Rooting of Hardwood Cuttings of Grape (*Vitis vinifera* L.) Response to Pre-treatments and Rooting Media.

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Abstract

Three natural plant extracts (Aloe vera, garlic and licorice), indole butyric acid (IBA) and three rooting media (soil, peatmoss, and soil + peatmoss 1:1 v/v) were used to study their effects on rooting of hardwood stem cuttings of grape (*Vitis vinifera* L.) cv. Thompson Seedless. The research was undertaken during January 15th – May 10th 2021, at Ankawa Ornamental Nursery, General Directorate of Agriculture – Erbil, Ministry of Agriculture and Water Resources, Kurdistan Region- Iraq. The results revealed that, plant extracts were near to IBA in promoting rooting attributes, since garlic treatment significantly improved fresh and dry root weight, rooting percentage and root index. While, licorice enhanced root shoot ratio other than IBA. Moreover, rooting media (peatmoss and soil+ peatmoss) enhanced average number of roots, root dimeter fresh and dry root weight, rooting percentage and root index. While the effect of the interaction between the pretreatments and the rooting media differed on the rooting of cuttings and the growth of plants, garlic with soil+ peatmoss, and Aloe vera with each peat moss and soil+ peatmoss have recorded the highest values. Lastly, it could be concluded that using plant extracts as IBA alternatives for a clean environment with suitable rooting media have an effective impact in rooting of grape cuttings.

Keywords: Cutting; Grape, *Vitis vinifera* L.; Aloe vera; Garlic; Licorice; IBA.

تجذير الأقلام الخشبية للعنب (*Vitis vinifera* L.) واستجابتها للمعاملات ووسط التجذير

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الخلاصة

تم استخدام ثلاث مستخلصات نباتية طبيعية (ألو فيرا، الثوم وعرق السوس)، حامض اندول بيوترك (IBA) وثلاث أوساط للتجذير (التربة، بتموس، والتربة + بتموس ١:١ حجماً) لدراسة تأثيرهم على تجذير العقل الخشبية للعنب (*Vitis vinifera* L.) صنف ثومبسن سيدليس عديمة البذور. تم إجراء البحث خلال الفترة من ١٥ كانون الثاني – ١٠ أيار ٢٠٢١، في مشتل عنكاوه لنباتات الزينة، المديرية العامة للزراعة – أربيل، وزارة الزراعة والموارد المائية، إقليم كردستان - العراق. أظهرت النتائج أن تأثير المستخلصات النباتية كانت قريبة من تاثير IBA في تعزيز صفات التجذير، حيث أدت المعاملة بالثوم إلى زيادة معنوية في الوزن الطازج والجاف للجذور ونسبة التجذير ومؤشر الجذر. بينما المعاملة بعرق السوس عززت زيادة في نسبة التجذير أكثر من IBA علاوة على ذلك، عززت وسط التجذير (التربة، بتموس، والتربة + بتموس) زيادة في عدد الجذور، قطر الجذور والوزن الطازج والجاف للجذور ونسبة التجذير. بينما اختلف تأثير التداخل بين المعاملات ووسط التجذير على تجذير العقل ونمو النباتات، حيث سجلت المعاملة بالثوم مع وسط التجذير تربة + بيتموس والوفيرا مع بيتموس والتربة + بيتموس أعلى قيم في معظم الصفات وأخيرا يمكن الاستنتاج بان استخدام بدائل IBA من المستخلصات النباتية لبيئة نظيفة مع استخدام وسط ملائم للزراعة له تأثير فعال في تجذير الاقلام.

الكلمات المفتاحية: العقل، العنب، الوفيرا، الثوم، عرق السوس. حامض إندول بيوتيريك، *Vitis vinifera* L.

1. Introduction

Grape (*Vitis vinifera* L.) which also goes by the common name in Kurdistan "Mew and the fruit of it called “Tre" is amongst the most crucial economic subtropical vine, yields produced all across the planet except in limited regions of severe temperatures and high altitudes. It is belonged to the Vitaceae family, which is among the earliest, most widely grown and commercially substantial fruit yields worldwide (Jaleta and Sulaiman, 2019).

One of the most popular raisin and table grape cultivars is Thompson Seedless. While desire for colorful, bold, and seeded/Seedless varietals has transformed the grape industry in previous years worldwide, green Seedless grapes have remained popular. For its exceptional bunches and berries characteristics, Thompson Seedless is still the recommended cultivar. Fruit set is sometimes great weight; in this cultivar, and real fruit fall, that allows the plant to self-regulate its load, is insufficient to meet new market quality criteria (Maske *et al*., 2020). Thompson Seedless, often called as 'Sultana' grapes, are among the world's most widely farmed and renowned table grape kinds (Jadhav *et al*., 2021).

