

SURVEY ON INCREASING RATES OF THE HERBICIDE STRATOS ULTRA (100 G/L CYCLOXYDIM) ON YIELD AND GRAIN QUALITY OF DUO SYSTEM MAIZE HYBRIDS

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Abstract

The Duo System technology in maize is extensively used in agricultural practice. It is characterized by the cultivation of cycloxydim-tolerant hybrids, while the herbicide ensures efficient control of monocotyledonous weed species, which may compromise grain yields and quality. Overall, the selectivity of the herbicide primarily depends on the application rate but the hybrids differ in their tolerance levels. A research for evaluating the effects of increasing rates of Stratos Ultra was conducted in the experimental field of the Agricultural University Plovdiv, Bulgaria. Three Duo System hybrids were grown - Zanetixx DUO, Hexxagone DUO, and Elaraxx DUO. Each hybrid was treated five increasing herbicidal rates ranging from 1.00 to 5.00 L ha⁻¹. The obtained results were compared to Untreated (Earthed-up) control. After harvesting, yields and grain quality parameters such as moisture, 1000 grain weight, hectoliter seed mass, protein, oil and starch content were estimated. Due to the increased rates of 4.00 and 5.00 L ha⁻¹ of Stratos Ultra and the reported herbicide phytotoxicity significant decrease in grain yields and its quality was recorded.

Key words: maize, tolerance, cycloxydim, yields, quality.

INTRODUCTION

The area under maize cultivation is increasing significantly, with expectations that it will be the most widely grown crop in the next decade (Erenstein et al., 2022). Advances in maize genetics and good agronomic practices in its cultivation are inextricably linked, and in order to obtain sustainable production, they need to complement each other. This is also one of the main reasons why in recent years, numerous research centers, private investors, and companies have funded and promoted research to improve the genetic characteristics of maize, citing calculations that genetic improvement increases annual maize production by over 50% (Nuccio et al., 2021). One major limitation in maize production is the challenge of weed infestation (Ali et al., 2011; Rai et al., 2018). Maize, as a representative of cereal crops, contains the enzyme acetyl-CoA carboxylase, which makes it highly susceptible to graminicides (Gengenbach et al., 1990). This is the main reason why monocotyledonous weeds significantly reduce yields in fields where weed infestation is high. So far, integrated crop protection has proven to be the most effective

approach for weed control. The use of herbicides, mechanical methods, and biological weed control are essential for increasing the yield potential of maize fields. Herbicide-tolerant crops are compatible with the principles of integrated pest management and, when combined with appropriate weed control measures, can provide sustainable long-term benefits (Knezevic et al., 2003). Duo System is a maize production system based on herbicide-tolerant hybrids. This technology allows treatment against narrow-leaved weeds to be performed using herbicides to which the cultivated hybrids are tolerant. Few studies have addressed the issue of both cycloxydim efficacy and hybrids' tolerance level. Landes et al. (1996) reported excellent selectivity for maize at twice the recommended maximum dose for controlling grass weeds. Pferdmenges et al. (2010) reported studies in which DUO System technology plants were treated with the herbicide Focus Ultra. The results show excellent selectivity of the herbicide even under adverse weather conditions for crop development. A 17% increase in yield was reported for hybrids treated with Focus Ultra compared to the yields

obtained after application of sulfonylureas. Vancetovic et al. (2009) indicate that accomplishment of maize hybrids resistance to cycloxydim at rates up to 4.00 l ha⁻¹ is possible by “the introduction of just one CTM allele (heterozygote) into a single cross maize hybrid”.

According to Szel et al. (2010), cycloxydim-tolerant maize yields are affected by weather conditions during the growing season. This is evidenced by the results of a two-year trial of hybrids treated with cycloxydim. In the first year, yields were higher compared to those in the second year. This is explained by the significantly wetter conditions at the time of treatment with the herbicide in the second year, which may have increased the absorption of the active substance and had a negative effect.

