



The effectiveness of organic fertilizers in improving the chemical composition of different genotypes of watercress (*Eruca sativa* L.)

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ABSTRACT

The experiment was conducted in the village of Imam Ismail in the Hawija District of Kirkuk Governorate during the 2025 winter season. The study involved two factors: the first was the effect of four types of organic fertilizers (control, cow manure, sheep manure, and poultry manure), and the second was four genetic lines (local, Turkish, Iranian, and Syrian) and their interactions on certain phenolic compounds in watercress. These treatments were arranged according to a completely randomized block design (RCBD) as a factorial experiment with three replications. The results of the statistical analysis can be summarized as follows: Organic fertilizer achieved a significant increase in the studied traits, with the treatment yielding the highest mean values. Phenolic compounds: quercetin (100.3225) ppm, gallic acid (110.0342) ppm, catechol (83.7833) ppm, and benzoic acid (57.9958) ppm. The Syrian genotype showed superiority compared to the other cultivated genotypes (quercetin (109.49) ppm, gallic acid (119.4283) ppm, catechol (93.5367) ppm, and benzoic acid (67.5058) ppm). The interaction between organic fertilizers and the genotype and its relationship to the supplemental treatment was studied. (cow manure and the Syrian genetic composition) showed a significant increase with the highest averages. The phenolic compounds include quercetin (112.51) ppm, caffeic acid (122.23) ppm, and benzoic acid (70.49) ppm.

Keywords: *Eruca sativa*, Genotypes, Sheep manure, Phenolic compounds.

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كفاءة الأسمدة العضوية في تحسين المحتوى الكيميائي لتراكيب وراثية مختلفة من نبات الجرجير *Eruca sativa* L.

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المخلص

أجريت التجربة في قرية الامام اسماعيل في قضاء الحويجة بمحافظة كركوك للموسم الشتوي 2025. تتضمن الدراسة عاملين: الأول هو دراسة تأثير أربعة أنواع من الأسمدة العضوية (من دون إضافة للمقارنة، روث البقر، روث الأغنام، وروث الدواجن)، والثاني هو أربعة أنواع من التركيبات الوراثية (المحلية، التركية، الإيرانية، السورية) وتداخلاتها في بعض المركبات الفينولية لنبات الجرجير. وزعت هذه المعاملات وفق تصميم القطاعات العشوائية الكاملة (RCBD) كتجربة عاملية بثلاث مكررات. ويمكن تلخيص نتائج التحليل الإحصائي بما يلي: حقق السماد العضوي ارتفاعاً معنوياً في الصفات المدروسة، حيث تفوقت المعاملة بإعطاء أعلى القيم المتوسطة. المركبات الفينولية، الكورسيتين (100.3225) ppm، الكاليك (110.0342) ppm، الكاتيكول (83.7833) ppm، وحمض البنزويك (57.9958) ppm. أظهر التركيب الوراثي السوري افضلية مقارنة مع باقي التراكيب الوراثية المزروعة (الكورسيتين (109.49) ppm، وحمض الكاليك (119.4283) ppm، والكاتيكول (93.5367) ppm، وحمض البنزويك (67.5058) ppm. تم دراسة التداخل بين الأسمدة العضوية والتركيب الوراثي وعلاقته بالمعاملة التكميلية. (مخلفات الأبقار والتركيب الوراثي السوري) أظهرت زيادة معنوية مع أعلى المتوسطات. وتشمل المركبات الفينولية الكورسيتين (112.51) ppm، وحمض الكاليك (122.23) ppm، وحمض البنزويك (70.49) ppm.

