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Propagation

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Impact of some natural extracts on rooting performance of coratina olive cuttings

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Abstract - Stimulating root formation is the key to successful cutting propagation. Natural root stimulators are eco-friendly, biodegradable and sustainable tools that prevent the environment from pollution. Horticulturists have given the role of solvents in natural extracts little attention. Therefore, the aim of this study was to study the effect of three extract solutions (aqueous, vinegary and ethanol) for ten natural extracts (humic, licorice roots, ginger roots, cinnamon bark, garlic bulbs, bread yeast, moringa leaves, willow leaves, willow shoots and control at a concentration of 20% on rooting of Coratina hardwood olive cuttings. Regarding the effect of solvent on rooting performance of Coratina olive cuttings, both ethanol and vinegar as a solvent improved the efficiency of the natural extract in rooting behavior compared to the water as solvent. Regarding the effect of the natural extracts, ginger extracts generally recorded the highest root charcgters compared to the other natural extracts. As for the interaction effect, licorice vinegar extract recorded the highest rooting percent (25%, 32.77%) followed by both humic ethanolic (27.07%, 24.67%) and vinegary (25.03%, 19.67%) extract then ginger vinegar extract (20.83%, 18%) for both seasons, respectively. According to organic farm regulation, ginger vinegar extract can be recommended followed by licorice vinegar extract.

Index terms: Olea europaea, vinegar, ginger, licorice, humic, phenol, sugars, indole

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Impacto de alguns extratos naturais no desempenho de enraizamento de estacas de oliveira coratina

Resumo - Estimular a formação de raízes é a chave para a propagação de estacas bem-sucedida. Os estimuladores de raízes naturais são ferramentas ecologicamente corretas, biodegradáveis e sustentáveis que evitam a poluição do meio ambiente. Horticultores têm dado pouca atenção ao papel dos solventes nos extratos naturais. Portanto, o objetivo deste estudo foi estudar o efeito de três soluções de extrato (aquoso, em vinagre e etanol) para dez extratos naturais (húmicos, raiz de alcaçuz, raiz de gengibre, casca de canela, bulbo de alho, fermento de pão, folha de moringa, folha de salgueiro broto de salgueiro e controle) na concentração de 20% no enraizamento de estacas de oliveira Coratina. Em relação ao efeito do solvente no desempenho de enraizamento de estacas de oliveira Coratina, tanto o etanol quanto o vinagre e o solventes melhoraram a eficiência do extrato natural no comportamento de enraizamento, em comparação à água como solvente. Em relação ao efeito dos extratos naturais, os extratos de gengibre geralmente registraram os maiores percentuais de enraizamento em comparação com os outros extratos naturais. Quanto ao efeito de interação, o extrato de vinagre de alcaçuz registrou o maior percentual de enraizamento (25%;32,77%) seguido pelo extrato húmico etanólico (27,07%; 24,67%) e de vinagre (25,03%;19,67%) e extrato de vinagre de gengibre, (20,83%; 18%) para ambas as estações, respectivamente. De acordo com o regulamento de fazenda orgânica, o extrato de vinagre de gengibre pode ser recomendado, seguido pelo extrato de vinagre de alcaçuz.

Termos para indexação: *Olea europaea*, vinagre, gengibre, alcaçuz, húmico, fenol, açúcares, indol.

Introduction

Cultivation of the olive tree (Olea europaea L.) is one of the most important trees with high economic returns and environmental values in the Mediterranean basin. In Egypt, oleiculture consider one of the main strategic economic and agricultural sectors. In fact, about 932,927 tons from 100826 ha (FAO, 2022). Recently, olive production and consumption are increasing due to the human health benefits, economic importance and organoleptic properties of olive oil (GOUVINHAS et al., 2017; HASHMI et al., 2015).

Hardwood cuttings are the most effective asexual propagation method for olive propagation (MOHAMMED, 2021; EID et al., 2018; RASHEDY et al., 2021). Synthetic auxin IBA (indole-3-butyric acid) is the most common growth regulators used to stimulate rooting of olive cuttings in conventional agriculture (RASHEDY et al., 2021). But it is not allowed according to organic farming regulations (CENTENO; GOMEZ-DEL-CAMPO, 2008). In Egypt, Coratina olive variety is one of the most popular olive varieties and is easier to root compared to Picual and Manzanillo varieties (RASHEDY et al., 2021). Growing organic olives requires IBA substitutes to stimulate root formation. Biostimulants are a powerful tool for improving the efficiency of vegetative cuttings propagation. However, their optimal utilization rates are often species-specific (WISE et al., 2020).

Humic substances include humic acids, humins and fulvic acids which stimulate the growth and development of plant roots (ELMONGY et al., 2018). The positive effects of humic acid can be attributed to the hormone-like activity of its components and to (indole-3-acetic acid) IAA-independent mechanisms (TREVISAN et al., 2011). Also, humic acid at 0.5, 1 or 2% increased shoot length fresh and dry weight of leaves and roots of Zard olive cultivars (ASL MOSHTAGHI et al., 2011). Humic acid has recently been used to counteract abiotic stress as ecco-friendly tools (RASHEDY et al., 2022).

Licorice or liquorice (*Glycyrrhiza glabra*) root extract contains mevalonic acid, phenolic compounds, vitamins, biotin, amino acids, folic acid, pantothenic acid, and many minerals which consider a source of natural stimulant compounds that can be used in place of synthetic growth stimulants (EID et al., 2018). Also, it counted a source of phytohormones which stimulated root formation (RADY et al., 2019). EID et al. (2018) recorded rooting percent between 44% and 66% for Picual olive cuttings soaked in licorice extract at 5 and 10g/L for half an hour which could be considered as a substitute for IBA. Moreover, treating olive hardwood cuttings with willow and licorice extracts at 0, 3, 6 and 9 $g.L^{-1}$ achieved the highest rooting by 66.66% for 6 and 9 $g.L^{-1}$ licorice extract for 1 hour and 38.8% for 6 $g.L^{-1}$ willow extract. Both 9 $g.L^{-1}$ willow extract and 6 $g.L^{-1}$ licorice extract increased root number, root length, shoot length and leaf number.

Willow (*Salix babylonica* L.) bark or leaf extracts contain large amounts of the phytohormone and salicylic acid, which have exhibited biostimulating effects on root growth of many plant species (HAYAT et al., 2010). More recently, Wise et al. (2020) reported that 1.06 µL L^{-1} willow bark increased formation of adventitious roots in both lavender and chrysanthemum cuttings.

The scientific community has given Moringa (*Moringa oleifera*) a lot of attention due to its rich source of growth hormones, vitamins, antioxidants and mineral nutrients (FOIDL et al., 2001). Moringa leaves are rich in zeatin and indole acetic acid, which are plant growth stimulators (SACHAN et al., 2011). In addition, moringa leaves are rich in phenols, ascorbates, carotenoids, calcium and potassium which have plant growth-promoting abilities and are often used as exogenous plant growth promoters (FOIDL et al., 2001).

