)

and Thimman (1935) as a naturally occuring compound having considerable auxin activity and was soon found to promote adventitious root formation. The activity of IAA was originally demonstrated by biological tests using etiolated pea epicotyle under a set of standard condition by Went (1929, 1934a, 1934b).

The growth regulators generally used for rooting of cuttings are IAA, IBA and NAA. Various authors have compared the root forming capacity of these compounds in several ornamental plant species. (Gardner and Hatcher, 1955).

a. Influence of growth regulators on the rooting of cuttings of hibiscus

Van Overbeek *et al.* (1946) found that some factors essential for rooting of hibiscus cuttings were present in the leaves of red variety which were either absent or were present in much smaller quantities in the leaves of white flowered variety.

Shanmughavelu (1959) studied the anatomical response of hibiscus cutting to IBA. He noted increased activation of cambial and cortex region consequent to the application of IBA. According to Shanmugavelu (1960a), NAA was better than Indole compound in producing copious, stouter, thicker and longer root in hibiscus. Shanmugavelu (1960b) reported that with soft wood cuttings of *Hibiscus rosasinensis*, the best rooting (75 per cent) was with 1000 ppm NAA dust treatment. He further reported that dipping semi hard wood cuttings for five seconds in a solution containing 6000 ppm of IBA or NAA gave over 90 per cent rooting compared to 10 per cent in untreated cuttings.

Shanmugavelu (1961 a) obtained 70 per cent rooting in soft wood cuttings with 2000 ppm IBA. Both IBA and NAA at 6000 ppm produced 100 per cent rooting by quick dip method in semi hard wood cuttings in 44 days. In hard wood cuttings NAA proved to be the best as it gave 85 to 95 per cent rooting.

Herman and Hess (1963) were able to increase the rootability of the hard to root white hibiscus namely 'Wilsons White' by etiolation. The more significant results from etiolation were obtained by the intermediate rooting variety of hibiscus namely 'Ruth Wilcox'. Hess (1963) isolated the different rooting cofactors from easy and difficult to root red and white varieties of hibiscus. He found that easy rooting forms had larger content of promoters. Stoltz and Hess (1966a) reported that red varieties of hibiscus accumulated approximately three times as much starch as in the difficult to root white variety.

Bose _et al._ (1973a) studied the changes in rooting factors during the regeneration of roots in easy and difficult to root cultivars of hibiscus. They found that in the easy rooting materials P-hydroxy benzoic acid, ferulic acid and P-coumaric acid occured in appreciable amounts but in difficult to root ones only P-hydroxy benzoic acid was present. Bose _et al._ (1973b) reported that the cultivars of hibiscus which failed to root from cuttings or showed low percentage of rooting under open conditions developed good roots under intermittant mist condition. The treatment with IBA and NAA further increased rooting percentage and number of roots.

b. Effect of growth regulators on rooting in other ornamental plants

As early as 1940, Kirkpatrik observed the favourable effect of IAA on rooting of rose cuttings. El - Hakim (1954) studied the efficiency of IAA in rooting of Jasminum sambac and found that 25 ppm of IAA was the most effective. Bajpai and Parmar (1958) working on Jasminum sambac reported that hard wood cuttings gave the highest percentage of rooting with 400 ppm of IAA. Shanmugavelu (1960a) obtained maximum percentage of rooting (55 per cent) in Allamanda cathartica with IAA 100 ppm in soak method.

El Hakim et al.(1962) found that IBA and NAA were more effective than IAA to induce rooting in Phyllanthus. Rousseau (1967) concluded that in general, IBA at 0.4 per cent was most effective to promote rooting in Protea longifolia. Kirceva (1967) in a trial with 12 rose varieties treated with heteroauxin or seradix at 100 mg/litre for 3 hours noted improved rooting and increased root length. Read and Hoysler (1968) showed that 2500 ppm of B-nine was effective to produce greater number of roots and weight of roots in dahlia, chrysanthemum and geranium cuttings.

Fretz and Davis (1971) stated that IBA at 5000 ppm and 2500 ppm gave maximum response in rooting of cuttings of *Ilex corneta* and *Juniperus horizontalis* respectively. Read and Hoysler (1971) obtained good results in rooting of carnation (*Dianthus caryothyllus*) with 2500 ppm SADH. Misra (1971) observed that out of 64 varieties of Bougainvillea only five showed profuse rooting and gave the maximum survival percentage (90) by Seradix B-3 treatment. Papandreou (1972) obtained 80 per cent rooting in *Rosa indica* with the use of IAA (5000 ppm) or NAA (2000 ppm). Kale and Bhubjal (1972) observed that IBA (1000 ppm) was the most effective (75 per cent) in the rooting of cuttings of Bougainvillea var. 'Merry Palmer'. The beneficial effect of IBA on rooting of cuttings of dahlia and chrysanthemum was also stressed by Bose and Mondal (1972). IAA and IBA at 5000 ppm gave 85 per cent rooting in Bougainvillea var. 'Thimma' (Nathulal *et al.* 1972).

Chibber *et al.* (1974) reported that rooting efficiency of stem cuttings of *Ipomea fistulosa* was enhanced by dipping the basal 6 cm portion of cutting in IBA 1000 ppm. By comparing the numerious commercial materials for stimulating rooting of poinsettia cuttings, Beck and Sink (1974) concluded that those containing IBA and/or NAA gave the best results. Maurya *et al.* (1974) got 70 per cent rooting in Bougainvillea var. 'Merry Palmer' by dipping the basal end of cuttings in IAA and NAA at 4000 ppm for 12 hours while no rooting was obtained in control.

In a trial with IBA by quick dip method in *Jasminum sambac* cultivar 'Motia', Singh (1979) obtained the highest rooting percentage with IBA 4000 ppm. Response to varying concentrations of auxins for rooting of ixora cuttings was studied by Singh (1980). He immersed the cuttings into the solutions of IAA, IBA and NAA at 1000 ppm, 2000 ppm, 3000 ppm, 4000 ppm, 5000 ppm and 6000 ppm for 15 seconds. He reported that IAA upto 4000 ppm, IBA upto 3000 ppm and NAA upto 2000 ppm increased percentage of rooting significantly.

Misra and Majundar (1983) conducted vegetative propagation studies in *Peltophorum*, *Bauhinia* and *Poinciana regia*. The experiment was carried out to evaluate the effective concentrations of IBA, IBA + IAA and IBA + IAA + NAA on rooting of air layers. From the studies they concluded that IBA, IAA and NAA at 6000 ppm proved to be the best for rooting of *Peltophorum* air layers. Mixture of IBA + IAA at 4000 ppm was the best for air layers of Bauhinia and IBA alone at 4000 ppm was the best for air layers of *Poinciana regia*.

# MATERIALS AND METHODS

# MATERIALS AND METHODS

The present investigations were carried out in the Department of Pomology and Floriculture, College of Horticulture, Vellanikkara during 1980-81. The investigations consisted of the following main aspects.

A. survey and collection of hibiscus types or varieties
B. morphological description of all types or varieties
C. pollen viability studies
D. standardisation of vegetative propagation methods

## A. Survey and collection of hibiscus types or varieties

Although shoe flower (*H. rosasinensis*) is grown in several home gardens of Kerala, many of the local varieties are not named or described. This necessitated a detailed survey and collection of types or varieties and their morphological descriptions. The districts of Trivandrum and Alleppey representing coastal belts, Malappuram, Palghat, Ernakulam and Trichur representing midlands and Idukki representing high ranges were selected for the survey.

Distinct types were only collected based mainly on flower characters. The types collected earlier from one district were not collected subsequently as the purpose was only to collect different types.

Twenty five semi hardwood cuttings each were collected from thirty seven types during August, 1980. The types collected were given accession numbers. Locality from where collected and the details of mother plants were also recorded. The cuttings were then planted in mud pots with potting mixture containing sand, soil and cowdung in equal proportions and were kept in nursery. The rooted cuttings were repotted after one month. When the plants were ten months old they were transplanted to the main field during July, 1981. Thirteen varieties of H.rosasinensis from Indian Institute of Horticultural Research, Bangalore and one variety from Tamil Nadu Agricultural University, Coimbatore were also added to the above collection.

B. Morphological description of all types or varieties

Morphological characters of mother plants of different types or varieties were studied in detail as per the proforma suggested by Bhat (1976, 1979) and Bhat and Verma (1980) with suitable modifications (Table 1).

Table 1. Morphological characters recorded

A. Location

B. Habit - Vigour of plant - vigorous/moderately vigorous/ not vigorous

C. Lateral branching - erect/slightly drooping/drooping

D. Leaves

a. Shape - ovate/oval/lanceolate/cordate ovate/ cordate/deltoid/oblong

b. Size

$b_1$. Length cm to cm

$b_2$. Breadth cm to cm

c. Margin - dentate/serrate/serrulate/crenate/entire/
undulate/parted(pinnately)

d. Apex - acute/acuminate/cuspidate/mucronate/eliptic

E. Flower characters

a. Nature - single/double
erect/slightly pendulous/pendulous

b. Shape - saucer/cup/ball/funnel/tubular

c. Diameter cm to cm

$E_1$.Pedicel

a. Jointed/not jointed

b. Length cm to cm

$E_2$.Epicalyx

a. Shape - linear/ovate/lance pointed

b. Number of lobes

$E_3$.Calyx

a. Shape - shallow cup/linear cup/tubular/compamulate

$E_4$.Corolla

a. Nature - crinkled/medium/smooth
entire/dissected

b. Number of whorls - single/double/multiple

c. Colour of petals

upper side

base

tip

boarder

lower side

E5. Stamens

a. Length cm

b. Colour

E6. Pistil

a. Colour of stigma head

b. Length of pistil cm

Detailed descriptions of all the 51 types or varieties were made oneyear after planting in the field. For the purpost of description only healthy plants were selected. In the case of flowers and leaves, samples consisting of 10 flowers/leaves were studied.

C. Pollen viability studies

Pollen viability was studied during January, 1981 by acetocarmine staining technique.

Ten types Acc.2, Acc.5, Acc.7, Acc.8, Acc.19, Acc.22, Acc.36, Acc.38, Acc.42 and Acc.44 of persistent flowering habit formed the materials for this investigation. The considerations for selection of these tyes were mainly the availability of flowers.

Fresh pollen grains were collected at 9 a.m. The pollen grains mounted in acetocarmine were examined after 30 minutes. Those which took stain and appeared normal were taken as viable one and the unstained and shrivelled ones as non viable. Observations were made in five different microscopic fields and the mean percentage of viability was calculated. Five such observations were made from each type.

D. Standardisation of vegetative propagation methods

1. Effect of leaves on rooting of cuttings

The investigations were carried out in ten hibiscus types mentioned earlier. The basis for selection was the availability of a large number of cuttings in and around Trichur. Semi hardwood cuttings of 15 cm length were used for the study. The treatments consisted of the following.

a. shoots with leaves intact

b. shoots in which leaves were removed.

The design of the experiment was Randomised Block Design. Fifty cuttings were used in each treatment. The cuttings were then planted in pots filled with potting mixture consisting of two parts sand, two parts soil and one part cowdung and watered daily to keep it sufficiently moist. The observations on number and length of roots were taken on 60th day. The percentage of rooting was also worked out.

2. Effect of growth regulators on percentage of rooting of stem cuttings

The following different concentrations of IAA, IBA and NAA were tried to study the effect of growth regulators on rooting of stem cuttings. The study was done during January to March, 1981 in the types mentioned earlier.

Semi hardwood cuttings of pencil thickness were selected from mother plants, located at different regions of Trichur district and cut into uniform size of 15 cm length. Twenty cuttings from each type were then treated with IAA, IBA and NAA using two methods prolonged dip method and quick dip method. Details of treatments are given below.

| Method of application | Growth regulators | | |
|---|---|---|---|
| | IAA | IBA | NAA |
| | 0 ppm Control | 0 ppm Control | 0 ppm Control |
| Prolonged dip | 25 ppm | 25 ppm | 25 ppm |
| | 50 ppm | 50 ppm | 50 ppm |
| | 75 ppm | 75 ppm | 75 ppm |
| | 100 ppm | 100 ppm | 100 ppm |
| Quick dip | 1000 ppm | 1000 ppm | 1000 ppm |
| | 3000 ppm | 3000 ppm | 3000 ppm |
| | 5000 ppm | 5000 ppm | 5000 ppm |
| | 7000 ppm | 7000 ppm | 7000 ppm |
| | 10000 ppm | 10000 ppm | 10000 ppm |

The study was done in Factorial Experiment in Completely Randomised Design with four replications.

a. Preparation of growth regulators

The growth regulator was first dissolved in 5 ml. of ethyl alcohol. The stock solution of 10,000 ppm was prepared first by making 100 ml solution with .1 g of growth regulator. This was then diluted with water to obtain 7000 ppm, 5000 ppm, 3000 ppm, 1000 ppm, 100 ppm, 75 ppm, 50 ppm and 25 ppm of growth regulator solutions.

i. prolonged dip method

The basal ends of cuttings were dipped in aqueous solutions of 25 ppm, 50 ppm, 75 ppm and 100 ppm of growth regulator for 24 hours. The cuttings were then washed with tap water and then planted in pots.

ii. quick dip method

The basal ends of cuttings were dipped in aqueous concentrated solutions of 1000 ppm, 3000 ppm, 5000 ppm, 7000 ppm and 10000 ppm of plant growth regulators for ten seconds and then planted directly.

The treated cuttings were planted in mud pots filled with potting mixture consisting of two parts sand, two parts soil and one part cowdung and kept under partial shade in nursery. Watering was done daily to keep them sufficiently moist.

The effect of plant growth regulators on rooting percentage of stem cuttings was assessed by pulling out twenty cuttings from each treatment on 60th day.

3. Effect of growth regulators onroot length, root number and root weight during rooting of cuttings

The experiment was conducted from January to April, 1981 using cuttings from types Acc.2, Acc.5, Acc.7, Acc.8, Acc.19, Acc.22, Acc.36, Acc.38, Acc.42 and Acc.44. Semi hardwood cuttings of 15 cm length of the above types were collected from mother plants distributed at different localities of Trichur district. These cuttings were then treated with

IAA, IBA and NAA each at 25 ppm, 50 ppm, 75 ppm and 100 ppm in prolonged dip method and 1000 ppm, 3000 ppm, 5000 ppm, 7000 ppm and 10000 ppm in quick dip method. The study was done in factorial experiment in C.R.D. with four replications and the number of cuttings per treatment was 20.

The treated cuttings were planted in mud pots filled with potting mixture. Ten cuttings were planted in each pot. The pots were then kept under partial shade in nursery. Watering was done daily to keep it moist.

Observations on root length, root number and root weight were taken at 20 days interval, from 20th to 100th day of planting by pulling out four cuttings from each treatment.

4. Studies on air layering

Air layering was done from October to December, 1980 in the mother plants of the above ten types.

The layering was done in mother plants distributed at different localities of Trichur district. Four mother plants of each type were selected in the field and on each of the selected plants five shoots of one year old were tagged for air layering. The selected shoots were of pencil thickness. Air layering was done by removing a ring of bark at a distance of 15 to 20 cm from the tip and tying a piece of gunny thread in the centre of the ring to prevent the cut ends of the bark from joining together. Wet sphagnum moss was placed around the ringed portion in the form of a ball to serve as rooting medium.

It was then tightly wrapped with polythene and the ends were tied tightly with gunny thread. Observations on rooting percentage of air layering was recorded on 60th day.

The data on different characters were subjected to statistical analysis as per the methods described by Snedecor and Cochran (1967). Significant results were compared after finding out critical differences.

# RESULTS

## RESULTS

The results of the present investigations are presented under the following sections.

A. Collection and maintenance of hibiscus types or varieties

Details regarding the region, source and form of planting materials of thirty four types of H.rosasinensis, one type of H.mutabilis and two types of H.schizopetalous collected are furnished in table 2. Thirteen varieties of H.rosasinensis collected from I.I.H.R. Bangalore and one variety from T.N.A.U. Coimbatore has also been added to the above collection.

B. Morphological description

Detailed morphological description in respect of habit, foliar and floral characteristics of forty eight types or varieties of H.rosasinensis, one type of H.mutabilis and two types of H.schizopetalous are presented in table 3a. Photographs are presented in plates 1 to 10.

The local types of hibiscus were found to be very vigorous, hardy and drought resistant compared to hybrids and Hawaiian varieties. Most of the Hawaiian varieties and hybrids bore flowers of large size, often measuring 15 to 17 cm across and were of the most striking and contrasting colours. The petals of local types were generally of single shade whereas most of the hybrids possessed petals of different shades.

Table 2. Source and number of hibiscus types/varieties collected

| Source: State | Source: District/ Nurseries | Form of planting materials | No. of types/ varieties collected | Remarks |
|---|---|---|---|---|
| Kerala | Trivandrum | Cuttings | 2 | |
| | Alleppey | ,, | 1 | |
| | Idukki | ,, | 1 | |
| | Ernakulam | ,, | 3 | |
| | Trichur | ,, | 16 | |
| | Palghat | ,, | 2 | |
| | Malappuram | ,, | 2 | |
| Tamilnadu | T.N.A.U. Coimbatore | Rooted cuttings | 1 | Thilagam |
| | Coimbatore | cuttings | 4 | |
| Karnataka | I.I.H.R. Bangalore | Rooted cuttings | 13 | Shanti, Nartaki, Nazneen, Chitralekha, Tribal Queen, Banazeer, Smt. Indira Gandhi, Phulkary, Basant, Bharat Sundari, Priya, Akita and Arunodaya |
| | U.A.S. Bangalore | Cuttings | 1 | |
| | Lal Baugh, Bangalore | ,, | 2 | |
| | Indo American Hybrid seeds, Bangalore | Rooted cuttings | 1 | |
| | Karnataka Garden Suppliers, Bangalore | ,, | 2 | |

Plates I - X. Types/varieties of hibiscus

Plate I ( $\times \frac{1}{5}$)

1. Acc.33
2. Acc. 2
3. Acc.1

Plate II ( $\times \frac{1}{5}$)

1. Acc. 3
2. Acc. 5
3. Acc. 9


1
2
3


1
2
3

Plate III ( x $\frac{1}{5}$)   1 & 2. Acc. 8

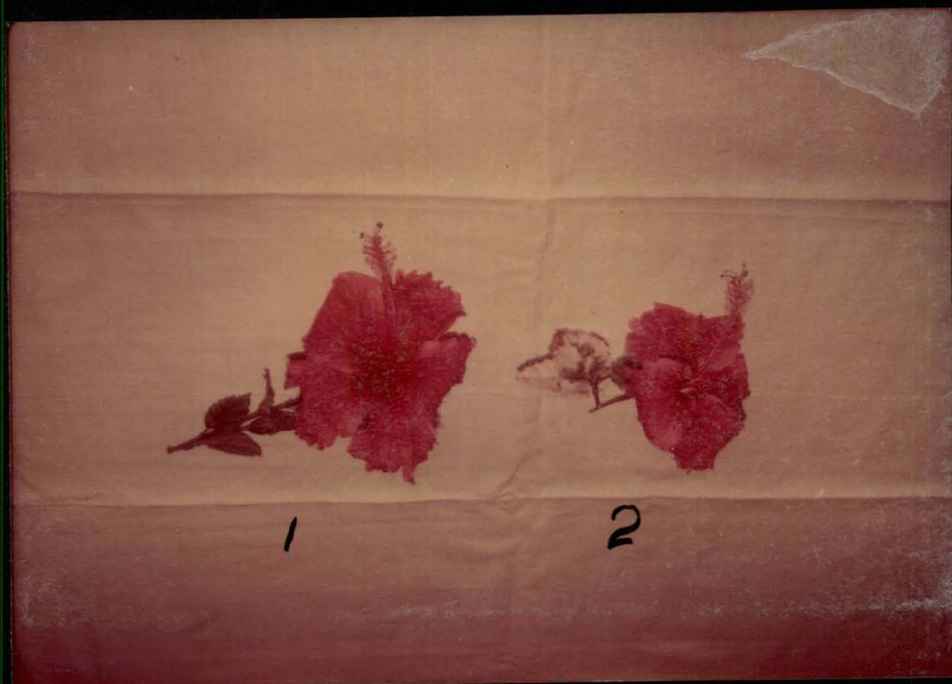
3 & 4. Acc. 6

Plate IV ( x $\frac{1}{5}$)   1. Acc. 7

2. Acc.13


1 2 3 4


1 2


1
2


1
2

Plate VII ( x $\frac{1}{5}$)

1. Acc. 45

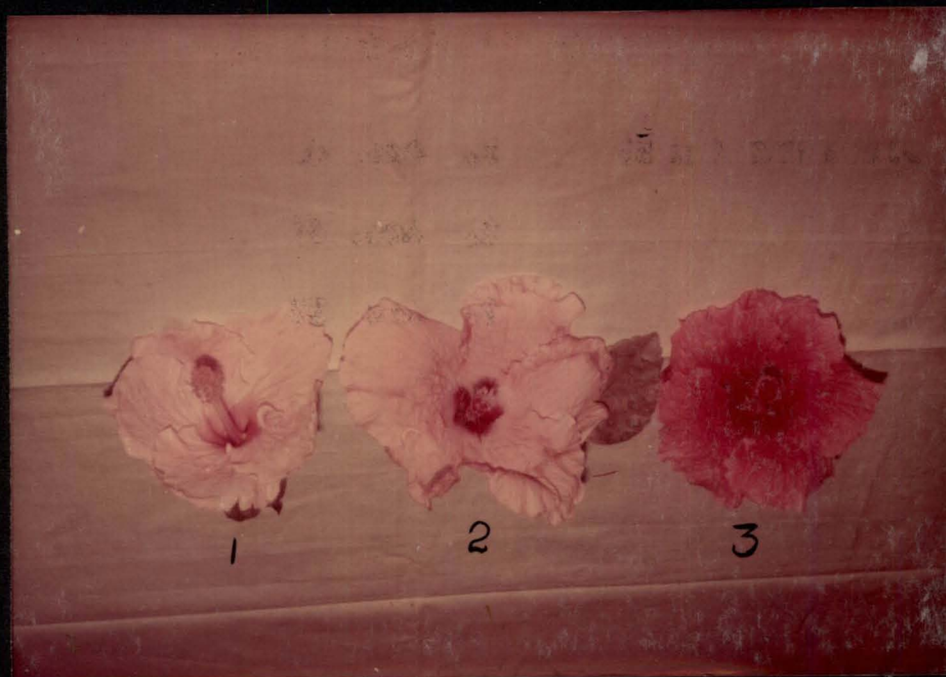
2. Acc. 46

3. Acc. 52

Plate VIII ( x $\frac{1}{5}$)

1. Acc. 22

2 & 3. Acc. 38


1
2
3


1
2
3

Plate IX ( x $\frac{1}{5}$)

1. Acc. 5

2. Acc. 44

Plate X ( x $\frac{1}{5}$)

1. Acc. 42

2. Acc. 41

3. Acc. 36


1
2


1
2
3

The leaf shape varied widely among types or varieties ranging from deeply lobbed to round or cordate ones. Generally the local types had ovate, serrate leaves while the Hawaiian varieties and some hybrids had cordate ovate and crinkled leaves with almost entire or serrulate margins. The numerical arrangement of floral parts, the number of epicalyx (5 to 9), number of lobes of calyx, pedical length, flower size, length of staminal column and length of style varied among species, varieties and types. Double flowers had extremely short styles while the singles possessed long styles. All the single types had monodelphous staminal column whereas in doubles multi-delphous condition was observed. In most of the double flowers petaloidy of staminal column extended to the ovary.

