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EFFECTS OF SOME BIOSTIMULATORS AT TWO POTATO CULTIVARS CULTIVATED AT DIFFERENT PLANT DENSITIES

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Abstract

The application of biostimulators to plants leads to the accumulation of a higher content of nutrients in their tissue and to positive metabolic changes improving plant nutrient use efficiency and tolerance to stress factors. The aim of this paper is to present the effects of some biostimulators at potato crop according to variety and plant density. The research was conducted in the years 2023 and 2024 at the National lnstitute of Research and Development for Potato and Sugar Beet Brasov, Romania. The experimental variants were the following: potato variety (Darilena; Ultra); plant density (45.000 plants/ha; 53.000 plants/ha); Biostimulator product (no biostimulator - control variant; Genaktis 1; Irys; Terram Number One; Wuxal Macromix). Compared to control (untreated) variant, all the used biostimulator products determined an increased number of stems per hill, an increased aerial part weight, and an increased tuber yield regardless the potato variety, plant density and climatic conditions of the year. The tuber yield increase determined by using biostimulators is higher in better climatic conditions and at higher plant density. Having all these into account, the inclusion of the biostimulators in the potato crop technology can be considered as a good strategy.

Key words*: biostimulator, potato, cultivar, plant density, plant traits.*

INTRODUCTION

Potato (*Solanum tuberosum* L.) is cultivated in about 160 countries all over the world and consumed every day by over a billion people (Camire et al., 2009; Bishwoyog and Swarnima, 2016). In the world production, potato is an important agricultural plant, not only on account of its consumer importance, but also due to its industrial and fodder significance (Zgórska and Grudzińska, 2012).

Plant biostimulator have been identified as one of the most important agronomic factors that scientists have been looking for in a range of natural sources over the last few decades (Yaseena and Takacs-Hajosa, 2022).

Biostimulator are substances applied to plants, intended to improve their status. Through the effects they produce, they are the equivalent of food supplements and vitamins for improving people's health. Thus, biostimulators help plants to grow and develop well and to go well through periods of stress.

In the actual context of climate change, biostimulators have gained increasing importance in supporting plants to overcome water stress.

Various biostimulators are classified based on application method (soil and foliar), source (plant and animal) or production method (hydrolysis, fermentation and extraction) (Suman et al., 2025). These natural products (seaweed extracts, humic substances, hydrolyzed proteins and products containing amino acids or microorganisms) contain a bioactive substance that improves plant growth, increases nutritional efficiency and tolerance to abiotic stress, improves plant protection against pathogens and improves plant traits and yield quality regardless of nutrient content (Calvo et al., 2014; du Jardin, 2015; van Oosten et al., 2017; Bulgari et al., 2019).

According to Regulation (EU) 2019/1009 of the European Parliament and of the Council, a plant biostimulator shall be an EU fertilising product the function of which is to stimulate plant nutrition processes independently of the product's nutrient content with the sole aim of improving one or more of the following characteristics of the plant or the plant

rhizosphere: nutrient use efficiency, tolerance to abiotic stress, quality traits, or availability of confined nutrients in the soil or rhizosphere.

The application of biostimulators to plants leads to the accumulation of a higher content of nutrients in their tissue and to positive metabolic changes.

For these reasons, the development of new biostimulators has become a point of scientific interest (Nardi et al., 2002). The biostimulator stand as powerful tools for more eco-friendly and productive agricultural systems (Suman et al., 2025).

The biostimulating effects of humic substances are characterized by both structural and physiological changes in plants, related to the absorption, assimilation and distribution of nutrients, as well as changes in the primary and secondary metabolism of plants related to tolerance to abiotic stress (Cioroianu et al., 2022).

The biostimulator action is to stimulate the development of leaves, stems and roots of plants, to supplement nutrient deficiency during the growing season caused, among others, by intensive plant development, drought or agrotechnical errors (Bienia et al., 2018).

Foliar treatments have been demonstrated to increase the efficiency with which macro- and micronutrients are absorbed and utilized (Karak et al., 2023).

An important element in potato agrotechnics is the "greening" process and the constant reduction of unit costs of production (Mystkowska, 2022). We are currently facing clearly visible climate changes and increasingly extreme weather conditions, which are accompanied by various stress factors for plants, like high and low temperatures, periodic droughts, floods, frosts (Abd EL-Wahab et al., 2016; Fleming et al., 2019).

In all traditional areas of potato cultivation in Romania, a constant trend of increasing air temperature and decreasing precipitation during the summer has been observed, especially in the flowering-maturing phenophase, when the plants achieve maximum water consumption (Stefan et al., 2024).

In this context, the aim of this paper is to present the effects of some biostimulators at potato crop according to variety and plant density.

MATERIALS AND METHODS

The performed field experiment was carried out in the years 2023 and 2024 at the National Institute of Research and Development for Potato and Sugar Beet Brașov (NIRDPSB Brașov), Romania, on a chermozem soil with a pH of 5.77.

