Response of varieties of beetroot *Beta vulgaris* L. to putrescine spraying and its effect on vegetative traits and yield in Kirkuk Governorate

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Abstract

To explore its validity, the experiment began on August 2025 to November 2025 in the Al-Sayada region of the Agricultural Research and Experiment Station of the College of Agriculture, University of Kirkuk and was accompanied by laboratory and chemical analysis until January 2026. The aim of the research was to experiment the effects of the growth regulator sug Putrescine foliar sprayed on different chemical, qualitative, and sensory characteristics of three beetroot cultivars, (Pinky and Beetroot Detroit Dark Red 2 Christel, and Fredi) (Beta vulgaris L.): The experiment was carried out in a randomized complete block design (RCBD) based on split-plot system and three replications. The cultivars were contained in the main plots and the four concentrations of Putrescine (0, 10, 20 and 30 mg L -1) were contained in the sub plots. The spraying was done three times and a 15 days time interval was observed between spraying applications and the initial spraying was carried out two weeks after planting. The characteristics observed were: determination of a number of chemical and qualitative components in the roots that comprised nitrogen, phosphorus, potassium, iron, crude protein and betalain pigment and determination of sensory characteristics such as color, shape, firmness and size. Sensory assessment among 40 randomly selected consumers among students, staff and faculty of the College of Agriculture of Kirkuk University was done using a questionnaire. The participants were requested to rate each of the treatments by giving a rating of 1 to 10 based on each of the sensory attributes. The results showed that the Fredi (V3) type was superior in several chemical and qualitative attributes, the highest accumulation of nutrients in the roots, namely nitrogen, phosphorus, potassium and iron and high content of crude protein and betalain pigments. Putrescine concentration of 30 mg/L (P4) primarily changed most of the characteristics studied with the greatest level of change in most of the chemical and qualitative characteristics. The sensory response was also different according to the trait; consumers were more willing to accept the

ISSN 2072-3857

color of roots at higher levels and a concentration of 20 mg/L was more effective in response to the size trait. Generally, the findings suggest that the combination of the Fredi variety and Putrescine spraying led to increased root quality, both in chemical and sensory quality, in the environment of the area of the research.

Keywords: Beetroot (*Beta vulgaris* L.), Varieties, putrescine, Chemical composition, Sensory traits.

(It is not necessary that the keywords are taken from the title)

Introduction

Beetroot (Red Beetroot), scientifically named Beta vulgaris L., is considered a winter vegetable crop belonging to the family Amaranthaceae. It is known by several names, including (Table beet) or (Red beet) [7]. It is one of the main crops in temperate and cold regions of the world, with its cultivation period extending from August to December [1]. For the purpose of improving beetroot cultivation in Iraq, the importance of studying developed varieties becomes evident, as improving varieties is one of the most important means of developing agricultural production through breeding or introducing varieties with superior morphological and physiological traits. Choosing the appropriate variety for the prevailing environmental conditions is one of the main factors that determine the quantity and quality of production, as it plays a role in enhancing growth efficiency and improving production and quality traits. Beetroot has a high ability to adapt and grow within a wide range of temperatures and different lighting conditions, which contributes to its spread and cultivation in various regions of the world and enhances its productivity and quality when the suitable variety is chosen [15]

Recent research has focused on using modern plant growth regulators to improve plant growth and increase their production efficiency, among the most prominent of which are polyamines, which are considered essential compounds necessary for plant growth and development [13] Putrescine is considered one of the most important of these low molecular weight organic compounds, as it contains two or more amino groups in its structure. It is characterized by high biological efficacy, and putrescine has recently been classified as a plant growth regulator due to its multiple roles in producing clear physiological responses in plant tissues, in addition to its effective role as an antioxidant in maintaining the stability of cell membranes and regulating the plant's defense responses against various types of environmental stresses [2] [19]Since it acts as an antioxidant, it is well known that it also plays a role in breaking down compounds into more stable end products [3]

The genetic varieties of beet plants differ in terms of vegetative growth and root growth, and they can be classified based on the color and shape of the root [13] Each variety of the Amaranthaceae family possesses traits and characteristics that distinguish it from others, and each variety has specific environmental requirements. When a variety is transferred to an environment different from its original environment in terms of soil and climate, it may lose some of its genetic traits or become more susceptible to diseases, in addition to experiencing changes in flowering time, which may manifest as early or delayed flowering or even complete failure to flower [5] [17] conducted an experiment to determine the effect of spraying biotensin at 30 mg L-1 on some vegetative traits and the yield and chemical properties of broccoli, which showed a significant superiority in most vegetative traits and yield over two consecutive seasons. Due to the importance of the interaction between genetic factors (varieties) and physiological factors (growth regulators), this research aims to study the response of some beet varieties to foliar spraying with biotensin and to evaluate its effect in improving the vegetative traits and yield of the plant under the environmental conditions of Kirkuk Governorate.)

