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STUDY OF THE EFFECT OF JASMONIC ACID (JA) AND NANO-FERTILIZER ON QUALITATIVE INDICATORS AND SOME ACTIVE COMPOUNDS IN THE LEAVES OF THREE CULTIVARS OF THE ROCKET PLANT ERUCA SATIVA MILL.

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Abstract

An experiment was carried out in the Orchards and Nurseries Development Project - Karbala Agriculture Directorate for the two agricultural seasons 2020-2021 and 2021-2022 to study the physiological effects of jasmonic acid (JA) and nano-fertilizer on qualitative indicators and some active substances for the leaves of three cultivars of Rocket plant. The experiment was designed according to the Split Split Plot Design System and using the Randomized Complete Block Design (R.C.B.D), and the experiment included 27 treatments distributed randomly and with three replicates (81 experimental units) from three factors, the main factor is three varieties of Rocket plant, one of them French variety and the other Turkish variety and comparing them with the local variety, and the secondary factor is NPK nano fertilizer (0, 2, 4) gm. L^{-1}, while the sub-secondary factor is the growth regulator jasmonic acid (0, 15, 30) mg. L^{-1}, ANOVA was performed, then the rates were compared according to the comparison between the means using Duncan's Multiple Range Test at a probability level of 0.05, and the data were analyzed by the statistical program GenStat Release 12.1, the most important results are summarized as follows: Spraying with acid Jasmonic and nano-fertilizer on the leaves of the three cultivars of Rocket plant showed significant differences in the studied indicators, as the local cultivar that sprayed its plants with nano-fertilizer significantly outperformed 4 g. L^{-1} and jasmonic acid 30 mg.L^{-1} V1N2J2, which gave the highest results for both seasons of the experiment compared to plants of the other two cultivars in all qualitative indicators of the plant, as it reached in the leaf content indicators of total chlorophyll (123.88 and 113.68 mg.100). gm^{-1} fresh weight), the percentage of total soluble carbohydrates (9.25 and 9.17%) and ascorbic acid (128.76 and 126.72 mg.L^{-1} and jasmonic acid 30 mg.L^{-1} V2N2J2 significantly outperformed the two indexes of the leaves content of the active compounds, as it reached in the leaves content of glucosinolate (9.98 and 11.89 mg.g^{-1} dry weight) and glutathione (4.05 and 3.99 mg.g- 1 dry weight) sequentially for both seasons of the experiment.

Keywords: Rocket varieties, Nano fertilizer, jasmonic acid, qualitative indicators and active ingredients in leaves.

Introduction

The Rocket plant is one of the plants of medical and nutritional importance belonging to the family Brassicaceae and its cultivation is widespread in temperate regions throughout the year, except for very hot or cold months (Mohammed and Rafiq, 2009), where it is believed that its original home is Central Asia and Eastern Europe, and its cultivation is good in the Mediterranean countries The Mediterranean, Egypt, the Levant, Saudi Arabia, India and Iran, and Rocket leaves have a high nutritional value, as they contain sugars, amino and fatty acids, vitamins and a wide range of nutrients, as well as their content on a group of active substances of medicinal benefit such as sulfur glycosides (AL-Thamir et al., 2009). Recent studies conducted at the National Research Center in Egypt show that Rocket Oil reduces the percentage of total fats and cholesterol in the body (Younes, 2005).

The researchers worked on finding ways to increase the efficiency of fertilizer use and reduce waste and pollution. Hence, nanotechnology entered as a useful means in developing the agricultural aspect, especially in the fields of fertilization, because nano-fertilizer is an alternative to traditional fertilizers to reduce the amount of chemical fertilizers used and increase the speed of their absorption from the plant. Then increasing the ability to store them inside the plant for a longer period, improving the quality of crops, ensuring their sustainability, and increasing productivity (Al-Hchami and Alrawi, 2020).