In 2020, Hristova et al. (2021) conducted a field trial with the CT maize hybrid “Blazon Duo” in an experimental field of the Agricultural University - Plovdiv. The efficacy of the herbicide product Starane Gold (100 g/l fluroxypyr + 1 g/l florasulam) was evaluated at increasing rates (1.20, 1.80 and 2.40 l ha⁻¹). The highest efficacy against broadleaf weeds was found at doses of 1.80 and 2.40 l ha⁻¹, but phytotoxic symptoms were assessed for the higher rate. Simultaneously with the decrease in the density of broadleaf weeds, a significant increase in the values of the studied traits such as plant height and number of ears per plant was observed. The absolute and hectoliter seed mass, as well as grain yields, were highest in the treatments with rates of 1.20 and 1.80 l ha⁻¹. During the period 2012-2014 Delchev and Barakova (2016) conducted an experiment with a maize hybrid from the DUO System technology - Ultrafox Duo, treating the plants with various soil-applied and post-emergence herbicides, as well as combinations between them. Analysis of the data collected over the three-year experiment shows that the highest grain yield was obtained from the combination of the soil herbicide Merlin Flex, the herbicide Kalam and Focus Ultra. The technology successfully controlled the perennial grass weeds *Agropyrum repens* (L.) and *Cynodon dactylon* (L.) Pers, as well as all broad-leaved weeds within the boundaries of the experimental field.

Malidža et al. (2020) conducted an experiment by growing cycloxydim-tolerant maize integrated with beans in order to enlarge the monocotyledons weeds control potential. The possibility to use cycloxydim in system with other herbicides results in efficacy over 90% against *S. halepense* from rhizomes.

In Iran, Annabestani et al. (2020) carry out a trial in order to establish effective weed management program. The study showed that treatments with low rates of cycloxydim (75-150 g ha⁻¹) come out with analogous results compared with herbicide treatments including nicosulfuron, foramsulfuron, eradicane, and 2,4-D + MCPA. Nevertheless, increasing the rates of cycloxydim sprayed brings about adequate control of perennial grass weeds without any significant yield reduction.

In practice, the cultivation of herbicide-tolerant crops is widely used and the further improvement of these technologies is important for a number of aspects of agriculture - obtaining high crop yields at lower production costs, environmentally friendly production and a sustainable solution to the weed problem in the future. Trials conducted with hybrids of Duo System technology to date have primarily focused on assessing the weed control efficacy of cycloxydim herbicides, with some experiments using multiple application rates. However, data regarding the effects of increasing rates of cycloxydim on primary compounds of maize grain such as oil, starch and protein (Guo et al., 2013) are insufficient. For practical purposes, more information is needed on whether Duo System hybrids combine high productivity with herbicide tolerance (Simic et al., 2013).

The purpose of the present study is to evaluate the influence of increasing application rates of cycloxydim on the grain yield and quality of three Duo System maize hybrids.

MATERIALS AND METHODS

In 2024 and 2025, a field trial was conducted in the research plot of the Department of “Agriculture and Herbology” at the Agricultural University of Plovdiv, Bulgaria (Latitude 42°7'58"N, Longitude 24°48'19"E). The experimental field underwent soil cultivation and a combination of

fertilizers (500 kg ha⁻¹ N:P:K (15%-15%-15%) + 7% SO₃ + Zn (Borealis – L.A.T Company, Austria) was used. The evaluated hybrids (Zanetixx DUO, Hexxagone DUO and Elaraxx DUO) were planted in the latter part of April with a seeding rate 60 000 seeds per ha⁻¹, marking the beginning of the cultivation period. The experiment was conducted using a randomized complete block design, with each plot measuring 20 m². Stratos Ultra (100 g/l cycloxydim) was sprayed in phenophase 3rd-5th leaves. For broadleaved weeds management a treatment with Casper (50 g/kg prosulfuron + 500 g/kg dicamba) inter-rows only was done. There were no other pesticides used for pests or diseases management. Six experimental variants for every hybrid were included in the study: 1. Untreated control; 2. Stratos Ultra - 1.00 L ha⁻¹; 3. Stratos Ultra - 2.00 L ha⁻¹; 4. Stratos Ultra - 3.00 L ha⁻¹; 5. Stratos Ultra - 4.00 L ha⁻¹; 6. Stratos Ultra - 5.00 L ha⁻¹. Manual harvesting was performed. Moisture content (%) and hectoliter weight (kg hL⁻¹) were determined using a Wile 200 grain moisture meter. In order to monitor grain quality measuring of 1000 grain weight was done. Estimation of crude protein content according to Kjeldahl / Total nitrogen (%),

