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Selectivity of Some Herbicides to Perennial ryegrass (*Lolium perenne* L.), Grown for Seed Production

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SUMMARY

During the period 2008-2010, on the experimental field of the Institute of Forage Crops – Pleven, on slightly leached chernozem a study was conducted with the purpose to determine the selectivity of some herbicides to perennial ryegrass (*Lolium perenne* L.), and their influence on the seed productivity. As a result of the study the following was found: herbicides for broadleaf weeds control – Arat (500 g/l dicamba + 250 g/l tritosulfuron) at rate of 100 ml/ha, Korida 75 VDG (750 g/kg tribenuron-methyl) – 15 g/ha and Cambio SL (320 g/l bentazone + 90 g/l dicamba) – 1250 ml/ha had high selectivity to perennial ryegrass, applied at 2-4 leaf stage during establishing year of the stand and until the stage of the beginning of shooting up in seed production year. Herbicide for grass weeds control: Topik 080EK (80 g/l clodinafop-prop-argyl + antidote) at rate of 300 ml/ha, applied at the same stage can be applied in seed production stands of perennial ryegrass. Herbicide for grass weeds control – Grasp 25SK (250 g/l tralkoxydim) + Atplus 463 at rate of 1000 + 1000 ml/ha showed phytotoxic effect on *L. perenne* and caused the reduction of seed and dry biomass productivity. Realization of the biological potential concerning seed and dry mass yield of perennial ryegrass demands application of selective herbicides Arat, Korida 75 VDG and Cambio SL in control of broadleaf weeds and Topik 080EK in control of grass weeds.

Keywords: Perennial ryegrass (*Lolium perenne* L.); Herbicides; Selectivity; Seeds; Dry biomass

INTRODUCTION

Efficient weed control has an important place in technology for establishment and growth of highly productive seed production stand of perennial ryegrass (*Lolium perenne* L.), which is valuable component in sown pastures. Perennial ryegrass is the economically main forage grass sown in Europe, New Zeland, and in the temperate regions of Japan, Australia, South Africa and South America. Perennial ryegrass is also widely used in amenity grassland including sports turf. This is reflected in a 100 years period of effort in plant breeding activity, in high number of varieties on the OECD list in 2011 (1362) and in seed production concerning that since 2000 the EU-27 countries have produced, on average, 83,660 t perennial ryegrass seed per year and on global scale 209674 t per year (Humphreys et al., 2010). First Bulgarian perennial ryegrass IFK Harmoniya was registered on the Official Variety List of the Republic of Bulgaria (OVL) for the years 2010 and

2011, on OECD list for the year 2010 and 2011, and on Common EU catalogue for agricultural crops for 2009, with Certificate of the Patent Office of the Republic of Bulgaria from 2010 (Katova, 2011).

The weed concurrence at early stages of perennial ryegrass development has negative influence on distribution and development of the stand and decreases dry mass per area unite (Haggar and Kirkham, 1981; Dimitrova, 1995; Dimitrova and Katova, 2010).

Perennial ryegrass is very sensitive to weed concurrence during establishing and seed production years. The highest efficacy reported by Dimitrova and Katova (2010) was obtained by chemical weed control, when the seed yield exceeded the yield from the check plot by 27%.

In strategy for weed control during last years the chemical method took considerable place in the integrated system. In spite of limited studies for this crop the selective and efficient herbicides were found to control broadleaf weeds (Dimitrova, 1995, 2002; Brown et al., 1998; Lepies et al., 2000; Rijckaert et al., 2000; Rijckaert et Lepies, 2001). The control of grass weed species in cereal crops is difficult, because they have very similar morphology and physiology (Khoday, 1983). Nevertheless, in studies of some authors the efficient solutions for grass weed control were found (Clinkspoor et al., 1990; Madiot, 1992, Rijckaert, 1995; Dimitrova, 2007).

The aim of the study is to determine new herbicides, registered in our country for some crops, but without information on their selectivity to perennial ryegrass, in particular to newly developed and first Bulgarian variety – IFK Harmoniya.