Jasmonic acid was also considered a growth regulator at the World Conference on Plant Growth Regulators held in the mid-eighties of the last century, as this compound was isolated for the first time from the fungus Lasiodipiodia the obromae, and it was extracted from the essential oils of white jasmine and rosemary. Linolenic acid is the raw material for the production of jasmonic naturally inside the plant (Taiz and Zeiger, 2006), and the site of its production in the cell is the plastids and peroxisomes, and some studies have confirmed that jasmonic acid has an effect on the growth and flowering of some horticultural plants, as Ataei et al. (2013) The spraying of some plants with different concentrations on *Calendula officinalis* L plants led to an increase in their height and an increase in the weight of their seeds. (Renata, 2006) confirmed that the seed yield and vegetative growth of Rocket plants are affected by growth regulators. Because of the nutritional and medical importance of the Rocket plant, it is necessary to search for modern agricultural means to increase the yield of vegetables and improve the production of oil in its seeds, as the cultivation of varieties and the introduction of new ones is one of the important means in improving production in quantity and quality. Therefore, the effect of jasmonic acid and nano-fertilizer on qualitative indicators and some active compounds for the leaves of three varieties of Rocket plant different in genotype has been studied.

Materials and Methods

1- Field preparation and soil service operations:

After the process of preparing the soil of the field by plowing and then leveling it homogeneously, it was divided into plots with an area of (2.5 m x 1.5 m), the plot contains 8 lines, the distance between them is 30 cm, and the distance between plants is 15 cm, leaving an area of 0.5 m between plots to facilitate The different service operations, the number of plants in each experimental unit 80 plants, the lines of the experimental unit were divided into two parts, three lines were used for measurements of vegetative growth indicators and the other three for measurements of indicators of seed and oil yield. Two sprays were applied to plants of vegetative indicators. The first spray after 20 days of planting with nano-NPK, i.e. after 3-4 leaves appear on the plant, followed by the first spray of jasmonic acid, and the second spray of nano-NPK after 30 days of planting, followed by the second spray of jasmonic acid after 40 days of planting, i.e. the period between two sprays And another was ten days. A third spray was added to the plants of the seed growth indicators and the total yield after 60 days of planting. It started by spraying nano-NPK, followed by spraying jasmonic acid for a period of ten days before the beginning of flowering (Renata, 2006) for the purpose of seed yield and active substances. Before starting the cultivation process, the soil of the field was analyzed, a sample of the soil was taken at random for the purpose of knowing its chemical and physical properties, as shown in Table (1).

Table 1. Some chemical and physical properties of field soil in the two seasons of the experiment

feature	Unit	2021 -2020	2022 -2021
E.C	ds/m	2.7	2.2
PH	-------------	6.75	7.0
N	Mg.kg	77.3	81.8
P	Mg.kg	21.6	24.5
K	Mg.kg	118.2	134.6
$SO_4^{=}$	Mg.kg	3.4	3.8
Organic matter	%	1.17	1.49
Soil components			
sand	%	19.1	18.5
silt	%	49.4	51.8
Clay	%	31.5	29.7
soil texture	-------	Silty – Clay	Silty – Clay

2- studied indicators

1- Total chlorophyll content of leaves (mg. 100gm^{-1} fresh weight)

Weigh 1 g of fresh leaves and crush well with 10 ml of 80% acetone by a ceramic mortar and then put in a glass test tube and leave in the refrigerator for twenty hours at 4 °C in the dark, then shake and leave also for 1-2 hours in the same conditions and put In a centrifuge at 3000 rpm for 10 minutes, 1-2 drops of hydrochloric acid (0.1 N) were added to the filtrate and the filtrate was taken to measure the absorbance by spectrophotometry at the wavelength 663 and 645 nm (Parry et al., 2014) and the chlorophyll concentration was calculated in One of the laboratories of the College of Agriculture / University of Karbala, and then the equation below was applied:

Total chlorophyll=20.2 x D(645) +8.02 x D(663)(V/W x1000) x 100

D = optical absorption reading

V = final volume of extract (20 ml)

W = weight of plant leaf tissue (1g)

2- Total carbohydrates in leaves(%)

The percentage of total carbohydrates in the leaves was estimated according to the method (Duboies et al., 1956), 1 mg dry weight was taken from each treatment and 1 ml phenol and 5 ml sulfuric acid 80% concentration were added to it, the solution was left for 10 minutes, then the optical absorption was measured at the wavelength 490 nm after The empty tube (Blank) was prepared by taking 1 ml of phenol with a concentration of 5% and 5 ml of sulfuric acid at a concentration of 80%. As for the standard curve, glucose concentrations of 100, 200, 300, 400 and 500 mg L^{-1} were prepared, then 1 ml of each concentration was taken and 1 ml of phenol 5% concentration and 5 ml of sulfuric acid 80% concentration were added to it, it was left for 10 minutes, then the optical absorption readings were taken and the standard curve was drawn for the purpose of calibrating the readings.