Grapevines may reproduce in both sexual and nonsexual methods (Amiri *et al.,* 2019). Vegetative reproduction is the process of growing new plants from the parent plants' vegetative organs, like buds, leaves, stalks and roots. Cuttings are among the most traditional ways to propagate plants vegetatively or asexually. Cuttings may be achieved from any part of the plant dependent on the rooting capability of a plant variety. Forms of cuttings encompass stem, root, leaf, and leaf bud cuttings. Herbaceous, softwood, semi-hardwood and hardwood cuttings are the four types of stems cuttings (Hartmann *et al.,* 2002).

Hardwood cuttings are amongst the most cost-effective and simple ways of vegetative propagation When comparing to terminal and medium cuttings, basal cutting from the limb were the greatest at rooting and offered the largest rate of survival and rooting (Singh *et al.,* 2018). Cuttings' capability for rooting is determined by phenolic substances, enzymes, and auxin concentration (Aghdaei *et al.,* 2019).

Due to its great capacity to induce root initiation and low toxicity, IBA "indole-3-butyric acid" is the greatest growth regulator auxin for encouraging root growth in a wide range of plants. It is the most extensively employed in encouraging the process of root growth in cuttings (Daskalakis *et al*., 2018).

Garlics (*Allium sativum* L.) are extremely fragrant bulb crops grown in mild and tropical climates around the world. Garlic extracts contain a large number of allelopathic compounds. Fiber, carbohydrate, lipid, lysine, leucine, arginine, sodium, magnesium, calcium, potassium, manganese, phosphorus, sulphur, aspartic acid, glutamic acid and vitamins. Utilizing the extract of garlic on the rooting of grapevine cuttings has vital impression on length of roots and also rooting of grapevines, as in 50 g/L garlic extracts, the longest root length (19.67 cm) was greater than just the longest root length (12 cm) in the controls (Abbasifar *et al*.,2020).

Aloe (*Aloe vera* L.) is an essential medical native plant in Africa and belongs to the Asphodelaceae family It is known as the (Miracle Plant) because of its multiple properties. Alternate plant natural rich in growth factors such as auxins and gibberellins, as well as plant root development boosters like salicylic acid, is made from the leaves of Aloe vera (Surjushe *et al*., 2008), To encourage rooting of cuttings, it might be utilized rather of synthetic growth regulators or pure natural hormones as a natural source hormone. Because of its capacity to hold enormous amounts of water inside its thick leaf, it can withstand long times of droughts (Waithaka, 2018). Aloe vera gel extract is the most natural substance that may be utilized as a rooting hormone alternative for industrial rooting hormones in grapevine propagation, according to a research, grapes administered with Aloe vera gel had the largest roots (12.9 cm), followed with IBA (10.9 cm), but control grapes cuttings had the smallest roots (5.2 cm) (Uddin *et al.,* 2020).

Licorice (*Glycyrrhiza glabra* L.) is an herbaceous perennial plant that is used to promote plant development. A range of compounds can be found in its roots. Mevalonic acid (the starter of GA3 production in plants), Triterpene saponins (containing glycyrrhizin), proteins, phenolics, polysaccharides, amino acids, vitamin B1, vitamin B2, vitamin B3, vitamin B6, vitamin E, and vitamin C), lignins, biotin pantothenic acid and folic acid, are among the most significant. Also, many minerals like Al, P, Ca K Fe Co Mn Zn Na and Si) which work an essential function in refining the growing of the plants. Furthermore, the entire plant helps to restore drought-stricken soil. Microorganisms in the licorice rhizosphere create mutualistic relationships with the hosts, assisting in development and stress response (He *et al.*, 2020). Green techniques to increase plant development and productivity is the utilizing naturally available ingredients, such as the root extracts of licorice are desperately required (Elrys and Merwad, 2017). Minerals, vitamins, flavonoids, phenolic chemicals, amino acids, in addition to mevalonic acids, which are involved in the formation of gibberellins, may all be found in the root extract of licorice (Abd El-Azim *et al*. 2017). Comparison of two natural extracts (licorice and seaweed) with indole butyric acid (IBA) were used at different concentrations, cuttings of Dog Ridge hard rooted grape rootstock have been planted in the greenhouse to see how they affected rooting. Licorice was found to be similar to IBA in terms of increasing rooting qualities, because both procedures raised root numbers/cutting, fresh and dried mass, plant height, and leaf number/plant. Furthermore, IBA and licorice 100 percent treatments had the greatest indole acetic acid (IAA)values and the smallest abscisic acid (ABA) values, suggesting that seaweed and licorice extracts have an efficient rooting impact and may be inexpensive natural IBA substitutes suitable for cleaning cultures (El Botaty and Saleh, 2018).

