A Comparative Study of the Sensitivity of Maize Lines to Some Herbicides

Dimitriya Ilieva

Abstract: *In 2008-2010, on a soil type highly leached chernozem, a field experiment was conducted on the effects of herbicides for johnsongrass control rimsulfuron (Titus 25 DF) and nicosulfuron (Mistral 4 CK), administered at an optimal dose, once and twice, within an interval of 14 to 20 days. The sensitivity and yield of four maize lines - RM 619, MO 17, 61/31 and 302/12 was tested. The aim of the current experiment is to obtain information on the impact of the herbicides rimsulfuron and nicosulfuron on the sensitivity and yield of inbred maize lines.The most sensitive to herbicides for johnsongrass control with the highest percentage of perishing plants is line RM 619, and the most resistant one is MO 17. The grain yield reported in the test lines treated with herbicides for johnsongrass control was lower than the control variants of the relevant genotype. Only MO 17 and 302/12 lines treated twice with herbicide Titus 25 DF reported yield increase of 7% and 6 % against the control group.*

Ke words*: maize, inbred, herbicides, rimsulfuron, nicosulfuron, yield*

INTRODUCTION

Maize belongs to the group of cereal crops grown in Bulgaria. They determine the structure of the Bulgarian wholesale agriculture. It is a major crop providing 62,4% of the grain used for animal food.

The biological potential of each plant is not only genetically predetermined but it is influenced by the conditions of cultivation (Bazitov, Ret all., 2010; Христов и др. 2010; Кунева и др. 2014). The elements of high yield and quality of the agricultural crops are a complex of interconnected factors such as appropriate crop rotation, soil quality, selection of appropriate for the particular agroecological region variety and hybrid, as well as the usage of high quality seeds (Делибалтова В. и кол., 2009; Митков А. и кол., 2009; Мънгова М. и кол., 1986). The plant protection activities and fertilization are an integral part of these factors, as evidences by a large number of scientific studies (Титянова М. и кол., 2007; 2010).

Green and Ulrich (1993), Molnar et al. (2001) and Milivojevic et al. (2003) examine more than 100 maize hybrids that showed resistance to rimsulforon, nicosulforon, primisulforon and tidensulforon. In maize fields with mixed weeds, both grass-like and broadleaf weeds, the highest level of herbicide efficacy has the combined usage of the herbicides Titus + Arat Titus + Harmony (Kopmanis and Gaile, 2008 и 2010).

In their study, Waligora et al. (2008) investigated the herbicides atrazine, formasulfuron + iodosulfuron, S-metolachlor, MCPA + dicamba, fluroxypyr + 2.4-D, florasulam + 2.4-D, rimsulfuron, bromoxynil, isoxaflutol + flufenacet, petoxamide, and flumidioxin cyflidoxidine. The herbicides were applied individually and in combination, according to the doses recommended by the manufacturers, in phase 3th- 4th leaf of the crop, showing high selectivity, with the exception of the administered rimsulfuron. The highest yields (cobs) were obtained from the combination of formasulfuron + iodosulfuron and fluroxypyr + 2.4-D, and the lowest yield was reported after the application of the herbicides S-metolachlor and MCPA + dicamba. Ivanovic et al. (1998) reported that leaf herbicides rimsulfuron, primsulfuron-methyl, prosulfuron + prsulfuron-methyl and nicosulfuron have a retardant effect - they increase grain yield but also reduce plant height. However, Stefanovic et al. (2001 and 2006) reported an increase in corn height under the influence of nicolsulfuron, rimsulfuron and primsulfuron-methyl.

The aim of the current study is to obtain information on the impact of the johnsongrass control herbicides - rimsulfuron and nicosulfuron on the sensitivity and yield of inbred maize lines.

MATERIAL AND METHODS

In 2008 – 2010, a field experiment on maize was carried out with the perpendicular method of Shanin in four replications with a size of the experimental plot of 10 m2 ((Shanin, 1977) in the experimental field of the Institute of Agriculture and Seed science "Obraztsov Chiflik" - Rousse, on a soil type highly leached chernozem, low humus content (1.98%), low mineral N content(10.75 mg.1000 g^{-1} soil) and mobile P_2O_5 (6.31 mg.1000 g^{-1} soil) and good reserve of K_2O (22.50 mg.1000 g^{-1} soil) in the layer 0 – 40 cm. The sensitivity of four inbred maize lines was examined – PM 619 , MO -1 7 , 61/31 and 302/12 to the herbicides rimsulforon and nicosulforon. The sowing was carried out within the optimal period for the region (first 10 days of April) with crop density 5500 plants per da (Popov and Pavlov, 1966).