MATERIAL AND METHODS

During the 2008-2010 period on the experimental field of the Institute of Forage Crops (IFC) in Pleven a study was conducted. The soil type was leached medium deep chernozem, poor to medium in humus, medium sandy clay one. The humus horizon reached 60 to 65 cm. When laying out the trails the following content was found in soil samples: mobile forms of nitrogen (50-87 mg/1000 g), phosphorus and potassium 3-9.3 and 20-34 mg/100 g respectively, pH_{KCl} 5.4-6.8, and humus 2.6 %. The soil supply of hydrolizable nitrogen was medium to good, of phosphorus – poor to medium and of potassium – medium to very good. The soil has slightly acidic to neutral reaction and low humus content. These soil conditions are favorable for perennial ryegrass growth and development. The experiment was established by the long plot method in three replications with the size of the harvested plot – 5 m^2, precipitation in mm is presented in Table 1.

The sowing was done in spring (March) with perennial ryegrass new variety IFK Harmoniya, developed in IFC (Katova et al., 2010), inter-row distance 36 cm and sowing rate – 20 kg/ha. Fertilizing was conducted with P_2O_5 – 100 kg/ha and N – 120 kg/ha (½ in spring + ½ in autumn), each year.

The manual removal of the weed was done during the growing season to eliminate their negative influence on crop and to measure only the effect of the herbicides.

Table 1. Precipitation for 2008–2010 period (mm)

Year \ Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
2008	62.2	3.2	20.8	78.1	57.8	31.1	31.5	17.1	65.3	62.3	9.3	30.4
2009	39.9	98.7	40.1	22.3	31.5	58.4	95.5	35.0	60.6	56.4	10.7	63.9
2010	42.2	74.1	78.8	60.5	73.7	85.1	110.0	22.8	23.6	–	–	–

Table 2. Treatments in the trial

Treatments	Application rate –commercial product ml (g) ha	Application rate – active ingredient ml (g) ha
V_1 – Check - untreated	–	–
V_2 – Arat (500 g/l dicamba+250 g/l tritosulfuron)	100	75
V_3 – Korida 75VDG (750 g/kg tribenuron-methyl)	15	11
V_4 – Cambio SL (320 g/l bentazone + 90 g/l dicamba)	1250	513
V_5 – Grasp 25SK (250 g/l tralkoxydim) + Atplus 463	1000 + 1000	250 + 1000
V_6 – Topik 080EK (80 g/l clodinafop-propargyl + antidote)	300	24

The subject of the study were systemic foliar herbicides, which are registered in our country for cereal crops (www.videnovisin.com, 2009, 2010, 2011). Concerning the spectrum of activity they control annual and some perennial broadleaf weeds including these resistant to the herbicides: Arat (500 g/kg dicamba + 250 g/kg tritosulfuron), Korida 75VDG (750 g/kg tribenuron-methyl), Cambio SL (320 g/l bentazone + 90 g/l dicamba); and the group of annual grass weeds, including wild oat (*Avena fatua* L.): Grasp 25SK (250 g/l tralkoxydim) + Atplus 463 and Topik 080EK (80 g/l clodinafop-propargyl + antidote). Trial treatments and herbicide application rates are shown in Table 2.

The treatment was conducted with 400 l/ha spray liquid by hand sprayer "Mathaby", conic nozzle, pressure – P max 3 bar, V max 1.56 l, Q max 0.6 l/ min. at 2-4 leaf stage during establishing year of the stand, and from spring growth until the stage of the beginning of shooting up in seed production year.

The perennial ryegrass has a winter type of development and generative tillers are formed during the second year of the stand. For that reason, seeds were harvested from first to third year of the crop growing.

The following characteristics were observed to obtain in the purpose of the study: phytotoxicity of the herbicides to the crop 7, 14 and 30 days after treatment (DAT) and during seed harvesting – by logarithmic scale of EWRS (European Weed Research Society) from 1 to 9 score (score 1 – no damages and score 9 – the crop is completely destroyed); structural analysis of the elements of the productivity in 60 generative tillers for each treatment; number of generative tillers per m^2; seed yield and dry biomass yield with statistical method of dispersion data analysis; seed qualities (1000 seed weight – TSW, germination energy and germination).