Rooting media is described as the medium in which grown plants' roots develop, with the primary function of providing supports for plant growth. The appropriateness of the media is determined by the species, cutting form, period, reproduction mechanism utilized, as well as the price and availability of medium composition, as confirmed by the other researches. The quality and proportion of rooting are significantly influenced by the rooting media. Cuttings' roots and foliage development have been affected greatly by the medium used. Since rooting competence is dependent upon the kind of medium employed, rooting media must be regarded a vital element of the reproduction process (Farooq *et al*., 2018). It is well understood that proper growing medium serves as a storage for plant nutrients that holds plant accessible water, allows for exchange of gases, and offers adequate plant anchoring (Galavi, *et al*., 2013). For the development of new seedlings and cuttings, various rooting medium such as peatmoss, soil, sand, coconut shell, perlite, and vermiculite are utilized. However, the effectiveness of rooting media varies by location, materials employed, and propagation strategy, among other factors (Shanker *et al*., 2019).

An agricultural environment's most important resource is soil. Diverse land usages have a substantial impact on soil organic carbon supply and structures that affects soil characteristics, function, and micro biome composition. Market pricing, technologies, and legislation all impact land usage and shift in agricultural land utilization, making one sort of land usage greater cost-effective than others (Frąc *et al*., 2020).

Peatmoss appears to be a viable natural resource for the creation of low-cost, environmentally friendly natural sorbents that do not need renewal. During wet climates it is generated by the partial decay of mosses as well as other biological substances including trees, shrubs, grasses, and sedges. They exist numerous in plenty of other areas of the world occupying around 1-2 percent of the planet's surface. Humic acid, fulvic acid, cellulose, and lignin are the main ingredients of peatmoss, and they include many active groups of hydroxylic, phenolic, and carboxylic moieties (Pandey and Alam, 2019).

The goal of the study is to replace the IBA (a synthetic growth regulator induces rooting) which used in the rooting of grape cuttings by some plant containing auxins such as Aloe vera, garlic and licorice extract on the rooting of stem hardwood cuttings of grapevine, to offer natural and cheap alternative of IBA and concentrating on relative impacts of rooting media on bud rooting and root development of grape stem hardwood cuttings.

2. Materials and Methods

The research was undertaken during the period January 15th - May 10th 2021, at Ankawa Ornamental Beauty Nursery, General Directorate of Agriculture – Erbil, Ministry of Agriculture and Water Resources, Kurdistan Regional - Iraq to replace the IBA (a synthetic growth regulator induce rooting) which was utilized in the rooting of grape cuttings by certain plant extracts containing auxins such as Aloe vera, garlic and licorice and converging on relative impacts of rooting media (three rooting media) on seedling and rooting development of grape cuttings. Hardwood stem cuttings of grape (*Vitis vinifera* L.) cv. Thompson Seedless were obtained from vineyard (Directorate of Agriculture Researches, Ankawa, Erbil, Ministry of Agriculture and Water Resources, Kurdistan Regional – Iraq) on January 7 of 2021.The plants are 15 years old. Selection of branches from these plants as experimental material was based on their uniformity in appearance, growth habit and vigor, basal cuttings were manually taken from one year old branches.

Experimental materials

The plant extracts Aloe (*Aloe vera* L.) extract, Garlic (*Allium sativum* L.), Licorice (*Glycyrrhiza glabra*) (Fig. 1) and rooting hormone IBA (Indole-3-butyric acid) which were used as powders, in addition of control (only water). Agricultural soil (100%), Peatmoss (100%) and soil+ Peatmoss (1:1 v/v), were used as rooting media during the experiment (tables 1 and 2).

"**Fig. 1**" Licorice Garlic Alo vera

Table1. Physical and chemical characteristics of used soil.

Characteristics		Unit	Soil
pH		-	8.10
Electrical Conductivity		$ds.m^{-1}$	0.60
Organic Matter		$mg\ kg^{-1}$	8.70
Total CaCo3		$mg\ kg^{-1}$	340
Cation Exchange Capacity		$cmol.\ kg^{-1}$	22.20
Particle- Size Distribution	Clay	%	30.20
	Silt	%	57.60
	Sand	%	12.20
	Textural name		Silty clay loam

Table2. Chemical analysis of the used peat moss.

