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STUDIES ON THE PROPAGATION OF GUAVA BY STEM CUTTINGS

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Hard-wood cuttings rooted better than the semi-hard wood cuttings. Soft-wood cuttings failed in both the seasons and defied all the growth regulators. Highest values of rooting success were obtained for IBA and $KMNO_4$ treated cuttings which were planted on 7th March. Sucrose treated cuttings gave better results when planted on 17th March.

INTRODUCTION

The guava (*Psidium guajava* L.) is commercially propagated from seed, therefore, the standard varieties of this fruit do not exist in the country and they are either named after the colour of the flesh i.e. white or red or its shape or after the locality of production. The standard varieties can be propagated vegetatively. but unfortunately this plant does not lend itself easily to usual asexual methods of propagation. Therefore, the present studies were started in ordor to determine suitable time and type of wood for propagating this fruit tree from stem cuttings. Certain growth regulators were also tried for inducing root formation by the cuttings.

REVIEW OF LITERATURE

Singh and Teotia (1951) reported that application of 1 per cent NAA to marcot cuts induced 100 per cent rooting with Dusehri, while with Langra 2 per cent, IAA gave a higher percentage (70 per cent).

According to Gardner, *et al* (1952), Leclerc du Sablon's found that hemicellulose tended to accumulate in the wood storage tissues of pear and chestnut as the growing season advanced and it disappeared in the spring as it was utilized for new growth. During cold weather quantitative change of hexosans into sugar occurred in the beginning of September-October for the periderm and cortex phloem and in October for the xylem tissues. Gardner, et al (1952) also stated that growth regulators vary in quantity at different times of the year, which have both inducing and inhibiting effects on the rooting of cuttings.

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Adriance and Brison (1955) used dilute solution of vinegar and cane sugar successfully with some types of plants. The most widely used growth regulators are IAA, IBA and NAA.

Hartmann and Kester (1960), reported rooting of tomato and privet cuttings, treated with sugar as well as compounds of manganese, iron, and phosphorus. Better results were obtained especially with potassium permanganate. According to them many research workers found that differential behaviour of different types of cuttings may be due to differences in some biochemical factors such as carbohydrates in the different parts of the same shoot.

June was found to be the best month for air layering. A treatment of 10,000 ppm of an equal mixture of NAA and IBA in talc; was found to be the best (Anon, 1961).

In grafting experiments by Ahmad (1961) no success was achieved with side or veneer grafting. Grafting success by inarching method was 80 per cent in autumn and 60 to 84 per cent in spring seasons. March was found to be better than April, and August was better than September. However, he also reported 75 per cent success with guava cutting treated with IAA 50 ppm in the spring season. Teaotia and Pandey (1961) reported that both NAA and IAA at 50 ppm and 100 ppm encouraged rooting of semihard wood etiolated guava cuttings. Results with IBA were unsatisfactory, in their studies.

Sinha, *et al* (1962) treated cuttings of 'Allahabad Safeda', with IAA, IBA, NAA and phenyl acetic acid, at 40, 60 and 80 ppm under normal and reduced pressure, for 12, 24, 48 or 60 hours. Maximum rooting was obtained with an 80 ppm IAA dip maintained for 48 hours under reduced pressure, cuttings were taken in the second week of May. In general, IBA was the most useful regulator, and the best responses were obtained with cuttings taken from late January to May.

In the studies conducted by Srivastava (1962) the best results were obtained with 12 hours dip in 100 ppm NAA, and the second best treatment was application of IBA at the same concentration and duration. Joliceour (1962) treated cuttings of two pink seedling trees with 0.1, 0.3, and 0.8 per cent IBA in talc and rootone plus thiran and raised them under mist. Rooting occurred in 44 per cent cuttings treated with 0.8 per cent IBA.

Pennock and Maldonado (1963) planted under inter-mittent mist, the cuttings taken from the side shoots which sprung out as a result of drastic pruning. Overnight emersion of the basal ends of the cuttings in 200 ppm of IBA markedly accelerated the rooting especially with the addition of 2 per cent sucrose. Numerous growth substances were tried by Ahmad (1963) on the cuttings of guava. NAA (100 ppm) seradix A and IBA (100 ppm) were found to be most effective for rooting. Only 12.5 per cent of sprouted cuttings produced roots.