A key for identification of hibiscus types was prepared based on important characters (table 3b and 3c). According to the key, out of fifty one hibiscus types or varieties described, 22 types were vigorous, seven non vigorous and the remaining 22 moderately vigorous. Regarding the lateral branching of the 22 vigorous types, eleven were erect, nine drooping and the remaining two slightly drooping. In the moderately vigorous types, eleven had erect lateral branching, three types drooping and eight types of slightly drooping nature while in non vigorous types, lateral branching of one type was of erect nature, three slightly drooping and three of drooping nature. Leaf margins of 28 types were serrate while 6 types had serrulate leaves. Regarding leaf tip it was mainly acute

Table 3b

Key for the identification of hibiscus types

I. Plant habit

1. Vigorous 2. Moderately vigorous 3. Not vigorous

II. Nature of branching

1. Erect 2. Slightly drooping 3. Drooping

Further divisions with leaf characters (A) and floral Characters (B)

A. Leaf characters

Aa Leaf shape

$Aa_1$ Ovate

$Aa_2$ Oval

$Aa_3$ Lanceolate

$Aa_4$ Cordate ovate

$Aa_5$ Cordate

$Aa_6$ Deltoid

$Aa_7$ Oblong

Ab Leaf margin

$Ab_1$ Dentate

$Ab_2$ Serrate

$Ab_3$ Serrulate

$Ab_4$ Crenate

$Ab_5$ Entire

$Ab_6$ Undulate

$Ab_7$ Parted (Pinnately)

$Ac$ Leaf tip

$Ac_1$ Acute

$Ac_2$ Acuminate

$Ac_3$ Cuspidate

$Ac_4$ Mucronate

$Ac_5$ Eliptic

B. Floral characters

$Ba$ Erect/Pendulous

$Ba_1$ Erect

$Ba_2$ Pendulous

$Bb$ Pedicel jointed/not jointed

$Bb_1$ Jointed

$Bb_2$ Not jointed

$Bc$ Epicalyx - number of lobes

$Bc_1$ 5 lobes

$Bc_2$ 6 lobes

$Bc_3$ 7 lobes

$Bc_4$ 8 lobes

$Bc_5$ 9 lobes

$Bd$ Shape of calyx

$Bd_1$ Linear cup

$Bd_2$ Shallow cup

$Bd_3$ Tubular

$Be$ Number of petals

$Be_1$ 5 petals

$Be_2$ 10 petals

$Be_3$ 15 petals

$Be_4$ 20 petals

$Be_5$ 25 petals

$Be_6$ 30 petals

$Be_7$ 35 petals

$Be_8$ 40 petals

Bf Colour of petals

Bg Length of staminal column

$Bg_1$ Short

$Bg_2$ Medium

$Bg_3$ Long

Bh Colour of stigma head

Table 3c

Scheme of classification of hibiscus

**I Plant habit**

- 1. Vigorous
  - Erect (1.1)
  - Drooping (1.2) — A, B
  - Slightly drooping (1.3) — A, B
- 2. Moderately vigorous
  - Erect (2.1) — A, B
  - Drooping (2.2) — A, B
  - Slightly drooping (2.3) — A, B
- 3. Non vigorous
  - Erect (3.1) — A, B
  - Drooping (3.2) — A, B
  - Slightly drooping (3.3) — A, B

(1.1) →

**A. Leaf Characters**

| | | | | | |
|---|---|---|---|---|---|
| Aa | Shape | Ab | Margin | Ac | Apex |
| Aa1 | Ovate | Ab1 | Dentate | Ac1 | Acute |
| Aa2 | Oval | Ab2 | Serrate | Ac2 | Acuminate |
| Aa3 | Lanceolate | Ab3 | Serrulate | Ac3 | Cuspidate |
| Aa4 | Cordate ovate | Ab4 | Crenate | Ac4 | Mucronate |
| Aa5 | Cordate | Ab5 | Entire | | |
| Aa6 | Deltoid | Ab6 | Undulate | | |
| Aa7 | Oblong | Ab7 | Parted (Pinnately) | | |

**B. Flowers Characters**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Ba | Erect/ Pendulous | Bb | Pedical | Bc | Epicalyx No.of lobes | Bd | Shape of calyx |
| Ba1 | Erect | Bb1 | Jointed | Bc1 | 5 lobes | Bd1 | Linear cup |
| Ba2 | Pendulous | Bb2 | Not jointed | Bc2 | 6 lobes | Bd2 | Shallow cup |
| | | | | Bc3 | 7 lobes | Bd3 | Tubular |
| | | | | Bc4 | 8 lobes | | |
| | | | | Bc5 | [illegible] lobes | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Be | No.of Petals | Bf | Colour of petals | Bg | Length of staminal column | Bh | Colour of stigma head |
| Be1 | 5 petals | | | | | | |
| Be2 | 10 petals | | | | | | |
| Be3 | 15 petals | | | | | | |
| Be4 | 20 petals | | | | | | |
| Be5 | 25 petals | | | | | | |
| Be6 | 30 petals | | | | | | |
| Be7 | 35 petals | | | | | | |
| Be8 | 40 petals | | | | | | |

while a few types had acuminate apex. The flowers generally had single whorl of petals while 12 types had multiple whorl of petals. The length of pedicel varied from 0.8 cm to 8.6 cm and the number of epicalyx from 5 to 9.

C. Pollen viability

Pollen grains appeared as powdery mass and were found to be more or less of similar shape. Pollen grains were panto-porate, spheroidal and spinose. Along with normal pollen grains abnormal grains like elongated and pollinated bodies were also observed.

Data on pollen viability of ten types of hibiscus are presented in table 4. Acc.22 had maximum percentage of pollen viability (89.8) while Acc.7 showed minimum pollen viability (4.6). The types Acc.22, Acc.36 and Acc.2 did not record any significant differences among themselves with regard to pollen viability. Similarly there were no significant differences in pollen viability among the types Acc.8, Acc.5 and Acc.19. Among the ten types, Acc.22, Acc.36 and Acc.2 recorded higher percentage of viability whereas Acc.42 and Acc.7 recorded poor viability. The pollen viability among types varied from 4.6 per cent in Acc.7 to 89.8 per cent in Acc.22.

D. Standardisation of vegetative propagation methods

The response of hibiscus types to ordinary methods of vegetative propagation like stem cuttings and air layering was assessed and the observations are given below.

Table 4. Percentage of pollen viability in 10 types of hibiscus

| Acc.No. | Pollen viability in percentage |
|---|---|
| Acc. 02 | 85.6 (67.726) |
| Acc. 05 | 64.6 (53.510) |
| Acc. 07 | 4.6 (12.308) |
| Acc. 08 | 81.0 (64.122) |
| Acc. 19 | 60.4 (51.041) |
| Acc. 22 | 89.8 (71.338) |
| Acc. 36 | 87.5 (69.348) |
| Acc. 38 | 81.0 (64.122) |
| Acc. 42 | 20.9 (27.164) |
| Acc. 44 | 52.0 (46.150) |
| C.D. (P = 0.05) | 4.747 |

Figures in parenthesis indicate the means of transformed data

1. Effect of leaves on rooting of cuttings

Rooting behaviour of semi hardwood stem cutting was assessed on 60th day under two treatment conditions viz. with and without leaves. The results on rooting percentage, root number and root length are presented in tables 5, 6 and 7.

Comparing the two methods treatment with leaves was statistically superior to treatment without leaves for rooting percentage. Among the ten types of hibiscus, Acc.19 (87 per cent) and Acc.38 (85.5 per cent) were on par in rooting percentage and were significantly superior to all other types. The lowest response for rooting percentage was shown by Acc.7 and it was statistically inferior to all other types.

Retention of leaves showed significant influence in root number over the treatment without leaves in all the types except Acc.7 and Acc.38. Regarding root number also maximum response was exhibited by Acc.19 (5.90) followed by Acc.38 (5.55). Statistically the differences between these treatments were not significant. Minimum number of roots was in Acc.7 (2.55) which was on par with Acc.22 (2.77) and Acc.42 (2.67).

Maximum root length was observed in Acc.19 (8.22) and it was statistically superior to all other types. This was followed by Acc.38 (5.76), Acc.5 (5.31) and Acc.8 (4.96). The differences among the treatment effects of Acc.8, Acc.22

Table 5. Effect of retention of leaves on rooting of cuttings on 60th day

| Acc.No. | Percentage of rooting | | |
|---|---|---|---|
| | With leaves | Without leaves | Mean |
| Acc. 2 | 40.0 (39.23) | 32.0 (34.45) | 36.0 (36.03) |
| Acc. 5 | 54.0 (47.29) | 52.0 (46.15) | 53.0 (46.72) |
| Acc. 7 | 11.0 (19.37) | 8.0 (16.43) | 9.5 (17.95) |
| Acc. 8 | 80.0 (63.44) | 78.0 (62.03) | 79.0 (52.72) |
| Acc. 19 | 90.0 (71.56) | 84.0 (66.42) | 87.0 (68.87) |
| Acc. 22 | 75.0 (60.00) | 73.0 (58.69) | 74.0 (59.34) |
| Acc. 36 | 69.0 (56.17) | 62.0 (51.94) | 65.5 (54.03) |
| Acc. 38 | 87.0 (68.87) | 84.0 (66.42) | 85.5 (67.62) |
| Acc. 42 | 25.0 (30.00) | 21.0 (27.28) | 23.0 (28.66) |
| Acc. 44 | 75.0 (60.00) | 67.0 (54.94) | 71.0 (57.42) |
| Mean | 45.9 (51.59) | 44.1 (48.40) | |

C.D. (P = 0.05 ) transformed data

i. Types 1.7913

ii. Retention of leaves 1.1320

Figures in parenthesis indicate the transformed data.

Table 6. Effect of retention of leaves on root number during rooting of cuttings on 60th day

| Acc. No. | Root number | | |
|---|---|---|---|
| | With leaves | without leaves | Mean |
| Acc. 2 | 3.87 | 3.00 | 3.43 |
| Acc. 5 | 4.97 | 4.25 | 4.61 |
| Acc. 7 | 2.60 | 2.50 | 2.55 |
| Acc. 8 | 4.83 | 4.50 | 4.66 |
| Acc. 19 | 6.30 | 5.50 | 5.90 |
| Acc. 22 | 3.05 | 2.50 | 2.77 |
| Acc. 36 | 3.46 | 3.00 | 3.23 |
| Acc. 38 | 5.60 | 5.50 | 5.55 |
| Acc. 42 | 2.85 | 2.50 | 2.67 |
| Acc. 44 | 5.57 | 4.50 | 5.12 |
| Mean | 4.32 | 3.77 | |

C.D. (P = 0.05)

i. Types 0.4106

ii. Retention of leaves 0.2596

Table 7. Effect of retention of leaves on root length during rooting of cuttings on 60th day

| Acc. No. | Root length (cm) | | |
|---|---|---|---|
| | with leaves | without leaves | Mean |
| Acc. 2 | 4.96 (2.165) | 4.10 (2.024) | 4.38 (2.094) |
| Acc. 5 | 5.70 (2.387) | 4.95 (2.224) | 5.31 (2.305) |
| Acc. 7 | 3.39 (1.841) | 3.27 (1.808) | 3.32 (1.824) |
| Acc. 8 | 5.03 (2.242) | 4.90 (2.213) | 4.96 (2.227) |
| Acc. 19 | 8.96 (2.993) | 7.53 (2.744) | 8.22 (2.868) |
| Acc. 22 | 4.90 (2.263) | 4.65 ( 2.156) | 4.77 (2.184) |
| Acc. 36 | 4.23 (2.056) | 3.75 (1.936) | 3.98 (1.996) |
| Acc. 38 | 5.83 (2.414) | 5.70 (2.387) | 5.76 (2.401) |
| Acc. 42 | 3.53 (1.878) | 3.40 (1.843) | 3.46 (1.860) |
| Acc. 44 | 4.96 (2.227) | 4.35 (2.085) | 4.64 (2.156) |
| Mean | 5.22 (2.241) | 4.66 (2.142) | |

C.D. (P = 0.05) transformed data

i. Types 0.0831

ii. Retention of leaves 0.0525

Figures in parenthesis indicate the transformed data

(4.77) and Acc.44 (4.64) were not statistically significant. The shortest root was observed in Acc.7 (3.32) and it was on par with Acc.42 (3.46).

Retention of leaves had definite advantage over complete removal of leaves for rooting percentage and root number. The type Acc.19 was the best for rooting percentage, root number and root length while Acc.7 had the lowest performance in rooting percentage, root number and root length.

2. Effect of growth regulators on percentage of rooting of cuttings in hibiscus types

Data on the effect of growth regulators on the percentage of rooting of ten types of hibiscus cuttings as observed on 60th day are presented in table 8a, 8b and illustrated in figures 1a and 1b. The effect of growth regulators on rooting of cuttings are illustrated in plates 11 to 22.

a. Quick dip method

The effect of different growth regulators by quick dip method showed that the highest percentage of rooting was obtained when the cuttings were treated with NAA 3000 ppm (78.0 per cent) followed by NAA 5000 ppm (74.1 per cent) and IBA 5000 ppm (72.1 per cent). NAA 3000 ppm was significantly superior to all other treatments. There was no significant difference between NAA 5000 ppm and IBA 5000 ppm. The lowest rooting percentage was obtained when cuttings were treated with IAA 1000 ppm (60.7 per cent) which was on par with

Table 8a. Effect of growth regulators on rooting percentage of hibiscus on 60th day of planting

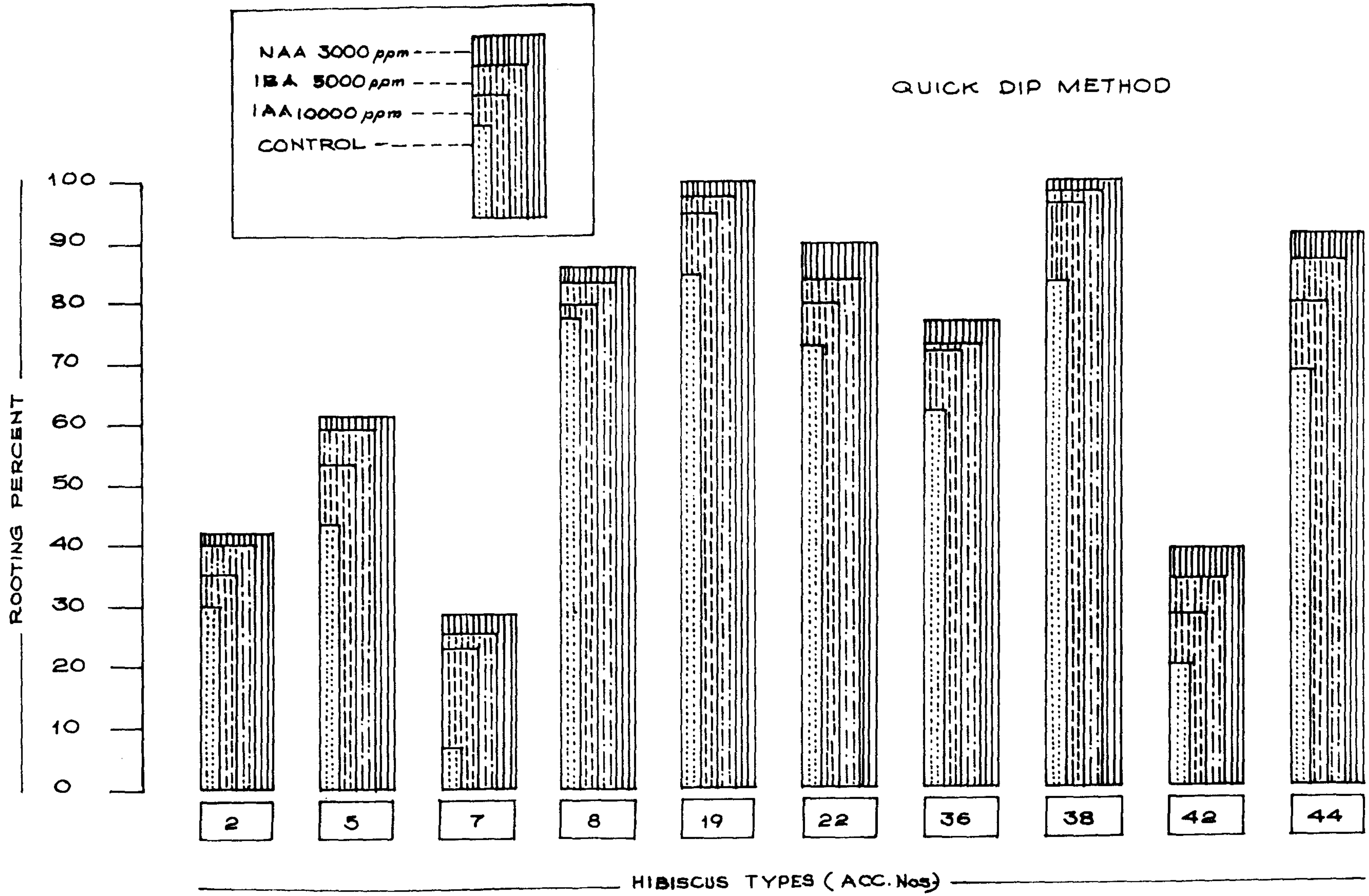
| Treatment (in ppm) | Mean rooting percentage |
|---|---|
| Control | 56.2 (48.58) |
| NAA 25 | 64.5 (53.41) |
| 50 | 74.2 (59.47) |
| 75 | 71.2 (57.58) |
| 100 | 66.1 (54.37) |
| 1000 | 67.2 (55.04) |
| 3000 | 78.0 (66.02) |
| 5000 | 74.1 (59.43) |
| 7000 | 68.1 (55.61) |
| 10000 | 61.5 (51.68) |
| IBA 25 | 62.7 (52.39) |
| 50 | 67.2 (55.07) |
| 75 | 70.1 (56.88) |
| 100 | 66.2 (54.47) |
| 1000 | 63.7 (52.93) |
| 3000 | 69.0 (56.16) |
| 5000 | 72.1 (58.15) |
| 7000 | 67.5 (55.27) |
| 10000 | 61.3 (51.95) |
| IAA 25 | 60.8 (51.26) |
| 50 | 62.0 (51.98) |
| 75 | 65.1 (53.82) |
| 100 | 66.2 (54.49) |
| 1000 | 60.7 (51.21) |
| 3000 | 62.4 (52.17) |
| 5000 | 65.4 (53.97) |
| 7000 | 68.0 (55.52) |
| 10000 | 70.2 (56.91) |
| C.D. (P = 0.05) | 1.998 |

Figures in parenthesis indicate the transformed data

Table 8b. Effect of growth regulators on rooting percentage of different types of hibiscus on 60th day of planting

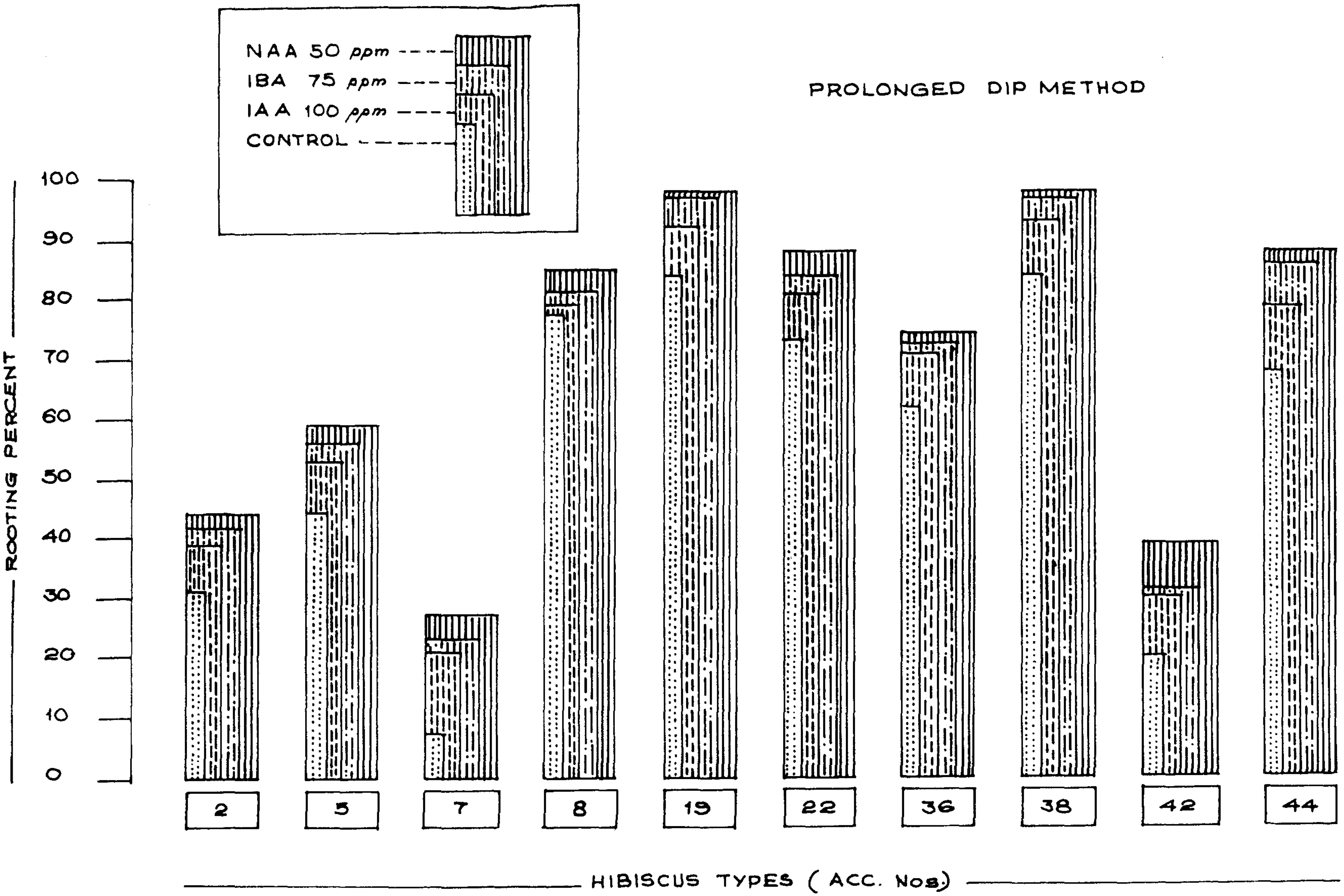
| Acc. No. | Mean rooting percentage |
|---|---|
| Acc. 2 | 37.4 (37.33) |
| Acc. 5 | 54.5 (47.50) |
| Acc. 7 | 20.7 (27.00) |
| Acc. 8 | 81.3 (64.35) |
| Acc. 19 | 93.2 (74.86) |
| Acc. 22 | 84.3 (64.60) |
| Acc. 36 | 69.8 (56.68) |
| Acc. 38 | 93.1 (74.84) |
| Acc. 42 | 29.7 (33.01) |
| Acc. 44 | 80.1 (63.55) |
| C.D. (P = 0.05) | 1.194 |

Figures in parenthesis indicate the means of transofmred data




EFFECT OF GROWTH REGULATORS ON ROOTING PERCENTAGE DURING ROOTING OF DIFFERENT TYPES OF HIBISCUS ON 60th DAY

FIG: 1a.



