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EFFECTS OF DIFFERENT FOLIAR TREATMENTS AT MAIZE CROP

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Abstract

Foliar treatments are an important tool to enhance productivity of the maize plants and their ability to support stress factors, especially in the present when climate change has become the biggest global challenge to agriculture and food production. These treatments can be done with foliar fertilizers, biostimulator products or by using fungicide products with a stay-green effect on maize plants. Starting from these realities, the aim of this paper is to present the effect of different foliar treatments (foliar fertilisers, biostimulator products and the fungicide Retengo with the stay green effect) on maize under the specific growing conditions from South Romania. In this respect, field research was performed in the specific growing conditions of South Romania (44°12`55``N, 26°51`51``E) under rainfed conditions in the years 2022 and 2023. The experimental variants were represented by two foliar fertilizers (Microfert-U and Kingfol Zn), two biostimulator products (Terra Sorb and Atonik), and one fungicide (Rentengo) with a stay-green effect. The obtained results brought attention to the positive effects of fungicide Retengo as a fungicide with AgCelence effect to the maize grain yield. Among the tested biostimulators and foliar fertilizers, the highest grain yield were obtained when there was applied the biostimulator Atonik and the foliar fertilizer Kingfol Zn, Atonik being more effective in the less favourable climatic conditions and Kingfol Zn in the more favourable climatic conditions.

Key words: *maize, grain, yield, plant height, foliar fertilizer, biostimulator, stay green effect.*

INTRODUCTION

Maize is an important grain forage and food crop, this being of strategic importance for agriculture (Stoyanov & Kuneva, 2024). Due to its production potential, the highest among cereals (Ion et al., 2015), it is known worldwide as the queen of cereals (Tajamul et al., 2016). Together with wheat, maize represents the most important cereals in the world (Soare et al., 2018).

The great variety of genotypes and the high ecological plasticity in maize made it possible to cultivate maize in very varied conditions in terms of soil, climate, and relief conditions (Kusmec et al., 2018).

Maize responds favourably to various levels of agricultural technologies, both in subsistence conditions and in conditions of high-performance technologies (Gouse, 2012; Lana et al., 2018). Maize requires a specific crop technology, within which an important role is played by fertilization (Băşa et al., 2016; Ştefan et al., 2018). In fact, fertilization is a key component of any crop production system and it is one of the technological elements where improvement is always searched (Haraga & Ion, 2023).

Usually fertilization consists in applying nutrients to soil, this method being the most effective for nutrients required by plants in high amounts. But, foliar fertilization of crops can complement soil fertilization, this being an important crop management strategy in maximizing crop yields (Fageria et al., 2009). In this respect, most studies revealed a positive impact of foliar fertilization (Luţă et al., 2022).

In the present, in order to achieve high yields, cultivated plants cannot always get enough microelements from the soil, therefore the importance of foliar fertilization increased (Jakab et al., 2016). Nutrient uptake through leaf stomata is faster compared to root absorption, making it an efficient approach to promptly rectify plant nutrient deficiencies (Asare et al., 2023).

Foliar fertilization determines a great number of positive effects in the plant, principally at physiological level (respiration and photosynthesis), at morphological level, (root length and leaf area index), and upon the yield of various crops (Tejada & Gonzalez, 2003;

Tejada et al., 2016). Foliar application of fertilizers improves the absorption of nutrients that are immobile and difficult for plant root absorption, thus reducing the plant deficiency symptoms, and it can be used as a remedy for drought affecting maize at the vegetative stage to maximize yield (Asare et al., 2023).

Nowadays, more farmers use different bacterium preparations in nutrient supply of arable crops, which can improve the nutrient supply of plant (Jakab-Gábor et al., 2007). Also, foliar application of specific organic matters has demonstrated to be a powerful tool for stimulating the plant to a more intense but balanced vegetative development (Gheorghe et al., 2014). Biostimulants are increasingly being integrated into production systems with the goal of modifying physiological processes in plants to optimize productivity (Yakhin et al., 2017).

The aim of this paper is to present the effect of different foliar treatments (foliar fertilisers, biostimulator products and the fungicide Retengo with the stay green effect) on maize under the specific growing conditions from South Romania.

MATERIALS AND METHODS

Research was performed in field experiments located in South Romania, respectively at Agribest Mânăstirea Farm (44°12`55``N latitude, 26°51`51`` E longitude), in the area of Mânăstirea commune, Călărași county. The field experiments were performed under rainfed conditions in the years 2022 and 2023. The soil is a chernozem cambic with a humus content of 3.29% and a pH of 6.4.