3- Leaves content of ascorbic acid (vitamin C) (mg. 100 gm^{-1} fresh weight(

The estimation was done by direct titration method with 2,6-dichlorophenol Indophenol dye. 5 gm of fresh leaves were crushed using a Blender with 50 ml of oxalic acid at a concentration of 6%. The mixture was filtered and 10 ml was taken from it, and the volume was completed to 50 ml by adding 3% oxalic acid, then taken 10 ml of the last solution and titration against the dye whose parameter (mg/vitamin C equivalent to 1ml/tincture) before titration was 0.1 mg/vitamin C, calculated the vitamin in the papers based on the following equation described before. (A.O.A.C 1980)

Ascorbic acid content = (volume of dye consumed x titration factor x dilution / weight of the sample (g)) x 100.

4- Glucocinolate (mg.gm^{-1} dry weight)

Reduction of Ferricyanide of Ferricyanide was used to estimate the leaf content of glucosinolate as described before (Jezek et al. , 1999), which depends on the reduction of Ferricyanide by glucosinolate, then the product was broken down in an alkaline medium and releasing a yellow-colored 1-thioglucose. It was colored using a spectrophotometer with a wavelength of 420 nanometers.

5- Glutathione (mg.gm^{-1} dry weight)

The method adopted by Alscher (1989) using Dithiobis 2-nitro 5,5 (DTNB) benzoic acid, which combines with a thiol group SH in the glutathione molecule in the presence of an alkaline medium (pH = 8.9), forms mixed disulfides that release an ion The thiol, which is a yellow compound, has a color intensity that was measured using a spectrophotometer with a wavelength of 412 nanometers.

Results and Discussion

1- Total chlorophyll content of leaves (mg.100gm^{-1} fresh weight)

It is clear from tables (2) that the cultivar had a significant effect on the total chlorophyll content of the leaves, where the plants of the local variety were significantly superior for both seasons of the experiment compared to the plants of the other two cultivars, as well as the plants of the Turkish variety significantly outperformed the plants of the French variety, due to the difference in genotypes in Manufacture of chlorophyll pigment and the ratio between it and the rest of the other plant pigments. It was observed in the field that the stems of the plants of the local variety were colored green chlorophyll pigments, while the stems of the French and Turkish plants were colored red-purple, which is anthocyanin pigment, and this may have a role in increasing the concentration of chlorophyll pigments (Morales and Janick, (2002.

It was also found that the increase in the level of the added nano-fertilizer had a significant effect on increasing the total chlorophyll content of the leaves for both seasons of the experiment, as its effect increased the higher the level of the added nano-fertilizer, the increase in the proportion of chlorophyll may be attributed to the combined effect of nitrogen and phosphorus in the bio-building and formation processes Pyruvrine Unit, which participates in the construction of the chlorophyll molecule, and is also due to the role of potassium, which contributes to the activation of a number of enzymes responsible for the manufacture of chlorophyll that help in the formation of chloroplasts and its role in stimulating the enzymes responsible for the synthesis of carbohydrates, thus increasing some chemical characteristics such as carbohydrates and chlorophyll in leaves (Garhwal). and others, 2014.(

It was also found that spraying with jasmonic acid had a significant effect in increasing the total chlorophyll content of the leaves for both seasons of the experiment, as the effect increases with the increase in the concentration of spraying with plant hormone, as spraying plants with acid JA led to an increase in chlorophyll pigment, as the plant content of chlorophyll increased after treatment. With JA acid because it increases the ability of the plant to absorb light and this affects the greenness of the leaf and thus increases the process of carbon metabolism. This is consistent with (Rezai et al., 2018.(

The triple interaction between the experimental factors had a significant effect in this trait, as it gave the plants of the local variety that were sprayed with nano-fertilizer at a level of 4 g. L^{-1} and jasmonic acid 30 mg. L^{-1} were the highest rates for both seasons of the experiment, which recorded 123.88 and 113.68 mg. 100 g^{-1} fresh weight, respectively, compared to the lowest rates, which were 84.85 and 80.73 mg. 100 g^{-1} fresh weight, respectively. Of the French variety plants sprayed with distilled water only. .

