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Effect of fertilizing with boron and spraying with tyrosine on the growth and yield of two cultivars of Beetroot

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Abstract

The experiment was carried out in one of the fields belonging to the Department of Horticulture and Landscape Engineering, College of Agriculture, University of Kerbala, Al-Hasaniyya district, on 3/10/ 2023, which is located within latitude 32° north and longitude 44° east in mixed soil. The experiment was implemented according to a randomized complete block design (R.C.B.D) in the order of working experiments and with three replications. The first factor included two cultivars of beetroot (Local cultivar and Keshtzar cultivar). While the second factor included 9 fertilizer treatments (control, adding boron at a level of 10 kg ha^{-1}, adding boron at a level of 20 kg ha^{-1}, spraying tyrosine at a concentration of 100 mg L^{-1}, spraying tyrosine at a concentration of 150 mg L^{-1}, adding boron at a level of 10 kg ha^{-1} + spraying tyrosine at a concentration of 100 mg L^{-1}, adding boron at a level of 10 kg ha^{-1} + spraying tyrosine at a concentration of 150 mg L^{-1}, adding boron at a level of 20 kg ha^{-1} + spraying tyrosine at a concentration of 100 mg L^{-1}, boron addition at a level of 20 kg ha^{-1} + spraying of tyrosine at a concentration of 150 mg L^{-1}), they are indicated by symbols (T1, T2, T3, T4, T5, T6, T7, T8 and T9). The results showed that the T9 treatment (boron addition at a level of 20 kg ha^{-1} + spraying of tyrosine at a concentration of 150 mg L^{-1}) was superior in leaf content of nitrogen, phosphorus, potassium and boron, with averages of (2.770%, 0.5533%, 2.3800% and 41.50 mg kg^{-1}), respectively. The same treatment also excelled in plant height, leaf area, root weight and yield marketing averages of (48.908 cm, 180.90 cm^{2}, 275.8 g plant^{-1} and 45.34 ton ha^{-1}), respectively. The results also showed that the local variety excelled in the aforementioned traits with averages of (2.071%, 0.3926%, 1.6244%, 30.91 mg kg^{-1}, 53.447 cm, 194.29 cm^{2}, 342.2 g plant^{-1} and 55.94 ton ha^{-1}). As for the interaction between the factors, it was significant in all the characteristics under study.

Keywords: Beetroot, Boron, Tyrosine, Growth and yield indicators.

Introduction

Beetroot (*Beeta vulgaris* L.) belongs to the saprophytic family Chenopodiaceae. It is a herbaceous root plant with two years, the first is vegetative growth and the second is directed towards flowering and seed formation [1]. Beetroot is a natural mine of nutritional elements and compounds, as it contains manganese, phosphorus, magnesium, silicon, zinc and potassium, as well as vitamins, carbohydrates, amino and organic acids [2]. It is characterized by being rich in effective compounds that have a medical effect, such as betalains [3]. Beetroot are classified as root crops, while the edible part is the enlarged lower embryonic stalk in addition to the upper part of the taproot. It is one of the globally important crops [4].

The cultivation and productivity of Beetroot in Iraq is still low, as the cultivated area for this crop reached 3000 dunums, with an estimated productivity of 8200 tons, at a average of 2.733 tons d^{-1} [5]. One of the most important reasons that contributed to the decline in the productivity of the Beetroot crop is the failure to follow scientific methods in agriculture, especially fertilization, which is considered one of the basic and important factors in increasing production per unit of cultivated area [6]. To improve the reality of Beetroot cultivation in Iraq, new quality varieties must be introduced. Good and high production, as Beetroot varieties are characterized by the presence of great variation between their varieties in many phenotypic traits, therefore, choosing the variety is one of the determining factors for the production of roots and seeds and their quality [7].

Boron is one of the important nutrients in plants, as it plays an important role in food metabolism, and is involved in the process of transporting sugars and enzymatic reactions as well as building proteins [8]. Boron works to increase the transport of carbohydrates to their storage places and the accumulation of starch and sugar. Which leads to improving the quality of the roots, reducing the phenomenon of cracking, and preventing the occurrence of black spots in them and deformation of young leaves, which consequently reflects an increase in the yield, both quantitatively and qualitatively [9]. Boron deficiency causes the Beetroot crop to suffer from brown heart disease, which may lead to the death of the plant [10].