Property	Values
Moisture content (%)	16.9
Water holding capacity (%)	468.8
pH	4.50
E C (dsm^2)	0.56
Organic carbon (%)	46.68
Organic matter (%)	80.72
Total N (%)	1.24
C/N ratio	37.64

Experimental procedure

Cutting preparations: A total of 450 one-year-old healthy and disease-free hardwood stem cuttings were chosen and taken from their parent plants of “Thompson Seedless” Grapevines each stem cutting was (30-35 cm) in length and consisted of (3-5) buds/cutting. Cuttings should have a diameter of at least 7 mm and a length of 30-40 cm in functional grapevine cultivation (Türkmen *et al*., 2011). Furthermore, Hunter et al. (2004) employed other effective predictor of cane fitness for reproduction: the pithy surface area should not exceed a fifth of the surface area of the cane diameter in winter. The bottom end of the cuttings was cut off a straight cut and the top end near the top bud an angle cut in the opposite direction to the bud. The cuttings were surrounded with wet tissues and put in groups of (50 cuttings) in one plastic bag and then placed in the refrigerator under (4 ^{o}C) for one month from January- February, 2021.

Black poly grow bags (PGBs) and media preparation: Field soil was taken from Grdarasha (Field of Agricultural Engineering Sciences Collage) and sieved from the stones, gravels and weeds were removed manually then exposed to sunlight for assassination the spores of pathogens, fully dried, insects and sterilized soil were then collected and stored on clean sacks till pot filling, then adding it to the black poly grow bags (PGBs) measured (40 cm) depth (60 cm) width and (10 cm) diameter. The number of planting pots used in the research were (45) PGBs. The potting bags were divided into three replications of sets of (15 bags). Each set was filled with three types of rooting media, the first type consisted of field soil, eight (8 kg) put in each bag, the second media was a mixture of soil and peatmoss, eight (4 kg) and (1.25 kg) of peatmoss were put in each bag (1:1 v/v), the third type of media was only peatmoss, (2.5 kg) were put in each bag. Each PGBs contained (10 cuttings), lightly or slowly signed until the bottom was only about 5 cm underneath the upper portion of the container. From over course of the experimentation, the pot capacity was sufficient to even provide sufficient rooting area and nutrients for the plants (Kawaletz *et al*., 2014).

Treatment of cuttings and method of planting: Four pretreatments were used for each media including IBA, Aloe vera, Garlic, Licorice and one of the grow bags of each media was left out as a control (water). Aloe vera gel was extracted from the plant, while the other treatments were used as powders. The outer layer of the bottom end of the cuttings was scratched in prior to treatment, to expose the cambium which will help in better absorption of the treatments. After storage of cuttings for one month, the bottom end of the cuttings was dipped approximately (5 cm) in water one day before planting except for (100 cuttings) which were meant to be treated with (Aloe vera) and IBA. The scratched bottom end of the cuttings was immersed in the treatments as follows: (30 cuttings) in garlic powder, (30 cuttings) in IBA powder, (30 cuttings) in licorice powder, (30 cuttings) in Aloe vera gel and (30 cuttings) in water. Then the cuttings of each treatment were distributed on the three media with three replications.

Management of cuttings: All management practices like watering; weeding were carried out during the experimental period. The cuttings were watered every day after planting as well as every two days following the first bud burst, and the pots were positioned appropriately to ensure that all of the cuttings received adequate sunshine. All across the trial, handpicking was used to keep pots free of budding opportunist weed seedlings. The experiment was free of insects and pathogens.

Experimental Design: (15) treatments were assessed in a factorial experimentation at completely randomized design (CRD), every treatment having (10) cuttings with (3) replications. Planting was done inside a plastic house with (9 m) length, (3.1 m) width, and (2.2 m) height. Throughout the period of rooting, the mean temperature was fixed at (20 ℃) and the mean moisture was adjusted at (45 -50%).

Data collection and analysis: For three months, samples were taken weekly from each treatment, and during time the root and shoots were growing in preparation for the hardening-off stage. The data was analyzed using the SAS statistical tool (SAS 2003), and when distinction is made, the means were suitably isolated and mean values were examined using Duncan's Multiple Range Test at P≤0.05 significant level (Mead *et al*., 2017).

Cuttings were displaced from the pots via digging rooting media without ripping the roots. The base of each cutting was rinsed carefully in a pail of water without harming the roots. The measurements on root properties were recorded using standard procedures (Hartmann *et al*., 2002). Then data were gathered for the succeeding parameters:

Number of roots.cutting^{-1} (No. roots.cutting^{-1}): The overall number of roots generated from the rooted cuttings were counted and divided by the overall quantity of rooted cuttings.

Root length (cm): A scale was used to measure the root length of chosen cuttings and the overall length was recorded. Afterward, the length of the roots was computed for each cutting via the division of the overall length of shoots by (3) plants of each treatment.

Root diameter (mm): Root diameter was measured by digital caliper for all selected samples (3 plants) of each treatment and the average was calculated.

Fresh and dry root weight (g) (F.W. and D.W. root g): Average fresh and dry root weights was measured according to the method (Dardeniz *et al*., 2006).

