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Selectivity of some herbicides applied to Bulgarian variety of perennial ryegrass (*Lolium perenne* L.) IFK Harmoniya during stand establishment and seed production

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Abstract

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During the period 2014-2016 on the experimental field of the Institute of Forage Crops – Pleven a study was conducted with the purpose to determine the selectivity of some herbicides to Bulgarian variety of perennial ryegrass (*Lolium perenne* L.) IFK Harmoniya during stand establishment and seed production. It was found that herbicides Accurate 60 WG (600 g/kg of metsulfuron-methyl) – 10 g/ha, Ally Max (143 g/kg tribenuron methyl + 143 g/kg metsulfuron methyl) – 35 g/ha and Eagle 75 WG (750 g/kg chlorsulfuron) – 20 g/ha showed high selectivity to perennial ryegrass (*Lolium perenne* L.) and can be applied at the growth stage BBCH 12-14 on the crop, during establishing year of the stand for control of broadleaf weeds. Accurate 60 WG – 10g/ha and Ally Max – 35 g/ha applied at the growth stage (BBCH 28-30) in the year of seed production had a high selectivity to perennial ryegrass and can be applied for control of broadleaf weeds. Applied low dose of Axial One (45 g/l pinoxadene + 5 g/l florasulam) – 350 ml/ha had hormesis effect to perennial ryegrass and can be used for stimulation the accumulation of fresh and dry biomass during the year of stand establishment and, as well as in the years of seed formation. The herbicide tolerance of perennial ryegrass to key herbicides with complex action (for weed control against annual monocotyledonous and dicotyledonous weeds) has been determined, which could serve as a means of increasing the efficiency of the breeding process.

Keywords: perennial ryegrass; herbicides; selectivity; biomass; seed productivity

Introduction

Perennial ryegrass (*Lolium perenne* L.) is the subject of study by a number of researchers, due to the multifunctional uses – highly productive potential for forage and seed production including amenity grassland, sports turf and other. It is widely distributed throughout the world, including North and South America, South Africa, Europe, New Zealand, and the temperate regions of Japan and Australia (Smit et al., 2005; Matthew et al., 2012; Abraha et al., 2015; Cui et al., 2015; Katova, 2016b; He et al., 2017; Keren, 2017).

According to studies by Humphreys et al. (2010), Sampoux et al. (2013), Katova (2015a, 2015b, 2015c, 2016a, 2016c, 2017a, 2017b) is performed reflected in a 100 years period of effort in plant breeding activity and high number of varieties (1558) on the OECD list and in 2017 and seed production since 2000 the EU-27 countries had produced, on average 83 660 t perennial ryegrass seed per year and in global scale 209 674 t per year.

The first Bulgarian variety of perennial ryegrass (*Lolium perenne* L.) IFK Harmoniya for establishment of pastures and meadows, in stands intended to control soil erosion, and for maintaining landscape coverage. The variety was created at the Institute of Forage Crops – Pleven (Katova, 2011). It is a diploid, early, high-productive, environmentally stable (winter-resistant and drought-tolerant) and long-lasting, registered in the Official List of Bulgaria, in the OECD list for 2010–2017 and in the Common European Catalog of Varieties of Agricultural Cultures for 2009-2017.

Perennial ryegrass, and other members of the group of perennial grasses, are characterized with slow growth and development during the year of stand establishment and and seed production years. During these periods of their development they are very sensitive to the competitive influence of weeds (Dimitrova & Katova, 2010, 2011, 2013; Sanna et al., 2014; Katin-Grazzini, 2018).

In recent years, there has been a tendency to improve the chemical method for weed control by increasing selectivity of herbicides and expanding their spectrum of action for efficient weed control at a number of agricultural crops (Tanetani et al., 2013).

Although weed control in the perennial ryegrass (*Lolium perenne* L.) are extremely limited in Bulgaria and abroad we had established herbicides that can be used to control broadleaf weeds during establishing and seed production years (Dimitrova, 1984, 1995, 2002; Mueller-Warrant & Rosato, 2002a, 200b; Dimitrova & Katova, 2010, 2011; Katova & Dimitrova, 2013).

Grass weed species control in cereal crops is difficult because they are very similar morphology and physiology, irrespective of which some herbicides had been identified to the grass weed control in the perennial ryegrass (Dimitrova, 2007; Katova et al., 2018).