Table (2) The effect of jasmonic acid (JA) and nano-fertilizer on the total chlorophyll content of leaves (mg. 100 g^{-1} fresh weight) for the three varieties of Rocket

varieties) V(	jasmonic acid (mg L^{-1}(	**first season**			**second season**		
		nano-fertilizer (gm L^{-1}(			nano-fertilizer (gm L^{-1})		
		$_0$)0N(	$_1$)2N(	$_2$)4N(	$_0$)0N(	$_1$)2N(	$_2$)4N(
local variety V_1	$_0$) 0J(	103.19 fg	110.54 d	114.53 c	95.03 h	103.12 e	107.18 c
	$_1$) 15J(	107.84 e	111.47 d	119.21 b	98.44 g	105.42 d	109.6 b
	$_2$) 30J(	109.72 de	115.80 c	**123.88 a**	100.93 f	108.40 bc	**113.68 a**
French variety V_2	$_0$) 0J (	**84.85 n**	93.74 k	96.74 ij	**80.73 r**	86.70 no	88.20 mn
	$_1$) 15J(	87.48 m	94.75 jk	98.64 hi	83.25 q	87.72 m-o	90.55 jk
	$_2$) 30 J(	90.52 l	97.57 hi	101.7 g	84.96 p	89.08 lm	91.44 j

Turkish variety V_3	0) 0J(	86.71 mn	94.8 jk	98.74 hi	81.95 qr	87.23 no	88.78 lm
	1) 15J(	89.62 l	96.58 ij	101.77 g	84.69 p	87.93 m-o	90.83 jk
	2) 30 J(	91.69 l	99.42 h	104.80 f	86.51 o	89.76 kl	92.85 i
varieties) V(		**V1**	**V2**	**V3**	**V1**	**V2**	**V3**
		112.91 **A**	**94.00** **C**	96.01 B	**104.64** **A**	**86.96** **C**	87.84 B
nano-fertilizer (gm L^{-1}(		**$_0$N**	**$_1$N**	**$_2$N**	**$_0$N**	**$_1$N**	**$_2$N**
		94.62 **C**	101.63 B	**106.67** **A**	**88.49** **C**	93.92 B	**97.01** **A**
jasmonic acid (mg L^{-1} (		**J0**	**J1**	**J2**	**J0**	**J1**	**J2**
		98.201 **C**	100.82 B	**103.90** **A**	**90.99** **C**	93.15 B	**95.28** **A**

2- Leaves content of total soluble carbohydrates(%)

Table (3) shows that the cultivar had a significant effect on the percentage of total soluble carbohydrates in the leaves, as the plants of the local cultivar (V1) scored significant superiority for both seasons of the experiment, as they gave 8.80 and 8.76 %, respectively, compared to the plants of the other two cultivars, and they also significantly outperformed The plants of the Turkish variety (V3), which scored 8.57 and 8.46 percent, respectively, compared to the plants of the French variety (V2), which gave the lowest results, reaching 8.42 and 8.31%, respectively, as the plants with a large vegetative group get a greater amount of light energy compared to In plants with a small vegetative total, and therefore carbohydrates are manufactured more highly in the process of photosynthesis by the influence of internal and external factors such as the nutritional conditions of the elements and the age of the plant, which ultimately leads to an increase in the percentage of carbohydrates.

It was also shown that there was a significant effect when spraying with nano-fertilizer on the studied plant, through the moral superiority of the spray treatment at a level of 4 g. L^{-1} (N2) for both seasons of the experiment, which recorded 8.87 and 8.77%, respectively, compared to the other two treatments, and the spraying treatment at a level of 2 g was significantly superior. L^{-1} (N1), which amounted to 8.62 and 8.53%, respectively, compared to the treatment 0 g (L^{-1} N0)), which gave the lowest results, as it was 8.30 and 8.22%, respectively, as this agrees with (Garhwal et al., 2014) for the role that The macronutrient NPK increases the proportion of carbohydrates in the plant when present.