BDS EN ISO 17025/2006; starch content according to Evers (%), BDS EN ISO 17025/2006 and oil content was done. Statistical analysis of the data was performed using Duncan's Multiple Range Test with SPSS, considering differences significant at a p-value of less than 0.05.

RESULTS AND DISCUSSIONS

A number of studies have been conducted to determine the effects of herbicides on the growth and development of crops and their subsequent yields. However, there is limited information in the scientific literature on their effects on grain quality parameters (Wilkinson & Hardcastle, 1972).

Variations in grain moisture content strongly influence the analysis of machine performance during harvest and post-harvest operations (Mousaviraad et al., 2020).

In order to determine whether there are statistically significant differences in grain moisture content due to increasing rates of cycloxydim mean comparisons were performed using Duncan's multiple range test at $p \leq 0.05$ (Table 1).

Table 1. Grain moisture, %

Year of the experiment	Hybrids	Variants					
		1.Untreated control	2.Stratos Ultra – 1 L ha ⁻¹	3.Stratos Ultra – 2 L ha ⁻¹	4.Stratos Ultra – 3 L ha ⁻¹	5.Stratos Ultra – 4 L ha ⁻¹	6.Stratos Ultra – 5 L ha ⁻¹
2024	Zanetixx DUO	12.46 a	12.40 a	12.60 a	12.70 a	12.23 a	12.06 a
	Hexxagone DUO	13.20 a	12.70 ab	12.43 b	12.53 b	12.76 ab	12.60 b
	Elaraxx DUO	12.83 c	13.53 a	13.11 ab	12.86 c	12.96 bc	12.96 bc
2025	Zanetixx DUO	12.63 a	12.80 a	12.80 a	12.90 a	12.96 a	13.06 a
	Hexxagone DUO	13.66 a	13.46 a	13.63 a	13.66 a	13.16 a	13.43 a
	Elaraxx DUO	13.96 a	13.70 a	13.93 a	13.90 a	13.46 a	13.90 a
Average for the period	Zanetixx DUO	12.54	12.60	12.70	12.80	12.59	12.56
	Hexxagone DUO	13.43	13.08	13.03	13.09	12.96	13.01
	Elaraxx DUO	13.39	13.61	13.52	13.38	13.21	13.43

Means followed by different letters are significantly different according to Duncan's multiple range test at $p \leq 0.05$.

Table 1 shows the grain moisture content (%) for the individual treatments of the three hybrids, calculated as the mean of three replications for each treatment. No statistically significant differences in grain moisture content were found for the individual variants of any of the hybrids in the second experimental year. It is necessary to store the maize at a humidity lower than 14%. Maize grain is not a significant source of proteins, and

their content in maize hybrids is a quality indicator that is influenced by numerous external factors, including the application of herbicides (Gołębiowska & Rola, 2010). The qualitative analysis of the production during the two experimental years shows that the percentage of crude protein in the grains decreases in direct proportion to the increase in the dose of the herbicide Stratos Ultra, and this is valid for all three hybrids. Statistically

significant differences are found between the first four variants and variants 5 and 6, in which the values for this indicator are significantly lower. The highest crude protein content was measured in 2025 in the Untreated control of the hybrid Elaraxx DUO - 17.77.

Variant 6 exhibited the lowest mean values over the two-year experimental period, and for the three hybrids the percentage decrease compared to the untreated control is as follows - Zanetixx DUO - 9.34%, Hexxagone DUO - 10.25% and Elaraxx DUO - 8.52% (Table 2).

