Analysis of Productivity Indicators of Helwani and Zeni Grape Varieties (*Vitis vinifera* L.) as Affected by Foliar Spray with Different Concentrations of Humic Acid

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Abstract:

This research was conducted in the village of Sejar, located in Idlib province, during the agricultural season 2022. This study aimed to investigate the productivity indicators of Helwani and Zeni grape varieties under the influence of foliar spray with two different concentrations of humic acid (5, 15 mL/L) and control (0 mL/L). A completely randomized design (CRD) was employed to distribute the experimental replications.

The results indicated that Helwani variety outperformed in several productivity indicators such as shoot length (146.3 cm), internode length (5.1 cm), number of internodes per shoot (27.7), bunch weight (469.7 g), bunch volume (456.7 cm³), number of berries per bunch (65.8), and pH (4.38). On the other hand, Zeni variety exhibited superiority interms of the number of bunches (72.1), berry weight (6 g), berry volume (5.75 cm³), 1000-seed weight (64.13 g), total productivity (24.3 kg/shrub), and TA (0.3%). Moreover, foliar spray with a concentration of 5 mL/L of humic acid showed significant superiority in the number of bunches (83), 1000-seed weight (61.5 g), and total productivity (31.9 kg/shrub) comparedto the other concentrations (0 and 15 mL/L). Additionally, a concentrationof 15 mL/L of humic acid exhibited significant superiority in TA (0.28%) compared to the other two concentrations (0 and 15 mL/L). The concentration of 15 mL/L also showed significant superiority in traits such as internode length (4.9 cm), bunch weight (455.8 g), bunch volume (345.1 cm³), number of berries (69.8), and berry volume (5.8 cm³) compared to the control (0 mL/L).

In terms of the interaction between experimental factors, spray Helwani variety with a concentration of 5 g/L of humic acid showed significant superiority in shoot length (165.3 cm), number of internodes per shoot (29.7), TSS (16.5%), and TS (14.8%). Similarly, spray the same variety with a concentration of 15 mL/L resulted in the highest values for internode length (5.6 cm), bunch weight (518.6 g), bunch volume (510.4 cm³), and number of berries per bunch (91). Furthermore, spray Zeni variety with a concentration of 5 mL/L of humic acid yielded the highest values in leaf area (87.6 cm²), number of bunches (103.7), 1000-seed weight (75.1 g), and total productivity (34.7 kg/shrub). Conversely, spray with a concentration of 15 mL/L exhibited the highest values for berry weight (6.4 g), berry volume (5.9 cm³), and TA (34%).

Keywords: Grape, Helwani variety, Zeni variety, Foliar spray, Humicacid, Productivity

تحليل المؤشرات الإنتاجية لصنفي العنب (*Vitis vinifera* L.) حلواني وزيني بتأثير الرش الورقي بعدة تراكيز من حمض الهيوميك

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الملخص:

أُجريَ البحث في قرية سيجر التابعة لمحافظة إدلب خلال الموسم الزراعي 2022، بهدف دراسة المؤشرات الإنتاجية لصنفي العنب حلواني وزيني بتأثير الرش الورقي بتركيزين من الهيوميك (5، 15 مل/ل) والشاهد (0 مل/ل)، واعتمد التصميم العشوائي الكامل في توزيع مكررات التجربة.

تشير النتائج إلى تفوق الصنف الحلواني في مؤشرات طول الفرع (146.3 سم)، طول السلامية (5.1 سم)، عدد السلاميات (27.7)، وزن العنقود (469.7 غ)، حجم العنقود (456.7 سم3)، عدد الحبات بالعنقود (65.8)، ودرجة الحموضة (4.38). بينما تفوق الصنف الزيني في عدد العناقيد (72.1)، وزن الحبة (6 غ)، حجم الحبة (5.75 سم^3)، وزن الألف بذرة (64.13 غ)، الإنتاجية الكلية (24.3 كغ/شجرة)، والحموضة الكلية (0.3%). من جهة أخرى، أظهر الرش بحمض الهيوميك تركيز 5 غ/ل تفوقاً معنوياً في عدد العناقيد (83)، وزن الألف بذرة (61.5 غ)، والإنتاجية الكلية (31.9 كغ) مقارنة بالتراكيز الأخرى (0 و15 مل/ل). بينما أظهر تركيز رش 15 مل/ل تفوقاً معنوياً في نسبة الحموضة الكلية (0.28%) على التركيزين الآخرين (0 و15 مل/ل). كما أظهر تركيز 15 مل/ل تفوقاً معنوياً في صفات طول السلامية (4.9 سم)، وزن العنقود (455.8 غ)، حجم العنقود (345.1 سم^3)، عدد الحبات (69.8)، وحجم الحبة (5.8 سم^3) على التركيز 0 مل/ل (الشاهد).

وباختبار تفاعل العوامل التجريبية، أظهر رش الصنف الحلواني بالهيوميك تركيز 5 غ/ل تفوقاً معنوياً في صفات طول الفرع (165.3)، عدد السلاميات في الفرع (29.7)، المواد الصلبة الذائبة الكلية (16.5%)، والسكريات الكلية (14.8%). بينما أظهر رش نفس الصنف بتركيز 15 مل/ل أعلى قيمة في صفات طول السلامية (5.6 سم)، وزن العنقود (518.6 غ)، حجم العنقود (510.4 سم^3)، وعدد الحبات بالعنقود (91). أما رش شجيرات الصنف الزيني بالهيوميك تركيز 5 مل/ل، فأعطى أعلى قيمة في صفات مساحة الورقة (87.6 سم^2)، عدد العناقيد (103.7)، وزن ألف بذرة (75.1 غ)، والإنتاجية الكلية (34.7 كغ/شجرة). أما الرش بتركيز 15 مل/ل، فأظهر أعلى قيمة في صفات وزن الحبة (6.4 غ)، حجم الحبة (5.9 سم3)، والحموضة الكلية (0.34%).