Amino acids are considered one of the primary metabolic components, and they are considered a basic substrate in the construction of proteins, so they play an important role in plant growth and development [11]. L-Tyrosine (Tyr) AAA is one of the aromatic amino acids necessary for protein synthesis in all living organisms. This acid is synthesized only in plants and microorganisms, and it has various physiological roles as electron carriers, antioxidants, attractants and defensive compounds, it can also be Some forms of it are used in human medicine, such as morphine and vitamin E, for example [12]. Tyrosine is a hydroxyphenyl amino acid used in building hormones [13]. Tyrosine has an important role in water oxidation and the transfer of electrons in the process of photosynthesis [14]. Therefore, the current study aimed to test the efficiency of some Beetroot cultivars, in addition to determining the best fertilizer combinations, in addition to finding the best interactions between the factors used and the extent to which this reflects on improving the productivity and quality of the Beetroot plant.

Materials and Methods

The experiment was carried out in one of the fields belonging to the Department of Horticulture and Landscape Engineering, College of Agriculture, University of Kerbala, Al-Hasaniyya district, on 3/10/ 2023, which is located within latitude 32° north and longitude 44° east in mixed soil. The experiment was implemented according to a randomized complete block design (R.C.B.D) in the order of working experiments and with three replications. The first factor included two cultivars of beetroot (Local cultivar and Keshtzar cultivar). While the second factor included 9 fertilizer combinations (control, adding boron at a level of 10 kg ha^{-1}, adding boron at a level of 20 kg ha^{-1}, spraying tyrosine at a concentration of 100 mg L^{-1}, spraying tyrosine at a concentration of 150 mg L^{-1}, adding boron at a level of 10 kg ha^{-1} + spraying tyrosine at a concentration of 100 mg L^{-1}, adding boron at a level of 10 kg ha^{-1} + spraying tyrosine at a concentration of 150 mg L^{-1}, adding boron at a level of 20 kg ha^{-1} + spraying tyrosine at a concentration of 100 mg L^{-1}, boron addition at a level of 20 kg ha^{-1} + spraying of tyrosine at a concentration of 150 mg L^{-1}), they are indicated by symbols (T1, T2, T3, T4, T5, T6, T7, T8 and T9). Boron fertilizer was added to the soil after dissolving it in water in quantities of 10 and 20 kg per hectare, four weeks after planting. As for tyrosine, it was sprayed in two stages, the first after growth was complete and the second after the roots matured.

Before planting the seeds, random samples of the field soil were taken at a depth of 30 cm and laboratory analyzes were conducted for its physical and chemical characteristics in the laboratories of the Kerbala Agriculture Directorate (Table 1). Plowing and soil amendment operations were also carried out after irrigating the field abundantly to get rid of the weeds. After that, the field was divided into 18 terraces, each terrace contained two lines, the distance between one line and another 30 cm, and between one hole and another 20 cm. The field was divided into three replicates, each replications containing 18 experimental units randomly distributed. As for fertilizing the field, animal manure, which is poultry manure 6 ton ha^{-1}, was added before planting. As for chemical fertilization, an amount of 150 N kg ha^{-1} 120 P kg ha^{-1} and 120 K kg ha^{-1} was used [15]. Some agricultural operations were also carried out, including irrigation, hoeing, weeding, grafting, and pest control, as needed. The harvesting process took place on 1/2/2024.

Table (1): Some physical and chemical properties of field soil

Trait	Unit	Value
Electrical conductivity (EC)	dsm^{-1}	1.55
pH	--------	7.8
Ready nitrogen ($N\text{-}NH_4^+$)	ppm	345.8
Ready nitrogen ($N\text{-}NO_3^-$)	ppm	175.56
Ready potassium	ppm	648.78

Ready phosphorus	ppm	0.891	
Organic matter	%	1.241	
Soil texture		Sandy	
Soil separators	%	clay	3.0
		Silt	9.5
Water analysis			
Electrical conductivity (EC)	dsm^{-1}	2-1	
pH	--------	8-7	
Total dissolved salts (TDS)	ppm	1565	

Data recorded

The percentage of nitrogen, phosphorus, potassium, and boron in the leaves was estimated by taking five leaves from each experimental unit and drying them until the weight was constant after washing them of dirt and dust. After the digestion process was complete, it was estimated according to the method of [16]. Plant height (cm) and leaf area (cm^2) were also calculated In addition, root shoot weight (g $plant^{-1}$) and marketing yield (kg ha^{-1}).

