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RESPONSE OF THREE BEETROOT CULTIVARS TO ORGANIC FERTILIZATION AND FOLIAR APPLICATION

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ABSTRACT

A field experiment was conducted for autumn season 2021-2022 in the fields of the Department of Horticulture and Landscape Engineering, College of Agricultural Engineering Sciences, University of Baghdad, Al-Jadriya Campus, Station A- To study the effect of cultivars (Red, Dark Red, and Cylindra), organic fertilizer, vermicompost, and cow manure, as well as control treatment (soil only), and spraying with silicon and calcium elements and distilled water (control) on the growth, yield, and quality of beetroot plant Within a completely randomized block design as a split plot experiment, where the cultivars were counted as the main factor, organic fertilizer, and foliar spray as the secondary factor, with three replicates, the number of treatments was 27, and the averages were compared according to the least significant difference L.S.D at the level of probability 5% for each cultivar, and the results were as follows:

There is a significant effect of the triple interaction between cultivars, culture medium and foliar spraying on the percentages of the elements N, P, K, and Ca as well as the concentration of Si in the leaves of the beetroot plant, as it was noted that the treatments V2×F1×S2, V2×F2×S2, and V3×F1×S2 gave them the highest percentage of nitrogen in leaves amounted to 3.50%,The triple interaction treatment V2×F1×S2 was significantly excelled in the percentage of phosphorus and potassium in the leaves by giving it (0.43%, 4.69%) respectively, while the treatment V2×F2×S2 was significantly excelled by giving it the highest percentage of calcium in the leaves, amounting to 2.17%.The results also indicated that the two treatments V2×F1×S2 and V3×F1×S2 were excelled in the concentration of silicon in the leaves by giving them 0.00739 ppm. the triple interaction treatment the cultivar Cylindra and Vermicompost medium with silicone spray V3×F1×S2 Significantly excelled gave it the highest leaf yield of 67.50 tons ha^{-1}, While the treatment V2×F1×S2 excelled in (root yield, percentage of total soluble solids, percentage of sugars and percentage of phenols) given (74.49 ton ha^{-1}, 11.66%, 948.7% and 0.18%), respectively.

Keywords: Vermicompost, cow manure, calcium, silicon, beetroot

* **The research is extracted from the doctoral thesis of the first researcher.**

استجابة ثلاثة أصناف من الشوندر للتسميد العضوي والرش الورقي

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الخلاصة

نفذت تجربة حقلية للموسم الخريفي 2021-2022 في الحقول التابعة لقسم البستنة وهندسة الحدائق، كلية علوم الهندسة الزراعية، جامعة بغداد، مجمع الجادرية، محطة A لدراسة تأثير الاصناف (Red،Dark Red و Cylindra) والاسمدة العضوية (سماد دودة الأرض وسماد الابقار) فضلا عن معاملة المقارنة (تربة فقط) والرش بعنصري السليكون والكالسيوم والماء المقطر(مقارنة) في نمو وانتاج ونوعية نبات الشوندر، ضمن تصميم القطاعات التامة التعشية كتجربة قطع منشقة اذ عدت الأصناف العامل الرئيس والاسمدة العضوية والرش الورقي العامل الثانوي وبثلاث مكررات، بلغ عدد المعاملات 27 وتم مقارنة المتوسطات حسب اقل فرق معنوي L.S.D وعند مستوى احتمال 5 % لكل صنف، وكانت النتائج كالاتي:

وجود تأثير معنوي لمعاملات التداخل الثلاثي بين الأصناف والسماد العضوي والرش الورقي في النسب المئوية للعناصر NوPوKوCa فضلا عن تركيز عنصر Si في أوراق نبات الشوندر، اذ تبين تفوق المعاملات F1×S2×V2 وF2×S2×V2 وF1×S2×V3 بإعطائها اعلى نسبة مئوية للنتروجين في الأوراق بلغت 3.50%، كما تفوقت المعاملة التداخل الثلاثي F1×S2×V2 معنويا في النسبة المئوية للفسفور والبوتاسيوم في الأوراق بإعطائها (0.43%، 4.69%) بالتتابع، فيما تفوقت المعاملة F2×S2×V2 معنويا بإعطائها اعلى نسبة مئوية للكالسيوم في الأوراق بلغت 2.17%، كما دلت النتائج على تفوق المعاملتين F1×S2×V2 وF1×S2×V3 في تركيز عنصر السليكون في الأوراق بإعطائها 739.00 ملغم لتر$^{-1}$.

