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EFFECTS OF FOLIAR APPLICATION WITH GA3 AND SALICYLIC ACIDS ON VEGETATIVE GROWTH AND CHEMICAL CONTENT OF SEEDLING FIG (FICUS CARICA L.) CV. ASWAD DIALA

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Abstract
During the growing season of 2023, this study was conducted inside the wooden canopy of one of the private nurseries in Kirkuk, Iraq, to investigate the effect of leaf spraying with gibberellic acid GA3 at three concentrations (0, 50, 100) mg L-l and salicylic acid at the same three concentrations (0, 50, 100) mg L-l on some growth traits as well as the mineral content of Aswad Diala type fig seedlings. Three repeat tests were conducted out as a factorial experiment utilizing five seedlings for each experimental unit, using a randomized complete block design (R.C.B.D.).. The results obtained indicated that leaf spraying with gibberellic acid at a concentration of 100 mg L-l led to a significant increase in their chemical content of the total chlorophyll, and the percentage of nitrogen in the leaves. Such spraying also increased most of the vegetative growth traits of the fig seedlings, the length and diameter of the main stem, number of branched leaves, and leaf index. Spraying gibberellic acid at the concentration 50 mg L-l led to a significant increase in leaf areas, and the percentage of phosphorous and potassium in the leaves. Salicylic acid is sprayed at a dosage of 100 mg L-l resulted in a significant rise in the majority of the qualities evaluated (the rate of increase in the length and diameter of the main stem, number of branched leaves, total chlorophyll index, and the percentage of macronutrients in leaves NPK). The combined interaction between the sprayed gibberellic and salicylic acids had a significant effect as well.

Keywords: Gibberellic acid GA3, salicylic acid, Ficus carica L.

Introduction

Ficus carica L. belongs to the genus Ficus, which belongs to the mulberry family Moraceae, and this genus includes about 400 species and 700 cultivars. It is a deciduous tree that needs a short rest phase. Its name Carica is derived from the name of a region in western Anatolia known for growing figs, and its English name Fig evolved from the Indian name Feg, which is believed to have originated in the Arabian Peninsula and after the Islamic conquest. Muslims spread its cultivation in North Africa and the countries of the Mediterranean Basin. It endures high temperatures around 50°C, but it produces good fruits at temperatures approaching 37°C, and the skin of the fruit dries up if the temperature rises above 40°C (Ibrahim, 1996). Some varieties of figs give three crops, others give two crops. The first crop is called the Air Fig, the second crop is called the Free Fig or the Main or Commercial Fig, and the third crop is called the Late or Suhaili (Al-Ani, 1985). The Aswad Diala fig variety is considered one of the most widespread fig varieties in Iraq, especially in

Volume 2, Issue 9, September - 2024
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Web of Agriculture: Journal of Agriculture and Biological Sciences
webofjournals.com/index.php/8

the central and southern regions. Its fruits are small to medium size, black in color, its flesh is purple-black, pear-shaped, medium-sized, not suitable for drying, and its trees are less productive compared to other varieties (Al-Jumaili and Al-Dujaili, 1989 and Youssef, 2002).

Plant Growth Regulators are considered to be non-nutritive organic substances that have the ability to affect plant growth at very small concentrations, they may be natural or artificial and include substances that encourage or inhibit growth or modify any physiological process (Nickell, 1983). Gibberellins are terpene-type chemicals that are naturally found in all plants and consist of four isoprene units with 19 or 20 carbon atoms in their makeup. Gibberellins are produced mostly by freshly grown leaves, newly formed embryos, and developing fruits, however some roots may also produce them (Hartmann and Kester, 2003). Salicylic acid is an organic acid that is made from the amino acid phenylalanine in the form of pale-colored crystals. It is used as a plant hormone and is widely derived from the metabolism of salicin, and it is chemically similar to aspirin as a chemical compound. Salicylic acid is a plant hormone belonging to the phenolic group found in plants and has many roles in growth, development and increasing the efficiency of photosynthesis, transpiration, ion absorption and transport (Peter and Thomas, 2006).