INTRODUCTION

Watercress, scientifically known as *Eruca sativa*, is a leafy green vegetable belonging to the Brassicaceae family, the same family that includes broccoli, cabbage, and kale (Grami et al., 2024). Watercress is known for its distinctive, pungent flavor and is widely cultivated throughout the world, where it has numerous culinary and medicinal uses. Its use dates back to Roman times (Algreiby,

2024). Watercress is considered an important medicinal and aromatic plant because it contains various phytochemicals such as flavonoids, phenolic acids, terpenes, carotenes, glycosides, saponins, sterols, and alkaloids, which are secondary metabolites, in addition to other compounds. Recent studies have shown that the watercress plant is used as an antioxidant, antibacterial, antidiabetic, anti-ulcer, anti-cancer, blood pressure reducer, and it effectively stimulates hair growth. It is also used as a sexual stimulant and antifungal (2019 Jaafar and Jaafar). The distinctive pungent taste and flavor of this plant, characteristic of some plants in this family, is due to the presence of the compound singrin in its leaves and seeds. Singrin is the most important glucosinolare compound and is hydrolyzed by the enzyme myrosinase. This sulfur-containing compound is responsible for the pungent or bitter taste in these plants. When cell rupture occurs, this compound is further broken down by the enzyme Isothiocyanatease (Bell et al., 2021). It also plays an important role in insect resistance, but when thiocyanate levels exceed the required limit, it becomes toxic to humans, as it leads to goiter and causes iodine deficiency (Boras et al. 2011). Medicinal and aromatic plants perform better in terms of yield, quality, and quantity under organic farming systems. Currently, the unbalanced application of chemical fertilizers has caused a decrease in the quality of products, not only lower quality but also a residual effect that enters the food chain and threatens the health of humans and other organisms. However, organic fertilizer, in addition to improving the crop, provides organic matter and nutrients to the soil, ultimately leading to an improvement in soil type (Badalingappanavar et al 2018). *Eruca sativa* is characterized by its high content of vitamins such as B1, B2, B3, and C, in addition to potassium, iodine, calcium, iron, zinc, and sulfur compounds (Baggio & Pimpini, 1994). study was conducted on the medical importance of watercress, jojoba, henna leaves, and frankincense, considering their economic importance and their role in traditional and modern medicine. Using precise instruments, the study revealed the presence of important chemical compounds in the oils of watercress and jojoba seeds (Al-Jabir et al 2020). Therefore, it has been known for its historical importance in traditional medicine, as it has been shown to contain flavonoids, carotenoids, vitamins, antioxidant compounds, and minerals (Al-Sulivany et al 2024).

This medicinal plant belongs to the same plant family as turnips, mustard, and others. It is also characterized by its ability to withstand drought, as it possesses an efficient root system that helps it obtain moisture from deep within the soil. It is a suitable plant for cultivation in arid and semi-arid regions (Yadav, et al 2013).

There were significant variation and difference in the behavior of 102 genotypes of arugula plants in terms of traits the number of pods, the number of secondary branches per plant, the highest average yield, and the number of rows in each pod. (Jakhar, et al 210) (Shinwari, et al 2013)

It has been shown that the use of organic fertilizer, or what is called farm manure, contributes

significantly to soil nutrition because it is rich in nitrogen, calcium, magnesium, sulfur, and iron. [(Yousaf et al., 2024) (Sushila & Gajendra, 2000) (Marculescu et al., 2002)].

The use of a mixture of yeast and compost contributed to a significant increase in nitrogen and phosphorus uptake, which in turn positively impacted organic matter synthesis and improved crop quality and quantity (Marculescu et al., 2002)

It turned out that the use of compost and poultry helped increase the total number of leaves in rapeseed plants in greenhouses (Salaman Dane, et al 2022).

The aim of this research:

Evaluate several genetic makeups of the rocket plant. Identifying the best organic fertilizer for producing the active compounds for the rocket plant. Understanding the effect of organic fertilizer interaction and genetic makeup on the chemical composition of the arugula plant.

