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المستخلص:

استخدم في هذه الدراسة التي أجريت خلال عامي 2016-2017، أشجار جوافة بذرية عمر ٢٢ عام صنف مختب الصباحية من مزرعة البحثية بالبرامون معهد بحوث البساتين محافظة الدقهلية، مصر. تم رش نصف عقل عدد الأشجار المستخدمة بالإثيفون بتركيز ١٠٠٠ جزء في المليون في شهر فبراير أخذت عقل نصف خشبي في مايو و يوليو. بعد أخذ العقل مباشرة تم نقعها جميعاً لمدة ٣ ساعات في الفحم النشط بنسبة ١٥% . صممت التجربة كقطاعات كاملة العشوائية، بلغ عدد المعاملات ٩ معاملات حيث استخدم اندول حمض البيوتريك بثلاث تركيزات ٣٠٠٠٠، ٤٥٠٠٠، ٥٠٠٠٠ جزء في المليون و الإثيفون بتركيز ١٠٠٠ جزء في المليون و حمض البنزويك و الستريك بتركيز ١٠٠ جزء في المليون. تم الحصول على نتائج أكثر ملاءمة في التاريخ الأول لأخذ العقل (مايو) ، ومن بين المعاملات المعالمة الخامسة (الإثيفون ١٠٠٠ جزء في المليون + حمض البنزويك ١٠٠ جزء في المليون + اندول حمض البيوتريك ٤٥٠٠ جزء في المليون) سجلت أفضل النتائج في نسبة التذجير ٧٠% ، عدد الجذور في العقلة ٣٦٣، طول الجذور ٤٣٢ سم، وزن الجذور الطازج لكل عقلة ٣٠٥ جم ونسبة البقاء من العقل التي تم تجذيرها ٥٠% .

كلمات مفتاحية: الخضرى، التكاثر، البقاء و الفحم النشط.
Abstract:

Ten well established mature seedling trees (22 years old) of guava cv. Montakab El-Sabahia CV., grown at the Baramoon experimental farm, horticulture research institute Dakahlia governorate, Egypt were used in present study during two seasons 2016-2017. Half of the selected trees were sprayed with Ethephon at 600 ppm applied in February of each year. The other half was left as a control without spraying. The semi-hard wood cuttings were taken in May and July. Immediately after collection, all cuttings were soaked for 3 hours in activated charcoal (AC) 15%. The experiment was laid out in complete randomized blocks design. The total number of treatments amounted to 9 treatments. IBA at 3000, 4500, 5000 ppm, Ethephon at 600 ppm, Benzoic acid at 100 ppm and Citric acid at 100 ppm. The more favorable results were obtained in the first collecting date (May), and among the treatments, T5 (Ethephon 600 ppm + Benzoic acid 100 ppm + IBA 4500 ppm T5) recorded the best results in percentage of rooted cuttings 70%, number of roots per cutting 4.3, length of roots 4.32 cm, root fresh weight per cutting 3.35 g and survival percentage of rooted cuttings 50%.

Keywords: Vegetative, Propagation, Survival, Activated Charcoal.

Introduction

Guava (Psidium guajava L.) can be propagated by seeds (Zamir et al., 2003) as well as by vegetative (layering, budding, grafting and cuttings) (Chandra et al., 2004). Propagation from seeds features individuals that are genetically heterogeneous (yield and quality of fruits), due to highly cross pollinated 35% (Yadava, 1996; Paull and Bittembender, 2006 and Mehmood et al., 2013, 2014). Hence, seed propagation is used in the breeding programs to produce rootstock and it’s not recommended in commercial orchards of high productivity (Giri et al., 2004).
Vegetative propagation of guava is a very efficient method to produce true-to-type plants with short juvenile phase, because it perpetuates all characteristics of each cultivar (Singh, 2007). Propagation by cutting has been more effective in comparison with other vegetative methods in major guava producers (Davies and Hartman, 1988; Abdullah et al., 2006; Kareem et al., 2013 and Shahzad et al., 2019).