تفوقت معنويا معاملة التداخل الثلاثي للصنف Cylindra والوسط Vermicompost مع رش السيليكون F1×S2×V3 بإعطائها اعلى حاصل ورقي بلغ 67.50 طن هكتار$^{-1}$، فيما تفوقت المعاملة F1×S2×V2 في (الحاصل الجذري، النسبة المئوية للمواد الصلبة الذائبة الكلية، النسبة المئوي للسكريات والنسبة المئوية للفينولات) بإعطائها (74.49 طن هكتار$^{-1}$، 11.66%،948.7%و0.18%) بالتتابع

الكلمات المفتاحية : سماد دودة الأرض، سماد الابقار، كالسيوم، سليكون ،شوندر

INTRODUCTION

Intensive farming using chemical fertilizers increased crop yields at the expense of product quality and environmental degradation **(Al-Halfi *etal.*, 2022)** and the importance of the beetroot plant, which is characterized by its richness of antioxidants because it contains the red betalain pigment with anti-cancer properties, as well as containing vitamins A and C, folic acid (vitamin B9) in the roots, and a high percentage of iron **(Shayaa & Hussein, 2019)** and since the growth and productivity of the beetroot crop is affected by many factors, foremost of which is soil with a high surface area and a continuous supply of nitrogen, phosphorus and potassium throughout the growing season, therefore, interest in organic amendments increased as alternative agricultural practices to maintain high production of agricultural crops with minimal environmental pollution **(Elias & Al- Halfie, 2019)**Hence the importance of vermicompost, which is the product of biodegradation of organic matter through interactions between earthworms and microorganisms. It is characterized by high porosity, aeration, drainage, water retention capacity and microbial activity **(Aziz & Alwan, 2022)**. Earthworm manure contains the main nutrients in forms more ready for absorption by the plant, such as nitrates, phosphates, calcium and potassium, as well as an increase in microbial activity for its richness in fungi and bacteria that help in biodegradation of waste, provide nutrients and aerate the soil, which enhances crop growth **(Joshi *& Vig* 2010; Abdulrasool & AL-Malikshah, 2022)**.Cow manure is also one of the environmentally friendly organic fertilizers with an improving effect on soil properties that can be used as a catalyst for plant growth and the production of safe products for consumption due to its natural properties as it provides macro and micro nutrients, improves cation exchange capacity, increases water retention capacity and soil microbiological activity**(Al-Mharib *etal.*, 2020)**.Optimum nutrition in plants contributes to obtaining high productivity with good quality value, and the fact that the beetroot plant is one of the plants with a high need for nutrients, in addition to that the plants are susceptible to insect infestations due to the root content of sugars, which increases the directions to search for solutions to ensure productivity and quality without chemical residues **(Crecente-Campo *etal.*, 2012)** Silicon enhances the rigidity of the cell wall structure in plants, as well as its role in improving yield quality by increasing the proportion of sugars **(Yaghubi *etal.*, 2019)**.Calcium is an important nutrient that contributes to increasing the hardness of the crop, as it is included in the composition of cell walls and membranes, as well as its entry into the middle lamina **(Thor, 2019)**. Therefore, based on the foregoing, the study aimed to increase the productivity and quality of the beetroot crop by using organic fertilizers (earthworm manure and cow manure) and foliar spraying (with silicon and calcium).

MATERIALS AND METHODS

The study was carried out in the fields of the Department of Horticulture and Landscape Engineering, College of Agricultural Engineering Sciences, University of Baghdad, Al-Jadriya Complex , Station A for the fall season 2021-2022, the field was divided into sheets with a length of 1.25 m and a width of 2 m. Seeds were sown on 4 lines, the distance between one line and another was 20 cm, and a distance of 15 cm between one plant and another, and fertilizer recommendations were added for the beetroot plant (150 kg N/ ha, 120 kg P/ ha, and 120 kg K/ ha) **(Al-Nuaimi, 1999)**.

Treatments and experimental design

An experiment was conducted with three factors (3 * 3 * 3) within the split plot design with factorial design, where the first factor represents three cultivars distributed on the main plots, the second factor represents the agricultural media (3 treatments), and the third factor is spraying with nutrients (3 treatments). The number of treatments reached 27, with three replicates, and the total number of experimental units reached 81 experimental units (27 treatments * 3 replicates). Seeds were sown directly on 10/1/2021 Statistical analysis was carried out using genistat: (plant density =1.845 plant ha^{-1}) .