MATERIALS AND METHODS:

1-Experimentation and Treatments:

The experiment was conducted in the village of Imam Ismail in the Hawija district of Kirkuk Governorate Latitude (Circle of Latitude): (35.332822) (N) Latitude: (43.652341) (E). during the winter season of 2025. The study included two factors: the first factor was (4) genetic combinations of arugula plants (local V1, Turkish V2, Iranian V3, and Syrian V4), and the second factor was (4) types of organic fertilizers (no additives F0, cow manure (10) ton/hectare-1 F1, sheep manure (10) ton/hectare-1 F2, and poultry manure (10) ton/hectare-1 F3). (Note that all organic fertilizers were decomposed.)

2-Soil preparation and sowing:

The land is plowed, harrowed, and leveled before being divided into 16 experimental units per replicate, each measuring 2 x 2 meters (4 square meters). The experimental units are arranged in rows within plots, with each unit containing 5 rows and 35 plants planted in each unit. Rows are spaced 40 cm apart, and plants within rows are spaced 30 cm apart. A 10 cm margin is left around the sides of each experimental unit, while the distance between units is 50 cm, and between replicates, 100 cm (Hassan, 1989). Seeds are sown at a rate of 3-4 seeds per hole to ensure the highest germination rate. Thinning is carried out one month after germination, leaving only one plant per planting hole Planting took place on Monday, September 15, 2025.

3-Chemical Characteristics:

Ultrasonic extraction of phenolic compounds: Ministry of Science and Technology / Department of Environment and Water Management

Phenolic compounds were extracted from a homogenized plant. 100 mL of chloroform was added to 20 g of the finely ground plant and subjected to an electric vibrator for 3 hours to remove lipids. The chloroform layer was then removed, and after drying the sample at 50°C to ensure the absence of any chloroform residue, 10 g of the dried sample was extracted using an ethanol/water (70/30) solvent. The extraction was carried out using a room-temperature ultrasonic bath for 1 hour. The sample was then filtered and the solvent removed using a rotary evaporator under vacuum at 40°C until mass stability was achieved. The dried extracts were stored in sealed bottles at 4°C to prevent oxidation until analysis. Individual phenolic compounds were measured using reverse-phase high-performance liquid chromatography (HPLC). A SYKAM HPLC instrument with a UV detector and a C18-OSD column (25 cm × 4.6 mm) was used. The column temperature was set to 30 °C. A step-down dissolution method was employed using solvents A (methanol) and B (1% formic acid dissolved in water at a v/v ratio): for the first 6 minutes, the concentration of solvent B was 40%; then from minutes 6 to 15, the concentration of solvent B was increased to 50%. The fluid flow rate was maintained at 1.0 mL/min. Samples and standards were injected in 100 µL volumes using an automated sampling device, and spectra were recorded at a wavelength of 280 nm (Radovanovic et al., 2015).

4- Experimental Design and Statistical analyses:

The experiment will be conducted using a randomized complete block design (RCBD), with three replicates to ensure accuracy. Data on the studied traits were statistically analyzed, and statistically significant differences between means were determined using Duncan's Multiple Range Test at a significance level of 5%, based on the methodology (Al-Rawi and Khalaf Allah, 2000). fertilizer will be applied according to the recommended amounts to ensure optimal experimental conditions

RESULTS AND DISCUSSION

1- The effect of organic fertilizers, genetic makeup, and the interaction between them in determining the phenolic compounds (Quercetin) of the rocket plant.

Table (1) illustrates the effect of the type of organic fertilizer, genetic makeup, and their interaction on quercetin concentration. The cow manure treatment significantly outperformed the control treatment (100.3225%) compared to the control treatment (no fertilizer) (94.9375%). Regarding genetic makeup, the Syrian genetic makeup was superior (109.49%) compared to the local genetic makeup (85.99%). As for the interaction, the combined treatment (cow manure and the Syrian genetic

makeup) significantly outperformed the local genetic makeup (112.51%) compared to the control treatment (no fertilizer) (84.4067%).

Table 1. The effect of organic fertilizers, genetic makeup, and the interaction between them in determining the phenolic compounds (corticoids) of the rocket plant.

