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Effect of Humic Acid, Calcium, and Some Growth regulators on some Quantitative and Qualitative Traits for Yield of Fig cultivar Aswad Diyala (*Ficus carica.* L)

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Abstract: *The study was performed on fig trees of(CV. Black Diyala), situated in a private orchard in the Al-Mahawil District in Babylon province in 2024, season starting from (March -10-2024) to (Sep. 1-2024) , to study the influence of the addition of humic acid and calcium oxide to the soil at concentrations (0- humic acid 10 ml / L - calcium oxide 5 ml / L - humic acid 10 ml / L + calcium oxide 5 ml / L) as well as spraying growth regulators NAA and GA3 at a concentrations of (0, naphthalene 75, gibberellin 100 mg / L). Treatment effects were evaluated on quantitative and qualitative characteristics of fig fruits. The factorial experiment was executed in a randomized complete block design (RCBD) (4×3) With three replicates. The results showed that adding the treatments individually or jointly led to a significant increase in (fruit diameter, fruit length, fruit weight, total yield, fruit cracking%, fruit fall, and number of days until fruit ripening). Treatment A4B3 gave the highest value for fruit length (3.82 cm), fruit diameter (3.99 cm), and fruit weight (35.31 g). Treatment A3B2 gave the lowest rate of fall (5.78%), and the lowest rate of cracking (6.18%). Treatment A1B2 gave the lowest number of days to ripening (70.00 days),and treatment A4B2 gave the highest total yield (28.91).*

Keywords: *Humic acid, calcium, growth regulators (GA3, NAA), Ficus carica. L*

1. INTRODUCTION:

Deciduous fruit trees of the Moraceae family included fig (Ficus carica L.). Some studies have found that the original homeland extends from Persia in the east to the Mediterranean basin in the west, Some believe that Anatolia is the original homeland of figs, and then its cultivation spread to the rest of the world (George 2019). In fig cultivation, Turkey ranks 1 st in the world, followed by the Republic of Egypt and Algeria. The global production of figs is estimated at 1,051,795 t(F.A.O, 2020). Iraq's annual production is estimated at (9681 t), and the average production per tree is (23.45 Kg) according to statistics(Central Statistical Organization, 2021). Figs are characterized by their substantial nutritional value, with each 100 g of fresh fruit comprising 78 g water, 1.3 g protein, 0.3 g fat, 17 g carbs, 2 g of fiber, 50 mg vitamin B, and 7 mg vitamin C (Al-Baytar, 2015). The leaves contain methoxsalen, a chemical that is used to cure vitiligo, psoriasis, and skin cancer caused by exposure to UV light(Isaac, 2000). Figs are also considered a type of fruit rich in high mineral content, about four times the iron and copper compared to fresh and dried fruits and vegetables(Sadia et al. 2014). Some researchers have resorted to using humic acid, which is basically a brown substance with a high molecular weight and is soluble in alkaline solutions. Humic acids are formed naturally in soils through plant materials and residues that fall into the soil, so it becomes necessary to return plant residues to the soil (Susic, 2016). Farmers utilise these compounds to decrease the amount of agrochemicals they use and to make better use of nutrients, which helps them produce food in a more sustainably. This is because these compounds are known to have biostimulant effects (Monda et al. , 2021). Humic acid has been shown to have a beneficial impact on plants by increasing the amount of nutrients they absorb. This is because humic acid improves the availability of minerals in the soil, particularly microelements(Lutzow et al. , 2006). Calcium is important in plant nutrition, as it reduces fruit cracking, forms the cell wall, and maintains the cell membrane. It is also important in cell elongation and cell division, and it plays a stimulating role in some enzymes important for vital processes within the plant. Plants need an amount of calcium of 5-20 mg per 1 gram of dry matter (Yaqoub and Abu Gharsa, 2022). Calcium is involved in the formation of pectin substances that bind cell walls; which leads to reducing damage during storage due to the increased thickness of cell walls and cell membranes; thus, the resistance of fruits to deterioration or aging increases, and trees that suffer from calcium deficiency have smaller fruits, contain less sugar, and less color and flavor (Johnson, 2008). He stated that the stage of fruit ripening depends on the internal content of plant hormones, especially auxin, as auxin plays an important role in increasing cell division, delaying aging, and increasing growth, besides its impact on the properties of fruits, as they ripen and its ability to reduce the proportion of falling (Radi , 2021). Where (Al-Lami and Hashem , 2024) .indicated that spraying NAA on palm trees at different stages led to a significant increase in all the studied traits. In addition to their genetic effect, gibberellins have biological efficacy in promoting cell division, elongation, or both. Many enzymes are activated by dwarfing, flowering, the creation of parthenogenetic fruits, and the elimination of dormancy in seeds and flowers, which supports plant growth and development and enhances the activity of the cell's essential and physiological functions(Radi , 2021).