Cinnamon is an important medicinal plant that contains active compounds such as pilot oil, cinnamon aldehyde, cinnamyl alcohol, cinnamic acid, cinnamyl acitate, tannin, eugeuol and minerals (GUNJAN; ANART, 2009). In a bottle brush plant (*Melaleuca viminalis* L.) Hameed and Adil (2019) reported that, adding cinnamon extract to growth regulators solution (750 IBA + 750 (1–Naphthylacetic acid)NAA mg L^{-1} + 2 mg 100 ml^{-1} cin) improved rooting behavior compared to growth regulators alone. MUSTAFA et al (2021) soaked hardwood cuttings of *Callistemon viminalis* separately in 3 and 6 g/L aqueous extracts of licorice root, moringa leaf, cinnamon bark and willow shoot for one hour. They found that, the highest rooting was recorded by 6 gL^{-1} licorice extract, while Cinnamon 3 g/L extract gave the lowest rooting. The longest root was recorded by 6 g/L moringa extract and the longest shoot was recorded by 3 g/L willow extract. Moreover, licorice root extract at 6 g/L improved root measurements similar to 3000 ppm IBA. On the opposite side, moringa extract recorded the lowest values in all rooting and vegetative characteristics in Picual olive cuttings compared to garlic, Licorice and algae extracts (EID et al., 2018).

Bread yeast contains some hormones such as IAA, (Gibberellins) GA, cytokinin as well as organic compounds, several nutrients (N, K, P, Mg, Ca, Mn, Na, , Zn, Cu, Mo, B), carbohydrates and protein (TARTOURA et al., 2001). Also, garlic contains ascorbic acid, vitamins, flavonoids, minerals, sulphur, iodine and amino acids (EID et al., 2018). The highest Picual cutting rooting percentages were recorded by garlic at 10 or 20%, Licorice at10 g and algae at 2.5 or 5 g compared to yeast and were significantly similar to NAA and IBA treatments (EID et al., 2018).

Horticulturists have given the role of solvent in natural extracts little attention. Vinegar is a safe and natural substance for home use which used in organic farming for weed control (RADHAKRISHNAN et al., 2002; IVANY, 2010; BRAINARD et al., 2013) and plant protection (MATYJASZCZYK, 2018). It has been known for more than 10000 years (JOHNSTON; GAAS 2006). It is rich in bioactive substances such as vitamins and polyphenols along with its antioxidant activity (NISHINO et al., 2005). It has benefits for human health, antibacterial activity and antioxidant activity (BUDAK et al., 2014). In addition, GANLIN et al. (2015) show that vinegar from sugar cane contains vinegar with 3.04 % (w/v) total acid and 4° alcoholicity and several sugars (glucose, fructose, sucrose) and organic acids (acetic acid, tartaric acid, oxalic acid, citric acid, succinic acid). Citric acid was used to stimulate rooting of cuttings of many plant species such as guava (EL-SHARONY et al., 2018), rose (Rosa × hybrida 'Love Letter') (GHAZIJAHANI et al., 2017) and olive (RASHEDY et al., 2021). Also, ethanol also resulted from the same production of vinegar from fermentation of sugarcane juice (BUDAK et al., 2014).

It used to extract many chemical compounds and dissolve phenols (GHASEMZADEH et al., 2010). Water is frequently used as a solvent in different previous researches (MOHAMMED, 2021; MUSTAFA et al., 2021; ALBARIDI et al., 2022) while, ethanol as solvent has little attention (MOHAMMED, 2021; ALI et al., 2022). On the contrary, there is no information about vinegar as solvent for some natural substances like moringa, willow, ginger, licorice, cinnamon, bread yeast, garlic and humic acid which some of them which are extracted with water or vinegar may use in organic farm in the future. Thus, this study was conducted to evaluate different natural extracts prepared in either vinegar, ethanol and water as solvents to stimulate rooting of hardwood olive cuttings.

Material and methods

This experiment was conducted during two seasons (2020-2021) in the nursery and laboratory of Pomology department, Faculty of Agriculture, University of Cairo, Egypt (30°01'04"N31°12'30"E) to evaluate the effect of some natural extracts at 20% concentration extracted by three different solvents (water, ethanol and vinegar) to stimulate rooting of Coratina hardwood olive cuttings.

Plant extract preparation

Three solvents were studied in this experiment which were water, vinegar and ethanol. Vinegar and ethanol come from processing sugar cane. Extracts of water, vingar and ethanol from natural substances were prepared according to Mohammed (2021) and Mustafa et al. (2021) with some modification. Twenty-five gram crushed powder of licorice roots (*Glycyrrhiza glabra* L.), ginger roots (*Zingiber officinale* Roscoe), cinnamon barks (*Cinnamomum verum* L.), humic acid and bread yeast (*Saccharomyces cerevisiae*) were dissolved in 125 ml of the extracted solution (water, vinegar (3%) and ethanol (70%) for two days at 5ºC. Bread yeast prepared by soaking 25g of active dry yeast in a small amount of water with 5g sugars after 30min it complete with solvent for the final volume.

For fresh material garlic bulb (*Allium sativum*), moringa leaves (*Moringa oleifera*), weeping willow leaves and shoots (*Salix babylonica* L.) were cut into small pieces then 25 g were mixed in a blender for 5 min in 125 ml of extracted material (70% ethanol, vinegar (0.1%) or water) and then stored at 5ºC for two days beside extract solution alone (solvent alone) as control. For willow shoot extracts, 0.1 cm diameter was selected to be a larger proportion of bark. Before the cuttings were planted, the previous prepared solution was filtered by filter paper (White Man No. 1) and become ready for treatments.

Cuttings preparation and planting

Three 30-year-old stock trees of Coratina olive cultivars were selected to prepare the cuttings. At first of September each year, thirty hardwood cuttings of Coratina olive (were prepared for each treatment from one-year-old shoots, with 15 cm long, 4 upper leaves and 0.8 cm in diameter. All cuttings were soaked in previous prepared solution for 30 minutes before planting according to Eid et al. (2018). Plastic boxes (50*70cm) washed well, then filled with peatmoss: sand in a ratio of 1:4 and irrigated well before planting. In addition to a polyethylene sheet is placed under under perforated boxes to keep water.

Coratina cutting bases were soaked in the previously prepared solution for 30min. After planting, the shaded polyethylene tunnel system was established as alternative system for fog irrigation system (HUSSAIN et al., 2020; RASHEDY, 2021) with 1m width and 80cm high which covered with clear polyethylene plastic and then black saran shade net (40%) under a saran shaded greenhouse to avoid exceesive solar radiation and transpiration. The cuttings were planted under polyethylene plastic tunnel until the end of December and irrigated as needed according to vapour under the tunnel (once a month).

Morphological study

At the end of December, the following parameters were recorded. Rooting percent by dividing rooted cuttings by the total number of cuttings. Root length was calculated by measuring roots length. Number of roots and leaves was calculated by counting number of roots and leaves.

Biochemical analysis

Total phenols

Determination of total phenols were determined in plant sample (cuttings base) and for filtered extracted soloution according to the Folin Ciocalteu method (SHARMA et al., 2019). For determination of total phenols in aqoueous, vinegar and ethanol solution carried out before planting. One ml of filtered extract solution was directly treated (without methanol extract step) with 1 mL of Folin, and 5 mL Na_2CO_3 (20%), then 3 ml of distilled water was added to adjust the final volume to 10 mL. For plant samples (0.5 g FW) were carried out a month after planting and extracted for a week in 20 mL of methanol (80%) in the dark. Then 1 mL of this plant extract was treated with Folin, Na_2CO_3 and distilled water as mentioned previous in determination phenol in aqueous solution. Finally, the mixture (for both plant and extraction solution sample) kept in the dark for 1 hour and then absorbance was determined by a spectrophotometer at 765 nm. The total phenol content was expressed as equivalents of gallic acid in mg g-1 of fresh bark weight and mg ml-1 for plant extract and extract solution, respectively.

Total indols

Total indole content was determined according to (LARSEN et al., 1962) for the extracted solution. The samples (1ml) were mixed directly with 4 mL of P-dimethyl amino benzaldehyde which prepared with dissolving 1g of P-dimethyl amino benzaldehyde in 50 mL of ethanol 95% + 50 mL of HCL. The mixture was kept at 30°C for 90 min and absorbance was determined by a spectrophotometer at 530 nm. The total indole content was expressed as ml/L indole acetic acid.

