Scientific Papers. Series A. Agronomy, Vol. LXVII, No. 1, 2024
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

THE DYNAMICS OF THE HEIGHT IN MAIZE HYBRIDS IN DIFFERENTIATED FERTILIZATION AND TREATMENT CONDITIONS WITH THE BIOSTIMULATOR UTRISHA, ON THE CHERNOZEM FROM CARACAL

Alex Emanuel PRIVANTU[1], Emilia CONSTANTINESCU[2], Gabriela PĂUNESCU[3], Aurel Liviu OLARU[2]

[1]University of Craiova, Doctoral School of Animal and Plant Resources Engineering (IRAV), 13 A.I. Cuza Street, Craiova, Romania
[2]University of Craiova, Faculty of Agronomy, Department of Agricultural and Forestry Technologies, 13 A.I. Cuza Street, Craiova, Romania
[3]University of Craiova, SCDA Caracal, 106 Vasile Alecsandri Street, Caracal, Romania

Corresponding author email: emiliaconst2000@yahoo.com

Abstract

A trifactorial trail hybrid maize x level fertilization x biostimulants treatment (Instinct and Utrisha) was placed on the chernozem from Caracal in the spring of 2023. The doses of urea administered at sowing were 50, 100, 150 kg/ha, and the graduations of the biostimulator treatment factor consisted of untreated, Instinct 1 L/ha + Utrisha 250 g/ha, Instinct 1.7 L/ha + Utrisha 333 g/ha and Instinct 2.5 L/ha + Utrisha 400 g/ha. The greatest plats height was recorded in the first two weeks in the variant treated with Instinct 2.5 L/ha + Utrisha 400 g/ha, regardless of the maize hybrid and the dose of urea used - 182%. In the next measurement interval, the height decreased, but the highest value was also recorded in the previous variant and with the recommended dose - 47%. At the last measurement, the height was greatly diminished (under 20%) and the variants treated with Instinct and Utrisha, regardless of the dose, did not emphasized significant differences. Urea fertilization did not affect the plants height at any of the measurement moments.

Key words*: hybrid, corn, waist dynamics, biostimulator, chernozem.*

INTRODUCTION

Specialists estimate that the human population will reach 9.8 billion by 2050, which will consequently require at least a doubling of current agricultural production (Porfirio et al., 2018). Combining conventional plant breeding techniques with molecular bioengineering is one of the most modern methods to ensure global food security (De Souza, 2022[a]; 2022b). Following improvement programs, new grains varieties and hybrids with performance characteristics were created and selected (Paunescu et al., 2016; 2021; 2023).

The increase in demand for food, including plant origin, stimulates activities aimed at improving the productivity and quality characteristics of the crops obtained. Maize (*Zea mays* L.) is one such plant, which, along with wheat and rice, is one of the three most important crops in the world due to its many uses in food, feed, raw materials industrial and bioenergy (Maitra and Singh, 2021; Ranum et al., 2014; Shah et al., 2016). It can be appreciated that maize is the most versatile cereal crop in terms of its adaptability, types and uses.

The main producers of corn are the United States, Brazil and China, where corn production in the US is almost six times higher than in the European Union (Krzyzanowski, 2016).

Modern agriculture tends to minimize the use of mineral fertilizers and chemical plant protection products, which are replaced by preparations of natural origin (Kapela et al., 2020). This group of preparations includes biostimulants that have, one of the main tasks, alleviation of stress (Yakhin et al., 2017; Kapela et al., 2020).

Plant biostimulants are substances that can improve the productivity and quality of crops, they can increase soil nutrient availability, improve plant nutrient use efficiency, and promote soil organic matter decomposition and humification. Recently, biostimulants have

become widely used in traditional crop production because they can improve plant productivity and quality and meet the economic and sustainability requirements of production (Caradonia et al., 2019). Biostimulants have attracted the attention of maize growers due to their effectiveness in promoting morphological, physiological and biochemical processes in crops (Del Buono et al., 2021). In addition, the use of biostimulants can also significantly reduce the cost of fertilizers, which reduces the environmental impact of agricultural technologies (Puglia et al., 2021). It is likely that the use of urease inhibitors and biological preparations will allow more efficient use of nitrogen fertilizers to achieve optimal maize grain yields. The implementation of optimal fertilization technologies must include the right source of nutrients, the right dose, the right time and place of release (Rosculete et al., 2023). Such an approach can increase crop nitrogen use efficiency and reduce N_2O emissions (Snyder et al., 2009). From an agroecological perspective, high N_2O emissions from maize crops are due to discrepancies between nitrogen content and demand, as fertilizers are usually applied well in advance of rapid plant growth (Sawyer et al., 2006).