The application of the rimsulforon and nicosulforon herbicides was done during 4^{th} - 5^{th} leaf phase with a backpack sprayer and concentration of work solution of 20 l.da-1. It was applied in optimal doses, once and twice at intervals of 14 to 20 days (Table 1). The experimental field was maintained weed free for the entire maize growing season through two inter-row treatments. The maize was grown without inter-row cultivation after a precursor wheat. It was fertilized with N_{10} P_8 K8. The fertilizers were applied as follows: phosphorus (superphosphate) and potassium (potassium chloride) imported with the main autumn tillage, and all the nitrogen fertilizer (ammonium nitrate) before sowing.

Table 1 *Variants of the experiment*

Variants		Doses - herbicides, g.da^{-1} (ml.da^{-1})	Doses - active substance, g.da^{-1}
1	Control - untreated	-	-
2	Titus 25DF (250 g.kg^{-1}rimsulfuron)	3+2	0.75+0.50
3	Titus 25DF (250 g.kg^{-1}rimsulfuron	5	1.25
4	Mistral 4SK (40 g.l^{-1} nicosulfuron)	100+50	4+2
5	Mistral 4SK (40 g.l^{-1} nicosulfuron)	150	6

The following indicators were reported for the realization of the experiment:

phytotoxicity of the herbicides on the 7-th, 17-th and 30-th day after their application (according to logarithmic scale (1-9 points) of EWRS at score 1 - no damage and at score 9 - the crop was completely destroyed and seed yield kg.da^{-1}.

Statistical processing of the experimental data was performed using the method of disperse analysis of Shanin.

RESULTS AND DISCUSSION

The experimental field of the Institute belongs to a region with moderate continental climate. For the period of the study (2010-2008), the agrometeorological conditions in terms of temperature and precipitation amounts vary by month, both in individual years and in comparison with the multiannual averages (climate normals) for the period 1896 - 2005.

The period 2008 – 2009 was moderately favorable for maize (Figure 1). In 2008, the amount of precipitation in April (51.6 mm) and May (58 mm) was close to the climate norm (51.1 mm and 66.2 mm). In 2009, the monthly precipitation for the same period was 12.7 mm (April) and 29.8 mm (May), which were respectively 25% and 45% below the multi-annual

rate (51.1 mm and 66.2 mm). The average monthly air temperature for the period April - September ranges from 12.79 to 25.03 ^{0}C (for 2008) and from 12.37 to 25.13 ^{0}C (for 2009) at the multiannual rate of 11.39 to 23, 86 ^{0}C. Extremely high temperatures and significant water stress did not adversely affect maize development. The soil moisture content was better in 2010. The precipitation in April (38.4 mm) and May (81.7 mm) created favorable conditions for the emergence, growth and development of the maize plants. Precipitation in June (81.5 mm) was decisive for the yield. In terms of temperature, 2009 (for the entire maize growing season) differs in temperatures (589.6 ^{0}C) around the norm (572.2^{0}C). In August, higher temperatures (25.13 ^{0}C) were recorded than the multiyear norm of 23.86 ^{0}C, which is a characteristic of the global warming observed in recent years.