Understanding herbicide tolerance of breeding lines and new variety could help breeders develop selection strategies that maximize herbicide tolerance in new variety with high productivity. However, little is known about herbicide tolerance variability in perennial ryegrass (*Lolium perenne* L.) (Leon & Tillman, 2015).

Relevant studies for perennial ryegrass are very scarce, which is why this research was carried out. The aim of the study is to determine some systemic foliar herbicides, registered in our country for cereal crops and their selectivity to perennial ryegrass (*Lolium perenne* L.), variety IFK Harmoniya, to be applied during stand seed production and forage and to determine herbicide tolerance to key herbicides which could serve as a tool for increasing the efficiency of breeding process.

Materials and Methods

During the period of 2015–2017, a study was conducted in the experimental field of the Institute of Forage Crops – Pleven on a slightly leached chernozem soil under non-irrigating conditions. The experiment was set up using the perpendicular method and the size of the treatment plot of 3 m^2. Treatments of the trial are shown in Table 1.

The herbicidal formulations used in this study were registered for weed control in cereal-grain grown crops in Bulgaria with herbicide action against broadleaf weeds including resistant ones to the herbicides: Accurate 60 WG (600 g/kg metsulfuron methyl), Ally Max (143 g/kg metsulfuron + 143 g/kg tribenuron methyl), and with complex action against annual and broadleaf weeds – Eagle 75 WG (750 g/kg chlorsulfuron), including wild oat (*Avena fatua* L.), Axial One (45 g/l pinoxadene + 5 g/l florasulam), Basis 75 DF (250 g/kg thifensulfuron methyl + 500 g/kg rimsulfuron) and Pacifica WG (30 g/kg mesosulfuron-methyl + 10 g/kg odosulfuron-methyl sodium + 90 g/kg mefenpyr-diethyl) + Adjuvant Biopower.

For the field experiment the first Bulgarian variety perennial ryegrass (*Lolium perenne* L.) IFK Harmoniya, created at the Institute of Forage Crops – Pleven (Katova, 2011) was used.

The perennial ryegrass (*Lolium perenne* L.) was sown in the early spring at inter-row distance of 36 cm and sowing rate of 20–22 kg/ha. Stockpiling fertilizing was done with P_2O_5 – 100 kg/ha and N – 120 kg/ha (½ in spring + ½ in autumn each year).

Table 1. Trial treatments – herbicides and dose of an application

Treatments	Herbicides		Doses of commercial product, ml(g)/ha		
1	Control (untreated) K_u				
2	Accurate 60 WG	600 g/kg metsulfuron methyl	5	10	15
3	Axial One	45 g/l pinoxadene + 5 g/l florasulam	350	700	1050
4	Pacifica WG + Adjuvant Biopower	30 g/kg mesosulfuron-methyl + 10 g/kg odosulfuron-methyl sodium + 90 g/kg mefenpyr-diethyl	175+350	350+700	525+1050
5	Ally Max	143 g/kg metsulfuron + 143 g/kg tribenuron methyl	17.5	35	52.5
6	Eagle 75 WG	750 g/kg chlorsulfuron	10	20	30
7	Basis 75 DF	250 g/kg thifensulfuron methyl + 500 g/kg rimsulfuron	12	24	36

The application of the all herbicides was conducted with 400 l/ha water solutions using a spreading machine PTP 18 with conic nozzle, pressure P *max* 3 bar, V *max* 1.64 l, and *Q max* 0.64 l/min, at the growth stage 2–4 leaf (BBCH 12-14) during establishing year of the stand, and from spring growth until the stage of the beginning of shooting up (BBCH 21-34) in seed production year.

The following characteristics were assessed: phytotoxicity on herbicides to the perennial ryegrass (*Lolium perenne* L.) on 7, 14, 21, 30 and 45 days after treatment (DAT), using the 1–9 logarithmic scale of EWRS (EuropeanWeed Research Society) (score 1 – no damage and score 9 – completely destroyed crop); frech, dry biomass and seed yield productivity kg/ha. Major agro-climatic characteristics of the period of study were recorded: rainfall amount (mm) and average year air temperature (°C). The De Martonne aridity index (*Iar-DM*) was used to characterize the aridity during the study period.

All experimental data were statistically processed using the software STATGRAPHICS Plus for Windows Version 2.1. and Statistika ver. 10.