In several investigations of the effect of the studied acids on the growth of fruit trees and seedlings, Shahien et al., (2010) found that spraying Anna-type apple trees with gibberellic acid at concentration 20 mg L^{-1} led to a significant increase in leaf area, chlorophyll and nitrogen concentrations. While the concentrations of phosphorous and potassium were not significantly affected when spraying with gibberellic acid. However, Allaf, (2017) found that spraying seedlings of two cultivars of Aswad Diala and White Adriatic fig seedlings with gibberellic acid at concentrations 25 mg L^{-1} and 50 mg L^{-1} led to a significant increase in the length of the main stem, the number of lateral branches and leaf area, as follows: 23.33- 27.00 cm, 2.16-2.04 branches.Seedlings^{-1}, 73.87 and 72.62 cm^2, respectively. While the spraying the same at concentration 25 mg L^{-1} led to superior effects in terms of stem diameter and number of leaves (2.70 mm, 7.66 leaves. seedling^{-1}), respectively, compared to the other treatments. Hamdan (2019) explained that when spraying pomegranate seedlings (Wonderful variety) with gibberellic acid at concentration 100 mg L^{-1}, led to a significant increase in the height of the plant, the total chlorophyll content of leaves and the percentage of nitrogen, phosphorous and potassium in the leaves, as follows: 71.18 cm, 317.6 mg.100 g^{-1} fresh weight, 2.11%, 0.149%, 1.82%, respectively, compared to other treatments. While the same spraying at concentration 50 mg L^{-1} led to a significant increase in the number of lateral branches, stem diameter and number of leaves, as follows: 5.95 branches.plant^{-1}, 5.03 mm, 381.8 leaves, compared with other treatments in each case.

When Al-Hamidawi and Al-Shammari (2012) studied the effect of spraying grape vines of the Halwani type with salicylic acid (100 mg L^{-1}), they discovered that it resulted in a significant increase in leaf area and cluster, total chlorophyll content, percentage of carbohydrates and nitrogen, and the ratio of C/N in the stalks, as follows (21.68 m^2.Karma^{-1}, 3906.75 cm^2.Karma^{-1}, 183.62 mg/100g fresh weight, 16.23%, 1.24%, and 8.74%, respectively. The two researchers also discovered (2016) that spraying grape vines cultivar Kamali with salicylic acid (125 mg L^{-1}) resulted in a substantial increase in vine leaf area of 22.95 m^2 when compared to the control treatment. When Hussein (2019) studied the effect of spraying different concentrations of salicylic acid on the growth of apricot trees/cultivar Royal, he recorded that the acid at 100 mg L^{-1} causes significant increases in most growth traits.

Volume 2, Issue 9, September - 2024
ISSN (E): 2938-3781

Web of Agriculture: Journal of Agriculture and Biological Sciences
webofjournals.com/index.php/8

Materials and working methods

This study was conducted in the wooden canopy of one of the private nurseries in Kirkuk governorate, Iraq, during the period April 1st to Oct 1st/2023, on fig seedlings of approximately one year of age, homogeneous in size and free from pathological and fungal infections, and planted in black polyethylene bags, size of 3 kg. Samples were taken from the soil in which seedlings were planted to analyze some of the physical and chemical properties as shown in Table 1.

Table 1: Some physical and chemical properties of seedling soil

K mg kg^{-1}	P mg kg^{-1}	N mg kg^{-1}	Organic matter %	EC mg kg^{-1}	PH	Mud mg kg^{-1}	Silt mg kg^{-1}	Sand mg kg^{-1}	Analysis Type
29	14.05	3.17	5.07	0.32	7.15	288	189	377	Analysis Results

All analyses were carried out in the laboratory of Kirkuk Directorate of Agriculture,Iraq.