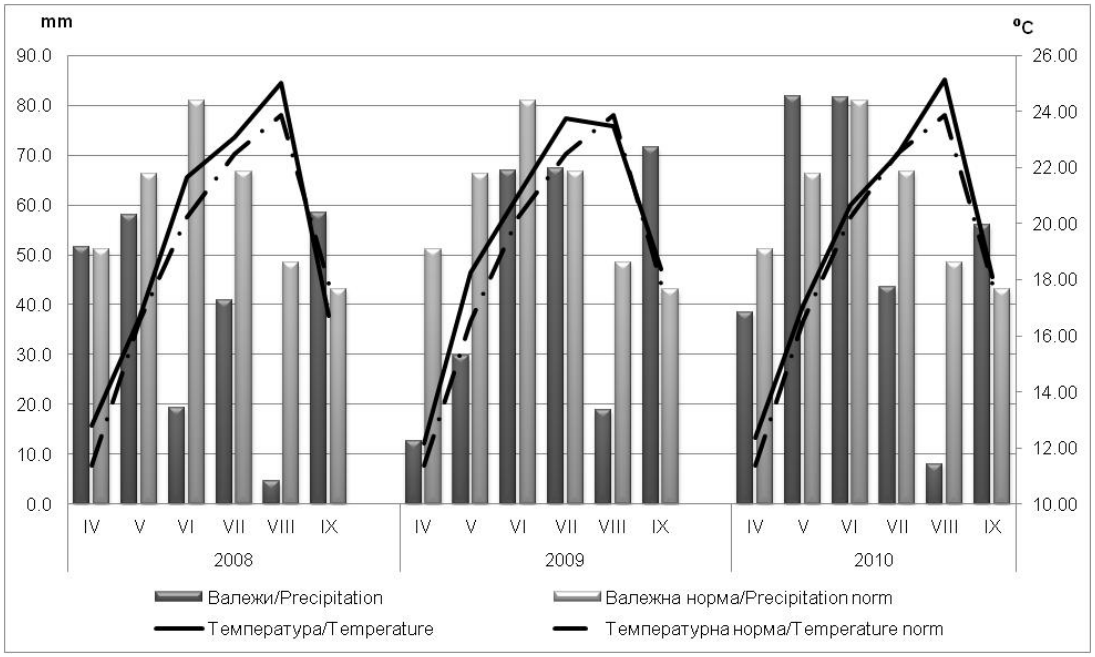

Fig. 1 Average monthly air temperatures and precipitation by month for period 2008 - 2010

On average, for the three-year test period, line RM 619 showed the highest sensitivity, where the rate of plant loss reached 46.6% with the use of Mistral 4CK administered twice at the optimal dose (Table 2). In the variant with the application of the Titus 25DF herbicide at the optimal dose once, the percentage of dead plants was 26.8%, and administered in a system, respectively 21.3%. The next most sensitive to johnsongrass control herbicides is line 61/31, with the highest rate of dead plants of 25.0% reported after a single treatment of Titus 25 DF at the optimal dose, followed by the single-dose treatment with Mistral 4CK at the optimal dose - 20.8%. The third most susceptible line to herbicides is 302/12 line, with a mortality rate ranging from 10.9% to 21.3%.

The highest resistance to the administered johnsongrass control herbicides Titus 25DF and Mistral 4CK+, administered in optimal doses, both once and in a system, was observed in line MO 17 where the percentage of dead plants varied from 0.4% to 2.3%.

The disperse analysis shows that there are differences between the compared factors (emerged and perished plants) with a difference of the examined factor of 5% and 0,1%.

Table 2 *Effect of herbicides Titus 25DF and Mistral 4CK on the growth of maize lines RM 619, MO 17, 61/31 и 302/12*

Variants	Number of plants emerged	Number of plants perished	%
RM 619			
Control - untreated Doses - active substance	47	0	0
Titus 25DF (250 g.kg^{-1}rimsulfuron)	49	10.4*	21.3
Титус 25ДФ (250 g.kg^{-1} римсулфорон) Titus 25DF (250 g.kg^{-1}rimsulfuron	48	12.9*	26.8
Mistral 4СК (40 g.l^{-1} nicosulfuron)	48	22.2*	46.6
Mistral 4СК (40 g.l^{-1} nicosulfuron)	47	1.2*	2.5
MO 17			
Control-untreated Doses - active substance	45	0	0
Titus 25DF (250 g.kg^{-1}rimsulfuron)	46	0.2*	0.4
Titus 25DF (250 g.kg^{-1}rimsulfuron	47	0.5*	1.0
Mistral 4СК (40 g.l^{-1} nicosulfuron)	44	1.0*	2.3
Mistral 4СК (40 g.l^{-1} nicosulfuron)	46	0.2*	0.5
61/31			
Control –untreated Doses - active substance	47	0*	0
Titus 25DF (250 g.kg^{-1}rimsulfuron)	48	7***	14.6
Titus 25DF (250 g.kg^{-1}rimsulfuron	48	12***	25.0
Mistral 4СК (40 g.l^{-1} nicosulfuron)	48	5***	10.4
Mistral 4СК (40 g.l^{-1} nicosulfuron)	46	10***	20.8
302/12			
Control-untreated doses - active substance	47	0	0
Titus 25DF (250 g.kg^{-1}rimsulfuron)	46	5***	10.9
Titus 25DF (250 g.kg^{-1}rimsulfuron	48	9***	18.8
Mistral 4СК (40 g.l^{-1} nicosulfuron)	47	6***	12.8
Mistral 4СК (40 g.l^{-1} nicosulfuron)	47	10***	21.3