The major challenge for agriculture in the coming decades will be the sustainable production of enough food crops to meet ever-increasing global demand (Emmanuel and Babalola, 2020). Current agricultural systems rely heavily on the continuous application of mineral inputs, including mineral fertilizers, mainly nitrogen (N), phosphorus (P) and potassium (K), which contribute to increased yields but also lead to decreased biological fertility terrestrial. This overdependence results in several problems in soil, plant and human health through negative consequences on food quality, soil health, atmosphere and water (Igiehon and Babalola, 2017). As a result, in recent years there has been an emphasis on reducing agricultural systems with high input input and on intensifying research to develop sustainable and ecological alternatives for food production. In this context, Corteva Agriscience launched in Europe Utrisha™ N, the biostimulator with a role in improving nutrition, as part of the portfolio of biological products, thus contributing to the fulfillment of the more sustainable demand for plant protection products. The product is available for a wide range of crops, including field crops, vegetables, orchards, vines (https://www.corteva.ro/noutati).

MATERIALS AND METHODS

Utrisha™ N is an alternative source of nitrogen that can provide vegetative plants with additional nitrogen to facilitate their growth. This innovative technology delivers value through the efficiency of integrated nutrition management under natural field conditions, adapting to plant growth needs and sustainably contributing to maximizing yield potential.

A three-factor hybrid corn x urea fertilization level x treatment with Instinct and Utrisha biostimulators was placed on the Caracal chernozem in the spring of 2023. The corn hybrids used (factor A) were: P9944, P0260 and P0450. The P9944 hybrid from the FAO 360 category is of Dual type (grain or silage) and lends itself to all crop areas. Hybrid P0260 is a semi-late hybrid from the FAO 430 group, with extraordinary production potential, recommended for areas in the south and west of the country. The P0450 hybrid from the FAO 450 category is a semi-late hybrid, with exceptional tolerance to drought and heat, recommended for the south and west of the country. The doses of urea administered in the spring at sowing (factor B) were: 50, 100, 150 kg/ha s.a., and the graduations of factor C (treatment with the Utrisha biostimulator in combination with Instinct) consisted of the variants: untreated, Instinct 1 L/ ha + Utrisha 250 g/ha, Instinct 1.7 L/ha + Utrisha 333 g/ha (recommended dose) and Instinct 2.5 L/ha + Utrisha 400 g/ha. In order to quantify the development of the vegetative mass related to the studied factors, the dynamics of the waist was performed at an interval of two weeks and at the end, on the dates of 14.06, 29.06, 13.07 and 31.08.2023. The height was determined using the previously stated data for the same 5 plants/plot. Averages were performed, and data were statistically interpreted according to the split-plot design of trifactorial experiments.

Climatic conditions were favorable for corn cultivation but the experience was located in the irrigated system.

RESULTS AND DISCUSSIONS

From the interpretation of the interaction A x B x C (hybrid x level of fertilization with urea x treatment with Utrisha) the following resulted (Table 1):

- In the first hybrid, regardless of the amount of urea administered, the height of the plant at the first measurement is influenced with statistical assurance by the treatment with Utrisha at any of the doses tested, after which, dynamically, the influence remains only at the dose of Instinct 1 L/ha + Utrisha 250 g/ha – lower dose than recommended. The fact that at the recommended dose (Instinct 1.7 L/ha + Utrisha 333 g/ha) and at the increased dose (Instinct 2.5 L/ha + Utrisha 400 g/ha), the waist is not significantly influenced in relation to the untreated variant, suggests that the biostimulator treatment in this hybrid does not lead to an increase in plant height;
- In the second hybrid, there is a significant increase in waist but only at the level of fertilization with urea 50 kg s.a/ha at the reduced dose of Utrisha;
- In the third hybrid, regardless of the amount of urea administered, the height of the plant in dynamics is greater with statistical assurance when treated with the dose of Instinct 1 L/ha + Utrisha 250 g/ha – lower dose than the recommended one, and as the amount of urea increases, even at the recommended dose.

