ROOTING OF SOFT AND SEMI - HARD WOOD CUTTING OF GUAVA AS AFFECTED BY IBA

BY

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ABSTRACT

The present investigation was carried out during 1989 - 1990 at the university of Jordan campus to study the effect of time taking cuttings , various indolebutyric acid concentration,and cutting type on rooting percentange,number of roots , root length, and shoot length after 6, 8, and 12 weeks, and after 4 and 8 weeks of planting for semi-hard wood and soft wood guava cuttings, respectively.

The result indicated that the second collecting date (January 15,1990) for semi-hard wood and soft wood cuttings (July 15, 1990), gave the greatest average rooting percentage and the longest average shoot length . Moreover, the second collecting date resulted in the greatest number and the longest roots per cutting.

The best time for taking semi-hard wood and soft wood was January and July, respectively . The use of IBA improved the success of guava cuttings, average number of roots, average root length, and average shoot length .

Treating semi-hard wood cuttings with IBA 1000 PPm or soft wood cuttings with IBA 4000 ppm produced significantly higher percentage of rooted cuttings , greatest number of roots per cutting and the longest length of roots .

The differences in average rooting percentage , average root length , and average number of roots ,as influenced by different IBA treatments were statistically significant. Rooting was obtained after 6 weeks in semi-hard wood cuttings and 4 weeks after planting in soft wood cuttings, ~~no rooting~~

and 4 weeks after planting in soft wood cuttings, no rooting was observed in the control (untreated cuttings) . It was observed that , soft wood guava cuttings surpassed in their rooting capacity the semi-hard wood cuttings.

"تاثير حامض اندول بيوتريك على تجذير عقل غضة وشبة متخشبة من الجوافة"

ملخص

اجريت هذه الدراسة فى احد البيوت الزجاجية التابعة لكلية الزراعة فى الجامعة الاردنية فى موسمين متعاقبين(١٩٨٩ - ١٩٩٠) بهدف معرفة تاثير موعد جمع العقل(١٥ تشرين ثانى ١٩٨٩، ١٥ كانون ثانى ١٩٩٠، ١٥ ايار ١٩٩٠ و ١٥ تموز ١٩٩٠) ، ونوع العقل(غضة او شبه متخشبة) وتاثير المعاملة بحامض اندول بيوتريك على نسبة العقل المجذرة ، متوسط عدد الجذور للعقلة الواحدة متوسط طول الجذورللعقلة الواحدة، ومتوسط طول النمو الخضري للعقل المجذرة .

اظهرت نتائج هذه الدراسة ان عقل الجوافة شبه المتخشبة والغضة غير المعاملة بحامض اندول بيوتريك غير قادرة على انتاج الجذوربينما اظهرت العقل المعاملة بحامض اندول بيوتريك تفاوتافي انتاج الجذور وذلك بناء على تركيز حامض اندول بيوتريك المستخدم ونوع العقل المستخدمة .

تم الحصول على افضل النتائج باستخدام حامض اندول بيوتريك بتركيز (١٠٠٠ ، ٤٠٠٠ جزء من المليون) ، فى التجربة الاولى والثانية على التوالى .

فيما يتعلق بموعد جمع العقل المناسب فقد اظهرت النتائج ان موعد جمع العقل الثانى فى كل تجربة (١٥ كانون ثانى للتجربة الاولى ١٥، تموز ١٩٩٠ للتجربة الثانية) اعطى اعلى نسبة تجذير ، وعدد اكبر من الجذور واكبر اطوال للجذور .

كذلك اظهرت النتائج ان عقل الجوافة الغضة التى جمعت فى ١٥ ايار و١٥ تموز ١٩٩٠ اعطت نتائج افضل من حيث نسبة التجذير، ،عدد الجذور،طول الجذور بالمقارنة مع عقل الجوافة شبه المتخشبة .

يستنتج من هذه الدراسة ما يلى:

١. ان حامض اندول بيوتريك ضروري لتجذير عقل الجوافة .

٢. ان افضل تركيز حامض اندول بيوتريك ملائمة لعقل الجوافة شبة المتخشبة والغضة هى ١٠٠٠ و ٤٠٠٠ جزء من المليون ، على التوالى .

٣. اعطت عقل الجوافة الغضة نتائج افضل بالمقارنه مع عقل الجوافة شبة المتخشبة .

٤.الموعد المناسب لاخذ عقل الجوافة شبه المتنخشبة والغضة هو ١٥ كانون الثانى و ١٥ تموز على التوالى .

INTRODUCTION

The common guava (Psidium guajava L.) is an evergreen tree and belongs to the Myrtaceae (21, 27, 42, 95) . It is a minor fruit tree crop in Jordan where the area planted to this crop in 1990 was about 1474.3 dunum , with a total production of about 1552.9 ton (8) .

The guava originated from tropical America where it is found cultivated and growing wild(72).Guava fruits are particulary rich in vitamin C, up to 10 mg/g(27, 50, 53, 73, 92, 103) .

In addition to the nutritional value,guava root bark and young leaves were used in local medicine , hard wood is also used for engraving and for tool handles (72, 74). It is a hardy fruit plant and can withstand the diversities of soil and climate (72, 100). Guava is more resistant to drought than most of the other tropical fruit trees (27) . The tree seems to do well on different soils from open sand to rather compact clay (53).

According to El-Baradi (27) highest yields in guava are obtained at a mean temperature of 23 to 28 °c. However, the same author states that , guava tree tolerates temperature as high as 45°c,or even more, and as low as 4.5°c.Under suitable climatic conditions and cultural practices the tree produces two crops a year(53). Guava grows at altitudes ranging from sea-level up to 1500 m,preferably under climatic conditions characterized by moderate winters and summers with an annual average rainfall of 1000 to 2000 mm (27). Propagation by *seeds is the common method for raising guava trees (26,27,33,101).However,seedlings produced show considerable variation in the growth of the trees, the form and size of fruits , seedinss and some other morphological character, (6,26,27,33,100,101).Vegetative propagation in guava is preferred as, produced trees are true-to type, uniform,bear early and produce about 3-4 times more fruit each year (6,27). Methods of vegetative propagation include: air layering(9,13,25,27,67,74,94,101,105,113),grafting(4,23,27,33 ,37,57,65,102), budding (27,37,74,102), stooling (83),tissue culture (6,7,33,50,77), stem and root cuttings (3,11,12,15, 16,24,26,27,32,49,52,56,57,58,68,79,80,82,85,86,87,97,102,104 ,113,116) . A fairly common method of vegetative propagation of guava plants in India is air layering,which is slow, expensive and the number of plants obtained is small (6,27) .*

Grafting has been generally recommended for vegetative propagation of seedless guava.This method, however, is difficult and requires long time and hard labour (57).Shield budding is rarely used(26) .The use of root cuttings is not recommended since it is hard to get a large number of cuttings without a serious damage of mother plants , also its influenced by the time of isolation and planting (26,33,57). The application of tissue culture propagation for large scale production of many temperate fruit trees has been well documented, but very little is known about in vitro clonal propagation of mature tropical fruit tree (6). The use of stem cuttings is the least expensive method for vegetative propagation (47). However, guava hard wood stem cuttings were found hard to root (114,116). The use of semi-hard wood and soft wood stem cuttings under mist in propagation of guava trees was studied by Bhandary and Mukherjee (11) Bharath(12),Blommaert (14,15), Dhua et al. (24), El-Agamy et al. (26), El-Baradi (27), Hafeez-ur-Rahman et al. (42), Khattak et al. (54), Kiani (56), Kilany and Gabr (57), Manohar (68), Pereira et al. (80), Rathore et al. (82), Sharma (100), Shigeura and Richard (102), Singh and Gaur (105), and Teaotia and Pandey (113).Rooting of guava stem cuttings could be improved by some external treatments. Auxins for example were found essential in rooting of cuttings(11,12,14,15,26,27,32,40,42,53,56,57,68,80,82,97,102, 105,112).

The success of soft and and semi-hard wood cuttings is greately associated with leaf retention and auxin treatment (14,15) . Mist propagation was found to be a good tool for leaf retention of cuttings (26). Intermittent mist propagation increased rooting of auxin treated semi-hard wood and soft wood guava cuttings (14,57,117) .

Cuttings which received no hormone virtually failed to root (14,52).

The present investigation was conducted to achieve the following objectives through studying:

1. The effect of different levels of indolebutyric acid (IBA) on rooting of semi-hard wood and soft wood guava cuttings .

2. The different rooting ability of semi-hard wood and soft wood guava cuttings .
3. The effect of time for taking guava cuttings for propagation purposes .