Table 2. Crude protein content, % in grain

Year of the experiment	Hybrids	Variants					
		1.Untreated control	2.Stratos Ultra – 1 L ha ⁻¹	3.Stratos Ultra – 2 L ha ⁻¹	4.Stratos Ultra – 3 L ha ⁻¹	5.Stratos Ultra – 4 L ha ⁻¹	6.Stratos Ultra – 5 L ha ⁻¹
2024	Zanetixx DUO	16.62 a	16.20 b	16.11 b	15.67 c	15.41 d	14.75 e
	Hexxagone DUO	16.02 a	16.06 a	15.97 a	15.69 b	14.84 c	14.34 d
	Elaraxx DUO	16.95 a	16.87 a	16.54 b	16.21 c	15.83 d	15.66 e
2025	Zanetixx DUO	17.20 a	17.51 a	1675 b	16.60 b	16.12 c	15.91 c
	Hexxagone DUO	17.13 a	17.08 a	16.72 ab	16.35 bc	16.07 c	15.41 d
	Elaraxx DUO	17.77 a	17.46 ab	17.21 bc	16.93 c	16.44 d	16.10 d
Average for the period	Zanetixx DUO	16.91	16.85	16.43	16.13	15.76	15.33
	Hexxagone DUO	16.58	16.57	16.34	16.02	15.45	14.88
	Elaraxx DUO	17.36	17.16	16.88	16.57	16.14	15.88

Means followed by different letters are significantly different according to Duncan’s multiple range test at p ≤ 0.05.

Sugars in plants are stored mainly in the form of starch (Wang et. al., 2023). It is produced as a result of photosynthesis in plants. Despite its tolerance to a particular herbicide, when treating the hybrids with rates higher than the maximum accepted, the production of assimilates during photosynthesis may be reduced. Based on the analysis conducted, in 2024 this indicator decreased most significantly in the Elaraxx DUO hybrid, due to the higher rates applied in variants 5 and 6 of the experiment. In the Hexxagone DUO hybrid, a decrease was also reported, while in the Zanetixx DUO hybrid, the difference in the values of starch in the grains between the

variants was insignificant, although statistically proven according to Duncan's test. However, in the second experimental year, the starch content in the grain decreased significantly as a result of the treatment with increasing rates, with the lowest values measured in variant 6 in all three hybrids. The Elaraxx DUO hybrid showed the highest grain starch content, with the maximum value for the entire experimental period (63.08%) observed in the untreated control. Compared to the variant without treatment, in variant 6 the starch decreased by 4.89%, 4.34% and 8.53% in the Zanetixx DUO, Hexxagone DUO and Elaraxx DUO hybrids, respectively (Table 3).

Table 3. Starch content, % in grain

Year of the experiment	Hybrids	Variants					
		1.Untreated control	2.Stratos Ultra – 1 L ha ⁻¹	3.Stratos Ultra – 2 L ha ⁻¹	4.Stratos Ultra – 3 L ha ⁻¹	5.Stratos Ultra – 4 L ha ⁻¹	6.Stratos Ultra – 5 L ha ⁻¹
2024	Zanetixx DUO	59.81 a	59.69 b	59.64 b	59.62 b	59.51 c	59.3 d
	Hexxagone DUO	60.18 b	60.67 a	60.59 a	59.45 c	59.41 c	58.35 d
	Elaraxx DUO	62.65 a	62.28 b	62.12 c	61.42 d	59.45 e	58.30 f
2025	Zanetixx DUO	61.13 b	62.69 a	60.42 bc	59.54 c	57.87 d	55.80 e
	Hexxagone DUO	61.82 b	61.51 a	60.67 a	59.15 b	58.93 b	58.36 b
	Elaraxx DUO	63.08 a	62.22 ab	62.71 ab	61.20 b	59.15 c	56.71 d
Average for the period	Zanetixx DUO	60.47	61.19	60.03	59.58	58.69	57.51
	Hexxagone DUO	61.00	61.09	60.63	59.30	58.90	58.35
	Elaraxx DUO	62.86	62.25	62.41	61.31	59.30	57.50

Means followed by different letters are significantly different according to Duncan’s multiple range test at p ≤ 0.05.