The results demonstrated that spraying gibberellic acid on fig trees enhances both the quality and quantity of the figs(Al-Omrani and Al-Dolaimi, 2023). Therefore, the study aims to understand the influence of factors individually or together on fruit yield and characteristics, and to reduce the phenomenon of fig fruit falling and cracking, which is considered one of the most important problems of figs.

2. Materials and method:

2.1. Location.

The experiment was conducted in one of the private orchards located north of the Al-Mahawil District in Babylon province in 2024

2.2. Choosing Trees and Conducting Agricultural Service Operations.

36 fig trees were selected for three replicates (one tree in an experimental unit) at the age of 8 years, homogeneous in size and growth strength, and planted at distances of (5 x 5) m, and all service operations were carried out, including irrigation and fertilization during the study period. To investigate the impact of humic acid, calcium oxide, and growth regulators. This research employed a randomized complete block design (RCBD) factorial experiment (4×3) with three replications. The experiment included 12 treatments with three replicates at concentrations (0- humic acid 10 ml/L - calcium oxide 5 ml/L - humic acid 10 ml/L + calcium oxide 5 ml/L) and symbolized by (A1, A2, A3, A4) added to the soil and the second factor is growth regulators at concentrations (0, naphthalene 75 gibberellin 100 mg/L) for (B1, B2, B3) and the treatments were repeated three times for treatment A and twice for treatment B, noting that between one addition and another a month. The V12 GenStat statistical tool was employed to analyze the findings, and the averages were contrasted using the least significant difference (L.S.D) at a significant threshold of 0.05(Al-Rawi,2000).

2.3.The treatments were as follows:

1. The comparison was sprayed with distilled water.
2. Humic acid 10 ml/L.
3. Calcium oxide 5ml/L .
4. Humic Acid 10ml/L + Calcium Oxide 5ml/L .
5. Naphthalene 75mg/L .
6. Gibberellin 100mg/L .
7. Humic Acid 10ml/L + Naphthalene 75mg/L .
8. Calcium Oxide 5ml/L + Naphthalene 75mg/L .
9. Humic Acid 10ml/L + Calcium Oxide 5ml/L + Naphthalene 75mg/L .
10. Humic Acid 10ml/L + Gibberellin 100mg/L .
11. Calcium Oxide 5ml/L + Gibberellin 100mg/L .

12. Humic Acid 10ml/L + Calcium Oxide 5ml/L + Gibberellin 100mg/L.

2.4.Measured fruit traits:

2.4.1.Average fruit length at maturity:

(10)Ripe fruits were randomly taken from each experimental unit, and their lengths were measured using a scale, and then the average was extracted.

2.4.2.Average fruit diameter: It was measured as in the previous step.

2.4.3.Average fruit weight at maturity:

A sample of 10 fruits was taken from each experimental unit randomly and weighed using a sensitive balance; then the average fruit weight in grams was extracted.