Material and Methods

The experiment was conducted in the field belonging to the Agricultural Research and Experiment Station / Sayada site – College of Agriculture – University of Kirkuk, located at 44° E longitude and 35° N latitude, for the period from August2025 to November 2025. This was done to study the effect of foliar spraying of the growth regulator putrescine on three varieties of beetroot in certain growth and yield traits. Seeds of three varieties, Pinky, Detroit Dark Red 2, and Fredi, were obtained from one of the private agricultural offices in Erbil Governorate. The experimental field was prepared by plowing with a moldboard plow to a depth of 0–30 cm, after which the soil was smoothed and leveled and divided into experimental units according to the design used in the experiment. Soil samples were taken from different locations of the field prior to planting at a depth of 0–30 cm, then mixed together to form a composite sample for the purpose of

ISSN 2072-3857

conducting physical and chemical analyses of the field soil, as shown in Table .(1)

Analysis	Unit of measurement	Result
Soil acidity Ph	---	7.1
Electrical conductivity (EC)	dS m^{-1}	2.21
Organic matter	%	0.84
Nitrogen N	ppm	0.43
Phosphorus P	ppm	7.4
Potassium K	ppm	43.66
Clay	%	31.35
Sand	%	52.65
Silt	%	16
Soil texture	---	Silty sandy soil
Apparent density	g cm^{-3}	1.4
True density	gm / cm3	2.227
Porosity	%	37.1351
Moisture content	%	2.2572

The soil was analyzed in the laboratories of the College of Agriculture, University of Kirkuk

Service and Combat Operations

Field operations were carried out, including cleaning, plowing, soil preparation, and leveling, and then the field was heavily irrigated before layout. After that, the land was divided into plots representing the experimental units, with each plot measuring 2 × 2 square meters, totaling 36 plots, with a 2 m spacing between each plot,The field area used for research is approximately 250 square meters. The experiment was conducted in 3 replicates, and irrigation was applied by sprinkler using two sprinkler lines between replicates to ensure an equal

ISSN 2072-3857

distribution of water. Sowing was done on 28/8/2025, with a distance of 30 cm between rows and 15 cm between plants within the same row. To prevent seed loss due to birds, all plots were covered with protective nets. Irrigation was applied twice daily until the germination stage. Chemical fertilizers (DAP and urea) were also added according to recommended fertilization guidelines.

After the germination stage, thinning was carried out for some plants / hills / seedlings. After that, the growth regulator putrescine aqueous solution was sprayed, with the addition of a surfactant for the spraying solution (liquid soap) at a concentration of 0.1% at four concentrations: 0, 10, 20, and 30 mg L^{-1}. The spraying was carried out two weeks after planting, for a total of three sprays, with an interval of 15 days between each spray. Irrigation was done according to the crop requirements, in addition to hoeing, weeding, and pest control as needed to ensure healthy plant growth. The crop was harvested on 20/11/2025, and chemical measurements continued until January 2026, and five plants were selected from the middle row of each experimental unit to record the required data on growth traits and yield.

Treatments and Experimental Design

The experiment was conducted using a split-plot design in a split-plot arrangement within a randomized complete block design (RCBD) for the main plots. varieties were allocated to the main plots, and putrescine was applied to the subplots according to a randomized complete block design (RCBD) with three replications, with treatments randomly distributed [7]The treatments are as follows:

The first factor is three beet varieties:

1. V1 Pinky variety
2. V2 Detroit Dark Red 2 variety
3. V3 Fredi variety

The second factor is putrescine spraying As in [6]

1. P1 distilled-water spray control
2. P2 10 mg L^{-1}
3. P3 20 mg L^{-1}
4. P4 30 mg L^{-1}

Results and Discussion

Average increase in plant height (cm)

The results of Table (2) indicated the presence of significant differences in the average increase in plant height among the studied varieties, as the V2

ISSN 2072-3857

Beetroot Detroit dark red2 Christel variety excelled in providing the highest plant height, reaching 55.28 cm, compared to the V1 Pinky variety, which reached 45.33 cm. As for spraying with Putrescine and its interaction with the varieties, no significant differences in plant height were observed.