Legend: *, **, ***, where GD < 5 %; 1 % and 0.1%.

Both herbicides, Titus 25DF and Mistral 4CK, showed no phytotoxicity when used once and twice in the optimal dose, based on the phonological observations carried out on 7-th, 17-th and 30-th day after the treatment of MO 17 and 302/12 lines (table 3).

Sensitivity was observed to the used johnsongrass control herbicides Titus 25DF and Mistral 4CK in lines RM 619 and 302/12. It was expressed in tumor-like formations (EWRS score 3-5) which lead to the suppression of the plants and some of them perished.

***Table 3** Herbicide selectivity for maize lines RM 619, MO 17, 61/31, 302/12*

Day of report / Herbicide		7th day	17th day	30th day
RM 619				
Titus 25DF	3+2 g.da^{-1}	4	4	3
	5 g.da^{-1}	5	5	4
Mistral 4CK	100+50 ml.da^{-1}	5	3	2
	150 ml.da^{-1}	3	1	1
MO 17				
Titus 25DF	3+2 g.da^{-1}	1	1	1
	5 g.da^{-1}	1	1	1
Mistral 4CK	100+50 ml.da^{-1}	2	1	1
	150 ml.da^{-1}	1	1	1
61/31				
Titus 25DF	3+2 g.da^{-1}	4	4	3
	5 g.da^{-1}	5	5	4
Mistral 4CK	100+50 ml.da^{-1}	5	3	2
	150 ml.da^{-1}	3	1	1
302/12				
Titus 25DF	3+2 g.da^{-1}	1	1	1
	5 g.da^{-1}	1	1	1
Mistral 4CK	100+50 ml.da^{-1}	2	1	1
	150 ml.da^{-1}	1	1	1

For the research period the maize realized its productive potential through the grain yield to varying degrees under the influence of the studied factors – climate, genotype and herbicides.

The negative influence of herbicides on the number of plants, their growth and development had also affected the yield of seeds (table 4).

On average for the period of research, the highest decrease in yield is reported when the herbicides are used twice. The yield in line RM 619 treated with Titus - 3+2 g.da-1 is 25 % lower than the control crop in comparison with Mistral 4 CK - 100+50 ml.da-1 – 31%.

The Mistral 4 CK herbicide had a more suppressing effect on the grain yield in comparison to Titus 25 DF. On average for the reported period, the yield of RM 619 line treated twice with Titus 25 DF was 227 kg.da^{-1}, and Mistral 4 CK was 209 kg.da^{-1}. The trend is similar in line 61/31, where in the variant treated with Titus 25 DF twice had a decrease in the yield of 21 % compared to the control crop. In relation to the yields MO 17 and 302/12 lines showed better resistance to the double treatment with herbicides in optimal dose.

There is a similar trend in the single application of the examined herbicides in relation to the yield. Lines RM 619 and 61/31 showed higher sensitivity towards the herbicides.

The proof of difference in the analysis of variance is reported in the following factors: genotype and dosa. There are no proven differences in relation to the impact of the examined herbicides.