الكلمات المفتاحية: العنب، حلواني، زيني، الرش الورقي، الهيوميك، الإنتاجية.

1- Introduction:

Grapes hold a special importance and prominent position among fruit shrubs due to their successful cultivation in various environmental conditions (FAO, 2007). Grapevine adapts well to different lighting conditions and can be successfully grown in full sun or partial shade. (Atef, 1987) stated that grape cultivation is widespread in the northern hemisphere between the latitudes 20 and 51 degrees north, while in the southern hemisphere, it grows between the latitudes 20 and 40 degrees south. *Vitis* species share several common characteristics, climbing plants through internodes that usually emerge from the third, fourth, or fifth node. They have two consecutive nodes carrying internodes, followed by a node without internodes, and then two nodes carrying internodes again. European grapes are divided into wild European grapes (*Vitis vinifera* ssp. *Silvestris*) and cultivated European grapes (*Vitis vinifera* ssp. *Sativa*). The cultivated grape varieties include all globally known or local varieties in any production region, and these varieties have their direct origin from wild grapes in different regions or are the result of hybridization between agricultural varieties, or they may be the result of mutations (Gabriel, 2004). The Syrian grape traces its origin back to the European type known as *Vitis vinifera* L. (Hamed *et al*., 1998). Grapes are of great nutritional importance, as they contain a high percentage of carbohydrates (18%) and very low amounts of fats (0.16%), proteins (0.72%), and fibers (0.9%). In addition, they contain vitamins (Vitamin A: 66 IU, Vitamin B complex: 2.6 mg, Vitamin C: 10.8 mg, Vitamin E: 0.19 mg, Vitamin K: 14.6 mg/100g fresh matter) and mineral salts (Potassium: 191 mg, Calcium: 10 mg, Copper: 0.13 mg, Iron: 0.36 mg, Magnesium: 7 mg, Manganese: 0.07 mg, Zinc: 0.07mg) (A.O.A.D., 2020).

Humic substances have been widely used globally in agriculture as organic growth stimulants for several decades. Their usage has significantly increased in Syria during the past decade, especially in greenhouse vegetable cultivation and open-field agriculture, as well as in fertilizing grapevines. According to (Abu Nukta,1995), humic acids are complex organic compounds that result from the decomposition of organic materials in the soil by microorganisms, and they are also known as "black gold." They are divided into humic acid and fulvic acid, classified based on their acidity and solubility in water. These acids constitute about 22% of the organic matter content in the soil (Yildirim, 2007). According to (Atiyeh *et al*., 2002) humic acids affect the soil and plants through three pathways: the physical effect by enhancing the soil's water retention capacity, improving its aeration, and resistance to drought; the chemical effect by forming beneficial complexes with nutrients to facilitate their ptake by plants, increasing ion exchange and nitrogen levels in the soil; and the biological effect by stimulating cell division in plants, activating growth, and enhancing seed germination and growth. Humic acids form complexes with mineral ions and also enhance plant enzymes and stimulate DNA metabolism and hormonal activity. These are some hypotheses that explain the positive effects of humic acid on plant growth (Turkmen *et al*., 2004).

2- Research Justification and Objectives:

2.1- Justification:

The varieties of Helwani and Zeni grapes are generally the most widespread in Syria in general, particularly in northwestern Syria. However, the area cultivated with grapes has been continuously decreasing due to population growth in the region and the shift of focus to other shrub or plant species at the expense of grapevines. Consequently, the current trend focuses on vertical expansion and increased productivity per unit area. To achieve this expansion, globally recognized safe organic compounds are used. These compounds are considered safe as they do not leave any residual effects, do not harm the environment or plants, and do not affect human health. Accordingly, this research was conducted to study the effect of foliar application of humic acid on the growth and productivity of Helwani and Zeni grape varieties.

2.2- Objectives:

This research aims to:

1) Study the effect of the different concentrations of the sprayed substance on the growth and productivity of Helwani and Zeni grape varieties. Evaluation of their impact on growth characteristics such as size increase, weight, leaf development, and fruit development.
2) Compare the response of Helwani and Zeni grape varieties to the treatment with humic acid. Evaluation of the different effects on growth and productivity characteristics. This aims to determine the most responsive variety and understand the variations in their response to humic acid.

Achieving these objectives will contribute to a better understanding the effect of foliar spray of on grape growth and productivity, and it will allow for determining the optimal concentration to achieve the desired results. Additionally, the research will provide valuable information for farmers and researchers to make better decisions in selecting the appropriate variety and using humic acid correctly to improve grape cultivation and increase productivity.

3- Literature Review:

Humic acids are complex compounds obtained from decomposed organic materials (Morales-Payan, 1998). Humates are the most widespread type of humic substances and are commercially prepared products typically composed of 40% humic acids and 60% leonardite, which is a plant-derived material containing humates and fulvates. Commercial humates are likely a mixture of humic acids, fulvic acids, humins, and other substances found in leonardite deposits (Stevenson, 1994; Tan, 1998; Garcia-Mina *et al.,* 2004). (Lee and Bartlett, 1976) and (Larcher, 2003) stated that humic acids are natural, heterogeneous substances with colors ranging from yellow to black, high molecular weights, and slow solubility. Commercial humic acid products have concentrations ranging from 0.5% to 4% nitrogen, 6% to 8% hydrogen, 26% to 42% oxygen, and 44% to 58% carbon, along with various other elements (Garcia-Mina *et al*., 2004).