In conclusion, the biostimulation by treatment with Instinct 1.7 L/ha + Utrisha 333 g/ha, from the point of view of increasing the waistline, has an effect only on the hybrid P0450 on a background of urea 100 kg/ha s.a. and urea 150 kg/ha s.a., at the recommended dose and at the increased dose of Utrisha treatment. Also, the results suggest that the analyzed interaction quite influences the waist in its dynamics.

In the same table (Table 1) the hybrid x fertilization level interaction was also analyzed. The results categorically showed its lack of influence on the waistline. So in each of the hybrids, regardless of the fact that the dose of urea was increased to 100 and 150 kg s.a./ha, the waist did not change dynamically compared to the dose of 50 kg s.a./ha.

Table 1. Results regarding the A x B x C interaction (hybrid x level of fertilization with urea x treatment with Utrisha)

Factor A	Factor B	Factor C	Waist (cm) at the date :							
Hybrid	Fertilization	Treatment Utrisha	14.06.2023		29.06.2023		13.07.2023		31.08.2023	
a1	b1	c1- Untreated	**69.1**	Mt	**167.3**	mt	**245.2**	mt	**284.5**	mt
P9944	urea 50 kg s.a./ha	c2-I 1 L/ha + U 250 g/ha	**59.5**	-9.6^{oo}	**155.0**	-12.3	**219.7**	-25.5^{oo}	**266.9**	-17.6^{oo}
		c3-I 1.7 L/ha + U 333 g/ha	**62.8**	-6.3	**157.0**	-10.3	**230.7**	-14.5		-5.2
		c4-I 2.5 L/ha + U 400 g/ha	**57.5**	-11.6^{oo}	**164.7**	-2.6	**234.9**	-10.3	**278.0**	-6.5
			62.2	**Mt**	**161.0**	**mt**	**232.7**	**mt**	**277.2**	**mt**
	b2	c1- Untreated	**70.7**	Mt	**167.6**	mt	**244.1**	mt	**282.5**	mt
	urea 100 kg s.a./ha	c2-I 1 L/ha + U 250 g/ha	**60.3**	-10.4^{oo}	**153.4**	-14.2	**223.7**	-20.4^{o}	**265.1**	-17.4^{oo}
		c3-I 1.7 L/ha + U 333 g/ha	**63.1**	-7.6^{o}	**158.6**	-9.0	**233.5**	-10.6	**273.7**	-8.8
		c4-I 2.5 L/ha + U 400 g/ha	**59.1**	-11.6o^{o}	**159.5**	-8.1	**231.9**	-12.2	**274.3**	-8.2
			63.3	**1.1**	**159.8**	**-1.2**	**233.3**	**0.6**	**273.9**	**-3.3**
	b3	c1- Untreated	**69.5**	Mt	**170.3**	mt	**239.7**	mt	**278.5**	mt
	urea 150 kg s.a./ha	c2-I 1 L/ha + U 250 g/ha	**62.3**	-7.2^{o}	**152.1**	-18.2^{o}	**224.1**	-15.6^{o}	**261.2**	-17.3^{oo}
		c3-I 1.7 L/ha + U 333 g/ha	**60.6**	-8.9^{o}	**159.6**	-10.7	**230.0**	-9.7	**273.3**	-5.2
		c4-I 2.5 L/ha + U 400 g/ha	**56.0**	-13.5^{ooo}	**156.9**	-13.4	**234.7**	-5.0	**287.1**	8.6
			62.1	**-0.1**	**159.7**	**-1.3**	**232.1**	**-0.6**	**275.1**	**-2.1**
a2	b1	c1- Untreated	**62.7**	mt	**157.4**	mt	**220.3**	mt	**247.7**	mt
P0260	urea 50 kg s.a./ha	c2-I 1 L/ha + U 250 g/ha	**60.7**	-2.0	**166.1**	8.7	**237.0**	16.7*	**260.2**	12.5*
		c3-I 1.7 L/ha + U 333 g/ha	**55.5**	-7.2^{o}	**142.1**	-15.3	**212.9**	-7.4	**245.7**	-2.0