2.4.4.Fruit fall percentage:

The fallen fruits from each experimental unit were calculated randomly after treatment, then the fruits that reached the ripening stage were calculated and this percentage was extracted from the following equation:

$$\text{fruits to fall percentage ratio} = \frac{\text{treatment after falling fruits number}}{\text{total fruits number}} \times 100$$

2.4.5.Total cracking percentage:

Where the number of healthy fruits and cracked fruits was calculated during the ripening stage from the beginning of fruit ripening until 1/9 according to the following equation:

$$\text{fruits to crack percentage ratio} = \frac{\text{cracked fruits number}}{\text{total fruits number}} \times 100$$

2.4.6.Number of days from the first fruit bud to ripening:

The days were calculated from the beginning of fruit formation until the ripening of the indicated fruits for all treatments, where a number of fruits were selected from four sides of the tree at different times and were marked from the time of their appearance until ripening and the average was extracted.

2.4.7.Total production:

This was done by weighing the fruits harvested in each harvest from each experimental unit from the beginning of ripening until the end of the season, then the harvests were collected for each experimental unit.

3-Results and discussion:-

3.1. Fruit length at maturity cm**:**

The results in Table (1) indicate a substantial impact of humic acid and calcium oxide on fig fruit length, with treatment A4 yielding the highest measurement (3.67 cm) compared to the lowest measurement (3.32 cm) in the control treatment. The results in the same table showed that the growth regulators had a substantial effect. The maximum rate was (3.70 cm) in treatment B3, whereas the control treatment delivered the lowest rate for fruit length, which was (3.31 cm). The interaction among the research variables significantly influenced fruit length, with the interaction treatment (A4B3) yielding the maximum value of (3.82 cm), in contrast to the lowest value of (2.92 cm) observed in the control treatment.

Table. 1 Effect of humic acid, calcium oxide, and some growth regulators and their interaction on the Average fruit length (cm)

B	factor A				average
	A1	A2	A3	A4	
B1	2.92	3.45	.330	3.57	3.31
B2	3.43	3.50	.347	3.64	3.51
B3	3.62	3.72	3.67	3.82	3.70
average	.332	3.55	3.48	3.67	

L.S.D 0.05	B 0.0542	A 0.0626	interaction 0.1084

3.2.Fruit diameter at maturity.

Table (2) There is a significant effect when treating humic acid and calcium oxide on the average fruit diameter, which reached (3.76 cm) in treatment A4 compared to the lowest average fruit diameter for untreated trees (control), which reached (3.38 cm). Treatment with growth regulators significantly influenced fruit diameter, with the highest measurement of 3.71 cm observed in treatment B3, in contrast to the lowest measurement in the control treatment. The interaction between the two research factors demonstrated a substantial impact on the average fruit diameter, with the maximum measurement of 3.99 cm observed in treatment A4B3, in contrast to the minimum measurement of 3.11 cm in the control treatment.

Table 2 Effect of humic acid, calcium oxide, and some growth regulators Interaction between them on the average Fruit diameter (cm)

B	factor A				average
	A1	A2	A3	A4	
B1	3.11	3.46	3.25	3.61	3.35
B2	3.40	3.57	3.44	3.69	3.52
B3	3.64	3.86	3.76	3.99	3.71
average	3.38	3.63	3.48	3.76	
L.S.D 0.05	A 0.1129		B 0.0978		Interaction 0.1956

3.3. Average fruit weight at maturity:

Table (3) indicates that the incorporation of humic acid and calcium oxide significantly influenced the average fruit weight, with the maximum value of (34.64g) observed in treatment A4, contrasting with the minimum value in the control treatment. We observe that growth regulators significantly influenced this feature, with the maximum value of (33.93g) achieved with B3, in contrast to the minimum value of 30.62 in the control treatment. The interaction between the two research parameters resulted in a significant difference in fruit weight, with the maximum value of 35.31 seen in treatment A4B3, contrasted with the minimum value of 27.44 in treatment A1B1.