The field experiment was organized as subdivided plots with 4 replications being of type 2 x 2 x 5, with the following experimental factors:

- Factor A – Potato variety, with two graduations:
  - a1. Darilena;
  - a2. Ultra.
- Factor B – Plant density, with two graduations:
  - b1. 45.000 plants/ha;
  - b2. 53.000 plants/ha.
- Factor C – Biostimulator product, with five graduations:
  - c1. No biostimulator – control variant;
  - c2. Genaktis 1;
  - c3. Irys;
  - c4. Terram Number One;
  - c5. Wuxal Macromix.

Darilena is a mid-early variety created by NIRDPSB Brașov, with oval tubers of yellow skin colour and light yellow flesh colour.

Ultra variety is a mid-early variety created by Solana Holland, with long oval tubers of yellow skin colour and light yellow flesh colour.

Genaktis 1 is a foliar biostimulator based on seaweed and silica extracts, with the effect of intensifying metabolic processes. It contains: 9% total nitrogen under the form of urea nitrogen, 5% P_2O_5 soluble in water, 7% K_2O soluble in water, 0.01% B soluble in water, 0.002% Cu soluble in water chelated with EDATA, 0.02% Fe, 0.001% Mo soluble in water. The biostimulant Genaktis 1 was applied twice during the vegetation period: the first application at the beginning of flowering and the second 15 days after the first application, at a rate of 3 l/ha/application.

Irys is a root biostimulator based on humic substances and plant extracts with a growth and development effect on the root system. It contains: 7% total nitrogen under the form of urea nitrogen, 9% P_2O_5 soluble in water, 13%

K_2O soluble in water, 0.01% B soluble in water, 0.002% Cu soluble in water chelated with EDATA, 0.04% Fe soluble in water chelated with EDATA, 0.01% Mn soluble in water chelated with EDATA, 0.001% Mo soluble in water, 0.002% Zn soluble in water chelated with EDATA. The biostimulant Irys was applied first at planting in the ridge and then at the three-differentiated-leaf stage, at a rate of 4 l/ha/application.

Terram Number One is a root biostimulator with high carbon content and organic substances, amino acids and polysaccharides. It contains: 1.2% total nitrogen under the form of soluble organic nitrogen, 12% organic carbon of biological origin, 7-8% K_2O, 35.5% organic substance with normal molecular weight <50 kDa, 7% alginic acid, 1.2-2.4% mannitol. The biostimulant Terram Number One was applied at a rate of 3 l/ha/application during the vegetation period, in two passes at 15-day intervals from the first application.

Wuxal Macromix is a foliar fertilizer with a biostimulating effect that has a well-balanced nutrient suspension indicated for sustaining plant growth under physiological stress conditions, having also a stabilizing effect on plant health. It contains: 16% N, 16% P_2O_5, 12% K_2O, 0.02% B, 0.05% Cu, 0.1% Fe, 0.05% Mn, 0.001% Mo, 0.05% Zn. The foliar fertilizer with a biostimulant effect on plants, Wuxal Macromix, was first applied at the beginning of tuber formation, with the second application 14 days after the first, at a rate of 5 l/ha/application.

In the spring of 2023 and 2024, NPK 15:15:15 fertilizers were applied at a rate of 1000 kg/ha, which were later incorporated into the soil during land preparation for planting. After ridge formation, the first herbicide application was performed using Sencor Liquid 600 SC (Metribuzin 600 g/l) at a rate of 0.6 l/ha for controlling annual dicotyledonous and monocotyledonous weeds, and Titus 25 DF (Rimsulfuron 25%) at a rate of 60 g/ha for controlling perennial grasses and certain susceptible broadleaf weeds. During the vegetation period, treatments were applied for pest control and preventive disease using a tractor equipped with a spraying pump.

The tubes were planted on 28th of April in 2023 and on 10th of April in 2024. The row spacing was of 75 cm.

The plot size for each variant was of 18 m^2, this resulting from four rows of potato plants at row spacing of 75 cm, which means 3 m, and 6 m along the rows.

The number of main stems and the weight of aerial part from two plants from each variant and replication were analysed.

On 21st of September in 2023 and 20th of September in 2024, the tubers were harvested and their weight from each plot and replication was determined, and then the yield per hectare was calculated.

The results were statistically analysed using ANOVA program (analysis of variance for fully randomized polyfactorial experiments).

Weather conditions during field research

In 2023, the month of April was rich in precipitation (83.1 mm), exceeding the multiannual amount by 33.1 mm, and the average temperature (7.3°C) was lower than the multiannual average (8.5°C). In May, the average temperature has almost the same value (13.8°C) as the multiannual average (13.6°C) and a relatively high amount of precipitation (77.5 mm) were recorded. The summer months (June-August) recorded average temperatures above the multiannual averages by 1.1°C, 2.4°C and 3.4°C respectively, and the precipitation level was higher in June with 14.4 mm and in August by 1.1 mm, but much lower in July (40.7 mm). In September, the average temperature was higher with 3.3°C and the amount of precipitation especially low, with only 11 mm (Table 1).