Total sugars

Total soluble sugars were determined according to Dubois et al. (1956). Plant samples (0.5 g FW) from cuttings base one month after planting were extracted for a week in 10 mL of 70 % ethanol. One mL from previous extract was combined with 1 mL of 5 % phenol then 4mL of H_2SO_4 (98%). After that the mixture was kept for an hour to stop the reaction. Finally, a spectrophotometer at 490 nm used to determine samples sugars contenet. Total soluble sugars content which expressed as mg g-1 FW.

Statistical analysis

The treatments were were arranged into a split plot design with two factors (Solvent and natural extract). Each treatment contain three replicates. Significances of differences between treatments were analyzed using Anova by MSTAT-C statistical package according to Freed et al. (1990). LSD values were calculated at 0.05 level (SNEDECOR; COCHRAN, 1989).

Results

Rooting percent

For the effect of solvent type on rooting percentage of Coratina olive cuttings (Table 1), both ethanol and vinegar as solvent recorded the highest rooting percent than water as solvent. As for the effect of natural substances extract on rooting percentage, humic acid recorded the highest rooting efficiency, followed by ginger and licorice extract. For the interaction effect between solvent and natural extracts, the results indicated that, the highest significant rooting percent was recorded by licorice vinegar extract (25, 32.77%) followed by humic ethanolic extract (27.07, 24.67%) then ginger ethanol extract (20.17, 22.70%) and ginger vinegar extract (20.83, 18%). Also, ethanolic extracts of garlic (22.17, 17.47%) and cinnamon (14.67, 16.47%) have a good effect on rooting. While, willow extracts gave the lowest values.

Roots number

For the effect of solvent type on root number (Table 2), ethanol followed by vinegar as solvent recorded the highest root number compared to water as solvent. Also, for the effect of natural extract substances on root number, ginger recorded the highest root number followed by control then cinnamon, licorice and humc acid. For the interaction effect, the results indicated that, the highest significant roots number was recorded by ginger ethanolic extract (14, 15) followed by vinegar alone (5, 6), licorice ethanolic extract (5.67, 4.67) then ginger vinegar extract (4, 1.33) while, the lowest values recorded by extracts of willow and moringa.

Table 1. Effect of different natural substances extracted in Water, vinegar and ethanol as solvent on rooting percent of Coratina hardwood olive cuttings during two season (2020-2021).

Natural substances (B)	Extract solution (A)							
	First season 2020				Second season 2021			
	Water	Vinegar	Ethanol	Mean B	Water	Vinegar	Ethanol	Mean B
Control	1.00 k	9.20 e	4.90 fg	5.03 E	0.67 m	8.00 efg	4.90 hij	4.52 E
Ginger	5.23 f	20.83 b	20.17 b	15.41 B	4.57 h-k	18.00 cd	22.70 b	15.09 B
Licorice	4.47 fgh	25.00 a	2.43 g-k	10.63 C	5.47 ghi	32.77 a	5.93 fgh	14.72 B
Cinnamon	2.77 f-k	4.07 f-i	14.67 c	7.17 D	3.10 i-m	7.70 efg	16.47 d	9.09 C
Humic	12.03 d	25.03 a	27.07 a	21.38 A	8.33 ef	19.67 c	24.67 b	17.56 A
Bread yeast	4.00 f-i	8.17 e	2.00 h-k	4.72 E	4.00 h-l	10.23 e	4.67 h-k	6.30 D
Garlic	1.00 k	0.33 k	22.17 b	7.83 D	1.67 lm	1.00 m	17.47 cd	6.71D
Moringa	0.67 k	1.00 k	1.33 jk	1.00 F	1.00 m	1.33 lm	2.00 klm	1.44 F
Willow Leaf	1.33 jk	1.33 jk	1.33 jk	1.33 F	1.67 lm	1.33 lm	1.33 lm	1.44 F
Willow shoot	1.67 ijk	1.67 ijk	3.63 f-j	2.32 F	1.00 m	1.33 lm	2.30 j-m	1.54F
Mean A	3.42 B	9.66 A	9.97 A		3.15 B	10.14 A	10.24 A	

Means followed by a different letters in the same column are significantly different at 0.05 level

Table 2. Effect of different natural substances extracted in Water, vinegar and ethanol as solvent on roots number of Coratina hardwood olive cuttings during two season (2020-2021).

Natural substances (B)	Extract solution (A)							
	First season 2020				Second season 2021			
	Water	Vinegar	Ethanol	Mean B	Water	Vinegar	Ethanol	Mean B
Control	2.00 d	5.00 b	4.00 bc	3.67 B	1.67 ghi	6.00 b	4.67 bcd	4.11 B
Ginger	2.67 cd	4.00 bc	14.00 a	6.89 A	3.00 d-i	4.33 b-e	15.00 a	7.44 A
Licorice	1.67 d	1.67 d	5.67 b	3.00 BC	1.33 hi	2.00 f-i	4.67 bcd	2.67 CDE
Cinnamon	1.00 d	4.00 bc	5.33 b	3.44 B	1.67 ghi	5.33 bc	4.67 bcd	3.89 BC
Humic	1.33 d	4.00 bc	2.67 cd	2.67 BCD	1.67 ghi	4.00 b-f	3.00 d-i	2.89 BCD
Bread yeast	1.00 d	2.33 cd	1.33 d	1.56 DEF	1.00 i	3.67 c-g	2.33 e-i	2.33 DEF
Garlic	1.33 d	1.33 d	4.00 bc	2.22 CDE	1.33 hi	1.33 hi	3.33 c-h	2.00 DEF
Moringa	1.33 d	1.33 d	1.33 d	1.33 EF	1.33 hi	1.33 hi	1.33 hi	1.33F
Willow Leaf	1.33 d	1.67 d	1.00 d	1.33 EF	1.33hi	1.33 hi	1.67 ghi	1.44 EF
Willow shoot	1.00 d	1.00 d	1.00 d	1.00 F	1.33 hi	1.33 hi	1.33 hi	1.33 F
Mean A	1.47 C	2.63 B	4.03 A		1.57 C	3.07 B	4.20 A	

Means followed by a different letters in the same column are significantly different at 0.05 level

Root length

For the effect of solvent type on root length (Table 3), vinegar followed by ethanol as solvent recorded the highest root length than water as solvent. Also, for the effect of natural extract substances on root length, ginger recorded the highest root number followed by garlic then bread yeast. For the interaction effect on root length, the results indicated that, the highest significant root length was recorded by garlic ethanolic extract (15.33, 15.33cm) followed by yeast vinegar extract (11.67, 11.67cm). The control treatment of vinegar (alone) increased root length significantly compared to all other ethanol or vinegar extracts of licorice, cinnamon, willow extracts and moringa.

Table 3. Effect of different natural substances extracted in Water, vinegar and ethanol as solvent on root length (cm) of Coratina hardwood olive cuttings during two season (2020-2021).