Table(3) Effect of humic acid, calcium oxide, and some growth regulators and their interaction on the average fruit weight (g)

B	factor A				average
	A1	A2	A3	A4	
B1	27.44	31.56	29.63	33.88	30.62
B2	30.23	32.69	32.77	34.74	32.60

B3	31.50	34.94	33.99	35.31	33.93
average	29.72	33.06	32.13	34.64	
L.S.D 0.05	A 1.408		B 1.219		interaction 2.438

3.4.Percentage of fruit fall :

The results in Table (4) indicate a considerable impact on fruit drop, with the lowest rate recorded at 7.22% in treatment A3, contrasted with the highest rate of 10.04% in the control treatment. It is shown that growth regulators significantly influenced this feature, with the minimum rate being 6.43% in treatment B2, contrasted with the maximum rate of 10.62% in the control treatment. The interaction between the two study parameters resulted in the lowest fruit fall percentage (5.78%) in treatment A3B2, whereas the highest percentage (14.65%) was observed in treatment A1B1.

Table (4) Effect of humic acid, calcium oxide, and some growth regulators and their interaction on the rate of Percentage of fruit fall%

B	factor A				average
	A1	A2	A3	A4	
B1	14.65	10.73	8.71	8.40	10.62
B2	6.98	6.92	5.78	6.04	6.43
B3	8.51	7.02	7.18	7.37	7.52
average	10.04	8.22	7.22	7.27	
L.S.D 0.05	A 0.645		B 0.559		interaction 1.118

3.5.Total cracking percentage:

The results of Table (5) showed that adding humic acid and calcium oxide reduced the total cracking percentage of fig fruits, as treatment A3 gave the lowest cracking percentage (6.97%) compared to the highest cracking percentage (10.45%) in the control treatment. The growth regulators had a notable impact, with the lowest cracking percentage recorded at 8.19 in treatment B2, whereas the control treatment exhibited the greatest percentage at (10.17%). The interaction among the research variables exerted a substantial influence on the percentage, with the interaction treatment (A3B2) yielding the lowest value of (6.18%), in contrast to the maximum value observed in the control treatment (13.86%).

Table (5) Effect of humic acid, calcium oxide, and some growth regulators and their interaction on the cracking percentage rate %

B	factor A				average
	A1	A2	A3	A4	
B1	13.86	10.04	7.83	8.96	10.17
B2	8.05	9.89	6.18	8.66	8.19

B3	9.44	10.86	6.91	8.12	8.83
average	10.45	10.26	6.97	8.58	
L.S.D 0.05	A 0.771		B 0.668		interaction 1.336

3.6.Number of days until maturity

According to Table (6), the treatment of fig trees with humic acid and calcium oxide did not have a significant impact on the number of days it took for the trees to mature. As for growth regulators, they had a significant effect, as the lowest number of days to maturity was in treatment B2, which was (71.00 days), compared to the highest number of days to maturity (74.33 days) in B1. Also, the interaction between the study treatments had a significant effect on maturity, as the lowest period to maturity was (70.00 days) in treatment A1B2, while the highest number of days from the first fruit bud to maturity was in the control treatment, which was (74.33 days).

Table (6) The effect of humic acid, calcium oxide, growth regulators and their interaction on the rate of Number of days to maturity / day

B	factor A				average
	A1	A2	A3	A4	
B1	74.33	73.66	73.33	73.66	73.74
B2	70.00	71.67	71.00	71.33	71.00
B3	71.00	72.33	72.00	72.67	72.00
average	71.77	72.55	72.11	72.55	
L.S.D 0.05	A 1.854		B 1.606		interaction 3.211

3.7.Total production:

The results of Table (7) showed that the total yield of Aswad Diyala fig trees increased significantly when using humic acid and calcium oxide, as treatment A4 achieved the highest rate of fruit yield of (27.02) kg compared to the lowest rate in the control treatment (20.75) kg. Growth regulators also gave a significant increase in fruit yield, as it gave the highest rate of (25.73) kg at B2 compared to the lowest rate in the control treatment of (22.09) kg. As for the interaction between the treatments, it had a significant effect, as it recorded the highest total yield of (28.91) kg when compared to the lowest yield recorded by the control treatment of (17.28) kg.