Laupheer and Meahl (1963) reported that in juniperous and Texus species the root forming capacity was highest when cutings were made from late fall to late winter. The application of IBA promoted roots only where the plant had developed high rooting capacity during certain time of the year.

In the experiments by Singh and Gaur (1966) cuttings from hard, semi-hard and soft wood, each with two pairs of leaves failed to root either in full sunlight or in the partial shade of a lath-house. Semi-hard wood cuttings gave the best results with a rooting and establishment level of 51.25 per cent. The treatment with 500 ppm IBA increased the root number only.

Manohar (1966) reported that soft-wood cuttings of guava taken from plants grown from cuttings in the previous year and treated with IBA showed 38 per cent rooting after 12 weeks. Corresponding percentage for soft wood cuttings, taken from different branch types, from 7-years old trees were: sucker cutting 20 per cent, water shoot cuttings 11 per cent, sprouts from twigs cut back 7–weeks previously 7 per cent, and cuttings from ordinary twig, nil.

Meridith, *et al* (1970) conducted experiments to find root promoting or inhibiting factors in *Feijoa sellowiana* stem cuttings and reported that ability to root in response to IAA or kinetin varied greatly between the clones, both the growth regulators induced rooting in one clone, but had no effect on two others and an unknown compound believed to be an inhibitor was also found in both moderately easy and difficult-to-root clones but the contents were 5 times higher in the later. Effective levels of kinetin and IAA were found to be 0.10 and 70.00 mg/l, respectively, when applied as an 8 hour basal soak.

MATERIALS AND METHODS

These studies were carried out in the Department of Horticulture, University of Agriculture, Lyallpur during the year 1972-73. Cuttings were taken from the hard-wood, semi-hard wood and soft-wood portion of 1-1½ year old branches of guava plants of uniform age and vigour. The length of various cuttings varied according to their wood type, hard wood and semi-hard wood cuttings measured 5-6 inches, the soft-wood cuttings were 3-5 inches.

The growth regulators were applied by dilute solution dip method (Hartmann and Kester, 1960). The bases of the cuttings (1-1½ in.) were dipped in different concentrations of growth regulators for 24 hours before planting in the field. For control the cuttings were dipped in the tap water for 24 hours to equalise the effect. Experiments were laid out according to the split plot design. Treatments were given more importance and wood types were the next important.

Cuttings were planted twice in each season i.e. on 21st September, 1972 and 1st October, 1972 in autumn and on 7th and 17th March, 1973 in spring season.

Growth Regulator Treatments

Indolebutyric acid 50, 100, 150 and 200 ppm concentrations, sucrose 200, 300, 400 and 500 ppm concentrations and potassium permanganate 50, 100, 150 and 200 ppm concentrations were applied to the cuttings before planting. Each treatment was replicated 4 times whereas the number of cuttings per treatment was 10.

Sprouted cuttings which remained green after about six months of planting time were considered as to have formed the roots. These were counted on 21st September, 1973 for each treatment in every replication. Cuttings were dug from the soil with earth ball on 23rd October, 1973 and soil was removed by washing the cuttings in water and the roots were counted on each cutting. For determining the root length the roots were removed from each cutting and were placed from end to end in a straight line, and measured in inches.

Analysis of variance was used for the statistical analysis of the data. In addition D.M.R. test was also applied for comparison of means wherever needed.

RESULTS

Rooting of Cuttings. All the sprouted cuttings from autumn 1972 plantings survived for one month only and then died, therefore, the rooting of these cuttings was not studied. The data in respect of the rooted cuttings from the lots planted on two different dates during spring 1973 are presented in Table 1.

It is apparent from the data that rooting of the cuttings planted on 7th March, 1973 was better as compared to those planted on 17th March, 1973. About wood types, hard-wood cuttings rooted better (23.1 per cent) than semi-hard wood cuttings (3.3 per cent), while all the soft-wood cuttings failed to root. With regard to growth regulators, 14.2, 13.4 and 13.3 per cent cuttings rooted in case of IBA, sucrose and $KMNO_4$ treatments, respectively as compared to 6.7 per cent for the control.