Table (2) Effect of foliar spraying with different concentrations of Putrescine and the interaction with varieties on the increase rate in plant height (cm)

Categories (V)	putrescine concentrations (mg L^{-1})P				Item Averages (V)
	P1	P2	P3	P4	
V1	41.53	45.46	46.53	47.8	45.33
V2	53.66	55.86	54.93	56.66	55.28
V3	54.33	55.73	54.26	53.86	54.55
putrescine averages (P)	49.84	52.35	51.91	52.77	

LSD 0.05 (V*P) = NS LSD 0.05 (P)= NS LSD 0.05 (V)= 2.22

Average increase in the number of leaves

The results of Table (3) indicated the presence of significant differences in the rate of increase in the number of leaves due to foliar spraying with Putrescine concentrations and the studied varieties. Regarding the effect of varieties, no significant differences were recorded between the varieties. As for the effect of foliar spraying, the spraying treatment with biotersin concentration P2 was significantly superior, recording the highest average number of leaves of 17.08, compared to the control treatment P3,which recorded the lowest average of 15.48. Regarding the effect of varieties, no significant differences were recorded between the varieties. As for the interaction effect between varieties and foliar spraying with Putrescine concentrations, the results showed the superiority of the interaction treatment V3 × P2, giving the highest number of leaves of 19.26, compared to the lowest number for the treatment V3 × P3, which gave 13.46 leaves..

ISSN 2072-3857

Table (3) Effect of foliar spraying with different concentrations of Putrescine and the interaction with cultivars on leaf number

Categories (V)	putrescine concentrations (mg L^{-1})P				Item Averages (V)
	P1	P2	P3	P4	
V1	16.86	14.6	16.33	17.26	16.26
V2	15.66	17.4	16.66	14.46	16.05
V3	14.61	19.26	13.46	16.4	15.93
putrescine averages (P)	15.71	17.08	15.48	16.04	

LSD 0.05 (V*P) = 1.46 LSD 0.05 (P)= 0.84 LSD 0.05 (V)= NS

Average paper area per sheet (cm²)

The results of Table (4) indicated the presence of significant differences in the rate of increase in leaf area as a result of foliar spraying with pyrethrin concentrations and the studied varieties. Regarding the effect of varieties, variety V3 was significantly superior, giving the highest average leaf area of 159.86 cm² compared to variety V1, which gave the lowest average of 126.02 cm², while variety V2 recorded an average of 131.17 cm². In contrast, the foliar spray treatment with pyrethrin concentration P4 was significantly superior, giving the highest average leaf area of 162.46 cm² compared to the control treatment P1 without addition, which recorded the lowest average of 122.62 cm². As for the interaction treatment, foliar spraying with Putrescine and the varieties did not show significant differences among them.

Table (4) Effect of foliar spraying with different concentrations of Putrescine and interaction with varieties on leaf area (cm²)

Categories (V)	putrescine concentrations (mg L^{-1})P				Item Averages (V)
	P1	P2	P3	P4	
V1	107.53	120.87	130.36	145.31	126.02
V2	112.86	129.41	125.08	157.34	131.17
V3	147.48	148.98	158.27	184.72	159.86
putrescine averages (P)	122.62	133.09	137.90	162.46	

LSD 0.05 (V*P) = NS LSD 0.05 (P)= 8.60 LSD 0.05 (V)= 5.45

Leaf content of chlorophyll CCI

The results of Table (5) indicated the presence of significant differences in the rate of increase in chlorophyll content in the leaves as a result of foliar spraying with Putrescine concentrations and the studied varieties. Regarding the effect of varieties, variety V1 significantly excelled by giving the highest chlorophyll content in the leaves, which reached 54.49, compared to variety V2, which gave the lowest chlorophyll content of 43.53, while variety V3 had a chlorophyll content of 53.65. As for the spraying treatment, the Putrescine concentration P4 significantly excelled and gave the highest chlorophyll content in the leaves, reaching 56.56, compared to the control treatment P3, which reached 46.76. However, regarding the interaction treatment, foliar spraying with biotersen and the varieties showed no significant differences among them.