Table 4 *Grain yields (kg.da-1) of maize inbred lines treated with the herbicides Titus 25DF and Mistral 4CK*

Variants	Inbred lines	Herbicides	*Grain yields (kg.da-1) of maize*			
			2008г.	2009г.	2010г.	Average for the period
control	RM619	untreated	221	384	311	305
once	R6M19	Titus - 5 g.da^{-1}	200	272	155	209
twice	RM619	Titus - 3+2 g.da^{-1}	314	222	144	227
control	MO17	untreated	251	208	273	244
once	MO17	Titus - 5 g.da^{-1}	292	239	166	232
twice	MO17	Titus - 3+2 g.da^{-1}	368	248	169	262
control	61/31	untreated	105	427	269	267
once	61/31	Titus - 5 g.da^{-1}	201	336	148	228
twice	61/31	Titus - 3+2 g.da^{-1}	165	250	221	212
control	302/12	untreated	88	423	338	283
once	302/12	Titus - 5 g.da^{-1}	247	355	228	277
twice	302/12	Titus - 3+2 g.da^{-1}	248	339	311	299
control	RM619	untreated	221	384	311	305
once	RM619	Mistral - 150 ml.da^{-1}	301	367	157	275
twice	RM619	Mistral - 100+50 ml.da^{-1}	200	272	155	209
control	MO17	untreated	251	208	273	244
once	MO17	Mistral - 150 ml.da^{-1}	355	291	88	245
twice	MO17	Mistral - 100+50 ml.da^{-1}	292	239	166	232
control	61/31	untreated	427	269	267	267
once	61/31	Mistral - 150 ml.da^{-1}	127	362	104	198
twice	61/31	Mistral - 100+50 ml.da^{-1}	48	360	161	190
control	302/12	untreated	88	423	338	283
once	302/12	Mistral - 150 ml.da^{-1}	180	357	136	224
twice	302/12	Mistral - 100+50 ml.da^{-1}	128	398	258	261

ANOVA (analysis of variance)

	F- Fisher's coefficient	Degree of freedom	mistake	probability - p
Dose	7,245	6	30,000	0,000076
Line	3,056	9	36,657	0,007852
Herbicides	2,015	3	15,000	0,155103

CONCLUSIONS

1. The highest sensitivity to the examined herbicides was reported in line RM 619, followed by line 61/31, where the highest percentage of mortality rate of 25% was reported when Titus 25 DF was applied in optimal dose once, followed by the variant treated once with Mistral 4 CK in optimal does – 20.8%. Third most sensitive one was 302/12 line where the percentage of dead plants varies from 10.9 % to 21.3%.

2. The percentage of mortality rate in MO 17 and 302/12 lines as a result of the applied herbicides Titus 25 DF and Mistral 4 CK was lower that the relevant untreated control line.

3. Based on the experiment's results we do not recommend the usage of johnsongrass control herbicides in seed production.

4. The yield of grain in the experimental lines treated with johnsongrass control herbicides is lower than the control variant of the relevant genotype. Only MO 17 and 302/12 lines, treated with Titus 25 DF twice, reported an increase in yield of 7% and 6% against the control crop.

REFERENCES

[1] Bazitov, R., Ganchev, G., Bazitov, V., Michailova, M., (2010) The role of processing and soil fertilizacion on changes in chemical composition of pea-wheat mixture. International scientific online journal "Science & Technologies", Plant studies (6):205-208.

[2] Beloev H., Dimitrov, P., Kuncheva, G., (2018) Comparative Research on Advanced Technologies for Minimum and Unconventional Soil Tillage with Application of Different Mulching Materials, for Growing Maize for Grain, on Sloping Agricultural Lands. Agricultural, Forest and Transport Machinery and Technologies (ISSN: 2367– 5888) Volume V – Issue 1, 2018, pp. 38 – 48.

[3] Delibaltova, V., Jeliazkov, Il., Tonev, T. (2009) Vlianie na niakoi herbicidi varhu zaplevelenostta i produktivnostta na obiknovenata pshenica (Triticum aestivum L.), Agrarni nauki, № 2, str. 19-25.

[4] Green, J., Ulrich, J., (1993) Response of corn (Zea mays L.) inbreds and hybrids to sulfonylurea herbicides. Weed science, 41(3), 508- 516.

[5] Hristov, I., Davidov, E., Georgiev, D., Angelov, V., Petrov, P., Cvetanova, G., (2010) Dobiv na suha masa i energiina efektivnost na kulturite v petpolno seitboobrashtenie v zavisimost ot toreneto International scientific on-line journal "Science & Technologies", Plant studies (6), 154-159.

[6] Ivanovic, M., Jelicic, Z., Markovic, S., Dragovic, G., Martic, M., (1998) Reactions of inbred lines of maize on herbicides from the sulfonilurea group. Zbornik naucnih trudove, 4(1), 87-93.