The experiment was designed as a factorial experiment according to the randomized whole block design RCBD, including two factors, spraying with GA_3 in three concentrations (0, 50, 100) mg L^{-1} and with salicylic acid at the same concentrations, and with three replicates. Five seedlings were utilised in each experimental unit, so the number of seedlings in each replicate consisted of 45 seedlings, for a total of 135 seedlings per experiment. The treatment acids were sprayed three times during the growing season, with a 20-day laps between consecutive sprayings, as follows: 20/04, 10/05 and 01/06/2023. The seedlings were sprayed until fully wet in the early morning, and 1 ml of dish-washing detergent was added as a diffuser to break the surface tension of the water, and the service operations of hoeing, weeding, irrigation and control were carried out as needed throughout the experiment period. The data of the experiment were statistically analyzed according to the analysis of variance table (ANOVA TABLE) using the (2001 SAS, V9.0) system for the analysis of agricultural experiments and methods were compared using Duncan's multiple range test at the 0.05 probability level by Roger Mead and Hasted (2003).

Studied traits: All measurements were on 01/09/2023.

First: the characteristics of vegetative growth:

1- The rate of increase in the length of the main stem (cm)
2- The rate of increase in the diameter of the main stem (mm)
3- The rate of increase in the number of leaves (Leaf.$Seedling^{-1}$)
4- The rate of increase in the number of branches (Branch.$Seedling^{-1}$)
5- Leaf area (cm^2): The method applied by (Saieed, 1990) the leaf area was calculated following the equation:

Leaf Area = Area of large leaf x Weight of the cut part/Weight of large leaf.

Second: Chemical content characteristics:

1- Leaf Chlorophyll index (SPAD): It was measured by a Japanese chlorophyll meter type SPAD-502 by taking several readings from several spots, followed by measuring its average.

Volume 2, Issue 9, September - 2024
ISSN (E): 2938-3781

2- Nitrogen percentage in leaves (%): It was estimated using the Micro-Kjeldahl apparatus as mentioned by A.O.A.C (1980). The fully grown leaves were collected from different regions and from all seedlings of the experimental units. Drying in electric oven at (65 °C+5) for 48 hours. They were finely ground and 0.2 gm were taken and digested using a 1:4 ml mixture of concentrated sulfuric acid H_2SO_4 and $HCIO_4$, as per Johnson and Ullrich (1959).

3- Phosphorous Percentage in leaves (%): After the samples were digested using the above-mentioned method for nitrogen estimation, the percentage of phosphorous was estimated by colorimetric method and the light absorption was recorded at a wavelength of 410 nm using a Spectro photometer type (100 1-v lab EMC), as described by Estefan et al. (2013).

4- Potassium percentage in leaves (%): After the samples were digested using the above-mentioned method in estimating nitrogen, potassium content in leaves was measured using a Flame Photometer type (Elico CL-378) as described in Estefan et al. (2013).

Results:

First, the characteristics of vegetative growth:

It is noted from the results of Table 2 that leaf spraying with gibberellic acid (100 mg L^{-1}) on fig seedlings led to a significant increase in the rate of increase of the length and diameter of the main stem and the number of leaves and branches of the seedlings, as follows: 39.72, 131.7, 159.14, and 139.1%, respectively, compared with the control treatment. A significant increase in the area of a leaf after spraying with GA_3 (50 mg L^{-1}) was also recorded, which increased by 21.92% compared to the control treatment. Spraying salicylic acid (100 mg L^{-1}) significantly improved most of the vegetative growth traits of fig seedlings. Compared with the control treatment, the increase rates of the length and diameter of the main stem and the number of leaves and branches were as follows: 8.79%, 20.6%, 23.8% and 43.25%, respectively, while the trait of leaf area was significantly increased (4.94%) when sprayed with salicylic acid (50 mg L^{-1}) compared to the control treatment. As for the bilateral interaction between the gibberellic and salicylic acids, the spraying of gibberellic acid (100 mg L^{-1}) overlapped with salicylic acid (100 mg L^{-1}) had a significant boosting effect on the rate of increase in the length, diameter and number of leaves of seedlings, which amounted to 29.83 cm, 4.15 mm, 11.05 leaves.seedling^{-1}, respectively, compared to the rest of the treatments. As for the rate of increase in the number of branches, the interaction of gibberellic acid (50 mg L^{-1}) with salicylic acid (100 mg L^{-1}) had a significant boosting effect that exceeded the rest of the treatments, as it to 5.14 branches.seedlings^{-1}, while the interaction of gibberellic acid (50 mg L^{-1}) with salicylic acid (50 mg L^{-1}) was significant for the single leaf area character over the rest of the treatments, which amounted to 147.76 cm^2.