Natural substances (B)	Extract solution (A)							
	First season 2020				Second season 2021			
	Water	Vinegar	Ethanol	Mean B	Water	Vinegar	Ethanol	Mean B
Control	1.33 f	6.33 cd	1.33 f	3.00 DE	1.67 f	8.00 c	1.67 f	3.78 C
Ginger	6.33 cd	8.33 c	5.67 de	6.78 A	7.00 cd	11.33 b	4.67 de	7.67 A
Licorice	1.33 f	7.33 cd	3.33 ef	4.00 CD	1.33 f	7.33 c	3.33 ef	4.00 C
Cinnamon	1.33 f	7.33 cd	3.33 ef	4.00 CD	1.33 f	7.33 c	3.33 ef	4.00 C
Humic	1.33 f	8.00 cd	1.67 f	3.67 CD	1.67 f	8.00 c	1.67 f	3.78 C
Bread yeast	1.00 f	11.67 b	1.67 f	4.78 BC	1.67 f	11.67 b	1.67 f	5.00 BC
Garlic	1.67 f	1.00 f	15.33 a	6.00 AB	1.67 f	1.67 f	15.33 a	6.22 B
Moringa	1.33 f	1.67 f	1.67 f	1.56 E	2.00 f	1.33 f	2.00 f	1.78 D
Willow Leaf	1.33 f	2.33 f	2.67 f	2.11 E	3.00 ef	2.00 f	2.00 f	2.33 D
Willow shoot	1.33 f	2.67 f	1.67 f	1.89 E	2.00 f	1.33 f	2.00 f	1.78 D
Mean A	1.83 C	5.67 A	3.83 B		2.33 C	6.00 A	3.77 B	

Means followed by a different letters in the same column are significantly different at 0.05 level

Leaves number

For the effect of solvent type on leaves number of Coratina olive cuttings (Table 4), vinegar followed by ethanol as solvent recorded significantly increased root length than compared to water as solvent. As for the effect of natural substances on leaves number, ginger extracts recorded the highest root number followed by cinnamon extracts then humic ethanolic extracts.

For the interaction effect on root length, the results indicated that, the highest significant leaves number was recorded by ginger vinegar extract (21.67, 19.33), followed by ginger ethanolic extract (19.33, 16.67) then cinnamic ethanolic extract (10.50, 10.50) and humic vinegar extract (10.0, 10.0). The control treatment of vinegar (alone) increased root length significantly compared to all other ethanolic or vinegary extracts of liqurice, cinnamon, willow extracts and moringa.

Biochemical analysis

Cuttings total sugars content

For the effect of solvent type on total sugars content of Coratina olive cuttings (Table 5), there are no differences between extracted solution in total sugars content. Also, for the effect of natural substances, willow shoot followed by willow leaf recorded the highest total sugars content then garlic extracts.

For the interaction effect on total sugars content of the cuttings, all willow shoot extracts recorded the highest total sugars content followed by willow leaf ethanolic extract.

Cuttings total phenols content

For the effect of solvent on total phenols content of Coratina olive cuttings, vinegar recorded the highest significant total phenols content for extract substances compared ot water and ethanol solution. Also, for the effect of natural substances on total phenols content, ginger ectracts recoreded the highest total phenols content followed by cinnamon then licorice extract. For the interaction effect, the results indicated that, the highest significant total phenols content was recorded by cinnamon vinegar extract followed by cinnamon water extract then both vinegar and ethanolic extract of ginger.

Table 4. Effect of different natural substances extracted in Water, vinegar and ethanol as solvent on leaves number of Coratina hardwood olive cuttings during two season (2020-2021).

Natural substances (B)	Extract solution (A)							
	First season 2020				Second season 2021			
	Water	Vinegar	Ethanol	Mean B	Water	Vinegar	Ethanol	Mean B
Control	1.00 ij	5.00 fg	2.33 hij	2.78 D	1.00 gh	4.33 de	4.00 def	3.11 D
Ginger	7.67 de	21.67 a	19.33 b	16.22 A	8.67 bc	19.33 a	16.67 a	14.89 A
Licorice	0.67 ij	0.67 ij	0.67 ij	0.67 F	1.00 gh	1.00 gh	1.00 gh	1.00 EF
Cinnamon	10.67 c	9.33 cd	10.50 c	10.17 B	10.67 b	9.33 b	10.50 b	10.17 B
Humic	6.17 ef	10.00 c	0.67 ij	5.61 C	6.50 cd	10.00 b	1.33 fgh	5.94 C
Bread yeast	1.00 ij	3.67 gh	2.67 hi	2.44 DE	1.00 gh	3.67 efg	2.67 e-h	2.44 DE
Garlic	0.67 ij	0.67 ij	2.33 hij	1.22 EF	0.67 h	0.67 h	3.00 e-h	1.44 EF
Moringa	1.00 ij	1.00 ij	1.00 ij	1.00 F	1.33 fgh	1.33 fgh	1.33 fgh	1.33 EF
Willow Leaf	0.33 j	0.33 j	0.33 j	0.33 F	1.00 gh	1.00 gh	1.00 gh	1.00 EF
Willow shoot	0.33 j	0.33 j	0.33 j	0.33 F	1.00 gh	0.67 h	0.67 h	0.78 F
Mean A	2.95 C	5.27 A	4.02 B		3.28 C	5.13 A	4.22 B	

Means followed by a different letters in the same column are significantly different at 0.05 level

Table 5. Effect of different natural substances extracted in Water, vinegar and ethanol as solvent on total sugars content (mg g-1 FW) and total phenols content (mg g-1 FW) of Coratina hardwood olive cuttings during 2021season.

Natural substances (B)	Extract solution (A)							
	Total sugar (mg g^{-1} FW)				Total phenol (mg g^{-1} FW)			
	Water	Vinegar	Ethanol	Mean B	Water	Vinegar	Ethanol	Mean B
Control	37.33 de	33.00 efg	30.33 fgh	33.56 DE	35.07 lm	34.57 lm	34.50 lm	34.71 F
Ginger	32.80 efg	45.00 cd	33.33 efg	37.04 CD	52.43 d	54.33 c	55.33 c	54.03 A
Licorice	31.03 fgh	25.17 f-i	24.70 ghi	26.97 F	50.33 e	51.67 de	42.07 i	48.02 C
Cinnamon	25.17 f-i	25.60 f-i	29.63 fgh	26.80 F	58.10 b	62.10 a	31.00 n	50.40 B
Humic	29.63 fgh	35.67 ef	17.37 ij	27.56 EF	15.23 p	47.30 f	37.23 k	33.26 G
Bread yeast	35.13 efg	21.47 hij	37.63 de	31.41 F	46.10 fgh	29.73 n	39.60 j	38.48 E
Garlic	55.60 c	32.07 fgh	35.43 efg	41.03 C	45.17 gh	44.77 h	43.07 i	44.33 D
Moringa	34.57 fg	35.00 fg	12.00 j	27.19 F	35.30 l	39.80 j	25.43 o	33.51 G
Willow Leaf	37.00 e	37.00 e	70.67 b	48.22 B	46.53 fg	34.80 lm	35.40 l	38.91 E
Willow shoot	92.00 a	91.67 a	91.67 a	91.78 A	50.53 e	46.77 f	33.67 m	43.66 D
Mean A	41.03 A	38.16 A	38.28 A		43.48 B	44.58 A	37.73 C	

Means followed by a different letters in the same column are significantly different at 0.05 level.

Table 6. Effect of different natural substances extracted in Water, vinegar and ethanol as solvent on total indole (mg L^{-1}) and phenol content(mg L^{-1}) of extract solution during 2021 season.

