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EVALUATION OF INCREASED RATES OF STARANE GOLD AT THE MAIZE HYBRID "BLASON DUO"

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Abstract

In 2020 a field trial with the maize hybrid "Blason Duo" was conducted. The trial was stated on the experimental field of the Agricultural University of Plovdiv, Bulgaria. The performance of the herbicide product Starane Gold (100 g/l fluroxypyr + 1 g/l florasulam) in increased rates (1.20, 1.80 and 2.40 l ha^{-1}) was evaluated. Untreated plot was accepted as a control. The efficacy and the selectivity of the herbicide, several biometrical parameters, and as well as the yields and its components were studied. The highest biological efficacy against the existing broadleaf weeds at the rates of 1.80 and 2.40 l ha^{-1} were reported but phytotoxic symptoms score 4 (by the 9-score scale of European Weed Research Society) for the rate of 2.40 l ha^{-1} were reported. Simultaneously with the decrease of the density of the broadleaf weeds a significant increase in the values of the studied traits as stem height and ear number per plant were found. The absolute and hectoliter seed mass as well as the yields were the highest for the treatment with application rates of 1.20 and 1.80 l ha^{-1}.

Key words*: Triticum aestivum L., efficacy, biometry, herbicide, yield.*

INTRODUCTION

Maize (*Zea mays* L.) is main grain and forage crop with adaptability to different agro-ecological conditions. That is the reason for the successful growing of the crop in many regions around the world. In Bulgaria it is strategical field crop. Maize has the highest energy value in comparison to the others forage crops (Tomov and Yordanov, 1984).

One of the main negative factors for agricultural production is the weeds. They decrease the yields and the quality of corn grain (Mitkov et al., 2019; Changsaluk et al., 2007; Tonev et al., 2007; Werner et al., 2004; Tonev, 2000; Masqood et al., 1999; Vengris et al., 1955). Weeds are annually emerging all over the fields and are causing great damage of the maize production (Tonev et al., 2011).

The chemical weed control is the most distributed among farmers. It is effective, fast and easy to apply. The proper herbicide application reduces the weed management costs up to 60% (Valcheva, 2011).

Today, high-yield agriculture is dependent on herbicides as they are an important component of weed management practices (Goranovska and Yanev, 2016). Nowadays weed control with post emergence herbicide application at maize is rising (Whaley et al., 2006; Airoldi, 2000). In maize, chemical weed control is mainly performed by application of broad-leave and soil herbicides.

The aim of our study is to evaluate the efficacy and selectivity of Starane Gold in maize.

MATERIALS AND METHODS

The experiment was situated in the experimental field of the base for training and implementation of the Agricultural University of Plovdiv, Bulgaria. The trial was conducted by the randomized block design in 3 replications. The size of the experimental plot was 10 m^2.

Variants of the trial were: 1. Untreated control; 2. Starane Gold (100 g/l fluroxypyr + 1 g/l florasulam) – 1.20 l ha^{-1}; 3. Starane Gold - 1.80 l ha^{-1}; 4. Starane Gold - 2.40 l ha^{-1}.

The sowing was done in April, and the herbicide treatment is applied in 3rd - 5th leaf stage (BBCH 13-15). The trial was conducted with the maize hybrid "Blason Duo". For removing the influence of the grass weeds the whole experimental area was treated with Stratos Ulra (100 g/l cycloxidim) at rate of 2.00

l ha^{-1}. The treatment with Stratos Ultra was done one week after the Starane Gold treatment.

Characteristics of the maize hybrid "Blason Duo": FAO Group 450; tolerant to the herbicide cycloxidim; high-yielding hybrid forming ears low and uniformly (https://euralis.bg//43-es-blason-duo/)

Precrop of maize was the winter wheat variety "Enola". On the whole experimental field combined fertilization with 250 kg ha^{-1} with N:P:K (15:15:15), followed by deep ploughing was done. Before sowing of the crop, disking on the depth of 15 cm and two harrowings on 8 cm of depth as well as spring dressing with 250 kg ha^{-1} NH_4NO_3 was also performed.

The efficacy of the studied herbicide rates against the weeds by the 10 score scale of EWRS (European Weed Research Society) on the 14th, 28th and 56th day after application was studied. The selectivity of the herbicide by the 9 score scale of EWRS was also evaluated (Zheliazkov et al., 2017).