		c4-I 2.5 L/ha + U 400 g/ha	**54.9**	-7.8°	**154.9**	-2.5	**218.7**	-1.6	**250.0**	2.3
			58.5	**mt**	**155.1**	**mt**	**222.2**	**mt**	**250.9**	**mt**
	b2	c1- Untreated	**62.4**	mt	**154.1**	mt	**223.9**	mt	**253.5**	mt
	urea 100 kg s.a./ha	c2-I1 L/ha + U 250 g/ha	**62.8**	0.4	**167.0**	12.9	**237.3**	13.4	**262.4**	8.9
		c3-I 1.7 L/ha + U 333 g/ha	**54.7**	-7.7°	**142.6**	-11.5	**214.1**	-9.8	**243.5**	-10.0
		c4-I 2.5 L/ha + U 400 g/ha	**54.2**	-8.2°	**155.6**	1.5	**230.1**	6.2	**251.3**	-2.2
			58.5	**0**	**154.8**	**-0.3**	**226.4**	**4.2**	**252.7**	**1.8**
	b3	c1- Untreated	**60.4**	mt	**160.1**	mt	**229.5**	mt	**253.6**	mt
	urea 150 kg s.a./ha	c2-I1 L/ha + U 250 g/ha	**60.0**	-0.4	**160.9**	0.8	**237.3**	7.8	**255.5**	1.9
		c3-I 1.7 L/ha + U 333 g/ha	**57.7**	-2.7	**149.9**	-10.2	**223.9**	-5.6	**251.7**	-1.9
		c4-I 2.5 L/ha + U 400 g/ha	**54.9**	-5.5	**155.6**	-4.5	**227.4**	-2.1	**255.7**	2.1
			58.3	**-0.2**	**156.6**	**1.5**	**229.6**	**7.4**	**254.1**	**3.2**
a3	b1	c1- Untreated	**56.9**	mt	**155.1**	mt	**213.7**	mt	**249.0**	mt
P0450	urea 50 kg s.a./ha	c2-I1 L/ha + U 250 g/ha	**61.9**	5.0	**168.3**	13.2	**232.3**	18.6*	**263.0**	14.0*
		c3-I 1.7 L/ha + U 333 g/ha	**57.1**	0.2	**148.9**	-6.2	**223.8**	10.1	**252.7**	3.7
		c4-I 2.5 L/ha + U 400 g/ha	**48.7**	-8.2°	**137.5**	-17.6	**205.3**	-8.4	**246.3**	-2.7
			56.1	**mt**	**152.5**	**mt**	**218.8**	**mt**	**252.8**	**mt**
	b2	c1- Untreated	**59.0**	mt	**149.2**	mt	**211.7**	mt	**251.3**	mt
	urea 100 kg s.a./ha	c2-I1 L/ha + U 250 g/ha	**61.7**	0.0	**166.3**	0.0	**241.1**	29.4***	**252.5**	1.2
		c3-I 1.7 L/ha + U 333 g/ha	**59.8**	-1.9	**158.8**	-7.5	**231.4**	19.7*	**260.1**	8.8
		c4-I 2.5 L/ha + U 400 g/ha	**47.9**	-13.8°°°	**139.4**	-26.9°	**209.0**	-2.7	**248.7**	-2.6
			57.1	**1.0**	**153.4**	**0.9**	**223.3**	**4.5**	**253.2**	**0.4**
	b3	c1- Untreated	**53.5**	mt	**142.5**	mt	**207.1**	mt	**246.7**	mt
	urea 150 kg s.a./ha	c2-I1 L/ha + U 250 g/ha	**64.3**	10.8**	**170.0**	27.5*	**239.7**	32.6***	**260.8**	14.1*
		c3-I 1.7 L/ha + U 333 g/ha	**59.3**	5.8	**159.6**	17.1	**230.0**	22.9**	**255.7**	9.0
		c4-I 2.5 L/ha + U 400 g/ha	**49.5**	-4.0	**139.9**	-2.6	**212.3**	5.2	**247.7**	1.0
			56.7	**0.6**	**153.0**	**0.5**	**222.3**	**3.5**	**252.7**	**-0.1**