REVIEW OF LITERATURE

1. Auxins and Auxin Synergists

The study of auxins began in 1880 by Charles Darwin, but it was the work of Went in 1928 that showed their importance in plant growth (59,76).Before the discovery of auxin several chemical compounds, such as permanganate and carbon monoxide, were reported to increase rooting in cuttings (90). A number of naturally occurring and synthetic auxins have been used to induce the rooting of cuttings but only two are in common use Indole-3-butyric acid (IBA) and 1.Naphthaleneacetic acid (NAA) (53,69,75,77,84).Ahmad (3) studied the effect of different concentrations of NAA, IBA and Seradix on the rooting of stem cuttings of guava and reported about 12% success with NAA, IBA and Seradix at the rate of 100 ppm. Similarely Teaotia and Pandey (113) got encouraging results with semi-hard wood guava cuttings imersed in 50-100 ppm solution of NAA and IBA before planting . Srivastava (110) found best results in rooting of guava cuttings by using a dip for 12 hours in NAA or IBA solution . Treatment of guava stem cuttings with 200 ppm of IBA markedly improved and accelerated rooting (79) . In India, IBA treated soft wood guava cuttings taken from one year old plants grown from cuttings gave 38% rooting after 12 weeks of planting (68) . Khattak et al. (54) reported that IAA at the rate of 9000 ppm,resulted in maximum rooting of semi-hard wood guava cuttings ,followed by IBA at the rate of 6000 ppm , where as NAA failed to induce any improvement in rooting . According to Kilany and Gabr (57) maximum rooting of semi-hard wood and leaf-bud guava cuttings was obtained with IBA 2500 ppm , followed by NAA at the same concentration .On the other hand Sadhu and Bose (94) found that guava cuttings did not root unless treated with auxins.Moreover, the combination of IBA or NAA with α- Naphthole at 10 ppm increased rooting percentage.Such increase in the rooting percentage of cuttings treated with a combination of auxin and α-Naphthole was noticed by Reddy and Majumdar (86) and Wally et al. (117) working on guava cuttings. In addition , the response of guava cuttings to the added growth promoting materials was studied by Blommaert (14,15) who found that a pre-planting treatment of guava cuttings with IBA increased the rooting percentage. In addition Majumdar and Mukherjee (67) found that IBA applied to guava shoot were essential to induce rooting. Treeby (115) reported that rooting percentage increased from 0 to 30.51 in guava cuttings treated with 0 to 5000 ppm IBA respectively. Singh and Gaur (105) were able to obtain 51.25% rooted cuttings with 500 ppm of IBA. El- Agamy et al. (26) concluded that presence of hormone increased rooting of semi-hard wood cuttings up to 90%. According to Sadhu and Bose (94) guava is difficult to root material because non of guava cuttings produced rooting unless the cuttings were treated with IBA. In addition, the same authors reported that a combination of ethephon at 50 ppm and IBA at 2500 ppm improved significantly the initiation of roots of guava cuttings. Tingwa and Abbadi (114) found that treating guava cuttings with IBA greately improved rooting. Blommaert (15) found that leaf cuttings of guava taken with axillary bud and a portion of the stem gave 80% rooting under mist after treatment with IBA 4000 ppm. Dhua et al. (24) carried out an experiment with ethephon and IBA on soft wood cuttings of guava. They observed that rootings was best (100%) in cuttings after treatment with ethephon at 50 or 100 ppm followed by IBA at 3000 ppm. Bharath (12) working on guava propagation from stem cuttings found that rooting took place within 18 days when the cuttings are dipped in a solution of 6000 ppm of either IBA or NAA. Bhujbal (13) obtained best results (86.6%) in rooting guava cuttings treated with 3000 ppm IBA. Jolicoeur (52) mentioned that optimum rooting (44%) of guava cuttings treated with 0.8% IBA was obtained after one month under mist. Rathore et al.(82) obtained best results with IAA followed by IBA each at 2500 ppm for rooting soft wood cuttings of guava. Kiani(56) studied the effect of different concentrations of Paclobutrazol, IBA, Seradix and cow urine on the rooting of stem cuttings of guava and reported that IBA at 50 ppm and Paclobutrazol at 6ppm possessed more Potential than Seradix and cow urine. Anon (9) mentioned that 10000 ppm of an equal mixture of NAA and IBA, was the best concentration for rooting in guava. According to Sen and others. (97) non - ringed hard wood guava cuttings treated with IBA 5000 ppm induced sucessful rooting .Sinha (107) mentioned that IBA was the most useful growth regulator for rooting guava cuttings. Sharma et al. (101) reported that percentage of rooted guava cuttings was higher in case of IBA with 500 ppm and NAA with 1000 pmm mixtures than in case of IBA and NAA applied separately. The same authors reported that, the best rooting was observed in leafless hard wood guava cuttings treated with IBA at 200 ppm. According to Wally et al. (117) IBA concentrations at 200 or 500 ppm combined with 5 or 10 ppm α- Naphthole markedly increased the rooting percentage of guava cuttings. Chandler (20) mentioned that vegetative propagation of guava is very difficult. He observed various rooting results in soft wood cuttings of guava treated with hormones. Khattak et al. (55) reported that the effect of 1-Naphthaleneacetic acid was comparatively inferior to indole -3- acetic acid and indole-3-butyric acid. Hartmann and Hansen. (45) they studied the rooting of soft wood cuttings of several fruit species under mist using different IBA concentrations. They found that IBA at 4000 ppm was difinitely benefical,giving a higher percentage of rooted cuttings. Hartmann and Kester (47), and Blommaert(14) reported that rooting of guava soft- and semi hard-wood cuttings is greately associated with leaf retention as found in some other fruit crops. However, El-Agamy et al.(26) found that leaf retention could be successfully obtained by means of misting and Hare's powder which contains fungicide and IBA. In addition the same authors reported that IBA - beside its stimulatory effect on rooting prevents abscission of leaves.

Galston and Purves (36) reported various theories to explain the mechanism of auxin action on plant growth, such as increased cell wall plasticity, water uptake, altered permeability pattern,decreased protoplasmic viscosity, altered respiratory patterns and altered nucleic acid metabolism. According to Scott (96), no single molecular, cytological , or tissue site has been identified with certainty as the location of auxin effect in root growth by cutting. In addition the same author reported that only the cell wall persists as the most likely place where auxin has its first effect, and perhaps the plasma-membran .However, it does seem clear that reports on the role of auxin in nucleic acid synthesis and enzyme synthesis and activation play further role in root development. Further support to the effect of auxin on rooting was reported by Sourial et al. (108,109) who found that IBA treatments speeded the process of protein degradation and translocation in the basal part of cuttings. This was necessary for root initiation. Breen and Muraoka (18) found that presence of leaves often has a stimulating influence on the rooting of cuttings. In addition they reported that, the reason for this is unclear, but some suggest that leaves supply substances to the bases of cuttings which enhance the rooting process. These substances may include co-factors which work in conjunction with auxin to stimulate root initiation at the cutting base, moreover, leaves are also a source of carbohydrates, and the starch, and sugar content of leaves declines during rooting, where as carbohydrate increase in cuttings.

2. Time Of Taking Cuttings.

2.1 Semi - hard wood and soft wood cuttings.

Hartmann and Kester (47) reported that broad-leaved evergreens usually root most readily if the cuttings are taken after a flush of growth has been completed and the wood is partially matured. This occurs, depending upon the species from Spring to late Fall. In addition, the same authors reported that, in rooting cuttings of narrow leaved evergreens, best results were obtained if the cuttings were taken during the period from late Fall to late Winter. On the other hand, Hartmann and Hansen (45) found that, optimum time for collecting cuttings of deciduous fruit species, was when the new shoots were long enough and have attained some degree of woodiness but were still actively growing. Kilany and Gabr (57) working on guava, found the best time for preparing and planting guava cuttings (hard wood, semi-hard wood and leaf - bud cuttings) Was September. In addition the same authors mentioned that, this may be due to the highest concentration of soluble sugars in that month . On the other hand, Sinha and et al. (107) indicated that best guava rooting was obtained from late January to May in India, while Rathore et al. (82) obtained best results when soft wood cuttings of guava were taken at the end of July. According to Blommaert (14) semi-hard wood guava cuttings rooted very poorly. In addition, Pereira et al. (80) reported that, soft wood guava cuttings generally rooted better than semi-hard wood cuttings. However, Wally. et al (117) indicated that, best results were obtained from cuttings prepared from one year old branches followed by those prepared from shoots older than one year. In addition the time of taking olive cuttings from their parent trees had a strong influence on thier rootingability. Such effect was reported for olive cutting by Hartmann and Loreti (46) and Khan and Khalidy (53). Sourial et al. (108) found that, olive cuttings taken during March gave higher rooting percentage as compared with cuttings taken during other months.The same authors reported that olive cuttings taken during March and June were higher in carbohydrate percentage. Their results were in line with those reported by Hartmann and Loreti (46), and Khan and Khalidy (53) who found that more and faster rooting of olive cuttings of different varieties was obtained from cuttings taken in Spring. Also, Porlingis and Therios (81) reported that adult olive cuttings rooted best in Summer and showed lower results in Autumn and Winter. In support to these results Hartmann and Loreti (46), Hartmann (43,44), Loreti and Hartmann (63), reported that, rooting of cuttings taken during Spring and Summer was superior to that of cuttings taken in Fall and Winter. Troncoso et al. (116) stated that cuttings of the olive variety "Frangivento" taken in Spring gave excellent rooting and high content of N, P, and K, with normal levels of Ca, Mg and microelements.In addition,Shabana et al. (99) reported that, olive cuttings collected on the first of March gave the highest percentage of rooting. According to Rokba (91) the rooting of olive cuttings prepared during September and October was relatively higher than that of those prepared in November in all tested cuttings.