Regarding the individual growth regulator treatments, in case of Indole-butyric acid, 50, 7.5, 30 and 12.5 per cent of hard-wood cuttings planted on 7th March, 1973 were found to have developed roots for 50, 100, 150 and 200 ppm treatments, respectively. Among the untreated cuttings, 20 per cent produced roots. The similar cuttings planted on 17th March, 1973 showed rooting percentage of 17.5, 15, 30 and 25 per cent with the same treatments, respectively, against 15 per cent for the control. Rooting percentages of semi-hard wood cuttings planted on 7th March, 1973 were 0, 22.5, 2.5 and 0 per cent for 50, 100, 150 and 200 ppm IBA treatments, respectively as compared to 5 per cent for the control. The soft-wood cuttings did not root in any case.

Regarding sucrose treatments as applied to the hard-wood cuttings, planted on 7th March, 1973, as many as 17.5, 32.5, 10 and 20 per cent cuttings were found to have developed the roots, for 200, 300, 400 and 500 ppm treatments, respectively. Only 20 per cent cuttings rooted from the control lot. The similar cuttings planted on 17th March, 1973 showed 15, 15, 47.5 and 35 per cent rooting with the same treatments, respectively as compared to 15 per cent for the control. From the semi-hard wood cuttings planted on 7th March, 1973 after the similar treatments, only 5, 2.5, 0, and 5.5 per cent rooted as compared to the 5 per cent for the untreated lot. The values for the similar cuttings planted on 17th March, 1973 were 2.5, 2.5, 0 and 5 per cent for 200, 300, 400 and 500 ppm treatments, respectively, as compared to nil for the control. No root formation occurred for soft-wood cuttings.

TABLE 1. Effect of Growth Regulators on Rooting (Percentage) of Guava Cuttings planted on two different Dates during Spring, 1973.

Growth regulators	Concentrations	DATES					
		7.3.73			17.3.73		
		Hard wood	Semi-hard wood	Soft wood	Hard wood	Semi-hard wood	Soft wood
IBA	50 ppm	50.0	0.0	0.0	17.5	7.5	0.0
	100 ppm	7.5	22.5	0.0	15.0	7.5	0.0
	150 ppm	30.0	2.5	0.0	30.0	0.0	0.0
	200 ppm	12.5	0.0	0.0	25.0	0.0	0.0
Sucrose	200 ppm	17.5	5.0	0.0	15.0	2.5	0.0
	300 ppm	32.5	2.5	0.0	15.0	2.5	0.0
	400 ppm	10.0	0.0	0.0	47.5	0.0	0.0
	500 ppm	20.0	5.5	0.0	35.0	5.0	0.0
$KMNO_4$	50 ppm	17.5	7.5	0.0	15.0	0.0	0.0
	100 ppm	40.0	5.0	0.0	15.0	2.5	0.0
	150 ppm	35.0	0.0	0.0	20.0	2.5	0.0
	200 ppm	22.5	2.5	0.0	2.5	5.0	0.0
Control	H_2O	20.0	5.0	0.0	15.0	0.0	0.0

In the case of potassium permanganate, the hard-wood cuttings planted on the 7th March, 1973, after treating with 50, 100, 150 and 200 ppm concentrations, the rooting percentage was calculated as 17.5, 40, 35 and 22.5 per cent, respectively as compared to 20 per cent for the control. The average values for the similar cuttings planted on 17th March, 1973 were 15, 15, 20 and 2.5% respectively for the same treatments, against 15 per cent for the control. Regarding semi-hard wood cuttings planted on 7th March, 1973, the rooting success was recorded as 7.5, 5, 0 and 2.5 per cent for 50, 100, 150 and 200 ppm treatments, respectively as compared to 5 per cent for the control. The cuttings prepared from similar wood type planted on 17th March, 1973 with the same treatments showed 0, 2.5, 2.5 and 5 per cent rooting success, respectively, whereas untreated lot failed to develop any roots with any of these treatments.