(Majeed, 2010) pointed out that compost fertilizers are distributed and structured in clay-like plates and contain negatively charged sites that play a crucial role in cation exchange processes. Compost fertilizers also contain nutrients, humic acids, and humins. Upon foliar application of compost fertilizers, the available organic nutrients are taken up and absorbed by the leaves through stomata and intercellular spaces in the cell wall, reaching the plasma membrane and mesophyll cells. Humic acids are a natural mixture of similar humic acids that coexist and are extracted together, but they differ in composition and preparation methods depending on the source. Humic acids have high molecular weights and contain numerous active groups. When applied to leaves, humic acids directly provide amino acids, thereby increasing protein synthesis and contributing to plant growth. Humic acid enhances the effectiveness of vital biological and physiological processes for growth and contains the quinone group, which acts as a hydrogen receptor, promoting enzyme activity and contributing to both photosynthesis and respiration processes (Dantas *et al.,* 2007).

(Arnaout and Najari *et al*., 2008) indicated that foliar application of humic acid on the vegetative mass contributes to increase water use efficiency in crop irrigation. Humic acid also enhances membrane permeability, thereby promoting water and nutrient absorption (Osman *et al*., 2010; Pinton *et al*.,1992).

Leaves serve as central sites for numerous metabolic processes, in addition to their capacity to absorb nutrients like roots (Peuke *et al*., 1998). Nutrient absorption through leaves occurs through two methods: either through symplastic uptake, where it happens via plasmodesmata or cytoplasmic bridges present beneath the leaf cuticle layer of epidermal cells, subsequently transferring to other plant parts, or through apoplastic uptake, where it occurs via stomata or intercellular spaces between leaf cells, reaching the transport vessels and eventually other plant parts (Sahaf, 1989). (Ferrara and Brunetti, 2010) reported that the application of humic acid on Italia cultivar during the full flowering stage resulted in a significant increase in grape size (width and weight) and improved other quality parameters such as total acidity and sugar/total acidity ratio.

(Martin, 2002) emphasized the importance of adding nutrients in multiple doses rather than applying the total amount at once. This is due to the risks associated with applying large quantities of fertilizers in a single application, which can harm the plant's leaves. Consequently, fertilizer management using this method carries practical risks in the fields. Therefore, it is the researcher's responsibility to study the nature and behavior of fertilizers to ensure desired benefits with minimal plant risks. Additionally, (Turkmen *et al*., 2004) demonstrated that the application of humic acid during the full flowering stage led to a significant increase in grain size (width and weight) and improved other quality parameters such as total acidity and sugar-to-total acidity ratio.

According to (Al-Joborry, 2022), foliar nutrition does not affect vital processes that occur within the leaf, such as respiration and photosynthesis. On the contrary, it improves productivity both quantitatively and qualitatively. It helps prevent the depletion of nutrients within the leaves, which positively ensures and positively impacts plant growth. Furthermore, biostimulants contribute to enhancing plants' natural resistance to diseases and promoting plant growth and development. These biostimulants can be applied directly to plants or added to the soil. Biostimulants are considered a natural source, and their use significantly reduces the need for chemical inputs in the food chain (Rafiee *et al.*, 2016). Humic acids can be used in plant nutrition as they enhance growth and productivity and have a similar effect on plants as plant growth regulators like indole acetic acid (Arancon *et al*., 2006). Studies have shown that the use of humic acids increases the plant's content of cytokinins and auxins, promoting plant growth and development (Zhang and Ervin, 2004).

However, there are still proposed explanations for the activity of humic acids in promoting plant growth. One of these explanations is that humic acid increases cell membrane permeability, which is necessary for nutrient transport and availability, nutrient absorption, and respiration in plants (Serenella *et al*., 2002). It is also believed to contribute to root cell elongation and phosphate uptake and to influence photosynthesis, protein synthesis, and DNA in plants (Kristeva *et al*., 1967; Jackson, 1993). Moreover, it has been postulated that humic acids play a pivotal role in facilitating the exchange of cations, thereby promoting their retention and increasing nutrient accessibility, consequently resulting in enhanced plant growth (Chunhua *et al.,* 1998).

Humic acids can be used in foliar fertilization due to their similar effects to other plant growth factors. Studies have shown that foliar application of humic acids increases the plant's water-holding capacity, improves photosynthetic processes, enhances antioxidants in photosynthesis, increases root length and leaf area, and contains organic compounds that promote plant growth, productivity, and root system development (El-Hefny, 2010).

Studies also indicate that humic acids activate certain enzymes, inhibit others, enhance plant resistance to harsh environmental conditions such as high temperatures and salinity, improve cell membrane permeability, and stimulate biochemical reactions in plants (Shalash *et al*., 2011).

A study by (Nardi *et al*., 2002) indicated that the use of humic and fulvic acids on plants leads to improvement in the quantitative and qualitative characteristics of fruits. This is attributed to the increase in respiratory processes, photosynthetic activity, and total protein in plants. Furthermore, in another study conducted by (Omar and Abdelall, 2005), it was found that humic acid application at different concentrations (15, 22.5, 30) g/L, divided into four doses, and irrigating the plants with different amounts (up to 40 L/plant) for varying periods, increased the carbohydrate content of stems, leaf area, length of the shoots, and length and diameter of the internodes in the Superior Labrusca Grape Variety.