In 2024, the month of April was warmer than normal, and the amount of precipitation was 43.5 mm, lower by 6.5 mm compared to multiannual average. In May, the average temperature was at the level of the multiannual average, but the amount of precipitation was much lower than the multiannual average value, registering only 42.7 mm compared to 82 mm. The summer months (June-August) recorded higher average temperatures, with 4.6°C higher in June. Also, the volume of precipitation was much lower in all three months, setting in the phenomena of atmospheric and pedological drought. It should be emphasized that a large volume of precipitation fell in a very short time (for example, the month of August when 90% of the total quantity of the month fell in four

days). The month of September recorded an average temperature with 3.5°C higher than the multiannual average and a volume of precipitation of 57.8 mm (Table 1).

Table 1. Average air temperatures and rainfalls during the performed field experiments in the studied area

Year	Month						
	IV	V	VI	VII	VIII	IX	
Air temperature (°C)							Average
2023	7.3	13.8	17.6	20.5	20.9	16.9	16.2
2024	12.2	13.8	21.1	22.2	21.2	15.9	17.7
MAA*	8.5	13.6	16.5	18.1	17.5	13.6	14.6
Rainfalls (mm)							Amount
2023	83.1	77.5	111.1	59.1	77.5	11.0	419.3
2024	43.5	42.7	54.5	79.4	28.9	48.7	297.6
MAA*	50.0	82.0	96.7	99.8	76.4	52.5	457.4

*MAA - multiannual average

RESULTS AND DISCUSSIONS

Number of stems/hill

Regarding Darilena variety in 2023 (Table 2), at the first assessment (3rd of July, 2023), the number of stems/hill at the density of 45.000 plants/ha varied between 3.38 stems/hill to the control variant (untreated variant) and 5.38 stems/hill to the variant treated with Genaktis 1. There was recorded a significant difference only for the variant treated with Genaktis 1. At the same date but at density of 53.000 plants/ha the lowest number of stems/hill was to the control variant (3.00) and the highest again to the variant treated with Genaktis 1 (4.88), but there was not registered statistical differences.

At the second assessment (28th of July, 2023), the number of stems/hill at the density of 45.000 plants/ha varied between 4.13 stems/hill to the control variant and 5.13 stems to the variant treated with Terram Number One (Table 2). At the density of 45.000 plants/ha no treated variant determined significant differences compared to control one. At the same date but at the density of 53.000 plants/ha the lowest number of stems/hill was to the control variant (3.88) and the highest to the variant treated with Irys (5.38). At the densities of 53.000 plants/ha, the application of the biostimulators Irys and Wuxal Macromix determined statistically significant differences compared to control variant.

Table 2. Darilena cv. main stems/hill assessment in 2023

Experimental variant	Plant density of 45.000 pl/ha			Plant density of 53.000 pl/ha		
	Aver.	Dif.	Sign.	Aver.	Dif.	Sign.
No of main stems at 03rd of July, 2023						
Control	3.38	-	-	3.00	-	-
Genaktis 1	5.38	2.00	*	4.88	1.88	ns
Irys	4.25	0.88	Ns	3.63	0.63	ns
Terram Number One	4.38	1.00	Ns	3.63	0.63	ns
Wuxal Macromix	5.13	1.75	Ns	3.25	0.25	ns
	DL5% 1.92 DL1% 2.62 DL0.1% 3.56			DL5% 1.44 DL1% 1.97 DL0.1% 2.67		
No of main stems at 28th of July, 2023						
Control	4.13	-	-	3.88	-	-
Genaktis 1	4.25	0.13	ns	4.13	0.25	ns
Irys	4.63	0.50	ns	5.38	1.50	*
Terram Number One	5.13	1.00	ns	4.88	1.00	ns
Wuxal Macromix	4.50	0.38	ns	5.13	1.25	*
	DL5% 1.47 DL1% 2.01 DL0.1% 2.73			DL5% 1.14 DL1% 1.56 DL0.1% 2.11		

Regarding Darilena variety in 2024 (Table 3), at the first assessment (10th of June, 2024), the number of stems/hill at the density of 45.000 plants/ha varied between 4.25 to the control variant and 6.25 to the variant treated with Wuxal Macromix. At the same date but at the density of 53.000 plants/ha, the lowest number of stems/hill was to the control variant (4.00) and the highest was to the variant treated with Genaktis 1 (6.38). For both plant densities the variants treated with Genaktis 1 and Wuxal Macromix registered differences statistically significant compared to control (untreated) variant.

At the second assessment (17th of July, 2024), the number of stems/hill at the density of 45.000 plants/ha varied between 3.50 to the control variant and 5.63 to the variants treated with Genaktis 1 and Wuxal Macromix (Table 3). For this assessment at the density of 45.000 plants/ha, all the tested biostimulators determined differences statistically significant compared to control (untreated) variant.

At the same date but at the density of 53.000 plants/ha the lowest number of stems/hill was registered to the control variant (3.63) and the highest to the variants treated with Genaktis 1 and Terram Number One (6.13). At this plant density, the biostimulators Genaktis 1 and Terram Number

One determined differences statistically distinct significant compared to control variant, while the biostimulator Wuxal Macromix determined a difference statistically significand and the biostimulator Irys determined no significant differences.