2.2 Hard wood cuttings.

The use of stem cuttings is the least expensive method for vegetative propagation (47). However, guava hard wood stem cuttings were found hard to root according to Treeby (115) and Wally et al. (117). Bhandry and Mukherjee (11), suggested that difficulty in rooting of guava may be due to the presence of a hard sclerenchyma ring. According to Wally et al. (117) highest percentage of rooted guava hard wood cuttings was observed in October. On the other hand, Reddy and Singh (87) mentioned that, hard wood guava cuttings treated with 2500 ppm IBA and taken during July gave the highest rooting percentage . It may be concluded that guava hard wood cuttings exhibited seasonal fluctuation in their capacity of regeneration during different periods of the year (56,115) . This may be due to biochemical rather than anatomical factors (115) or seasonal changes in the stored food (47) or changes in endogenous inhibitors in shoots as cited by Kilany and Gabr (57) . The latter mentioned that root inhibiting substances existed in seedless and Baladi guava stem cuttings exerted clearly their effect during the period from February to mid-August, and they began to *disappear in early September. Moreover, no inhibiting substances were noticed in the cuttings during October and November. Wali et al. (118) reported that, hard wood olive cuttings collected in April gave higher percentage of rooting, greater number of roots and leaves, higher accumulation of dry matter in both roots and shoots, greater percentage of carbohydrate and low percentage of nitrogenous substances. El-Nabawy et al. (28,29,30) reported that September, October, November, December, January, February were the proper months for the propagation of olive cuttings. In addition the same authors obtained the highest rooting percentage of hard wood cuttings of the olive cultivars "Chemlali" and "Aghizi" in October and November, where as December and January were best for rooting the "Toffahi" olive cultivar.*

3. Carbohydrate Content.

The related literature reveal that high carbohydrate level in shoot promotes root formation (109). Hartmann and Kester (47) indicated that, for various species, rooting can be improved by increasing the carbohydrates in the shoots and by the use of juvenile cuttings. Sourial et al. (108,109) stated that, variation in rooting respone of olive stem cuttings was directely related to their carbohydrate content. In addition the same authors found that root initition was directely proportional to the C/N ratio where as shoot formation showed an inverse relationship. On the other hand, Troncoso et al.

(116) working on olive, found that in Spring with a phenological stage characterized by a strong vegetative growth, rooting was excellent and high contents of N, P and K were obtained, with normal levels of Ca,Mg and microelements. MD Faruque and Mahmood (72) reported that, physiologically, an adequate and high proportionate amount of nitrogen, carbohydrate, and vitamins in relation to auxin is needed for rooting in leafy cuttings. Sen and others.(97) found that ringing hard wood cuttings resulted in rooting of mango (60%) ,litchi (40%), and guava (80%) . However non - ringed cuttings of the three species failed to root under mist. Porlingis and Therios (81) working on rooting of olive cuttings, showed that, leaves promoted rooting particularly in juvenile olive cuttings, such cuttings may pocess a greater ability to utilize carbohydrates and other substances supplied by the leaves for the rooting process. Kilany and Gabr (57) working on guava, concluded that, the regeneration ability of guava hard wood, semi-hard wood and leaf-bud cuttings was proportional with high shoot content of total soluble sugars and high concentrations of soluble indoles as well as the higher ratios of sugar , amino acids, and indoles / phenols. On the other hand the presence of phenolic compounds at a low level was the most suitable for rooting guava cuttings.

4. Environmental Factors Affecting the Regeneration Ability of Plants from Cuttings.

Factors that affect rooting of cuttings have been thoroughly discussed by Hartmann and Kester (47). The most important prerequisites involved for optimal root initiation are: Use of good rooting medium, maintenance of sufficent moisture, and choice of suitable light, temperature, aeration, and humidity (41 , 47 , 71, 94,).

4.1 Rooting medium

A rooting medium serves three essential functions. It provides (a) support for the cutting (b) water and (c) aeration (41,47, 62, 71). An ideal rooting medium provides sufficent porosity to allow good aeration, has a high water holding capacity, well drained, loose and easily worked to facilitate planting of the cuttings, and particularly the removal of the cuttings with little damage to roots, it should be free from fungi and bacteria which might attack cuttings, and it should be available at reasonable cost (2,47). Cuttings of many species root easily in a variety of rooting media but those more diffcult to root may be greately influenced by the kind of rooting medium, not only in the percentage of cuttings rooted, but in the quality of root system (44,47). Combination of different materials often gave better results than any one used alone (47) . Soil is ordinarily used for planting deciduous hard wood cuttings. A well - aerated sandy loam is perferable to a heavy clay soil. In general soil is usually not considered a suitable rooting medium for soft wood and semi - hard wood types of cuttings (47). Sand is a widely used rooting medium for cuttings, it is inexpensive and readily availabe (12, 14, 30, 42, 47, 51, 62) . Sand is not as retentive of mositure, however, as most other rooting media, necessitating more frequent watering (47) . The sand should be fine enough to retain some moisture around the cuttings, Yet coarse enough to allow water to drain freely through it (2) . For evergreens , sand is probably the most satisfactory rooting medium to use (47). With some species, however cuttings rooted in sand produce a long, unbranched, brittle root system in contrast to the more desirable fiberous and branched systems developed in other media (2, 44 , 47).

Peatmoss is often added to sand in varying proportions manily to increase the water - holding capacity of the mixtures. This combination makes a good rooting medium for cuttings of many speies . Mixtures vary from 2 parts sand and 1 part peatmoss to 1 part sand and 3 parts of peatmoss , or 1 part soil : 1 part peat, 1 part vermiculite (2,47). Vermiculite is generally considerd to be quite a satisfactory medium for rooting cuttings, (10,13, 16, 47, 58) .According to Loreti and Hartmann (63,64) working on olive,the best rooting percentage and the highest number of roots per cutting and longest roots were obtained when a 1:1 perlite and vermiculite rooting medium was used. Perlite is widely used as a rooting medium for leafy cuttings espically under mist, owing to its good drainage properties, it may be used alone but is best when used in combination, in varying proportions, with peatmoss or vermiculite (2, 46, 47, 70, 81,89, 119) . Water can be used to root cuttings(1,47). In Egypt , Abou El-Azayem(1) obtained promising results with mango, guava, and apple by using water culture.In India Reddy and Majumdar(86)reported that planting cuttings of mango and guava in a medium of finely chopped sphagnummoss and girt sand (1:1) favoured rapid rooting in a very high percentage of the cuttings.

4.2 Maintenance Of Sufficient Moisture.

Different methods were reported to keep high relative humidity during rooting, including intermittent mist(2, 14, 117), out door frames (2,45) , propagation under polyethylene coverings and plastic - house (17, 49, 61, 62, 82, 88, 107), plastic bags (38),boom travling irrigator (71), a spray champer (110) , rotating spray (39), and fogging (69). However,the use of anti-transpirants as an alternative to the use of mist is possible to reduce water loss from leafy cutting by dipping the leaves into one of various anti-transpirant materials prior to sticking (39 , 47 , 61).

The concept of intermittent mist and mist propagation has been developed world wide as a standered and effective system for rooting cuttings(66). In addition,misting of cuttings is possibly the most critical environment to be created (71). It is becoming well established that the use of mist is an important advancement in the propagation of plants by leafy cuttings, and improve their survival and rooting (34,45, 78, 111) . Since the cuttings are unable to obtain enough water from the rooting medium, thus the first requirments in any propagation system for leafy cuttings is to conserve water in the cuttings, and a high degree of humidity should by maintained in the cutting bed in order to maintain the cuttings without wilting and drying until the roots are produced (2, 47, 88). On the other hand,the utilization of intermittent mist has resulted in the following physiological benefits : a) Increased success with the rooting of leafy cuttings (26, 118), b) cuttings of many species can be rooted under high light intensities with little or no leaf scorch (35), c) maintenance of high atmospheric relative humdity during the rooting period (17, 35, 47,62,66,88). d) In addition,intermittent mist provides a cooling effect as water is evaporated from leaf surfaces of the cuttings. (35). Thus , with intermittent mist, transpiration is reduced (2, 35, 47, 61, 66,88), leaf tissue is cooled (35) , respiration is reduced and photoysnthesis continues allowing for the increased production of carbhohydrates necessary for rapid development of root system (2, 35, 47, 61, 66, 88). On the other hand intermittent mist maintains a film of water on leaf surface so as to keep cuttings turgid and leaves wet until new roots have developed (61) . Aside from the physiological benefits, mist has many other advantages. They can be easily divide to a: (a)cutural, (b) labour saving, and (c) economic (35, 47) . Culturally , the mist system enables the propagator to take larger leafy cuttings that provide larger, stronger plants when rooted. In addition, soft wood cuttings of many plants can be taken earlier in the growing season (35,47).This sucullent material is fast growing and has active cambium tissues which increases the chances of rooting (47) . Mist also provides an extension of the propagation season for most plants (35,47) . Labour saving , without the need for shading, no labour is required to apply and remove shading materials from green house glass (35). Nutrients also can be added to this mist, thus reducing the need for manual fertilizing of plants(35, 47, 58, 119). Probably most evident among the advantages is that mist eliminate the need for constant syringing(spraying water on the foliage of plants to reduce wilting) and watering that previously were standerd propagation parctices (35). When using intermittent mist system a greator percentage of cuttings root, and rooting occurs at faster rate. This is important in that there is a faster turnover of cuttings, thus making greater economic use of propagating space (35). In general soft - and semi hard - wood cuttings of guava are usually associated with leaf retention (16,26). Leaf retention in guava and other species could be successfully obtained by means of misting (28,47,118). Intermittent mist propagation causd a great increase in rooting of soft wood guava cuttings which received auxin, while tender soft wood cuttings of guava are killed if grown without misting (16,26) .