The natural broadleaf weed infestation was presended by the weeds *Xanthium strumarium* L.; *Chenopodium album* L.; *Amaranthus retroflexus* L.; *Solanum nigrum* L.; *Portulaca oleracea* L.

During the growing season, two of the studied traits were reported - stem height and number of ears. From each repetition at random (in the beginning, in the middle and at the end of the trial plot) 12 plant total were measured.

After harvest, measurements of three quantitative traits were done – ear length and diameter as well as number of seeds per ear. Ten maize ears from each replication were measured.

From each variant for the three repetitions, 1000 air-dried seeds were counted and the absolute mass of the grains in grams was established. The hectoliter mass in kg was calculated for each replication.

Due to the close values of the indicators between the different variants, the comparisons were performed only with the control and the other variants. The initial data were processed by analysis of variance and variation using SPSS 19 program.

The maize grain yield (kg ha^{-1}) was recorded by weighting of the seeds of 10 maize ears for each treatment in three replications. The obtained results were divided on 10 and the grain yield was recalculated multiplying the result by the number of plants in one hectare.

The data for the grain yield were processed by Duncan's multiple range test ($p<0.05$).

RESULTS AND DISCUSSIONS

The obtained results regarding the efficacy of Starane Gold against the present weed species on the 14th, 28th and 56th day after application is presented. The efficacy is lower in the beginning of the reporting period and it is increasing in time.

On Table 1 is presented the efficacy of Starane Gold against *Xa. strumarium*. This species is among the most dangerous weeds in maize (Karimmojeni et al., 2010). In a trial conducted by Konstantinović and Korać (2011) 86% efficacy against *Xa. strumarium* was reported after the evaluation of Starane 300. In this experiment, for all evaluated rates of the herbicide product, excellent efficacy against this noxious weed was recorded - 95-100%. Mitkov (2020) also reported 95% efficacy for the evaluated rates (1.20 and 1.50 l ha^{-1}) of Startane Gold.

Table 1. Efficacy of Starane Gold against *Xa. strumarium*, %

Treatments/days after application	14th	28th	56th
1. Untreated control	-	-	-
2. Starane Gold - 1.20 l ha^{-1}	75	90	95
3. Starane Gold - 1.80 l ha^{-1}	80	95	100
4. Starane Gold - 2.40 l ha^{-1}	90	100	100

On table 2 is presented the efficacy of Starane Gold against the weed *Ch. album*.

Table 2. Efficacy of Starane Gold against *Ch. album*, %

Treatments/days after application	14th	28th	56th
1. Untreated control	-	-	-
2. Starane Gold - 1.20 l ha^{-1}	25	35	45
3. Starane Gold - 1.80 l ha^{-1}	40	55	55
4. Starane Gold - 2.40 l ha^{-1}	65	75	85

This species was the most difficult-to-control in the trial, independently the applied herbicide rate. Even the rate of Starane Gold - 2.40 l ha^{-1} did not ensure 100% control. On the 56th day after treatment 85% efficacy was found. In our previous study we reported excellent (100%)

control of *Ch. album* after the application of Principal Plus WG - 0.44 kg ha^{-1} + Trend 90 - 1.00 l ha^{-1} (Mitkov et al., 2019).

The efficacy data against *A. retroflexus* is presented on Table 3. Damalas et al. (2018) report that *A. retroflexus* can be successfully controlled after application of with herbicide mixtures based on tembotrione + rimsulfuron, nicosulfuron or foramsulfuron. In our study it is found that the weed can be successfully controlled by all studied Starane Gold doses.

Table 3. Efficacy of Starane Gold against *A. retroflexus,* %

Treatments / days after application	14th	28th	56th
1. Untreated control	-	-	-
2. Starane Gold - 1.20 l ha^{-1}	75	85	95
3. Starane Gold - 1.80 l ha^{-1}	80	95	100
4. Starane Gold - 2.40 l ha^{-1}	95	100	100

All evaluated rates of the herbicide product were able to control the weed *S. nigrum* from the first evaluation date to the 56th after the treatments (Table 4). We have found excellent control of this species in our experiments conducted with different herbicide products in the past (Tonev et al., 2016; Mitkov et al., 2018; Mitkov et al., 2019).