The oil content in the maize grain is of great importance as an indicator of the nutritional

quality of the product. As a result of the use of herbicides, changes can occur in both the oil

content and its qualitative composition (Wilkinson & Hardcastle, 1973). In their experiment, Guo et al. (2013) reported that treatment with the herbicide atrazine at the maximum recommended rates led to changes in the fatty acid composition of maize oil. However, no significant effect was observed on the total oil content. These findings suggest that, while herbicide application may alter the qualitative profile of maize oil, the overall quantity of oil remains largely unaffected. As it

is a major representative of the group of ACCase inhibitors - a key enzyme for the synthesis of fatty acids in plants, treatment with cycloxydim can negatively affect lipid synthesis, which can affect the formation of membranes and plant growth. In the present study, a significant decrease in oil content was found as a result of increasing rates of herbicide application. The tolerance of the hybrids is lower in variants 5 and 6, which is evident from the results (Table 4).

Table 4. Oil content, % in grain

Year of the experiment	Hybrids	Variants					
		1.Untreated control	2.Stratos Ultra – 1 L ha ⁻¹	3.Stratos Ultra – 2 L ha ⁻¹	4.Stratos Ultra – 3 L ha ⁻¹	5.Stratos Ultra – 4 L ha ⁻¹	6.Stratos Ultra – 5 L ha ⁻¹
2024	Zanetixx DUO	5.03 a	4.96 a	4.86 ab	4.74 b	4.50 c	4.30 d
	Hexxagone DUO	4.12 a	4.07 ab	3.96 b	3.78 c	3.58 d	3.24 e
	Elaraxx DUO	4.12 a	4.11 a	3.99 ab	3.88 b	3.65 c	3.34 d
2025	Zanetixx DUO	4.81 a	4.71 b	4.59 c	4.46 d	4.34 e	4.17 f
	Hexxagone DUO	3.81 a	3.70 b	3.35 c	3.24 d	3.14 e	2.92 f
	Elaraxx DUO	3.85 a	3.79 ab	3.69 b	3.53 c	3.44 c	3.16 d
Average for the period	Zanetixx DUO	4.92	4.84	4.72	4.60	4.42	4.23
	Hexxagone DUO	3.97	3.88	3.66	3.51	3.36	3.08
	Elaraxx DUO	3.99	3.95	3.84	3.71	3.50	3.25

Means followed by different letters are significantly different according to Duncan's multiple range test at $p \leq 0.05$

Grain oil content reached its highest value in the untreated control of the Zanetixx DUO hybrid in 2024 - 5.03%, while the lowest value was observed in variant 6 of the Hexxagone DUO hybrid in 2025 - 2.92%. The highest average values for the indicator are recorded in the Zanetixx DUO hybrid, as in all variants, the oil content exceeds 4%. Thousand-seed weight is an important indicator of seed size and overall seed quality. The highest value during

the experimental period was registered in 2024 in the variant without treatment of the hybrid Hexxagone DUO – 336.68g. The value of this indicator largely characterizes the studied hybrids, but can be significantly influenced by the crop management system and other external factors (Petrov, 2013). The analysis shows that the value of this indicator is significantly influenced by the increase in the rate of herbicide application (Table 5).

Table 5. Thousand-seed grain weight, g

Year of the experiment	Hybrids	Variants					
		1.Untreated control	2.Stratos Ultra – 1 L ha ⁻¹	3.Stratos Ultra – 2 L ha ⁻¹	4.Stratos Ultra – 3 L ha ⁻¹	5.Stratos Ultra – 4 L ha ⁻¹	6.Stratos Ultra – 5 L ha ⁻¹
2024	Zanetixx DUO	308.36 a	319.28 a	317.82 a	278.81 ab	256.57 b	213.22 ab
	Hexxagone DUO	336.68 a	314.54 ab	289.80 bc	277.09 c	264.61 d	232.66 cd
	Elaraxx DUO	280.92 ab	318.78 a	324.46 a	299.60 a	282.64 ab	217.42 b
2025	Zanetixx DUO	320.06 a	296.86 ab	281.38 bc	280.86 bc	291.70 ab	249.13 c
	Hexxagone DUO	326.17 a	320.30 a	322.79 a	321.30 a	302.17 b	298.44 b
	Elaraxx DUO	325.62 a	318.42 ab	317.34 ab	309.28 ab	290.25 b	285.75 b
Average for the period	Zanetixx DUO	314.21	308.07	299.60	279.83	274.13	231.17
	Hexxagone DUO	331.42	317.42	306.29	299.19	283.39	265.55
	Elaraxx DUO	303.27	318.60	320.90	304.44	286.44	251.58