The rooting of guava cuttings is influenced by several internal and external factors, which include: age, health, nutritional status (carbohydrate reserves and nitrogen compounds), hormonal balance (auxin and cytokinin) of the mother plant, cutting age, type of cutting, presence or not of leaves at cutting, time of taking cuttings, environment conditions temperature and humidity, rooting medium, phenolic compound oxidation and treatment of cuttings with growth regulators (Evans, 1992; Hartman and Kester, 2002; Sardoei, 2014; Sohnika et al., 2015; Abdul et al., 2016; Mitra and Pathak 2018 and Singh, 2018).

Guava has high content of phenolic compounds in branches and leaves which poses browning problem during in rooting process. It is a serious problem associated with the oxidation of phenolic substances leaches out from the basal ends of cuttings resulting in browning of the basal cuttings. Polyphenol oxidase (PPO) is a nuclear-coded copper-containing enzyme, which catalyses the oxidation of phenols and quinones (Vaughn et al., 1988: Kim et al., 2001), plays an important role in cell division and the development of root primordial considerably (Gonzalez et al., 1991: Gaspar et al., 1997) and act as catalyzes in the degradation of indole-3-butyric acid (IBA) (Vaughn et al., 1988: Kim et al., 2001).

Pretreatment of the cuttings with solutions of antioxidants [ascorbic acid, citric acid, Polyvinylpyrrolidone (PVP)] and
activated charcoal (AC) could solve the problem of oxidation of phenolic substances and enhance root formation (Chevre et al., 1983; Tagelsir et al., 2006; Rai et al., 2008 and El-Sharony et al., 2018).

Results of recent investigation indicate that cutting can be an alternative method of propagating superior guava varieties (Nitin et al., 2015; Akram et al., 2017 and Shahzad et al., 2019). As such, this study aimed to reach the best treatment that causes the high rooting, survival percentages and root characteristics improvements in guava semi-hard wood cuttings.

**Materials and Methods**

**Study Area and Plant Material Collection.**

Ten well established mature seedling trees (22 years old) of guava cv. Montakab El-Sabahia CV., grown at the Baramoon experimental farm, horticulture research institute Dakahlia governorate, Egypt were used in the present study during 2016 and 2017. The trees were subjected to the common horticultural management practices.

**Ethephon Treatment.**

Half of the selected trees were sprayed with ethephon (2-Chloroethyl Phosphonic Acid) at 600 ppm applied in February of each year. The other half was left as a control without spraying (with tap water).

The ethephon dose (600 ppm) was diluted according to the commercial recommendation for the product (240g/ L\(^{-1}\) of ethephon), which was used to determine the specific dose for treatment. The ethephon was diluted inside a backpack sprayer and applied to the canopy of the tree, at an approximate volume of 4 liter /tree.

**Preparation of Cuttings.**

Semi-hard wood cuttings were prepared from current years shoots of seedling trees, after a flush of growth took place.
and have attained some degree of maturity. The cuttings material was collected early in the morning, and transferred immediately to the site of propagation. Length of each cutting was about 25 cm four to six 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 all cuttings were immediately dipped for 3 hours in activated charcoal (AC) solution 15% and allowed to drain for few minutes (Tagelsir et al., 2006), then a fresh cut was made at the base of each cutting before the treatment with IBA (3000, 4500 and 5000 ppm), Benzoic acid at 100 ppm and Citric acid at 100 ppm.

**Preparation of Benzoic Acid, Citric Acid and IBA Solutions.**

Following the preparation of the cuttings, a hydro solution of Benzoic acid was prepared by weighing 0.1 g of Benzoic acid and dissolving it in 1000 ml of distilled water. Solution of Citric acid at 100 ppm was prepared according to the previous method. A hydroalcoholic solution of indole-3-butyric acid (IBA) was prepared by weighing 3 g of IBA and dissolving it in 50 mL of 96º alcohol, in a beaker. Once the IBA had completely dissolved, the volume was completed to 1000 ml with distilled water, obtaining an IBA concentration of 3000 ppm. The same procedure was repeated for the remaining doses used (Hortman and Kester, 1960).