Natural substances (B)	Extract solution (A)							
	Total indole mg L-1				Total phenols mg L-1			
	Water	Vinegar	Ethanol	Mean B	Water	Vinegar	Ethanol	Mean B
Control	0.0000 n	0.0000 n	0.0000 n	0.0000 G	0.00 i	0.00 i	0.00 i	0.00 I
Ginger	0.0430 b	0.0351 c	0.0187 e	0.0322 B	25.09 c	25.50 b	25.61 b	25.09 C
Licorice	0.0067 i	0.0035 kl	0.0187e	0.0096 E	24.91 c	24.09bcd	24.94 bc	24.91 C
Cinnamon	0.0430 b	0.0683 a	0.0435 b	0.0516 A	25.98 b	25.38 b	25.35 b	25.98 B
Humic	0.0045 jk	0.0057 ij	0.0057 ij	0.0038 F	15.38 g	4.307 h	6.367 h	15.38 G
Bread yeast	0.0016 m	0.0016mn	0.0016mn	0.0016 F	21.67 e	21.82 e	21.75 e	21.67 E
Garlic	0.0086 h	0.0126 g	0.0086 h	0.0099 E	23.11de	18.03 f	18.41 f	23.11 CDE
Moringa	0.0014 n	0.0015mn	0.0015mn	0.0014 F	24.17bcd	24.15 cd	24.15bcd	24.17 BCD
Willow Leaf	0.0156 f	0.0235 d	0.0023 lm	0.0138 D	22.23de	35.88 a	36.11 a	22.23DE
Willow shoot	0.0234 d	0.0163 f	0.0235 d	0.0210 C	35.58 a	36.04 a	35.35 a	35.58 A
Mean A	0.0120 B	0.0177 A	0.0118 B		43.48B	44.58 A	37.73 C	

Means followed by a different letters in the same column are significantly different at 0.05 level

As for the effect of the solvent on the total phenol content of Coratina olive cuttings, vinegar recorded the highest significant content of total phenols for the extracts compared to water and ethanol as solvent. Also, for the effect of natural substances on total phenol content, ginger extracts recorded the highest total phenol content followed by cinnamon then licorice extract. Regarding the interaction effect, the results indicated that cinnamon recorded the highest significant content of phenols in vinegar extract and cinnamon water extract, followed by vinegar and ethanolic extract of ginger.

Total indoles of the extracted solutions

For the effect of solvent on solution total indole content (Table 6) vinegar recorded the highest significant total indole content compared to water and ethanol solvents. For the effect of natural extract substances on total indoles content in the prepared solution, cinnamon extracts recorded the highest significant values followed by ginger extract solutions then willow shoot extract solutions, while, humic, yeast and moringa extract solutions after control recorded the lowest ones.

Regarding the effect of the interaction on total indole content of the prepared solution, the results showed that, the highest significant total indole content was recorded in solution of cinnamon vinegar extract followed by both cinnamon water and ethanolic solution and ginger water solution with no significant differences between them. Also, ginger vinegar solution solution recorded have high total indol content.

Total phenols of the extracted solutions

For the effect of solvent type on total phenols content of the prepared solution (Table 5) as root stimulator, vinegar solution recorded the highest significant total phenols content followed by water solution while ethanol gave the lowest values. Also, for the effect of natural substance, willow shoot recorded the highest significant total phenols content followed by cinnamon then both licorice and ginger substances.

Regarding the effect of the interaction on total phenols content of the prepared solution,all willow shoot extract solution as well as both vinegar and ethanol solution of willow leaves recorded the highest values. Also, all cinnamon extracts solution as well as both vinegar and ethanol extracts of ginger solution gave a significantly higher total phenols content compared to humic, garlic , bread yeast, moringa and control extracts solutions.

Discussion

The results showed the efficiency of licorice and humic extracts in increasing rooting percent. Humic substances stimulate the growth and development of plant roots (ELMONGY et al., 2018) may be due to the hormone-like activity of their component and for IAA-independent mechanisms (TREVISAN et al., 2011), promoting H+ATPase activity in the plasma membrane (DOBBSS et al, 2010) and it has stimulatory effects similar to auxin or gibberellin (SCAGLIA et al., 2016) and cytokinin (ZHANG; ERVIN, 2004). The effect of licorice extract on improving rooting percent was previously reported in several plant species such as dog ride grape cuttings (EL-SHAIMA et al, 2018) and Callistemon viminalis cuttings (MUSTAFA et al., 2021). Also, EID et al.(2018) where they observed that, Licorice extract at10 g/L recorded the highest rooting percent of Picual olive cuttings which was similar to NAA and IBA effect. The stimulating effect of licorice root extract may be due to its content of natural stimulant compounds that can be used in place of synthetic growth stimulants such as phenolic compounds, vitamins, biotin, amino acids, folic acid, pantothenic acid (EID et al., 2018) as well as it counted source of phytohormones (RADY et al., 2019). Since, treating Dog Ridge grape cuttings with 100% licorice showed 90.50% rooting percentage, due to increasing endogenous content of indole acetic acid and decreasing abscisic acid (EL-SHAIMA et al.2018). Increasing IAA content in grapevine cutting tissues has a positive role in improving the formation of callus and new vascular tissue, thus improving the success of propagation in grapevine (FAYEK et al. 2022). Previous studies cleared that licorice extract more effective than cinnamon, yeast, willow, moringa (EID et al., 2018) and cinnamon (MUSTAFA et al., 2021) in stimulating rooting of cuttings. moreover, it had a positive effect like IBA (EID et al., 2018; MUSTAFA et al., 2021). While moringa extract failed in improving rooting of Picual olive cuttings (GAD; IBRAHIM, 2018).

One of the most promising natural substances in this study was ginger natural extract. It increased rooting percent and root characteristics which may be attributed to its multifunctional compounds such as zingiberene, camphene, 6-gingerol, sabinene, β-sesquiphellandrene, α-farnesene, α-curcumene, neral, cinnamic ,gallic, salicylic, ferulic, vanillic acid, tannic acid, flavonoids and ascorbic acid (YEH et al., 2014; GHASEMZADEH et al., 2010; KISIRIKO et al., 2021). Also, the study showed the effectiveness of garlic ethanol extract on rooting which mentioned previous in Picual olive cuttings for roting percent (EID et al., 2018; GAD; IBRAHIM, 2018) and root length Mohammed (2021). The most promising effect of garlic extract on root length could be attributed to ascorbic acid, vitamins, flavonoids, minerals, sulphur, iodine and amino acids content (EID et al., 2018) which may make them perfect natural alternatives for cuttings rooting (RAJAN; SINGH, 2021).

The type of solvent determined the extractive capability of phenolic components and the type of phenol (GHASEMZADEH et al., 2010; SEPAHPOUR et al., 2018). Also, for compounds quantity HPLC revealed that the amount of phenolic compounds varied depending on the types of solvents used (SEPAHPOUR et al., 2018). Ghasemzadeh et al. (2010) recommended methanol to extract phenolic compounds from ginger compared to chloroform and acetone. While, 80% acetone recommended for total phenolic compounds from turmeric, torch ginger and lemon grass compared to 80% acetone, 80% ethanol. Also, water can be extract phenolic compounds (WHANGSOMNUEK et al., 2018; ALBARIDI et al.,2022). From the previous results it can be observed that vinegar and ethanol as a solvent were more efficient than water as a solvent to increase the efficiency of extracting the active compounds from the natural materials responsible for rooting. Ethanol more use in extracting chemical compounds and solvent for many chemical compounds such as phenols (WHANGSOMNUEK et al., 2018); ALBARIDI et al., 2022) and sugars (DUBOIS et al., 1956).

The important of vinegar as solvent for increase efficiency of natural substances come from their acceptance usage in Organic farm (RADHAKRISHNAN et al., 2002; IVANY, 2010; BRAINARD et al., 2013; MATYJASZCZYK, 2018) as well as it was a safety food additives for human (JOHNSTON; GAAS, 2006).