Means followed by different letters are significantly different according to Duncan's multiple range test at $p \leq 0.05$.

A significant decrease in the thousand-seed grain weight is clearly observed in variants 5 and 6, treated with the highest rates. However,

in the second growing year, the noted decrease in these variants is relatively small. According to the Duncan test ($p < 0.05$), statistically

significant differences were found between the untreated control and variant 6.

The most severely affected when applying the maximum rate was this indicator in the Zanetixx DUO hybrid, for which a reduction of 31% was reported in 2024, and 22% in 2025, compared to the untreated control. In 2024, the values of the indicator in the Hexxagone DUO and Elaraxx DUO decreased by 31% and 23%, respectively, and by 9 and 12% in 2025.

According to the average values obtained for the two experimental years, as a result of the application of the herbicide Stratos Ultra at a rate of 5 L ha⁻¹ (var. 6), the thousand-seed grain weight parameter decreased most significantly in the Zanetixx DUO hybrid by 26.43%, followed by Hexxagone DUO - 19.88% and Elaraxx DUO - 17.04%.

The hectoliter weight of the grain is an important quality parameter assessed in the grain trade.

A slight variation in the values of this indicator is reported when analyzing the average values for the two experimental years. The decrease in the hectoliter weight in variant 6 compared to the untreated control is only 1.62% for Zanetixx DUO, 2.00% and 0.92% for Hexxagone DUO and Elaraxx DUO. No statistically significant differences were found among the values obtained for this parameter during the second experimental year, as determined by Duncan's multiple range test. Although differences were observed during the first year of the trial, it cannot be concluded that the treatment with Stratos Ultra had an effect on this parameter (Table 6).

Table 6. Hectoliter weight (kg hL⁻¹)

Year of the experiment	Hybrids	Variants					
		1.Untreated control	2.Stratos Ultra – 1 L ha ⁻¹	3.Stratos Ultra – 2 L ha ⁻¹	4.Stratos Ultra – 3 L ha ⁻¹	5.Stratos Ultra – 4 L ha ⁻¹	6.Stratos Ultra – 5 L ha ⁻¹
2024	Zanetixx DUO	79,5 ab	82,1 a	79,43 ab	79,06 ab	78,1 b	77,2 b
	Hexxagone DUO	79,63 ab	79,83 a	79,40 ab	78,5 b	79,02 b	78,43 ab
	Elaraxx DUO	75,73 a	76,53 a	75,90 a	74,13 b	75,93 a	73,46 b
2025	Zanetixx DUO	77,30 a	77,66 a	78,06 a	77,60 a	77,60 a	77,06 a
	Hexxagone DUO	77,90 a	78,46 a	78,23 a	77,96 a	77,63 a	77,90 a
	Elaraxx DUO	75,03 a	75,20 a	75,36 a	75,33 a	75,83 a	75,93 a
Average for the period	Zanetixx DUO	78,40	79,88	78,74	78,33	77,85	77,13
	Hexxagone DUO	79,76	79,14	78,81	78,23	78,32	78,16
	Elaraxx DUO	75,38	75,86	75,63	74,73	75,88	74,69

Means followed by different letters are significantly different according to Duncan's multiple range test at $p \leq 0.05$.

Under conditions of severe weed infestation, herbicide application has been shown to significantly improve crop productivity (Stoimenova et. al., 2004; Mahmood and Swenton, 2005; Zhelyazkov, 2007; Tonev et al., 2010; Stoyanova et al., 2021).