Statistical analysis

After collecting and tabulating the data related to the study, it was statistically analyzed according to the factorial experiment system applied by randomized complete blocks designing (R.C.B.D), the least significant difference ($L.S.D_{0.05}$) test was used to compare and separate the means [17].

Results and Discussion

Qualitative traits

Nitrogen %

The results (Table 2) showed that the effect of fertilizer treatments was significant on the nitrogen content of the leaves, as treatment T9 was superior (2.770%) and did not differ significantly from treatment T8 (2.502%), while control treatment gave the lowest percentage of nitrogen in the leaves, amounting to (1.337%). The results also showed that the effect of the variety was significant on the nitrogen content of the leaves, as the local variety was superior, giving a percentage of (2.071%), while the Keshtzar variety gave (1.998%). As for the interaction between the fertilizer treatment and the variety, it was significant in the percentage of nitrogen, as it reached the highest value in treatment T9 with the local variety (2.827%) and the lowest value was found in the control treatment with the Keshtzar variety (1.075%).

Table (2): Effect of cultivars, fertilizer combinations and their interaction on the percentage of nitrogen in beetroot leaves (%)

Fertilizer combinations	Cultivars		Means
	Local cultivar	Keshtzar cultivar	
T1	1.697	1.075	1.377
T2	1.740	1.573	1.657
T3	1.920	1.850	1.885
T4	1.833	1.743	1.788
T5	1.917	1.817	1.890
T6	2.140	2.123	2.132
T7	2.357	2.353	2.310
T8	2.593	2.410	2.502
T9	2.827	2.713	2.770
Means	2.071	1.998	
L.S.D $_{0.05}$	Combinations	Cultivars	Interaction
	0.3497	0.0648	0.4945

Phosphorus %

The results (Table 3) showed that the effect of fertilizer treatments was significant on the phosphorus content of the leaves, as treatment T9 was superior by a percentage of (0.5533%), while the comparison control treatment gave the lowest percentage of (0.2233%). It was noted from the same table that the local variety was superior by a percentage of (0.3926%), while the Keshtzar variety gave a percentage of (0.3616%). It is also noted from the table that there is a significant interaction between the fertilizer treatments and the varieties, as the highest interaction was in the T9 treatment with the local variety at a average of (0.5767%), while the lowest interaction was in the control treatment of the Keshtzar variety at a average of (0.2100%).

Table (3): Effect of cultivars, fertilizer combinations and their interaction on the percentage of phosphorus in beetroot leaves (%)

Fertilizer combinations	**Cultivars**		**Means**
	Local cultivar	**Keshtzar cultivar**	
T1	0.2367	0.2100	0.2233
T2	0.3100	0.2367	0.2733
T3	0.3.133	0.2767	0.2950
T4	0.3667	0.3433	0.3550
T5	0.3867	0.3800	0.3833
T6	0.4200	0.4067	0.4133
T7	0.4600	0.4200	0.4417
T8	0.4633	0.4500	0.4567
T9	0.5767	0.5300	0.5533
Means	0.3926	0.3619	

L.S.D 0.05	Combinations	Cultivars	Interaction
	0.00585	0.1240	0.01754

Potassium %

It was noted from the results of Table (4) that there were significant differences between the fertilizer treatments in the percentage of potassium in the leaves. The results showed that the T9 treatment was significantly superior with the highest percentage (2.8300%), while the control treatment gave the lowest percentage (1.3150%). It is clear from the results of the table that there is no significant difference between the types. As for the interaction, it was significant. The treatment T9 with the local variety gave the highest interaction (2.4633%), while the control treatment with the Keshtzar variety gave the lowest interaction (1.134%).