There is no data available in the literature regarding the effect of vinegar as solvent for natural extracts. In addition, vinegar increased rooting efficiency of licorice from 4.47% and 5.47 to 25% and 32.77%, while ethanol extract increased it to 20.17% and 22.70% for both seasons. Also, vinegar solvent increased rooting efficiency of ginger extract from 5.23% and 4.57% to 20.83% and 22.70%, while ethanol solvent increased it to 20.17% and 22.70% in both seasons. Moreover, vinegar increased rooting efficiency of humic substance from 12.03% and 8.33% to 25.03% and 24.67%, while ethanol extract increased it to 27.07% and 24.67% for both. The efficient of vinegar in extracted the root stimulate compounds compared to water may be due to rich content with vitamins and polyphenols, antioxidant activity and organic acids such as acetic acid, tartaric acid, oxalic acid and citric acid, succinic acid) (DAVALOS; OTHERS 2005; NISHINO et al., 2005; GANLIN et al. 2015). The positive point for vinegar may be due to their acidity which contain that may be gave an PH suitable for solube many compounds as well as citric acid content which used to stimulate rooting of cuttings of many plant species (El-SHARONY et al., 2018; GHAZIJAHANI et al., 2017; RASHEDY et al., 2021). While, ethanol solvent succeeded in increasing rooting percent of licorice ginger and humic but it not allowed to use in organic farming yet which depend on natural substances and eco-friendly tools as alternatives to synthetic chemicals.

For the total indole and total phenols in the extraction solution of natural substances, Total indole in the different natural extracts solution showed the relative high total indole content for cinnamon, ginger and willow (leaf and shoot) extracts which support their role as root stimulators. While the study showed the effective of ginger but both of cinnamon and willow extracts had no or little positive effect on olive cuttings rooting. This may be due to natural extract is a complex from tens or hundreds of chemical compounds which may be differ in their activity and effects, which consider one of the most obstacles for using natural substances as root stimulator yet. Also, the results refer to the difference of natural substances solution in total phenol content which is a digamma on their effect on rooting. Since the old theory was more phenol content coincided with low rooting percent (ABD EL HAMEED, 2018; WOJTANIA et al., 2019; ABDEL-RAHMAN et al., 2020), while the modern theory on the opposite side more phenols content stimulate rooting of cuttings (WOJTANIA et al., 2019; DENAXA et al., 2021; GHIMIRE et al., 2022; MARTINS et al., 2022; ABDEL-RAHMAN et al., 2020). The modern theory concluded that phenol effects depend on their type and concentration. Differences of opinion can be solved by the effect of specific phenol type on rooting, Denaxa et al. (2021) reported that, Chromogenic acid, rutin and quercetin have an important effect in the rooting of ‘Arbequina’ cuttings through the protection of IAA degradation during the induction and initiation phases while lower concentration of them in ‘Kalamata’ cuttings may be one of the reasons for the poor rooting.

Also, high rooting percentages coincided with presence of tyrosol, luteolin-7-glycoside, rutin, oleuropein, total sugars, total *o*-diphenols, and total flavanols in ‘Kalamata’ cuttings. Tyrosol, rutin and luteolin-7-glucoside, as well as total o-diphenols protect IAA from oxidation, during root formation

(OSTERC et al., 2009; DENAXA et al., 2021). Moreover, in 'kalamata' olive cultivar, chlorogenic acid considered a possible rooting cofactor (DENAXA et al., 2020). More recently, IBA treatment stimulates the synthesis and accumulation of gentisic acid, protocatechuic acid, biochanin A, chlorogenic acid, salicylic acid, glycitein, caffeic acid and luteolin in *C. indicum* stem cuttings (GHIMIRE et al., 2022). More recently, stated that, the important role of phenolic compounds in adventitious root formation in some olive cuttings (Grappolo 541, Ascolano 315, Santa Catalina, and Maria da F´e) resulted from their presence in the cambial region, since phenolic compounds have close relationships with enzymes related to auxin metabolism and transport (MARTINS et al., 2022). For the content of natural extract of phenols which stimulate root formation, it can be found that Ginger is richest natural substances by containing 4 compounds: chlorogenic (WHANGSOMNUEK et al., 2018), Quercetin (GHASEMZADEH et al., 2010; SEPAHPOUR et al., 2018; GHASEMZADEH et al., 2010) Luteolin 7 glucoside, and quercitin (ALBARIDI et al., 2022) and rutin (GHASEMZADEH et al., 2010). Also, cinnamon contains 3 compounds chlorogenic acid (NGUYEN; STAMPER) quercetin and rutin (JAYAPRAKASHA et al., 2006). Willow containss chlorogenic acid (IKONEN et al., 2001).

From the previous results it can be seen that vinegar and ethanol as a solvent were more efficient than water as a solvent to increase the efficiency of extraction of the active compounds responsible for the rooting of natural materials. Also, ginger contain more phenolic compounds related to root formation as well as relatively high of total indole content. This study do a preliminary fast screen for efficiency of some natural extract in stimulate rooting of cuttings. Thus, more research is necessary in order to further improve the root induction with natural extract in other plants as well as reach to optimum concentration, soaking period, type and content of phenol and optimum mixing of some natural extracts together.

Conclusion

Vinegar and ethanol as solvent were more efficiency than water. Also, humic. Licorice and ginger gave the best results for rooting of cuttings. some of natural extracts suach as ginger, licoricec contain more phenolic compounds which some of them stimulate root formation in addition to some of natural extracts such as ginger, cinnamon willoe contain total indole. Ginger and licorice extracts in vinegar can be used to stimulate rooting of olive cuttings as a safe method in organic farm.

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References

ABD EL HAMEED, N.S. Effect of indole butyric acid (IBA), cutting type and planting date on cuttings rooting of Myrtus communis. **Middle East Journal of Agriculture Research**, Giza, v.7, n.3, p. 1135-45, 2018.

ABDEL-RAHMAN, S.S.A.; ABDUL-HAFEEZ, E.Y.; SALEH, A.M.M. Improving rooting and growth of conocarpus erectus stem cuttings using indole-3-butyric acid (iba) and some biostimulants. **Scientific Journal of Flowers and Ornamental Plants**, Cairo, v.7, n.2, p.109-29, 2020.

ALBARIDI, N.A.; BADR, A.N.;ALI, H.S.; SHEHATA, M.G. Outstanding approach to enhance the safety of ready-to-eat rice and extend the refrigerated preservation. **Foods**, Basel, v.11, p.1928, 2022.

ALI, E.F.; AL-YASI, H.M.; ISSA, A.A.; HESSINI, K.; HASSAN, F.A.S. Ginger extract and fulvic acid foliar applications as novel practical approaches to improve the growth and productivity of damask rose. **Plants**, Basel, v.11, p.412, 2022.

ASL MOSHTAGHI, E.; SILVA, J.A.T. da; SHAHSAVAR, A.R. Effects of foliar application of humic acid and gibberellic acid on mist-rooted olive cuttings. **Fruit, Vegetable and Cereal Science and Biotechnology**, Isleworth, v.5, n.2, p.76-9, 2011.

BRAINARD, D.C.; CURRAN, W.S.; BELLINDER, R.R.; NGOUAJIO, M.; VANGESSEL, M.J.; HAAR, M.J.; LANINI, W.T.; MASIUNAS, J.B. Temperature and relative humidity affect weed response to vinegar and clove oil. **Weed Technology**, Champaign, v.27, n.1, p.156-64, 2013.

BUDAK, N.H.; AYKIN, E.; SEYDIM, A.C.; GREENE, A.K.; GUZEL-SEYDIM, Z.B. Functional properties of vinegar. **Journal of Food Science**, Champaign, v.79, n.5, p.R757-64, 2014.