4.3 Light Intensity and Temperature.

There is a definite relationship among mositure, light, and temperature. However, failure to provide a balance between these factors will ultimately affect the rooting percentage of cuttings. According to Adriance and Brison (2) control of temperature is a very important factor in rooting of cuttings. Though high temperature is favorable for the rooting of some species,it stimulates a high rate of transpiration particularly for herbaceous and semi - hard wood cuttings, which may result in wilting and death unless a high humidity is maintained. It is well documented that an increase in temperature beyond a certain minimum will not produce a corresponding increase in photosynthesis even though, respiration continues to rise, and that the effect of high temperature on photosynthesis is more marked under low light conditions (48). Greever (41) reported that soil temperature affects rooting, also it has a direct influence on the rapidity of root formation. Hartmann and Kester(47) specifically state that when artifical heating is used, the temperature at the base of the cuttings should be higher than at the buds to induce root development before buds burst. On the other hand,Adriance and Brison (2) mentioned that, root formation may occur over a wide range of temperature, but a soil temperture of 65 to 70°F gives satisfactory results with many plants. As shown by Hartmann and Kester (47) hot beds, with electric soil- heating cables to provide bottom heat, are commonly used for rooting green house plants and germinating seeds. In addition,bottom heat from thermostatically - controlled, lead - covered heating cables maintained the temperature at the base of the cuttings at about 70° F (4,44). In India (84) cuttings of mango and guava were kept at 30±2° c by means of electric bulbs, this heated medium favoured rapid rooting in a very high percentage of the cuttings. On the other hand Hartmann and Kester (47) reported that light is the source of energy for photosynthesis in rooting leafy cuttings, the products of photosynthesis are important for root initiation. In addition the same authors mentioned that light intensity and duration must be great enough so that carbohydrates will accumulate in excess of those used for respiration.

MATERIALS AND METHODS

1.1 Plant Material.

Ten, well established mature seedling trees of <u>Psidium guajava</u> L., grown at the experimental station of the University of Jordan in the Jordan Valley were used in the present investigation during 1989 and 1990 . The trees were subjected . to the common horticultural management practices.

1.2 Preparation Of Cuttings.

Semi-hard and soft wood cuttings were prepared from current years shoots of the seedling trees.Semi-hard wood cuttings were taken after a flush of growth took place and have attained some degree of maturity.Soft wood cuttings were taken from the tips of the current seasons growth when the new shoots were long enough and actively growing . The cuttings material was collected early in the morning , wrapped with moist burlap,and transferred immediatly to the site of propagation.

Length of each cutting was about 15 - 20cm . Two to four leaves were retained near the top of each cutting. Leaf blade area was reduced to 50% by a vertical cut across the leaf. Soon after preparation the cuttings were immediately dipped in a benlate (31) solution (1000ppm) and allowed to drain for few minutes, then a fresh cut was made at the base of each cutting before the treatment with IBA.Solutions of indole-3-butyric acid (IBA) at the various concentrations were prepared by dissolving the assigned amount of IBA in 400 ml pure ethanol .Then the volume was brought up to one litre by distilled water . In addition , four to seven drops of ammonium hydroxide (NH4OH) were added to prevent crystalization of IBA (47).The control solution contained 40% ethanol and 60% distilled water plus four to seven drops of (NH4OH), Dipping duration in IBA solution for the basal ends of cuttings was two minutes and five seconds for semi-hard wood and soft wood cuttings, respectively. After dipping the basal ends of cuttings were allowed to dry, then the cuttings were planted in benches under mist in a green house at the University of Jordan Campus. Thermostatically controlled bottom heat was secured by electric cables(85). Temperature near the bottom of the cuttings was maintained at about 25°C , misting was applied for 30 seconds every hour.Horticultural perlite was used as rooting medium.

Two experiments were carried out. The first was conducted using semi-hard wood cuttings and two collecting dates (Nov. 15, 1989 and Jan . 15, 1990). On both dates, 40 cuttings per treatment were treated with one of the following IBA concentrations 0,500,1000,and 1500 ppm. The second experiment was carried out using soft wood cuttings and two collecting dates(May 15,1990 and July 15,1990).Forty cuttings were used per experimental unit. The cuttings of each experimental unit were subjected to one of the following IBA concentrations 0,2000,3000,and 4000 ppm IBA. The experimental design in both experiments was randomized complete block design with 10 replicates and 4 treatments. The data were statistically treated by analysis of variance and differences between means of various treatments were determined using Duncans Multiple Range Test (60). Data concerning averages of rooting percentage number of roots per cutting, root length per cutting, and shoot length per cutting were taken after 6,8, and 12 weeks of planting for the first experiment and after 4 and 8 weeks of planting for the second experiment, respectively.

RESULTS

1- First experiment:

This experiment was carried out using semi-hard wood guava cuttings with two collecting dates Nov.15,1990 and Jan. 15,1990. Average rooting percentage ,average root number per cutting, average root length per cutting, and average shoot length per cutting were recorded for both collection dates after six, eight and twelve weeks from planting.

Semi-hard wood guava untreated with IBA cuttings from both collection dates, showed no rooting response.These data were not tabulated since all the cuttings failed to root. On the other hand IBA treated semi-hard wood guava cuttings showed various rooting results six,eight, and twelve weeks after planting for both collection dates(table 1,4).

1.1 First collecting date .

1- Average rooting percentage

Different levels of IBA affected the rooting percentage of semi-hard wood cuttings to variable extent (Table 1). The significantly highest rooting percentage (43%) was obtained from the IBA 1000 ppm treatment compared with 500 and 1500 ppm (Table 1) . Furthermore,IBA at 500 ppm , gave , although not significantly different,better rooting than the 1500 ppm treatment (Table1).Extending the planting period to 8 or 12 weeks did not cause any further increase in the percentage of of rooted cuttings (Table 1) .

Table 1. Effect of indolebutyric acid on average rooting percentage of semi-hard wood guava cuttings six eight, and twelve weeks after planting on Nov. 15, 1989.

Treatment	Average rooting percentage		
	6 weeks	8 weeks	12weeks
IBA 500 ppm	22.0 b	22.0 b	22.0 b
IBA 1000 ppm	43.0 a	43.0 a	43.0 a
IBA 1500 ppm	13.0 b	13.0 b	13.0 b

* Means in each column followed by the same letter are not singnificantly different at the 5% level according to Duncan's Multiple Range Test.

2-Average number of roots per cutting:

The greatest number of roots per cutting (10.18) six weeks after planting was obtained from the IBA 1000 ppm treatment which was significantly higher than that for IBA 500 and 1500 ppm treatments (Table 2). The lowest number of roots per cutting (3.58)was obtained from the 1500 ppm treatment which did not differ signficantly from the 500 ppm treatment (Table 2) Average number of roots per cutting eight weeks after planting was increased when compared to six weeks after planting (Table 2).The greatest number of roots per cutting (11.73) was recorded for the IBA 1000 ppm treatment , which was significantly higher than the IBA 500 and 1500 ppm treatments (Table 2).The lowest number of roots (4.75) was obtained from the IBA 1500 ppm treatment which was at the same level of significance as the IBA 500 ppm treatment (Table 2) .After twelve weeks of planting all the IBA treatments gave the same number of roots per cutting which did not differ significantly from each other (Table 2).

3- Average root length

The IBA 1000 ppm treatment resulted after six weeks of planting in the significantly longest root per cutting (3.95cm). The shortest root length (2.04) for the same period was obtained from the IBA 1500 ppm , while the IBA 500 ppm treatment gave an intermediate result (2.67).

Table.2. Effect of indolebutyric acid on average number of roots of semi-hard wood guava cuttings six, eight and twelve weeks after planting on Nov 15,1989.

Treatment	Average number of roots/cutting		
	6 weeks	8 weeks	12 weeks
IBA 500 ppm	5.45 b	6.53 b	10.66 a
IBA 1000 ppm	10.18 a	11.63 a	15.49 a
IBA 1500 ppm	3.58 b	4.75 b	10.21 a

* *Means in each column followed by the same letter are not significantly different at the 5% level according to Duncan's Multiple Range Test.*

Differences between all the three treatments were significant(Table 3). Root length for all treatments eight weeks after planting was increased compared to six weeks (Table 3).The longest root length (5.95 cm) was obtained from IBA 1000 ppm which was significantly different from the two other IBA treatments (Table 3). The shortest root length (3.18 cm) was obtained from IBA 1500 ppm which was significantly lower than that for IBA 1000 or 500 ppm treatments (Table 3). After twelve weeks from planting average root length was increased compared to six and eight weeks after planting (Table 3). The longest root length (7.32 cm) was obtained by the IBA 1000 ppm which was significantly different from IBA 1500 and 500 ppm treatments (Table 3). The shortest root length (3.71cm) was obtained from IBA 1500 ppm which was significantly lower than that for IBA 500 and IBA 1000 ppm treatments (Table 3).

4- Average shoot length:

Semi-hard wood guava cuttings treated with IBA 500,1000 or 1500 ppm failed to develop any shoots after six, eight and twelve weeks from planting, therefor data for this parameter were not tabulated.

2.1 Second collecting date .

1- Average rooting percentage :

The highest average rooting percentage (96.0 %) six weeks after planting was significantly obtianed from 1000 ppm treatment(Table 4). Significant differences in the rooting percentage were evident between all IBA concentrations

Table. 3. Effect of indolebutyric acid on average root length of semi-hard wood guava cuttings six, eight, and twelve weeks after planting on Nov. 15,1989.