Additionally, another study conducted by (Gouda and El-Zahraa, 2022) demonstrated that humic acid, in addition to turmeric or selenium, effectively improves the vegetative growth, yield, and bunch characteristics of plants. These treatments also significantly improved fruit quality, including increased fruit weight and total soluble solids, and reduced sugar content in the fruits compared to those not sprayed. The best results were obtained when using humic acid or turmeric extract at a concentration of 0.1%.

Moreover, (Asgharzade and Babaeian, 2012) showed, through a field experiment conducted in 2010 to study the effect of different concentrations of foliar-applied humic acid on the yield and leaf nutrient content of grapes, that the foliar application treatments had a significant impact on the yield, bunch length, diameter, and leaf content of iron, potassium, and phosphorus. The highest quantity of fruits was obtained when using the T3 group (humic acid), while the lowest quantity was recorded in the T1 group (control). The highest values for grape bunch length, diameter, and leaf iron content were recorded in the T4 group (acetic acid + humic acid), while the maximum phosphorus and potassium values were recorded in the T3 group (humic acid). The lowest values for all traits were recorded in the T1 group.

(Omar *et al.*, 2022) conducted a study to evaluate the effect of different concentrations of sugarcane molasses (10, 15, 20 cm3/100 L) and Canada Humex product (2, 4, 6 g humic acid/100 L) on the yield and quality of (flames) seedless grapes during 2018 and 2019 seasons. Foliar spray was applied three times at intervals of 10 days after the grape bud break. The results showed an improvement in overall yield and fruit quality compared to the control during both seasons. The most pronounced effects were observed when using two concentrations of sugarcane molasses (20 cm3/100 L and 15 cm3/100 L), followed by the Canada Humex product (13% humic acid + fulvic acid) at a concentration of 4 g/100 L.

According to a study by (Aly *et al.*, 2021), it was discovered that the use of 7.5 g/shrub of humic acid and foliar spray with calcium carbonate nanoparticles twice, two weeks and four weeks after fruit set, resulted in achieving the best values in several traits. These treatments recorded the highest values in terms of bunch weight, the number of bunches per shrub, shrub productivity, morphological indicators such as bunch length and width, juice quantity per 100 berries, berry firmness, the chemical composition including soluble solids, soluble solids-to-acidity ratio, vitamin C content, and carbohydrates. These results were compared to the control treatment, which recorded the lowest values for those traits during both seasons.

In a study conducted by (Sabir *et al*., 2021) to compare the effect of foliar spray with urea, humic acid powder, and vermicompost (liquid earthworm fertilizer) on 4-year-old Alphonse Lavallée grapevines, the treatments showed a significant increase in shoot length and grape skin thickness. The highest bunch weight was obtained by using vermicompost and humic acid with similar effects. These treatments significantly enhanced berry detachment force and skin tearing, which are essential characteristics determining the quality of table grapes.

In their study on the effect of foliar spray with different levels of yeast and potassium humate on the growth and development of the "Sabe'i" grape variety, (Al-Mustou, 2018) found that foliar spray with a concentration of 6 g/L of yeast was superior in terms of the percentage increase in vegetative growth (251.6%), leaf surface area (53.16 cm^2), and root length (34.69 cm) compared to the control group. Additionally, foliar spray with a concentration of 2 mL/L of potassium humate solution showed significant superiority in the percentage increase in vegetative growth (131.8%), the percentage increase in the number of shoots (221.1%), total chloropHyll concentration (4.37 mg/g), root length (37.52 cm), and dry weight of roots (19.24 g) compared to the control group.

(Saleh *et al*., 2006) confirmed that increasing the amount of added humic acids, whether in the form of soil fertilizer or foliar solution, led to an increase in phosphorus concentration in grape leaves compared to plants that received only mineral fertilization, while potassium content decreased compared to the control.

Furthermore, (Linechan, 1976) and (Balasubramanian *et al*., 1989) explained that the increase in leaf number, root length, and overall green mass can be attributed to increased cell division and cell expansion due to the accumulation of humic acid.

(Kassem et al., 2002) demonstrated that foliar spray with humic acid on grapes at two concentrations (5 and 20 mL/L) had a slight effect on growth. However, they observed a clear increase in the content of chlorophyll and nitrogen in the leaves. An increase in yield was also recorded. These results indicate that the use of humic acid in foliar spray improves leaf composition and increases the quantity of nutrients such as chlorophyll and nitrogen, ultimately leading to increased production. However, it is important to consider the concentration used and specific growth conditions to achieve the best results.

4- Materials and Methods:

4-1- Study Location: The research was conducted in one of the fields in the town of Sijar, located approximately 10 km west of Idlib City in the Al-Rouj Plain region, with an annual rainfall of 450 mm.

4-2- Plant Material: The study was carried out on non-grafted grapevines, specifically on two grape varieties:

- **Zeni**: Belongs to late-maturing table grape Varieties with good taste. It can withstand long-distance shipping.
- **Helwani**: The vine is characterized by heavy fruiting, and its fruits have a reddish-green color. The fruits are firm with thick skin, making them more transportable and storable without damage.

4-3- Experimental procedures:

The grapevines were pruned on February 20, 2022, using a (2/5) pruning method. They were then sprayed with winter oil on March 1, 2022. The vines were irrigated using irrigation canals, and nitrogen fertilizer was added on April 14, 2022. Fungicides were applied alternately in the fifth month to control powdery and downy mildew. Boron and micronutrients were sprayed in the fifth and seventh months, and fungicides for gray mold were sprayed in the seventh and eighth months.