Rooting percentage (%): The number of branch cuttings that produced root was recorded. This number was expressed as percentage of total branch cuttings planted (Owais, 2010) using the formula:

$$\text{Rooting percentage (\%)} = \frac{\text{No. of cuttings rooted}}{\text{Total no. of cuttings sprouted}} * 100 \qquad 1$$

Rooting index: Root index = root number X root length an artificial estimate of the total root length for a cutting by combining the effects of root number and root length.

Root-shoot ratio: The shoot – root ratio for each treatment was calculated (Fageria and Moreira, 2011) as follows:

$$R/S = \frac{\text{Root dry weight}}{\text{Shoot dry weight}} * 100 \qquad 2$$

3. Results and Discussion

3.1. The effect of pre-treatments on root growth in hardwood cuttings of "Thompson Seedless":

3.1.1. No. roots. cutting^{-1}: All pre-treatments had the impact of high numbers of roots per cuttings as shown in table (3) which demonstrates the effects of growing media on the total quantity of roots in each cutting in hardwood cuttings of “Thompson Seedless” grapevines.

3.1.2. Root length (cm): In table (3) which displays the influences of pre-treatments on the length of roots in hardwood cuttings of “Thompson Seedless” grapevines, all pre-treatments developed great root lengths.

3.1.3. Root diameter (mm): In table (3) which shows the influences of pre-treatments on the diameter of roots in hardwood cuttings of “Thompson Seedless” grapevines, Aloe vera, garlic and IBA pre-treatments had the greatest impact on root diameter (0.74, 0.75 and 0.71 mm), respectively, compared to control pre-treatment. They have no significant differences with control pre-treatment. Licorice pre-treatment had the smallest impact on root diameter (0.59 mm).

3.1.4. F.W. root (g): Table (3) shows the impact of pre-treatments on the fresh weight of roots in hardwood cuttings of “Thompson Seedless” grapevines. Both Aloe vera and garlic pre-treatments had the best influence on the fresh weight of roots (3.95 and 3.76 g), respectively, compared to control pre-treatment. Where, licorice pre-treatment had the slightest influence (3.13 g).

3.1.5. D.W. root (g): Table (3) shows the impacts of pre-treatments on the dry weight of roots in hardwood cuttings of “Thompson Seedless” grapevines. Licorice, Aloe vera, garlic and pre-treatments had the most effectiveness on the dry weight of roots (2.43, 2.00 and 1.83 g), respectively, compared to control pre-treatment. Control and IBA pre-treatments had the minimum effectiveness (0.75 g).

3.1.6. Rooting percentage (%): In table (3) which demonstrates the influences of pre-treatments on the thickness of roots in hardwood cuttings of “Thompson Seedless” grapevines, Licorice pre-treatment had the highest rooting percentage (94.39%) compared to control which had the lowest rooting percentage (87.48%).

3.1.7. Rooting index: In table (3) which illustrates the impact of pre-treatments on rooting index in hardwood cuttings of “Thompson Seedless” grapevines, Garlic pre-treatment had the maximum influence on rooting index value (20.5) compared to control which had the minimum rooting index value (9.01).

3.1.8. Root/shoot ratio: Table (3) shows the influence of pre-treatments on the ratio of root to shoot in hardwood cuttings of "Thompson Seedless" grapevines. Licorice pre-treatment had the highest effect (0.26) compared to control pre-treatment. Both control and IBA pre-treatments had lowest effect (0.08).

Table 3. Effect of pre-treatments on root growth in hardwood cuttings of Thompson Seedless*

Pre-treatments	Parameters							
	No. roots. cutting-1	Root length (cm)	Root diameter (mm)	F.W. root (g)	D.W. root (g)	Rooting percentage (%)	Rooting index	Root/shoot ratio
Control (water)	20.02 a	12.06 a	0.64 ab	3.15 b	0.75 b	87.48 e	9.01 e	0.08 d
Aloe vera	23.00 a	12.83 a	0.74 a	3.95 a	2.oo a	90.63 c	17.01 c	0.21 b
Garlic	26.03 a	13.33 a	0.75 a	3.76 a	1.83 a	93.57 b	20.5 a	0.14 c
Licorice	27.44 a	12.46 a	0.59 b	3.13 b	2.43 a	94.39 a	19.23 b	0.26 a
IBA	20.69 a	11.63 a	0.71 a	3.37 b	0.75 b	88.49 d	13.18 d	0.08 d

*Values within each column followed by the same letter are not significantly different from each other according to Duncan's Multiple Range Test at ($P\leq 0.05$) level of probability.

3.2. The effect of growing media on root growth in hardwood cuttings of "Thompson Seedless":

3.2.1. No. roots. cutting^{-1}: Table (4) shows the stimulus of growing media on the number of roots per cuttings in hardwood cuttings of "Thompson Seedless" grapevines. Both soil and peatmoss with soil growing media produced the highest number of roots per cuttings (25.73 and 25.62), respectively. While (18.95) is the least number of roots per cuttings produced by peatmoss growing media.