The preceding crop was winter wheat in both experimental years.

Tillage consisted in a disc harrowing passage performed after harvesting the winter wheat, followed in October by ploughing at 25 cm depth. The seedbed preparation was done one day before sowing.

Fertilization was performed with 222.2 kg of DAP (18:46:0) complex fertilizer, which was applied at sowing to ensure a quantity of 40 kg/ha of nitrogen and 102.2 kg/ha of phosphorus (P_2O_5). In the growth stage of 6 leaves of maize plants, there was applied 200 kg/ha of Ammonium Nitrate (NH_4NO_3) with 33.5% nitrogen content, which means a nitrogen rate of 67 kg/ha. So, the total applied nitrogen rate was of 107 kg/ha.

Sowing was performed in first decade of April in both experimental years. The sowing density was of 70,000 germinal seeds/ha, the row spacing was 70 cm and the sowing depth was of 7 cm. The maize hybrid used into the experiments was KWS Kasmir from FAO group 370.

Weed control was performed by two herbicides. First herbicide was Adengo (Isoxaflutole 225 g/l + Thiencarbazone-methyl 90 g/l + Cyprosulfamide (safener) 150 g/l) applied immediately after sowing in a rate of 0.35 l/ha, and the second herbicide was Arigo (Nicosulfuron 12% + Rimsulfuron 3% + Mesotrione 36%) applied in a rate of 330 g/ha in the growing stage of maize plants of 6 leaves.

The field experiments were based on the method of subdivided plots into 3 replications. The experimental factor was the foliar treatment which the following graduations:

- Without foliar treatment – Control variant;
- Microfert-U;
- Kingfol-ZN;
- Terra Sorb Complex;
- Atonik;
- Retengo.

Microfert-U is a foliar fertilizer containing 90 g/l N, 30 g/l P_2O_5, 30 g/l K_2O, 12 g/l S, 0.5 g/l B, 0.3 g/l Mn, 0.5 g/l Zn, 0.25 g/l Cu, 0.15 g/l Mg, 0.2 g/l Fe. This product was applied in a rate of 5 l/ha in the growth stage of 6 leaves of the maize plants.

Kingfol Zn is a suspension liquid foliar fertilizer with a highly concentrated single element (70% Zn) designed to correct zinc deficiency. This product was applied in a rate of 0.5 l/ha in the growth stage of 6 leaves of the maize plants.

Terra-Sorb Complex is a biostimulator product based on L-α-amino acid from enzymatic hydrolysis, designed for foliar spray. The product has a high concentration of free amino acids (20%), a nitrogen content of 5.5%, magnesium content of 0.8% MgO, and a full and balanced proportion of micronutrients (1.5% B, 1% Fe, 0.1% Mn, 0.1% Zn, 0.001% Zn). This product was applied in a rate of 3 l/ha

in the growth stage of 7 leaves of the maize plants.
Atonik is a plant growth regulator and biostimulator based on three nitrophenolates (3 g/l sodium p-nitrophenolate, 2 g/l sodium o-nitrophenolate, 1 g/l sodium 5-nitroguaiacolate), naturally occurring compounds in plant cells. This product was applied in a rate of 0.6 l/ha in the growth stage of 6 leaves of the maize plants.
Retengo® is a high-performance fungicide based on Pyraclostrobin (200 g/l), with AgCelence® effects, which improves the production and quality of maize crops. Due to the stay green effect, it reduces senescence and premature ripening of plants. This product was applied in a rate of 1 l/ha in the growth stage of 7 leaves of the maize plants.
Practically, the experiment included 2 foliar fertilizers, 2 biostimulator products and 1 fungicide with the effect of stay green.
Each experimental variant consisted in 12 lines of maize plants at 70 cm between rows, which means 8.4 m, with a length of 10 m along rows for each experimental variant.
In the present paper, there are presented the results regarding plant height and grain yield reported at moisture content of 14%.
The mean average temperature recorded for the period March-September in the year 2022 was of 17.8ºC, while for the same period in the year 2023, it was of 18.6ºC (Table 1).
The sum of rainfall recorded for the period March-September in the year 2022 was of 281.7 mm in the year 2022, while for the same period in the year 2023, it was of 238.4 mm (Table 1).
Comparing the two experimental years from a climatic point of view, one can conclude that the year 2023 was warmer and drier than the year 2022.