Between two averages of the C factor at the same averages of the A and B factors	DL 5%		7		18.2		15.5	11.4
	DL 1%		9.3		24.4		20.6	15.3
	DL 0.1%		12.1		31.7		26.8	19.9
Between two averages of factor B to the same average of factor A	DL 5%		3.1		6.5		8.1	7.9
	DL 1%		4.4		9.1		11.4	11.1
	DL 0.1%		6.2		12.8		16.1	15.6

With regard to the percentage increase in the waist only according to the biostimulator treatment (Table 2), the results obtained showed that the largest increase in the waist in the first two weeks after the first measurement was presented by the variant treated with Instinct 2.5 L/ha + Utrisha 400 g/ha, regardless of the hybrid and the dose of urea used - 182%. In the next measurement interval, waist growth decreased, but the highest value was also recorded in the previous version but also in the one with the recommended dose - 47%.

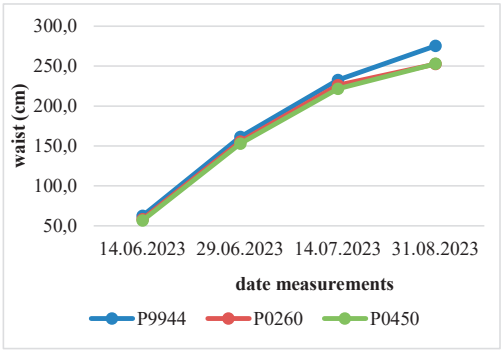
Table 2. Correlation coefficients according to species and year of testing

Factor C	Date of measurements				Growing (%)		
	14.06 (M1)	29.06 (M2)	13.07 (M3)	31.08 (M4)	M1/M2	M1/M3	M1/M4
C1	62.7	158.2	226.1	266.5	253	143	118
C2	61.5	163.3	232.5	260.8	266	142	112
C3	58.9	153.0	225.6	259.5	260	147	115
C4	53.7	151.6	222.7	259.9	282	147	117

At the last measurement, the growth was much reduced (below 20%) and the variants treated with Utrisha, regardless of the dose, did not differ. Urea fertilization did not influence waist at any of its measurement times.

The results suggest that urea and the biostimulant have little influence on plant development during the growing season under Caracal conditions.

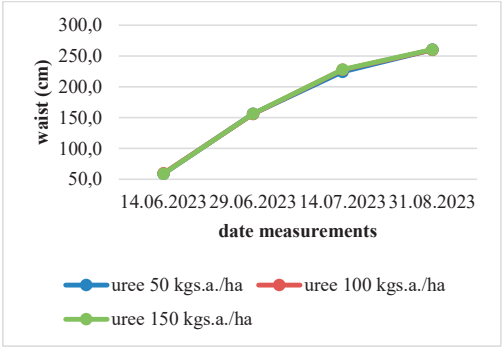
From the analysis of the influence of the hybrid on the waist (Figure 1 and the attached table), it was observed dynamically that the waist of the P0260 and P0450 hybrids is smaller, statistically assured, in relation to the P9944 hybrid. This difference can be explained by the influence of the genetic structure of the tested hybrids, the technological conditions being identical for each of them.



Hybrid	14.06. 2023	29.06. 2023	13.07. 2023	31.08. 2023
P9944 (mt)	62.5	161.4	232.7	275.4
P0260	58.4^{oo}	155.5^{o}	226.0^{o}	252.6^{oo}
P0450	56.6^{ooo}	153.0^{oo}	221.5^{oo}	252.9^{oo}
DL 5%	1.4 cm	5 cm	6.7 cm	11.2 cm
DL 1%	2.3 cm	8.3 cm	11.1 cm	18.5 cm
DL 0.5%	4.3 cm	15.7 cm	20.9 cm	34.7 cm