RESULTS AND DISCUSSION

Perennial ryegrass has slow pace of growth and development during establishing year of the stand, and therefore low concurrence ability concerning weeds. Important circumstance for real estimation of the influence of the herbicides to cultivated crops is presence of stand with high density and uniform development. Rainfalls immediately after sowing at quantity of 20.8 mm and next rainfalls of 109.7 mm made favorable conditions for germination (Table 1). The observations and measurements by logarithmic scale of EWRS (Table 3) showed differences in values of presented selectivity of the herbicides. Arat (dicamba + tritosulfuron), Korida 75VDG (tribenuron-methyl) and Cambio SL (bentazone + dicamba) did not cause any phytotoxic effects to perennial ryegrass during the first year, as well as in seed production year. Different phytotoxic effects were registered for Grasp 25SK (tralkoxydim) + Atplus 463 and Topik 080EK (clodinafop-prop-argyl + antidote). Higher phytotoxicity was caused by Grasp 25SK. 14 DAT the damages were serious (score 6), expressed as inhibition and weaker tillering of the plants. The same effects were also observed 30 DAT. Topik 080EK had more tolerant action to the crop. Until 7 DAT during the first year there was no phytotoxic effect, and during next period it was weak, and reached the score 3.

In seed productive years selectivity of herbicides in control of broadleaf weeds was confirmed, while herbicides for control of grass weeds caused different phytotoxic effects. 7 DAT Grasp 25SK caused weak to moderate inhibition of the growth (score 4), which became stronger 14 DAT (score 5) with necrotic parts on the leaf mass. Damages were serious 30 DAT (score 7), with negative reflection on the heading. The herbicide Topik 080EK during the seed productive years expressed selectivity to crop, which allowed its application in this period for control of annual grass weeds, including wild oat (*Avena fatua*).

Table 3. Selectivity of herbicides to perennial ryegrass (*Lolium perenne* L.)

Herbicide	Damage score (According to EWRS*)					
	Days after treatment					
	7		14		30	
	A**	B***	A	B	A	B
Arat	1	1	1	1	1	1
Korida 75BDG	1	1	1	1	1	1
Cambio SL	1	1	1	1	1	1
Grasp 25SK	1	4	6	5	6	7
Topik 080EK	1	1	3	1	3	1

*EWRS – logarithmic scale (1-9) – score 1 – without damages; score 9 – the crop is completely destroyed
**A – during the establishing year of the stand
***B – during seed production year

Table 4. Influence of herbicides on growth and development of perennial ryegrass (*Lolium perenne* L.) during harvesting of I-st cut in the year of establishing of the sward

Treatment*	Parameters					
	Vegetative tillers, number/m^2	SD (±)	Height of the stems, cm	SD (±)	Fresh weight of the stems, g/m^2	SD (±)
V_1	6355	St	21.3	St	1890	St
V_2	6407	+ 52	20.5	– 0.8	1862	– 28
V_3	6375	+ 20	21.5	+ 0.2	1824	– 66
V_4	6311	– 44	21.5	+ 0.2	1848	– 42
V_5	2711	– 3644	14.5	– 6.8	690	– 1200
V_6	5980	– 375	18.5	– 2.8	1714	– 176
Average	**5690**		**19.6**		**1638**	
min	**2711**		**14.5**		**690**	
max	**6407**		**18.5**		**1890**	

* Treatments are the same as in Table 1

Herbicide effects and estimations obtained by logarithmic scale of EWRS confirmed the results of harvesting for the forage in the first year (Table 4). The values of fresh weight of vegetative tillers per m^2, and also the height of the stands, treated with Arat, Korida 75 VDG and Cambio SL, were in harmony with those of an untreated check (V_1). As a result of expressed phytotoxicity of the herbicides to control grass weeds these characteristics were significantly reduced: according to the number of vegetative tillers by 6% (V_6) to 43% (V_5), and according to their weight by 9 to 63%, respectively.