Table 1. Climatic conditions during maize plant's vegetative period at Mânăstirea, Călărași county, Romania

Month	Temperature (ºC)		Rainfall (mm)	
	2022	2023	2022	2023
March	3.7	8.3	15.8	7
April	11.9	10.8	68.8	25.6
May	17.7	16.2	31.9	97
June	22.3	21.6	69.2	52.8
July	25.1	25.9	17.3	14.2
August	25.1	25.7	13.5	30.7
September	18.6	21.4	65.2	11.1
Average/Sum	***17.8***	***18.6***	***281.7***	***238.4***

RESULTS AND DISCUSSIONS

The used foliar treatments, either foliar fertilizer or biostimulator or fungicide with the effect of stay green, they had strong impact on the vegetative growth of the maize plants. Regarding the maize plant height, comparing to control variant, all the treatments determined very significant differences in both experimental years except in 2023 for the product Microfert-U which determined a distinct significant difference compared to control (Table 2).
The highest height plant in 2022 were obtained in the case of the products Atonik and Kingfol Zn with 228 cm. In the year 2023, the highest height plant was registered in the case of the fungicide Retengo (222 cm), which is interesting because this product determined in the previous year (2022) the smallest plant height among the tested products. This means that in the conditions of high temperatures and low rainfall which characterised the year 2023 the fungicide Retengo with the stay green effect had the most important effect upon the vegetative growth of the maize plants, respectively on the plant height. In the better climatic conditions of 2022 compared to 2023, the most important effect upon the vegetative growth of the maize plants determined the biostimulator Atonik and the foliar fertilizer Kingfol Zn.
The foliar fertilizer Microfert-U determined the smallest value of the plant height in 2023 (210 cm) and one of the smallest value in 2022 (222.6 cm), this coming after the product Retengo.

As limits of variation, the maize plants had a height between 186 cm in the unfertilized version from the year 2023 and 228 cm in the case of Atonik biostimulator in the year 2022.

The less favourable climatic conditions of the year 2023 determined a smaller average plant height for the entire experiment (210.8 cm) compared to 2022 (218.6 cm).

Table 2. Maize plant height at different foliar treatments under different climatic conditions in South Romania

Foliar treatment	Plant height in 2022			Plant height in 2023		
	Plant height (cm)	Differences to control		Plant height (cm)	Differences to control	
		cm	%		cm	%
Untreated	187.0	Control	-	186.0	Control	-
Microfert-U	222.6	35.6 ***	19.0	210.0	24.0 **	12.9
Kingfol Zn	228.0	41.0 ***	21.9	214.7	28.7 ***	15.4
Terra Sorb Complex	224.3	37.3 ***	19.9	214.6	28.6 ***	15.4
Atonik	228.0	41.0 ***	21.9	217.6	31.6 ***	17.0
Retengo	222.0	35.0 ***	18.7	222.0	36.0 ***	19.4
	$LSD_{5\%}$ = 14.61 cm $LSD_{1\%}$ = 20.18 cm $LSD_{0.1\%}$ = 28.95 cm			$LSD_{5\%}$ = 14.36 cm $LSD_{5\%}$ = 20.13 cm $LSD_{5\%}$ = 28.46 cm		

If in the case of the maize plant height all the treatments determined differences statistically significant compared to control variant, in the case of maize grain yield in 2022 only the fungicide Retengo determined differences distinct significant compared to control variant (Table 3). In the year 2023, the fungicide Retengo determined differences very significant compared to control variant, and the biostimulator Atonik determined differences distinct significant and the biostimulator Terra Sorb Complex and the foliar fertilizer Kingfol Zn determined significant differences.

Compared to control variant, the fungicide Retengo determined the highest differences of 1441 kg/ha (14.6%) in the year 2022 and of 665 kg/ha (14.8%) in the year 2023. So, the highest grain yields were obtained in both experimental years in the condition of South Romania using Retengo as a fungicide with AgCelence effect, respectively 11,332 kg/ha in 2022 and 5,125 kg/ha in 2023.

Among the tested biostimulators and foliar fertilizers, as in the case of plant height, the highest grain yield were obtained when there was applied the biostimulator Atonik and the foliar fertilizer Kingfol Zn, Atonik being more effective in 2023 and Kingfol Zn in 2022.

In both experimental years, the smallest grain yield differences not statistically significant compared to control were obtained in the case of using the foliar fertilizer Microfert-U (459 kg/ha in 2022, respectively 158 kg in 2003).

The grain yields obtained in 2023 are much lower than those obtained in 2022, the year 2023 being warmer and drier not only than 2022 but also than the last decade in the experimented region. Thus, the average grain yield for the experiment was of 10,509 kg/ha in 2022 and of 4,785 kg/ha in 2023. The average grain yield obtained in 2023 represent less than half of those obtained in 2022, respectively 45.5%.