It was also clear that spraying with jasmonic acid had a significant effect in increasing the leaves' content of total soluble carbohydrates for both seasons of the experiment, as the effect increases as the concentration of spraying with plant hormone increases. On the plant, such as a lack of water, the accumulation of salts in the cell membranes, an increase in the hormone ABA in the leaves, in addition to an increase in the duration of stomata closure, a decrease in the rate of transpiration and an increase in the concentration of Co2 and thus raising the efficiency of carbon metabolism and carbohydrate manufacturing. The results were in agreement with the study of Sadaghiani et al. (2019.(

The triple interaction between the experimental factors had a significant effect in this trait, as it gave the plants of the local variety that were sprayed with nano-fertilizer at a level of 4 g. L^{-1} and jasmonic acid 30 mg. L^{-1} (V1N2J2) had the highest rate in the percentage of total soluble carbohydrates in the leaves for both seasons of the experiment, which amounted to 9.25 and 9.17%, respectively, compared to the lowest rates were 8.03 and 7.89%, which were obtained from plants of the French variety Which sprayed with distilled water only (V2N0 J0), with the presence of non-significant differences for most of the triple interactions among all the factors of the studied experiment.

Table (3) Effect of jasmonic acid (JA) and nano-fertilizer on the leaves content of total soluble carbohydrates (%) for the three varieties of Rocket

varieties) V(	jasmonic acid (mg L^{-1}(	**first season**			**second season**		
		nano-fertilizer (gm L^{-1}(			nano-fertilizer (gm L^{-1})		
		$_0$)0N(	$_1$)2N(	$_2$)4N(	$_0$)0N(	$_1$)2N(	$_2$)4N(
local variety V_1	$_0$) 0J(	8.42 i-n	8.67 e-i	8.90 b-e	8.46 d-j	8.65 b-g	8.81 a-e
	$_1$) 15J(	8.51 g-l	8.79 c-f	9.14 ab	8.50 c-j	8.74 a-f	9.05 ab
	$_2$) 30J(	8.59 f-j	9.01 a-d	**9.25 a**	8.56 c-i	8.93 a-c	**9.17 a**
French variety V_2	$_0$) 0J (	**8.03 p**	8.32 k-o	8.50 g-l	**7.89 l**	8.23 g-l	8.42 d-k
	$_1$) 15J(	8.14 op	8.41 i-n	8.72 e-h	7.97 kl	8.32 f-l	8.63 b-h
	$_2$) 30 J(	8.23 m-p	8.62 f-j	8.81 c-f	8.11 i-l	8.51 c-j	8.75 a-f
Turkish variety V_3	$_0$) 0J(	8.19 n-p	8.47 h-m	8.64 e-i	8.08 j-l	8.38 e-k	8.55 c-i
	$_1$) 15J(	8.27 l-p	8.55 f-k	8.89 b-e	8.17 h-l	8.46 d-j	8.74 a-f
	$_2$) 30 J(	8.36 j-o	8.76 d-g	9.02 a-c	8.29 f-l	8.63 b-h	8.86 a-d
varieties) V(		**V1**	**V2**	**V3**	**V1**	**V2**	**V3**
		8.80 A	**8.42 C**	8.57 B	**8.76 A**	**8.31 C**	8.46 B

nano-fertilizer (gm L-1(	0N	1N	2N	0N	1N	2N
	8.30 C	8.62 B	**8.87 A**	**8.22 C**	8.53 B	**8.77 A**
jasmonic acid (mg L-1 (	**J0**	**J1**	**J2**	**J0**	**J1**	**J2**
	8.46 C	8.60 B	**8.73 A**	**8.38 B**	**8.50 B**	**8.64 A**

3- Ascorbic acid content of the leaves (mg.100gm^{-1} fresh weight)

Tables (4) show that the cultivar had a significant effect on the leaves content of ascorbic acid, where the plants of the local variety outperformed significantly for both seasons of the experiment compared to the plants of the other two cultivars. It plays an important role in determining the amount of ascorbic acid in the leaves, and these results agree with Lenzi and (Tesi 2000.(

It is also clear that the increase in the level of the added nano-fertilizer had a significant effect in increasing the contents of the leaves from ascorbic acid for both seasons of the experiment, as its effect increased the higher the level of the added nano-fertilizer, due to the fact that the added nitrogen element in the nano-fertilizer played a role in increasing the vital activities in the cell, which It led to an increase in the compounds that participate in the redox reactions. These results are consistent with what was found by Renata (2006.(

It was found that an increase in the level of added jasmonic acid (JA) had a significant effect on increasing the content of plant leaves of ascorbic acid for both seasons of the experiment, as its effect increased with the increase in the added concentration. Ascorbic , by promoting the expression of enzymes involved in its biosynthesis , agrees with what was found by Suza et al. , 2010.