Study factors

The first factor: Cultivars

V1- The Red cultivar (a cultivars produced by Delta seeds, Holland. Purity 99% and germination 85%)

V2- Dark Red cultivar (cultivars produced by Golden land seed company, California. Purity 99.9% and germination 85%)

V3- Cylindra Cultivar (cultivars produced by Mountain valley seed company. Denmark. Germination 90%)

The second factor: organic fertilizers

S1- Soil only.

S2- Vermicompost (1% of the weight of the soil was added at a depth of 30 cm when planting, mixing with the soil of the experimental unit)

S3- Cow waste (1% of the weight of the soil was added at a depth of 30 cm when planting, mixing with the soil of the experimental unit)

The third factor: Foliar spraying
F0- Without spraying (spraying with distilled water only).
F1- Silicon Si (1.25 mg/L) Source: Growsil Fertilizer.
F2- Calcium Ca (2g/l) Source: Tecnokel calcium.

After completing the indicators of the field study, the averages were compared according to the least significant difference (L.S.D) at a probability level of 5%.

Study Characteristic

The percentage of nitrogen, phosphorus, potassium and calcium in the leaves of the beetroot plant:

Random samples of leaves were taken from all experimental units 10 days after scratching. The samples were dried in an electric oven at 60-70 °C until the weight stabilized. Then the samples were digested and the elements were estimated by the following methods.

Nitrogen: using the Microkjeldahl apparatus by the distillation process **(Jackson, 1958).**
Phosphorus: Spectrophotometer **(Olsen & Sommers, 1982)**
Potassium and Calcium: Using a Flame Photometer **(Al Sahhaf, 1989)**
Silicon: Spectrophotometer according to the method given in **A.O.A.C (1980)**

yield Characteristic

The measurements of the yield of 24 randomly selected plants from each experimental unit were recorded as follows:

Foliar yield / plant (ton ha^{-1}): Separation of vegetative growth from the area of contact with the stem and then according to the weight of the selected plants.

Total root yield (ton ha^{-1}): The yield weights of all plants of the experimental unit were calculated according to the following equation

$$\text{Total root production (ton ha}^{-1}) = \frac{\text{root weight (g) x plant density (ha)}}{1{,}000{,}000 \text{ g.ton}^{-1}}$$

Qualitative Characteristic

Percentage of total soluble solids T.S.S: Use the Hand Refractometer according to the method mentioned by **Al-Ani (1985).**
Percentage of total sugars: Calculated according to **(Joslyn, 1970)**
Percentage of total Phenols: Total phenols were estimated using the Folin-Ciocalteau method **(Vernon *etal.*, 1999)**