Table 3. Darilena cv. main stems assessment in 2024

Experimental variant	Plant density of 45.000 pl/ha			Plant density of 53.000 pl/ha		
	Aver.	Dif.	Sign.	Aver.	Dif.	Sign.
No. of main stems at 10th of June, 2024						
Control	4.25	-	-	4.00	-	-
Genaktis 1	5.63	1.38	*	6.38	2.38	*
Irys	5.00	0.75	ns	4.75	0.75	ns
Terram Number One	5.38	1.13	ns	6.00	2.00	ns
Wuxal Macromix	6.25	2.00	*	6.13	2.13	*
	DL5% 1.33 DL1% 1.83 DL0.1% 2.48			DL5% 2.08 DL1% 2.85 DL0.1% 3.86		
No. of main stems at 17th of July, 2024						
Control	3.50	-	-	3.63	-	-
Genaktis 1	5.63	2.13	*	6.13	2.50	**
Irys	5.38	1.88	*	5.00	1.38	ns
Terram Number One	5.25	1.75	*	6.13	2.50	**
Wuxal Macromix	5.63	2.13	*	5.50	1.88	*
	DL5% 1.68 DL1% 2.30 DL0.1% 3.12			DL5% 1.44 DL1% 1.97 DL0.1% 2.68		

Regarding Ultra variety in 2023 (Table 4), at the first assessment (3rd of July, 2023), the number of stems/hill at the density of 45.000 plants/ha varied between 2.88 stems/hill to the untreated variant and 5.88 stems/hill to the variant treated with Genaktis 1. For the variant treated with Genaktis 1 there was recorded a very distinctly significant difference, while for variants treated with Irys and Wuxal Macromix distinctly significant difference and variant treated with Number One only a significant difference towards the control variant. At the same date but at the density of 53.000 plants/ha, the lowest number of stems/hill was to control (untreated) variant (3.75) and the highest to the variant treated with Irys (5.63), been recorded distinctly significant differences to the variants treated with Irys and Number One, and a significant difference to the variant treated with Wuxal Macromix.

At the second assessment (27th of July, 2023), the number of stems/hill at the density of 45.000 plants/ha varied between 4.5 to the control variant and 6.0 to the variant treated with Genaktis 1 (Table 1). Compared to control variant, a distinct significant difference was registered at the variant treated with Genaktis 1 and a significant one at the variant treated with Terram Number One. At the same date but at the density of 53.000 plants/ha, the lowest number of stems was registered to the control variant (4.25) and the highest to the variant treated with Irys (5.63). At this plant density, compared to control variant, the biostimualtors Irys and Wuxal Macromix determined differences statistically significant.

Table 4. Ultra cv. main stems assessment in 2023

Experimental variant	Plant density of 45.000 pl/ha			Plant density of 53.000 pl/ha		
	Aver.	Dif.	Sign.	Aver.	Dif.	Sign.
No. of main stems at 03rd of July, 2023						
Control	2.88	-	-	3.75	-	-
Genaktis 1	5.88	3.00	***	4.00	0.25	ns
Irys	4.75	1.88	**	5.63	1.88	**
Terram Number One	4.00	1.13	*	5.25	1.50	**
Wuxal Macromix	5.13	2.25	**	5.13	1.38	*
	DL5% 0.92 DL1% 1.26 DL0.1% 1.71			DL5% 1.07 DL1% 1.47 DL0.1% 1.99		
No. of main stems at 28th of July, 2023						
Control	4.50	-	-	4.25	-	-
Genaktis 1	6.00	1.50	**	5.25	1.00	ns
Irys	5.50	1.00	ns	5.63	1.38	*
Terram Number One	5.88	1.38	*	4.88	0.63	ns
Wuxal Macromix	4.88	0.38	ns	5.63	1.38	*
	DL5% 1.05 DL1% 1.43 DL0.1% 1.94			DL5% 1.27 DL1% 1.73 DL0.1% 2.35		

Regarding Ultra variety in 2024 (Table 5), at the first assessment (10th of June, 2024), the number of stems/hill to the density of 45.000 plants/ha varied between 4.13 stems/hill to the untreated variant and 6.13 stems/hill to the variant treated with Irys. Only the variants treated with Genaktis 1 and Irys recorded a distinctly significant difference towards the untreated variant. At the same date but at the density of 53.000 plants/ha, the lowest number of stems was to the control variant (4.0) and the highest to the variant treated with Number One (5.63), been recorded significant differences to variants treated with Genaktis 1, Number One and Wuxal Macromix.

At the second assessment (17th of July, 2024), the number of stems/hill at the density of 45.000 plants/ha varied between 4.13 to the control variant and 5.88 to the variant treated with Terram Number One, this variant being

the only one registering a difference statistically significant compared to control variant (Table 5). At the same date but at the density of 53.000 plants/ha, the lowest number of stems was to the control variant (4.25) and the highest to the variant treated with Genaktis 1 (6.00), this variant being the only one registering a difference statistically significant compared to control variant.