Table (7) Effect of humic acid, calcium oxide, and growth regulators and their interaction in Total production/kg

B	factor A				average
	A1	A2	A3	A4	
B1	17.28	23.74	22.12	25.25	22.09
B2	23.06	26.71	24.27	28.91	25.73

B3	21.93	25.09	24.19	26.90	24.52
average	20.75	25.18	23.52	27.02	
L.S.D 0.05	A 1.193		B 1.033		interaction 2.066

The augmentation in the metrics of weight, diameter, length of fruits, and overall production due to varying concentrations of growth regulators can be ascribed to their influence on cell division and the enhancement of leaf area, which positively impacts nutrient synthesis in the leaves and their transference to the fruits, thereby enhancing their inherent qualities and ultimately boosting yield(Radi 2021). as auxin works in conjunction with gibberellic acid to manufacture cellulose and increase the plasticity of the wall of plant cells, thus increasing the width and elongation of the cells, which in turn is due to increasing the length, diameter, and weight of the fruits and thus increasing the total yield of the tree. Adding humic to the soil also results in a greater absorption of nutrients, an increase in proteins, and an increase in the creation of sugars. Humic also increases the activity of microorganisms in the soil and encourages root growth, which helps enhance the efficiency of nutrient absorption. This has a good effect on the quantity and quality of the fruits(Evans and Hartwigson 2000). The reason for the increase in the rates of diameter, length and weight of fruits when adding calcium may be due to its important role in the process of division and elongation of plant cells, as the calcium element stimulates the formation of the cytokinin hormone at high concentrations inside the plant, and this works to increase the branches, number of leaves and quantity of manufactured materials. It also works to increase the elongation of plant cells, and thus the characteristics of the fruits increase(Al-Naimi 2000). The reason for the decrease in the percentage of fruit falling and cracking as a result of treating trees with auxin and gibberellin is due to the role of these regulators in increasing and maintaining cell walls, as well as the role of gibberellin in attracting nutrients to the leaves and increasing their growth, thus providing adequate nutrition and good growth for the fruits and reducing their falling. Auxin also works to reduce the decomposition of the middle plate in the separation area of the fruit(Abdul Qader 2019). When humic is added, the percentage of Aswad Diyala fig fruits that fall and break decreases. This may be because humic helps the fruit parts grow by increasing the amount of nutrients they absorb from the soil, which protects them from falling and cracking. It also works to inhibit the enzyme IAA oxidase, which oxidizes auxin, thus regulating the hormonal balance of the plant(Chen et al. 2004). The reason for the decrease in the rates of cracking and falling of fruits when adding calcium to the soil may be due to its role in increasing the strength and hardness of the fruits, which works to reduce the rate of their exposure to physiological diseases and increase the formation of cell walls for them, which reduces their falling and cracking (Noor Al-Din 2012). As for the reason for the short days from the emergence of the first fruit bud until maturity when treating Aswad Diyala fig trees with auxin, it is due to its role in the synthesis of ethylene, which is called the ripening hormone, and thus helped accelerate ripening by a few days compared to untreated trees (Al-Asadi and Al-Khaikani 2019).

Conclusions:

1- The application of growth regulators, calcium, and humic acid boosted the fig trees' vegetative development and improved the fruits' quality and quantity.

2- The best concentrations used for the first factor are 10 ml humic acid and 5 ml calcium oxide.

3- Regarding the second factor (growth regulators), the best results were achieved when using naphthalene acetate 75 mg/liter combined with gibberellic acid 100 mg/liter.

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