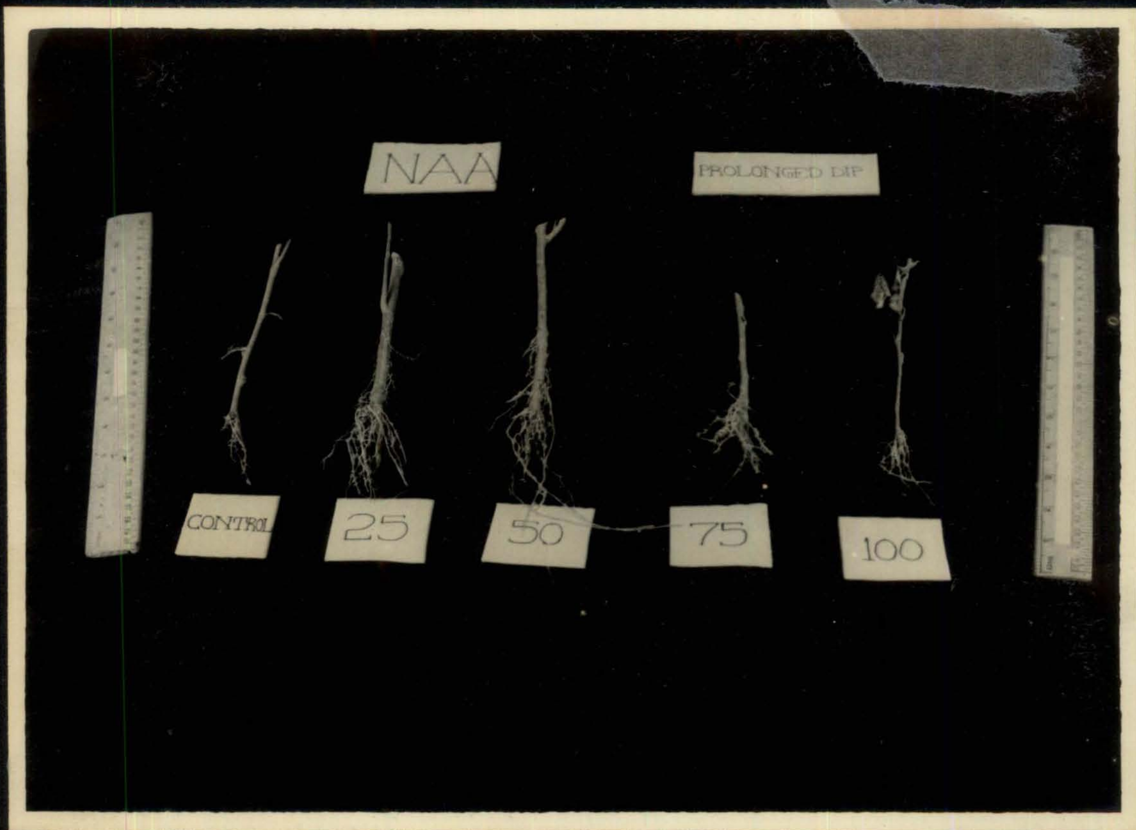

EFFECT OF GROWTH REGULATORS ON ROOTING PERCENTAGE DURING ROOTING OF DIFFERENT TYPES OF HIBISCUS ON 60th DAY

FIG. 1 b.

Plates XI - XVI. Effect of growth regulators on rooting of cuttings of hibiscus (Acc. 19)

Plate XI. Effect of NAA (prolonged dip method) on rooting of cuttings on hibiscus.

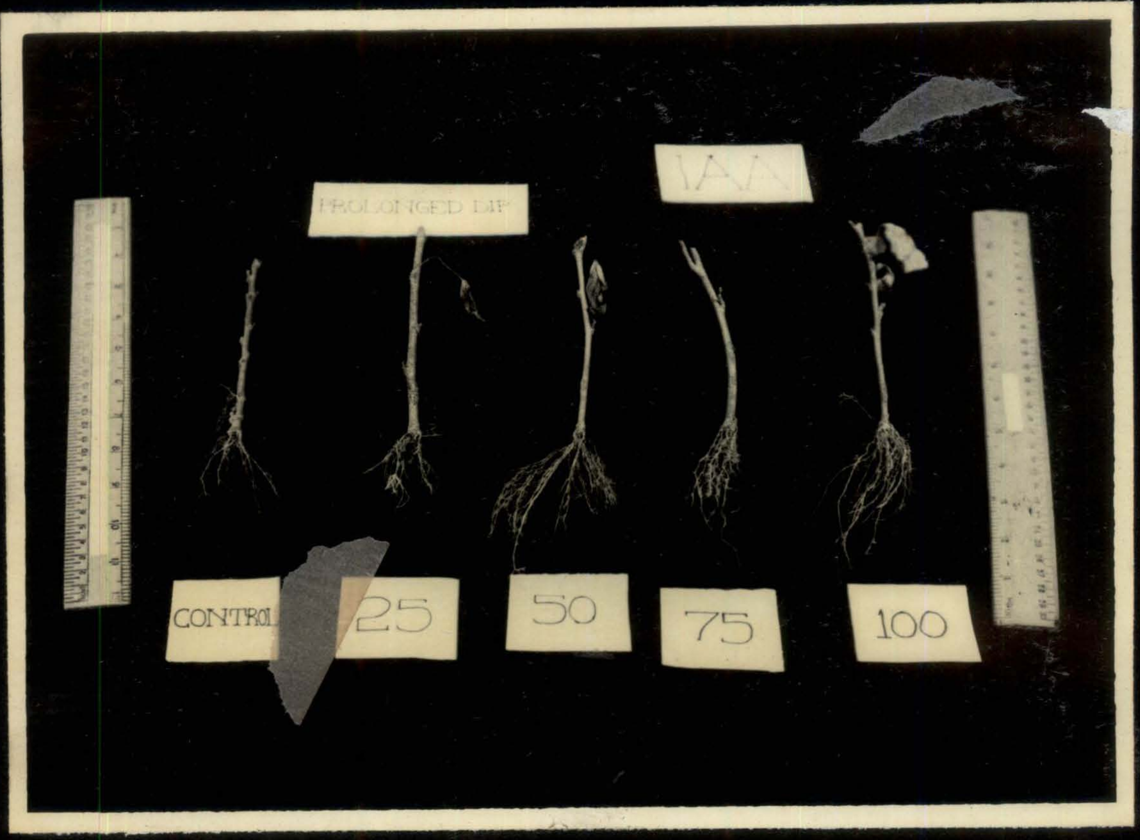
Plate XII. Effect of IBA (prolonged dip method) on rooting of cuttings of hibiscus.


NAA
PROLONGED DIP
CONTROL
25
50
75
100


PROLONGED DIP
CONTROL
25
50
75
100

Plate XIII. Effect of IAA (prolonged dip method) on rooting of cuttings of hibiscus.

Plate XIV. Effect of NAA (quick dip method) on rooting of cuttings of hibiscus.


IAA
PROLONGED DIP
CONTROL
25
50
75
100

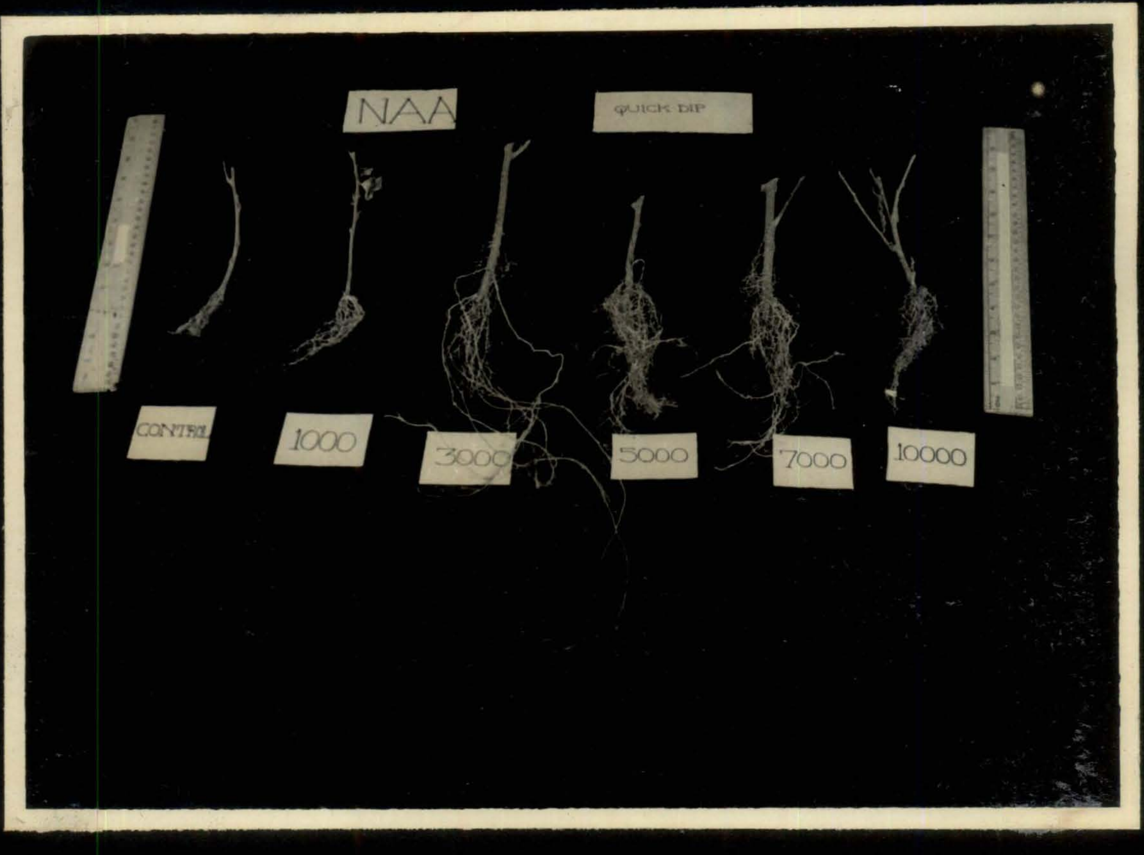
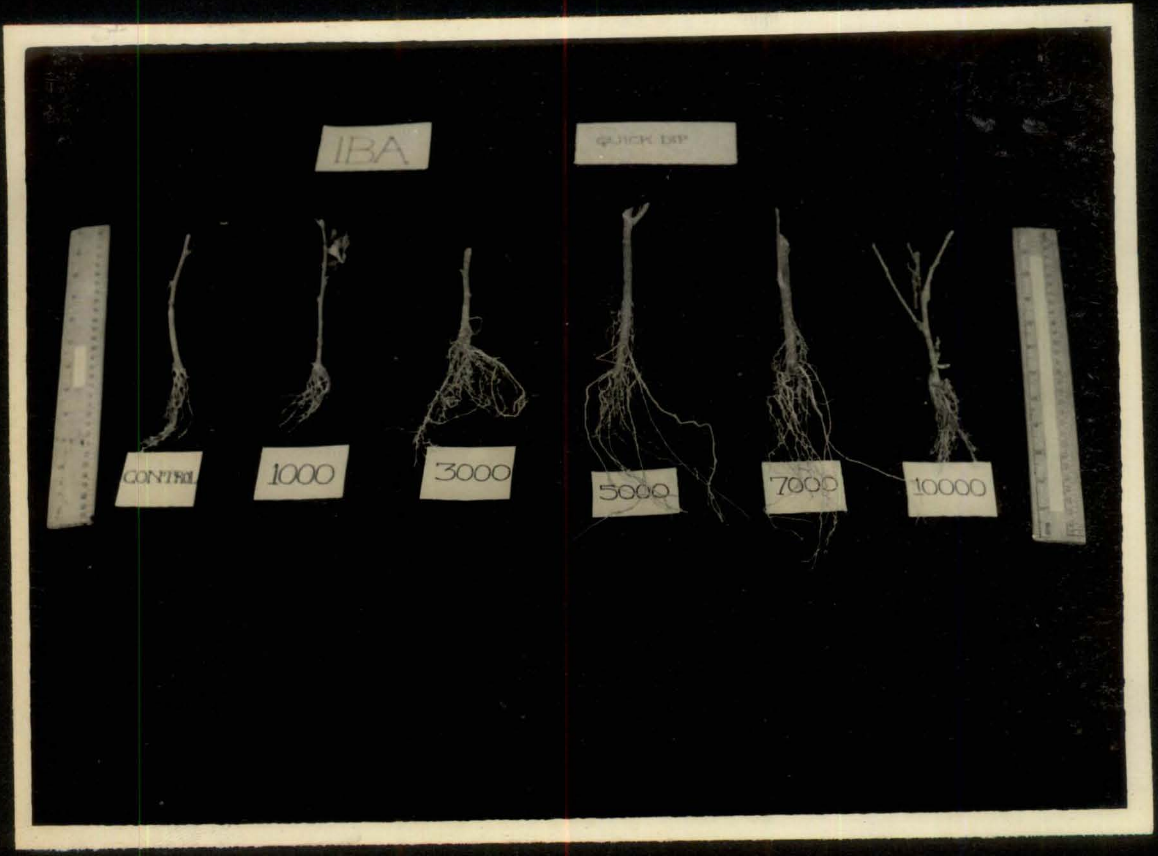
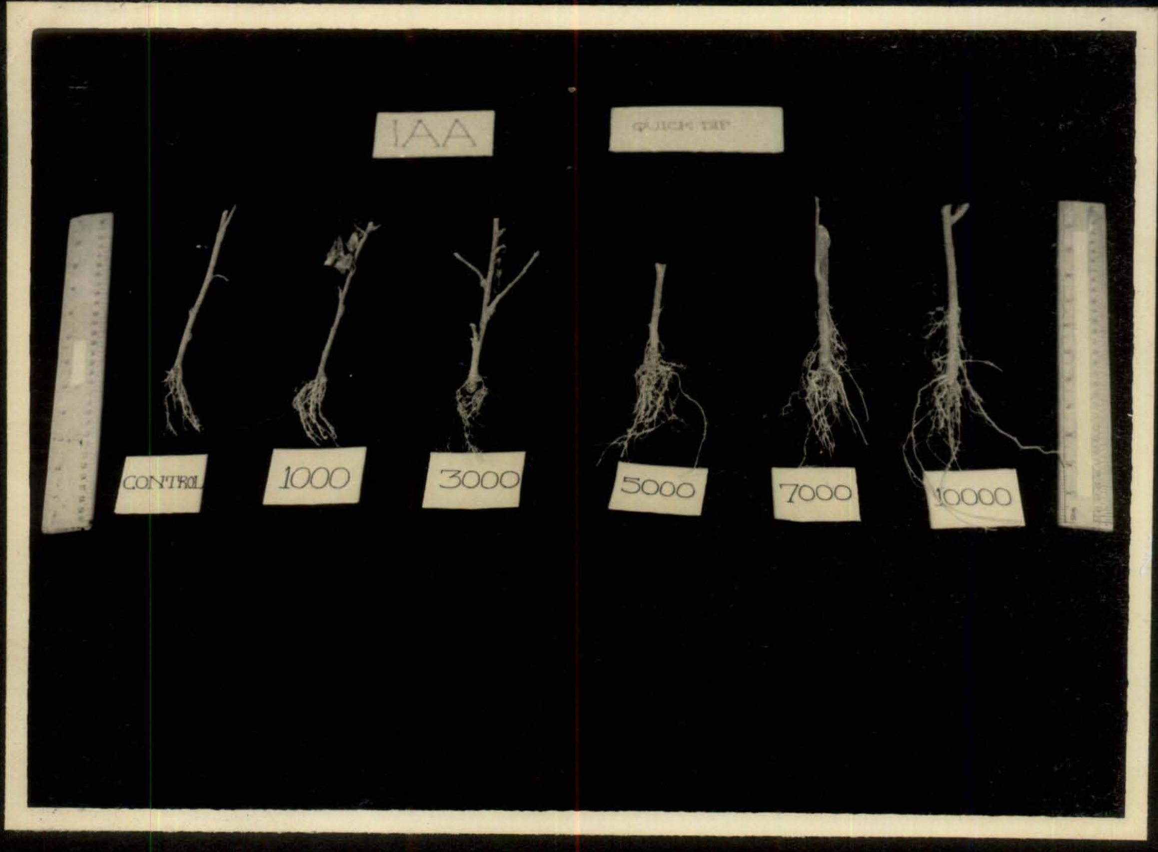

NAA
QUICK-DIP
CONTROL
1000
3000
5000
7000
10000

Plate XV. Effect of IBA (quick dip method) on rooting of cuttings of hibiscus.

Plate XVI. Effect of IAA (quick dip method) on rooting of cuttings of hibiscus.

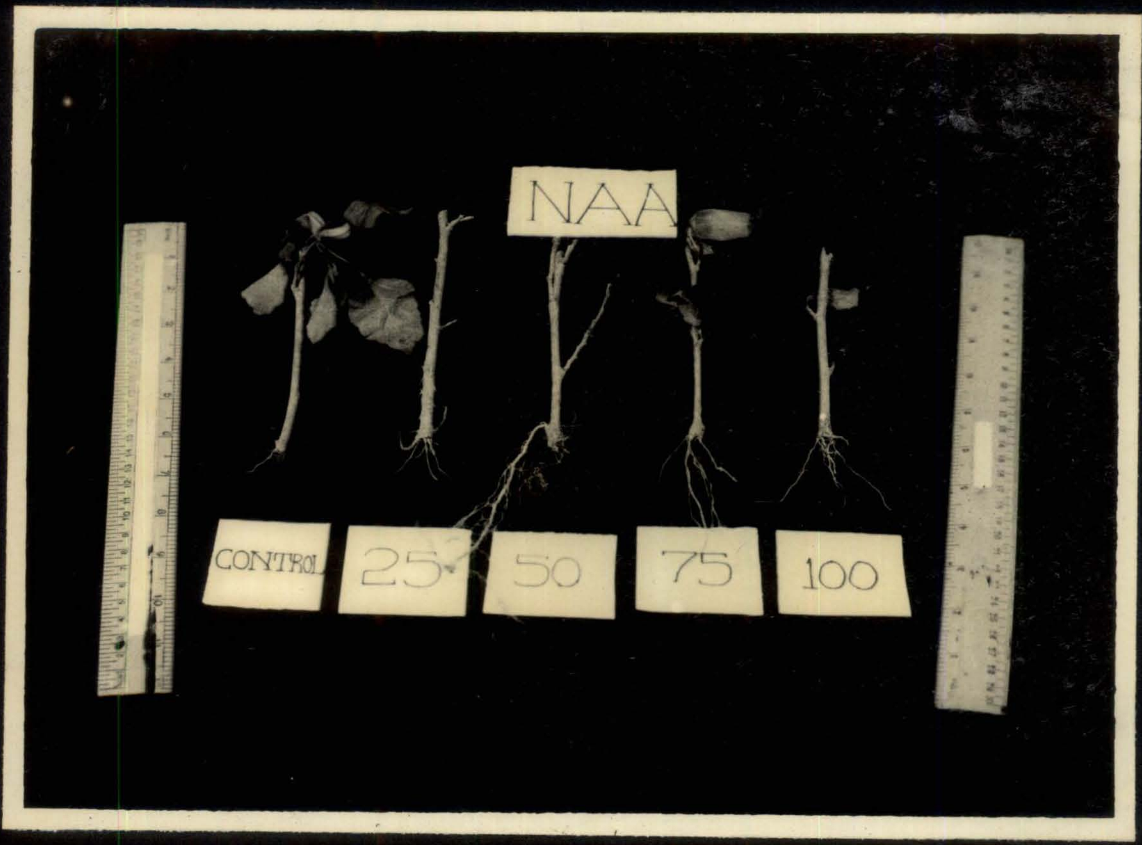

IBA
QUICK DIP
CONTROL
1000
3000
5000
7000
10000


IAA
QUICK DIP
CONTROL
1000
3000
5000
7000
10000

Plates XVII - XXII. Effect of growth regulators on rooting of cuttings of hibiscus (Acc. 22).