Table 3. Maize grain yields at different foliar treatments under different climatic conditions in South Romania

Foliar treatment	Grain yield in 2022			Grain yield in 2023		
	Grain yield (kg/ha)	Differences to control		Grain yield (kg/ha)	Differences to control	
		kg	%		kg	%
Untreated	9891	Control	-	4487	Control	-
Microfert-U	10350	459	4.6	4645	158	3.5
Kingfol Zn	10570	679	6.9	4798	311 *	6.9
Terra Sorb Complex	10400	509	5.1	4762	275 *	6.1
Atonik	10515	624	6.3	4866	379 **	8.4
Retengo	11332	1441 **	14.6	5152	665 ***	14.8
	$LSD_{5\%}$ = 778.05 kg/ha $LSD_{1\%}$ = 1090.84 kg/ha $LSD_{0.1\%}$ = 1541.82 kg/ha			$LSD_{5\%}$ = 258.73 kg/ha $LSD_{5\%}$ = 362.75 kg/ha $LSD_{5\%}$ = 512.71 kg/ha		

Despite the significant differences compared to control variant concerning the maize plant height obtained by applying the foliar treatments (very significant differences in both experimental years except in 2023 for the product Microfert-U which determined distinct significant differences), the differences obtained in the case of grain yield by applying foliar treatments were not so strong. The increased of plant height determined by applying different foliar products has correlated positively with the obtained grain yield, but this was a weak correlation (Figure 1).

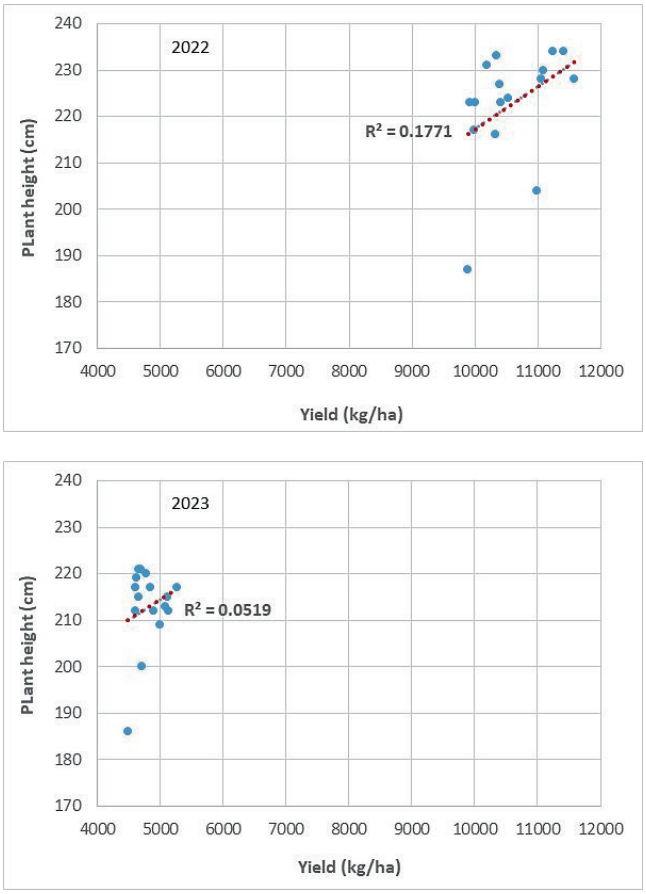

Figure 1. Correlation of the maize grain yield with the plant height

CONCLUSIONS

Following the research carried out under the specific conditions of South Romania, in the conditions of high temperatures and low rainfall the fungicide Retengo with the stay green effect had the most important effect upon the vegetative growth of the maize plants, respectively on the plant height. In better climatic conditions, the most important effect upon the vegetative growth of the maize plants determined the biostimulator Atonik and the foliar fertilizer Kingfol Zn.

The highest grain yields were obtained regardless of the climatic condition by using Retengo as a fungicide with AgCelence effect, respectively with the stay green effect. Among the tested biostimulators and foliar fertilizers, the highest grain yield were obtained when there was applied the biostimulator Atonik and the foliar fertilizer Kingfol Zn, Atonik being more effective in the less favourable climatic

conditions and Kingfol Zn in the more favourable climatic conditions.

The increased of plant height determined by applying different foliar products has correlated positively with the obtained grain yield, but this was a weak correlation.

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