RESULTS AND DISCUSSION

It is clear from the results of Table (1-A) that there is a significant effect of the triple interaction treatment between cultivars, the agricultural medium and foliar spraying on the percentages of the elements N, P, K and Ca as well as the concentration of the Si element in the leaves of the beetroot plant. The results of the table showed that the treatments V2×F1×S2, V2×F2×S2, and V3×F1×S2 were distinguished by giving them the highest percentage of nitrogen in the leaves, amounting to 3.50%, which did not differ significantly from the treatment V2×F2×S3, compared with the treatment V1×F0×S1, which It gave the lowest rate of 2.45%.The treatment V2×F1×S2 also excelled significantly in the percentage of phosphorous in the leaves by giving it 0.43%, which did not differ significantly from the treatment V3×F1×S2, compared with the lowest percentage in the treatment V1×F0×S1 of 0.19%. As for the effect of the interaction of study factors on the percentage of potassium, the results of Table (1-A) indicated that treatment V2×F1×S2 was significantly excelled on 4.69%, compared with treatment V1×F0×S1, which gave the lowest percentage of 2.07%. While the treatment V2×F2×S2 was significantly distinguished by giving it the highest percentage of calcium in the leaves, amounting to 2.17%, compared to the lowest percentage in the treatment V1×F0×S1, which gave 0.96%. The results of the same table also indicated bi- treatments V2×F1×S2 and V3× F1×S2 excelled in the concentration of silicon in the leaves by giving it .00739 ppm compared to the lowest value in the treatment V1×F0×S1 that gave 287.00 ppm.The results of table (1-B) indicated the bi- interaction treatment between cultivar and medium V2 × S2 excelled in the percentage of nitrogen, phosphorus, potassium and calcium in the leaves of the beetroot plant, as it gave (3.40, 0.40, 4.00, 1.84%), respectively, compared to the lowest percentage of nitrogen in bi- treatments V1 × S1 and S2×V1 as it amounted to 2.74%, and the lowest percentage of phosphorus and potassium in the treatment V1×S1 amounted to (0.22 and 2.48%), respectively. While the lowest percentage of calcium in the treatment V1×S2 was 1.14%. As for the concentration of silicon in the leaves, it was characterized by the treatment V2×S3, as it gave 670.33 ppm, and the lowest concentration was for the treatment V3×S1 amounted to 446.00 ppm. While the results of the interaction between the cultivar and foliar spraying showed that the treatment V2×F2 excelled in the percentage of nitrogen amounting to 3.32%, while the treatment V2×F1 excelled in the percentage of phosphorus and potassium, reaching (0.39 and 4.08%), respectively. While the treatment V2×F2 excelled in the percentage of calcium by giving it 1.79%, without significant differences from the two treatments V2×F1 and V2×F0. As for the lowest percentage of nitrogen, phosphorus, potassium and calcium, the treatment V1×F0 witnessed (2.62, 0.21, 2.80, 1.14%). As for the concentration of silicon in the leaves of the beetroot, the treatment V2×F1 was significantly distinguished by giving it 710.67 ppm compared to the lowest concentration of 340.67 ppm in the treatment V3×F0. As for the effect of the interaction between the medium and foliar spraying, it was characterized by the treatment S2×F1 in the percentage of nitrogen, as it gave 3.26% compared to the lowest percentage of the treatment S3×F0, which amounted to 2.88%, while the treatment S2×F1 was significantly excelled in the percentage of P and K elements and the concentration of Si in the leaves by giving it (0.41%, 4.35%, and 729 ppm) compared to treatment S1×F0, which amounted to (0.26%, 2.71%, and 313.00 ppm), respectively. While the treatment S2 × F2 excelled in the percentage of calcium by giving it (1.80%) compared to the lowest percentage of treatment F0 × S1, which amounted to 1.20%. Regarding the effect of the individual study factors, it is noted from Table (1-c) that the V2 cultivar was excelled in the percentage of the elements N, P, K, Ca, and the concentration of the element Si in the leaves of the beetroot plant by giving it (3.24%, 0.38%, 3.70%, 1.73%, and 599.33 ppm) respectively compared to the lowest concentrations of the V1 cultivar, which amounted to (2.79%, 0.26%, 3.11%, 1.23%, and 510.89 ppm), respectively. It is also noted that the S2 medium was excelled in the percentage of nitrogen, phosphorus, potassium and calcium, as it gave (3.12, 0.36, 3.68, 1.55%), respectively .While the S3 culture medium excelled in the concentration of silicon in the leaves, reaching 606.44 ppm, while the soil medium S1 witnessed the lowest percentage of nitrogen, phosphorus, potassium and calcium, and the lowest concentration of silicon reached (2.96, 0.28, 3.15, 1.34% and 494.56 ppm), respectively. Without significant difference from S3, While the treatment of foliar spraying with silicon F1 was significantly distinguished in the percentage of nitrogen, phosphorus, potassium and the concentration of silicon in the leaves of the beetroot plant, as it gave (3.08, 0.35, 3.77% and 678.22 ppm), respectively. While the treatment of spraying with calcium F2 excelled in the percentage of calcium as it gave 1.53%, while the treatment of spraying with distilled water only F0 gave the lowest percentage of nitrogen, phosphorus, potassium and calcium, and the lowest concentration of silicon reached (2.93, 0.30, 3.05, 1.37% and 413.22 ppm) respectively.

Table (1a): The effect of the triple interaction of cultivars, medium and organic fertilizers on the concentration of nutrients in beetroot leaves of beetroot for the fall season 2021.

Parameters / Treatments	N(%)	P(%)	K(%)	Ca(%)	Si (ppm)
F×S×V					
V1×F0×S1	2.45	0.19	2.07	0.96	287.00
V1×F1×S1	2.80	0.22	3.06	1.32	618.00
V1×F2×S1	2.98	0.25	2.32	1.21	577.00
V1×F0×S2	2.63	0.21	2.64	1.02	382.00
V1×F1×S2	2.80	0.40	4.19	1.10	709.00
V1×F2×S2	2.80	0.32	3.75	1.32	386.00
V1×F0×S3	2.80	0.24	3.69	1.46	549.00
V1×F1×S3	2.87	0.29	3.13	1.45	604.00
V1×F2×S3	2.98	0.26	3.19	1.29	594.00
V2×F0×S1	3.15	0.37	3.44	1.52	339.00
V2×F1×S1	3.26	0.36	3.73	1.56	693.00
V2×F2×S1	3.15	0.34	3.69	1.93	599.00
V2×F0×S2	3.22	0.38	3.25	1.53	491.00
V2×F1×S2	3.50	0.43	4.69	1.84	739.00
V2×F2×S2	3.50	0.40	4.06	2.17	522.00
V2×F0×S3	2.94	0.39	3.44	1.86	645.00
V2×F1×S3	3.15	0.40	3.88	1.57	700.00
V2×F2×S3	3.33	0.38	3.13	1.64	666.00
V3×F0×S1	3.15	0.24	2.63	1.14	313.00
V3×F1×S1	2.98	0.30	3.41	1.10	625.00
V3×F2×S1	2.73	0.29	4.06	1.38	400.00
V3×F0×S2	3.15	0.38	3.16	1.79	331.00
V3×F1×S2	3.50	0.41	4.19	1.29	739.00
V3×F2×S2	3.05	0.37	3.25	1.93	490.00
V3×F0×S3	2.92	0.33	3.16	1.09	378.00
V3×F1×S3	2.87	0.34	3.75	1.31	677.00
V3×F2×S3	2.80	0.33	3.52	1.59	645.00
LSD 0.05	**0.20**	**0.03**	**0.10**	**0.03**	**7.62**