Table 5. Ultra cv. main stems assessment in 2024

Experimental variant	Plant density of 45.000 pl/ha			Plant density of 53.000 pl/ha		
	Aver.	Dif.	Sign.	Aver.	Dif.	Sign.
No. of main stems at 10th of June, 2024						
Control	4.13	-	-	4.00	-	-
Genaktis 1	5.88	1.75	**	5.50	1.50	*
Irys	6.13	2.00	**	4.75	0.75	ns
Terram Number One	4.38	0.25	ns	5.63	1.63	*
Wuxal Macromix	4.75	0.63	ns	5.50	1.50	*
	DL5% 1.23 DL1% 1.69 DL0.1% 2.29			DL5% 1.26 DL1% 1.72 DL0.1% 2.34		
No. of main stems at 17th of July, 2024						
Control	4.13	-	-	4.25	-	-
Genaktis 1	5.25	1.13	ns	6.00	1.75	*
Irys	5.38	1.25	ns	5.25	1.00	ns
Terram Number One	5.88	1.75	*	5.50	1.25	ns
Wuxal Macromix	5.63	1.50	ns	5.13	0.88	ns
	DL5% 1.60 DL1% 2.20 DL0.1% 2.98			DL5% 1.38 DL1% 1.89 DL0.1% 2.56		

Aerial part weight

Regarding Darilena variety in 2023 (Table 6), at the first assessment (3rd of July, 2023), the aerial part weight to the density of 45.000 plants/ha varied between 340.2 g to the control variant to 447.5 g to the variant treated with Terram Number One, to this variant been registered a very distinctly significant difference. At the same date but at the density of 53.000 plants/ha, the lowest weight was also to the control variant (219.6 g) and the highest to the variant treated with Genaktis 1 (391.7 g). At this plant density, the variant treated with Terram Number One registered a difference significant compared to control variant and very significant differences were registered to the variants treated with Genaktis 1 and Irys.

At the second assessment (28th of July, 2023), the aerial part weight at the density of 45.000 plants/ha varied between 305.7 g to the untreated variant and 433.4 g to the variant treated with Wuxal Macromix (Table 6). To this density there were recorded significant differences to variants treated with Genaktis 1 and Irys and a distinctly significant difference to the variant treated with Wuxal Macromix. At the same date but at the density of 53.000 plants/ha the lowest weight was to the control variant (325.7 g) and the highest to the variant treated with Irys (380.0 g) and were observed to all treated variants significant differences.

Table 6. Darilena cv. aerial part weight assessment in 2023

Experimental variant	Plant density of 45.000 pl/ha			Plant density of 53.000 pl/ha		
	Aver.	Dif.	Sign.	Aver.	Dif.	Sign.
Aerial part weight (g) at 03rd of July, 2023						
Control	340.2	-	-	219.6	-	-
Genaktis 1	342.0	1.75	ns	391.7	172.13	**
Irys	349.7	9.50	ns	367.7	148.13	**
Terram Number One	447.5	107.25	***	347.9	128.25	*
Wuxal Macromix	386.1	45.88	ns	317.0	97.38	ns
	DL5% 54.80 DL1% 74.99 DL0.1% 101.73			DL5% 101.6 DL1% 139.0 DL0.1% 188.60		
Aerial part weight (g) at 28th of July, 2023						
Control	305.7	-	-	325.7	-	-
Genaktis 1	386.1	80.38	*	373.0	47.25	*
Irys	389.0	83.25	*	380.0	54.25	*
Terram Number One	363.5	57.75	ns	371.5	45.75	*
Wuxal Macromix	433.4	127.63	**	376.5	50.75	*
	DL5% 75.63 DL1% 103.49 DL0.1% 140.40			DL5% 42.6 DL1% 58.3 DL0.1% 79.09		

Regarding Darilena variety in 2024 (Table 7), at the first assessment (10th of June, 2024), the aerial part weight at the density of 45.000 plants/ha varied between 217.75 g to the control variant and 309.75 g to the variant treated with Wuxal Macromix, to this variant being registered a very significant difference. Also a significant difference was recorded to the variant treated with Terram Number One and a distinctly significant one to the variant treated with Genaktis 1. At the same date but at the density of 53.000 plants/ha the lowest weight was also to the untreated variant (205.75 g) and the highest to the variant treated with Wuxal Macromix (268.0 g). At this plant density, a significant difference was registered at the variant treated with Irys, distinctly significant at the variant treated with Terram Number One and very significant differences at the variant treated with Wuxal Macromix.

At the second assessment (July, 17th, 2024), the aerial part weight to the density of 45.000 plants/ha varied between 139.75 g to the control variant and 201.88 g to the variant treated with Wuxal Macromix (Table 7). To this plant density, there were recorded very significant differences to variants treated with Wuxal Macromix and Genaktis 1 (195.5 g) and distinctly significant differences to variants treated with Irys (190.0 g) and Terram Number One (186.75 g). At the same date but at the density 53.000 plants/ha, the lowest weight was to the control variant (193.63 g) and the highest to the variant treated with Wuxal Macromix (241.25 g), where there were observed a distinctly significant difference as well as to the variant treated with Terram Number One, while the variants treated with Genaktis 1 and Irys registered no significant differences.