Table 4. Efficacy of Starane Gold against *S. nigrum,* %

Treatments / days after application	14th	28th	56th
1. Untreated control	-	-	-
2. Starane Gold - 1.20 l ha^{-1}	80	95	100
3. Starane Gold - 1.80 l ha^{-1}	95	100	100
4. Starane Gold - 2.40 l ha^{-1}	95	100	100

On Table 5 are the obtained results for the efficacy of Starane Gold against *P. oleracea*.

Table 5. Efficacy of Starane Gold against *P. oleracea,* %

Treatments / days after application	14th	28th	56th
1. Untreated control	-	-	-
2. Starane Gold - 1.20 l ha^{-1}	85	85	90
3. Starane Gold - 1.80 l ha^{-1}	90	100	100
4. Starane Gold - 2.40 l ha^{-1}	100	100	100

The reported efficacy is close to those recorded for the weeds discussed above. On the 56th day after treatments the efficacy is excellent for all evaluated rates - 90-100%. Herbicides are xenobiotics - "foreign" substances for the plants. When the tolerance of cultivated plants to the absorbed herbicide is not enough to destroy the crop, the result is herbicide stress leading to various structural and functional distortions (Vischetti et al., 2002). The visual phytotoxicity recorded is presented on Table 6.

Visual phytotoxic symptoms were not observed when the herbicide was applied in the rate of 1.20 l ha^{-1} and the phytotoxicity score by the scale of EWRS was 0.

For the application the Starane Gold rare of 1.80 l ha^{-1} phytotoxicity score on the 7th day after the treatments was 1. The observed symptoms were yellowing between the veins without affecting the midrib. The symptoms were observed in the leaf sheath. The phytotoxicity signs disappear completely on the 14th day after herbicide application. Mitkov (2020) also reported that the application of Starane Gold SE - 1.5 l ha^{-1} caused temporary phytotoxicity that was completely overcome.

Table 6. Visual phytotoxicity of Starane Gold for maize, score by EWRS

Treatments / days after application	7th day after treatment	14th day after treatment
1. Untreated control	-	-
2. Starane Gold - 1.20 l ha^{-1}	0	0
3. Starane Gold - 1.80 l ha^{-1}	1	0
4. Starane Gold - 2.40 l ha^{-1}	4	1

Greater phytotoxicity signs for the high rate (2.40 l ha^{-1}) of Starane Gold were recorded. On the 7th day after treatment the visual phytotoxicity score was 4. The symptoms were expressed in yellowing between the veins not only in the area of the sheath, but on the whole leaf blade. Also crimping on the blade base was recorded.

On the 14th day after the herbicide treatment the plants overcome the herbicide stresses in some extend and the phytotoxicity score decreased to score 1. Later in time the visual herbicide toxicity disappeared, but stunning and growth retardation was recorded for treatment 4 (Starane Gold - 2.40 l ha^{-1}).

The data for the growth parameters and its statistical analyses are presented on Table 7. The meanings of t are as follows: 2,001 ($p<0.05$), 2.663 ($p<0.01$) and 3.466 ($p<0.001$).

After performing these analyses significant differences were not recorded. The increasing

of Starane Gold rates did not influence the growth and development in one-way performance. Only the trait stem height for the three evaluated doses showed a significant difference in comparison to the untreated control at level of significance $p<0.001\%$. For the weed control in the trial all three rates of the herbicide helped the maize hybrid grown in the experiment to show its growing potential (this trait is also determined to group I – the most distant group according to the control.

Table 7. Data analyses for 7 quantitative parameters of maize (growth and productive traits)