Table (1b): Effect of bi-interaction of cultivars, medium and organic fertilizers on the concentration of nutrients in beetroot leaves of beetroot for the fall season 2021.

Parameters / Treatments	N(%)	P(%)	K(%)	Ca(%)	Si (ppm)
S×V					
V1×S1	2.74	0.22	2.48	1.16	494.00
V1×S2	2.74	0.31	3.52	1.14	492.33
V1×S3	2.88	0.26	3.33	1.40	582.33
V2×S1	3.18	0.35	3.62	1.67	543.67
V2×S2	3.40	0.40	4.00	1.84	584.00
V2×S3	3.14	0.39	3.48	1.69	670.33
V3×S1	2.95	0.27	3.36	1.20	446.00
V3×S2	3.23	0.38	3.53	1.67	520.00
V3×S3	2.86	0.33	3.47	1.33	566.67
LSD 0.05	0.11	0.01	0.06	0.02	5.66
F×V					
V1×F0	2.62	0.21	2.80	1.14	407.33
V1×F1	2.82	0.30	3.46	1.29	643.67
V1×F2	2.92	0.27	3.08	1.27	517.67
V2×F0	3.10	0.38	3.37	1.63	491.67
V2×F1	3.30	0.39	4.08	1.78	710.67
V2×F2	3.32	0.37	3.64	1.79	595.67
V3×F0	3.07	0.31	2.98	1.34	340.67
V3×F1	3.11	0.35	3.78	1.32	680.33
V3×F2	2.86	0.33	3.61	1.54	511.67
LSD 0.05	0.11	0.01	0.06	0.02	5.66
F×S					
S1×F0	2.91	0.26	2.71	1.20	313.00
S1×F1	3.01	0.29	3.38	1.54	645.33
S1×F2	2.95	0.29	3.37	1.29	525.33
S2×F0	3.00	0.32	3.01	1.44	402.67
S2×F1	3.26	0.41	4.35	1.41	729.00
S2×F2	3.11	0.36	3.68	1.80	464.67
S3×F0	2.88	0.32	3.43	1.47	524.00
S3×F1	2.96	0.34	3.58	1.44	660.33
S3×F2	3.03	0.32	3.28	1.50	635.00
LSD 0.05	**0.12**	**0.01**	**0.06**	**0.02**	**3.89**

Table (1c): effect of individual factors for cultivars, medium and organic fertilizers on the concentration of nutrients in beetroot leaves of beetroot for the fall season 2021.

Parameters / Treatments	N(%)	P(%)	K(%)	Ca(%)	Si (ppm)
V					
V 1	2.79	0.26	3.11	1.23	510.89
V 2	3.24	0.38	3.70	1.73	599.33
V 3	3.01	0.33	3.45	1.40	522.89
LSD 0.05	0.08	0.01	0.04	0.01	5.55
S					
S1	2.96	0.28	3.15	1.34	494.56
S2	3.12	0.36	3.68	1.55	532.11
S3	2.96	0.32	3.43	1.47	606.44
LSD 0.05	0.06	0.01	0.03	0.01	2.25
F					
F0	2.93	0.30	3.05	1.37	413.22
F1	3.08	0.35	3.77	1.46	678.22
F2	3.03	0.32	3.44	1.53	541.67
LSD 0.05	**0.06**	**0.01**	**0.03**	**0.01**	**2.25**

V1 Red cultivar, V2 Dark Red cultivar, V3 Cylindra cultivar
S1 Soil only, S2 Vermicompost at 1%, S3 Cow manure at 1%
F0 spray distilled water, F1 spray silicon (1.25 ppm), F2 spray calcium (2 g L^{-1})