The triple interaction between the experimental factors had a significant effect in this trait, as it gave the plants of the local variety that were sprayed with nano-fertilizer at a level of 4 g. L^{-1} and jasmonic acid 30 mg. L^{-1} (V1N2J2) had the highest rate in the leaf content index of ascorbic acid for both seasons of the experiment, as it reached 128.76 and 126.72 mg.100 g^{-1} fresh weight, respectively, compared to the lowest rates, which were 89.75 and 87.69 mg. 100gm^{-1} fresh weight, respectively, resulted from plants of the French variety sprayed with distilled water only (V2N0J0), with non-significant differences for most of the triple interactions among all the studied experimental factors.

Table (4) The effect of jasmonic acid (JA) and nano-fertilizer on the leaves content of ascorbic acid (mg.100 gm^{-1} fresh weight) for the three varieties of Rocket

varieties) V(	jasmonic acid (mg L^{-1}(	**first season**			**second season**		
		nano-fertilizer (gm L^{-1}(			nano-fertilizer (gm L^{-1})		
		0)0N(	1)2N(	2)4N(	0)0N(	1)2N(	2)4N(
local variety V_1	0) 0J(	103.56 h-l	114.56 c-f	119.66 b-d	102.31 kl	113.73 f	118.53 d
	1) 15J(	108.62 e-i	116.73 b-e	124.69 ab	106.57 hi	116.81 e	123.79 b
	2) 30J(	111.36 d-h	121.56 a-c	**128.76 a**	110.39 g	120.69 c	**126.72 a**
French variety V_2	0) 0J (	**89.75 o**	97.44 k-o	99.4 j-n	**87.69 r**	96.55 o	100.61 m
	1) 15J(	93.39 no	98.56 j-n	103.65 h-l	92.57 q	98.59 n	102.71 kl
	2) 30 J(	94.51 m-o	100.42 i-n	106.33 f-k	94.49 p	101.58 lm	105.18 ij
Turkish variety V_3	0) 0J(	96.38 l-o	104.49 g-l	107.49 f-j	92.35 q	103.60 jk	105.20 ij
	1) 15J(	101.43 i-n	105.44 g-k	112.72 d-g	98.52 n	104.58 j	110.83 g
	2) 30 J(	102.57 h-m	108.79 e-i	117.70 b-d	100.69 m	107.71 h	114.43 f
varieties) V(		**V1**	**V2**	**V3**	**V1**	**V2**	**V3**
		116.61 A	**98.16 C**	106.33 B	**115.50 A**	**97.77 C**	**104.21 B**
nano-fertilizer (gm L^{-1}(		**0N**	**1N**	**2N**	**0N**	**1N**	**2N**
		100.17 C	107.55 B	**113.38 A**	**98.40 C**	107.09 B	**112.00 A**
jasmonic acid (mg L^{-1}(		**J0**	**J1**	**J2**	**J0**	**J1**	**J2**
		103.64 C	107.25 B	**110.22 A**	**102.29 C**	106.11 B	**109.10 A**

4- Glucocinolate content of the leaves (mg. g^{-1} dry weight)

It is clear from Table (5) that the variety had a significant effect on the index of leaf content of glucosinolate, as the leaves of the French (V2) and Turkish (V3) cultivars recorded a significant superiority for both seasons of the experiment compared to the leaves of the local cultivar (V1), while it was not observed There are significant differences in the results of the studied trait for the same two cultivars (V2 and V3), perhaps due to the difference in genotypes in the ratio of food conversion from carbohydrates to glycosides, according to the difference in genotypes between cultivars and plant parts affected by the amount of tolerance to unsuitable environmental conditions, such as high rates of temperature, as this agrees with. (Redovnikovi et al., 2008(

It was also shown that increasing the level of the added nano-fertilizer had a significant effect on increasing the content of the leaves from glucosinolate and for both seasons of the experiment, as its effect increased the higher the level of the added nano-fertilizer, the increase may be attributed to the main nutrients NPK working to stimulate all cellular metabolism processes, especially the processes of cellular metabolism. The formation of amino acids, which in turn has a basic role in the formation of glucosinolate and increasing its concentration as one of the by-products of metabolism, and these results agree with (Jin et al., 2017) in increasing the content of watercress leaves of glucosinolate over the addition of NPK.