Table (4): Effect of cultivars, fertilizer combinations and their interaction on the percentage of potassium in beetroot leaves (%)

Fertilizer combinations	Cultivars		Means
	Local cultivar	Keshtzar cultivar	
T1	1.3367	1.2933	1.3150
T2	1.3700	1.3443	1.3567
T3	1.4468	1.4432	1.4450
T4	1.4300	1.4167	1.4233
T5	1.5433	1.4700	1.5067
T6	1.6033	1.5300	1.5667
T7	1.6400	1.6167	1.6283
T8	1.8700	1.8200	1.8450
T9	2.4633	2.2296	2.3800
Means	1.6244	1.5904	
L.S.D 0.05	Combinations	Cultivars	Interaction
	0.04347	N.S	0.06148

Boron (mg kg^{-1})

It is noted from the results of Table (5) that there are significant differences between the fertilizer treatments in the boron content of the leaves, as the T9 treatment excelled by giving it the highest value of (41.50 mg kg^{-1}), while the control treatment gave the lowest average of (18.73 mg kg^{-1}). The results of the same table also showed that there were significant differences between the two varieties, as the local variety was superior with an average of (30.91 mg kg^{-1}), while the Keshtzar variety gave an average of (29.81 mg kg^{-1}). It is also noted from the table that there is a significant interaction between the fertilizer treatments and the varieties, as the highest interaction was in the T9 treatment with the local variety at a average of (42.13 mg kg^{-1}), while the lowest was in the control treatment of the Keshtzar variety at a average of (18.73 mg kg^{-1}).

Table (5): Effect of cultivars, fertilizer combinations and their interaction on the percentage of boron in beetroot leaves (mg kg-1)

Fertilizer combinations	Cultivars		Means
	Local cultivar	Keshtzar cultivar	
T1	19.80	18.73	19.27
T2	29.57	29.17	29.37
T3	32.30	30.67	31.48
T4	28.43	24.77	26.60
T5	28.77	25.93	27.35
T6	30.50	30.50	28.60
T7	32.30	28.93	30.62
T8	38.35	38.37	38.45
T9	42.13	40.87	41.50
Means	30.91	29.81	
L.S.D $_{0.05}$	Combinations	Cultivars	Interaction
	1.369	0.645	1.936

Growth and yield indicators

Plant height (cm)

It was clear from Table (6) that there were significant differences between the fertilizer treatments in plant height, as the T9 treatment was superior with an average of (48.908 cm), and did not differ significantly from the T8 treatment, which gave an average of (48.402 cm). Compared to the control treatment, which gave the lowest average (43.130 cm). It was also shown through the results that the variety had a significant effect on plant height, as the local variety was superior to an average of (53.507 cm), while the Keshtzar variety gave an average of (38.310 cm). It was also noted that there was a significant interaction between fertilizer treatments and varieties, as the highest interaction was in treatment T9 for the local variety, with an average of (56.507 cm). While the least interaction (34.110 cm) was in the control treatment for the Keshtzar variety.

Table (6): Effect of cultivars, fertilizer combinations and their interaction on the plant height in beetroot (cm)

Fertilizer combinations	Cultivars		Means
	Local cultivar	Keshtzar cultivar	
T1	52.150	34.110	43.130
T2	50.957	35.393	43.175
T3	50.647	38.750	44.698
T4	52.190	36.723	44.475
T5	52.487	38.287	45.700
T6	54.447	39.563	46.367
T7	55.483	39.563	47.523
T8	56.160	40.643	48.402

T9	56.507	41.310	48.908
Means	53.447	38.188	
L.S.D $_{0.05}$	Combinations	Cultivars	Interaction
	0.8380	0.3950	1.1851

Leaf area (cm^2)

The results (Table 7) showed that there were significant differences between the fertilizer treatments in leaf area, as the T9 treatment excelled by giving it the highest average of (180.90 cm^2), and it did not differ significantly from the T7 and T8 treatments, which had averages of (177.58 and 178.42 cm^2), respectively, compared to the control treatment, which amounted to (166.48 cm^2). The results of the same table also showed that the local variety was superior with an average of (194.29 cm^2), while the Keshtzar variety gave an average of (152.76 cm^2). As for interference, the highest average was (203.83 cm^2) in treatment T9 for the local variety, while the lowest interference was in the control treatment with an average of (148.57 cm^2) for the Keshtzar variety.