Table (5) Effect of foliar spraying with different concentrations of Putrescine and the interaction with varieties on leaf chlorophyll CCI content

Categories (V)	putrescine concentrations (mg L^{-1})P				Item Averages (V)
	P1	P2	P3	P4	
V1	56.64	55.31	47.89	58.13	54.49
V2	40.76	43.96	43.08	46.33	43.53
V3	50.57	49.48	49.30	65.23	53.65
putrescine averages (P)	49.32	49.58	46.76	56.56	

LSD 0.05 (V*P) = NS LSD 0.05 (P)= 6.06 LSD 0.05 (V)= 4.00

Dry weight of the vegetative mass (g)

The results of Table (6) indicated the existence of significant differences in the rate of increase in the dry weight of the vegetative mass as a result of foliar spraying with Putrescine concentrations and the studied varieties. Regarding the effect of varieties, variety V3 was significantly superior, giving the highest average dry weight of the vegetative mass at 173.43 g compared to variety V1, which gave the lowest average at 133.69 g, while variety V2 came with an average of 149.73 g. As for the spray treatment, the Putrescine concentration P4 was significantly superior, giving the highest average dry weight of the vegetative mass at 196.65 g compared to the control treatment P1 without addition, which recorded the lowest average at 96.09 g.

Regarding the interaction treatment, it shows that foliar spraying with Putrescine and varieties had significant differences among them.

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Table (6) Effect of foliar spraying with different concentrations of Putrescine and the interaction with varieties on the dry weight of the vegetative mass (g)

Categories (V)	putrescine concentrations (mg L⁻ ¹)P				Item Averages (V)
	P1	P2	P3	P4	
V1	84.70	126.14	158.22	165.69	133.69
V2	96.79	152.58	168.6	180.93	149.73
V3	106.77	161.88	181.76	243.32	173.43
putrescine averages (P)	96.09	146.87	169.53	196.65	

LSD 0.05 (V*P) = NS LSD 0.05 (P)= 21.79 LSD 0.05 (V)= 11.39

Average total root weight (g)

The results of Table (7) indicated the presence of significant differences in the rate of increase in total root weight as a result of foliar spraying with Putrescine concentrations and the studied varieties. Regarding the effect of varieties, variety V3 was significantly superior, giving the highest average total root weight of 311.14 kg compared to variety V1, which gave the lowest average of 205.85 kg, while variety V2 had an average of 222.08 kg. On the other hand, the foliar spraying treatment with Putrescine concentration P4 was significantly superior, giving the highest average total root weight of 305.04 kg compared to the control treatment P1 without addition, which recorded the lowest average of 214.24 kg.

As for the interaction treatment, foliar spraying with Putrescine and the varieties showed that the interaction treatment V3P4 was superior, giving the highest average of 409.9 g compared to the lowest average in treatment V1P1, which was 186.73 g.

Table (7) Effect of foliar spraying with different concentrations of Putrescine and the interaction with varieties on total root weight (g)

Categories (V)	putrescine concentrations (mg L⁻ ¹)P				Item Averages (V)
	P1	P2	P3	P4	
V1	186.73	197.0	197.76	241.9	205.85
V2	200.43	200.66	223.9	263.3	222.08
V3	255.5	287.9	292.2	409.9	311.14
putrescine averages (P)	214.24	228.52	237.62	305.04	

LSD 0.05(V*P)=26.5 LSD 0.05 (P)= 15.34 LSD 0.05 (V)= 14.51

ISSN 2072-3857

Total yield (1 ton per hectare)

The results of Table (8) indicated significant differences in the rate of increase in total yield due to foliar spraying with Biorcin concentrations and the studied varieties. Regarding the effect of varieties, variety V3 was significantly superior, giving the highest average total yield of 64.55 tons per hectare compared to variety V2, which gave the lowest average of 50.53 tons per hectare, while variety V1 had an average of 55.01 tons per hectare. Meanwhile, the foliar spray treatment with Biorcin concentration P4 was significantly superior, giving the highest average total yield of 61.93 tons per hectare compared to the control treatment P1 without addition, which recorded the lowest average of 50.84 tons per hectare .

As for the interaction treatment, the foliar spraying with Biorcin and the varieties showed that the interaction treatment V3P4 was superior, giving the highest yield of 71.2 tons per hectare compared to the lowest yield in treatment V2P1, which amounted to 47.3 tons per hectare .