4-4- Experimental treatments:

- Factor 1 (Varieties): The study was conducted on two grape varieties, Zeni and Helwani.
- Factor 2 (Treatment Concentration): Three concentrations of humic acid were used (0, 5, and 15 mL/L).

4-5- Methodology:

The humic extract was prepared by adding water to humic acid (according to the desired concentration). A spreading agent was also added to facilitate the dispersion and adhesion processes. The spray was carried out using a backpack sprayer, and the spray process continued until the complete wetting of the treated shrubs (at a rate of 5 liters per shrub). This was done early in the morning, and the foliar spray was conducted in three stages:

1- The first spray before flowering (May 1, 2022).
2- The second spray after the berry set (June 1, 2022). 3- The third spray before maturity (July 23, 2022).

4-6- Parameters and characteristics measured:

The study relied on the characterization of the International Plant Genetic Resources Institute (IPGRI, 1983) and the method developed by Galet, a researcher at the Faculty of Agriculture, University of Montpellier in France, as well as the characterization by (Manzo and Tamponi, 1987). The morphological traits of the grape varieties were studied by selecting three closely-aged vines from each treatment. Thirty leaves were taken between the eighth and eleventh nodes when the shoot growth ceased. Regarding the bunches, ten bunches were taken from each variety. As for the berries, 100 mature berries were taken from the central region of each bunch, and the same was done for the seeds, where 1000 fully formed seeds were collected. Initially, the grapes (berries) were crushed using a fruit blender, and the crushed sample (20 g) was diluted with distilled water up to 250 mL. Based on this, the following measurements and characteristics were taken:

4-6-1- Measurements of vegetative growth:

1. Leaf Area (LA): Image-J software was used on a computer device (Schneider *et al.*, 2012).
2. Length of vegetative shoots (LS): The length of the shoot at the end of the growing season was measured using a metric scale.
3. Number of internodes per shoot (NI): Ten measurements were taken for each treatment.
4. Length of internode per shoot (LI): Ten measurements were taken for each treatment.

4-6-2- Measurements of productivity:

1. Number of bunches per shrub (NB).
2. Weight of a single bunch [g] (WB): The weight of 10 bunches was measured using a sensitive balance for each replication, and then the average weight of a single bunch was calculated.
3. Volume of a single bunch [cm^3] (VB): Measured using the water displacement method.
4. Number of berries per bunch (NBe): Three bunches were counted

for each treatment, and then the average number of berries per bunch was calculated.

5. Weight of a single berry [g] (WBe): Based on 100 berries taken from the middle part of the bunch and from 10 bunches, the weight of the berries was calculated.
6. Volume of a single berry [cm^3] (VBe): Measured using the water displacement method.
7. Weight of 1000 Seeds [g] (WS).
8. Total yield per shrub [kg] (TY): Calculated by multiplying the average number of fruit bunches per vine by the weight of a single bunch.

4-6-3-The qualitative measurements of the fruits:

1. Total soluble solids (TSS%): Measured using a refractometer. 1-2 drops of the clarified grape juice were added to the refractometer for measurement.
2. Total acidity (TA%): The total acidity was calculated using the following equation:

Total Acidity % = [(0.1 × base titer value) × malic acid constant (0.075) × titration volume in the consumer] / (sample volume) × 100

Previous studies such as (Watkins *et al.*, 1995) and (Graham *et al.,* 2004) were considered for estimating total acidity.

3. Total Sugars (TS%): Estimated by titrating 25 mL of the prepared filtrate in a 100 mL volumetric flask and then completing the volume to the mark with distilled water. A precise 10 mL of a 3.3% potassium ferricyanide ($K_3Fe(CN)6$) solution and 5 mL of a 10% sodium hydroxide (NaOH) solution, were added to another flask. The mixture was heated to boiling and a 1% methylene blue indicator was added. The resulting mixture was titrated with a known 2% glucose solution until the color of the solution disappeared. Total sugars (reference sugar + sugar resulting from sucrose hydrolysis) were calculated according to the method described by (Cantarelli *et al.*, 2008) and (Al *et al.*, 2009) and (Al-Kheirat, 2015).

$$\text{Reducing sugar } \% = (3.3 \times V \times C) / (Q \times W)$$

Where:

Reducing sugar %: Percentage of reducing sugar.

V: Volume of the flask used in the calibration process.

C: Concentration of the glucose sugar solution used for calibration.

Q: Quantity of the consumed glucose sugar solution.

W: Weight of the sample.

4. pH: The acidity degree was measured using a pH-Meter. Grape juice was obtained and placed in a cup for measurement after calibrating the device.

4-7 -Experimental design and statistical analysis:

The experiment was conducted on 18 grapevines (Helwani, Zeni), with 9 vines of each variety. Three treatments were applied based on spray concentration (0, 5, 15 mL/L). Each treatment had three grapevines. Therefore, the total number of grapevines used in the experiment was 2 × 3 × 3 = 18.

A completely randomized design (CRD) was used in this study. The data were analyzed using the statistical software GenStat V-12. Means were compared using the least significant difference (L.S.D.) test at a significance level of 5% for field readings and 1% for laboratory experiments. The correlation coefficient (r) was calculated using the SPSS software.