Treatment	Average root length (cm)/cutting		
	6 weeks	8 weeks	12 weeks
IBA 500 ppm	2.67 b	3.67 b	4.79 b
IBA 1000 ppm	3.95 a	5.95 a	7.32 a
IBA 1500 ppm	2.04 c	3.18 c	3.71 c

* Means in each column followed by the same letter are not significantly different at the 5% according to Duncan's Multiple Range Test.

Table. 4. Effect of indolebutyric acid on average rooting percentage of semi-hard wood guava cuttings six, eight, and twelve weeks after planting on Jan. 15, 1990.

Treatment	Average rooting percentage		
	6 weeks	8 weeks	12 weeks
IBA 500 ppm	82.0 b	82.0 b	82.0 b
IBA 1000 ppm	96.0 a	96.0 a	96.0 a
IBA 1500 ppm	68.0 c	68.0 c	68.0 c

* Means in each column followed by the same letter are not significantly different at the 5% according to Duncan's Multiple Range Test.

(table 4). The lowest average rooting percentage 68% was obtained from IBA 1500 ppm. The IBA 500 ppm treatment gave 82% thus being intermediate between the 1000 ppm and 1500 ppm treatments(Table 4)

2- Average number of roots per cutting :

The greatest and least average number of roots per cutting six weeks after planting were obtained from IBA 1000 ppm and 1500 ppm treatments , respectively . The IBA 500 ppm treatment was intermediate (Table 5) .In addition the differences in number of roots per cutting,six weeks after planting were significant for all three IBA concentrations (Table 5). After eight weeks from planting average number of root was increased compared to six weeks from planting (Table 5).The highest average number of roots (17.42) was recorded for IBA 1000 ppm which was significantly different from the two other IBA treatments (Table 5). The least number of roots (8.19) was obtained by 1500 ppm which was significantly lower than that of 500 and 1000 ppm IBA (Table 5). After twelve weeks from planting number of roots was increased compared to earlier readings (Table 5).IBA 1000 ppm gave the highest average number of roots per cutting (22.18) followed by the IBA 500 with 16.98 roots per cutting and the IBA 1500 ppm treatment with 11.33 roots per cutting. eight weeks after plantingthese results were significantly different from each other (Table 5) .

3 - Average root length :

The IBA 1000 ppm treatment gave the highest average root

Table. 5. Effect of indolebutyric acid on average number of roots of semi-hard wood guava cuttings six, eight, and twelve weeks after planting on Jan. 15,1990.

Treatment	Average number of roots/cutting		
	6 weeks	8 weeks	12 weeks
IBA 500 ppm	9.04 b	11.50 b	16.98 a
IBA 1000 ppm	12.67 a	17.42 a	22.18 a
IBA 1500 ppm	6.86 b	8.19 c	11.33 b

* Means in each column followed by the same letter are not significantly different at the 5% according to Duncan's Multiple Range Test.

length (3.99 cm) after six weeks from planting , while the least average root length (2.11 cm) was obtained from IBA 1500 ppm. The IBA 500 ppm treatment gave , an intermediate root length (2.41 cm). Differences in average root length between the different treatments were not significant (Table 6).After eight weeks of planting average root length was increased compared to six weeks after planting,but the data for all three treatments were not significantly different(Table 6).Twelve weeks after Planting average root length was increased compared to earlier readings (Table 6). The longest average root length (8.99) was obtained from IBA 1000 ppm which was significantly different from IBA 500 and 1500 ppm treatments (Table 6). IBA 500 ppm and 1500 ppm treatment gave an average root length of (4.94 cm) and (3.82 cm), respectively without being significanntly different from each other (Table 6).

4- Average shoot length:

The significantly tallest average shoot length was obtained from IBA 1500 ppm treatment after six ,eight, and twelve weeks of planting as compared with IBA 5oo and 1000 ppm treatments (Table 7). There were no significant differences between IBA 500 and 1000 ppm treatments (Table 7). Extending the planting period f`rom six to eight and twelve weeks resulted in improved shoot length (Table 7).

Table. 6. Effect of indolebutyric acid on average root length of semi-hard wood guava cuttings six, eight, and twelve weeks after planting on Jan. 15,1990.

Treatment	Average root length (cm)/cutting		
	6 weeks	8 weeks	12 weeks
IBA 500 ppm	2.41 b	3.26 a	4.94 b
IBA 1000 ppm	3.99 a	5.26 a	8.99 a
IBA 1500 ppm	2.11 b	3.76 a	3.82 b

* Means in each column followed by the same letter are not significantly different at the 5% according to Duncan's Multiple Range Test.

Table.7. Effect of indolebutyric acid on average shoot length of semi-hard wood guava cuttings six, eight , and twelve weeks after planting on Jan. 15, 1990

Treatment	Average shoot length (cm) /cutting		
	6 weeks	8 weeks	12 weeks
IBA 500 ppm	0.15 b	0.31 b	0.59 b
IBA 1000 ppm	0.10 a	0.17 b	0.42 b
IBA 1500 ppm	0.82 a	0.59 a	1.18 a

* Means in each column followed by the same letter are not significantly different at the 5% level according to Duncan's Multiple Range Test:

2- Second Experiment:

This experiment was carried out in 1990 using soft wood guava cuttings, two collecting dates May 15, and July 15, and three IBA concentrations (2000,3000 and 4000 ppm). Average rooting percentage , average root number per cutting, average root length per cutting, and average shoot length were recorded for both collection dates after four and eight weeks from planting.

Soft wood guava cuttings from both collecting dates , that were untreated with IBA showed no rooting response. These data were not tabulated since all the cuttings failed to root. On the other hand IBA treated soft wood guava cuttings from both collection dates showed various rooting results during the planting period (Table 8,12).

2.1 First collecting date.

1- Average rooting percentage.

Four and eight weeks after planting,the IBA 4000 ppm gave significantly the highest 85% and the IBA 2000 ppm gave the lowest 65% rooting percentage, while IBA 3000 ppm gave significantly an intermediate rooting percentage 73% (Table 8).Extending the rooting period to eight weeks did not improve the rooting percentage (Table 8).

2- Average number of roots per cutting:

The significantly greatest average number of roots per cutting (10.01), four weeks after planting was obtained from IBA 4000 ppm treatment , while IBA 2000 ppm and 3000 ppm gave significantly the least number of roots per cutting

Table. 8. Effect of indolebutyric acid on average rooting percentage of soft wood guava cuttings four and eight weeks after planting on May 15, 1990

Treatment	Average rooting percentage	
	4 weeks	8 weeks
IBA 2000 ppm	65.0 c	65.0 c
IBA 3000 ppm	73.0 b	73.0 b
IBA 4000 ppm	85.0 a	85.0 a

* Means in each column followed by the same letter are not significantly different at the 5% level according to Duncan's Multiple Range Test.

Table. 9 Effect of indolebutyric acid on average number of roots of soft wood guava cuttings four and eight weeks after planting on May 15, 1990

Treatment	Average number of roots / cutting	
	4 weeks	8 weeks
IBA 2000 ppm	3.94 b	6.13 c
IBA 3000 ppm	5.82 b	11.06 b
IBA 4000 ppm	10.01 a	19.47 a

* Means in each column followed by the same letter are not significantly different at the 5% level according to Duncan's Multiple Range Test.

(3.94).The average number of roots per cutting for IBA 3000 ppm was intermediate (5.82) . There were no significant differences in average number of roots between IBA 2000 and 3000 ppm (Table 9).After eight weeks of planting average root number was increased compared to four weeks of planting . The IBA 4000 ppm gave significantly the highest (19.47) and IBA 2000 ppm gave the least average number of roots per cutting (6.13).While the IBA 3000 ppm treatment resulted again in an intermediate number of roots per cutting (11.06) when compared to the 2000 and 4000 ppm treatments (Table 9). .

3- Average root length:

The greatest and least average root length per cutting four and eight weeks of planting were significantly recorded for soft wood cuttings treated with IBA 4000 ppm and 2000 ppm, respectively, while average root length for cuttings treated with IBA 3000 ppm was intermediate (Table 10).Prolonging the rooting period to eight weeks improved significantly root length per cutting ,where the 4000 ppm gave 3.01, 3000 ppm gave 1.79 and 2000 ppm gave 0.82 (Table 10).

4- Average shoot length .

Data concerning shoot length four and eight weeks after planting indicate that IBA 2000 ppm and IBA 4000 ppm resulted in the significantly greatest and least shoot length per cutting, respectively . The IBA 3000 ppm gave after four weeks of planting an intermediate shoot length per cutting without being significantly different from either IBA 4000 ppm or IBA 2000 ppm (Table 11).

Table. 10. Effect of indolebutyric acid on average root length of soft wood guava cuttings four and eight weeks after planting on May 15, 1990 .

Treatment	Average root length (cm)/cutting	
	4 weeks	8 weeks
IBA 2000 ppm	0.50 c	0.82 c
IBA 3000 ppm	0.93 b	1.79 b
IBA 4000 ppm	1.56 a	3.01 a

* Means in each column followed by the same letter are not significantly different at the 5% level according to Duncan's Multiple Range Test.

Table.11. Effect of indolebutyric acid on average shoot length of soft wood guava cuttings four and weeks after planting on May 15, 1990.

Treatment	Average shoot length(cm)/cutting	
	4 weeks	8 weeks
IBA 2000 ppm	1.79 a	3.55 ab
IBA 3000 ppm	1.55 ab	3.74 a
IBA 4000 ppm	1.04 b	2.25 a

* Means in each column followed by the same letter are not significantly different at the 5% level according to Duncan's Multiple Range Test.