Web of Agriculture: Journal of Agriculture and Biological Sciences
webofjournals.com/index.php/8

Volume 2, Issue 9, September - 2024
ISSN (E): 2938-3781

Web of Agriculture: Journal of Agriculture and Biological Sciences
webofjournals.com/index.php/8

Table 2. Shows the effect of leaf spraying with gibberellic and salicylic acids on some vegetative growth characteristics of fig seedlings (Ficus Carica L.) Cv. Aswad Diala.

Gibberellic (Mg L^{-1})	Salycilic (Mg L^{-1})	Studied Traits				
		Main stem Length(cm)	Main stem Diam (mm)	Leaves. seadling^{-1}	Branches. seadling^{-1}	Leaf Aria (cm^2)
0	0	19.91 i	1.06 h	3.73 i	1.60 f	110.53 i
	50	20.38 h	1.96 g	3.84 h	1.87 f	120.65 h
	100	22.18 g	2.17 f	4.40 g	2.20 e	123.89 g
50	0	23.36 f	2.81 e	5.97 f	3.44 d	141.74 c
	50	24.51 e	2.96 d	8.23 e	4.19 c	147.76 a
	100	25.95 d	2.99 d	8.38 d	5.14 a	143.34 b
100	0	28.41 c	3.85 c	9.51 c	3.65 d	136.63 f
	50	29.05 b	4.03 b	10.45 b	4.83 b	139.68 d
	100	29.83 a	4.15 a	11.05 a	5.09 ab	138.52 e
Gibberellic (Mg L^{-1})	0	20.82 c	1.73 c	3.99 c	1.89 c	118.34 c
	50	24.61 b	2.92 b	7.53 b	4.25 b	144.28 a
	100	29.09 a	4.01 a	10.34 a	4.52 a	138.28 b
Salycilic (Mg L^{-1})	0	23.89 c	2.57 c	6.41 c	2.89 c	129.63 c
	50	24.65 b	2.98 b	7.51 b	3.63 b	136.03 a
	100	25.99 a	3.10 a	7.94 a	4.14 a	135.24 b

The values with similar letters did not differ significantly according to the Duncan multiple tests under a probability level of 5%

Second: Chemical content characteristics

The results shown in Table 3 indicate that the chemical content of fig seedlings of the Black Diyala type was significantly affected upon spraying with gibberellic acid (100 mg L^{-1}) as the chlorophyll index and the percentage of leaf nitrogen increased by 31.72% and 98.23%, respectively, compared to the control treatment, while the percentage of phosphorous and potassium increased significantly upon spraying (50 mg L^{-1}) with an increase of 104.7% and 69.41%, respectively, compared to the control treatment. Spraying with salicylic acid (100 mg L^{-1}) resulted in a significant increase of the chlorophyll index and the proportion of macronutrients NPK in the leaves, as follows: 4.11%, 16.05%, 23.33%, 14.28%, respectively, compared to the control treatment.
As for the bilateral interaction between the gibberellic and salicylic acids, spraying a combination of both acids, each at concentration 100 mg L^{-1}, resulted in a significant increase over the rest of the treatments in relation to the chlorophyll index and the percentage of nitrogen in the leaves (35.44 SPAD, 2.38% respectively). While spraying the mixture of gibberellic acid (50 mg L^{-1}) combined with salicylic acid (100 mg L^{-1}) showed a significant increase in the percentage of phosphorous and potassium in the leaves, mounted to 0.46% and 1.52%, respectively, compared with the rest of the

Volume 2, Issue 9, September - 2024
ISSN (E): 2938-3781

treatments.

Table 3. The effect of spraying leaves with gibberellic and salicylic acids on some chemical content of fig seedlings (Ficus carica L.) Cv. Aswad Diala.