5- Results and Discussion:

5-1- Effect of Foliar Application of Humic Acid on Growth Traits of "Helwani" and "Zeni" Grape Varieties:

Table (1): Effect of Foliar Application of Humic Acid on Some Growth Traits

Treatment \ Trait		LA* (cm^2)	LS (cm)	LI (cm)	NI
Helwani		79.8	146.3	5.1	27.7
Zeni		83.5	79.2	4.0	19.4
LSD 5% (Varieties)		3.9	29.6	0.4	4.7
0 (Ctrl)		77.6	109.0	4.03	24.7
5 mL/L		85.7	126.5	4.8	25.2
15 mL/L		81.6	102.8	4.9	20.7
LSD 5% (Levels)		4.9	35.0	0.5	5.7
Helwani	**0 (Ctrl)**	78.7	131.8	4.3	27.2
	5 mL/L	83.9	165.3	5.4	29.7
	15 mL/L	76.9	141.9	5.6	26.1
Zeni	**0 (Ctrl)**	76.5	86.1	3.8	22.1
	5 mL/L	87.6	87.7	4.2	20.7
	15 mL/L	86.4	63.7	4.2	15.3
LSD 5% (V x L)		6.9	49.6	0.7	8.1
C.V. (%)		4.8	24.7	8.1	19.4

** Leaf Area (LA). * Length of vegetative shoots (LS)*
*Number of internodes per shoot (NI) * Length of internode per shoot (LI)*

From Table (1), it can be observed that foliar application of humic acid to "Helwani" grape shrubs showed significant superiority over "Zeni" grape shrubs in terms of shoot length, internode length, and number of internodes per shoot, with values of 146.3 cm, 5.1 cm, and 27.7, respectively. However, there were no significant differences between the two varieties in terms of leaf area (cm^2).

Furthermore, spray grape shrubs with humic acid at aconcentration of 5 mL/L resulted in a significant increase in leaf area (85.7 cm^2) compared to the control group. Additionally, the 15 mL/L concentration showed a significant increase in internode length (4.9 cm) compared to the control. However, there were no significant differences inshoot length and number of internodes per shoot among the studied spray levels (Table 1).

Regarding the interaction between the experimental factors (Table 1), foliar spray of "Helwani" grape shrubs with humic acid at a concentration of 5 mL/L resulted in the highest values for shoot length and number of internodes per shoot (165.3 cm and 29.7, respectively). On the other hand, spray "Zeni" grape shrubs with humic acid at aconcentration of 5 mL/L showed the highest leaf area (87.6 cm2).

Our results are consistent with previous studies conducted on grape varieties such as "Sabi'i" (Al-Mustou, 2018), "AlpHonse Lavallee" (Sabir *et al.*, 2021), and "Superior Labrusca" (Nardi *et al.*, 2002). This effect can be explained by the critical role of humic acid molecules, which have high molecular weights and contain many active groups. The foliar application of humic acid elicits a direct supply of amino acids to leaves, thereby instigating a significant upsurge in protein synthesis, consequently fostering robust plant growth. Humic acid also enhances the efficiency of vital biological and pHysiological processes necessary for growth. Moreover, humic acid contains the quinone group, which acts as a hydrogen acceptor, enhancing enzyme activity and contributing to pHotosynthesis and respiration (Dantas *et al.*, 2007). Additionally, humic acids form complexes with mineral ions, enhancing the enzymes present in plants and stimulating DNA metabolism and hormonal activity (Turkmen *et al.*, 2004).

5-2- The effect of humic acid spray on some productive traits: Table (2): The effect of humic acid spray on some productive traits

Treatment \ Trait		NB*	WB (g)	VB (cm^3)	NBe	WBe (g)	VBe (cm^3)	WS (g)	TY (kg)
Helwani		37.6	469.8	465.7	65.8	5.4	5.3	47.7	17.8
Zeni		72.1	335.3	327.8	52.0	6	5.8	64.1	24.3
LSD 5% (Cultivars)		11.9	42.2	41.1	12.2	0.4	0.3	1.4	6.66
0 (Ctrl)		39.2	346.7	345.1	45.2	5.3	5.1	51.8	12.9
5 mL/L		83.0	405.1	400.1	61.7	6.1	5.8	61.5	31.9
15 mL/L		42.3	455.8	445.0	69.8	5.8	5.8	54.5	18.4
LSD 5% (Levels)		14.6	51.7	50.3	14.9	0.5	0.4	1.8	8.2
Helwani	**0 (Ctrl)**	24.4	413.9	414.0	41.0	5.3	5.1	47.6	10.6
	5 mL/L	62.3	476.8	472.6	65.3	5.9	5.6	47.9	29.1
	15 mL/L	26.0	518.6	510.4	91.0	5.1	5.4	47.6	13.6
Zeni	**0 (Ctrl)**	54.1	279.5	276.2	49.4	5.4	5.1	56.0	15.2
	5 mL/L	103.7	333.5	327.6	58.0	6.2	5.9	75.1	34.7
	15 mL/L	58.7	393.0	379.7	48.7	6.4	6.2	61.3	23.1
LSD 5% (V x L)		20.7	73.1	71.1	21.2	0.6	0.6	2.5	11.5
C.V. (%)		21.2	10.2	10.1	20.2	6.4	5.9	2.5	30.8

**Number of bunches per shrub (NB).* **Weight of a single bunch (WB).*
**Volume of a single bunch (VB).* **Number of berries per bunch (NBe)*
**Weight of a single berry (WBe).* **Volume of a single berry (VBe)*
**Weight of 1000 Seeds (WS).* **Total yield per shrub (TY)*

Based on Table (2), significant superiority of Helwani variety over Zeni variety was observed in bunch weight, bunch volume, and number of berries, with values of (469.8 g, 465.7 cm^3, and 65.8), respectively. On the other hand, the Zeni variety showed significant superiority over Helwani variety in terms of the number of bunches, berry weight, berry volume, and thousand seed weight, with values of (72.1, 6.0 g, 5.8 g, and 64.1 g), respectively. However, there was no significant difference between the two varieties in terms of total yield (kg/shrub).