Plate XVII. Effect of NAA (prolonged dip method) on rooting of cuttings of hibiscus.

Plate XVIII. Effect of IBA (prolonged dip method) on rooting of cuttings of hibiscus.


NAA
CONTROL
25
50
75
100

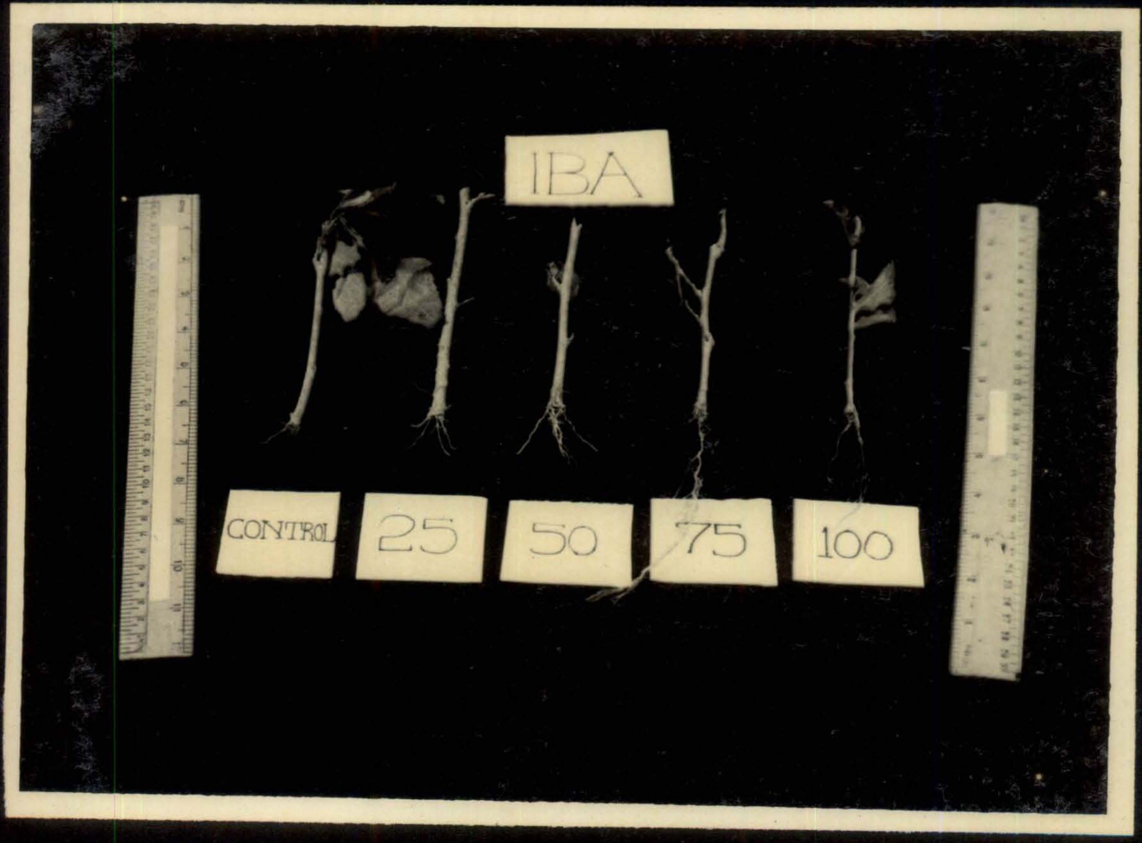
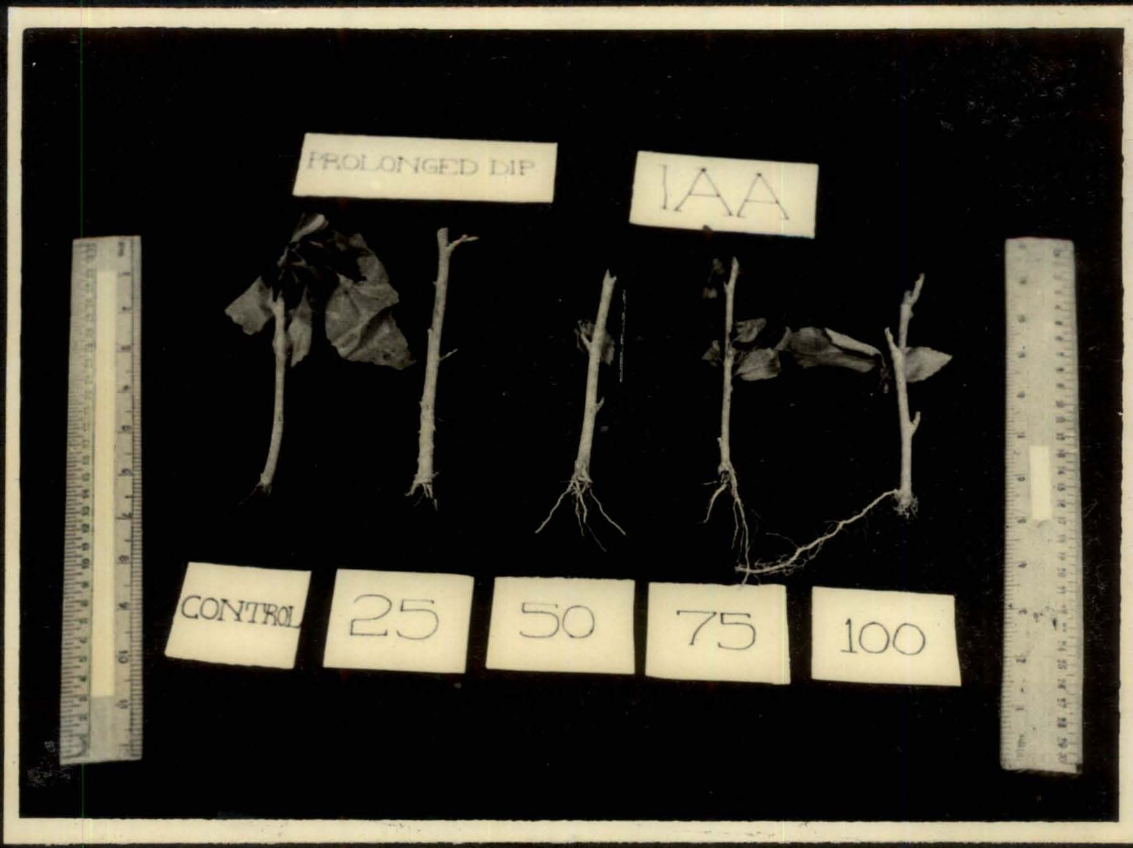

IBA
CONTROL
25
50
75
100

Plate XIX. Effect of IAA (prolonged dip method) on rooting of cuttings of hibiscus.

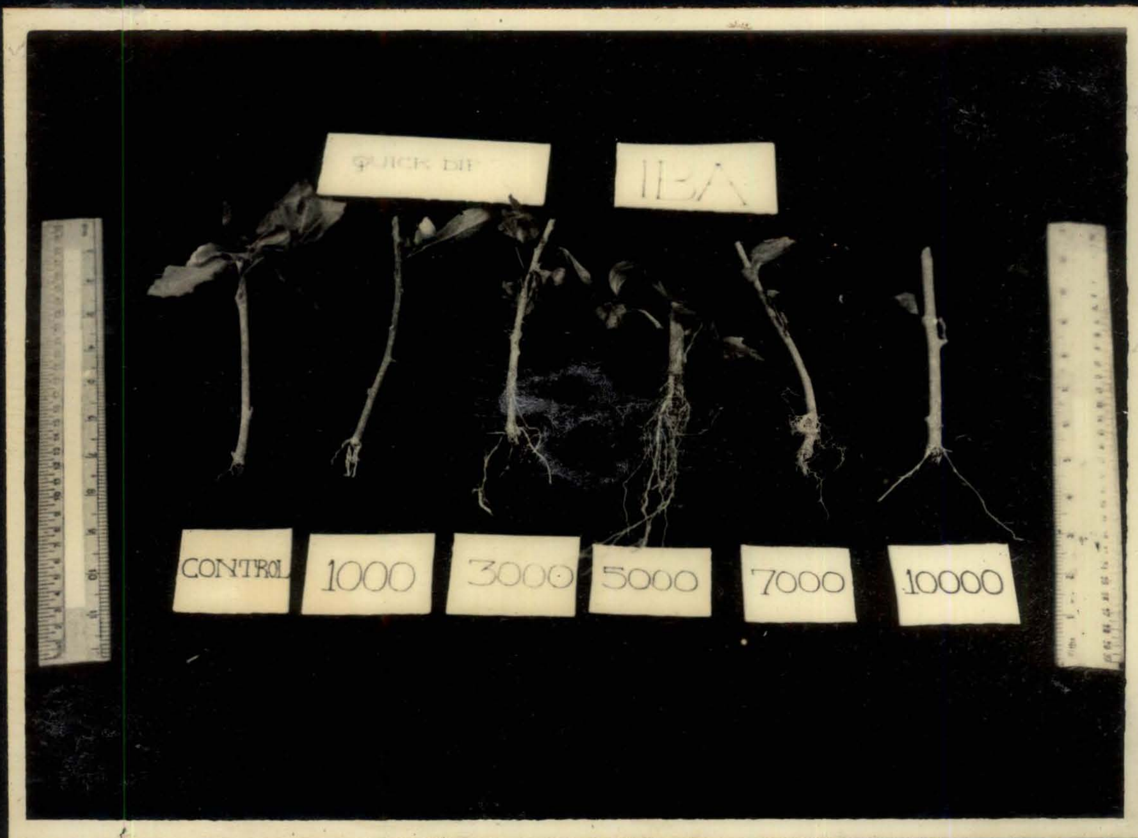
Plate XX. Effect of NAA (quick dip method) on rooting of cuttings of hibiscus.

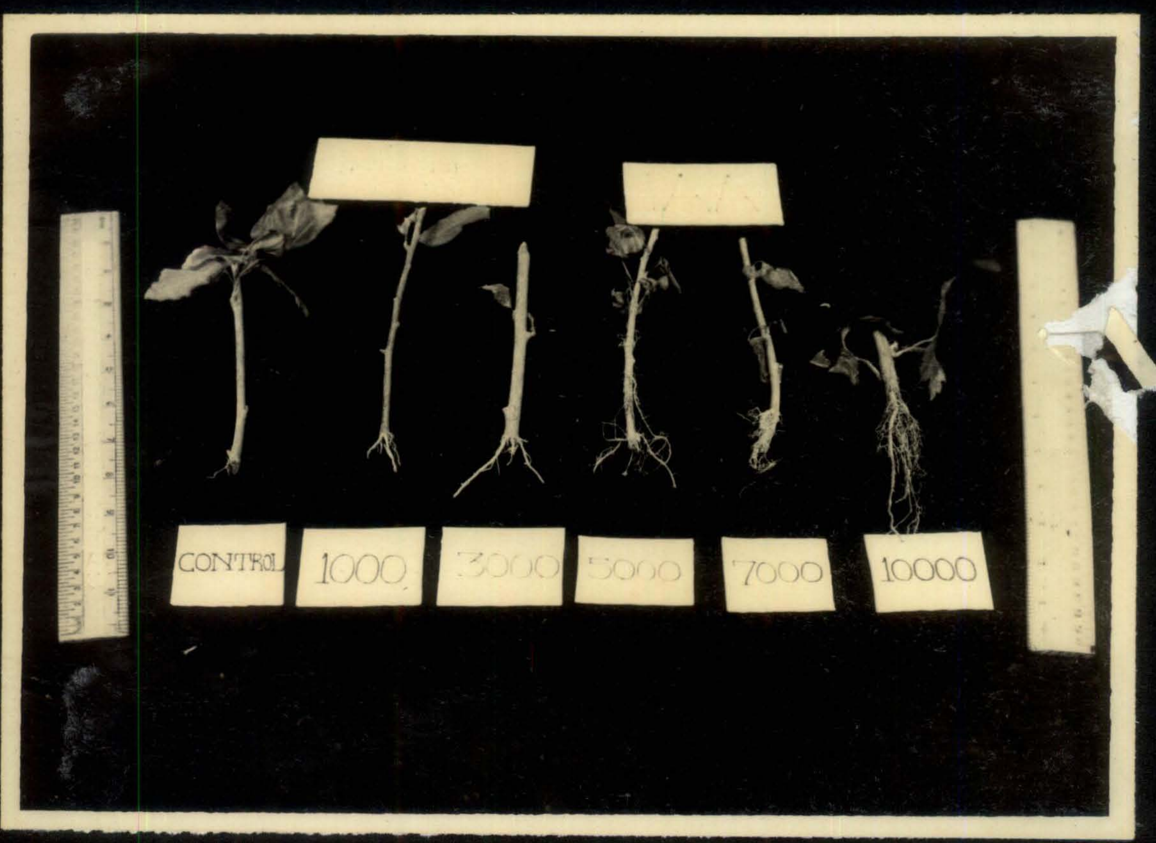

PROLONGED DIP
IAA
CONTROL
25
50
75
100


QUICK DIP
NAA
CONTROL
1000
3000
5000
7000
10000

Plate XXI. Effect of IBA (quick dip method) on rooting of cuttings of hibiscus.

Plate XXII. Effect of IAA (quick dip method) on rooting of cuttings of hibiscus.


QUICK DIP
IBA
CONTROL
1000
3000
5000
7000
10000


CONTROL
1000
3000
5000
7000
10000

IAA 3000 ppm, IBA 1000 ppm, IBA 10000 ppm and NAA 10000 ppm. When compared to control all growth regulator treatments exhibited significant influence in increasing rooting percentage.

b. Prolonged dip method

In prolonged dip method NAA 50 ppm was the best (74.2 per cent) for rooting percentage followed by NAA 75 ppm (71.2 per cent) and IBA 75 ppm (70.1 per cent). NAA 50 ppm was significantly superior to all other treatments. The treatments NAA 75 ppm and IBA 75 ppm were statistically on par. The lowest rooting percentage was found with IAA 25 ppm (60.8 per cent). No significant differences were observed among IBA 25 ppm, IAA 25 ppm and IAA 50 ppm. The percentage of rooting in the above treatments varied from 60.8 to 62.7 per cent.

Quick dip method was significantly superior to prolonged dip method with regard to rooting percentage.

c. Types of hibiscus

Comparison of the types showed that Acc.19 recorded the maximum percentage of rooting (93.2 per cent) followed by Acc.38 (93.1 per cent), Acc.22 (84.3 per cent), Acc.8 (81.3 per cent) and Acc.44 (80.7 per cent) respectively. Acc.19 and Acc.38 were significantly superior to all other types with respect to rooting. The percentage of rooting was significantly the lowest in Acc.7 (20.7 per cent)

Interaction of types and growth regulators was not significant regarding percentage of rooting.

3. Effect of growth regulators on root length, root number and root weight during rooting of cuttings

a. Effect of growth regulators on root length

The effects of NAA, IBA and IAA on root length during rooting of cuttings were assessed at 20 days interval, from 20th to 100th day of planting. The data are furnished in table 9a and 9b and illustrated in figures 2a and 2b.

i. 20th day of planting

Quick dip method

Maximum root length of cutting (1.90 cm) was recorded by NAA 3000 ppm followed by IAA 10000 ppm (1.64 cm) and IBA 5000 ppm (1.59 cm). The effects of these three treatments were statistically on par. IAA 1000 ppm exhibited the least effect on root length (0.31 cm) which was on par with IAA 3000 ppm (0.78 cm). Compared to control, all the growth regulators influenced root length significantly.

Prolonged dip method

Treating the cutting with IBA 75 ppm, NAA 50 ppm and IAA 100 ppm resulted in maximum root length, the difference between these treatments being statistically not significant. No significant difference was observed between NAA 50 ppm, IBA 50 ppm, IBA 75 ppm, IBA 100 ppm and IAA 100 ppm. The root length in the above types varied from 0.92 cm to 1.37 cm. IAA 25 ppm recorded the lowest root length (0.33 cm) which was on par with IAA 50 ppm (0.53 cm) and IAA 75 ppm (0.62 cm).

Types of hibiscus

The responses of different types to growth regulator treatments were also significant (Table 9b).

Acc.19 recorded the maximum root length (1.81 cm) which was significantly higher than all other types. No significant difference was observed between Acc.5 (1.24 cm) and Acc.44 (1.08 cm). The response of Acc.42 to growth regulator treatment was minimum (0.63 cm) which was on par with Acc.7 (0.65 cm).

ii. 40th day of planting

Quick dip method

The analysis of data on root length on 40th day showed that NAA 3000 ppm caused the maximum root length of 5.53 cm followed by IBA 5000 ppm (5.14 cm) and IAA 10000 ppm (4.75 cm). As in the case of 20th day, on 40th day also there was no significant difference among the treatment effects of NAA 3000 ppm, IBA 5000 ppm and IAA 10000 ppm. Both on 20th and 40th day, IAA 1000 ppm produced the shortest roots. With respect to root length all treatments were significantly superior to control where the root length was only 1.11 cm.

Prolonged dip method

Comparison of different growth regulators by prolonged dip method showed that the longest root was recorded in NAA 50 ppm followed by IAA 100 ppm and IBA 75 ppm. NAA 50 ppm was significantly superior to all other treatments for root length.

IAA 100 ppm and IBA 75 ppm were statistically similar and root length varied from 3.52 cm to 3.61 cm. Just like on 20th day, on 40th day also the lowest root length was found with IAA 25 ppm (1.91 cm) which was on par with IAA 50 ppm (2.02 cm).

Types of hibiscus

Acc.19 continued to record maximum root length on 40th day also which was statistically on par with Acc.5, Acc.38 and Acc.22. The root length in the above types varied from 4.34 cm to 4.81 cm. The shortest root was observed in Acc.7 (1.60 cm) which was statistically similar with that of Acc.42 (1.67 cm).

iii. 60th day of planting

Quick dip method

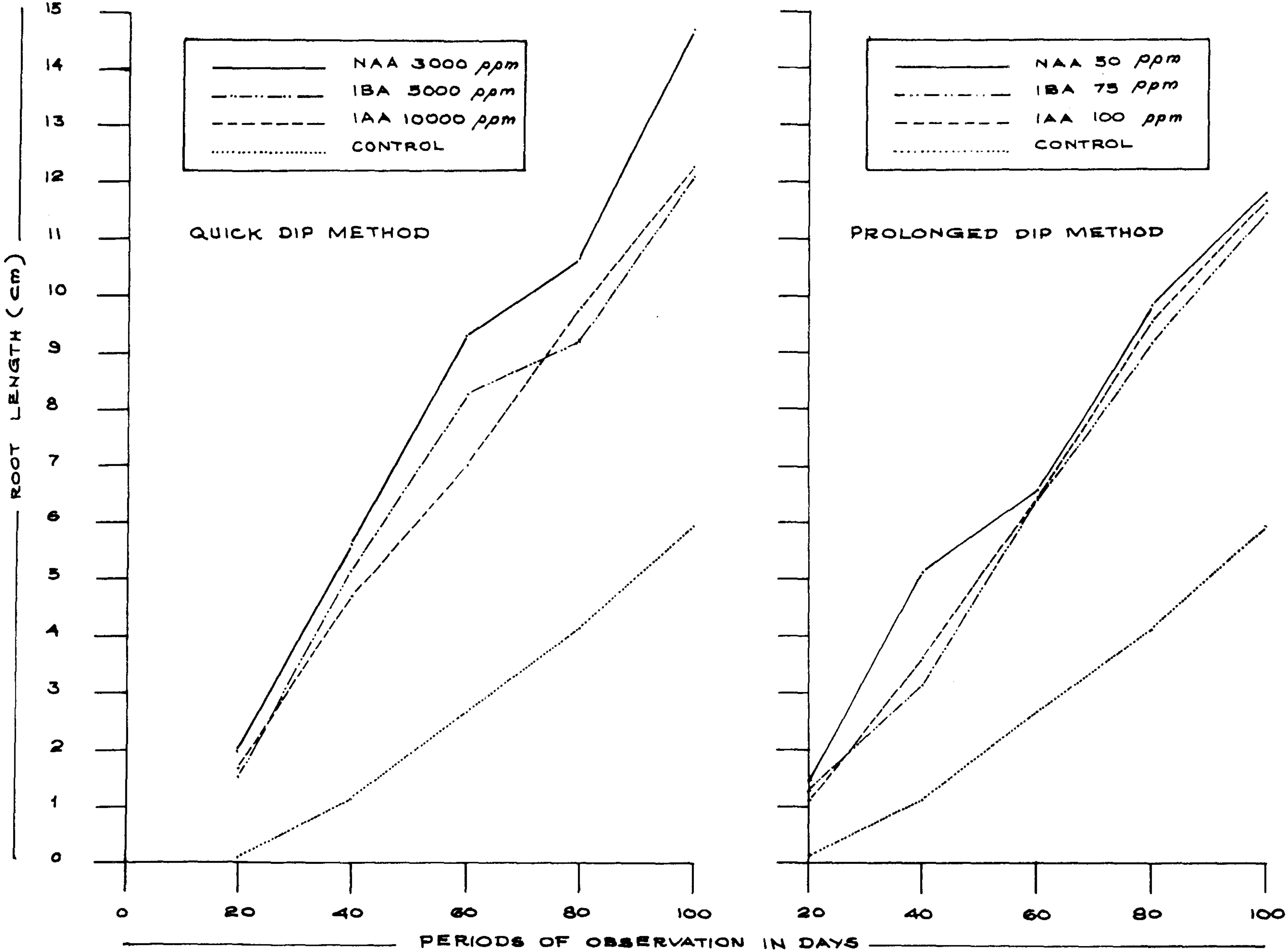
The cuttings treated with NAA 3000 ppm continued to exhibit maximum root length (9.35 cm) which was significantly superior to all other treatments. The next effective treatments were IBA 5000 ppm (8.26 cm) and NAA 5000 ppm (7.72 cm) which was statistically similar. Among the treatments, NAA 10000 ppm, IBA 1000 ppm, IBA 3000 ppm, IBA 7000 ppm, IBA 10000 ppm and IAA 5000 ppm, there was no statistical difference and their root length varied from 6.36 cm to 6.67 cm. As on 20th day and 40th day, on 60th day also IAA 1000 ppm produced the shortest roots (4.74 cm) which was on par with IAA 3000 ppm (5.56 cm). All the treatments were significantly superior to control in which case root length was 2.65 cm.