Influence of herbicides, depending on their selectivity, on seed productivity of perennial ryegrass is shown in Table 5. During first harvesting year the seed yield was from 70 to 865 kg/ha, and during the second one – from 278 to 738 kg/ha. The reason for the low seed yield of V_5 treatment in 2009 was high phitotoxicity of Grasp 25SK, but during second seed production year 2010, with aging of the stand it was overcome to some extent.

Significant deviation was observed in values of this character for the stand treated with Grasp 25SK, which were with a very good negative evidence. This tendency was kept during two seed productive years, as in the experimental period the average value of seed yield was 77.9% lower in comparison with untreated check (V_1). Insignificant differences in the seed yield from the stands treated with Arat, Korida 75VDG and Cambio SL and from these treated with Topik 080EK was the evidence of their high selectivity to the crop. No evidence of these differences in comparison with untreated check (V_1) confirmed this fact.

Data analysis of the elements of seed productivity showed relationship with those of the above mentioned character (Table 6). The density of generative tillers in stands, treated with selective herbicides was between margins from 3348 to 3411 tillers/m^2 during first harvest year and from 2766 to 2838 tillers/m^2 during second one. As a result of expressed phytotoxicity of Grasp 25SK, significantly lower number of generative tillers was formed, 276 and 832 tillers/m^2 (V_5), respectively. For that reason significant reduction in the values of height characters of generative tillers (38.5-54.2 cm) and the length of ear (12.3-15.1 cm) was found in comparison to the average values from 56.1 to 71.0 cm and from 16.5 to 18.7 cm, respectively. According to the 1000 seed weight there were no regular differences and it was from 1.60 to 1.65 g in the first and from 1.44 to 1.51 g in the second year.

Table 5. Influence of the herbicides on seed productivity of perennial ryegrass (*Lolium perenne* L.)

Treatment*	Seeds					
	2009		2010		Average 2009-2010	
	kg/ha	% V_1	kg/ha	% V_1	kg/ha	% V_1
V_1	852	100	724	100	788	100
V_2	850	99.8	722	99.7	786	99.7
V_3	847	99.4	735	101.5	791	100.4
V_4	861	101.1	738	101.9	800	101.5
V_5	70	8.2	278	38.4	174	22.1
V_6	865	102.0	719	99.3	792	100.5
GD $P_{5\%}$	**15.0**		**17.2**		**11.6**	
$P_{1\%}$	**21.4**		**24.4**		**16.5**	
$P_{0.1\%}$	**30.9**		**35.3**		**23.9**	

* Treatments are the same as in Table 1

Table 6. Parameters of seed yield of *Lolium perenne* L.

Treatment*	Generative tillers				Length of the ear, cm		1000 seed weight, g	
	number/m^2		height, cm					
	2009	2010	2009	2010	2009	2010	2009	2010
V_1	3360	2794	59.9	74.1	17.3	19.4	1.64	1.48
V_2	3348	2781	60.0	74.5	17.2	19.5	1.65	1.47
V_3	3392	2829	58.8	73.9	17.3	19.7	1.62	1.46
V_4	3395	2838	59.9	75.0	17.1	19.4	1.60	1.48
V_5	276	832	38.5	54.2	12.3	15.1	1.62	1.44
V_6	3411	2766	59.6	74.0	17.9	19.2	1.64	1.51
Average	**2864**	**2473**	**56.1**	**71.0**	**16.5**	**18.7**	**1.63**	**1.47**
min	**276**	**832**	**38.5**	**54.2**	**12.3**	**15.1**	**1.60**	**1.44**
max	**3411**	**2838**	**60.0**	**75.0**	**17.9**	**19.7**	**1.65**	**1.51**

* Treatments are the same as in Table 1

Table 7. Dry biomass productivity of *Lolium perenne* L.