Furthermore, the table (2) demonstrates significant effect of different spray levels on grapevines. The spray level of 5 mL/L outperformed both the control and the 15 mL/L level in terms of the number of bunches, thousand seed weight, and total yield, with values of (83.0, 61.5 g, and 31.9 kg/shrub), respectively. It also outperformed the control in terms of berry weight (6.1 g). Additionally, the 15 mL/L spray level outperformed the control in terms of bunch weight, bunch volume, number of berries, and berry volume, with values of (455.8 g, 445.0 cm^3, 69.8, and

5.8 cm^3), respectively.

Regarding the interaction between the experimental factors, spray Zeni grapevines with 5 mL/L concentration of humic acid showed the highest results in terms of number of bunches, thousand seed weight, and total yield, with values of (103.7 bunches, 75.1 g, and 34.7 kg), respectively. However, spray Helwani grapevines with 15 g/L concentration of humic acid resulted in the highest values for bunch weight, bunch volume, and the number of berries in a bunch, with values of (518.6 g, 510.4 cm^3, and 91 berries), respectively. Moreover, the treatment of Zeni grapevines with 15 g/L concentration of humic acid yielded the highest berry weight and berry volume, with values of (6.4 g and 6.2 cm^3), respectively.

The obtained results align with previous studies conducted by (Aly *et al.,* 2021), (Gouda and El-Zahraa, 2022), and (Kassem and Marzouk, 2002) on grapevines. These studies have demonstrated that humic acid improves growth and productivity and affects plants similarly to other plant growth regulators, such as indole-3-acetic acid. Moreover, the use of humic acid increases the plant's content of cytokinins and auxins, which are important growth hormones contributing to plant growth and development. Additionally, humic acid enhances cell membrane permeability in plants, thereby increasing nutrient uptake and translocation within the plant. These results are supported by the fact that foliar spray does not affect vital activities thatoccur inside the leaf, such as respiration and photosynthesis, but rather helps improve productivity by preventing nutrient depletion within the leaves (Al-Joborry, 2022).

5-3- The effect of humic acid spray on some qualitative traits:

Table (3): Effect of foliar spray with humic acid on some qualitative traits

Treatment \ Trait		TSS* (%)	TA (%)	TS (%)	pH
Helwani		16.2	0.23	14.3	4.4
Zeni		15.4	0.30	14.4	3.9
LSD 5% (Varieties)		1.1	0.02	0.2	0.1
0 (Ctrl)		15.4	0.24	13.9	4.3
5 mL/L		16.0	0.27	14.4	4.0
15 mL/L		15.9	0.28	14.7	4.2
LSD 5% (Levels)		1.3	0.02	0.2	0.1
Helwani	**0 (Ctrl)**	16.2	0.25	13.6	4.5
	5 mL/L	16.5	0.22	14.8	4.3
	15 mL/L	15.9	0.23	14.6	4.4
Zeni	**0 (Ctrl)**	14.7	0.24	14.2	4.1
	5 mL/L	15.6	0.32	14.3	3.8
	15 mL/L	16.0	0.34	14.8	3.9
LSD 5% (V x L)		1.8	0.03	0.4	0.1
C.V. (%)		4.7	4	1.1	1.1

**Total soluble solids (TSS%). *Total acidity (TA%). Total Sugars (TS%)*

Table (3) demonstrates that the Helwani variety outperformed Zeni variety in terms of the acidity level (pH) of the fruit juice when sprayed with, with a value of (4.4). On the other hand, the Zenivariety had a higher TA% in the fruits, with a value of (0.3%). However, no significant differences were observed between the two varieties in terms of TSS% and TS%.

Table (3) also indicates no significant differences between the levels of humic acid spray (0, 5, 15 g/L) in TSS%, with the highest value observed at the 5 mL/L level (16.0%). However, the levels of spray (15 and 5 mL/L) outperformed the control (0 g/L) in TA%, with values of 0.28%, 0.27%, and 0.24%, respectively, as well as in TS% with values of 14.7%, 14.4%, and 13.9%, respectively. Additionally, the levels of spray (0 and 15 mL/L) outperformed the 5 mL/L level in pH, with values of 4.3, 4.2, and4.0, respectively.

Regarding the interaction between the experimental factors, table (3) indicates that the highest content of TSS% and TS% in the fruits was observed in the interaction of the 5 mL/L concentration of humic acid with the Helwani variety, with values of (16.5% and 14.8%), respectively. The highest content of TA% was observed in the interaction of the third concentration level of humic acid spray (15 mL/L) with the Zeni variety, with a value of (0.34%). The highest pH value was observed in the interaction of the control (0 mL/L) with the Helwani variety, with a value of 4.5.

Our results align with previous studies conducted on Italy grape varieties (Ferrara and Brunetti, 2010), grape (Gouda and El-Zahraa, 2022), and Flame seedless grapes (Omar *et al*., 2022). These studies indicate that the spray of humic acid on the green canopy contributes to improving water consumption efficiency in crop irrigation (Arnaout and Najari, 2008). Humic acid also enhances membrane permeability, leading to increased water and nutrient absorption (Osman *et al.,* 2010; Pinton *et al.,* 1992), resulting in increased respiratory, photosynthetic, and total protein synthesis processesin plants (Nardi *et al.,* 2002).