The analysis of variance of these data revealed that the differences in the number of rooted cuttings due to the planting dates were non-significant. Highly significant differences existed among the wood types but the differences due to the treatments were nonsignificant.

D.M.R. test has shown that the average values for the two planting dates were statistically similar. The mean values for the wood types when compared with each other showed highly significant differences among them. The hard-wood cuttings proved their superiority over the other types. 50 ppm IBA was found better than 50 ppm $KMNO_4$ and 200 ppm IBA but equal to all other treatments. 500 ppm sucrose was better than 200 ppm IBA and similar to all other treatments.

The effect of different treatments on the cuttings planted on various dates was similar. There was positive interaction between wood types and treatments so that the cuttings prepared from hard-wood responded more favourably to the different treatments as compared to those prepared from other wood types. For the same reason the interaction to wood types × treatments × planting dates were also highly significant.

Number of Roots per Cutting. The pertinent data are presented in Table 2. The cuttings planted on 17th March, 1973 developed more roots than those planted on 7th March, 1973 and the cuttings prepared from the hard-wood rooted better than semi-hard wood cuttings. Among growth regulators, IBA gave the best results especially for those cuttings which were planted on 17th March, 1973 $KMNO_4$ treatments were next best and better than sucrose. None of the untreated cuttings were available for the study of their roots.

In case of IBA the average number of roots developed by the hard-wood cuttings planted on 7th March, 1973 were 1.5, 12, 10 with 50, 150 and 200 ppm treatments, respectively, as compared to similar cuttings, planted on 17th March, 1973 with the average values 45, 24.8, 25 and 56, respectively for the same treatments (Plates 1—4). An average of 10 roots was calculated for semi-hard wood cuttings planted on 7th March, 1973, with 100 ppm treatment while no other cutting was available for these studies from other treatments in this lot. For the similar cuttings planted on 17th March, 1973, the average values for the number of roots were 24.3 and 11 with 50 ppm and 100 ppm treatments, respectively. Cuttings treated with 150 and 200 ppm were not available for their roots.

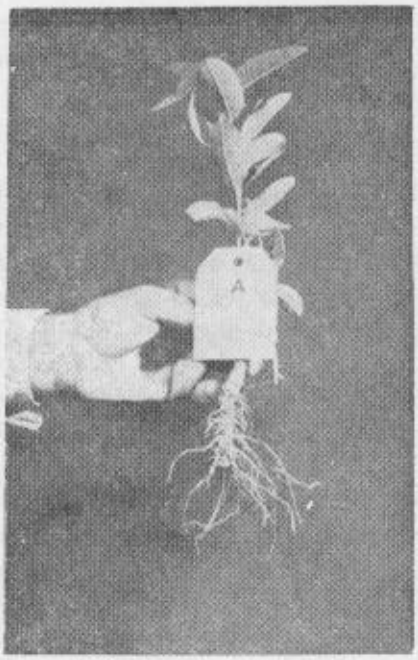

PLATE 1.
Plant from a hard-wood cutting treated with 50 ppm IBA, planted on 7.3.1973.

PLATE 2.

Plant from a hard-wood cutting treated with 100 ppm IBA, planted on 17.3.1973.

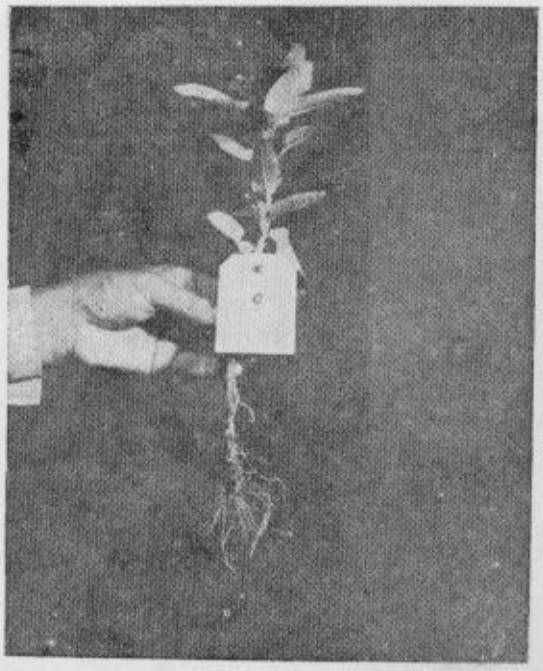

PLATE 3.