Table (7): Effect of cultivars, fertilizer combinations and their interaction on the leaf area in beetroot (cm^2)

Fertilizer combinations	Cultivars		Means
	Local cultivar	Keshtzar cultivar	
T1	184.40	148.57	166.48
T2	188.07	150.27	169.17
T3	189.97	1`50.60	170.28
T4	191.33	151.80	171.57
T5	193.43	153.10	173.27
T6	196.77	151.30	174.03
T7	199.93	155.23	177.58
T8	200.87	155.23	178.42
T9	203.83	157.97	180.90
Means	194.29	152.76	
L.S.D $_{0.05}$	Combinations	Cultivars	Interaction
	5.292	2.495	7.484

Marketing root weight (g $plant^{-1}$)

The results (Table 8) indicated that there were significant differences between the fertilization treatments in marketable root weight, as the T9 treatment excelled with an average of (275.8 g $plant^{-1}$), and did not differ significantly from the T8 treatment, which reached an average of (271.2 g $plant^{-1}$), compared to the control treatment that reached (271.2 g $plant^{-1}$). The lowest average was (224.5 g $plant^{-1}$). From the results of the same table, it was noted that the local variety was superior with an average of (342.2 g $plant^{-1}$), while the Kashtzar variety gave an average of (166.0 g $plant^{-1}$). The results also showed a significant interaction between fertilizer treatments and varieties, as the highest interaction was in the T9 treatment for the local variety, with an average of (357.7 g plant^{-1}), while the lowest interaction was in the control treatment for the Kashtzar variety, with an average of (120.0 g plant^{-1}).

Table (8): Effect of cultivars, fertilizer combinations and their interaction on the marketing root weight in beetroot (g plant^{-1})

Fertilizer combinations	Cultivars		Means
	Local cultivar	Keshtzar cultivar	
T1	329.0	120.0	224.5
T2	332.3	122.3	227.3
T3	332.0	129.7	230.8
T4	334.0	170.3	252.2
T5	342.7	185.7	264.2
T6	353.7	187.0	270.3
T7	352.0	188.3	270.5
T8	349.0	193.3	271.2
T9	357.7	194.0	275.8
Means	342.2	166.0	
L.S.D $_{0.05}$	Combinations	Cultivars	Interaction
	4.12	3.10	8.83

Marketing yield (ton ha^{-1})

The results (Table 9) show that there are significant differences between fertilizer treatments in plant productivity. The T9 treatment excelled by giving the highest average (45.34 ton ha^{-1}), compared to the control treatment, which gave the lowest average (41.49 ton ha^{-1}). The results also show that there are significant differences between the varieties, and the local variety gave the highest average (55.38 ton ha^{-1}), while the Kashtzar variety gave an average (32.31 ton ha^{-1}). As for the interference, the highest average was (58.38 ton ha^{-1}) in the treatment of the local variety, while the lowest interference was in the control treatment of the Kashtzar variety, with an average of (32.31 ton ha^{-1}).

Table (9): Effect of cultivars, fertilizer combinations and their interaction on the marketing yield in beetroot (ton ha^{-1})

Fertilizer combinations	Cultivars		Means
	Local cultivar	Keshtzar cultivar	
T1	54.43	28.56	41.49
T2	55.63	29.67	42.65
T3	55.78	29.87	42.82
T4	54.52	28.62	41.57
T5	54.56	28.63	41.59
T6	56.21	29.94	43.05
T7	56.34	30.21	43.27
T8	56.36	30.26	43.31
T9	58.38	32.31	45.34

Means	55.94	29.93	
L.S.D $_{0.05}$	Combinations	Cultivars	Interaction
	2.342	3.567	1.982

We note from the results (Tables 2, 3, 4 and 5) that fertilizer treatments caused significant differences in the plant's content of chemical elements. It was observed that the T9 treatment was superior (boron addition at a level of 20 kg ha^{-1} + spraying of tyrosine at a concentration of 150 mg L^{-1}) and this may be attributed to the role of tyrosine (amino acid), which contains nitrogen in its composition. In turn, it leads to an increase in the percentage of nitrogen in the leaves, and at the same time it can stimulate the absorption of other nutrients, which is reflected in an increase in their content in beetroot leaves [18,19]. In addition to the role of boron in transferring the outputs of photosynthesis to the roots, which increases root growth and increases the absorption surfaces in the root system, which increases the absorption of nitrogen, phosphorus, and potassium and increases the percentage of these elements in the leaves [20], as for increasing the percentage of boron. In the leaves, this may be due to the leaves obtaining a good percentage of boron during the fertilization process when it is added in the form of fertilizer (borax), causing an increase in the percentage of boron in the leaves [21,22].