Figure 1. Results regarding the influence of the hybrid on waistline

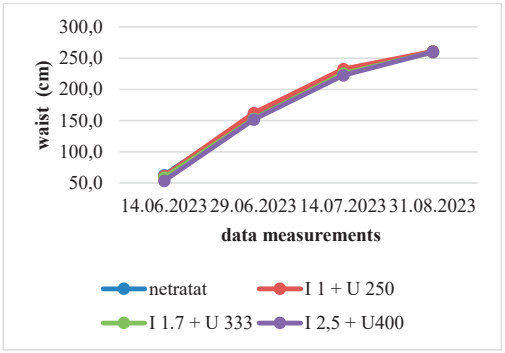
From the analysis of the influence of the level of fertilization on the waist (Figure 2 and the attached table), regardless of the hybrid and the treatment with biostimulator, it was observed that the waist is not influenced by the level of nitrogen at any of the doses. The explanation lies in the fact that the soil from Caracal - chernozem, is a soil rich in micro and macro elements that ensure a favorable development for corn plants. However, when the influence of nitrogen dose on yield was studied, it was influenced.



Fertilization	14.06. 2023	29.06. 2023	13.07. 2023	31.08. 2023
urea 50 kg s.a./ha (mt)	58.9	156.2	224.5	260.3
urea 100 kg s.a./ha	59.6	156.0	227.7	259.9
urea 150 kg s.a./ha	59.0	156.5	228.0	260.6
DL 5%	1.8 cm	3.7 cm	4.7 cm	4.6 cm
DL 1%	2.5 cm	5.2 cm	6.6 cm	6.4 cm
DL 0.5%	3.6 cm	7.4 cm	9.3 cm	9 cm

Figure 2. Results regarding the influence of fertilization level on waistline

The influence of Utrisha treatment on waistline is more unstable. While the recommended dose and the increased one, in the first phases of vegetation, delays the growth of the plant in height, in one month the plant rises significantly at the dose of Instinct 1 L/ha + Utrisha 250 g/ha (Figure 3 and the attached table). The study must be deepened in order to highlight the influence of temperature at the time of application, which seems to be closely related to nitrogen fixation.



Fertilization	14.06. 2023	29.06. 2023	13.07. 2023	31.08. 2023
Untreated (mt)	62.7	158.2	226.1	260.8
I 1 + U 250	61.5	162.1	232.5*	260.8
I 1.7 + U 333	58.9°°	153.0	225.6	259.5
I 2.5 + U400	53.7°°°	151.6°	222.7	259.9
DL 5%	2.3 cm	6.1 cm	5.2 cm	3.8 cm
DL 1%	3.1 cm	8.1 cm	6.9 cm	5.1 cm
DL 0.5%	4 cm	10.6 cm	9 cm	6.6 cm

Figure 3. Results regarding the influence of Utrisha treatment on waistline

The increase in the global demand for cereals is based on the ability to make unique food products and the increase in their consumption along with industrialization and westernization (Bonciu et al., 2021; Dihoru et al., 2023; Maitra and Singh, 2021; Roșculete et al., 2021). Results from the literature show that biostimulants increase plant resistance to different types of abiotic stress, the ability to cope with adverse conditions and the maintenance of productivity (Panfili et al., 2019). Also, biostimulants can improve the ability of maize plants to use and absorb nutrients, improve their growth and positively affect the quality of the final product (Rouphael et al., 2020).

Experiments with Utrisha were also carried out in Missouri (USA) by Steinkamp et al (2023). Experiments were arranged in randomized blocks with six replications. There was no significant interaction between years and treatments for late June leaf chlorophyll and yield. Leaf chlorophyll increased with increasing nitrogen dose. All biological N management treatments had leaf chlorophyll content values similar to urea at 100 lbs n AC-1. The number of plants at harvest were 32,150 to 34,640 plants. All treatments had similar or higher plant numbers than the untreated control (Steinkamp et al., 2023).

A summary of symbiotic products in N-fixation in the northern USA was recently synthesized by Franzen et al. (2023). In corn trials conducted in North Dakota, Minnesota, Illinois, Indiana, Missouri and Michigan, Envita significantly increased yield in 1 of 12 trials compared to the same rate of nitrogen applied alone. In North Dakota, Missouri, Michigan, Kentucky, and Ohio, Utrisha had no effect on corn grain yield compared to nitrogen application in eleven different trials. Finally, ProveN or ProveN 40 applied in furrow or as a seed treatment significantly increased yield in 1 of 26 corn trials in Minnesota, Illinois, Missouri, Kansas, Michigan, and Nebraska compared with the same N rate (Franzen et al., 2023).