**Planting of Cuttings.**

Dipping duration for the basal ends of cuttings (2.5-3 cm) was 2 minutes in Benzoic acid, Citric acid and IBA solutions. After dipping the basal ends of cuttings were allowed to dry, then the cuttings were planted in black polyethylene bags 30 cm in diameter at a depth of 6-8 cm. The bags contained a mixture of vermiculite and sand at ratio of 1:1 (v/v); the planted bags were placed on the soil surface in field condition and immediately after planting were irrigated.
Experimental Design and Treatment Details.

Experiments were carried out during 2016-2017, using two collecting dates (May and July). The experimental design in both collecting dates was complete randomized blocks design with 9 treatments; treatment was replicated two times, 10 cuttings each. The treatments consisted of IBA 3000ppm T1, IBA 4500ppm T2, IBA 5000ppm T3, Ethephon 600ppm + Benzoic acid 100ppm + IBA 3000ppm T4, Ethephon 600ppm + Benzoic acid 100ppm + IBA 4500ppm T5, Ethephon 600ppm + Benzoic acid 100ppm + IBA 5000ppm T6, Ethephon 600ppm + Citric acid 100ppm + IBA 3000ppm T7, Ethephon 600ppm + Citric acid 100ppm + IBA 4500ppm T8 and Ethephon 600ppm + Citric acid 100ppm + IBA 5000ppm T9.

2.7. Data collection and statistical analysis.

At 90 days after planting, the cuttings were assessed to determine average rooting percentage, average root number per cutting, average root length per cutting, average root fresh weight per cutting and average cuttings' survival percentage. The data were statistically treated by analysis of variance (ANOVA) and differences between means of various treatments were determined using LSD test, using Statistix 9 program (Analytical Software, Tallahassee, FL. USA).

Results and Discussion

Experiments carried out in the field condition where relative humidity (%) and mean temperature (°C) were recorded during the period of experimentation (May to October) in 2016-2017 seasons. As, shown in Fig. 1 mean monthly temperatures varied from 23.7 °C to 30.5 °C in 2016-2017 seasons. Mean monthly relative humidity varied from 39.7 % to 57.6 % in 2016-2017 seasons.
Fig. 1: Mean monthly weather data of the experiment site at Dakahlia governorate, Egypt during the period of experimentation (May - October) in 2016-2017 seasons.

Effect of Time of Taking Semi-Hard Wood Guava Cuttings on Rooting Percentage, Root Number per Cutting, Root Length per Cutting, Root Fresh Weight per Cutting and Cuttings Survival Percentage.

Time of taking cuttings (May and July) had a significant influence on rooting and survival percentage, roots number, roots length and roots fresh weight P<0.0001. These results are comparable with the results reported by (Sinha et al., 1962: Sharma, 1975 and Rathore et al., 1984). The first collecting date (May), gave the greatest values of rooting and survival percentage, roots number, roots length and roots fresh weight in comparison with the second collecting date (July) (Table 1 and 2). The present results were in harmony with the findings of El-Iraqy, 1994 who reported that guava cuttings collected in early May gave higher rooting and survival...
percentage, roots number, roots length and roots dry weigh than those collected in July or September. Climatic condition can influence the ability of stem cuttings to grow and root. The most common factors are light, temperature, humidity, moisture level of cutting and rooting medium (Hartman et al., 1997; Evans, 1992 and Singh 2018).

Table (1): Effect of the collecting date (May 2016 and 2017) of semi-hard wood guava cuttings on rooting percentage, root number per cutting, root length per cutting, root fresh weight per cutting and cuttings survival percentage.