It is also noted that the two varieties under study differ in their content of chemical elements, as the local variety is superior to the foreign variety Keshtzar in the leaves' content of nutritional elements. This may be attributed to genetic variation between the varieties, or to the positive interaction of the genetic makeup of the variety with environmental conditions, which contributed to exploitation. Optimization of the nutrients available in its surroundings and thus was reflected in an increase in the content of elements in the plant, and this is consistent with what was mentioned by [23].

The results presented (Tables 6, 7, 8 and 9) show that fertilization with boron and amino acids has an important role in promoting the growth of plants and increasing their height and the area of their leaves. The boron element helps in transporting sugars and other organic products from the leaves to the different parts of the plant, and this enhances the growth of plant tissues and increases the growth of roots. It also plays a vital role in increasing the absorption of other nutrients, such as which leads to efficient growth and development processes, and thus is reflected in increasing the height of the plant and increasing its leaf area. It is also reflected in increasing the weight of the roots, and thus these positive conditions together contribute to increasing the plant's yield [24]. As for the role of amino acids, they are the basic unit in building proteins that are necessary for the growth and development of plant cells. Increasing the availability of amino acids contributes to the formation of proteins necessary for tissue growth, which stimulates many vital processes such as photosynthesis and cellular respiration, which increases the production of energy that can It is reflected in an increase in growth indicators and yield [25], in addition to its role in increasing the efficiency of absorption of nutrients from the soil, which contributes to better growth and an increase in the size of leaves and plant height and thus reflects positively on an increase in plant yield [26].

It is also noted that the plant variety has a significant effect on vegetative growth indicators, as the local variety outperforms the Keshtzar variety in plant height and leaf area. This is attributed to the nature of the differences between the genetic compositions of the beet plant varieties, or the reason may be due to the extent of the variety's adaptation to environmental conditions, which results in a variation in The efficiency of the photosynthesis process, which leads to an increase in the accumulation of processed food materials (carbohydrates), which affects cell division and development in the plant, which is reflected positively in increasing the height of the plant and the leaf area of the beetroot plant [27,28].

We can conclude from this study that the genetic composition of the variety plays an important role in increasing the qualitative and vegetative indicators, as well as the yield and its components, through the variety's efficiency in adapting and responding to the prevailing conditions in the region. Also, the fertilizer combinations between boron and tyrosine acid played a fundamental role in increasing the plant's ability, to exploit the resources available in the soil, which was reflected in an increase in the characteristics under study.

References

1) Hassan, A. A. (2012). *Vegetable crop production* (2nd ed.). Arab House for Publishing and Distribution.

2) Kumar, Y. (2015). Beetroot: A superfood. *International Journal of Engineering Studies and Technical Approach, 1*(3), 12-30.

3) Carmen, S. (2008). *Food colorants: Chemical and functional properties*. Taylor and Francis.

4) Matlub, A. N., Sultan, I. A., & Abdul, S. (1989). *Vegetable product: Part one* (Rev. 2nd ed.). Dar Al Kutub Printing and Publishing Establishment.

5) Central Statistical Office (CSO). (2022). *Annual statistical collection*. Ministry of Planning-Directorate of Agricultural Statistics.

6) Al-Hlfie, R. G., & Hussin, W. A. (2023). Response of three beetroot cultivars to organic fertilization and foliar application. *Iraq Journal of Market Research & Consumer Protection, 15*(2), 1-12.

7) Buras, M., Abu Turabi, B., Albasit, A., & Abu Turab, S. (2006). *Vegetable crop production: Theoretical part*. Al-Daoudi Press.

8) Abu Dahi, Y. M. (1989). *Practical plant nutrition*. College of Agriculture, Baghdad University.

9) Al-Abidi, J. S. (2010). *Guide to using organic and chemical fertilizers*. Ministry of Agriculture.

10) Vera-Maldonado, P., Aquea, F., Reyes-Díaz, M., Cárcamo-Fincheira, P., Soto-Cerda, B., Nunes-Nesi, A., & Inostroza-Blancheteau, C. (2024). Role of boron and its interaction with other elements in plants. *Frontiers in Plant Science, 15*, 2-13.