[7] Kuncheva, G., Dimitrov, P., Beloev, H., (2018) Determination of Mineral Nitrogen Losses under the Action of Water Erosion Processes in Maize Growing on Sloping Terrains. Agricultural, Forest and Transport Machinery and Technologies (ISSN: 2367– 5888) Volume V – Issue 1, 2018, pp. 61 – 66.

[8] Kuncheva G., Beloev, H., Dimitrov, P., (2018) Losses of Mineral Nitrogen under the Influence of Water Erosion Processes in the Wheat Cultivation on Sloping Agricultural Lands. Agricultural, Forest and Transport Machinery and Technologies (ISSN: 2367– 5888) Volume V – Issue 1, 2018, pp. 67 – 73.

[9] Kuneva, V., Kalaidjieva, R., Matev. Al., (2014) Korelacionni zavisimosti mejdu strukturnite elementi na dobiva pri soiata, otglejdani pri razlichen poliven rejim, Nauchni trudove, Rusenski universitet, tom 53, seria 1.1., Ruse, 40-43, ISSN 1311-3321.

[10] Kopmanis, J., Gaile, Z., (2008) Use efficiency of herbicides in maize. Latvijas Lauku konsultaciju un izglitibas centrs, Ozolnieki, Jelgava reg. (Latvia), Ozolnieki (Latvia), 58-233.

[11] Kopmanis, J., Gaile, Z., (2010) Efficacy of weed control in maize for silage. Raksti - Latvijas Lauksaimniecibas universitate, 24 (319), 1- 11.

[12] Kollarova K., Pogran, S., Kangalov, P., (2015) Precision Tillage: on the Way from Information to Decisions - Scientific Monograph. University of Ruse "Angel Kanchev", ISBN 978-954-712-656-5.

[13] Mitkov, A., Titiyanova, M., Tonev, T., (2009) Selektivnost na herbicidniya preparat Uidmaster uam zarneno-jitni kulturi, Treti nacionalen simpozium „ Ekologichni podhodi pri proizvodstvoto na bezopasni hrani „, str. 245-252.

[14] Milivojevic, M., Stefanovic, L., Husic, I., Simic M., Hojka, Z., (2003) Selectivity of the sulfonylurea herbicide group in the crop of maize inbred lines. Pesticides, 18(3), 187-194.
[15] Molnar, I., Toth, E., Somlyay, I., Pakurar, M., (2001) Effects of environmental conditions on sensitivity of corn cultivars to herbicide treatments. Novenyvedelem Area of plant protection, Hungary, 3710, 483-489.
[16] Mangova, M., Veleva. V., (1986) Prouchvane vlianieto na herbicida tricilin varhu tehnologichnite kachestva na razlichni po sila sortove zimna pshenica, Rastenievadni nauki, № 4, str. 11-14.
[17] Popov, A., Pavlov, K., (1966) Plant growing. Cereal crops, Volume I. In: Maize, Zemizdat, Sofia, 413-461.
[18] Shanin, Y., (1977) Methodology of field experiment. In: Perpendicular method. Zemizdat, Sofia, 96-97.
[19] Stefanovic, L., Simic, M., Milivojevic M., Misovic, M., (2001) Effects of some herbicides on plant height and yield of commercial inbred lines of ZP maize hybrids. Pesticides, 16(3), 173-384.
[20] Stefanovic, L., Simic, M., Milivojevic, M., Misovic, M., (2006) The manifestation of symptoms of herbicide (sulfonylurea) phytotoxic effects in their application in seed maize crop. Acta Herbologica, 15(1), 35-45.
[21] Titiyanova, M., Tonev, T., Mitkov. A., (2007) Novi vazmojnosti za efektiven himicheski control na plevelite pri pshenicata, Rastenievadni nauki, 49, str. 154-160.
[22] Waligora, H., Szulc, P., Skrzypczak, W., (2008) Effectiveness of chemical weed control in sugar maize cultivation without triazyne. Acta Scientiarum Polonorum. Agricultura, 7(1), 111-118.

CONTACTS

Dimitriya Ilieva, Department of Agricultural Machinery, Agrarian and Industrial Faculty, University of Ruse, 8, Studentska Str., 7017 Ruse, Bulgaria, e-mail: dilieva@uni-ruse.bg