Table 9a. Effect of growth regulators on root length of hibiscus at different periods

| Treatment (in ppm) | Mean root length (cm) | | | | |
|---|---|---|---|---|---|
| | 20th day | 40th day | 60th day | 80th day | 100th day |
| Control | 0.115 | 1.117 | 2.657 | 4.160 | 5.910 |
| NAA 25 | 0.635 | 2.285 | 5.452 | 8.200 | 10.412 |
| 50 | 1.355 | 5.140 | 6.580 | 9.882 | 11.815 |
| 75 | 0.770 | 3.445 | 6.352 | 7.757 | 10.792 |
| 100 | 0.607 | 2.602 | 5.902 | 7.045 | 9.917 |
| 1000 | 1.302 | 3.602 | 6.265 | 8.352 | 11.012 |
| 3000 | 1.900 | 5.530 | 9.352 | 10.612 | 14.757 |
| 5000 | 1.162 | 4.557 | 7.720 | 8.965 | 12.025 |
| 7000 | 0.975 | 3.937 | 7.702 | 9.117 | 12.027 |
| 10000 | 0.895 | 3.197 | 6.670 | 8.457 | 10.637 |
| IBA 25 | 0.745 | 2.517 | 5.107 | 7.490 | 9.690 |
| 50 | 1.015 | 2.477 | 4.912 | 7.882 | 9.800 |
| 75 | 1.371 | 3.527 | 6.522 | 9.285 | 11.572 |
| 100 | 0.927 | 3.077 | 6.207 | 7.467 | 10.242 |
| 1000 | 0.907 | 3.787 | 6.302 | 7.820 | 10.337 |
| 3000 | 1.150 | 3.632 | 6.610 | 8.402 | 11.030 |
| 5000 | 1.590 | 5.140 | 8.265 | 9.225 | 12.110 |
| 7000 | 1.152 | 4.392 | 6.720 | 8.772 | 10.420 |
| 10000 | 0.805 | 4.522 | 6.367 | 7.937 | 10.237 |
| IAA 25 | 0.335 | 1.917 | 4.382 | 6.767 | 9.150 |
| 50 | 0.535 | 2.025 | 5.927 | 7.107 | 9.950 |
| 75 | 0.620 | 3.322 | 6.505 | 7.635 | 10.347 |
| 100 | 1.197 | 3.617 | 6.555 | 9.510 | 11.790 |
| 1000 | 0.312 | 1.830 | 4.745 | 7.290 | 9.910 |
| 3000 | 0.780 | 2.995 | 5.565 | 8.402 | 9.945 |
| 5000 | 0.897 | 4.422 | 6.422 | 8.512 | 10.410 |
| 7000 | 1.242 | 3.575 | 6.702 | 8.542 | 11.272 |
| 10000 | 1.640 | 4.752 | 7.080 | 9.852 | 12.215 |
| C.D. (P = 0.05) | 0.488 | 0.841 | 1.501 | 1.381 | 1.775 |

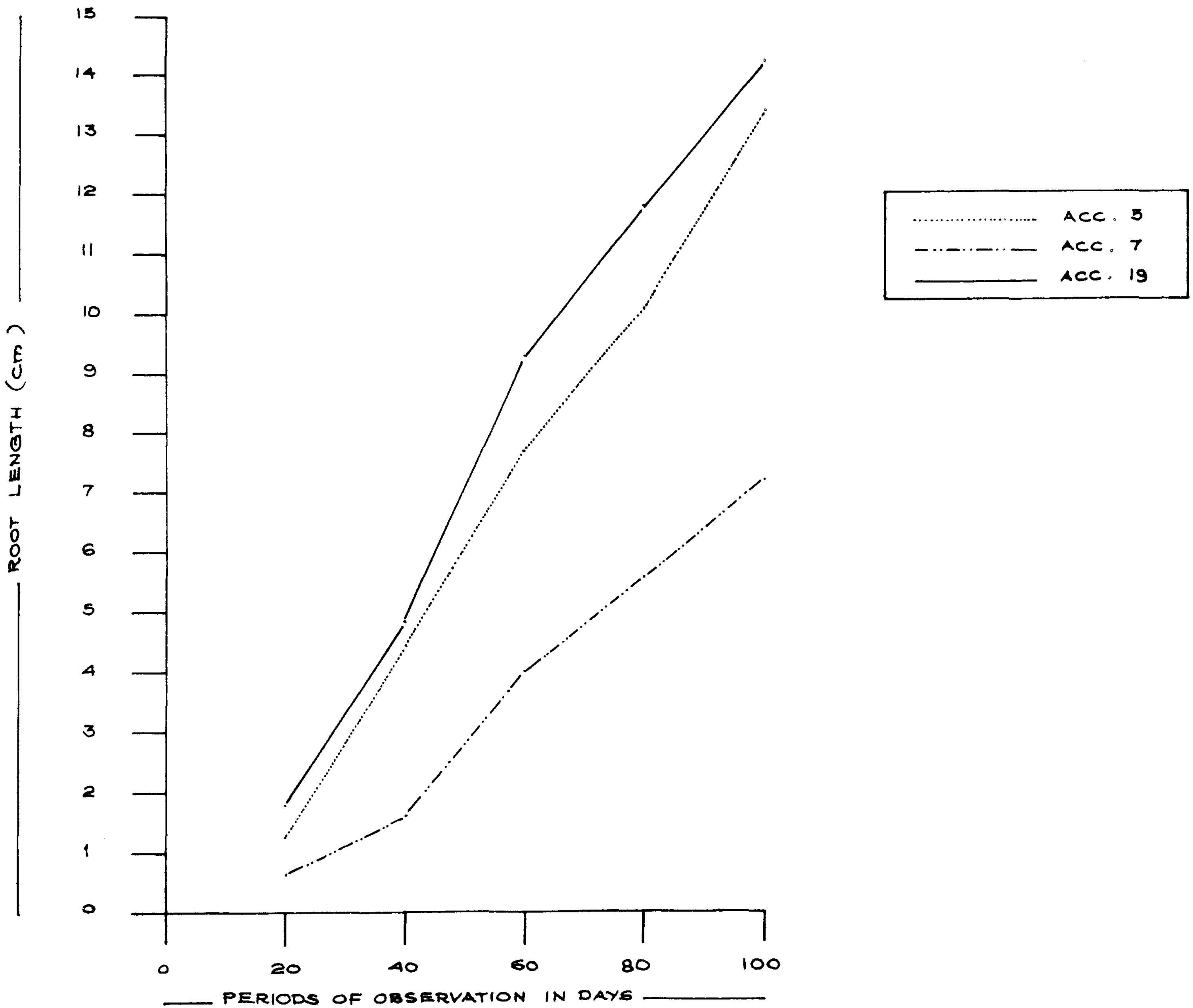
Table 9b. Effect of growth regulators on root length during rooting of different types of hibiscus at various periods

| Type No. | Mean root length (cm) | | | | |
|---|---|---|---|---|---|
| | 20th day | 40th day | 60th day | 80th day | 100th day |
| Acc. 2 | 0.850 | 2.830 | 5.464 | 7.504 | 10.254 |
| Acc. 5 | 1.241 | 4.526 | 7.776 | 10.095 | 13.422 |
| Acc. 7 | 0.659 | 1.602 | 4.016 | 5.633 | 7.200 |
| Acc. 8 | 0.878 | 3.227 | 5.833 | 7.944 | 9.616 |
| Acc. 19 | 1.815 | 4.816 | 9.381 | 11.822 | 14.285 |
| Acc. 22 | 0.900 | 4.347 | 6.910 | 9.039 | 10.687 |
| Acc. 36 | 0.682 | 2.990 | 5.720 | 7.706 | 10.101 |
| Acc. 38 | 0.852 | 4.492 | 7.816 | 8.622 | 11.179 |
| Acc. 42 | 0.633 | 1.674 | 3.962 | 5.378 | 7.800 |
| Acc. 44 | 1.086 | 3.972 | 6.553 | 8.356 | 10.792 |
| C.D. (P = 0.05) | 0.292 | 0.502 | 0.628 | 0.825 | 1.061 |




EFFECT OF GROWTH REGULATORS ON ROOT LENGTH DURING ROOTING OF HIBISCUS AT DIFFERENT PERIODS

FIG: 2a.




EFFECT OF GROWTH REGULATORS ON ROOT LENGTH DURING ROOTING OF THREE TYPES OF <u>HIBISCUS</u> AT DIFFERENT PERIODS

FIG: 2b.

Prolonged dip method

As in the case of 20th and 40th day the longest root of 6.58 cm length was obtained on 60th day when the cuttings were treated with NAA 50 ppm. There was no significant difference among the treatments NAA 50 ppm, IAA 100 ppm (6.55 cm), IBA 75 ppm (6.52 cm) and IAA 75 ppm (6.50 cm). IAA 25 ppm continued to produce the shortest root of 4.38 cm length which was on par with IBA 50 ppm (4.91 cm).

Types of hibiscus

Comparison of types on 60th day for root length showed that Acc.19 had maximum root length of 9.31 cm followed by Acc.38 (7.81 cm) and Acc.5 (7.77 cm). Acc.19 was significantly superior to all other types. Statistically the treatment effects were same in types Acc.5 and Acc.38. As on 20th day, on 60th day also the shortest root was observed in Acc.42 (3.96 cm) which was on par with Acc.7 (4.01 cm).

iv. 80th day of planting

Quick dip method

On 80th day also NAA 3000 ppm caused the longest root of 10.61 cm followed by IAA 10000 ppm (9.85 cm) and IBA 5000 ppm (9.22 cm). Statistically there was no difference between the treatment NAA 3000 ppm and IAA 10000 ppm. The difference between the treatments NAA 5000 ppm (9.11 cm) and IBA 5000 ppm was also not significant. IAA 1000 ppm continued to show the least response where the root length was 7.2 cm. Compared to control (4.16 cm) all growth regulator treatments influenced root length significantly.

Prolonged dip method

As in the case of 20th, 40th and 60th day, NAA 50 ppm caused the longest root length (9.88 cm) followed by IAA 100 ppm (9.51 cm) and IBA 75 ppm (9.28 cm). No significant difference was noted among these three treatments. IAA 25 ppm produced the shortest root of 6.76 cm.length which was on par with NAA 100 ppm and IAA 50 ppm. Root length in the above treatments varied from 6.76 cm to 7.10 cm.

Types of hibiscus

Acc.19 ranked first in producing long roots of 11.82 cm as in the 20th, 40th and 60th day and it was statistically superior to all other types. This was followed by types Acc.5 (10.09 cm) and Acc.22 (9.31 cm). As in the previous observation, Acc.42 showed the least response (5.57 cm) which was on par with Acc.7 (5.63 cm).

v. 100th day of planting

Quick dip method

NAA 3000 ppm which resulted in maximum root length on 20th, 40th, 60th and 80th day exhibited the best performance (14.75 cm) on 100th day also. NAA 3000 ppm was statistically superior to all the treatments, followed by IAA 10000 ppm (12.21 cm) and

IBA 5000 ppm (12.11 cm) as in the case of previous observations. IAA 1000 ppm produced the shortest root which was on par with IAA 3000 ppm, IBA 7000 ppm, IBA 10000 ppm and NAA 10000 ppm. Rot length in the above treatments varied from 9.9 cm to 10.63 cm. Compared to control (5.91 cm) all treatments significantly influenced root length.

Prolonged dip

As in the case of 20th, 40th, 60th and 80th day, on 100th day also, the longest root was observed when the cuttings were treated with NAA 50 ppm followed by IAA 100 ppm and IBA 75 ppm. The root length in the above treatments varied from 11.81 cm to 11.54 cm and the difference was not significant. IAA 25 ppm continued to cause the lowest performance for root length (9.15 cm) which was on par with IBA 25 ppm (9.69 cm) IBA 50 ppm (9.80 cm), IAA 50 ppm (9.95 cm) and NAA 100 ppm (9.91 cm).

Types of hibiscus

Acc.19 which produced the longest root on 20th, 40th, 60th and 80th day showed maximum response (14.28 cm) on 100th day also followed by Acc.5, Acc.38, and Acc.44 and their root length varied from 10.79 cm to 13.42 cm. Types Acc.19 and Acc.5 were not statistically different. The least performance as in the case of 40th day was observed in Acc.7 (7.20 cm) which was on par with Acc.42 (7.80 cm).

Analysis of data from 20th to 100th day revealed the following details.

Quick dip method

Treatments with growth regulators had better results than control. NAA 3000 ppm produced the best result when compared to other treatments followed by IBA 5000 ppm and IAA 10000 ppm. NAA 3000 ppm was statistically superior to all other treatments on 60th and 100th day of planting. There was no significant difference between root length produced by treatments IBA 5000 ppm and IAA 10000 ppm on 20th, 40th, 80th and 100th day but on 60th day IAA 10000 ppm was statistically inferior to IBA 5000 ppm.

Prolonged dip method

In prolonged dip method, NAA 50 ppm was the best followed by IAA 100 ppm and IBA 75 ppm in producing long roots. Statistically no significant difference was noticed among treatments NAA 50 ppm, IAA 100 ppm and IBA 75 ppm throughout the period of observation except on 40th day in which case NAA 50 ppm was significantly superior to IAA 100 ppm and IBA 75 ppm.

Comparing the two methods, quick dip method was significantly superior to prolonged dip method to produce long roots.

Types of hibiscus

The type Acc.19 had maximum root length followed by Acc.5 and Acc.38. Acc.42 and Acc.7 had shorter root length and the difference between the two types was not statistically significant.

Interaction between types and growth regulators was not significant both at one per cent and 5 per cent probability levels.

b. Effect of growth regulators on root number

Response to growth regulators for root number was observed at 20 days interval from 20th to 100th day. Data are presented in Table 10a, 10b and illustrated in figures 3a and 3b.

i. 20th day of planting

Quick dip method

As in the case of response to growth regulators for root length, NAA 3000 ppm showed its prominence in root number also which was on par with IBA 5000 ppm and IAA 10000 ppm. Root number in the above treatments varied from 1.09 to 1.42. Minimum root number (0.47) was observed in treatment IAA 1000 ppm. All treatments produced statistically better effects than control (0.15).

Prolonged dip method

The highest root number was found when cuttings were treated with IBA 75 ppm (0.97) followed by NAA 50 ppm (0.94) and IAA 100 ppm (0.73). There was no significant difference between treatments IBA 75 ppm and NAA 50 ppm. The lowest performance for root number was shown by IAA 25 ppm (0.32).

Types of hibiscus

Acc.19 which produced the longest roots ranked first here also with regard to response on root number. Acc.19 (0.96), Acc.5 (0.92) and Acc.22 (0.90) showed better performance for root number and statistically these three types were on par. The lowest number of roots was observed in Acc.7 (0.52). There was no statistical difference among treatment effects in Acc.2 (0.63), Acc.7 (0.52), Acc.8 (0.61), Acc.42 (0.57) and Acc.44 (0.62).

ii. 40th day of planting

Quick dip method

NAA 3000 ppm was found to be the best followed by IBA 5000 ppm and IAA 10000 ppm. NAA 3000 ppm was statistically superior to all other treatments. There was no significant difference among the treatments IBA 5000 ppm, IAA 10000 ppm and NAA 5000 ppm. IAA 1000 ppm (1.13) which showed the lowest performance on 20th day continued to exhibit the same trend. Regarding root number all treatments recorded significantly better influence over control in which case the root number was 0.65.

Prolonged dip method

Better response for root number was observed through NAA 50 ppm (2.37), IAA 75 ppm (2.08) and IBA 75 ppm (1.84). Statistically the effects of above three treatments were similar.

IAA 25 ppm which showed the lowest response on 20th day, recorded the minimum root number on 40th day also which was on par with NAA 25 ppm, NAA 100 ppm, IBA 25 ppm, IBA 50 ppm and IAA 50 ppm. The root number in the above treatments varied from 0.80 to 1.37

Types of hibiscus

As in 20th day, in 40th day also better root number was shown by Acc.19 (2.46), Acc.22 (2.47), Acc.38 (2.38) and Acc.44 (2.34) and statistically no difference was noticed among these four treatments. Acc.7 (1.12) which showed the least response on 20th day produced the lowest root number on 40th day also. There was no significant difference between the types Acc.7 and Acc.42 (1.23) for response on root number.

iii. 60th day of planting

Quick dip method

NAA 3000 ppm had the best performance for root number (9.41) on 60th day also. NAA 3000 ppm was statistically superior to all other treatments followed by IBA 5000 ppm, IAA 10000 ppm, IBA 7000 ppm and NAA 5000 ppm. The root number among these treatments varied from 6.54 to 7.66 and the difference being statistically non significant. IAA 1000 ppm which showed the lowest performance on 20th and 40th day continued to show the least performance (3.62) on 60th dayalso. Among the treatments IAA 1000 ppm, IBA 1000 ppm (4.78) and IAA 7000 ppm (4.74) there was no statistically significant difference. All treatments recorded better performance than control (2.40).

Prolonged dip method

As in20th and 40th day, on 60th day also NAA 50 ppm followed by IAA 100 ppm showed better performance. The root number in treatments NAA 50 ppm, NAA 75 ppm, IBA 75 ppm and IAA 100 ppm varied from 5.44 to 6.30. IBA 50 ppm treated cuttings resulted in minimum root number (2.58) which was on par with NAA 25 ppm (2.77) and IAA 25 ppm (3.03).

Types of hibiscus

As in 20th and 40th day, on 60th day also Acc.19 followed by Acc.5 showed better performance regarding root number. The differences among the treatment effects on Acc.19 (6.64), Acc.5 (6.09), Acc.22 (5.94) and Acc.44 (5.85) were not statistically significant. Acc.7 which had the lowest performance on 20th and 40th day, showed minimum response for root number (3.00) on 60th day also which was on par with Acc.42 (3.41).

iv. 80th day of planting

Quick dip method

NAA 3000 ppm which caused maximum effects during the previous planting dates recorded the best performance for root number (12.56) on 80th day also. NAA 3000 ppm was statistically superior to all other treatments, followed by the treatment IBA 5000 ppm and IAA 10000 ppm which was statistically similar. While it was IAA 1000 ppm that recorded the lowest performance on the previous observations, it was IBA 1000 ppm that caused the lowest response on 80th day (4.23). Statistically there was no difference among the treatment effects of IBA 1000 ppm, IBA 3000 ppm (4.98) and IAA 1000 ppm (5.65) which varied from 4.23 to 5.65. Compared to control (3.79) all treatments significantly influenced the root number.