<table>
<thead>
<tr>
<th>Cutting Treatments</th>
<th>Rooting percentage (%)</th>
<th>Number of roots</th>
<th>Root length (cm)</th>
<th>Root fresh weight (g)</th>
<th>Survival (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>15.0d</td>
<td>1.7c</td>
<td>2.0c</td>
<td>1.2c</td>
<td>7.0d</td>
</tr>
<tr>
<td>T2</td>
<td>27.0c</td>
<td>2.4c</td>
<td>2.4c</td>
<td>1.6c</td>
<td>13.0d</td>
</tr>
<tr>
<td>T3</td>
<td>22.0c</td>
<td>2.0d</td>
<td>2.1c</td>
<td>1.4c</td>
<td>10.0d</td>
</tr>
<tr>
<td>T4</td>
<td>57.0b</td>
<td>3.6b</td>
<td>3.6b</td>
<td>2.0bc</td>
<td>37.0b</td>
</tr>
<tr>
<td>T5</td>
<td>70.0a</td>
<td>4.3a</td>
<td>4.32a</td>
<td>3.35a</td>
<td>50.0a</td>
</tr>
<tr>
<td>T6</td>
<td>65.0b</td>
<td>3.8b</td>
<td>3.9b</td>
<td>2.8b</td>
<td>39.0b</td>
</tr>
<tr>
<td>T7</td>
<td>33.0bc</td>
<td>2.7b</td>
<td>2.3c</td>
<td>1.5c</td>
<td>25.0c</td>
</tr>
<tr>
<td>T8</td>
<td>45.0bc</td>
<td>3.5b</td>
<td>3.0bc</td>
<td>1.9c</td>
<td>34.0b</td>
</tr>
<tr>
<td>T9</td>
<td>40.0bc</td>
<td>3.0bc</td>
<td>2.8c</td>
<td>1.7c</td>
<td>31.0b</td>
</tr>
</tbody>
</table>

Etephon 600ppm + Benzoic acid 100ppm + IBA 3000ppm T4, Etephon 600ppm + Benzoic acid 100ppm + IBA 4500ppm T5, Etephon 600ppm + Benzoic acid 100ppm + IBA 5000ppm T6, Etephon 600ppm + Citric acid 100ppm + IBA 3000ppm T7, Etephon 600ppm + Citric acid 100ppm + IBA 4500ppm T8 and Etephon 600ppm + Citric acid 100ppm + IBA 5000ppm T9.

*Within the column of each characteristic, means sharing one or more letters are insignificantly differed at 5% level according to the LSD test.

Table (2): Effect of the collecting date (July 2016 and 2017) of semi-hard wood guava cuttings on rooting percentage, root number per cutting, root length per cutting, root fresh weight per cutting and cuttings survival percentage.
### Effect of Different Concentrations of IBA (3000, 4500 and 5000 ppm) on Rooting Percentage, Root Number per Cutting, Root Length per Cutting, Root Fresh Weight per Cutting and Survival Percentage in Semi-Hard Wood Guava Cuttings.

The present investigation was taken up to find out the most efficient concentrations of IBA which enhance rooting and survival percentage of cuttings and improve the rooting characters like root length, fresh weight and number. Analysis of variance revealed that different concentrations of the IBA resulted in significant differences (P<0.0001) in rooting percentage, root number, root length, root fresh weight, and survival percentage in semi-hard wood guava cuttings. The highest impact was observed under the treatment of IBA at the

<table>
<thead>
<tr>
<th>*Cutting Treatments</th>
<th>Rooting percentage (%)</th>
<th>Number of roots</th>
<th>Root length (cm)</th>
<th>Root fresh weight (g)</th>
<th>Survival (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>10.0d</td>
<td>1.0c</td>
<td>1.5c</td>
<td>0.9c</td>
<td>3.0d</td>
</tr>
<tr>
<td>T2</td>
<td>21.0c</td>
<td>2.0c</td>
<td>2.0c</td>
<td>1.3c</td>
<td>9.0d</td>
</tr>
<tr>
<td>T3</td>
<td>16.0c</td>
<td>1.9d</td>
<td>1.8c</td>
<td>1.0c</td>
<td>6.0d</td>
</tr>
<tr>
<td>T4</td>
<td>45.0b</td>
<td>3.0b</td>
<td>3.0b</td>
<td>1.7bc</td>
<td>30.0b</td>
</tr>
<tr>
<td>T5</td>
<td>63.0a</td>
<td>4.0a</td>
<td>4.0a</td>
<td>3.1a</td>
<td>44.0a</td>
</tr>
<tr>
<td>T6</td>
<td>55.0b</td>
<td>3.5b</td>
<td>3.2b</td>
<td>2.3b</td>
<td>37.0b</td>
</tr>
<tr>
<td>T7</td>
<td>22.0bc</td>
<td>2.3b</td>
<td>2.0c</td>
<td>1.0c</td>
<td>18.0c</td>
</tr>
<tr>
<td>T8</td>
<td>32.0bc</td>
<td>3.1b</td>
<td>2.8bc</td>
<td>1.7c</td>
<td>27.0b</td>
</tr>
<tr>
<td>T9</td>
<td>28.0bc</td>
<td>2.7bc</td>
<td>2.4c</td>
<td>1.3c</td>
<td>20.0b</td>
</tr>
</tbody>
</table>