Table 7. Darilena cv. aerial part weight assessment in 2024

Experimental variant	Plant density of 45.000 pl/ha			Plant density of 53.000 pl/ha		
	Aver.	Dif.	Sign.	Aver.	Dif.	Sign.
Aerial part weight (g) at 10th of June, 2024						
Control	217.75	-	-	205.75	-	-
Genaktis 1	278.38	60.63	**	217.00	11.25	ns
Irys	235.50	17.75	ns	249.00	43.25	*
Terram Number One	254.50	36.75	*	259.13	53.38	**
Wuxal Macromix	309.75	92.00	***	268.00	62.25	***
	DL5% 32.96 DL1% 45.11 DL0.1% 61.20			DL5% 32.97 DL1% 45.12 DL0.1% 61.22		
Aerial part weight (g) at 17th of July, 2024						
Control	139.75	-	-	193.63	-	-
Genaktis 1	195.50	55.75	***	217.75	24.13	ns
Irys	190.00	50.25	**	220.00	26.38	ns
Terram Number One	186.75	47.00	**	234.50	40.88	**
Wuxal Macromix	201.88	62.13	***	241.25	47.63	**
	DL5% 28.52 DL1% 39.03 DL0.1% 52.95			DL5% 28.92 DL1% 39.57 DL0.1% 53.69		

Regarding Ultra variety in 2023 (Table 8), at the first assessment (3rd of July, 2023), the aerial part weight at the density of 45.000 plants/ha varied between 426.5 g to the untreated variant and 479.5 g to variant treated with Terram Number One, to this variant been registered a very significant difference compared to untreated variant, as well as at the variant treated with Genaktis 1. At the same date but at the density of 53.000 plants/ha, the lowest weight was also to the untreated variant (425.75 g) and the highest to the variant treated with Terram Number One (491.88 g). At this plant density, there were recorded a significant difference compared to control at the variant treated with Genaktis 1, and very significant differences to the variants treated with Terram Number One and Wuxal Macromix.

At the second assessment (28th July, 2024), the aerial part weight at the density of 45.000 plants/ha varied between 475.0 g to the untreated variant and 549.25 g to the variant treated with Number One, to this variant been recorded a very significant difference (Table 8). To variants treated with Genaktis 1 (529.25 g) and Wuxal Macromix (535.25 g), there were registered a distinctly significant difference, and to the variant treated with Irys (480.25 g) there was registered no significant difference. At the same date but at the density of 53.000 plants/ha, the lowest weight was to the control variant (409.13 g) and the highest to the variant treated with Wuxal Macromix (445.25 g), observing to all treated variants a significant difference compared to control variant.

Table 8. Ultra cv. aerial part weight assessment in 2023

Experimental variant	Plant density of 45.000 pl/ha			Plant density of 53.000 pl/ha		
	Aver.	Dif.	Sign.	Aver.	Dif.	Sign.
Aerial part weight (g) at 03rd of July, 2023						
Control	426.5	-	-	425.75	-	-
Genaktis 1	463.63	37.13	***	451.25	25.50	*
Irys	462.38	35.88	**	456.0	4.75	ns
Terram Number One	479.5	53.00	***	491.88	66.13	***
Wuxal Macromix	458.75	32.25	**	465.0	39.25	***
	DL5% 19.41 DL1% 26.56 DL0.1% 36.03			DL5% 19.62 DL1% 26.85 DL0.1% 36.43		
Aerial part weight (g) at 28th of July, 2023						
Control	475.00	-	-	409.13	-	-
Genaktis 1	529.25	54.25	**	442.00	32.88	*
Irys	480.25	5.25	ns	439.50	30.38	*
Terram Number One	549.25	74.25	***	439.50	30.38	*
Wuxal Macromix	535.25	60.25	**	445.25	36.13	*
	DL5% 38.26 DL1% 52.35 DL0.1% 71.02			DL5% 27.54 DL1% 37.68 DL0.1% 51.12		

Regarding Ultra variety in 2024 (Table 9), at the first assessment (10th of June, 2024), the aerial part weight at the density of 45.000 plants/ha varied between 251.75 g to the control variant and 355.75 g to the variant treated with Irys. To this variant and to the variants treated with Genaktis 1 (349.0 g) and

Wuxal Macromix (345.0 g), there were registered significant differences compared to control variant. At the same date but at the density of 53.000 plants/ha, the lowest weight was also registered to the untreated variant (206.50 g) and the highest to the variant treated with Irys (368.63 g). At this plant density, there were recorded a significant difference compared to control at the variant treated with Wuxal Macromix, distinctly significant differences to the variants treated with Genaktis 1 and Number One, and a very significant difference to the variant treated with Irys.

At the second assessment (17th of July, 2024), the aerial part weight at the density of 45.000 plants/ha varied between 145.88 g to the variant treated with Irys and 219.63 g to the variant treated with Number One (Table 9). To this plant density, there was recorded only a distinctly significant difference compared to control at the variant treated with Terram Number One. At the same date but at the density of 53.000 plants/ha, the lowest weight was registered to the control variant (199.25 g) and the highest to the variant treated with Genaktis 1 (306.25 g), observing a very significant differences to this one, and a significant difference to the variant treated with Wuxal Macromix compared to control variant.