Table 10a. Effect of growth regulators on root number of hibiscus at different periods

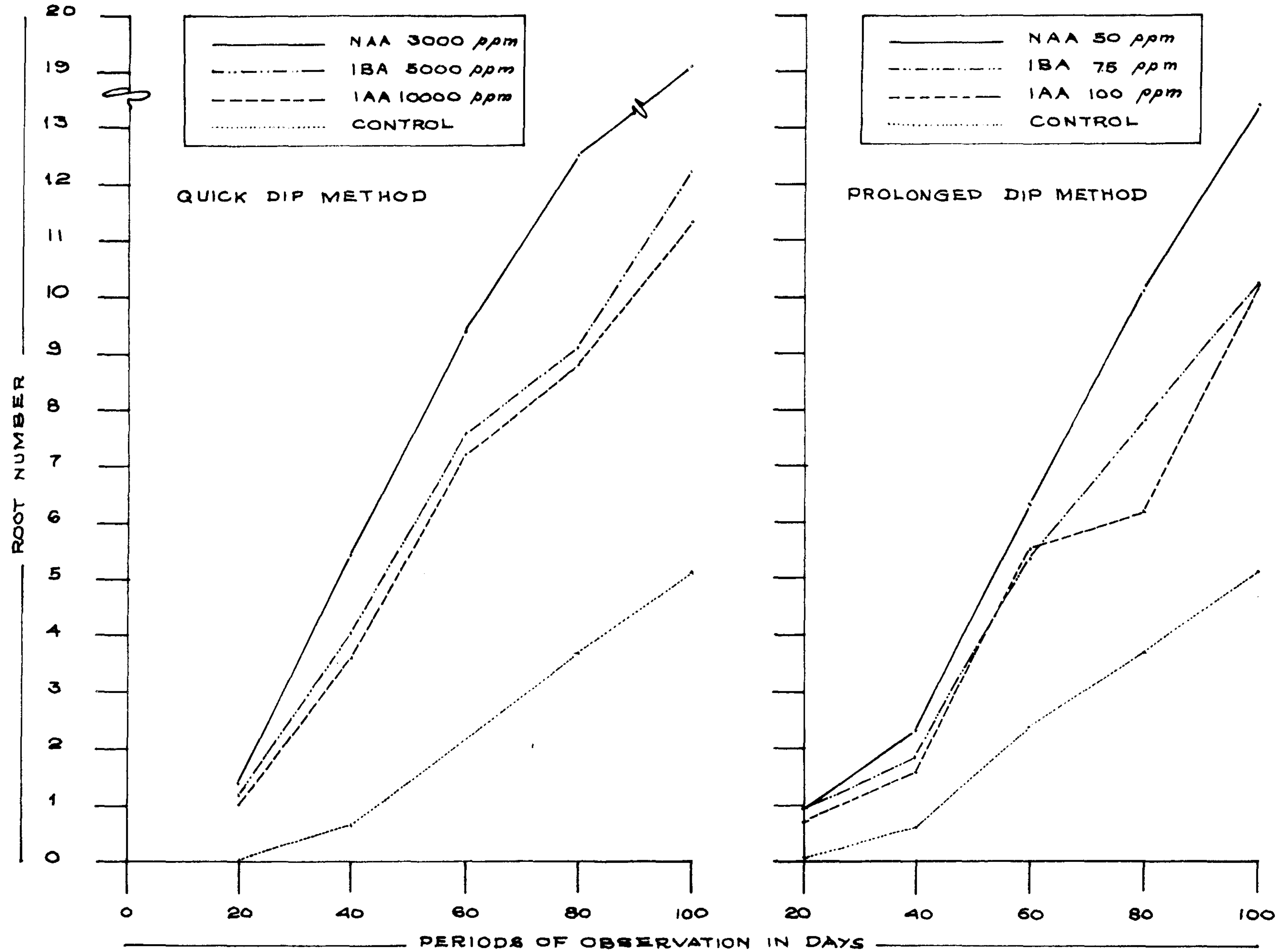
| Treatment (in ppm) | Mean root number | | | | |
|---|---|---|---|---|---|
| | 20th day | 40th day | 60th day | 80th day | 100th day |
| Control | 0.156(0.745) | 0.651(1.073) | 2.405(1.704) | 3.797(2.037) | 5.110(2.368) |
| NAA 25 | 0.609(1.052) | 1.144(1.282) | 2.773(1.809) | 7.079(2.753) | 10.126(3.258) |
| 50 | 0.944(1.200) | 2.374(1.695) | 6.305(2.608) | 10.157(3.264) | 13.462(3.736) |
| 75 | 0.588(1.043) | 1.832(1.527) | 5.446(2.433) | 7.340(2.800) | 12.790(3.680) |
| 100 | 0.486(0.993) | 1.144(1.282) | 4.340(2.200) | 6.198(2.586) | 9.844(3.216) |
| 1000 | 1.097(1.263) | 1.919(1.555) | 5.204(2.388) | 6.200(2.500) | 11.028(3.395) |
| 3000 | 1.427(1.388) | 5.470(2.443) | 9.413(3.148) | 12.566(3.614) | 19.158(4.433) |
| 5000 | 0.965(1.210) | 3.358(1.964) | 6.545(2.654) | 8.524(3.004) | 12.030(3.539) |
| 7000 | 0.689(1.090) | 2.306(1.675) | 6.184(2.565) | 8.195(2.948) | 10.709(3.348) |
| 10000 | 0.748(1.117) | 1.816(1.521) | 5.594(2.468) | 7.375(2.805) | 10.415(3.303) |
| IBA 25 | 0.555(1.027) | 1.372(1.363) | 4.236(2.176) | 5.795(2.509) | 9.316(3.133) |
| 50 | 0.590(1.044) | 1.238(1.318) | 2.581(1.755) | 4.496(2.235) | 7.808(2.882) |
| 75 | 0.974(1.214) | 1.849(1.532) | 5.371(2.423) | 7.809(2.882) | 10.272(3.372) |
| 100 | 0.669(1.085) | 2.020(1.507) | 4.954(2.335) | 5.902(2.530) | 9.443(3.153) |
| 1000 | 0.665(1.075) | 1.809(1.519) | 4.785(2.289) | 4.236(2.176) | 7.434(2.816) |
| 3000 | 0.710(1.100) | 2.144(1.626) | 5.754(2.500) | 4.985(2.322) | 10.586(3.290) |
| 5000 | 1.187(1.299) | 4.102(2.145) | 7.669(2.858) | 9.115(3.100) | 12.235(3.560) |
| 7000 | 0.896(1.181) | 2.342(1.686) | 6.556(2.656) | 7.274(2.788) | 9.976(3.236) |
| 10000 | 0.669(1.081) | 2.307(1.675) | 5.381(2.425) | 6.245(2.597) | 8.089(2.930) |
| IAA 25 | 0.382(0.910) | 0.800(1.140) | 3.034(1.880) | 4.633(2.265) | 8.058(2.924) |
| 50 | 0.344(0.919) | 1.026(1.235) | 4.911(2.326) | 5.778(2.515) | 9.859(3.218) |
| 75 | 0.495(0.997) | 2.089(1.609) | 5.254(2.398) | 5.906(2.531) | 9.596(3.177) |
| 100 | 0.731(1.109) | 1.697(1.482) | 5.569(2.463) | 7.293(2.391) | 10.293(3.285) |
| 1000 | 0.479(0.971) | 1.136(1.279) | 3.623(2.030) | 5.650(2.480) | 8.271(2.961) |
| 3000 | 0.538(1.071) | 1.896(1.548) | 5.092(2.364) | 6.139(2.576) | 9.625(3.182) |
| 5000 | 0.573(1.036) | 2.924(1.850) | 5.997(2.549) | 7.307(2.794) | 9.926(3.220) |
| 7000 | 0.815(1.147) | 1.876(1.541) | 4.741(2.289) | 6.963(2.731) | 11.303(3.435) |
| 10000 | 1.096(1.263) | 3.682(2.045) | 7.291(2.791) | 8.879(3.057) | 11.375(3.446) |
| C.D. (P 1 0.05) | 0.170 | 0.237 | 0.283 | 0.308 | 0.338 |

Figures in parenthesis indicate the means of transformed data

Table 10b. Effect of growth regulators on root number during rooting of different types of hibiscus at various periods

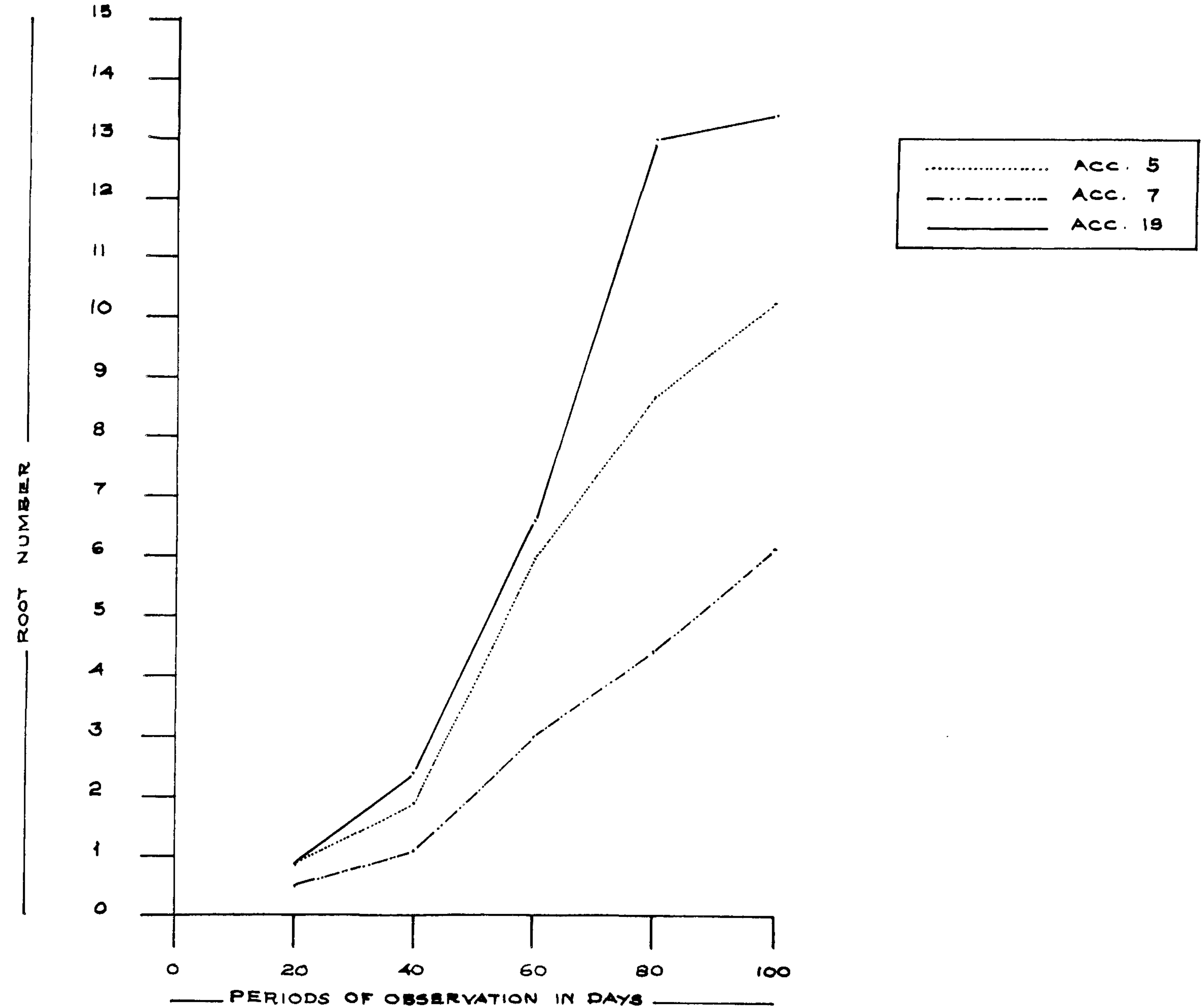
| Acc.No. | Mean root number | | | | |
|---|---|---|---|---|---|
| | 20th day | 40th day | 60th day | 80th day | 100th day |
| Acc.2 | 0.633(1.064) | 1.826(1.525) | 4.765(2.294) | 6.160(2.580) | 10.190(3.269) |
| Acc. 5 | 0.923(1.193) | 1.964(1.569) | 6.092(2.567) | 8.791(3.048) | 10.374(3.297) |
| Acc. 7 | 0.529(1.014) | 1.121(1.273) | 3.007(1.872) | 4.443(2.223) | 6.124(2.573) |
| Acc. 8 | 0.611(1.054) | 2.263(1.662) | 5.331(2.414) | 6.402(2.627) | 10.272(3.282) |
| Acc.19 | 0.962(1.209) | 2.460(1.726) | 6.674(2.678) | 14.094(3.898) | 14.405(3.860) |
| Acc.22 | 0.901(1.184) | 2.479(1.720) | 5.940(2.537) | 7.558(2.830) | 11.646(3.513) |
| Acc.36 | 0.594(1.046) | 1.997(1.580) | 5.109(2.368) | 6.607(2.677) | 10.072(3.251) |
| Acc.38 | 0.723(1.106) | 2.389(1.699) | 5.887(2.527) | 7.246(2.783) | 11.737(3.498) |
| Acc.42 | 0.570(1.034) | 1.237(1.318) | 3.416(1.978) | 4.923(2.320) | 6.625(2.669) |
| Acc.44 | 0.625(1.060) | 2.342(1.685) | 5.856(2.521) | 7.277(2.788) | 10.846(3.368) |
| C.D. (P = 0.05) | 0.102 | 0.141 | 0.169 | 0.184 | 0.202 |

Figures in parenthesis indicate the means of transformed data




EFFECT OF GROWTH REGULATORS ON ROOT NUMBER DURING ROOTING OF *HIBISCUS* AT DIFFERENT PERIODS

FIG. 3a.




EFFECT OF GROWTH REGULATORS ON ROOT NUMBER DURING ROOTING OF THREE TYPES OF *HIBISCUS* AT DIFFERENT PERIODS

FIG: 3 b.

Prolonged dip method

Treating the cuttings with NAA 50 ppm resulted in the highest root number (10.15) on 80th day as observed during 20th, 40th and 60th day, followed by IBA 75 ppm (7.80) and NAA 75 ppm (7.34). NAA 50 ppm was significantly superior to all other treatments. There was no statistical difference between IBA 75 ppm and NAA 75 ppm. IBA 50 ppm that cause the minimum root number on 60th day, showed the least response (4.49) on 80th day also. Differences between the treatment effects of IBA 50 ppm and IAA 25 ppm (4.63) were not statistically significant.

Types of hibiscus

Acc.19 had the highest root number (14.69) and was statistically superior to all other types followed by Acc.5 (8.79), and Acc.22 (7.55). Acc.7 produced the minimum root number (4.44) on 80th day which was on par with Acc.42 (4.92).

v. 100th day of planting

Quick dip method

The analysis of data on 100th day showed that NAA 3000 ppm which caused the highest root number on20th, 40th, 60th and 80th day, produced maximum roots (19.15) on 100th day also. Next to NAA 3000 ppm, IBA 5000 ppm (12.23) NAA 5000 ppm (12.03), and IAA 10000 ppm (11.37) caused more number of roots. NAA 3000 ppm was statistically superior to all other treatments. IBA 1000 ppm which caused the lowest performance on 60th and 80th day produced only minimum number of roots (7.43) on 100th day.

No statistical difference was noticed among the treatment effects of IBA 1000 ppm, IBA 10000 ppm (8.08) and IAA 1000 ppm (8.27). Compared to control (5.11) all treatments significantly influenced root number.

Prolonged dip method

The treatments NAA 50 ppm and NAA 75 ppm followed by IAA 100 ppm and IBA 75 ppm maintained the same trend on 100th day. The root number in the above treatments varied from 10.27 to 13.46. There was no significant difference between treatments NAA 50 ppm and NAA 75 ppm which were superior to all other treatments. Statistically IBA 75 ppm and IAA 100 ppm were similar. As in the case of 60th and 80th day, on 100th day also IBA 50 ppm treated cuttings exhibited minimum root number (7.80) which was on par with IAA 25 ppm (8.05).

Types of hibiscus

As in 20th, 40th, 60th and 80th day, Acc.19 recorded maximum root number (14.40) on 100th day also and it was statistically superior to all other types. This was followed by Acc.38 (11.73), Acc.22 (11.64) and Acc.44 (10.82) and statistically all these three types were same. Acc.7 which recorded the minimum root number in all the previous observations showed the lowest response on 100th day also (6.12) which was on par with Acc.42 (6.62).

The details of effects of growth regulators on root number from 20th to 100th day could be summarised as follows:

Quick dip method

All growth regulator treatments produced better results for root number over control. The best effect for root number was produced by the treatment NAA 3000 ppm followed by IBA 5000 ppm and IAA 10000 ppm. NAA 3000 ppm was significantly superior to all other treatments on 40th, 60th, 80th and 100th day of planting whereas on 20th day no significant difference was noticed between treatments NAA 3000 ppm, IBA 5000 ppm and IAA 10000 ppm.

Prolonged dip method

In the prolonged dip method maximum root number was produced by treatment NAA 50 ppm followed by IBA 75 ppm, IAA 100 ppm and NAA 75 ppm. NAA 50 ppm was significantly superior to all other treatments in prolonged dip method on 80th and 100th day of planting. No significant difference was noticed on root number by treatments IBA 75 ppm and IAA 100 ppm on 40th, 60th and 100th day.

Statistically, quick dip method was found to be significantly superior to prolonged dip method in producing more root number.

Types of hibiscus

Comparison of types revealed that Acc.19 produced the highest root number from 40th day onwards. No significant difference was noted on root number in types Acc.19 and Acc.5 during 20th, 40th and 60th day of planting. Minimum effect was produced by type Acc.42 and Acc.7 and statistically these types were on par.

Interaction of types and growth regulators was not significant for root number during the entire period of observation.

c. Effect of growth regulators on root weight

The response of growth regulators on root weight was assessed at 20 days interval, from 20th to 100thday and the results are presented in table 11a, 11b and illustrated in figures 4a and 4b.

i. 20th day of planting

Quick dip method

Treating the cuttings with IBA 5000 ppm (0.016g) and NAA 3000 ppm (0.013 g) resulted in maximum root weight. Lowest performance for root weight was recorded by IAA 1000 ppm (0.002 g). However all growth regulator treatments showed better performance over control.

Prolonged dip method

Comparing the effects of different growth regulators best performance was recorded by NAA 50 ppm (0.006g) followed by NAA 75 ppm (0.003g) IAA 100 ppm (0.003 g) and IBA 75 ppm (0.003 g). There was no significant difference among the treatments NAA 75 ppm, IAA 100 ppm and IBA 75 ppm. Lowest response was obtained in the treatment IAA 25 ppm (0.001 g) and IAA 50 ppm (0.001 g).

Types of hibiscus

As in the case of response to growth regulators for root length and root number, better performance was recorded by Acc.19 (0.01g) and Acc.2 (0.01 g) in root weight. Statistically there was no difference between the treatment effects of Acc.19 and Acc.2. Minimum root weight was exhibited in Acc.8 (0.002 g) which was on par with Acc.42, Acc.22 and Acc.7.

ii. 40th day of planting

Quick dip method

As in the case of 20th day, on 40th day also maximum root weight of 0.102 g was obtained when the cuttings were treated with IBA 5000 ppm and it was significantly superior to all other treatments. This was followed by NAA 3000 ppm, NAA 5000 ppm, and IAA 10000 ppm. The root weight in the above treatments varied from 0.060 g to 0.068 g. The differences among NAA 3000 ppm, NAA 5000 ppm and IAA 10000 ppm were not statistically significant. IAA 1000 ppm that produced lowest root weight on 20th day recorded lowest response on 40th day also (0.017 g). Compared to control all treatments significantly influenced root weight.

Prolonged dip method

The better influence regarding root weight was recorded in treatment IBA 75 ppm, NAA 50 ppm and IBA 50 ppm and statistically all these treatments were same. IAA 25 ppm recorded lowest response on 40th day. There was no significant difference among the treatment effects of IAA 25 ppm, NAA 25 ppm, NAA 100 ppm, IBA 25 ppm and IAA 75 ppm. The root weight in

Types of hibiscus

Better response for root weight was recorded in Acc.19, Acc.36, Acc.5 and Acc.2 and statistically no difference was noticed among these treatments. Root weight in the aboe types varied from 0.050 g to 0.068 g. Poor response was shown by Acc.38 which was on par with Acc.7, Acc.8 and Acc.44.

iii. 60th day of planting

Quick dip method

On 60th day, it was found that IBA 5000 ppm which had recorded best response on 20th and 40th day showed maximum root weight (0.63 g). This was followed by NAA 3000 ppm and IAA 10000 ppm and statistically these two treatments were not different. The root weight in the above treatments varied from 0.53 g to 0.55 g. As in the case of 20th and 40th day, on 60th day also lowest root weight of 0.19 g was recorded by IAA 1000 ppm which was on par with IAA 3000 ppm (0.26g). However, all treatments were better than control in which the root weight was only 0.12 g.

Prolonged dip method

The same treatments which recorded better influence on 20th and 40th day, showed better performance on 60th day also. Better performance regarding root weight was exhibited by treatments NAA 50 ppm (0.30g), IBA 75 ppm (0.27 g), NAA 75 ppm (0.23 g) and IAA 100 ppm (0.22 g). Statistically these treatments were similar in their response. Minimum root weight of 0.13 g was exhibited by IAA 25 ppm.

Types of hibiscus

Acc.19 which recorded better root weight in the previous observation showed highest root weight (0.83 g) on 60th day followed by Acc.2 (0.45 g), Acc.5(0.43 g) and Acc.42 (0.40 g). Acc.19 was statistically superior to all other types. Statistically no difference was noticed among types Acc.2, Acc.5, and Acc.42. Acc.8 was lowest with regard to response for root weight (0.06 g) which was on par with Acc.22 (0.10 g).

iv. 80th day of planting

Quick dip method

While it was IBA 5000 ppm that recorded maximum root weight in the previous cases, it was NAA 3000 ppm that produced best results for root weight on 80th day. Better performance for root weight was exhibited by NAA 3000 ppm, NAA 5000 ppm, IAA 10000 ppm and IBA 5000 ppm and statistically all these treatments were similar. The root weight in the above treatments ranged from 1.71 g to 1.94 g. As in the previous observations, least performance was recorded by IAA 1000 ppm (1.08 g) which was on par with IBA 1000 ppm (1.39 g) and IAA 3000 ppm (1.22 g). The root weight in the above treatments varied from 1.08 g to 1.39 g. Compared to control all treatments significantly influenced root weight.