It is noted from the results of table (2-a) that the treatment V3×F1×S2 excelled by giving it the highest leaf yield of 67.50 tons ha^{-1}, while the treatment V2×F1×S2 excelled in (root yield, percentage of total soluble solids, percentage of sugars And the percentage of phenols given (74.49 ton ha^{-1}, 11.66%, 948.7% and 0.18%), respectively. While the treatment V1×F0×S1 gave the lowest leaf yield, root yield and percentage of total soluble solids (28.43 tons ha^{-1}, 29.93 tons ha^{-1} and 1.96%), respectively. While the lowest percentage of sugars and percentage of phenols in treatment V3×F0×S1 were (195.6% and 0.07%) respectively. As for the results of the bi-interaction between the cultivar and the cultivation medium, the results of Table (2-b) indicated the superiority of the treatment S2×V3 by giving it the highest leaf yield of 60.46 tons ha^{-1}, while the treatment S1×V1 gave the lowest leaf yield of 33.08 tons ha^{-1}. As for the root crop, it was distinguished by the treatment S3×V2 by giving it (63.32 tons ha^{-1}) sequentially and without a significant difference from the treatment S2×V2. It was also noted that the treatment S3×V1 was significantly excelled in the percentage of total soluble solids, as it gave 10.16%. While the treatment S2×V2 excelled in the percentage of total sugars and the percentage of total phenols as it gave (718.5% and 0.14%) respectively, while the treatment S1×V3 gave the lowest rates for root yield, percentage of total soluble solids, percentage of sugars and percentage The total phenols amounted to (35.76 tons ha^{-1}, 5.06%, 360.3% and 0.08%), respectively. As for the results of the interaction between the cultivar and foliar spraying, the results of Table (2-b) indicated the superiority of the treatment F1×V3 by giving it the highest leaf yield of 60.12 tons ha^{-1}, while the treatment F0×V1 gave the lowest leaf yield of 31.03 tons ha^{-1}While the treatment F1×V2 was distinguished by giving it the highest rates of root yield, percentage of total sugars and percentage of total phenols, which amounted to (64.26 tons ha^{-1}, 732.1% and 0.14%), respectively. As for the lowest root yield, percentage of total sugars, and percentage of total phenols, it was witnessed by the treatment F0×V3, as it gave (38.76 ton ha-1, 264.3%, and 0.08%), respectively. It was also noted that the treatment F2×V1 excelled by giving it the highest percentage of total soluble solids, amounting to 9.95%, while treatment F2×V3 gave the lowest percentage of total soluble solids, amounting to 6.20%. As for the effect of the interaction between the medium and the foliar spraying, it was noted that the F1×S2 treatment was superior in leaf yield, root yield, percentage of total soluble solids, percentage of total sugars, and percentage of total phenols given (52.84 tons ha^{-1}, 67.30 tons ha^{-1}, 9.27%, 866.8% and 0.16%), respectively Compared with treatment F0×S1, which gave the lowest rates for leafy yield, root yield, percentage of total soluble solids and percentage of total sugars, they amounted to (36.12 tons ha-1, 34.13 tons ha^{-1}, 4.72% and 251.5%), respectively, while the treatment gave F2×S1 The lowest percentage of total phenols was 0.08%. As for the individual effect of the treatments, it is clear from the results of Table (4-c) that the V3 cultivar had the highest leaf yield, amounting to 55.39 tons ha-1. The root yield, the percentage of total soluble solids, the percentage of total sugars, and the percentage of total phenols were distinguished by the V2 cultivar, as it gave (57.26 tons ha^{-1}, 8.70%, 571.8%, and 0.12%), respectively, compared to the V1 cultivar, which gave the lowest leaf yield and The root yield and percentage of total soluble solids amounted to (34.09 tons ha^{-1}, 44.14 tons $ha^{-1}$and 6.59%), respectively. While the V3 cultivar gave the lowest percentage of total sugars and a percentage of total phenols, which amounted to (427.8% and 0.10%), respectively. While the results of the table showed the excelled of medium S2 by giving it the highest leaf yield, root yield, percentage of total soluble solids, percentage of total sugars, and percentage The total phenols amounted to (46.68 tons ha^{-1}, 55.69 tons ha^{-1}, 8.48%, 623.1% and 0.13%), respectively. It was not noticed that there was a significant difference from the treatment S3 in leaf yield, while the lowest rates were witnessed in the S1 medium, as it gave (40.08 ton ha^{-1}, 39.56 ton ha^{-1}, 6.55%, 377.0% and 0.09%), respectively, while the single effect of spraying The results of table (2-c) showed that treatment F1 was excelled in leaf yield, root yield, percentage of total sugars and percentage of total phenols, as it gave (49.36 tons ha^{-1}, 55.60 tons ha^{-1},672.2% and 0.13%), respectively. While the F2 spraying treatment excelled in the percentage of total soluble solids as it gave 8.47%, while the F0 treatment gave the lowest rates (40.36 tons ha^{-1}, 43.16 tons ha^{-1}, 7.27%, 343.1% and 0.09%), respectively.