However after 8 weeks of planting the IBA 3000 ppm gave significantly the greatest shoot length per cutting (3.74),while the IBA 2000 ppm treatment resulted in an intermediate shoot length per cutting (3.55) and IBA 4000 ppm gave the least shoot length per cutting (2.25) (Table 11).

2.2- Second collecting date .

1- Average rooting percentage.

Soft wood guava cuttings taken on the second collecting date (July 15, 1990) gave 100% rooting four and eigth weeks after planting irrespective the IBA concentration used (Table.12).

2- Average number of roots per cutting.

The data showed that the significantly greatest and least number of roots per cutting,four weeks after planting were obtained by IBA 4000 ppm and 2000 ppm, respectively. Average number of roots per cutting obtained from the IBA 3000 ppm was significantly intermediate (Table 13).Extending the planting period from four to eight weeks increased number of roots per cutting for all treatments as compared to four weeks of planting (Table 13). The IBA 4000 ppm and 3000 ppm treatments gave significantly greater number of roots per cutting when compared to the IBA 2000 ppm treatment (Table 13).

3- Average root length per cutting.

The longest (4.57) and shortest(2.23 , 0.89) average root length four weeks after planting were significantly recorded for soft wood cuttings treated with IBA 4000 ppm, IBA 3000

Table. 12. Effect of indolebutyric acid on average rooting percentage of soft wood guava cuttings four and eight weeks after planting on July 15, 1990.

Treatment	Average rooting percentage	
	4 weeks	8 weeks
IBA 2000 ppm	100	100
IBA 3000 ppm	100	100
IBA 4000 ppm	100	100

Table. 13. Effect of indolebutyric acid on average number of roots of soft wood guava cutting four and eight weeks after planting on July 15, 1990

Treatment	Average number of roots / cutting	
	4 weeks	8 weeks
IBA 2000 ppm	8.66 c	16.54 b
IBA 3000 ppm	14.22 b	29.55 a
IBA 4000 ppm	19.46 a	36.14 a

* Means in each column followed by the same letter are not significantly different at the 5% level according to Duncan's Multiple Range Test.

Table 14 Effect indolebutyric acid on average root length of softwood guava cuttings four and eight weeks after planting on July 15,1990 .

Treatment	Average Root Length / Cutting (cm)	
	4 Weeks	8 Weeks
IBA 2000 ppm	0.89 b	1.78 c
IBA 3000 ppm	2.23 b	4.54 b
IBA 4000 ppm	4.57 a	6.72 a

** Means in each column followed by the same letter are not significantly different at the 5% level according to Duncan's Multiple Range Test .*

Table 15. Effect of indolebutyric acid on average shoot length of soft wood guava cuttings four and eight weeks after planting on July 15,1990 .

Treatment	Average shoot length(cm)/Cutting	
	4 Weeks	8 Weeks
IBA 2000 ppm	1.23 a	2.41 a
IBA 3000 ppm	0.57 b	2.17 a
IBA 4000 ppm	0.41 b	1.44 b

** Means in each column followed by the same letter are not significantly different at the 5% level according to Duncan's Multiple Range Test .*

and 2000 ppm, respectively(Table 14). When the rooting period was extended to eight weeks average root length per cutting was increased for all concentrations when compared with that obtained after four weeks . (Table 14).Eight weeks after planting the IBA 4000 ppm significantly dominated with respect to average number of roots per cutting (6.72) followed by the IBA 3000 ppm (4.54) , while the IBA 2000 ppm gave the least average root length (1.87) (Table 14) .

4- Average shoot length.

Average shoot length after four weeks of planting was significantly longest (1.23) for the IBA 2000 ppm treatment and shortest (0.57, 0.41) for the IBA 3000 and 4000 ppm treatment(Table 15). Eight weeks from planting, only the IBA 4000 ppm gave significantly shortest shoot length per cutting (1.44), while IBA 3000 ppm and IBA 2000 ppm (2.17 , 2,41) was at the same level of significance (Table 15).

The combined analysis of variance.

A- The combined analysis of variance for semi-hard wood cuttings.

The combined analysis of variance for the two collecting dates (Nov. 15, 1989 and Jan. 15, 1990), is given in Appendix B table 16 . The average values for rooting percentage, number of roots , and shoot length are significantly different between the two collecting dates (Table 16). This conclusion shows that the second collecting date (Jan. 15, 1990) gave significantly higher average rooting percentage, number of roots and shoot length than the first collecting date (Nov. 15, 1990).

The Appendix B table 16 for semi-hard wood cuttings indicates that the date x concentration interaction is not statistically significant.

B- The combined analysis of variance for soft wood cuttings

The combined analysis of variance for the two collecting dates (May 15,1990 and July 15,1990) is given in Appendix B table 16 for the soft wood cuttings.

This table shows that average values for rooting percentage and number of roots are significantly different between the two collecting dates. This conclusion is illustrated by table 16.Where shows that the second collecting date (July 15, 1990) gave significantly higher average rooting percentage, root number and root length , than the first collecting date (May 15, 1990).The average shoot length in the first collection date is significantly higher than that

Table.16. Average values for the studied traits for both semi-hard wood and soft wood cuttings in the two collection dates.

Type of cuttings	Traits	Date 1	Date 2
Semi-hard wood	Rooting percentage	26.0 b	82.0 a
	Root length	5.27 a	5.916 a
	Number of roots	12.12 b	16.83 a
	Shoot length		0.73 a
Soft wood	Rooting percentage	74.33 b	100 a
	Root length	12.22 a	27.41 a
	Number of roots	1.873 b	4.105 a
	Shoot length	3.18 a	2.0066 b

* Means in each column followed by the same letter are not significantly differnt at the 5% level according to Duncan's Multiple Range Test .

of the second date. Table 16 shows that average root length is statistically similar in both collecting dates. The Appendix B table 16 for soft wood cuttings indicates that date x concentration interaction is not statistically significant .

DISCUSSION

The use of IBA improved in most cases the average rooting percentage, average root length, average number of roots and average shoot length in semi-hard wood and soft wood guava cuttings taken from seedling trees. The response of guava cuttings to IBA as indicated in the present work is in line with that reported by other researchers (3,12,14,15,17,26,56. ,71,74,78,79,82,92) who noticed that preplanting treatment of guava cuttings with IBA was essential for rooting. The consistency of this response has been supported by Chandler (20).Number of roots and average root length per cutting were in most cases greatest for semi-hard wood cuttings and soft wood cuttings treated with IBA 1000 and 4000 ppm, respectively. These results are in agreement with the findings of Singh and Gaur(105) working on guava, Loreti and Hartmann (63), and Hartmann and Kester (47) working on olive. The percentage of rooting, average root number and average root length increased in soft wood cuttings with the increase in IBA concentration. These results are in line with those reported by Hartmann and Hansen (45) working on rooting of soft wood cuttings of several fruit species. Moreover, root length in soft wood cuttings was directely proportional to the concentration of IBA. Such relationlship was observed in IBA treated Hibiscus rosa sinensis hard wood cuttings grown under intermittent mist conditions (105).

The presenat work indicatid that soft-and semi-hard wood guava cuttings responded differently to IBA application. These results are in harmony with those obtained by El-Agamy et al (26) working on guava cuttings. Moreover El-Nabawy et al. (28) reported that IBA was supperior as compared to other growth substances in improving the speed, intensity and percentage of rooting. According to Hartmann and Hansen (45) working on rooting of soft wood cuttings of several fruit species, IBA was generally required for satisfactory rooting of soft wood cuttings of several fruit tree species. In addition Loreti and Hartmann (63) working on olive, found that the influence of IBA was greater on the number of roots per cutting.The increase in average number of roots per cutting when the rootings period was extended could be attributed to the initiation of new roots in the basal region of th cutting and to the production of lateral roots on already established ones .

Guava could be classified as difficult-to root because non of the control cuttings rooted.These results are in line with those obtained by Sadhu and Bose (93) Bhandry and Mukherjee (11) suggested that the difficulty in rooting of guava cuttings may be due to the presence of a hard sclerenchyma ring. On the contrary El-Agamy et al .(26) suggested biochemical rather than anatomical factors to be involved in the hard rooting ability of guava cuttings . This suggestion of El-Agamy (26) et al. Find its support in the fact that IBA enhanced rooting of guava cuttings.

Moreover in the present study the obtained results showed that rooting of soft wood and semi-hard wood guava cuttings was greatly improved by dipping the basal ends of cuttings in IBA solution. In addition Bharath (12) reproted that rooting of guava took place within 18 days after planting. However, these results contradict those reported by kuperberg (58) working on rooting of guava stem cuttings, who found that 18% of the cuttings in the water mist unit produced roots after 12 weeks of planting. Moreover Manohar (68) working on soft wood cuttings,obtained 38% rooting after 12 weeks of planting.Guava soft wood cuttings generally rooted better than semi-hard wood cuttings, these results are in line with those obtained by Blommaret (14,15), Pereira et al. (80), and Wally et al.(117)

In general, rooting of guava soft-and semi-hard wood cuttings is greately associated with leaf retention as known for some other fruit tree crops(25,46). In the present work leaf retention was successfully obtained by means of misting and IBA.Indolebutyric acid-beside its rooting stimulatory effect-prevent abscission of leaves (25). Benefical effects of mist on root formation in cuttings were observed by many workers using cuttings of a wide variety of difficult to root species (14,15,17,25,26). In addition, Bose and Mondal (16) reported that intermittent mist sprays over the rooting-bed were effective in inducing roots from leafy cuttings. Moreover the same authors stated that, such sprays provide a film of water over the leaves which lowers the temperature, increase the humidity around the leaves and reduces transpiration and respiration .