Prolonged dip method

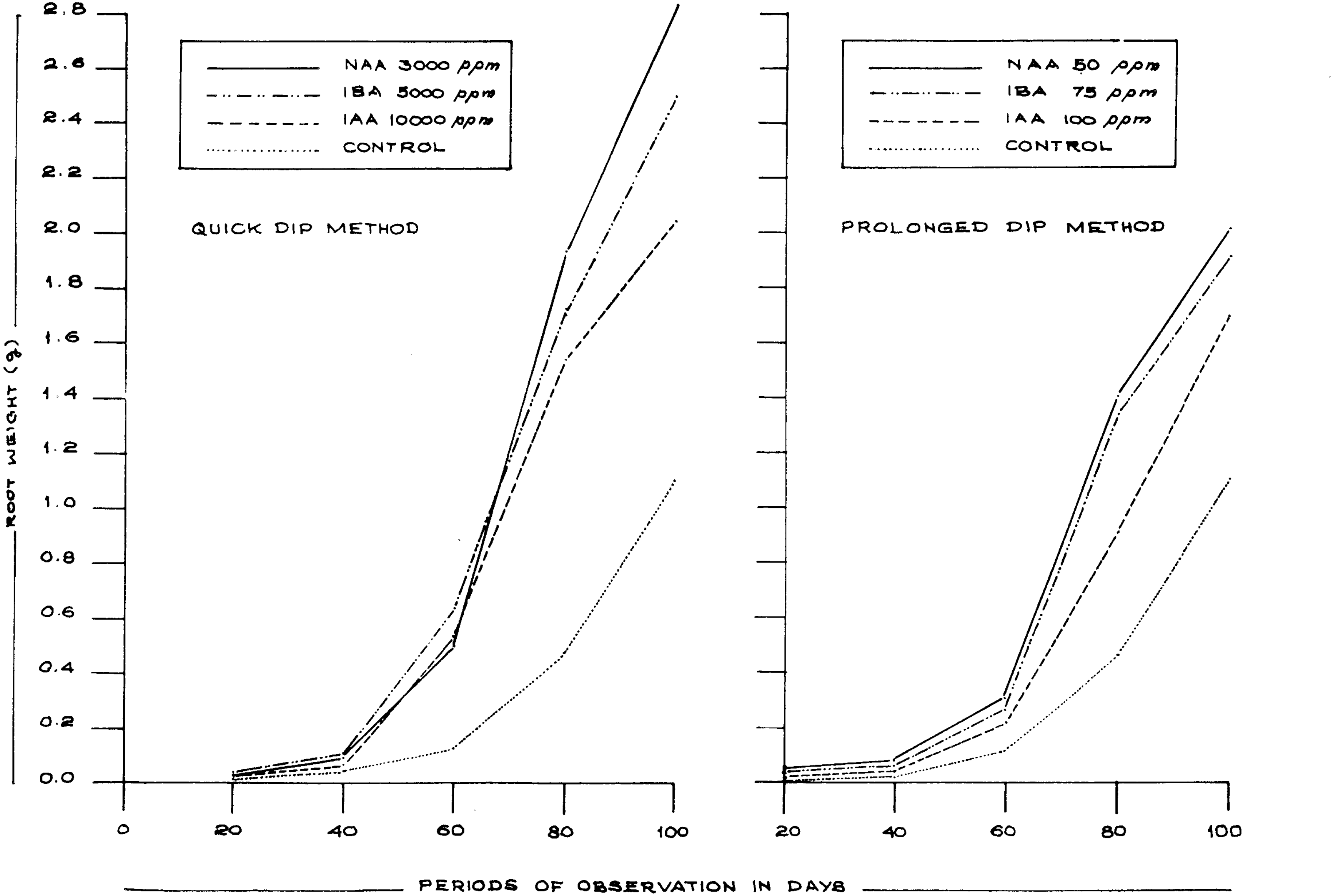
Superior performance for root weight was produced by the same treatments which recorded better performance in the previous cases ie. NAA 50 ppm (1.60g), NAA 75 ppm (1.37 g) and

Table 11a. Effect of growth regulators on root weight of hibiscus at different periods

| Treatment (in ppm) | Mean root weight (gm) | | | | |
|---|---|---|---|---|---|
| | 20th day | 40th day | 60th day | 80th day | 100th day |
| Control | 0.001 | 0.002 | 0.123 | 0.479 | 1.090 |
| NAA 25 | 0.002 | 0.014 | 0.144 | 1.200 | 1.785 |
| 50 | 0.006 | 0.024 | 0.300 | 1.602 | 2.147 |
| 75 | 0.003 | 0.016 | 0.231 | 1.372 | 2.015 |
| 100 | 0.002 | 0.014 | 0.209 | 1.235 | 1.790 |
| 1000 | 0.006 | 0.043 | 0.349 | 1.704 | 2.444 |
| 3000 | 0.013 | 0.068 | 0.556 | 1.947 | 2.865 |
| 5000 | 0.009 | 0.064 | 0.455 | 1.747 | 2.550 |
| 7000 | 0.006 | 0.048 | 0.444 | 1.695 | 2.322 |
| 10000 | 0.005 | 0.048 | 0.438 | 1.482 | 2.290 |
| IBA 25 | 0.002 | 0.015 | 0.147 | 1.040 | 1.460 |
| 50 | 0.002 | 0.022 | 0.185 | 1.192 | 1.690 |
| 75 | 0.003 | 0.024 | 0.270 | 1.352 | 1.900 |
| 100 | 0.002 | 0.019 | 0.206 | 0.835 | 1.730 |
| 1000 | 0.004 | 0.034 | 0.392 | 1.395 | 2.106 |
| 3000 | 0.003 | 0.054 | 0.533 | 1.505 | 2.250 |
| 5000 | 0.016 | 0.102 | 0.635 | 1.710 | 2.530 |
| 7000 | 0.008 | 0.058 | 0.512 | 1.610 | 2.270 |
| 10000 | 0.003 | 0.059 | 0.501 | 1.495 | 2.120 |
| IAA 25 | 0.001 | 0.013 | 0.138 | 0.732 | 1.270 |
| 50 | 0.001 | 0.019 | 0.152 | 0.784 | 1.410 |
| 75 | 0.002 | 0.014 | 0.186 | 0.879 | 1.520 |
| 100 | 0.003 | 0.018 | 0.221 | 0.900 | 1.720 |
| 1000 | 0.002 | 0.017 | 0.194 | 1.080 | 1.660 |
| 3000 | 0.003 | 0.026 | 0.268 | 1.222 | 1.740 |
| 5000 | 0.005 | 0.035 | 0.331 | 1.490 | 2.120 |
| 7000 | 0.006 | 0.045 | 0.437 | 1.513 | 2.160 |
| 10000 | 0.008 | 0.060 | 0.539 | 1.730 | 2.350 |
| C.D. (P = 0.05) | 0.002 | 0.014 | 0.097 | 0.333 | 0.378 |

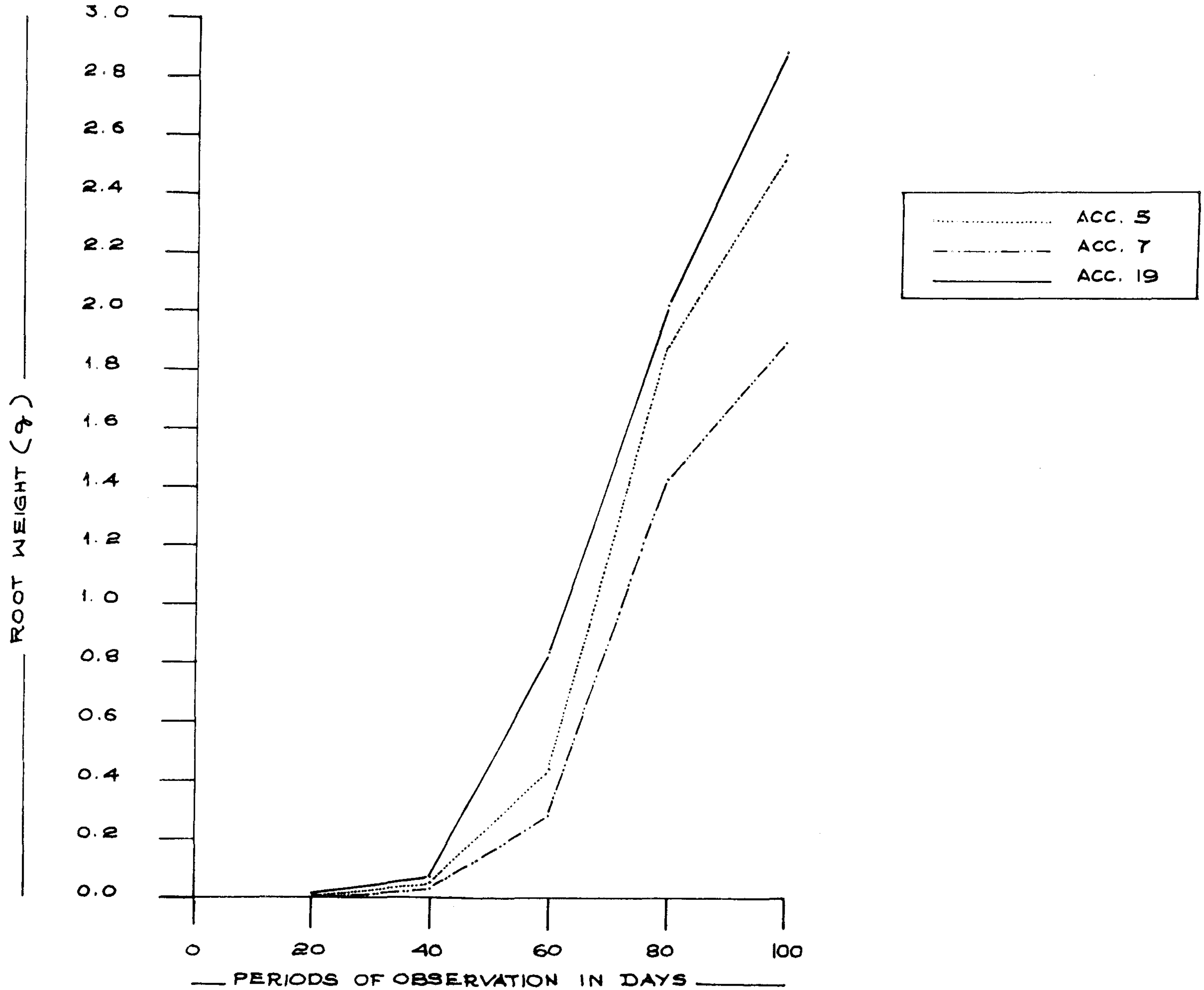
Table 11b. Effect of growth regulators on root weight during rooting of different types of hibiscus at various periods

| Type No. | Mean root weight (gm) | | | | |
|---|---|---|---|---|---|
| | 20th day | 40th day | 60th day | 80th day | 100th day |
| Acc. 2 | 0.010 | 0.050 | 0.455 | 1.714 | 2.242 |
| Acc. 5 | 0.005 | 0.052 | 0.433 | 1.886 | 2.532 |
| Acc. 7 | 0.003 | 0.017 | 0.290 | 1.425 | 1.881 |
| Acc. 8 | 0.002 | 0.017 | 0.064 | 0.887 | 1.539 |
| Acc.19 | 0.011 | 0.068 | 0.833 | 2.085 | 2.884 |
| Acc.22 | 0.003 | 0.031 | 0.102 | 1.009 | 1.671 |
| Acc.36 | 0.003 | 0.063 | 0.275 | 0.982 | 1.516 |
| Acc.38 | 0.003 | 0.012 | 0.279 | 1.842 | 1.631 |
| Acc.42 | 0.003 | 0.020 | 0.406 | 1.206 | 1.925 |
| Acc.44 | 0.004 | 0.016 | 0.142 | 0.935 | 1.614 |
| C.D. (P = 0.05) | 0.023 | 0.039 | 0.058 | 0.199 | 0.220 |




EFFECT OF GROWTH REGULATORS ON ROOT WEIGHT DURING ROOTING OF HIBISCUS AT DIFFERENT PERIODS

FIG. 4a.




EFFECT OF GROWTH REGULATORS ON ROOT WEIGHT DURING ROOTING OF THREE TYPES OF HIBISCUS AT DIFFERENT PERIODS

FIG: 4 b.

IBA 75 ppm (1.35 g) and the difference among these treatments were statistically insignificant. Lowest performance was recorded by IAA 25 ppm (0.73 g) which was on par with IAA 50 ppm (0.78 g).

Types of hibiscus

Acc.19 (2.08 g) and Acc.5 (1.88 g) recorded superior performance with regard to root weight. The difference between these types were not statistically significant. Minimum root weight was exhibited by Acc.8 (0.88 g) which was on par with Acc. 36 (0.98 g) and Acc.22 (0.98 g).

v. 100th day of planting

Quick dip method

Maximum root weight of 2.86 g was found with NAA 3000 ppm on 100th day, as in the case of 80th day. This was followed by NAA 5000 ppm (2.55 g), IBA 5000 ppm (2.53 g) and IAA 10000 ppm (2.35 g). There was no significant difference among NAA 5000 ppm, IBA 5000 ppm and IAA 10000 ppm. As in the case of 20th, 40th, 60th and 80th day, on 100th day also IAA 1000 ppm exhibited least performance (1.66 g) and it was on par with IAA 3000 ppm (1.74 g). Compared to control all treatments were better with regard to root weight.

Prolonged dip method

The treatments which recorded better root weight in the previous observations maintained the same trend, ie. NAA 50 ppm (2.14 g), NAA 75 ppm (2.01 g) and IBA 75 ppm (1.90 g) showed higher performance and the difference among the treatments were not statistically significant. As in the case of previous observations lowest response was recorded by IAA 25 ppm (1.27 g) which was on par with IAA 50 ppm (1.41 g).

Types of hibiscus

Comparison of types showed that Acc.19 (2.88 g) was best regarding root weight as in the previous cases. This was followed by Acc.5 (2.53 g) and Acc. 2 (2.24 g). Acc.19 was statistically superior to all other types. While it was Acc.8 that had been recording minimum root weight, it was Acc.36 that showed lowest response (1.51 g) on 100th day which was on par with Acc.8, Acc.44 and Acc.38.

The effect of growth regulator on root weight from 20th to 100th day can be summarised as follows:

Quick dip method

All growth regulator treatments produced better results than control for root weight. On the 20th, 40th and 60th day of planting IBA 5000 ppm was best while from 80th day onwards, NAA 3000 ppm caused maximum root weight. This was followed by IBA 5000 ppm, NAA 5000 ppm and IAA 10000 ppm on 80th day. There was no significant difference between the treatments NAA 3000 ppm and IBA 5000 ppm on 80th day.

Prolonged dip method

Regarding prolonged dip on 20th day of planting, NAA 50 ppm was the best followed by NAA 75 ppm, IAA 1000 ppm and IBA 75 ppm while on 40th day of planting IBA 75 ppm showed maximum performance followed by NAA 50 ppm, IBA 50 ppm and IAA 50 ppm. From

60th day onwards, NAA 50 ppm produced maximum root weight followed by NAA 75 ppm and IBA 75 ppm, their being no significant difference among treatments.

As in the case of root length and root number in root weight also, quick dip method was statistically superior to prolonged dip method.

Types of hibiscus

Acc.19 was superior to all other types on 20th, 40th, 60th, 80th and 100th day of planting. Lowest root weight was exhibited by Acc.8 on 20th, 60th and 80th day.

Interaction between types and growth regulators

The interaction between types and growth regulators were significant on 20th, 40th and 60th day of planting regarding root weight.

Quick dip method

NAA 3000 ppm produced higher root weight in types Acc.19 and Acc.8 on all these three days. NAA 3000 ppm was the best treatment for types Acc.38, Acc.42 and Acc.7 on 20th and 40th day of planting whereas IBA 5000 ppm was found to be superior in types Acc.44 and Acc.36 on 40th day. On 60th day of planting, IBA 5000 ppm recorded highest root weight in types Acc.36, Acc.38 and Acc.42. IAA 10000 ppm produced maximum response in types Acc.2 and Acc.22 on 40th day while on 60th day, it was best in Acc.22 only.

Prolonged dip method

Regarding prolonged dip, NAA 50 ppm caused maximum root weight in Acc.7, Acc.8 and Acc.22 on 20th, 40th and 60th day of planting. NAA 50 ppm produced highest response for root weight in types Acc.5 and Acc.19 on 40th and 60th day while in Acc.2 on 60th day only. IAA 100 ppm was best in Acc.5 on 20th day, Acc.2 on 40th day and Acc.44 on 60th day of planting.

The effect of growth regulators on number, length and weight of roots from 20th to 100th day can be summarised as follows:

It may be seen from the data that all types exhibited identical positive response to growth regulator treatments. In all the types NAA 3000 ppm followed by IBA 5000 ppm and IAA 10000 ppm in quick dip method and NAA 50 ppm in prolonged dip method recorded maximum root number, root length and root weight. Quick dip method was definitely superior to prolonged dip method. This response is well comparable with the results obtained in section 2 in response of rooting percentage.

Assessment of root number per cutting, length and weight of roots in all ten types as a function of time also recorded a positive relationship between time and rooting particulars under study. In this respect also NAA 3000 ppm as quick dip and NAA 50 ppm as prolonged dip were found superior.

4. Studies on air layering

It may be seen from the table 12 that Acc.38 (89.3 per cent), Acc.19 (87.1 per cent), Acc.8 (80.6 per cent) and Acc. 22 (79.9 per cent) had recorded higher rooting percentage during air layering. Statistically there were no significant differences among Acc.38, Acc.19, Acc.8 and Acc.22 regarding rooting in air layering. The rooting in air layering of types Acc.36 (66.0 per cent) and Acc.44 (73.1 per cent) were statistically similar. Poor response in air layering was obtained with types Acc.2 (35.0 per cent) and Acc.42 (24.8 per cent) which was statistically similar. Maximum percentage of success in air layering was recorded in Acc.38 (89.3 per cent) and minimum in Acc. 7 (13.4 per cent).

Compared to cuttings with growth regulator treatment, air layering recorded poor rooting. However, air layering showed increased rooting than rooting with cuttings alone.

Table 12. Percentage of success in air layering of hibiscus types

| Types | Percentage of success |
|---|---|
| Acc. 2 | 35.0 (36.25) |
| Acc. 5 | 53.0 (46.73) |
| Acc. 7 | 13.4 (21.49) |
| Acc. 8 | 80.6 (63.89) |
| Acc.19 | 87.1 (68.99) |
| Acc.22 | 79.9 (63.38) |
| Acc.36 | 66.0 (54.34) |
| Acc.38 | 89.3 (70.95) |
| Acc.42 | 24.8 (29.88) |
| Acc.44 | 73.1 (58.73) |
| C.D. (P = 0.05) | 13.02 |

Figures in parenthesis indicate the means of transformed data

# DISCUSSION

# DISCUSSION

Shoe flower (Hibiscus rosasinensis L.) is valued for its ornamental and medicinal values. Rao (1914) stated that the leaves of hibiscus can be applied externally to heal ulcers. Buds are used in medicine for piles and cholera. Flowers could be used to tinge liquors and to blacken shoes. Kerala can boost on the wealth of hibiscus types growing profusely under humid tropical climatic conditions. But there seems to be no systematic work made so far in Kerala for the collection, morphological evaluation and selection of superior types of hibiscus. The present studies were aimed mainly for the collection, morphological description and standardisation of propagation techniques in ten selected types of hibiscus under Vellanikkara conditions. These studies may pave way to evolve new types or selections with different shades and sizes of flowers suited to Kerala conditions.

## A. Collection and maintenance of hibiscus types or varieties

In the present investigation fifty one types or varieties of hibiscus were collected from the representative zones of Kerala, Tamilnadu and Karnataka. All these types were given accession numbers and these were utilised for morphological description and floral studies.

B. Morphological description

A large number of hibiscus types were found to occur in Kerala. The morphological description of the 51 types or varieties showed that many of them are different from the varieties already described by Bailey (1949), Rendle (1971), Sundar (1971), Bhat (1976, 1979) and Bhat and Verma (1980).

In the present studies, the growth habits, nature of lateral branching, leaf size, shape and apex, nature and shape of flower, pedicel length, lobe number in calyx, nature and colour of corolla, staminal column length, style length and stigma colour appeared to be diagnostic characters which could be used for classification of hibiscus types. A key was prepared for the classification of hibiscus based on their distinct vegetative and floral characters. Since all the vegetative and floral parameters were accounted for the preparation of key, the proposed key may prove satisfactory for the description of new accession and classification of hibiscus types.

Of the fifty one types or varieties studied, the types Acc.3, Acc.5, Acc.13, Acc.29, Acc.32, Acc.33, Acc.42 and Acc.52 were found to produce flowers of various attractive shades. The types Acc.46 and Acc.47 had large and showy flowers with yellow shades while Acc.7 and Acc.13 produced flowers of white shades and Acc.19 and Acc.38 with red shades. Large conspicous flowers of blue shade were produced by Acc.42 and Acc.43 and deep rose shaded flowers by Acc.50 and Acc.54.

The study also clearly revealed that the types Acc.43 and Acc.45 were very bushy in growth and hence these types could be recommended for growing in pots. Schimitt (1967) has stated the possibility of selecting bushy types of hibiscus suitable for growing in pots.

The hybrids 'Nartaki', 'Tribal Queen ' and Bharat Sundari' introduced from Bangalore were also found very promising under Vellanikkara conditions. Under the humid tropical conditions of Kerala, these hybrids were found to produce very showy flowers. The present studies showed that there is much scope for selecting promising types of hibiscus with attractive flowers of various shades and size suitable for Kerala.

C. Pollen viability studies

Ornamental hibiscus was included in highly polymorphic and cross compatible group (Gast, 1971). These genetic attributes provide ample avenues for evolving new varieties through hybridization.

Considerable variation existed in the floral characters of hibiscus types studied. Singh and Khoshoo (1970) attributed chromasomal polymorphism as the reason for this type of wide diversity in H.rosasinensis. Thereby it appear that an extensive breeding programme utilizing the promising collections could result in superior hybrids.

Viable pollen is an integral part of any breeding programme and hence pollen viability studies are of paramount importance in the crop improvement programme. Viability of pollen collected from ten types of hibiscus were studied. Wide variation in the pollen grain colour was observed. Various abnormal types of pollen grain were also noticed. Such variations were observed by Nair and Kapoor (1974) and Srivastava (1982). Significant variation in pollen viability was also observed. Maximum pollen viability was recorded in Acc.22 (89.8 per cent) followed by Acc.36 (87.5 per cent) and Acc.2 (85.6 per cent) while the minimum viability of 4.6 per cent was observed in Acc.7. Vilasini et al. (1966) and Markose (1984) also observed significant variations in the pollen viability among different types of hibiscus. Accordingly collections Acc.22, Acc. 36 and Acc.2 having high percentage of pollen viability could be used for further breeding programme.

D. Standardisation of vegetative propagation methods

Hibiscus types are propagated most commonly through cuttings. The inherent inability exhibited by certain types for the rooting of cuttings have been observed. Propagation of hibiscus through cuttings (with and without leaves) and cuttings with growth regulator treatment were tried.