Table (2a): Effect of the triple interaction of cultivars, medium and organic fertilizers on the concentration of nutrients in beetroot leaves of beetroot for the fall season 2021.

Parameters / Treatments	Leaf yield ton.ha-1	Root yield ton.ha^{-1}	T.S.S (%)	Sugars (%)	Phenols (%)
F×S×V					
V1×F0×S1	28.43	29.93	1.96	210.9	0.08
V1×F1×S1	38.50	42.45	9.80	526.2	0.10
V1×F2×S1	32.30	40.19	9.43	271.1	0.08
V1×F0×S2	30.54	43.09	9.96	440.9	0.11
V1×F1×S2	40.92	62.27	6.06	869.2	0.14
V1×F2×S2	30.98	44.35	6.93	574.1	0.13
V1×F0×S3	34.11	43.89	8.96	370.4	0.11
V1×F1×S3	39.85	48.16	10.56	624.1	0.13
V1×F2×S3	31.22	42.93	9.86	547.4	0.13
V2×F0×S1	31.84	38.16	6.43	348.1	0.09
V2×F1×S1	48.14	49.30	6.26	535.7	0.11
V2×F2×S1	30.92	48.77	9.86	420.1	0.09
V2×F0×S2	37.62	57.09	8.13	490.4	0.11
V2×F1×S2	50.09	74.49	11.66	948.7	0.18
V2×F2×S2	48.61	57.60	8.66	716.2	0.15
V2×F0×S3	42.51	60.01	7.90	434.2	0.10
V2×F1×S3	46.38	68.99	6.63	711.7	0.14
V2×F2×S3	45.88	60.95	6.86	540.9	0.10
V3×F0×S1	48.09	34.31	5.76	195.6	0.07
V3×F1×S1	53.29	38.16	3.46	520.6	0.09
V3×F2×S1	49.24	34.82	5.96	364.7	0.07
V3×F0×S2	56.18	43.70	9.73	309.6	0.08
V3×F1×S2	67.50	65.14	11.03	782.6	0.17
V3×F2×S2	57.72	53.47	5.30	476.4	0.10
V3×F0×S3	53.91	38.28	6.63	287.9	0.08
V3×F1×S3	59.56	51.47	6.50	530.6	0.11
V3×F2×S3	53.05	46.05	7.33	382.7	0.11
LSD 0.05	**5.715**	**1.369**	**0.63**	**17.91**	**0.006**

Table (2b): Effect of bi- interactions of cultivars, media and organic fertilizers on root and leaf yield indicators and quality traits of beetroot of beetroot for the fall season 2021.

Parameters / Treatments	Leaf yield ton.ha-1	Root yield ton.ha^{-1}	T.S.S (%)	Sugars (%)	Phenols (%)
S×V					
V1×S1	33.08	37.52	7.06	366.1	0.09
V1×S2	34.15	49.90	8.86	628.1	0.13
V1×S3	35.06	44.99	10.16	514.0	0.12
V2×S1	36.97	45.41	7.52	434.6	0.10
V2×S2	45.44	63.06	8.70	718.5	0.14
V2×S3	44.92	63.32	7.13	562.3	0.12
V3×S1	50.20	35.76	5.06	360.3	0.08
V3×S2	60.46	54.10	7.90	522.8	0.12
V3×S3	55.51	45.27	6.82	400.4	0.10
LSD 0.05	3.33	0.74	0.35	9.85	0.003
F×V					
V1×F0	31.03	38.97	6.96	340.7	0.10
V1×F1	39.76	50.96	9.17	673.2	0.12
V1×F2	31.50	42.49	9.95	464.2	0.11
V2×F0	37.33	51.75	7.48	424.2	0.10
V2×F1	48.20	64.26	6.61	732.1	0.14
V2×F2	41.80	55.77	9.25	559.1	0.11
V3×F0	52.72	38.76	7.37	264.3	0.08
V3×F1	60.12	51.59	6.21	611.2	0.12
V3×F2	53.34	44.78	6.20	408.0	0.09
LSD 0.05	3.33	0.74	0.35	9.85	0.003
F×S					
S1×F0	36.12	34.13	4.72	251.5	0.08
S1×F1	46.64	43.30	6.51	527.5	0.10
S1×F2	37.49	41.26	8.42	352.0	0.08
S2×F0	41.45	47.96	7.22	413.6	0.10
S2×F1	52.84	67.30	9.27	866.8	0.16
S2×F2	45.77	51.80	8.96	588.9	0.13
S3×F0	43.51	47.39	7.83	364.2	0.10
S3×F1	48.60	56.21	8.26	622.1	0.13
S3×F2	43.38	49.98	8.02	490.3	0.11
LSD 0.05	**3.31**	**0.81**	**0.37**	**10.63**	**0.003**