CENTENO, A.; GOMEZ-del-CAMPO, M. Effect of root-promoting products in the propagation of organic olive *(Olea europaea* L. cv. Cornicabra) nursery plants. **Hortscience**, Alexandria, v.43, n.7, p.2066–9, 2008.

DENAXA, N.K.; PETROS, R.A.; GEORGIOS, K.D.; STAVROS, V.N. Chlorogenic acid: a possible cofactor in the rooting of 'Kalamata' olive cultivar. **Journal of Plant Growth Regulation**, New York, v.40, n.5, p.2017-27, 2020.

DENAXA, N.K.; VEMMOS, S.N.; ROUSSOS, P.A. Shoot girdling improves rooting performance of kalamata olive cuttings by upregulating carbohydrates, polyamines and phenolic compounds. **Agriculture**, London, v.11, p.71, 2021.

DOBBSS, L.B.; CANELLAS, L.P.; OLIVARES, F.L.; AGUIAR, N.O.; PERES, L.E.P.; AZEVEDO, M.; SPACCINI, R.; PICCOLO, A.; FAÇANHA, A.R. Bioactivity of chemically transformed humic matter from vermicompost on plant root growth. **Journal of Agricultural and Food Chemistry**, Washington, v.58, p.3681–8, 2010.

DUBOIS, M.; GILLES, K.A.; HAMILTON, J.K.; REBERS, P.A.; SMITH, F. Colorimetric method for determination of sugars and related substances. **Journal of Analytical Chemistry**, London, v.28, p.350-6, 1956.

EID, A.M.H.; NOMIER, S.A.; IBRAHIM, M.M.; GAD, M.M. Effect of some natural extracts, indolbutiric acid and naphthalene acetic acid on rooting of picual olive cuttings. **Zagazig Journal of Agricultural Research**, Zagazig, v.45, n.1, p.119-36, 2018.

ELMONGY, A.M.S.; ZHOUA, H.; CAOA, Y.; LIUA, B.; XIAA, Y. The effect of humic acid on endogenous hormone levels and antioxidant enzyme activity during in vitro rooting of evergreen azalea. **Scientia Horticulturae**, Amsterdam, v.227, p.234-43, 2018.

EL-SHAIMA, M.; EL-BOTATY AND SALEH, M.M.S. Effect of some natural substances on grape cuttings rooting. **Middle East Journal of Agriculture**, Giza, v.7, n.4, p.1702-9, 2018.

EL-SHARONY, T.F.; RASHEDY, A.A.; ABD ALLATIF, A.M.; HASSAN, S.A.M. Stimulate rooting of guava cuttings by chemical and physical treatments. **Acta Horticulturae**, The Hague, n.1216, p.91-8, 2018.

FAO - Food and Agriculture Organization. **Crops and livestocks products**. Rome, 2022. Disponível em: https://www.fao.org/faostat/en/#data/QCL. Acesso em: 16 maio 2022 .

FAYEK, M.A.; ALI, A.E.M.; RASHEDY, A.A. Water soaking and benzyladenine as strategy for improving grapevine grafting success. **Revista Brasileira de Fruticultura**, Jaboticabal, v.44, n.3, p.e-946, 2022.

FOIDL, N.; MAKKAR, H.P.S.; BECKER, K. The potential of *Moringa oleifera* for agricultural and industrial uses. *In*: FUGLIE, L.J. (ed.). **The miracle tree**: the multiple attributes of moringa. Dakar: Church World Service, 2001. p.45-76.

FREED, R.; EISENSMITH, S.P.; GOETZ, S.; REICOSKY, D.; SMAIL, V.M.; WOLLBERG, P. **MSTAT-C a microcomputer program for the design, management and analysis of agronomic research experiments**. Michigan: Michagen State University, 1990. Disponível em: https://www.msu.edu/~freed/disks.htm.

GAD, M.M.; IBRAHIM, M.M. Effect of IBA and some natural extracts on rooting and vegetative growth of Picual olive sucker and shoot cuttings. **Current Science International**, Giza, v.7, n.2, p.191-203, 2018.

GANLIN, C.; FENGJIN, Z.; JIAN, S.; ZHICHUN, L.; BO, L.; YANGRUI, L. Production and characteristics of high quality vinegar from sugarcane juice. **Sugar Technology**, Amsterdam, v.17, n.1, p.89-93, 2015.

GHASEMZADEH, A.; JAAFAR, H.Z.E.; RAHMAT, A. Identification and concentration of some flavonoid components in malaysian young ginger (*Zingiber officinale* Roscoe) varieties by a high performance liquid chromatography method. **Molecules**, Basel, v.15, p.6231-43, 2010.

GHAZIJAHANI, N.; HADAVI, E.; HWANG, C. H.; JEONG, B. R. Regulating the rooting process of rose softwood cuttings by foliar citric and malic acid spray on stock plants. **Folia Horticulturae**, Berlin, v.29, n.2, p.155-9, 2017.

GHIMIRE, B.K.; KIM, S.; YU, C.; CHUNG, L. Biochemical and physiological changes during early adventitious root formation in chrysanthemum indicum linné cuttings. **Plants**,Basel, v.11, n.11, p.1440, 2022.

GOUVINHAS, I.; MACHADO, N.; SOBREIRA, C.; DOMÍNGUEZ-PERLES, R.; GOMES, S.; ROSA, E.; BARROS, A.I.R.N.A. Critical review on the significance of olive phytochemicals in plant physiology and human health. **Molecules**, Basel, v.22, p.1986, 2017.

GUNJAN, S.; ANART, R. N. Influence of explants type and plant growth regulators on *in vitro* multiple shoots regeneration of laurel from Himalaya. **Nature and Science**, New York, v.7, n.9, p.1-7, 2009.

HAMEED, R.L.; ADIL, A.M. Effect of wounding, auxins and cinnamon extract on the rooting and vegetative growth characteristics of bottle brush plant (*melaleuca viminalis* l.) Cuttings. **Scientific Journal of Flowers and Ornamental Plants**, Cairo, v.6, n.2, p.105-11, 2019.

HASHMI, M.A.; KHAN, A.; HANIF, M.; FAROOQ, U.; PERVEEN, S. Traditional uses, phytochemistry, and pharmacology of *Olea europaea* (olive). Evidence-based complement. **Evidence-Based Complementary and Alternative Medicine**, Oxford, v.2015, p.541591, 2015.

HAYAT, Q.; HAYAT, S.; IRFAN, M.; AHMAD, A. Effect of exogenous salicylic acid under changing environment: a review. **Environmental and Experimental Botany**, Oxford, v.68, n.1, p.14-25, 2010.

HUSSAIN, K.; QADRI, R.; AKRAM, M. T.; NISAR, N., IQBAL, A.; YANG, Y.; KHAN, M. M.; KHAN, R.I.; IQBAL, M.A. Clonal propagation of olive (olea europeae) through semi- hardwood cuttings using iba under shaded polyethylene tunnels (spts). **Fresenius Environmental Bulletin**, Basel, v.29, n.9a, p.8131-7, 2020.

IKONEN, A.; TAHVANAINEN, J.; ROININEN, H. Chlorogenic acid as an antiherbivore defence of willows against leaf beetles. **Entomologia Experimentalis et Applicata,** *v.*99, p.47–54, 2001.

IVANY, J.A. Acetic acid for weed control in potato (*Solanum tuberosum* L.). **Canadian Journal of Plant Science**, Ottawa, v.90: p.537-542, 2010.