At Absaraka, corn yield increased in one treatment by 120 pounds N/acre. Yields with the Utrisha and Envita treatments were not greater than corn yields fertilized with the rates of 0 N per acre or 80 pounds N/acre without the additive (Franzen et al., 2023).

CONCLUSIONS

The results suggest that fertilization and treatment with biostimulants have little influence on plant development during the growing season under Caracal conditions. However, the results suggest that the interaction of hybrid x urea fertilization level x Utrisha treatment greatly influences the waistline in its dynamics.

Biostimulation by treatment with Instinct 1.7 l/ha + Utrisha 333 g/ha, from the point of view of increasing the waistline, has an effect only on the hybrid P0450 on a background of urea 100 kg/ha s.a. and urea 150 kg/ha s.a., at the recommended dose and at the increased dose of Utrisha treatment.

REFERENCES

Bonciu, E., Păunescu, R.A., Roșculete, E., Florea, D. (2021). The variability of some characters and their correlations with the yield of an extensive assortment of autumn wheat varieties, tested on the chernozem from ARDS Caracal. *Annals of the University of Craiova - Agriculture, Montanology, Cadastre Series, 51*(1): 244-260.

Caradonia, F., Caradonia, V., Battaglia, L., Righi, G., Pascali, A. (2019). La Torre Plant biostimulant regulatory framework: Prospects in Europe and

current situation at international level. *J. Plant Growth Regul. 38*, 438-448.

Corteva Agriscience launches Utrisha™ N nutrition-enhancing biostimulator in Europe. Available at: https://www.corteva.ro/noutati/comunicate, accessed on 4.02.2024.

Del Buono, D., Regni, L., Del Pino, A.M., Bartucca, M.L., Palmerini, C.A., Proietti, P. (2021). Effects of megafol on the olive cultivar 'Arbequina' grown under severe saline stress in terms of physiological traits, oxidative stress, antioxidant defenses, and cyto-solic Ca2+. *Front. Plant Sci. 11*, 2188.

De Souza, C.P., Bonciu, E. (2022a). Progress in genomics and biotechnology, the key to ensuring food security. *Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development*, *22*(1): 149-157.

De Souza, C.P., Bonciu, E. (2022b). Use of molecular markers in plant bioengineering. *Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, 22*(1): 159-166.

Dihoru, E.D., Bonciu, E., Păunescu, G., Roşculete, C.A., Păunescu, R.A., Roşculete, E. (2023). The wheat plant ideotype and its specific morphological and physiological traits - a brief overview. *Annals of the University of Craiova-Agriculture, Montanology, Cadastre Series, 53*(1): 83-90.

Emmanuel O.C., Babalola O.O. (2020). Productivity and Quality of Horticultural Crops Through Co-Inoculation of *Arbuscular Mycorrhizal* Fungi and Plant Growth Promoting Bacteria. *Microbiol. Res. 239*, 126569.

Franzen, D., Camberato, J., Kaiser, D., Nelson, K., Singh, G., Ruiz-Diaz D., Lenyz, E., Steinke, K., Grove, J., Ritchey, E., Bortolon, L., Rosen, C., Maharjan, B., Thompson, L. (2023). Performance of Selected Commercially Available Asymbiotic N-fixing Products in the North Central Region. *NDSU Extension, april 2023*, https://www.ndsu.edu.

Igiehon N.O., Babalola O.O. (2017). Biofertilizers and Sustainable Agriculture: Exploring Arbuscular Mycorrhizal Fungi. *Appl. Microbiol. Biotechnol 101*, 4871–4881.

Kapela, K, Sikorska, A., Niewęgłowski, M., Krasnodębska, E., Zarzecka, K., Gugała. M. (2020). The Impact of Nitrogen Fertilization and the Use of Biostimulants on the Yield of Two Maize Varieties (*Zea mays* L.) Cultivated for Grain. *Agronomy 10*, 9, 1408.

Krzyżanowski, J. (2016). Prospects and threats for eu agriculture and consumers resulting from the potential TTIP agreement. *Probl. Agric. Econ. 3*, 3-23.