The results obtained for this parameter largely support this statement., as well as the results of biometric measurements, although this has not been statistically proven.

In the first experimental year for the Zanetixx DUO hybrid, the highest yield was obtained with variant 3 - 1103.02 kg/da, at an application rate of 200 ml/da of Stratos Ultra, reporting an increase of 16%.

In the Hexxagone DUO hybrid, the highest yield was obtained from the plants from the untreated control - 1144.96 kg/da, and in the Elaraxx DUO hybrid in variant 2, in which the

plants were treated with the indicated minimum effective rate of the herbicide - 1356.02 kg/da, which is 22% higher than the yield obtained from the plants grown without herbicide treatment. In the second experimental year, no statistically significant differences were found between the first three variants.

From the analysis of the average values for the entire experimental period, it was found that the treatment with 50% higher than the recommended maximum rate of the herbicide (variant 4) was accompanied by a slight decrease in the yields of the hybrids.

The values for this indicator in the three hybrids Zanetixx, Hexxagone and Elaraxx DUO decreased by 5%, 14% and 8%, respectively, compared to the variant without treatment (Table 7).

Table 7. Grain yields, t ha⁻¹

Year of the experiment	Hybrids	Variants					
		1.Untreated control	2.Stratos Ultra – 1 L ha ⁻¹	3.Stratos Ultra – 2 L ha ⁻¹	4.Stratos Ultra – 3 L ha ⁻¹	5.Stratos Ultra – 4 L ha ⁻¹	6.Stratos Ultra – 5 L ha ⁻¹
2024	Zanetixx DUO	9,25 bc	10,77 ab	11,03 a	9,08 c	6,17 d	5,60 d
	Hexxagone DUO	11,45 a	10,93 a	10,45 ab	9,04 bc	7,41 cd	7,08 d
	Elaraxx DUO	10,55 bc	13,56 a	11,82 ab	9,28 cd	7,19 de	6,50 e
2025	Zanetixx DUO	11,70 a	10,79 ab	10,71 ab	9,46 bc	8,65 c	6,48 d
	Hexxagone DUO	12,15 a	12,31 a	12,04 a	11,33 a	7,13 b	7,13 b
	Elaraxx DUO	12,50 a	11,26 a	12,11 a	11,82 a	7,16 b	6,90 b
Average for the period	Zanetixx DUO	10,48	10,78	10,87	9,27	7,32	6,04
	Hexxagone DUO	11,80	11,62	11,24	10,19	7,27	7,10
	Elaraxx DUO	11,52	12,41	11,96	10,55	7,18	6,70

Means followed by different letters are significantly different according to Duncan's multiple range test at $p \leq 0.05$.

After applying Stratos Ultra twice at the maximum recommended rate, a yield reduction of 30% was recorded for the Zanetixx DUO hybrid and 38% for the Hexxagone DUO and Elaraxx DUO hybrids. In variant 6 with the highest applied rate used in the experiment, the lowest values for this indicator were recorded, with the percentage yield reduction compared to the untreated control being as follows: 44%, 40% and 42% for the Zanetixx DUO, Hexxagone DUO and Elaraxx DUO hybrids.

CONCLUSIONS

Overall, the findings of the study suggest that the application of Stratos Ultra to the evaluated hybrids should be carried out at the maximum recommended rates (1 L ha⁻¹ and 2 L ha⁻¹) in order to achieve both sufficient level of weed management and optimal crop response. Increasing rates of the herbicide resulted in decrease in yields as well as in grain quality. The results of the experiment, conducted in 2024 and 2025, indicate that plants' performance was positively affected by the treatment with grass weed herbicide Stratos Ultra, provided that it is applied at the recommended application rates - 1 and 2 L ha⁻¹. The tested herbicide combined with a broadleaf herbicide, resulted in improved maize yields by successfully controlling weeds that had emerged at the time of application in the initial stages of crop development. Although yields in variants 5 and 6 decreased significantly with increasing application rates, none of the hybrids resulted in reduced crop density or total yield loss.

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