Stem height (m)					
Treatment	Average	Difference	t e	Significance	Group
1	2.40	-	-		IV
2	2.70	0.30	6.88	+ + +	I
3	2.80	0.40	10.56	+ + +	I
4	2.66	0.26	6.45	+ + +	I
Number of ears per plant					
Treatment	Average	Difference	t e	Significance	Group
1	1.08	-	-		IV
2	1.44	0.36	3.75	+ + +	I
3	1.69	0.61	6.73	+ + +	I
4	1.22	0.56	1.64	ns	IV
Ear length (cm)					
Treatment	Average	Difference	t e	Significance	Group
1	17.80	-	-		IV
2	18.77	0.97	1.71	ns	IV
3	19.24	1.44	2.55	+	IV
4	19.09	1.29	2.22	+	IV
Number of seeds per ear					
Treatment	Average	Difference	t e	Significance	Group
1	541.06	-	-		IV
2	571.46	30.40	1.12	ns	IV
3	586.26	45.20	1.91	ns	IV
4	561.06	20.00	0.81	ns	IV
Ear diameter (cm)					
Treatment	Average	Difference	t e	Significance	Group
1	3,53	-			IV
2	3,74	0.21	2.54	+	III
3	3,84	0.31	3.11	+ +	II
4	3,72	0.19	1.84	ns	IV
Absolute seed mass (g)					
Treatment	Average	Difference	t e	Significance	Group
1	352.92	-			IV
2	383.21	30.29	4.73	+ +	II
3	379.53	26.61	4.52	+	III
4	333.57	19.35	3.11	-	V
Hectoliter seed mass (kg)					
Treatment	Average	Difference	t e	Significance	Group
1	76.50	-			IV
2	77.10	0.60	2.00	ns	IV
3	77.30	0.80	2.50	ns	IV
4	74.60	-1.90	3.47	-	V

For the number of ears per plant for the rates of 1.20 and 1.80 l ha^{-1} a similar influence was found. The highest examined rate of Starane Gold (2.40 l ha^{-1}) decreased the number of ear per plant and the differences in comparison to the untreated control were insignificant. The two treatments were situated in the same group – IV. The effect of the application of the lowest evaluated rates of the herbicide was not significantly expressed for these two indicators. The increase of the herbicide rate led to significant changes of the number of seeds per

ear and hectoliter seed mass. The growth parameters of the maize hybrid were mostly influenced by the rates of the studied herbicide product while the productive indicators had insignificant change in the values in comparison to the control.

Maize grain yields are presented on table 8. Studies conducted from different authors show that, depending on the type and degree of weed infestation, the maize grain yield may decrease from 24% to 96,7% (Mitkov, 2020; Mitkov et al., 2019; Mitkov et al., 2018; Tonev et al., 2016; Najafi and Tollenar, 2005; Oerke and Dehne, 2004; Khan et al., 2003; Zhalnov and Raikov, 1996).

Table 8. Maize grain yields, t ha^{-1}

Treatments / days after application	Grain yields	% of yield increase
1. Untreated control	4.97 c	100%
2. Starane Gold – 1.20 l ha^{-1}	7.98 a	+60%
3. Starane Gold – 1.80 l ha^{-1}	7.84 a	+57%
4. Starane Gold – 2.40 l ha^{-1}	6.70 b	+35%

Values with different letters are with proved difference according to Duncan's multiple range test ($p < 0.05$).

The highest yields for the treatments with Starane Gold – 1.20 l ha^{-1} (7.98 t ha^{-1}) and Starane Gold – 1.80 l ha^{-1} (7.84 t ha^{-1}) were recorded. For these two variants the yield increase is 60 and 57% in comparison to the untreated control respectively. The herbicide rate of 2.40 l ha^{-1} led to yield decrease. It is important to remember that the yield decrease from uncontrolled weeds is higher than what might appear from injury by registered herbicide treatments (Hartzler, 2013). That statement was confirmed in our study. The productivity for treatment 4 (Starane Gold - 2.40 l ha^{-1}) was 6.70 t ha^{-1} - 35% increase when compared to the yield of the untreated control - 4.97 t ha^{-1}.

CONCLUSIONS

All studied rates of Starane Gold showed excellent control of the weeds *Xanthium strumarium* L., *Amaranthus retroflexus* L., *Solanum nigrum* L., and *Portulaca oleracea* L. The weed *Chenopodium album* L. was the most difficult-to-control in the study. The rate of Starane Gold - 2.40 l ha^{-1} ensured 85% efficacy on the 56th day after treatment.

The application of the high rate of the herbicide showed phytotoxicity symptoms that lead to depressed development of the plants, especially for treatment 4.

The highest yields for the treatments with Starane Gold – 1.20 l ha^{-1} and Starane Gold – 1.80 l ha^{-1} was recorded, and the rate of 2.40 l ha^{-1} lead to yield decrease.

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