Genotype	Type of organic fertilizer				Genotype mean
	Control	Cow manure	Sheep manure	Chicken manure	
Local	84.41 p	87.61 m	86.25 n	85.70 o	85.99 d
Turkey	90.41 l	96.35 i	94.20 j	92.71 k	93.41 c
Iranian	98.44 h	104.83 e	102.45 f	100.50 g	101.55 b
Syrian	106.50 d	112.51 a	110.46 b	108.50 c	109.49 a
Manure Mean	94.94 d	100.32 a	98.34 b	96.85 c	

2- The effect of organic fertilizers, genetic makeup, and the interaction between them in determining the phenolic compounds (calcic acid) of the rocket plant.

Table (2) illustrates the effect of the type of organic fertilizer, genetic makeup, and their interaction on the concentration of calcic acid. The cow manure treatment significantly outperformed the control treatment, with an average of (110.0342), compared to the control treatment, which had an average of (104.6542). Regarding genetic makeup, the Syrian genetic makeup significantly outperformed the local genetic makeup, with an average of (119.4283), compared to the local genetic makeup, which had an average of (94.9842). As for the interaction, the combination treatment of cow manure and the Syrian genetic makeup significantly outperformed the local genetic makeup, with an average of (122.23), compared to the combination treatment without fertilizer, which had an average of (93.29).

Table 2. The effect of organic fertilizers, genetic makeup, and the interaction between them in determining the phenolic compounds (calcic acid) of the rocket plant.

Genotype	Type of organic fertilizer				Genotype mean
	Control	Cow manure	Sheep manure	Chicken manure	
Local	93.29 p	96.42 m	95.55 n	94.68 o	94.98 d
Turkey	100.55 l	106.75 i	104.41 j	102.57 k	103.57 c
Iranian	108.40 h	114.74 e	112.13 f	110.55 g	111.45 b

Syrian	116.38 d	122.23 a	120.61 b	118.50 c	119.43 a
Manure Mean	104.65 d	110.03 a	108.17 b	106.57 c	

3- The effect of organic fertilizers, genetic makeup, and the interaction between them in determining the phenolic (catechol) compounds of the rocket plant.

Table (3) illustrates the effect of the type of organic fertilizer, genetic makeup, and the interaction between them on the concentration of catechol. The cow and sheep manure treatments showed a significant advantage, with averages of (83.7833) for cows and (83.5642) for sheep, followed by poultry manure and the no-fertilizer treatment, with averages of (79.6983) for poultry manure and (77.9425) for no-fertilizer. No significant differences were found between the two treatments.

Table 3. The effect of organic fertilizers, genetic makeup, and the interaction between them in determining the phenolic (catechol) compounds of the rocket plant.

Genotype	Type of organic fertilizer				Genotype mean
	Control	Cow manure	Sheep manure	Chicken manure	
Local	66.34 a	69.82 a	74.86 a	67.53 a	69.64 d
Turkey	72.41 a	80.45 a	78.40 a	74.48 a	76.43 c
Iranian	82.58 a	88.35 a	86.29 a	84.32 a	85.38 b
Syrian	90.45 a	96.52 a	94.71 a	92.47 a	93.54 a
Manure Mean	77.94 b	83.78 a	83.56 a	79.70 b	

4- The effect of organic fertilizers, genetic makeup, and the interaction between them in determining the phenolic compounds (benzoic acid) of the rocket plant.

Table (4) illustrates the effect of fertilizer type, genetic makeup, and their interaction on benzoic acid levels in arugula. Cow manure significantly outperformed the control treatment with an average of (57.9958), followed by sheep manure with an average of (56.3067), in contrast to the control treatment without fertilizer, which had an average of (52.7967). Regarding genetic makeup, the Syrian genetic makeup significantly outperformed the control treatment with an average of (67.5058), compared to the local genetic makeup, which had an average of (43.0333). As for the interaction, the combination treatment of cow manure and the Syrian genetic makeup significantly outperformed the control treatment with an average of (70.49), compared to the combination treatment without fertilizer for the local genetic makeup, which had an average of (41.34).