Plant from a hard-wood cutting treated with 150 ppm IBA, planted on 17.3.1973.

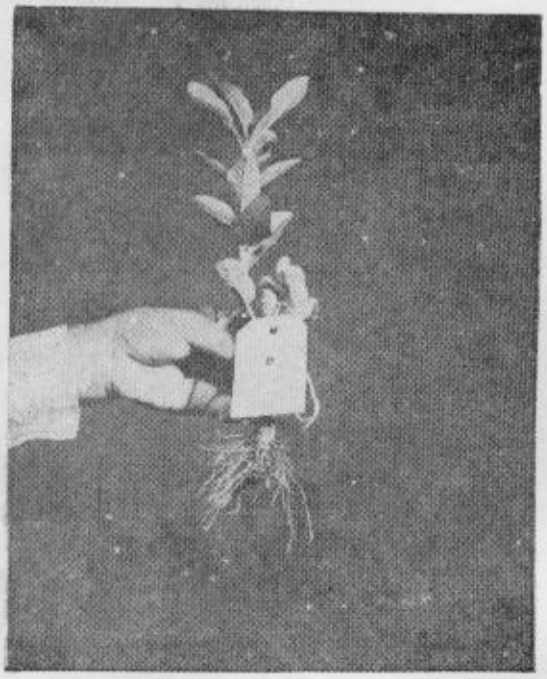

PLATE 4.

Plant from a hard-wood cutting treated with 200 ppm IBA, planted on 17.3.1973

TABLE 2. Average Number of Roots and Average Root Length (inches) per Cutting under Various Treatments

Growth Regulators	Concentration	DATES							
		7.3.1973				17.3.1973			
		Hard wood		Semi hard wood		Hard wood		Semi hard wood	
		No.	Length	No.	Length	No.	Length	No.	Length
IBA	50 ppm	1.5	1.6	0.0	0.0	45.0	32.8	24.3	56.2
	100 ppm	0.0	0.0	10.0	16.5	24.8	60.9	11.0	20.5
	150 ppm	12.0	18.0	0.0	0.0	25.0	34.3	0.0	0.0
	200 ppm	10.0	16.0	0.0	0.0	56.0	43.9	0.0	0.0
Sucrose	200 ppm	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	300 ppm	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	400 ppm	0.0	0.0	0.0	0.0	4.0	7.0	0.0	0.0
	500 ppm	0.0	0.0	0.0	0.0	4.0	8.0	0.0	0.0
$KMNO_4$	50 ppm	1.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0
	100 ppm	10.0	22.6	0.0	0.0	0.0	0.0	0.0	0.0
	150 ppm	5.0	8.6	0.0	0.0	0.0	0.0	0.0	0.0
	200 ppm	10.0	21.6	0.0	0.0	0.0	0.0	0.0	0.0
Control	H_2O	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

From the sucrose treatments, only the hard wood cuttings treated with 400 and 500 ppm solutions and planted on 17th March, 1973 were available for root studies and in each case an average of four roots were counted. In case of $KMNO_4$, only the hard wood cuttings planted on 7th March, 1973 could be studied for this character and average values of 1, 10, 5 and 10 were determined for 50, 100, 150 and 200 ppm treatments respectively.

Total Root Length. The data on total length of roots developed by different types of cuttings planted after different treatments on 7th and 17th March, 1973 are arranged in Table 2.

A perusal of the data of Table 2 would show that total length of roots per cutting was more in case of those cuttings planted on 17th March, 1973 than those planted on 7th March, 1973. The hard-wood cuttings developed greater root length than the semi-hard wood cuttings. Regarding growth regulators, IBA gave the best results for both the dates. $KMNO_4$ treatments were little better than the sucrose.