3.2.2. Root length (cm): In table (4) which displays the impacts of growing media on the length of roots in hardwood cuttings of "Thompson Seedless" grapevines, peatmoss growing media developed greatest root lengths (17.62 cm). However, peatmoss with soil growing media developed the shortest roots (9.3 cm).

3.2.3. Root diameter (mm): As table (4) shows the impact of the growing medium on the diameter of roots in hardwood cuttings of "Thompson Seedless" grapevines, peatmoss with soil growing media formed the thickest roots (0.9 mm). Where, soil growing media had the minimum impact on root thickness (0.55 mm).

3.2.4. F.W. root (g): In table (4) which demonstrates the impacts of growing media on the fresh weight of roots in hardwood cuttings of "Thompson Seedless" grapevines, peatmoss with soil growing media had the largest influence on the fresh weight of roots (3.84 g). However, soil growing media caused the lowest root fresh weight (3.25 g).

3.2.5. D.W. root (g): In table (4) which illustrates the impacts of the growing medium on the dry weight of roots in hardwood cuttings of "Thompson Seedless" grapevines, peatmoss and peatmoss with soil growing media had the greatest impact on the dry weight of roots (1.72 and 1.91 g), respectively. Whereas, soil growing media caused the lowest dry weight of roots (1.02 g).

3.2.6. Rooting percentage (%): As table (4) indicates the influences of growing media on the percentage of rooting in hardwood cuttings of "Thompson Seedless" grapevines, peatmoss with soil growing media had the highest rooting percentage (91%) and it has no significant difference with soil growing media. While, peatmoss growing media resulted in the lowest rooting percentage (90.06%).

3.2.7. Rooting index: Table (4) shows the impacts of growing media on the rooting index in hardwood cuttings of "Thompson Seedless" grapevines. Both peatmoss and peatmoss with soil growing media had the maximum influence on rooting index (15.83 and 16.52), respectively. But soil growing media had the minimum influence (15.02).

3.2.8. Root/shoot ratio: The influence of growing media on the ratio of root to shoot in hardwood cuttings of "Thompson Seedless" grapevines is shown in table (4). The most value spotted with peatmoss (0.18) and the least with soil (0.12).

Table 4. Effect of rooting media on root growth in hardwood cuttings of Thompson Seedless*

Rooting media	Parameters							
	No. root. cutting^{-1}	Root length (cm)	Root thickness (mm)	F.W. root (g)	D.W. root (g)	Rooting percentage (%)	Rooting index	Root/shoot ratio
Soil	25.73 a	10.47 b	0.55 b	3.25 b	1.02 b	91.00 a	15.02 b	0.12 b
Peatmoss	18.95 b	17.62 a	0.61 b	3.32 b	1.72 a	90.6 b	15.83 a	0.18 a
Peatmoss with soil	25.62 a	9.30 b	0.90 a	3.84 a	1.91 a	91.00 a	16.52 a	0.15 b

*Values within each column followed by the same letter are not significantly different from each other according to Duncan's Multiple Range Test at (P≤ 0.05) level of probability.

3.3. The effect of interaction between pre-treatments and growing media on root growth in hardwood cuttings of "Thompson Seedless":

3.3.1. No. roots.cutting^{-1}: Cuttings treated with licorice pre-treatment and planted in peatmoss with soil growing media created the most numbers of roots per cutting (34.66) compared to control as shown in table (5) that demonstrates the effect of interaction between pre-treatments and growing media on the quantity of roots for each cutting in hardwood cuttings of "Thompson Seedless" grapevines There was no significant difference with cuttings sprayed with water and planted in soil and peatmoss with soil growing medium, cuttings of all growing mediums that were treated with Aloe vera, pre-treatment, cuttings of all growing mediums that were treated with garlic pre-treatment, cuttings treated with licorice pre-treatment and planted in soil growing medium, and cuttings treated with IBA pre-treatment and planted in soil and peatmoss with soil growing mediums. The fewest number of roots (15.55) resulted from cuttings of control that were planted in peatmoss growing medium.

3.3.2. Root length (cm): Cuttings treated with Aloe vera pre-treatment and planted in peatmoss growing media and cuttings treated with garlic pre-treatment and planted in peatmoss growing media developed the longest roots (21.97 and 21.87 cm), respectively, compared to control as shown in table (5) that illustrates the effect of interaction between pre-treatments and growing media on the length of roots in hardwood cuttings of "Thompson Seedless" grapevines. The shortest roots (5.43 cm) obtained by cuttings planted in peatmoss with soil growing media and treated with Aloe vera pre-treatment.