It was also found that spraying with jasmonic acid had a significant effect, through the moral superiority of the two treatments of spraying plant hormones at levels 30 and 15 mg. L^{-1} (J2 and J1) for both seasons of the experiment, which amounted to 9.43 and 9.28 mg. g^{-1} dry weight, 10.92 and 10.76 mg. g^{-1} dry weight, respectively, compared to the treatment that sprayed with distilled water only 0 mg. L^{-1} J0)), which gave the lowest results, as it recorded 8.98 and 10.31 mg. g^{-1} dry weight, respectively, while no significant differences were observed in the results of the studied trait for the same two treatments (J2 and J1), and the reason for this may be attributed to the fact that JA leads to an increase in the production of secondary compounds in some plants, consistent with what Ataei found and others 2013 and Shiva and others 2013.

The triple interaction between the experimental factors had a significant effect in this trait, as it gave the plants of the French variety that were sprayed with nano-fertilizer at a level of 4 g. L^{-1} and jasmonic acid 30 mg. L^{-1} (V2N2J2) had the highest rate in the leaf content index of glucosinolate for both seasons of the experiment, which amounted to 9.98 and 11.89 mg. g^{-1} dry weight, respectively, compared to the lowest rates of 7.65 and 8.18 mg. 1 gm^{-1} dry weight, respectively, resulted from plants of the local variety that were sprayed with distilled water only (V2N0J0), with the presence of non-significant differences for most of the triple interactions among all the factors of the studied experiment.

Table (5) Effect of jasmonic acid (JA) and nano-fertilizer on the content of glucosinolate leaves for the three cultivars of Rocket

varieties) V(	jasmonic acid (mg L^{-1}(	first season			second season		
		nano-fertilizer (gm L^{-1}(			nano-fertilizer (gm L^{-1})		
		$_0$)0N(	$_1$)2N(	$_2$)4N(	$_0$)0N(	$_1$)2N(	$_2$)4N(
local variety V_1	$_0$) 0J(	**7.65 h**	8.27 gh	8.40 e-h	**8.18 d**	8.92 c	9.09 c
	$_1$) 15J(	8.32 f-h	8.49 d-h	8.59 b-h	9.01 c	9.16 c	9.30 c

	$_2$) 30J(	8.55 c-h	8.66 a-h	8.71 a-h	9.24 c	9.35 c	9.42 c
French variety V_2	$_0$) 0J (	9.16 a-g	9.58 a-g	9.70 a-e	10.53 b	11.40 a	11.59 a
	$_1$) 15J(	9.64 a-f	9.78 a-d	9.89 a-c	11.52 a	11.66 a	11.76 a
	$_2$) 30 J(	9.81 a-d	9.92 ab	**9.98 a**	11.69 a	11.81 a	**11.89 a**
Turkish variety V_3	$_0$) 0J(	9.08 a-g	9.46 a-g	9.54 a-g	10.44 b	11.28 a	11.43 a
	$_1$) 15J(	9.49 a-g	9.61 a-g	9.72 a-e	11.35 a	11.48 a	11.60 a
	$_2$) 30 J(	9.65 a-f	9.78 a-d	9.84 a-d	11.53 a	11.67 a	11.70 a
varieties) V(		**V1**	**V2**	**V3**	**V1**	**V2**	**V3**
		8.40 B	**9.71 A**	**9.57 A**	**9.07 B**	**11.53 A**	**11.38 A**
nano-fertilizer (gm L^{-1}(		**$_0$N**	**$_1$N**	**$_2$N**	**$_0$N**	**$_1$N**	**$_2$N**
		9.03 B	**9.28 A**	**9.37 A**	**10.38 B**	**10.74 A**	**10.86 A**
jasmonic acid (mg L^{-1}(		**J0**	**J1**	**J2**	**J0**	**J1**	**J2**
		8.98 B	**9.28 A**	**9.43 A**	**10.31 B**	**10.76 A**	**10.92 A**

5- Glutathione content of leaves (mg. g^{-1} dry weight)