1. Effect of leaves on rooting of cuttings

Rooting behaviour of stem cuttings of ten types of hibiscus were assessed under two treatment conditions with and without leaves. Retension of leaves showed significant influence on rooting percentage, root number and root length. In Acc.44, treatment with leaves recorded 75 per cent rooting while the treatment without leaves produced only 67 per cent rooting. The number of roots of Acc.44 by retention of leaves was 5.75 while in the treatment without leaves it was only 4.75. Nakasona and Bowers (1956) observed the increased rooting of cuttings with leaves intact over defoliated cuttings in hibiscus. The superiority of retention of leaves in the rooting of cuttings of '*Jasminum auriculatum*' was reported by Bose *et al*. (1975). According to Went (1929), Cooper (1938) and Rappaport (1940) the presence of leaves on cuttings exerts a strong stimulating influence on root initiation. Hartmann and Kester (1976) stated that the root promoting effects of leaves was due to carbohydrates resulting from the photosynthetic activity of leaves. According to Haissig (1973) the beneficial effect of retention of leaves might be due to hormonal translocation from leaves to cut portions.

**2. Effect of growth regulators on rooting of cuttings**

The beneficial effects of growth regulators on rooting of cuttings in ornamental plants was reported by Ailincai *et al.* (1964), Misra and Jauhari (1970), Bose and Mondal (1972), Heung and Mc Guire (1973) and Johnson and Hamilton (1977). The effect of growth regulators on rooting of cuttings varies widely with species and the physiological status of cuttings (Sadhu, 1980). IAA, IBA and NAA are the three growth regulators most commonly used for rooting of cuttings in ornamental plants. These growth regulators are concerned in the division of meristematic cells, their elongation and in the subsequent differentiation of cambial tissues in the root promordia. The growth regulators also help in the mobilization of reserve food materials and passing the metabolised sugars to the site of root initiation (Nanda 1970). Growth regulators applied as prolonged dip and quick dip, were tried with varying degrees of success in different species and types of cuttings (Shanmugavelu, 1961a and Patel and Verma 1964). Bose *et al.* (1973b) based on their studies on eleven cultivars of *Hibiscus rosasinensis* reported that only a low percentage of rooting was obtained under ordinary propagation practices while intermittant mist and treatments with IBA and NAA increased rooting percentage and number of roots. The survival of rooted cuttings was also very high.

In the present investigation ten types of hibiscus were evaluated for their rooting ability by the application of growth regulators.

The response of growth regulators by quick dip method on rooting percentage showed that the highest percentage of rooting was observed when cuttings were treated with NAA 3000 ppm (78.0 per cent) followed by NAA 5000 ppm (74.1 per cent) and IBA 5000 ppm (72.1 per cent). Minimum percentage of rooting (60.7 per cent) was observed in IAA 1000 ppm treated cuttings. Girouard (1967) stated that IBA and NAA was superior because of their greater chemical stability and their low mobility in the plant.

In the prolonged dip method NAA 50 ppm (74.2 per cent) followed by NAA 75 ppm (71.2 per cent) and IBA 75 ppm (70.1 per cent) recorded better percentage of rooting. IBA 25 ppm, IAA 25 ppm and IAA 50 ppm treated cuttings produced poor rooting percentage. The percentage of rooting in the above treatments varied from 60.8 to 62.7. NAA 50 ppm by soak method was found to be the best in hibiscus according to Shanmugavelu (1961b) and the percentage of rooting ranged from 85 to 90.

The present study also clearly indicated that the effect of growth regulators to different types of hibiscus was different. In Acc.7, NAA 3000 ppm treated cuttings produced 29.9 per cent rooting while in control, it was only 7.6 per cent. The same treatment produced only 86.3 per cent rooting in Acc.8 while in control, it had already recorded 78.2 per cent rooting. The types Acc.19 and Acc.38 recorded better rooting percentage while the rooting percentage in Acc.2, Acc.7 and Acc.42 was poor even with growth regulator treatment. Such varying response of growth regulator to rooting of cuttings was reported by Misra (1971).

The response of different types of hibiscus for rooting was different. Even without growth regulator treatments, Acc.8, Acc.19, Acc.22, Acc.38 and Acc.44 recorded high rooting percentage of 78.2, 84.8, 73.8, 84.1 and 68.5 respectively and hence these types could be propagated through semi hardwood cuttings without any growth regulator treatment.

Analysis of data of the response of growth regulator on the root length from 20th to 100th day revealed the following details. In quick dip method, NAA 3000 ppm treated cuttings produced maximum lengthy roots followed by IBA 5000 ppm and IAA 10000 ppm. The root length in the above treatments on 100th day varied from 12.11 cm to 14.75 cm. Fretz and Davis (1971) found that IBA 5000 ppm gave maximum response in _Ilex cornata_.

In prolonged dip method more lengthy roots were recorded in cuttings treated with NAA 50 ppm, IBA 75 ppm and IAA 100 ppm. The root length in the above treatments on

100th day ranged from 11.54 cm to 11.81 cm. El-Hakim et al. (1962) found that NAA and IBA were more effective than IAA in inducing rooting in Phyllanthus and Ficus. In an experiment with three growth regulators in hibiscus, NAA gave the maximum average root length of 47.7 to 95.8 cm as against 19.8 to 67.0 in IBA and 8.5 to 25.6 cm in IAA (Shanmugavelu, 1961b).

The response of types to growth regulator treatment revealed that Acc.19 was best (14.28 cm on 100th day) regarding production of maximum lengthy roots followed by Acc.5. Shortest roots were recorded in Acc.7 and Acc.42 and the root length on 100th day was 7.2 cm and 7.8 cm respectively. Thus varietal response to growth regulator treatment was evidenced. Similar response had been obtained in rooting percentage also.

Acc.19 which recorded maximum root length on 20th day continued to show the same trend throughout the period of observation. Similarly, Acc.7 and Acc.42 which produced shorter roots on 20th day continued the uniform rate of elongation upto 100th day. So the study revealed that the types followed a steady trend in root length throughout the period of observation.

As in the case of root length, in root number also, maximum number of roots in quick dip method was recorded in cuttings treated with NAA 3000 ppm followed by IBA 5000 ppm and IAA 10000 ppm. The root number in the above treatments on 100th day was 12.23, 12.03 and 11.37 respectively. Bose *et al.*(1970) reported marked increase in number of roots per cuttings treated with NAA 3000 ppm.

In prolonged dip method better root number was observed in cuttings treated with NAA 50 ppm, IBA 75 ppm, IAA 100 ppm and NAA 75 ppm. The root number in the above treatments ranged from 10.27 to 13.46 on 100th day. Shanmugavelu (1960a) also obtained similar results in *Allamanda cathartica*.

Regarding the response of growth regulator on types, it was revealed that highest number of roots were recorded in Acc.19 (14.4 on 100th day) followed by Acc.5 and Acc.22. Minimum root number was observed in Acc.7 (6.12 on 100th day).

Acc.19 which produced maximum number of roots on 20th day recorded the highest root number till 100th day. Acc.7 which showed the lowest root number on 20th day continued to be minimum during the entire period of observation. As in the case of root length in root number also the types followed a steady trend from 20th to 100th day.

The analysis of data for root weight revealed that better performance in quick dip method was observed in cutting treated with IBA 5000 ppm and NAA 3000 ppm. On 100th day the root weight in the above treatments were 2.53 g and 2.86 g respectively. Read and Hoysler (1968) reported increased root weight due to growth regulator application in dahlia, chrysanthemum and geranium cuttings.

In prolonged dip method NAA 50 ppm, NAA 75 ppm, IBA 75 ppm and IAA 100 ppm treated cuttings recorded better root weight. According to Shanmugavelu (1960a) thicker and stouter roots were produced by cuttings treated with NAA.

Acc.19 was superior to other types with regard to response on root weight. Poor response was recorded in Acc.8, Acc.7 and Acc.36.

Acc.19 which showed maximum root weight on 20 th day continued to show the same trend till 100th day. As in the case of root length and root number, in root weight also the types kept a steady trend throughout the period of observation.

Quick dip method was significantly superior to prolonged dip method during the entire period of study in rooting percentage, root length, root number and root weight. Supremacy of quick dip method over prolonged dip method has been reported earlier by Hartmann and Kester (1976).

Thus from the studies on the response of growth regulator on rooting percentage, root number, root length and root weight it was evident that in general, in quick dip method NAA 3000 ppm was best followed by IBA 5000 ppm and IAA 10000 ppm. Similar results were obtained by Shanmugavelu (1960a), Bose et al. (1970) and Fretz and Davis (1971).

Response of growth regulator on rooting percentage, number, length and weight of roots showed that in general, in prolonged dip method NAA 50 ppm was best followed by IBA 75 ppm and IAA 100 ppm. Shanmugavelu (1961b) and Felming (1966) also obtained similar results in Hibiscus and Ligustrum.

From the studies, it was clear that NAA treated cuttings showed increased rooting percentage and also produced thicker and stouter roots. Thicker and stouter roots were produced in the cuttings of Magnolia and Golden Red treated with NAA (Samantarai 1955 and Hamner and Marth 1943). NAA was found to be better in all the treatments compared to IAA and IBA. This is agreement with the statement of Hitchcock and Zimmerman (1937) who reported that naphthalene compounds were more effective than the indole compound in inducing rooting capacity.

Harrison (1937) studied the response of IAA in Iresine and found that the endodermis and cortical parenchyma were not very reactive whereas phloem, pericycle rays and extra fasicular cambium proliferated and gave rise to root initials. But Kraus et al. (1937), Delisle (1940), Blum (1941) and Shanmugavelu (1959) attributed increased rooting by auxin treatment due to enhanced activation of cambial and cortex region.

The effect of exogenously applied auxin on rooting of stem cuttings appears to be mediated primarly through their effect on mobilisation of starch caused by enhanced activity of hydrolysing enzymes which in itself is determined by morphoaphysiological status of the branches that govern the production of endogenous auxin (Nanda, 1970). It has been demonstrated that while nutrition acts as a source of carbon, auxins regulate the synthesis of oxidative as well as hydrolytic enzymes and their isoenzyme patterns. There is thus an increase in the activity of invertase and amylase by auxin application with the initiation and development of roots (Nanda et al. 1973, Bhattacharya et al. 1974).

The increase in rooting by auxin application was attributed to greater depletion of sugars from the root forming region (Sen and Bose, 1966) and was associated with the mobilisation of carbohydrates and protein (Basu et al. 1972). However as the changes in carbohydrates and nitrogenous substances was closely associated with the rooting of cuttings, the increased root generation capacity was considered in terms of interaction between nutritional, hormonal, non hormonal and possibly other as yet unidentified factors (Nanda 1975).

Fruther studies have to be conducted on transplanting and establishments of these rooted cuttings in the field. However, it may be presumed that better root growth is an indication of the post transplanting survival and performance. Accordingly it might be concluded that compared to control all the growth regulator treatments are better, the best being NAA 3000 ppm in quick dip method and NAA 50 ppm in prolonged dip method.

3. Studies on air layering

Since the rooting was found to be very poor in Acc.2, Acc.7 and Acc.42 even with NAA 3000 ppm in quick dip method and NAA 50 ppm in prolonged dip method, air layering was tried. The maximum percentage of success in air layering was noticed in Acc.38 (89.3 per cent) and the minimum was recorded in Acc.7 (13.4 per cent). Virupaksha (1961) obtained 65 per cent rooting in air layers of hibiscus. The better percentage of success in air layering of hibiscus might be due to accumulation of starch and amino acids above the girdled portion of the shoot and of more parenchyma tissue available for differentiation into root initials (Stoltz and Hess, 1966b). However, in the present studies, the rooting of layers was found to be low compared to rooting of growth regulator treated cuttings. Treating the cuttings of Acc.44 with NAA 3000 ppm produced a rooting percentage of 91.4 while the percentage of success in air layering was only 73.1. Increased rooting of air layers treated with growth regulator was reported by Sing (1954) and Misra and Majundar (1983). Further detailed studies on the effect of growth regulators on rooting of layers will be of interest.

According to Argles (1969) rooting was governed by physiological factors inherent in the layered shoot. Adarsh Bala (1969, 1970) observed that rooting of layers was related to mobilisation of starch to cut portions. The disappearance of starch was closely related to the activity of hydrolyzing enzymes causing mobilization of reserve food materials. Thus the hydrolytic activity was high when rooting was profuse causing more mobilization of reserve food materials (Nanda, 1975).

# SUMMARY

## SUMMARY

The present studies were conducted in the Department of Pomology and Floriculture, College of Horticulture, Vellanikkara during the years, 1979 to 1981. The summary of the work done and the salient findings obtained are given below:

1. Thirty seven types and fourteen varieties of *Hibiscus* were collected from the different zones of Kerala, Tamilnadu and Karnataka and maintained in the College garden.

2. Morphological description of all the fifty one collections were made.

3. A key for identification of different types of hibiscus was prepared.

4. Acc.3, Acc.5, Acc.13, Acc.29, Acc.32, Acc.33, Acc.42 and Acc.52 were found to produce very attractive showy flowers of various shades of colours.

5. Acc.43,and Acc.45 were very bushy types.

6. Pollen viability of ten types were studied by acetocarmine staining technique. Viability of pollen ranged from 4.6.per cent in Acc.7 to 89.8 per cent in Acc.22.

7. Rooting of stem cuttingsof ten types of hibiscus were assessed under two treatment conditions, with leaves and without leaves. Retention of leaves showed significant influence over the treatment without leaves regarding rooting percentage and root number.

8. Response of IAA, IBA and NAA on rooting percentage of ten types of hibiscus was studied. On 60th day of planting, it was revealed that in quick dip method, NAA 3000 ppm was best followed by NAA 5000 ppm and IBA 5000 ppm.

In prolonged dip method better rooting percentage was observed in types treated with NAA 50 ppm, NAA 75 ppm and IBA 75 ppm.

Better rooting percentage was recorded by Acc.19 and Acc.38 while Acc.2, Acc.7 and Acc.42 recorded poor rooting percentage.

9. Effect of IAA, IBA and NAA on root length, root number and root weight of ten types of hibiscus were studied. By analysing the data from 20th to 100th day, it was found that in quick dip method NAA 3000 ppm was the best followed by IBA 5000 ppm and IAA 10000 ppm regarding root number and root length. In root weight better performance was recorded by cuttings treated with IBA 5000 ppm and NAA 3000 ppm.

In prolonged dip method superior performance for root length and root number was recorded in NAA 50 ppm, IBA 75 ppm and IAA 100 ppm treated cuttings. Better performance regarding root weight was observed in NAA 50 ppm, NAA 75 ppm, IBA 75 ppm and IAA 100 ppm treated cuttings.

10. Out of two methods of growth regulator application, quick dip method was significantly superior to prolonged dip method throughout the period of observation for all the characters studied.

11. The types responded differently to growth regulator treatments, Acc.19 responded best while least response was exhibited by Acc.7.

12. Thus from the study it was clear that maximum percentage of success during rooting of hibiscus was obtained by NAA 3000 ppm in quick dip method and NAA 50 ppm in prolonged dip method.

13. Air layering tried in ten types showed that maximum rooting percentage of 89.3 was observed in Acc.38 while Acc.7 showed minimum percentage of success (13.4). Though air layering recorded better rooting than cuttings without growth regulator treatments, it showed lower rooting percentage when compared to growth regulator treated cuttings.

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* Originals not seen

# APPENDICES

Appendix 1. Analysis of variance for pollen viability in different types of hibiscus (transformed data)

| Source | Degrees of freedom | Mean sum of squares |
|---|---|---|
| Types | 9 | 1836.10* |
| Error | 40 | 13.79 |
| Total | 49 | |

* Significant at 5% level

Appendix II. Analysis of variance for percentage of rooting of cuttings by the effect of retention of leaves in different types of hibiscus (transformed data)

| Source | Degrees of freedom | Mean sum of squares |
|---|---|---|
| With leaves $V_s$ without leaves | 1 | 48.61* |
| Types | 9 | 592.068* |
| Error | 9 | 1.254 |
| Total | 19 | |

* Significant at 5% level

Appendix III. Analysis of variance for rooting of cuttings by the effect of retention of leaves on root number of different types of hibiscus

| Source | Degree of freedom | Mean sum of squares |
|---|---|---|
| With leaves Vs without leaves | 1 | 1.529* |
| Types | 9 | 3.185* |
| Error | 9 | 0.0659 |
| Total | 19 | |

* Significant at 5% level

Appendix IV. Analysis of variance for rooting of cuttings by the effect of retention of leaves on root length of different types of hibiscus (transformed data)

| Source | Degrees of freedom | Mean sum of squares |
|---|---|---|
| With leaves Vs without leaves | 1 | 0.050* |
| Types | 9 | 0.188* |
| Error | 9 | 0.0027 |
| Total | 19 | |

* Significant at 5% level

Appendix V Analysis of variance of percentage of rooting of hibiscus cuttings on 60th day of planting (transformed data)

| Source | Degrees of freedom | Mean sum of squares |
|---|---|---|
| Total | 1119 | |
| Types (T) | 9 | 33116.59* |
| Growth Regulator (G) | 27 | 385.167* |
| T x G | 243 | 17.226 |
| Error | 840 | 20.796 |

* Significant at 5% level

Appendix VI. Analysis of variance of root length during rooting of hibiscus cuttings at different periods.

| Source | Degrees of freedom | Mean sum of squares | | | | |
|---|---|---|---|---|---|---|
| | | 20th day | 40th day | 60th day | 80th day | 100th day |
| Total | 1119 | | | | | |
| Types (T) | 9 | 14.1144* | 154.3707* | 300.3720* | 396.4999* | 761.9030* |
| Growth Regulator (G) | 27 | 6.9189* | 49.2776* | 62.1774* | 68.8111* | 90.7881* |
| T x G | 243 | 0.4748 | 3.7126 | 4.5858 | 5.6594 | 6.1276 |
| Error | 840 | 1.2448 | 3.6860 | 5.7507 | 9.9390 | 16.4116 |

* Significant at 5% level of probability

Appendix VII. Analysis of variance of root number during rooting of hibiscus cuttings at different periods (transformed data)

| Source | Degrees of freedom | Mean sum of squares | | | | |
|---|---|---|---|---|---|---|
| | | 20th day | 40th day | 60th day | 80th day | 100th day |
| Total | 1119 | | | | | |
| Types (T) | 9 | 0.4819* | 2.9735* | 7.6843* | 8.7268* | 16.3726* |
| Growth Regulator (G) | 27 | 0.7593* | 3.7438* | 4.3521* | 4.8498* | 5.8135* |
| T x G | 243 | 0.0363 | 0.173 | 0.2155 | 0.2115 | 0.3084 |
| Error | 840 | 0.1518 | 0.2933 | 0.4193 | 0.4961 | 0.5961 |

* Significant at 5% level of probability

Appendix VIII Analysis of variance of root weight during rooting of hibiscus cuttings at different periods

| Source | Degrees of freedom | Mean sum of squares | | | | |
|---|---|---|---|---|---|---|
| | | 20th day | 40th day | 60th day | 80th day | 100th day |
| Total | 1119 | | | | | |
| Types (T) | 9 | 0.00184* | 0.0515* | 5.60748* | 21.3820* | 24.2857* |
| Growth Regulator (G) | 27 | 0.00069* | 0.02149* | 1.8484* | 4.7803* | 6.8192* |
| T x G | 243 | 0.000184** | 0.00414* | 0.26287* | 0.2147 | 0.1582 |
| Error | 840 | 0.000082 | 0.00116 | 0.0494 | 0.5780 | 0.7064 |

** Significant at 1% level of probability

* Significant at 5% level of probability

Appendix IX. Analysis of variance of percentage of success on account of air layering of different types of hibiscus (transformed data)

| Source | Degree of freedom | Mean sum of squares |
|---|---|---|
| Types | 9 | 579.56* |
| Error | 10 | 34.15 |
| Total | 19 | |

* Significant at 5% level

# MORPHOLOGICAL STUDIES OF DIFFERENT TYPES OF *Hibiscus rosasinensis* L. AND STANDARDISATION OF PROPAGATION TECHNIQUES

BY

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**ABSTRACT OF A THESIS**

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ABSTRACT

The investigations on collection, morphological description and standardisation of propagation techniques of different types of hibiscus were carried out in the Department of Pomology and Floriculture, College of Horticulture, during the period 1979 to 1981.

Thirty four types and fourteen varieties of Hibiscus rosasinensis, two types of H.schizopetalous and one type of H.mutabilis were collected from different zones of Kerala, Tamilnadu and Karnataka and were maintained in the College garden. Since the types collected had no specific varietal names, morphological descriptions of all the fifty one collections were made. Considerable variation both in vegetative and floral characters were exhibited by different types in the collection. A key was prepared based on important distinguishing characters for identification of different types of hibiscus. Acc.3, Acc.5, Acc.13, Acc.29, Acc.32, Acc.33, Acc.42 and Acc.52 were found to produce very attractive showy flowers of different shades of colours. Acc.43 and Acc.45 were bushy types.

Pollen viability of ten types of hibiscus were studied. Considerable variation existed with regard to pollen viability among different types. Maximum pollen viability of 89.8 per cent was observed in Acc.22 and minimum of 4.7 per cent in Acc.7.

Rooting of stem cuttings were assessed under two treatment conditions, with leaves and without leaves. Retention of leaves had significant influence over the treatment without leaves on rooting of cuttings.

The response of growth regulators, IAA, IBA and NAA on rooting of ten hibiscus types were studied. It was revealed that in quick dip method best performance was recorded by NAA 3000 ppm followed by IBA 5000 ppm and IAA 10000 ppm for rooting percentage, number and length of roots. In prolonged dip method, higher rooting percentage, root number, root length and root weight was observed when cuttings were treated with NAA 50 ppm, IBA 75 ppm and IAA 100 ppm.

Out of two methods of growth regulator application, quick dip method was significantly superior to prolonged dip method.

The types responded differently to growth regulator treatment, Acc.19 responded best while least response was exhibited by Acc.7.

From the studies on air layering, it was revealed that maximum rooting percentage of 89.3 was exhibited by Acc.38 and minimum percentage of success by Acc.7. Air layering recorded better rooting than cutting without growth regulator treatment. But, it showed lower rooting percentage when compared to growth regulator treated cuttings.