3.3.3. Root thickness (mm): Cuttings treated with Garlic pre-treatment and planted in peatmoss with soil growing media and cuttings treated with IBA pre-treatment and planted in peatmoss with soil growing media gave the highest value of root diameter (0.98 and 0.96 mm), respectively, compared to control as shown in table (5) that shows the effect of interaction between pre-treatments and growing media on the diameter of roots in hardwood cuttings of "Thompson Seedless" grapevines. They have no significant difference with cuttings sprayed with water and planted in peatmoss with soil growing media, and also cuttings treated with Aloe vera pre-treatment and planted in peatmoss with soil growing media. Water sprayed planted that were treated with soil growing media had the lowest impact on root diameter (0.49 mm).

3.3.4. F.W. root (g): Cuttings treated with Aloe vera pre-treatment and planted in peatmoss with soil growing media had the greatest impact on the fresh weight of roots (4.19 g) compared to control as shown in table (5) that displays the effect of interaction between pre-treatments and growing media on the fresh weight of roots in hardwood cuttings of "Thompson Seedless" grapevines. There was no significant difference among cuttings sprayed with water and planted in peatmoss with soil growing media, cuttings treated with Aloe vera pre-treatment and planted in soil and peatmoss growing media, cuttings of all growing mediums that were treated with garlic pre-treatment, cuttings treated with licorice pre-treatment and planted in soil growing media, and cuttings treated with IBA pre-treatment and planted in peatmoss with soil growing media. The least fresh weight (2.54 g) appeared in cuttings planted in soil growing media and sprayed with only water.

3.3.5. D.W. root (g): Cuttings treated with garlic pre-treatment and planted in peatmoss with soil growing media had the maximum effect on the dry weight of roots (2.88 g) compared to control as shown in table (5) that outlines the effect of interaction between pre-treatments and growing media on the dry weight of roots in hardwood cuttings of "Thompson Seedless" grapevines. No significant differences occurred among the cuttings treated with Aloe vera pre-treatment and planted in peatmoss and peatmoss with soil growing media, cuttings treated with garlic pre-treatment and planted in peatmoss growing media, cuttings of all growing mediums that were treated with licorice pre-treatment. The least dry weight (0.3 g) appeared in cuttings planted in soil growing media and treated with garlic.

3.3.6. Rooting percentage (%): Cuttings of all growing media that were treated with Garlic and licorice had the maximum ratio of rooting associated to control as shown in table (5) that summarizes the influence of interaction between pre-treatments and growing media on the percentage of rooting in hardwood cuttings of "Thompson Seedless" grapevines. The minimum percentage (86.65%) came from cuttings of control that were planted in peatmoss growing media.

3.3.7. Rooting index: Cuttings treated with garlic pre-treatment and planted in peatmoss with soil and peatmoss growing media and cuttings treated with licorice pre-treatment and planted in peatmoss with soil growing media had the best rooting index (21.69, 20.98 and 20.98), respectively, compared to control as shown in table (5) that identifies the influence of interaction between pre-treatments and growing media on the rooting index in hardwood cuttings of "Thompson Seedless" grapevines. Cuttings of control that were planted in peatmoss with soil had the lowest rooting index value (8.27).

3.3.8. Root/shoot ratio: In table (5) which outlines the impact of interaction between pre-treatments and growing media on the ratio of roots to shoots in hardwood cuttings of "Thompson Seedless" grapevines. Cuttings planted in peatmoss growing media and treated with licorice pre-treatment had the highest impact (0.35). Cuttings planted in soil growing media and treated with Garlic pre-treatment had the lowest impact (0.04).

Table (5). The effect of interaction between pre-treatments and rooting media on root growth in hardwood cuttings of Thompson Seedless *

Pre-treatments	Rooting media	Parameters							
		No. root. cutting^{-1}	Root length (cm)	Root diameter (mm)	F.W. root (g)	D.W. root (g)	Rooting percentage (%)	Rooting index	Root/shoot ratio
Control (water)	Soil	22.40 a-c	10.27 c-e	2.54 f	2.54 f	0.48 d	87.71 ef	9.43 e	0.06 fg
	Peatmoss	15.55 c	16.4 b	3.08 d-f	3.08 d-f	0.72 d	86.65 f	9.33 e	0.08 fg
	Peatmoss with soil	22.11 a-c	9.52 c-e	3.81 ab	3.81 ab	1.06 cd	88.09 de	8.27 e	0.10 e-g
Aloe vera	Soil	23.22 a-c	11.10 cd	3.96 ab	3.96 ab	1.37 b-d	90.11 bc	15.53 c	0.17 c-e
	Peatmoss	22.55 a-c	21.97 a	3.68 a-c	3.68 a-c	2.39 ab	90.87 b	17.63 b	0.23 bc
	Peatmoss with soil	23.22 a-c	5.43 e	4.19 a	4.19 a	2.23 a-c	90.90 b	17.88 b	0.22 bc
Garlic	Soil	28.55 a-c	8.67 de	3.89 ab	3.89 ab	0.30 d	93.64 a	18.83 b	0.04 g
	Peatmoss	23.55 a-c	21.87 a	3.67 a-c	3.67 a-c	2.30 ab	93.22 a	20.98 a	0.19 cd
	Peatmoss with soil	25.99 a-c	9.47 c-e	3.72 a-c	3.72 a-c	2.88 a	93.83 a	21.69 a	0.18 cd
Licorice	Soil	31.11 ab	12.03 b-d	2.88 ef	2.88 ef	2.48 ab	94.37 a	17.88 b	0.28 ab