In case of IBA treated lots the measurements of root length developed by the hard-wood cuttings planted on 7th March, 1973 averaged 1.6", 0", 18" and 16" for 50, 100, 150 and 200 ppm concentrations, respectively. The similar cuttings planted on 17th March, 1973 attained better root lengths, with averages of 32.8", 60.9", 34.3" and 43.9" with similar treatments, respectively. About the semi-hard wood cuttings treated with IBA, only the cuttings treated with 100 ppm and planted on 7th March, 1973 could be studied. The average root length for cutting was 16.5". For the similar cuttings planted on 17th March 1973 the average measurements were 56.2 inches and 20.5 inches with 50 and 100 ppm treatments, respectively, cuttings from other treatments were not available for these studies.

With regard to sucrose, only the hard wood cuttings treated with 400 and 500 ppm and planted on 17th March, 1973 could be measured for their root length and the averages were 7 inches and 8 inches, respectively. Similarly in case of $KMNO_4$ only the hard-wood cuttings treated with 50, 100, 150 and 200 ppm and planted on 7th March, 1973 were available for measurements and average values of 0.8", 22.6", 8.6", and 21.6" respectively were recorded.

DISCUSSION

Guava plant does not lend itself easily for any of the vegetative methods of propagation, therefore, it is usually raised by seed. Many research

workers like 'Singh and Teotia (1951), Anon. (1961) and Ahmad (1961) have tried to find some suitable asexual methods for its propagation but unfortunately results of practical importance have not been achieved so far.

The facts, that none of the cuttings of any type of wood rooted even with certain growth regulator treatments in autumn and more cuttings rooted when planted on 7th March as compared to 17th March lot, point to the conclusion that certain endogenous or exogenous or both factors obtaining around March 7 were conducive to the rooting of more cuttings on this date. The cuttings planted on the 7th March were in a better physiological condition for the purpose of developing a root system as compared to those planted on 17th March.

The cuttings planted in autumn altogether faild because these were not in a proper physiological condition of setting out the roots, whereas climatic conditions were also not favourable. This conclusion is also corroborated by Anon. (1961), and Sinha, *et al.* (1962), who pointed out that physiological conditions of the cuttings have much to do with the development of the root system. Lanphear and Meahl (1963) have also established that growth regulators are of any help in stimulating the root development of the cuttings when the endogenous and climatic factors are suitable for this purpose.

According to Gardner *et al* (1952), Leclerc du Sablon's found that the quantities of carbohydrates in the tissues of different trees varied in different seasons. They also stated that growth regulators vary in quantity at different times of the year, which have both inducing and inhibiting effects on the rooting of cuttings.

Regarding the wood types, the hardwood cuttings gave the best results, rooting success in case of semi-hard wood cuttings was not appreciable and the softwood cuttings failed altogether. According to Teaotia and Pandey (1961), Singh and Gaur (1966), the semi-hard wood cuttings of guava gave best results by using different growth regulators. But in present studies only 50 and 100 ppm IBA showed some success with semi-hard wood cuttings, while soft-wood cuttings failed in both the seasons. It is probably due to the high transpiration rate and desiccation of soft tissues. According to Hartmann and Kester (1960) rooting success in hard-wood or semi-hard wood cuttings may be due to the presence of elaborated food materials stored in their tissues so that these are able to survive the period untill the new roots and shoots are initiated and developed.

Semi-hardwood cuttings were intermediate in their rooting behaviour. As high as 22.5% of them rooted when planted on 7th March after treating with 100-ppm-IBA. In these studies none of the soft wood cuttings produced the roots. There could be many reasons for their failure. Firstly, the soft wood cuttings come from the immature soft terminal portions of the growing shoots and they are likely to suffer of drought very soon, unless appropriate measures, for preventing or retarding their transpiration are taken i.e. more humidity is provided around them. Secondly, very soft tissues are involved in their composition, therefore, these are vulnerable to the attack of micro-organisms. Thirdly, these cuttings may not have attained a physiological maturity in order to produce the roots.