11) Hounsome, N. B., Hounsome, D., Tomos, A. D., & Edwards-Jones, G. (2008). Plant metabolites and quality of vegetables. *Journal of Food Science, 73*(4), 48-65.
12) Maeda, A., Hiroshi, A., & Schenk, K. (2018). Tyrosine biosynthesis, metabolism, and catabolism in plants. *Phytochemistry*, *149*, 82-102.
13) Abd El-Aziz, N. G., & Balbaa, L. K. (2007). Influence of tyrosine and zinc on growth, flowering, and chemical constituents of *Salvia farinacea* plants. *Journal of Applied Sciences Research, 3*(13), 399-407.
14) Hildebrandt, T. M., Nesi, A. N., Araújo, W. L., & Braun, H. P. (2015). Amino acid catabolism in plants. *Molecular Plant, 8*(11), 1563-1579.
15) Al-Sahhaf, F. H. R. (1989). *Applied plant nutrition*. University of Mosul, Ministry of Higher Education and Scientific Research.
16) Jones, J. B., Jr., & Case, V. W. (1990). Sampling, handling, and analyzing plant tissue samples. In *Soil Testing and Plant Analysis* (3rd ed., pp. 389-427).
17) Al-Rawi, K. M., & Khalafallah, A. (2000). *Design and download of agricultural experiments*. Dar Al-Kutub for Printing and Publishing, University of Mosul.
18) Havlin, J. L., Tisdale, S. L., Nelson, W. L., & Beaton, J. D. (2017). *Soil fertility and fertilizers: An introduction to nutrient management* (6th ed.). India Education.
19) Pangestika, P., Suminarti, N. E., & Barunawati, N. (2021). Effect of nitrogen source and dosage on growth, yield, and quality of red beetroot (*Beta vulgaris* L.). *Natural Volatiles & Essential Oils, 8*(6), 430-446.
20) Shilova, O. V., Smirnova, T. I., & Akimov, A. A. (2021). Optimization of table beet cultivation using a boron-containing chelate. In *IOP Conference Series: Earth and Environmental Science, 845*(1), 3-12.
21) Czynnski, K., & Elkner, K. (2008). Effect of long-term organic and mineral fertilization on yield and quality of beetroot (*Beta vulgaris* L.). *Vegetable Crops Research Bulletin, 68*, 111-125.
22) Rukie, A. G. I. C., Mariga, Z., Gordana, P., Daniela, D., Zvezda, B., & Margarita, D. (2018). Yield and quality of beetroot (*Beta vulgaris* ssp. *Esculent* L.) as a result of microbial fertilizers. *Vegetable Crops Research Bulletin, 67*(1), 4-9.
23) Hájos, M. T., & Rubóczki, T. (2018). Evaluation of mineral element content of beetroot during different stages of the growing season. *Acta Agraria Debreceniensis*, 459-469.
24) Aly, E. F., Khalil, S. R., & Abdel Fattah, M. E. (2017). Effect of boron, potassium, and calcium on growth, yield, and quality of two sugar beet varieties under sandy soil conditions. *Journal of Plant Production, 8*(6), 699-704.
25) El-Sherbeny, M. R., & Da Silva, J. A. T. (2013). Foliar treatment with proline and tyrosine affects the growth and yield of beetroot and some pigments in beetroot leaves. *Journal of Horticultural Research, 21*(2), 95-99.
26) El-Kenawy, M. A. (2022). Effect of tryptophan, proline, and tyrosine on vegetative growth, yield, and fruit quality of Red Roumy grapevines. *Egyptian Journal of Horticulture*, *49*(1), 1-14.
27) Moosavi, S. G. R., Ramazani, S. H. R., Hemayati, S. S., & Gholizadeh, H. (2017). Effect of drought stress on root yield and some morpho-physiological traits in

different genotypes of sugar beet (*Beta vulgaris* L.). *Journal of Crop Science and Biotechnology*, *20*, 167-174.
28) Sapkota, A., Sharma, M. D., Giri, H. N., Shrestha, B., & Panday, D. (2021). Effect of organic and inorganic sources of nitrogen on growth, yield, and quality of beetroot varieties in Nepal. *Nitrogen*, *2*(3), 378-391.