*Within the column of each characteristic, means sharing one or more letters are insignificantly differed at 5% level according to the LSD test.

1. Ethephon 600ppm + Benzoic acid 100ppm + IBA 3000ppm T4
2. Ethephon 600ppm + Benzoic acid 100ppm + IBA 4500ppm T5
3. Ethephon 600ppm + Benzoic acid 100ppm + IBA 5000ppm T6
4. Ethephon 600ppm + Citric acid 100ppm + IBA 3000ppm T7
5. Ethephon 600ppm + Citric acid 100ppm + IBA 4500ppm T8
6. Ethephon 600ppm + Citric acid 100ppm + IBA 5000ppm T9

*Effects of Concentration of IBA on Rooting Percentage, Root Number, Root Length per Cutting, Root Fresh Weight per Cutting and Survival Percentage in Semi-Hard Wood Guava Cuttings.
rate of 4500 ppm in comparison with the different concentrations of IBA 3000 and 5000ppm (Table 3 and 4). Among all the IBA concentration, IBA (4500 ppm) showed the highest results in terms of, rooting percentage (24.0), root number (2.2), root length (2.2 cm), root fresh weight (1.5 g), and survival percentage (11.0) in semi-hard wood guava cuttings, respectively (Table 3). But, treatment IBA (3000 ppm) had the lowest results in terms of, rooting percentage (12.5), root number (1.4), root length (1.8 cm), root fresh weight (1.1g), and survival percentage (5.0) in semi-hard wood guava cuttings respectively (Table 4). The results of present findings are in close conformity with the results reported by (Marco et al., 1998: Bhagat et al., 1999 and Rymbai and Sathyanarayana, 2010).

Table (3): Influence of different concentrations of IBA (3000, 4500 and 5000 ppm) on rooting, number of roots, root length, root fresh weight and survival in semi-hard wood guava cuttings were taken during May and July 2016 and 2017.

<table>
<thead>
<tr>
<th>*Cutting Treatments</th>
<th>Rooting percentage (%)</th>
<th>Number of roots</th>
<th>Root length (cm)</th>
<th>Root fresh weight (g)</th>
<th>Survival (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>12.5 c</td>
<td>1.4 c</td>
<td>1.8 c</td>
<td>1.1 c</td>
<td>5.0 c</td>
</tr>
<tr>
<td>T2</td>
<td>24.0 a</td>
<td>2.2 a</td>
<td>2.2 a</td>
<td>1.5 a</td>
<td>11.0 a</td>
</tr>
<tr>
<td>T3</td>
<td>19.0 b</td>
<td>1.9 b</td>
<td>1.9 b</td>
<td>1.2 b</td>
<td>8.0 b</td>
</tr>
</tbody>
</table>

IBA 3000ppm T1, IBA4500ppm T2, IBA 5000ppm T3.*within the column of each characteristic, means sharing one or more letters are insignificantly differed at 5% level according to the LSD test.