On the other hand, Manohar (1966) successfully rooted the soft-wood cuttings of guava plants. It seams proper to conclude that soft-wood cuttings have to be manipulated in a different manner than the hard-wood cuttings. It is essential that proper environments, ensuring low transpiration and optimum temperatures are provided for rooting of soft-wood cuttings. It would not be advisible to try rooting of soft-wood cuttings in the field conditions.

Regarding the growth regulators, on the whole IBA treated cuttings gave better results. Rooting success appeared to be inversly proportional to the higher concentrations of IBA, excepting that the results for 100-ppm were out of line and it is difficult to assign anv reason for this This growth regulator also induced rooting in some of the semi hard-wood cuttings as 22.5 per cent of them rooted successfully with 100-ppm.

Rooting success in the cuttings planted ten days latter i.e. 17th March was lower than those planted earlier i.e. 7th March but it is interesting to note that on this date higher concentrations gave better results than the lower ones. The results for 150 ppm were similar for both the dates. IBA is being used by the horticulturists since long time for many responses including the rooting of cuttings and has been tried successfully by Sinha, *et al.* (1962), Srivastava (1962), Jolicoeur (1962), Pennock and Maldonado (1963), Ahmad (1963), Sing and Gaur (1966) and Manoher (1966) on guava. Meredith, *et al.* (1970) used kinetin and IAA on feijoa cuttings and obtained rooting in one clone only. They found an un-identified compound, believed to be inhibitor in both moderately easy and difficult-to-root clones but the contents were five times higher in latter clones.

Sucrose solutions of various concentrations 200—500 ppm, applied in the same way as IBA, have shown some interesting results. The maximum rooting success of 32.5 per cent of hard-wood cuttings planted on 7th March was recorded for 300 ppm treatment. The rooting success for all others was lower than this and the rooting success does not seem to correspond with the different levels of concentration used in these experiments. Rooting in semi-hard-wood cuttings planted on 7th March was very low. For the cuttings planted on 17th March the maximum success of 47.5 was noted in case of hard wood cuttings treated with 400 ppm solution.

In this case also the higher values were obtained for higher concentrations in contrast to those planted on 7th March where higher values were obtained for lower concentrations. Sucrose is very inexpensive, easily and commonly available substance and this was included in these studies for the simple reason that if it proves better than or equal to IBA or other growth regulators which are not available in the country, it will be great advantage for the nurserymen to use simple cane sugar for stimulation of root development in the hard-to-root cuttings. Cane-sugar has been advantageously used as a growth regulator for this purpose by many research workers like Pennock and Maldonado (1963) and Adriance and Brison (1955) for guava and other horticultural plants.

Potassium permanganate, another very inexpensive and easily available substance was also used as growth regulator. With this growth regulator, hard-wood cuttings planted on 7th March gave better results as compared to those planted on 17th March. A maximum value of 40 per cent was obtained for the cuttings treated with 100 ppm planted on 7th March. The values corresponded inversely to the higher concentrations while the minimum success was for the 50 ppm. For the cuttings planted on 17th March the maximum value was 20 per cent in case of 150 ppm. The rooting in case of semi-hard wood cutting was meager for both the dates. Hartmann and Kester (1960) obtained better results with potassium permanganate on tomato and privet cuttings.

It has been observed that more roots developed on the cuttings treated with IBA and planted on 17th March. There was a wide difference in the number of roots in the cuttings planted on 7th March and 17th March. In case of potassium permanganate treated cuttings only those planted on 7th March could be studied, therefore, the comparison of the dates was not possible. Similarly few cuttings treated with sucrose were available from

17th March lot. Therefore, in this case also no comparison could be made between the two dates. Sinha *et al.* (1962) and Singh and Gaur (1966) have also reported good root system with IAA, and NAA.

Data on the average root length per cutting with the various treatments are of similar nature i.e. maximum length of the roots was recorded for IBA treated cuttings prepared from hard-wood and planted on 17th March. Large number of cuttings probably with smaller and lesser roots could not survive due to exceptionally high rainfall during the monsoon of 1973 and later due to drought because all the canals were closed due to high floods. Therefore, cuttings from all the treatments could not be available for counting and measuring their roots.

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