It may be concluded from the present study that guava cuttings exhibited seasonal fluctutation in their capacity of regeneration during different periods of the year.Kilany and Gabr (57), and Wally et al. (117) came to a similar conclusion. These fluctutations may be due to seasonal changes in stored food (46) or changes in endogenous inhibitors in shoots as reported by Kilany and Gabr(57), who found that the root inhibiting substances in seedless and baladi guava stem cuttings exerted clearly their effect during the period from February to mid-August, while this effect began to disappear in early September. Analysis of the data of the present work showed that the best results were obtained with semi-hard wood and soft wood cuttings taken in January and July respectively. These results are in line with those obtained by Rathore (83), Sharma (100), Sinha et al. (107), working on guava, Hartmann and Loreti (46), Khan and Kalidy (53), and Rokba (91) working on olives.

The mode of action by which auxin enhances root formation could be explained by its role in speeding the process of protein degradation and translocation in the basal part of the cutting. This process is necessary for root initiation (28). According to Scott (96) auxin effect could be also explained on the basis of stimulation of cell division in the vascular cambium, or the lateral root. Further support to the effect of auxin on rooting was reported by Strydom and Hartmann(112). They found that IBA treatment increased the respiration rate of plum soft wood cuttings and resulted in accumulation of amino acids and nitrogenous substances in the basal parts of the treated cuttings. It is therefore possible that the endogenous levels of auxin in the non-treated control cuttings were not sufficent to induce rooting. Exogenous application of IBA to guava cuttings undoubtedly increased the auxin level and thus contributed to the favorable response observed under the conditions of this investigation.

SUMMARY AND CONCLUSION.

A green house trial was carried out in 1989 and 1990 to study the effect of collecting date (Nov. 15, 1989, Jan. 15, 1990, May 15, 1990 and July 15, 1990), type of cutting semi - -hard wood and soft wood guava stem cuttings and indole butyric acid (IBA) on averages of, rooting percentage, root length, number of roots and shoot length .

Untreated (control) semi-hard wood and soft wood guava cuttings failed to root, while those treated with IBA showed, depending upon the IBA concentration and the type of cuttings used ,variuos rooting results. The most promissing results were obtained from IBA 1000 and 4000 ppm treatments in the first and second experiment, respectively.

Concerning the propor collecting date for both types of guava cuttings, the results indicated that the second collecting date in each expereiment (January 15 for the first experiment and July 15 for the second experiment) gave the highest rooting percentage, root number and root length.

The results obtained with soft-wood guava cuttings from both collecting dates (May 15 and July 15 in 1990) indicate better rooting results in respect to rooting percentage, number of roots and average root length, when compared to semi-hard wood guava cuttings.

CONCLUSIONS.

1- IBA is necessary for rooting guava stem cuttings.

2- The most suitable IBA concentration for semi-hard wood and soft wood guava cuttings was 1000 and 4000 ppm respectively. .

3- Soft wood cuttings gave better rooting results than semi-hard wood cuttings.

4- The proper time for taking semi-hard wood and soft wood gauva cuttings was January 15 and July 15, respectively

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APPENDIX A

1- Analysis of variance for average rooting percentage of semi-hard wood guava cuttings six weeks after planting on Nov. 15.1989.

Source of variation	df	SS	MS	observ.F	Req F.at 5%
TRT	2	4740.0	23700	14.92	3.55
REP	9	1920.0	213.33	1.34	2.46
ERROR	18	2860.0			
TOTAL	29	9520.0			

2- Analysis of variance for average number of roots of semi-hard wood guava cuttings six weeks after planting on Nov. 15 .1989.

Source of variation	df	SS	MS	Observ.F	Req.F at 5%
TRT	2	231.4326	115.72	21.50	3.55
REP	9	155.8096	17.3123	3.22	2.46
ERROR	18	96.8673			
TOTAL	29	484.1096			

3- Analysis of variance for average root length of semi-hard wood guava cuttings six weeks after planting on Nov. 15. 1989.

Source of variation	df	SS	MS	Observe.F	Req.F at 5%
TRT	2	18.9446	9.472	49.54	3.55
REP	9	43.0680	4.785	25.02	2.46
ERROR	18	3.4420			
TOTAL	29	65.4546			

4- Analysis of variance for average shoot length of semi-hard wood guava cuttings six weeks after planting on Nov. 15 . 1989.

Source of variation	df	SS	MS	Observ.F	Req.F.at 5%
TRT	2	0.0	0.0	∞	3.55
RED	9	0.0	0.0	∞	2.46
ERROR	18	0.0	0.0		
TOTAL	29	0.0	0.0		

5-Analysis of variance for average rooting percentage of semi-hard wood guava cuttings eight weeks after planting on Nov .15.1989.

source of variation	df	SS	MS	observe.	Req.f at .5%
TRT	2	4740.0	2370.0	14.92	3.55
REP	9	1920.0	213.33	1.34	2.46
ERROR	18	2860.0			
TOTAL	29	9520.0			

6- Analysis of variance for average number of roots of semi-hard wood guava cuttings eight weeks after planting on Nov. 15.1989.

Source of variation	df	SS	MS	Observ.F	Req.F.at 5%
TRT	2	263.0960	131.548	21.8	3.55
REP	9	162.7430	18.08	3.00	2.46
ERROR	18	108.6240			
TOTAL	29	534.4630			

7- Analysis of variance for average root length of semi-hard wood guava cuttings eight weeks after planting on Nov. 15.1989.

Source of variation	df	SS	MS	Observ F	Req. F.at 5%
TRT	2	18.4806	9.24	35.49	3.55
REP	9	50.2470	5.583	21.45	2.46
ERROR	18	4.6860			
TOTAL	29	73.4136			

8- Analysis of variance for average shoot length of semi-hard wood guava cuttings eight weeks after planting on Nov. 15. 1989.

Source of variation	df	SS	MS	Observ. F	Req.F.at 5%
TRT	2	0.0	0·0	∞	3.55
REP	9	0.0	0·0	∞	2.46
ERROR	18	0.0	0·0		
TOTAL	29	0.0	0·0		

9- Analysis of variance for average rooting percentage of semi-hard wood guava cuttings twelve weeks after planting on Nov. 15. 1989.

Source of variation	df	SS	MS	Observ.F	Req.F. at 5%
TRT	2	4740.0	2370.0	14.92	3.55
REP	9	1920.0	213.33	1.34	2.46
ERROR	18	2860.0			
TOTAL	29	9520.0			

10- analysis of variance for average number of roots of semi-hard wood guava cuttings twelve weeks after planting on Nov.15. 1989.

Source of variation	df	SS	MS	Observ.F.	Req.F.at 5%
TRT	2	171.366	85.68	2.29	3.55
REP	9	493.108	54.789	1.46	2.46
ERROR	18	673.3340			
TOTAL	29	1337.8080			

11- Analysis of variance for average root length of semi-hard wood guava cutting twelve weeks after planting on Nov. 15. 1989.

Source of variation	df	SS	MS	Observ F.	Req.F.at 5%
TRT	2	68.6646	39.330	61.05	3.55
REP	9	35.5920	3.954	7.03	2.46
ERROR	18	10.1220			
TOTAL	29	114.3786			

12- Analysis of variance for average shoot length of semi-hard wood guava cuttings twelve weeks after planting on Nov. 15. 1989.

Source of variation	df	SS	MS	Observe.F.	Req.F.at 5%
TRT	2	0.0	0.0	∞	3.55
REP	9	0.0	0.0	∞	2.46
ERROR	18	0.0	0.0		
TOTAL	29	0.0	0.0		

13- Analysis of variance for average rooting percentage of semi-hard wood guava cuttings six weeks after planting on Jan. 15. 1990.

Source of variation	df	SS	MS	Observ. F	Req F at 5%
TRT	2	3920.0	1960	165.38	3.55
REP	9	746.67	82.96	7.00	2.46
ERROR	18	213.33			
TOTAL	29	4880.0			

14- Analysis of variance for average number of roots of semi-hard wood guava cuttings six weeks after planting on Jan. 15. 1990.

Source of variation	df	SS	MS	Observ.F	Req F.at 5%
TRT	2	172.2846	86.1423	10.53	3.55
REP	9	163.5136	18.168	2.22	2.46
ERROR	18	147.2353			
TOTAL	29	483.0336			

15- Analysis of variance for average root length of semi-hard wood guava cuttings six weeks after planting on Jan.15 1990.

Source of variation	df	SS	MS	Observe.F	Req.F.at 5%
TRT	2	20.4026	10.2	22.57	3.55
REP	9	26.2896	2.92	6.46	2.46
ERROR	18	8.1373			
TOTAL	29	54.8296			

16- Analysis of variance for average shoot length of semi-hard wood guava cuttings six weeks after planting on Jan. 15.1990.

Source of variation	df	SS	MS	Observe.F	Req.F at 5%
TRT	2	0.1726	0.0863	4.08	3.55
REP	9	0.4403	0.0489	2.31	2.46
ERROR	18	0.3806			
TOTAL	29	0.9936			

17- Analysis of variance for average rooting percentage of semi-hard wood guava cuttings eight weeks after planting on Jan 15. 1990.