Table (4): Pearson's simple linear coefficient (r) and its significance among the studied traits

	LA	LS	LI	NI	NB	WB	VB	NB	WBe	VBe	WS	TY	TSS	TA	TS	pH
LA	1															
LS	-.130	1														
LI	-.075	.699**	1													
NI	-.183	.929**	.462	1												
NB	.564*	-.259	-.271	-.254	1											
WB	-.159	.521*	.705**	.379	-.399	1										
VB	-.173	.551*	.706**	.418	-.412	.999**	1									
NBe	-.199	.245	.604**	.072	-.165	.567*	.558*	1								
WBe	.638**	-.224	-.144	-.285	.506*	-.237	-.259	-.108	1							
VBe	.519*	-.388	-.016	-.544*	.364	-.092	-.126	.178	.855**	1						
WS	.552*	-.609**	-.497*	-.548*	.750**	-.591**	-.613**	-.238	.562*	.550*	1					
TY	.586*	-.083	-.050	-.120	.918**	-.048	-.063	-.015	.515*	.384	.560*	1				
TSS	.175	.366	.454	.293	-.179	.448	.457	-.033	.158	.053	-.209	-.023	1			
TA	.661**	-.634**	-.466	-.618**	.443	-.371	-.401	-.365	.676**	.689**	.790**	.343	.020	1		
TS	.393	.026	.383	-.140	.223	.283	.255	.453	.448	.526*	.043	.369	.122	.121	1	
pH	-.565*	.686**	.514*	.648**	-.729**	.561*	.593**	.208	-.721**	-.674**	-.881**	-.610**	.287	-.768**	-.307	1

*. Correlation is significant at the 0.05 level **. Correlation is significant at the 0.01 level *See paragraph 4-6*

5-4- Correlation analysis:

Table (4): reveals the following relationships between the studied traits:

- **High significant positive linear correlation:** There is a high significant positive linear correlation between leaf area and both berry weight and TA, and between shoot length and both internode length, number of internodes per shoot and pH. Additionally, there is internode length and both bunch weight, bunch volume, and number of berries per bunch. Number of internodes per shoot is positively correlated with pH. There is also between number of bunches and both thousand-seed weight and total production, and between bunch weight and bunch volume, and between bunch volume and pH, and between berry weight and both berry volume and TA. Additionally, there is a correlation between berry volume and TA, and between thousand-seed weight and TA.
- **High significant negative linear correlation:** There is a high significant negative linear correlation between shoot length and both thousand-seed weight and TA. Number of internodes per shoot is negatively correlated with TA. There is also between number of bunches and pH. Additionally, and between bunch weight and thousand-seed weight, and between bunch volume and thousand-seed weight. And between berry weight and pH. Additionally, there is a correlation between berry volume and pH, and between thousand-seed weight and pH, as well as between total production and pH,and between TA and pH.

  Significant positive linear correlation: There is a significant positive linear correlation between leaf area and both number of berries per bunch, berry volume, thousand-seed weight and total productivity. Additionally, there is between shoot length and both bunch volume and bunch weight. And between internode length and pH. Furthermore, there isbetween bunch weight and both number of berries per bunch and PH. and between bunch volume and both thousand-seed weight and TS. Additionally, there is a correlation between berry weight and thousand-seed weight. And between berry volume and both thousand-seed weight and TS, as well as between thousand-seed weight and total productivity.
- **Significant linear negative correlation:** There is a significant negative linear correlation between leaf area and pH. Additionally, there is between internode length and both thousand-seed weight and total productivity. And between number of internodes per shoot and both berry volume and thousand-seed weight. And between number of bunches and berry weight.

6- Conclusions:

1. The Helwani variety outperformed the Zeni variety in shoot length, internode length, number of internodes per shoot, bunch weight, bunch volume, number of berries per bunch, and PH.
2. The Zeni variety outperformed the Helwani variety in bunch number,, berry weight, berry volume, total productivity, and TA.
3. Foliar spray of grapevines with 5 mL/L concentration of humic acid showed significant improvement in leaf area, shoot length, number of internodes per shoot, bunch number, berry weight, thousand-seed weight, and total productivity.
4. Foliar spray of grapevines with 15 mL/L concentration of humic acid showed significant improvement in internode length, bunch weight, bunch volume, number of berries per bunch, berry volume, TA,and TS.
5. The control treatment (0 mL/L humic acid) resulted in the highest PH.
6. The interaction between foliar spray of Helwani grapevines with 5 mL/L humic acid concentration showed significant improvement in shoot length, number of internodes per shoot, TSS, and TS.
7. The interaction between foliar spray of Helwani grapevines with 15 mL/L humic acid concentration showed significant improvement in internode length, bunch weight, bunch volume, and number of berries per bunch in the bunch.
8. The treatment of Zeni grapevines with 5 mL/L humic acid concentration resulted in higher leaf area, number of bunches, thousand-seed weight, and total productivity.
9. The treatment of Zeni grapevines with 15 mL/L humic acid concentration resulted in higher berry weight, berry volume, and TA.
10. There was a positive correlation between shoot length and number of internodes per shoot per shoot, bunch volume, and bunch weight.
11. There was a positive correlation between berry volume and weight, and bunch volume and weight.
12. There was a negative correlation between PH and number of bunches and total productivity.

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