JAYAPRAKASHA, G.K.; OHNISHI-KAMEYAMA, M.; ONO, H.; YOSHIDA, M.; YOSHIDA, M.; RAO, L.J. Phenolic Constituents in the Fruits of *Cinnamomum zeylanicum* and Their Antioxidant Activity. **Journal of Agricultural and Food Chemistry,** v.54, n.5,p1672-1679, 2006.

JOHNSTON, C.S.; GAAS C.A. Vinegar: medicinal uses and antiglycemic effect. **MedGenMed: Medscape General Medicine**, New York, v.8, n.2, p.61, 2006.

KISIRIKO, M.; ANASTASIADI, M.; TERRY, L.A.; YASRI, A.; BEALE, M.H.; WARD, J.L. Phenolics from medicinal and aromatic plants: characterisation and potential as biostimulants and bioprotectants. **Molecules**, Basel, v.26, p.6343, 2021.

LARSEN, P.; HARBO, A.; KLUNGRON, S.; ASHEIN, T.A. On the biosynthesis of some indole compounds in Acetobacter Xylinum. **Physiologia Plantarum**, Copenhagen, v.15, p.552-65, 1962.

MATYJASZCZYK, E. Plant protection means used in organic farming throughout the European Union. **Pest Management Science**, Sussex, v.74, n. p.505-10, 2018.

MOHAMMED, A.A. Application of different concentrations of licorice and willow extracts as rooting stimulator in hardwood cuttings of olive (*Olea europaea* L.). **International Journal of Environment, Agriculture and Biotechnology**, Geneva, v.6, n.6, p.58-63, 2021.

MUSTAFA, H.A.; AHMAD, T.A.; MOHAMMED, A.A.; LAZIM, Z.S.; IBRAHIM, C.O.; KAKBRA, R.F.; SALIH, S.R. Effect of some plant extracts on hardwood cuttings of Bottlebrush (Callistemon viminalis). **Euphrates Journal of Agriculture Science**, Al Qasim, v.13, n.3, p.98, 2021.

NISHINO, H.; MURAKOSHI, M.; MOU, X.Y.; WADA, S.; MASUDA, M.; OHSAKA, Y.; SATOMI, Y.; JINNO, K. Cancer prevention by phytochemicals. **Oncology**, Basel, v.69, p.38-40, 2005.

OSTERC, G.; STEFANCIC, M.; STAMPAR, F. Juvenile stock plant material enhances root development through higher endogenous auxin level. **Acta Physiologiae Plantarum**, Heidelberg v.31, p.899-903, 2009.

RADHAKRISHNAN, J.; TEASDALE, J.R.; COFFMAN, C.B. Vinegar as a potential herbicide for organic agriculture. *In*: ANNUAL MEETING OF THE NORTHEASTERN WEED SCIENCE SOCIETY, 2002, **Proceedings** [...]. King Ferry: Northeastern Weed Science Society, 2002.

RADY, M.M.; DESOKY, E.S.; ELRYS, A.S.; BOGHDADY, M.S. Can licorice root extract be used as an effective natural biostimulant for salt-stressed common bean plants. **South African Journal of Botany**, Pretoria, v.121, p.294-305, 2019.

RAJAN, R.P.; SINGH, G. A review on the use of organic rooting substances for propagation of horticulture crops. **Plant Archives**, Etawah, v.21, p.685-92, 2021. Supl. 1

RASHEDY, A.A.; ABD-ELNAFEA, M.H.; KHEDR, E.H. Co-application of proline or calcium and humic acid enhances productivity of salt stressed pomegranate by improving nutritional status and osmoregulation mechanisms. **Scientific Reports**, London, v.12, n.14285, 2022.

RASHEDY, A.A.; ELDEEB, W.A.M.; HAMED, H.H. Antioxidant procedure improve olive cuttings rooting during the cool season**. Egyptian Journal of Horticulture**, Cairo, v.48, n.2, p.267-75, 2021.

SACHAN, D.; JAIN, S. K.; SINGH, N. *In vitro* and *in vivo* efficacy of *Moringa oleifera* plant constituents in urolithiasis as antilithiatic drug. **International Journal Of Pharma Sciences And Research,** Chennai, v.2, n.7, p.1638-44, 2011.

SCAGLIA, B.; NUNES, R. R.; REZENDE, M. O. O.; TAMBONE, F.; ADANI, F. Investigating organic molecules responsible of auxin-like activity of humic acid fraction extracted from vermicompost. **Science of the Total Environment**, Amsterdam, v.562, p.289-95, 2016.

SEPAHPOUR, S.; SELAMAT, J.; ABDUL MANAP, M.Y.; KHATIB, A.; ABDULL RAZIS, A.F. Comparative analysis of chemical composition, antioxidant activity and quantitative characterization of some phenolic compounds in selected herbs and spices in different solvent extraction systems. **Molecules**, Basel, v.23, n.2, p.402, 2018.

SHARMA, A.; SHAHZAD, B.; REHMAN, A.; BHARDWAJ, R.; LANDI M.; ZHENG, B. Response of phenylpropanoid pathway and the role of polyphenols in plants under abiotic stress. **Molecules**, Basel, v.24, p.1-22, 2019.

MARTINS, M.; GOMES, A.F.G.; DA SILVA, É.M. ; DA SILVA, D.F.; PECHE, P.M.; MAGALHÃES, T.A.; PIO, R. Effects of anatomical structures and phenolic compound deposition on the rooting of olive cuttings, **Rhizosphere**, v.23, 100557,2022.

SNEDECOR, W.; COCHRAN, W.G. **Statistical methods**. $8^{th.}$ Iowa: Iowa State University Press, 1989. 503p.

TARTOURA, E.A.A. Response of pea plants to yeast extract and two sources of N fertilizers. **Journal of Agricultural Science**, Mansoura, v.26, n.12, p.7887-7901, 2001.

TREVISAN, S.; BOTTON, A.; VACCARO, S.; VEZZARO, A.; QUAGGIOTTI, S.; NARDI, S. Humic substances affect Arabidopsis physiology by altering the expression of genes involved in primary metabolism, growth and development. **Environmental and Experimental Botany**, Elmsford, v.74, p.45-55, 2011.

WHANGSOMNUEK, N.; MUNGMAI, L.; MANGUMPHAN, K.; AMORNLERDPISON, D. Bioactive compounds and its biological activity from leaves of torch ginger for value added as cosmetic product. *In*: GCIC, 2, NATIONAL, 46, INTERNATIONAL GRADUATE RESEARCH CONFERENCE, 9, 17-18 maio 2018, Chiang Mai. **Proceedings** [...] Chiang Mai: Maejo University, 2018.

WISE, K.; GILL, H.; SELBY-PHAM, J. Willow bark extract and the biostimulant complex Root Nectar® increase propagation efficiency in chrysanthemum and lavender cuttings. **Scientia Horticulturae**, Amsterdam, v.263, p.109108, 2020.

WOJTANIA, A.; SKRZYPEK, E.; MARASEK-CIOLAKOWSKA, A. Soluble sugar, starch and phenolic status during rooting of easyand difficult-to-root magnolia cultivars. **Plant Cell, Tissue and Organ Culture**, Dordrecht, v.136, p.499-510, 2019.

YEH, H.; CHUANG, C.; CHEN, H.; WAN, C.; CHEN, T.; LIN, L. Bioactive components analysis of two various gingers (*Zingiber officinale* Roscoe) and antioxidant effect of ginger extracts. **LWT—Food Science and Technology**, London, v.55, p.329-34, 2014.

ZHANG, X.Z.; ERVIN, E.H. Cytokinin-containing seaweed and humic acid extracts associated with creeping bentgrass leaf cytokinins and drought resistance. **Crop Science**, Madison, v.5, p.1737-45, 2004.