Gibberellic (Mg L^{-1})	Salycilic (Mg L^{-1})	Studied Traits			
		Total Chlorophyll (SPAD)	Nitrogen in Leaves %	Phosphorous in Leaves %	Potassium in Leaves %
0	0	25.84 g	1.07 h	0.16 i	0.76 h
	50	25.98 g	1.09 h	0.20 h	0.82 g
	100	27.33 f	1.21 g	0.28 g	0.96 f
50	0	31.38 e	1.65 f	0.41 c	1.38 c
	50	31.50 e	1.83 e	0.43 b	1.42 b
	100	32.15 d	2.06 d	0.46 a	1.52 a
100	0	33.98 c	2.13 c	0.34 f	1.22 e
	50	34.82 b	2.21 b	0.36 e	1.34 d
	100	35.44 a	2.38 a	0.38 d	1.37 cd
Gibberellic (Mg L^{-1})	0	26.38 c	1.13 c	0.21 c	0.85 c
	50	31.67 b	1.84 b	0.43 a	1.44 a
	100	34.75 a	2.24 a	0.36 b	1.31 b
Salycilic (Mg L^{-1})	0	30.39 c	1.62 c	0.30 c	1.12 c
	50	30.77 b	1.71 b	0.33 b	1.19 b
	100	31.64 a	1.88 a	0.37 a	1.28 a

The values with similar letters did not differ significantly according to the Duncan multiple tests under a probability level of 5%

Discussion

When spraying with gibberellic acid, the increase in vegetative growth characteristics (Table 2) and chemical content (Table 3) can be linked to its functions in (a) expanding the size of cells by increasing the softness of cell walls. (b) Increasing the production of enzymes like alpha-amylase, which decomposes starch inside the cell, hence increasing the cell's osmotic effort, which increases water absorption. (c) Increasing the vascular bundles and their size in stem cells, which works to transfer water and nutrients through the roots to vegetative growth, this results in an increased efficiency of the leaves in carbon formation, as indicated by Hassouna (2003) and Taiz and Zeiger (2010). (d) On the one hand, prevents the dye from being destroyed or oxidized by the action of chlorophyllase, and on the other hand, increases the uptake of elements, some of which contribute to the construction of the chlorophyll molecule. (e) As one of the youth hormones, it fights against the hormones that cause aging (Abu Zeid, 2000 and Hussein et. al., 2021).

As for the role of gibberellic acid in increasing the proportion of nutrients, it may be due to its role in increasing the strength of vegetative growth, which resulted in an increase in the activity of roots and the withdrawal of a greater amount of water and nutrients from the soil. The results of this work agree with the statements of Shahien et. el. (2010), Allaf (2017), Hamdan (2019), Hussein et. al., (2021), Al-Doori and Hussein (2023).

While the increase in vegetative growth characteristics observed after spraying with salicylic acid is due to the fact that (a) it is classified as an active plant hormone, (b) it stimulates vegetative growth, and (c) it works to reduce or prevent the impact of environmental stress that inhibits growth

Web of Agriculture: Journal of Agriculture and Biological Sciences
webofjournals.com/index.php/8

Volume 2, Issue 9, September - 2024
ISSN (E): 2938-3781

and reduces the amount of plant hormones, such as auxins and cytokinins, play important and potent roles in cell division and elongation, and (d) it has an important role in regulating the process of ion absorption, hormonal balance, opening and closing of stomata, which contribute in the formation of chlorophyll pigment and increasing the efficiency of photosynthesis, and the activity of enzymes positively reflected in an increase in the studied characteristics (Sakaabutdinova et al., 2003) and (Hayat, 2007). Research work resultss agree with Al-Hamidawi and Al-Shammari (2012), Al-Akhwa (2016), Hussein (2019) and Hussein and Al-Door (2021), Hana et al., (2024)

Conclusion:

It is concluded from this study that spraying fig seedlings Cv. Aswad Diala with GA_3 and salicylic acids at a concentration of (100 and 50) mg L^{-1}, respectively, for each of them significantly improved the vegetative growth characteristics and the chemical content of the seedlings alone or in combination with each other.

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Web of Agriculture: Journal of Agriculture and Biological Sciences
webofjournals.com/index.php/8

Volume 2, Issue 9, September - 2024
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