Table 9. Ultra cv. aerial part weight assessment in 2024

Experimental variant	Plant density of 45.000 pl/ha			Plant density of 53.000 pl/ha		
	Aver.	Dif.	Sign.	Aver.	Dif.	Sign.
Aerial part weight (g) at 10th of June, 2024						
Control	251.75	-	-	206.50	-	-
Genaktis 1	349.00	97.25	*	310.38	103.88	**
Irys	355.75	104.00	*	368.63	162.13	***
Terram Number One	280.75	29.00	ns	302.00	95.50	**
Wuxal Macromix	345.00	93.25	*	286.25	79.75	*
	DL5% 88.05 DL1% 121.11 DL0.1% 164.30			DL5% 65.73 DL1% 89.94 DL0.1% 122.02		
Aerial part weight (g) at 17th of July, 2024						
Control	155.25	-	-	199.25	-	-
Genaktis 1	170.88	15.63	ns	306.25	107.00	***
Irys	145.88	-9.38	ns	251.25	52.00	ns
Terram Number One	219.63	64.38	**	239.00	39.75	ns
Wuxal Macromix	190.00	34.75	ns	279.25	80.00	*
	DL5% 38.81 DL1% 53.11 DL0.1% 72.05			DL5% 68.02 DL1% 93.08 DL0.1% 126.28		

Tuber yield

Regarding Ultra variety in 2023 (Table 10) and at the density of 45.000 plants/ha, the tuber yield ranged from 40.3 t/ha for the control variant to 46.4 t/ha, with the highest yield recorded for the variant treated with Wuxal Macromix. At the density of 53.000 plants/ha, the tuber yield values ranged between 42.5 t/ha for the control variant and 47.8 t/ha for the variant treated with Terram Number One. Comparing the two plant densities, it stands out that the Ultra variety showed highly significant positive differences compared to the untreated variant in all four variants treated with biostimulants at the density of 45.000 plants/ha, and at the density of 53.000 plants/ha, highly significant positive differences were recorded for the variants treated with Genaktis 1, Irys, and Number One (Table 10).

Regarding Ultra variety in 2024 (Table 10), the highest tuber yield at the density of 45.000 plants/ha was obtained in the variant treated with Irys (26.8 t/ha), compared to the control variant (24.3 t/ha). At a density of 53.000 plants/ha, the yield ranged between 25.6 t/ha (for control variant) and 28.4 t/ha for the variant treated with Terram Number One. Among the tested biostimulators, only Wuxal Macromix registered differences very significant compared to control at both plant densities. Genaktis 1 determined distinct significant differences at density of 45.000 plants/ha and very significant differences at density of 53.000 plants/ha. Iris determined very significant differences at density of 45.000 plants/ha and distinct significant differences at density of 53.000 plants/ha. Terram Number One determined no significant differences at density of 45.000 plants/ha and very significant differences at density of 53.000 plants/ha.

Analysing the two planting densities, it can be observed that the tuber yield was higher at the density of 53.000 plants/ha than those obtained at density of 45.000 plants/ha in both experimental years (Table 10).

Regarding Darilena variety in 2023 (Table 11) and at the density of 45.000 plants/ha, the tuber yield ranged between 26.1 t/ha for the untreated variant and 29.4 t/ha for the variant treated with Irys.

At the density of 53.000 plants/ha, the tuber yield ranged between 26.1 t/ha and 29.8 t/ha for the variant treated with Wuxal Macromix. Following the statistical analysis, very significant positive differences compared to the untreated variant at the two analysed densities were found in the variants treated with Genaktis 1 and Wuxal Macromix. The variant treated with Irys determined a difference very significant compared to control at density of 45.000 plants/ha and a difference distinct significant at density of 53.000 plants/ha. The variant treated with Terram Number One determined a difference significant compared to control at density of 45.000 plants/ha and a difference very significant at density of 53.000 plants/ha.

Table 10. Tuber yield at Ultra cv. (2023-2024)

Experimental variant	Plant density of 45.000 pl/ha			Plant density of 53.000 pl/ha		
	Aver.	Dif.	Sign.	Aver.	Dif.	Sign.
Tuber yield (t/ha) – 21.09.2023						
Control	40.3	-	-	42.5	-	-
Genaktis 1	43.8	3.45	***	46.1	3.58	***
Irys	44.4	4.05	***	45.0	2.49	***
Terram Number One	44.2	3.91	***	47.8	5.28	***
Wuxal Macromix	46.4	6.05	***	43.1	0.64	ns
Average	*43.8*	*3.5*	-	*44.9*	*2.4*	-
	DL5% 0.67 DL1% 0.90 DL0.1% 1.18			DL5% 0.84 DL1% 1.13 DL0.1% 1.48		
Tuber yield (t/ha) – 20.09.2024						
Control	24.3	-	-	25.6	-	-
Genaktis 1	25.9	1.57	**	27.4	1.87	***
Irys	26.8	2.43	***	27.2	1.63	***
Terram Number One	25.3	0.92	ns	28.4	2.81	***
Wuxal Macromix	26.6	2.23	***	28.0	2.45	***
Average	*25.8*	*1.5*	-	*27.3*	*1.7*	-
	DL5% 1.08 DL1% 1.44 DL0.1% 1.89			DL5% 0.83 DL1% 1.11 DL0.1% 1.45		