Effect of the Combination of Ethephon 600ppm, Activated Charcoal (AC) 15%, Benzoic Acid 100ppm, Citric Acid 100ppm and IBA (3000, 4500 and 5000ppm) on Rooting Percentage, Root Number per Cutting, Root Length per Cutting, Root Fresh Weight per Cutting and Survival Percentage in Semi-Hard Wood Guava Cuttings.
The combination of Ethephon 600ppm, Activated Charcoal (AC) 15%, Benzoic acid 100ppm, Citric acid 100ppm and IBA (3000, 4500 and 5000ppm) showed increasing trend on rooting percentage, root number per cutting, root length per cutting, root fresh weight per cutting and survival percentage in semi-hard wood guava cuttings (table 4). These results are accordance with the finding of Prasada et al., 1988 and Marco et al., 1998. T5 (Ethephon 600ppm + Activated Charcoal (AC) 15% + Benzoic acid 100ppm + IBA 4500ppm) recorded the best values in percentage of rooted cuttings 66.5 %, number of roots per cutting 4.2, length of roots 4.2 cm, root fresh weight per cutting 3.2g and survival percentage of rooted cuttings 47.0% (Table 4). Similar results were reported by (El-Sharony et al., 2018) found that the application of IBA accompanied with antioxidant significantly increased rooting percent, root length, and number in guava.

Table (4): Influence of the combination of Ethephon 600ppm, Activated Charcoal (AC) 15%, Benzoic acid 100ppm, Citric acid 100ppm and IBA (3000, 4500 and 5000ppm on rooting, number of roots, root length, root fresh weight and survival in semi-hard wood guava cuttings were taken during May and July 2016 and 2017.

<table>
<thead>
<tr>
<th>Cutting Treatments</th>
<th>Rooting percentage (%)</th>
<th>Number of roots</th>
<th>Root length (cm)</th>
<th>Root fresh weight (g)</th>
<th>Survival (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T4</td>
<td>51.0 c</td>
<td>3.3 c</td>
<td>3.3 c</td>
<td>1.9 c</td>
<td>33.5 c</td>
</tr>
<tr>
<td>T5</td>
<td>66.5 a</td>
<td>4.2 a</td>
<td>4.2 a</td>
<td>3.2 a</td>
<td>47.0 a</td>
</tr>
<tr>
<td>T6</td>
<td>60.0 b</td>
<td>3.7 b</td>
<td>3.6 b</td>
<td>2.6 b</td>
<td>38.0 b</td>
</tr>
<tr>
<td>T7</td>
<td>27.5 f</td>
<td>2.5 f</td>
<td>2.2 f</td>
<td>1.3 f</td>
<td>21.5 f</td>
</tr>
<tr>
<td>T8</td>
<td>38.5 d</td>
<td>3.3 c</td>
<td>2.9 d</td>
<td>1.8 cd</td>
<td>30.5 cd</td>
</tr>
<tr>
<td>T9</td>
<td>34.0 e</td>
<td>2.9 e</td>
<td>2.6 e</td>
<td>1.5 e</td>
<td>25.5 e</td>
</tr>
</tbody>
</table>
Ethephon 600ppm + Benzoic acid 100ppm + IBA 3000ppm T4, Ethephon 600ppm + Benzoic acid 100ppm + IBA 4500ppm T5, Ethephon 600ppm + Benzoic acid 100ppm + IBA 5000ppm T6, Ethephon 600ppm + Citric acid 100ppm + IBA 3000ppm T7, Ethephon 600ppm + Citric acid 100ppm + IBA 4500ppm T8 and Ethephon 600ppm + Citric acid 100ppm + IBA 5000ppm T9.*Within the column of each characteristic, means sharing one or more letters are insignificantly differed at 5% level according to the LSD test.

Conclusion

The best time for taking semi-hard wood guava cuttings was May.

The IBA doses significantly influenced the rooting and survival percentage, root number, root length, root fresh weight in semi-hard wood guava cuttings, and the IBA treatment (4500ppm) produced the maximum values. The combination of Ethephon 600ppm, Activated Charcoal (AC) 15%, Benzoic acid 100ppm, Citric acid 100ppm and IBA (3000, 4500 and 5000ppm) produced a significant effect in rooting and survival percentage, root number, root length, root fresh weight in semi-hard wood guava cuttings.

The treatment 5 (Ethephon 600ppm + Benzoic acid 100ppm + IBA 4500ppm) produced the maximum rooting and survival percentage, root number, root length, root fresh weight of semi-hard wood cutting, the most recommended for the propagation of guava via semi-hard wood cutting.
References


time of guava propagation through cuttings under Jammu subtropics. The Bioscan, 10(3), 991-1001.