Table 4. The effect of organic fertilizers, genetic makeup, and the interaction between them in determining the phenolic compounds (benzoic acid) of the rocket plant.

Genotype	Type of organic fertilizer				Genotype mean
	Control	Cow manure	Sheep manure	Chicken manure	
Local	41.34 p	44.45 m	43.62 n	42.73 o	43.03 d
Turkey	48.90 l	54.48 i	52.51 j	50.40 k	51.57 c
Iranian	56.41 h	62.57 e	60.49 f	58.48 g	59.49 b
Syrian	64.54 d	70.49 a	68.62 b	66.38 c	67.51 a
Manure Mean	52.80 d	58.00 a	56.31 b	54.50 c	

The scientific reason for the results of phenolic compounds:

The increase in phenolic concentration is attributed to the vital role of organic matter in providing macronutrients such as nitrogen, phosphorus, and potassium to the plant. These elements contribute directly to promoting vegetative growth by stimulating meristematic cell division and growth, increasing leaf surface area, and improving the production of nutrients such as carbohydrates and proteins, which are the building blocks of plant tissues. These processes are clearly reflected in the elevated levels of phenolic compounds within the plant. Organic fertilizers and humic substances have a significant and vital effect on increasing plant physiological activities, which in turn affects growth and chemical composition. This leads to an increase in metabolic byproducts resulting from the increased biochemical activity of cells (Vanughan et al,1985). Likewise, the increase in phenol concentrations with an increase in organic matter can be attributed to the role of organic acids in increasing the photosynthesis process, which produces the compound (PEP) Phosphoenol pyruvate formed in the glycolysis process, as well as the substance Erythrose-4-phosphate formed in photosynthesis or the Pentose phosphate pathway. When these two compounds combine, they produce (Shikimic acid), and thus lead to an increase in the concentrations of phenolic compounds in the plant as products of secondary metabolism (Muhammad,1985). These compounds are considered secondary metabolic products, meaning they follow secondary biochemical pathways due to the increased activity of primary metabolism in the cell, i.e., the processes of building up and breaking down carbohydrates, fats, and proteins.

Numerous studies indicate that organic fertilization is superior to chemical fertilization in improving crop quality and antioxidant content:

1-Enhancing Phenolic Content via Organic Matter

A study by (Khalid et al., 2006). confirmed that adding organic waste (such as cow manure) led to a significant increase in the proportion of total phenols and volatile oils in aromatic and medicinal plants compared to mineral fertilization

2- The Role of the Interaction Between Plant Variety and Fertilizer

In a study conducted by (Ibrahim, M. H., et al 2013). it was found that the interaction between plant genetic makeup and the type of organic fertilizer plays a crucial role in the accumulation of secondary metabolites. The study demonstrated that organic fertilizer increases available carbon levels, supporting the C/N Balance Hypothesis, where increased carbon availability leads to increased phenol production.

3- The effect of cow manure specifically

In their research on crop productivity and quality under an organic fertilization system, (Riahi et al., 2009) indicated that cow manure increases the concentration of phenols due to improving the physical properties of the soil and activating microorganisms that secrete natural growth stimulants that encourage the plant to build its defense compounds

CONCLUSIONS

Our research investigated the impact of four arugula genotypes (local, Syrian, Turkish, and Iranian) and three types of animal fertilizers (poultry, sheep, and cow manure) on specific phenolic compounds. Among the fertilizers tested, cow manure demonstrated a significant advantage, consistently yielding higher levels of all phenolic compounds evaluated in the study. Regarding genetic variations, the Syrian genotype outperformed the others across the four phenolic compounds examined. For the interaction effects, the combination of cow manure and the Syrian genotype emerged as the most effective treatment for enhancing phenolic compounds, with the exception of the catechol compound.

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