It is clear from Table (6) that the cultivar had a significant effect on the index of glutathione content of leaves, as the plants of the two French cultivars (V2) and the Turkish cultivar (V3) recorded significant superiority for both seasons of the experiment compared to the plants of the local variety (V1), while no differences were observed. Significantly in the results of the studied trait for the same two cultivars (V2 and V3). As the watercress plant has a genetic map that includes 22 chromosomes that play an important role in determining the type, quantity and functions of glutathione. This indicates a very large genetic contribution to this plant in determining glutathione. These results agree with Hemmat (2004.(

It was also shown that increasing the level of the added nano-fertilizer had a significant effect on increasing the content of glutathione in the leaves for both seasons of the experiment, as its effect increased as the level of the added nano-fertilizer increased. Cystine, which determines the level of glutathione mainly in the cell, these results are consistent with the findings of Elke et al., 2004.

It was found that an increase in the level of added jasmonic acid (JA) had a significant effect in increasing the content of glutathione in the leaves for both seasons of the experiment, as its effect increased with the increase in the level of the added plant hormone. With low molecular weights such as glutathione by stimulating the creation of enzymes involved in building to face conditions unsuitable for growth as an antioxidant substance, this is consistent with what was found by Kerchev et al., 2011.

The triple interaction between the experimental factors had a significant effect in this trait, as it gave the plants of the French variety that were sprayed with nano-fertilizer at a level of 4 g. L^{-1} and jasmonic acid 30 mg. L^{-1} (V2N2J2) had the highest glutathione content index in the leaves for both seasons of the experiment, which reached 4.05 and 3.99 $mg.gm^{-1}$ dry weight, respectively, compared to the lowest rates were 2.87 and 2.81 mg.gm- 1 dry weight produced from plants of the local variety that was sprayed with distilled water only (V1N0J0), with the presence of non-significant differences for most of the triple interactions among all the factors of the studied experiment.

Table (6) The effect of jasmonic acid (JA) and nano-fertilizer on the glutathione content of the leaves of the three varieties of Rocket

varieties) V(	jasmonic acid (mg L^{-1}(	**first season**			**second season**		
		nano-fertilizer (gm L^{-1}(			nano-fertilizer (gm L^{-1})		
		$_0$)0N(	$_1$)2N(	$_2$)4N(	$_0$)0N(	$_1$)2N(	$_2$)4N(
local variety V_1	$_0$) 0J(	**2.87 m**	2.99 lm	3.30 jk	**2.81 k**	2.97 jk	3.29 hi
	$_1$) 15J(	3.18 kl	3.42 i-k	3.69 b-i	3.15 ij	3.38 g-i	3.62 b-h
	$_2$) 30J(	3.53 f-j	3.77 a-h	3.81 a-g	3.50 e-h	3.71 a-g	3.75 a-f
French variety V_2	$_0$) 0J (	3.51 g-j	3.61 d-j	3.73 b-i	3.49 e-h	3.58 c-h	3.67 a-g
	$_1$) 15J(	3.70 b-i	3.86 a-e	3.95 a-c	3.63 b-h	3.74 a-f	3.83 a-e
	$_2$) 30 J(	3.91 a-d	4.01 ab	**4.05 a**	3.78 a-e	3.92 a-c	**3.99 a**
Turkish variety V_3	$_0$) 0J(	3.48 h-j	3.57 e-j	3.65 c-i	3.41 f-i	3.51 e-h	3.61 b-h
	$_1$) 15J(	3.61 d-j	3.72 b-i	3.85 a-f	3.55 d-h	3.70 a-g	3.84 a-e
	$_2$) 30 J(	3.79 a-h	3.93 a-d	3.97 a-c	3.78 a-e	3.89 a-d	3.95 ab
varieties) V(		**V1**	**V2**	**V3**	**V1**	**V2**	**V3**
		3.39 B	**3.81 A**	**3.73 A**	**3.35 B**	**3.73 A**	**3.69 A**

nano-fertilizer (gm L^{-1}(	**$_0$N**	**$_1$N**	**$_2$N**	**$_0$N**	**$_1$N**	**$_2$N**
	3.50 C	3.65 B	**3.77 A**	**3.45 C**	3.60 B	**3.72 A**
jasmonic acid (mg L^{-1}(	**J0**	**J1**	**J2**	**J0**	**J1**	**J2**
	3.41 C	3.66 B	**3.86 A**	**3.37 C**	3.60 B	**3.80 A**

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