Table (2c): Effect of individual factors for cultivars, medium and organic fertilizers on root and leaf yield indicators and qualitative traits of beetroot of beetroot for the fall season 2021.

Parameters / Treatments	Leaf yield ton.ha-1	Root yield $ton.ha^{-1}$	T.S.S (%)	Sugars (%)	Phenols (%)
V					
V 1	34.09	44.14	6.59	492.7	0.11
V 2	42.44	57.26	8.70	571.8	0.12
V 3	55.39	45.04	7.78	427.8	0.10
LSD 0.05	2.55	0.44	0.24	6.31	0.003
S					
S1	40.08	39.56	6.55	377.0	0.09
S2	46.68	55.69	8.48	623.1	0.13
S3	45.16	47.68	8.04	492.2	0.11
LSD 0.05	1.91	0.47	0.37	6.14	0.002
F					
F0	40.36	43.16	7.27	343.1	0.09
F1	49.36	55.60	7.33	672.2	0.13
F2	42.21	47.68	8.47	477.1	0.11
LSD 0.05	**1.91**	**0.47**	**0.21**	**6.14**	**0.002**

V1 Red cultivar, V2 Dark Red cultivar, V3 Cylindra cultivar
S1 Soil only, S2 Vermicompost at 1%, S3 Cow manure at 1%
F0 spray distilled water, F1 spray silicon (1.25 ppm), F2 spray calcium (2 g L^{-1})

The addition of Vermicompost to the soil causes an increase in the content of nutrients in beetroot leaves. The reason may be due to the macro and microelements it contains, as well as enriching the soil with humic acids and improving the environment for root growth, which creates the appropriate conditions for processing nutrients **(Al-Halfie& Ahmed 2023)**.As for the effect of spraying organic silicon on increasing nutrient levels in beetroot leaves, it may be attributed to its role in improving the properties of cell walls, which maintains ionic balance and makes membranes more stable, as silicon increases the activity of the enzyme H+-ATPase, which generates an electrochemical and chemical gradient in the cell membrane. It regulates the absorption and transport of mineral elements across membranes **(Sheng *etal.*, 2018; Okab & Abed,2022)**. The reason for increasing the yield and improving its quality by using earthworm manure may be due to its retention of humic and fulvic acids in more active forms, which act as growth stimuli similar to hormones and lead to the conversion of plant nutrients into more ready-made forms, which may explain the high percentage of sugars **(Al-Khafaji *etal.*, 2022)**.The use of Vermicompost significantly improves the organic carbon content of the soil as it is enriched with stable organic matter, which reduces the loss of nutrients **(Barthod *etal.*,2020)**. In addition, the abundance of humic acids in compost improves plant health by promoting the synthesis of phenolic compounds that may improve yield quality **(Mala, 2022**).As for the effect of silicon on the quality traits of the beetroot root, it may be due to the significant increase in the nutrient content of the leaves (Table 1), which caused an increase in the manufactured carbon metabolites and the accumulation of carbohydrate compounds, and then their transmission from the source to the downstream of the storage roots **(Fleck *etal.*,2015)**, as well as the role of silicon in the regulation of sugar metabolism and hormonal homeostasis **(Hosseini *etal.*,2019; Obaid *etal.*,2022)**.

CONCLUSION

It was concluded from the study that the genetic composition of the cultivar has a clear effect on the characteristics of the leaf yield of the beet plant, and the use of vermicompost as an agricultural medium improved the physical, chemical and biological properties of the soil, which was reflected in the readiness of the elements and their absorption by the plant, and then increased the biological yield of the beet plant, especially the effect of Foliar application of silicon on the characteristics of the yield and quantity, and then the synergistic effect of the combined factors on the quality characteristics and the concentration of antioxidants in the roots.

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