Treatment*	Dry biomass							
	2008		2009		2010		Average 2008/2010	
	kg/ha	% V_1	kg/ha	% V_1	kg/ha	% V_1	kg/ha	% V_1
V_1	3430	100	9120	100	11190	100	7910	100
V_2	3620	106	9610	105	11000	98	8080	102
V_3	3260	95	8950	98	11330	101	7850	99
V_4	3470	101	9090	100	11420	102	7990	101
V_5	1250	36	3350	37	6220	56	3610	46
V_6	3080	90	9130	100	1129	101	7830	99
GD $P_{5\%}$	**700.9**		**201.9**		**256.2**		**352.0**	
$P_{1\%}$	**969.3**		**287.2**		**364.4**		**500.7**	
$P_{0.1\%}$	**1339.6**		**415.7**		**527.5**		**724.7**	

* Treatments are the same as in Table 1

From seed production tillers of perennial ryegrass (Table 7) significant quantity of additional dry biomass production was obtained, formed from crop residues and aftermath (Dimitrova, 1995; Katova, 2005).

Average values of formed yield from the stands treated with selective herbicides were from 7830 to 8080 kg/ha in the experimental period. Again for this character, a negative influence was recorded as the result of inhibiting effect of Grasp 25SK. The yield of dry biomass from this stand was 54% lower in comparison with untreated check with a very good negative significant difference in the yield.

CONCLUSIONS

Arat (500 g/l dicamba + 250 g/l tritosulfuron) at rate of 100 ml/ha, Korida 75 VDG (750 g/kg tribenuron-methyl) – 15 g/ha and Cambio SL (320 g/l bentazone + 90 g/l dicamba) – 1250 ml/ha (in control of broadleaf weeds) showed high selectivity to perennial ryegrass, applied at 2-4 leaf stage during establishing year of the stand and until the stage of the beginning of shooting up in the seed production year.

Topik 080EK (80 g/l clodinafop-prop-argyl + antidote) at rate of 300 ml/ha can be used in control of grass weeds in seed production stands of perennial ryegrass .

Grasp 25SK (250 g/l tralkoxydim) + Atplus 463 at rate of 1000 + 1000 ml/ha showed phytotoxic effects on perennial ryegrass, and reduced seed and dry biomass productivity.

The realization of the biological potential concerning seed and dry mass yield of perennial ryegrass demands application of selective herbicides Arat, Korida 75 VDG and Cambio SL in control of broadleaf weeds and Topik 080EK in control of grass weed species.

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Selektivnost nekih herbicida prema engleskom ljulju (*Lolium perenne* L.), gajenom za proizvodnju semena

REZIME

Tokom 2008-2010, na eksperimentalnom polju Instituta za krmno bilje, Pleven, na slabo propusnom černozemu sprovedeno je istraživanje sa ciljem da se utvrdi selektivnost nekih herbicida prema engleskom ljulju (*Lolium perenne* L.) i njihov uticaj na prinos semena. Kao rezultat istraživanja dobijeno je sledeće: herbicidi za suzbijanje širokolisnih korova – Arat (500 g/l dicamba + 250 g/l tritosulfuron) u količini primene 100 ml/ha, Korida 75 VDG (750 g/kg tribenuron-methyl) – 15 g/ha i Cambio SL (320 g/l bentazone + 90 g/l dicamba) – 1250 ml/ha ispoljili su visoku selektivnost prema engleskom ljulju, kada su primenjeni u fazi 2-4 lista prilikom zasnivanja useva i u kasnijim godinama gajenja. Herbicid namenjen za suzbijanje travnih korova: Topik 080EK (80 g/l clodinafop-prop-argyl + antidote) u količini primene 300 ml/ha, kada se primeni u istoj fazi može da se koristi u engleskom ljulju za proizvodnju semena. Herbicid za suzbijanje travnih korova – Grasp 25SK (250 g/l tralkoxydim) + Atplus 463 u količini primene 1000 + 1000 ml/ha ispoljio je fitotoksičan efekat na *L. perenne* i prouzrokovao smanjenje prinosa semena i suve biomase. Realizacija biološkog potencijala u vezi sa prinosom semena i suve mase engleskog ljulja zahteva primenu selektivnih herbicida Arat, Korida 75 VDG i Cambio SL u suzbijanju širokolisnih korova i Topik 080EK u suzbijanju travnih korova.

Ključne reči: Engleski ljulj (*Lolium perenne* L.); herbicidi; selektivnost; seme; suva biomasa