Table (8) Effect of foliar spraying with different concentrations of Putrescine and the interaction with varieties on total yield (ton ha-1)

Categories (V)	putrescine concentrations (mg L^{-1})P				Item Averages (V)
	P1	P2	P3	P4	
V1	50.73	53.83	56.06	59.43	55.01
V2	47.3	48.43	51.23	55.16	50.53
V3	54.5	63.73	68.76	71.2	64.55
putrescine averages (P)	50.84	55.33	58.68	61.93	

LSD 0.05 (V*P) = 2.58 LSD 0.05 (P)= 1.4 LSD 0.05 (V)= 1.26

Discussion

The results indicate that the response of beet plants to biostimulants varies depending on the trait studied, as there was no significant effect of the biostimulant on increasing plant height, indicating that this trait is primarily related to the genetic factors of the cultivar, which explains the superiority of the V2 cultivar. [16] pointed out that longitudinal growth traits are often less responsive to growth regulators compared to traits related to photosynthesis. These differences may also be related to each cultivar's ability to regulate internal physiological processes, such as enzyme activity and nutrient absorption efficiency, which reflects on the increase in both quantitative and qualitative yield [4]

ISSN 2072-3857

Plant cultivars are considered one of the main factors affecting crop productivity, as they differ in terms of genetic composition, physiological efficiency, and response to environmental conditions and various agricultural practices. Despite the diverse global distribution of beet cultivars, selecting the most suitable cultivar for local environmental conditions is crucial for ensuring high productivity and quality. Diversifying the cultivated varieties also contributes to reducing risks resulting from environmental pressures and diseases, and enhances production stability in the long term. [11] .On the other hand, putrescine showed a significant effect on the number of leaves and leaf area, leading to an increase in these traits, which is attributed to its role as one of the polyamines that stimulate cell division, meristem activity, and improvement of plant tissue growth [8]. Also, the increase in the number of leaves at concentration P2 indicates stimulation of vegetative organ formation, while the increase in leaf area at P4 reflects enhanced cell elongation and expansion. The increase in chlorophyll content at the high concentration P4 is attributed to the role of putrescine in stabilizing chloroplast membranes, reducing chlorophyll degradation, and improving photosynthetic efficiency, as confirmed by the study of [12] which explained that polyamines enhance the efficiency of the photosynthetic apparatus and protect it from stress. This increase in leaf area and chlorophyll was reflected in the increase in the dry weight of the vegetative mass, as a result of the increased accumulation of photosynthesis products, with biostimulants working to improve the activity of enzymes associated with photosynthesis and increase the efficiency of nutrient use [10]

As for the superiority of variety V3 in most traits, it is attributed to its high genetic efficiency and its ability to utilize environmental resources and agricultural practices more efficiently, which led to increased vegetative growth and thus improved productive traits. [20] indicated that the variation in response between varieties is due to genetic differences in the efficiency of using growth regulators.

These increases in vegetative growth were reflected in the increased root weight and total yield, as biostimulants, especially at concentration P4, promoted the translocation of carbohydrate materials from the leaves (source) to the roots (sink), resulting in increased root size and weight. This is in agreement with [14] who mentioned that polyamines play an important role in regulating the distribution of nutrients within the plant..

The clear superiority of the V3×P4 treatment in root weight and total yield also indicates the presence of a positive interaction between the variety and the high concentration of biotersen, as the V3 variety was able to respond better to this treatment, which reinforces the idea that selecting the appropriate variety with the optimal concentration

is a crucial factor in improving productivity .
In general, the results confirm that biotersen is considered an effective growth regulator in enhancing vegetative growth and increasing productivity in sugar beet, especially when using the appropriate concentration in combination with a highly efficient variety.

Conclusion

It can be concluded that different plant varieties of beet show a clear variation in growth, productivity, and yield, due to genetic and physiological differences among them. The study has proven that spraying with multiple amines such as biotersin enhances growth and yield traits and increases the content of essential and secondary nutrients in the plant by improving nutrient absorption and activating metabolic processes. Additionally, selecting the suitable variety for local environmental conditions is a key factor in achieving high productivity and better crop quality. Based on the results, it is recommended to use biotersin treatment as an aid to improve vegetative traits and yields of the cultivated beet varieties, while considering the compatibility between the variety and local environmental conditions to achieve maximum benefit.

References

[1]**Al-Jubouri**, Jasim Salem and Ali Nazem Akbar Mohammed. 2015. The effect of adding different levels of boron on the yield of beet plant Beta vulgaris ssp vulgar in some gypsiferous soils. Tikrit University Journal of Agricultural Sciences: 15(1) 109-117.

[2]**Al-Khafaji**, Maki Alwan. 2014. Plant Growth Regulators: Their Applications and Horticultural Uses. Ministry of Higher Education and Scientific Research. College of Agriculture - University of Baghdad - Republic of Iraq.