Maitra, S., Singh, V. (2021). Invited review on 'maize in the 21st century' Emerging trends of maize biorefineries in the 21st century: scientific and technological advancements in biofuel and bio-sustainable market. *Journal of Cereal Science, 101*, 103272.

Panfili, I., Bartucca, M.L., Marrollo, G., Povero, G., del Buono, D. (2019). Application of a plant biostimulant to improve maize (*Zea mays*) tolerance to metolachlor. *Journal of Agricultural and Food Chemistry, 67*, 12164–12171.

Paunescu, R.A., Bonciu, E., Rosculete, E., Paunescu, G., Rosculete, C.A. (2023). The Effect of Different Cropping Systems on Yield, Quality, Productivity Elements, and Morphological Characters in Wheat (Triticum aestivum). *Plants, 12*, 2802.

Paunescu R.A., Bonciu E., Rosculete E., Paunescu G., Rosculete C.A., Babeanu C. (2021). The Variability for the Biochemical Indicators at the Winter Wheat Assortment and Identifying the Sources with a High Antioxidant Activity. *Plants, 10*(11): 2443.

Paunescu, A., Babeanu, C., Dodocioiu, A.M., Paunescu, G., Buzatu, G.D. (2016). Antioxidant enzyme activities and proline content in maize plants under PEG-induced water stress. *International Multidisciplinary Scientific GeoConference: SGEM, 1*: 413-419.

Porfirio, L.L., Newth, D., Finnigan, J.J., Cai, Y. (2018). Economic shifts in agricultural production and trade due to climate change. *Palgrave Commun 4*, 111.

Puglia, D., Pezzolla, D., Gigliotti, G., Torre, L., Bartucca, M., Del Buono, D. (2021). The Opportunity of Valorizing Agricultural Waste, Through Its Conversion into Biostimulants, Biofertilizers, and Biopolymers. *Sustainability, 13*, 2710.

Ranum P., Peña-Rosas J.P., Garcia-Casal M.N. (2014). Global maize production, utilization, and consumption. *Ann. New York Acad. Sci., 1312* (1), 105–112.

Rosculete, C.A., Paunescu, R.A., Rosculete, E., Paunescu G., Florea D., Bonciu E. (2023). The influence of foliar fertilizer application on the macro and micro nutrient content and yield of wheat plants (*Triticum aestivum*). *Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, 23*(3): 786-795.

Roşculete, E., Păunescu, R.A., Bonciu, E., Roşculete, C.A., Voicea, I. (2021). Where are the foreign wheat cultivars in competition with the romanian cultivars? -Experiments on the chernozem from Caracal in the period 2019-2021. *Annals of the University of Craiova - Agriculture, Montanology, Cadastre Series, 51*(1): 144-158.

Rouphael, Y., Lucini, L., Miras-Moreno, B., Colla, G., Bonini, P., Cardarelli, M. (2020). Metabolomic responses of maize shoots and roots elicited by combinatorial seed treatments with microbial and non-microbial biostimulants. *Frontiers in Microbiology, 11*, 1–13.

Sawyer, J., Nafziger, E., Randall, G., Bundy, L., Rehm, G., Joern, B. (2006). Concepts and Rationale for Regional Nitrogen Rate Guidelines for Corn. *Iowa State University-University Extension: Ames*, IA, 6-24.

Shah, T.R., Prasad, K., Kumar, P. (2016). Maize-A potential source of human nutrition and health: A review. *Cogent Food Agric., 2*, 1166995.

Snyder, C., Bruulsema, T., Jensen, T., Fixen, P. (2009). Review of greenhouse gas emissions from crop production systems and fertilizer management effects. *Agric. Ecosyst. Environ. 133*, 247-266.

Steinkamp, D.J., Nelson, K.A., Singh, G. (2023). Corn response to asymbiotic nitrogen fixation products in Upstate Missouri. *Field Day Annual Report*. https://extension.missouri.edu/media/wysiwyg/Extensiondata/Pub/pdf/specialb/sr0605.pdf

Yakhin, O.I., Lubyanov, A.A., Yakhin, I.A., Brown, P.H. (2017). Biostimulants in plant science: A global perspective. *Front. Plant Sci., 7*, 2049.