In 2024, the control variant presented a yield of 15.5 t/ha, while the variant treated with Wuxal Macromix (17.8 t/ha) had the highest yield at the density of 45.000 plants/ha (Table 11). At the density of 53.000 plants/ha, the yield was 16.1 t/ha for the control variant, with the highest yield of 18.6 t/ha for the variant treated with Wuxal Macromix. Following the statistical analysis, the variants treated with Irys and Wuxal Macromix recorded very significant positive differences compared to control at both plant densities.

According to potato variety, plant density and climatic conditions of the year, the yield increase determined by using of biostimulator products compared to control variant (with no biostimulator) varied between 0.64 and 6.5 t/ha (Tables 10 and 11). It has to be underlined that yield increase determined by using biostimulators was higher in the better climatic conditions of the year 2023 than in the drought year 2024 (Tables 10 and 11). Also, yield increase determined by using biostimulators was higher at the density of 53.000 plants/ha except the average tuber yield obtained at Ultra variety in 2023 (Tables 10 and 11).

Table 11. Total yield Darilena cv. (2023-2024)

Experimental variant	Plant density of 45.000 pl/ha			Plant density of 53.000 pl/ha		
	Aver.	Dif.	Sign.	Aver.	Dif.	Sign.
Tuber yield (t/ha) – 21.09.2023						
Control	26.1	-	-	26.1	-	-
Genaktis 1	28.6	2.49	***	28.3	2.20	***
Irys	29.4	3.28	***	27.6	1.50	**
Terram Number One	27.1	0.97	*	28.4	2.25	***
Wuxal Macromix	28.5	2.39	***	29.8	3.71	***
Average	*27.9*	*1.8*	-	*28.0*	*1.9*	-
	DL5% 0.90 DL1% 1.20 DL0.1% 1.58			DL5% 1.01 DL1% 1.35 DL0.1% 1.77		
Tuber yield (t/ha) – 20.09.2024						
Control	15.5	-	-	16.1	-	-
Genaktis 1	16.4	0.87	ns	17.6	1.56	*
Irys	17.5	1.94	***	18.4	2.31	**
Terram Number One	16.2	0.65	ns	16.8	0.79	ns
Wuxal Macromix	17.8	2.26	***	18.6	2.50	**
Average	*16.7*	*1.2*	-	*17.5*	*1.4*	-
	DL5% 1.02 DL1% 1.37 DL0.1% 1.80			DL5% 1.43 DL1% 1.91 DL0.1% 2.51		

The tuber yields obtained in the experimental field in 2024 were much lower compared to 2023 (Figure 1). An important cause of lower production in 2024 is the deficit of water in the soil during the growth of plants and tubers and the uneven distribution of precipitation during the vegetation period.

As average values for the whole experiment obtained in the experimental variants treated with biostimulators, all the used biostimulator products determined increases of tuber yield compared to control variant varying from 2.2 to 2.79 t/ha (Figure 1). Also as average values, the tuber yields were higher at density of 53.000 plants/ha, and Ultra variety proved to be superior to Darilena variety (Figure 1).

CONCLUSIONS

The better climatic conditions of the year 2023, with moderate thermo-hydric stress make the potato plants to be more vigorous which leaded to higher tuber yields, regardless of variety and plant density, compared to the year 2024 when the potato crop experienced severe drought.

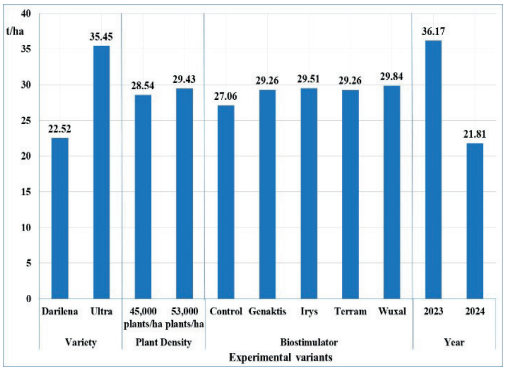

Figure 1. Average values of the tuber yield for the experimental variants

It is obvious that stem number is influenced by cultivars and potato tubers size, but all the used biostimulator products determined an increased number of stems per hill compared to control (untreated) variant. Also, all the used biostimulator products determined an increased aerial part weight compared to control variant.
By using biostimulator products, the tuber yield increased compared to control regardless the potato variety, plant density and climatic conditions of the year, the yield increase varying between 0.64 and 6.5 t/ha. The yield increase determined by using biostimulators is higher in better climatic conditions and at higher plant density. Having all these into account, the inclusion of the biostimulators in the potato crop technology can be considered a good strategy.

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