[3]**Alalwani,** A. K., Sekhi, Y. S., Kamis, A., Al-Dulaimy, A. F., Almohammedi, O. H., & Al-Taey, D. K. A. (2025, April). Physiological Activities of Reactive Oxygen Species (ROS) in Plants: A Review. In IOP Conference Series: Earth and Environmental Science (Vol. 1487, No. 1, p. 012063). IOP Publishing.

[4]**Al-Dulime,** M. L. A., & Al-Mohammedi, O. H. M. (2023, December). Effect of spraying with growth regulators Brassinolide and Thidiazuron on the chemical content of

ISSN 2072-3857

leaves and pods of three Okra hybrids under protected cultivation conditions. In IOP Conference Series: Earth and Environmental Science (Vol. 1252, No. 1, p. 012089). IOP Publishing.

[5]Al-Issawi, A. K., & Al-Mohammedi, O. H. M. (2023, August). A study of three planting dates and spraying with zinc, boron and polyamine (Putrescine) on the growth and yield of broccoli. In IOP Conference Series: Earth and Environmental Science (Vol. 1225, No. 1, p. 012029). IOP Publishing.

[6]Al-Issawi, A. K., & Al-Mohammedi, O. H. M. (2023, July). A study of three planting dates and spraying with zinc, boron and polyamine (Putrescine) on the qualitative characteristics of Broccoli. In IOP Conference Series: Earth and Environmental Science (Vol. 1213, No. 1, p. 012055). IOP Publishing.

[7]Al-Mohammadi, S. M., & Mohammadi, F. H. A. L. (2012). Statistics and experimental design. dar osama for publication and distribution/amman, jordan. pp: 376.

[8]Altaf, M. A., Shahid, R., Ren, M. X., Naz, S., Altaf, M. M., Khan, L. U., & Shahid, S. (2022).*Exogenous application of polyamines improves plant growth by regulating cell division, photosynthesis and*

[9]Britannica Editors (2025, December 11). Beet . Encyclopedia Britannica https://www.britannica.com/plant/beet.

[10]Chen, D., Shao, Q., Yin, L., Younis, A., & Zheng, B. (2019). *Polyamines regulate plant growth and photosynthesis: roles and* mechanisms. Plant Physiology and Biochemistry, 139, 102–110.

[11]FAO. *Crops and varieties: approaches for genetic diversification and adaptation*. FAO Knowledge Repository.

[12]Hasanuzzaman, M., Bhuyan, M. H. M. B., Zulfiqar, F., Raza, A., Mohsin, S. M., Mahmud, J. A., Fujita, M., & Fotopoulos, V. (2020).*Reactive oxygen species and antioxidant defense in plants under abiotic stress: revisiting the crucial role of a universal defense regulator*.

[13]Hassan, Ahmed Abdel Monem. 2024. Advances in the Study of Vegetable Cultivation to Improve Quality Traits (1st ed.). Cairo: Author. (Advances in Vegetable Studies Series, 9).

[14]Iqbal, N., Khan, N. A., Ferrante, A., Trivellini, A., Francini, A., & Khan, M. I. R. (2022).Ethylene role in plant growth, development and senescence: interaction with

ISSN 2072-3857

other phytohormones. Frontiers in Plant Science.

[15]Karklelienė, R., Juškevičienė, D., & Radzevičius, A. (2023). Application of genetic resources in the development of new Lithuanian vegetable cultivars. Plants, 12(4), 807. https://doi.org/10.3390/plants12040807

[17] Liu, Y., et al. (2023). Environmental regulation of flowering time and stress responses in plants. Plants, 12(5), 1050. https://doi.org/10.3390/plants12051050

[18]Mohamed, S.A., H.S. Ahmed and A.A. El-Bawab. 2018. Effect

[16]Khalil, A. B., et al. (2021). *Effects of plant growth regulators on morphological versus physiological traits in crop plants*. Journal of Plant Growth Regulation, 40(2),

of chitosan, Putrescine and Irrigation levels on the drought tolerance of sour orange seedlings.Egypt. J. Hort. 45 (2):257-273

[19]Napieraj, N., Reda, M., & Janeczko, A. (2023). Polyamines as regulators of plant growth, development, and stress responses. International Journal of Molecular Sciences, 24(4), 3621

[20]Singh, R., et al. (2023). Role of plant growth regulators in improving crop productivity. Agronomy, 13(5), 1100.

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