Source of variation	df	SS	MS	Observe.F	Req.F.at 5%
TRT	2	3920.0	1950.0	165.38	3.55
REP	9	79667	82.963	7.00	2.46
ERROR	18	213.33			
TOTAL	29	4880.0			

18- Analysis of variance for average number of roots of semi-hard wood guava cuttings eight weeks after planting on Jan 15. 1990.

Source of variation	df	SS	MS	Observe.F	Req.F.at 5%
TRT	2	437.3180	218.659	47.68	3.55
REP	9	219.623	24.40	5.32	2.46
ERROR	18	82.542			
Total	29	739.483			

19- Analysis of variance for average root length of semi-hard wood guava cuttings eight weeks after planting on Jan.15.1990.

Source of variation	df	SS	MS	Observe.F.	Req.F.at 5%
TRT	2	21.6676	10.833	2.06	3.55
REP	9	58.1653	6.463	1.23	2.46
ERROR	18	94.4666			
TOTAL	29	174.298			

20- Analysis of variance for average shoot length of semi-hard wood guava cuttings eight weeks after planting on Jan.15. 1990.

Source of variation	df	SS	MS	Observ.F.	Req.F.at 5%
TRT	2	0.9146	0.4573	10.66	3.55
REP	9	1.127	0.1252	2.92	2.46
ERROR	18	0.7720			
TOTAL	29	2.8136			

21- Analysis of variance for average rooting percentage of semi-hard wood guava cuttings twelve weeks after Planting on Jan. 15.1990.

Source of variation	df	SS	MS	Observ F.	Req.F.at 5%
TRT	2	3920.0	1950.0	165.38	3.55
REP	9	746.67	82.963	7.00	2.46
ERROR	18	213.33			
TOTAL	29	4880.0			

22- Analysis of variance for average number of roots of semi- hard wood guava cuttings twelve weeks after planting on Jan.15.1990.

Source of variation	df	SS	MS	Observ.F	Req.F.at 5%
TRT	2	3920.0	195.00	165.38	3.55
RED	9	174.4630	19.384	0.58	2.46
ERROR	18	213.33			
TOTAL	29	4880.0			

23- Analysis of variance for average root length of semi- hard wood guava cuttings twelve weeks after planting on Jan.15. 1990.

Source of variation	df	SS	MS	Observ.F	Req.F.at 5%
TRT	2	147.9526	73.976	15.38	3.55
REP	9	122.7083	13.63	2.83	2.46
ERROR	18	86.5806			
TOTAL	29	357.2416			

24- Analysis of variance for average shoot length of semi- hard wood guava cuttings twelve weeks after planting on Jan .15.1990.

Source of variation	df	SS	MS	Observ.F.	Req.F.at 5%
TRT	2	3.1820	1.591	18.07	3.55
REP	9	5.8963	0.655	7.44	2.46
ERROR	18	1.5846			
TOTAL	29	10.6630			

25- Analysis of variance for average rooting percentage of soft wood guava cuttings four weeks after planting on May. 15.1990.

Source of variation	df	SS	MS	Observ.F	Req.F.at 5%
TRT	2	1846.67	923.335	20.27	3.55
REP	9	2080.0	231.11	5.07	2.46
ERROR	18	820.0			
TOTAL	29	4746.67			

26- Analysis of variance for average number of roots of soft wood guava cuttings four weeks after planting on May. 15.1990.

Source of variation	df	SS	MS	Observ.F	Req.F.at.5%
TRT	2	193.1180	96.559	14.38	2.46
REP	9	137.1270	15.236	2.46	2.46
ERROR	18	120.8620			
TOTAL	29	451.1070			

27- Analysis of variance for average root length of soft wood guava cuttings four weeks after planting on May. 15.1990.

Source of variation	df	SS	MS	Observ.F	Req.F.at 5%
TRT	2	5.6846	2.842	35.81	3.55
REP	9	1.7363	0.1929	2.43	2.46
ERROR	18	1.4286			
TOTAL	29	8.8496			

28- Analysis of variance for average shoot length of soft wood guava cuttings four weeks after planting on May.15. 1990.

Source of variation	df	SS	MS	Observ.F	Req.F.at 5%
TRT	2	2.7420	1.371	3.54	3.55
REP	9	6.1816	0.686	1.77	2.46
ERROR	18	6.9613			
TOTAL	29	15.895			

29- Analysis of variance for average rooting percentage of soft wood guava cuttings eight weeks after Planting on May.15.1990.

Source of variation	df	SS	MS	Observ.F	Req.F.at 5%
TRT	2	2026.66.	1013.33	28.5	3.55
REP	9	2070.00	230.00	6.47	2.46
ERROR	18	640.00			
TOTAL	29	4736.66			

30- Analysis of variance for average number of roots of soft wood guava cuttings eight weeks after Planting on May.15.1990

Source of variation	df	SS	MS	Observ.F	Req.F.at 5%
TRT	2	909.962	454.98	35.27	3.55
REP	9	283.0146	31.446	2.44	2.46
ERROR	18	232.2313			
TOTAL	29	1425.2080			

31- Analysis of variance for average root length of soft wood guava cuttings eight weeks after Planting on May. 15.1990.

Source of variation	df	SS	MS	Observ.F.	Req.F.at.5%
TRT	2	24.0846	12.04	81.02	3.55
REP	9	6.4186	0.713	4.80	2.46
ERROR	18	2.6753			
TOTAL	29	33.1786			

32- Analysis of variance for average shoot length of soft wood guava cuttings eight weeks after Planting on May.15.1990.

Source of variation	df	SS	MS	Observ.F	Req.F.at 5%
TRT	2	13.154	6.577	3.21	3.55
REP	9	35.7346	3.9705	1.94	2.46
ERROR	18	36.8993			
TOTAL	29	85.7880			

33- Analysis of variance for average rooting percentage of soft wood guava cuttings four weeks after Planting on July . 15.1990.

Source of variation	df	SS	MS	Observ.F.	Req.F at 5%
TRT	2	0.0	0.0	∞	3.55
REP	9	0.0	0.0	∞	2.46
ERROR	18	0.0	0.0		
TOTAL	29	0.0	0.0		

34- Analysis of variance for average number of roots of soft wood guava cuttings four weeks after planting on July. 15.1990.

Source of variation	df	SS	MS	Observ.F	Req.F.at.5%
TRT	2	583.3706	291.685	31.80	3.55
REP	9	355.5080	39.5008	4.31	2.46
ERROR	18	165.0960			
TOTAL	29	1103.9746			

35- Analysis of variance for average root length of soft wood guava cuttings four weeks after planting on July. 15. 1990.

Source of variation	df	SS	MS	Observ.F	Req.F.at 5%
TRT	2	69.3786	34.689	7.25	3.55
REP	9	28.0830	3.12	0.65	2.46
ERROR	18	86.1480			
TOTAL	29	183.6096			

36- Analysis of variance for average shoot length of soft wood guava cuttings four weeks after Planting on July. 15. 1990

Source of variation	df	SS	MS	Observ.F	Req.F at 5%
TRT	2	3.7786	1.889	4.55	3.55
REP	9	6.4563	0.717	1.73	2.46
ERROR	18	7.4746			
TOTAL	29	17.7096			

37- Analysis of variance for average rooting percentage of soft wood guava cuttings eight weeks after planting on July. 15. 1990.

Source of variation	df	SS	MS	Observ.F	Req.F.at 5%
TRT	2	0.0	0.0	∞	3.55
REP	9	0.0	0.0	∞	2.46
ERROR	18	0.0	0.0		
TOTAL	29	0.0	0.0		

38- Analysis of variance for average number of roots of soft wood guava cuttings eight weeks after planting on July. 15. 1990.

ource of variation	df	SS	MS	Observ F	Req.F at 5%
TRT	2	1989.4940	994.747	12.36	3.55
REP	9	1400.027	155.558	1.93	2.46
ERROR	18	1448.3660			
TOTAL	29	4837.8870			

39- Analysis of variance for average root length of soft wood guava cuttings eight weeks after planting on July. 15. 1990.

Source of variation	df	SS	MS	Observ F	Req.F. at 5%
TRT	2	122.5903	61.295	73.92	3.55
REP	9	34.4241			
ERROR	18	14.92627			
TOTAL	29	171.9407			

40- Analysis of variance for average shoot length of soft wood guava cuttings eight weeks after planting on .July.15. 1990.

Source of variation	df	SS	MS	Observ F	Req.F.at 5%
TRT	2	5.10466	2.55	5.42	3.55
REP	9	15.8653	1.7628	3.75	2.46
ERROR	18	8.4686			
TOTAL	29	29.4386			

APPENDIX B

1- The combined analysis of variance for the two collection dates represented by mean squares (MS) for the studied traits for the semi-hard wood and soft wood guava cuttings

Type of cutting	Source of variation	df	Average rooting percent-age	Average root length	Average number of roots	Average shoot length
Semi-hard wood	Dates(D)	1	47040 **	6.2018 **	335.5935 **	7.49 **
	Reps/dates	18	148.15	8.79446	27.087	0.3275
	Cons(c)	2	4265.0	104.35	331.269	0.8525
	DXC	2	65.0	3.95466	48.88	0.738
	Error	36	85.36	2.86	35.47	0.044
Soft wood	Dates(D)	1	9629.67 **	52.6986	3461.041 **	20.65
	Reps/dates	18	115.55	2.2690	93.50	2.866
	Conc(c)	2	461.695	52.70029	1359.90	8.463
	DXC	2	461.33	20.637	89.82	0.726
	Error	36	22.77	0.48	46.68	1.28

** Significant at 1% level