	Peatmoss	16.55 bc	11.47 cd	2.92 ef	2.92 ef	2.47 ab	94.44 a	18.83 b	0.35 a
	Peatmoss with soil	34.66 a	13.87 bc	3.57 b-d	3.57 b-d	2.33 ab	94.36 a	20.98 a	0.14 d-f
IBA	**Soil**	23.40 a-c	10.27 c-e	2.97 ef	2.97 ef	0.48 d	89.17 cd	13.41 d	0.06 fg
	Peatmoss	16.55 bc	16.40 b	3.23 c-e	3.23 c-e	0.72 d	87.80 e	12.37 d	0.07 fg
	Peatmoss with soil	22.11 a-c	8.22 de	3.92 ab	3.92 ab	1.06 cd	88.50 de	13.77 d	0.10 e-g

*Values within each column followed by the same letter are not significantly different from each other according to Duncan's Multiple Range Test at ($P \leq 0.05$) level of probability.

The length of root was positively affected by IBA as compared to control. The effect may be owing to auxin's rapid translocation characteristic or fast destruction, increasing the enzymatic activity. This might be also due to the combined influence of kind of cuttings, substrate and IBA tested (Salim, 2016). On the other hand, the increment in root length as a result of IBA application may be attributed to the actuality that IBA proteins disrupt hydrogen bonds among cellulose micro fibrils which loosens cell walls and cells will ultimately elongate. At suitable concentration of IBA, the amount of cambium dedifferentiation is raised and hydrolytic activity is accelerated leading to produce better root length. Besides, IBA promotes root length by influencing the synthesis of enzymes which stimulate cell enlargement (Abdel-Rahman, 2020). IBA proteins disrupt hydrogen bonds among cellulose micro fibrils which loosens cell wall and cells will ultimately elongate. At optimum exogenous IBA, the amount of cambium dedifferentiation is raised, hydrolytic activity is accelerated and callus formation is improved which eventually results in longer roots. Nevertheless, the advantage of exogenous hormones in most varieties is only recognized when they are appropriately treated, that is, when the suitable concentration is used (Shiri *et al*., 2019).

Chemicals and minerals found in garlic extract are carbohydrates, lipids, potassium, sulfur, sodium, calcium, phosphorus, magnesium, glutamic acid, aspartic acid, leucine, arginine, lysine and vitamins (Al Mayahi and Fayadh, 2015). Garlic effectiveness is depending on the released sulfur compounds. These compounds may be assimilated through anaerobe, where spread inorganic sulphide like H_2S which has a toxicity effect for root knot nematodes (Mohsen *et al*., 2021).

Licorice root extract (LRE) is a wealthy source of phenolic compounds that are extremely vital for plants as their free radicals scavenging capacity because of the existence of hydroxyl group. Licorice extract is rich in many biological precursors of new protein necessary for growth, lignin, polysaccharides, vitamin C, vitamin E, vitamin B1, vitamin B2, vitamin B3, vitamin B6, and biotin (B7), folic acid and pantothenic acid which play a key role in enhancing the plant growth (Wanas and Khamis, 2021). It was indicated by (Quintana *et al.*, 2019) that the antioxidant and anti-microbial components of licorice boost the bioactive qualities of the portions generated in each separated cell.

Conclusion

Rooting and growing of stem hardwood cuttings of grape cv. Thompson Seedless is influenced by pre-treatments and rooting media. Plant extracts were shown to be comparable to IBA in terms of improving rooting qualities, as garlic treatment significantly enhanced fresh and dry root weight, rooting percentage, and root index. While, licorice enhanced root shoot ratio other than IBA did. Moreover, rooting media (peatmoss and soil+ peatmoss) enhanced average of quantity of roots. cutting^{-1}, root thickness, fresh and dry root weight, rooting percentage and root index, it could be concluded that using plant extracts is a viable substitute to chemically produced artificial hormones and plant growth regulators in promoting the growth of roots with suitable rooting media.

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