Results and Discussion

Estimating the complex effect of some major meteorological indicators, rainfall amount and average year air temperatures, with regard to perennial ryegrass (*Lolium perenne* L.) biological requirements during the studied years are differed significantly (Table 2).

The total rainfall amount during the period of study can be presented in the following ascending order: 2016 < 2015 < 2017 and in reverse dependence on regard to average year air temperatures: 2017 < 2016 < 2015. The agro-meteorological conditions during the years of study showed deviations for temperature (+0.9 to +1.8°C) and rainfall amount (from 12.0 to 43.0%), as compared to those for the multy-year period (1964–2014) (Table 2).

Assessing the complex impact of meteorological factors (rainfall and air temperatures) according the De Martonne aridity index *(Iar-DM*), periods during the study years can be classified conventionally as 2015 and 2016 are moderately arid, respectively I_{ar}-DM_{2016} – 27.0 and I_{ar}-DM_{2015} – 29.9, and 2017 year is slightly humid (*Iar-DM* – 35.0) (Table 2).

Perennial ryegrass (*Lolium perenne* L.), has slow pace of growth and development during establishing year of the stand, and therefore low concurrence ability concerning weeds (Dimitrova, 1984, 2002). Most important circumstance for real estimation of the influence of the herbicides applied postemergences to perennial ryegrass is presence of stand with high density and uniform development (Mueller-Warrant & Rosato, 2002a, 2002b; Dimitrova, 2007; Dimitrova & Katova, 2011; Katova & Dimitrova, 2013).

The tolerance of each plant species to the herbicide is within the scope of the divided boundaries. When the applied doses is higher than the registered from manufacturer, and especially when the herbicide treatment is under adverse weather conditions, it may had negative effects. In the majority of cases, negative effects are judged by the visual manifestations, which may be different, but most often are chlorosis, necrosis, delay and growth retardation, etc. However, it is known that many xenobiotics, including herbicides, can temporarily suppress physiological processes without this lead to a visual event (Ramel et al., 2012; Stoyanova et al., 2016).

The results of the observations and measurements by vizual logarithmic scale of EWRS (Table 3) show that phytotoxic effects on perennial ryegrass during the first year, as well as in seed production year were very weak (score 2-3) after Accurate 60 WG (600 g/kg metsulfuron methyl) and Ally Max (143 g/kg metsulfuron + 143 g/kg tribenuron methyl) were applied at optimal and one half to the higher doses.

The values of fresh and dry biomass accumulated per m^2 on perennial ryegrass (*Lolium perenne* L.) during the first year after treatment with Accurate 60 WG (600 g/kg metsulfuron methyl) and Ally Max (143 g/kg metsulfuron + 143 g/kg tribenuron methyl) were in harmony with those of an untreated control and the differences statistically not significant at P = 0.05.

Phytotoxic effects on perennial ryegrass were registered after applied the herbicides Eagle 75 WG (750 g/kg chlorsulfuron) and Basis 75 DF (250 g/kg thifensulfuron meth-

Table 2. Rainfall amount (mm), air temperature (°C) and De Martonne aridity index (*I_{ar}-DM*) for the study period

Years	Rainfall (mm)		Average year air temperature (°C)		Index of aridity (I_{ar}-*DM*) for the period (I – XII)
	I – XII	Deviation, %	I – XII	Deviation, °C	
2015	707.5	126.7	13.7	1.8	29.8
2016	625.4	112.0	13.2	1.3	27.0
2017	798.0	143.0	12.8	0.9	35.0
Average period (1964–2014)	558.2	100.0	11.9	0.0	25.5

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

Herbicides	Dose of commercial product, ml(g)/ha	Phytotoxicity damage score (according to EWRS)									
		7 DAT		14 DAT		21 DAT		30 DAT		45 DAT	
		A[1]	*B*[2]	*A*[1]	*B*[2]	*A*[1]	*B*[2]	*A*[1]	*B*[2]	*A*[1]	*B*[2]
Accurate 60 WG	5	1	1	1	1	2	2	2	2	2	2
	10	1	1	1	1	2	2	2	2	2	2
	15	1	1	3	2	3	2	3	2	3	2
Axial One	350	1	1	3	3	4	3	5	4	5	5
	700	4	1	6	3	6	5	7	6	8	6
	1050	4	9‡	7	9‡	7	9‡	8	9‡	9	9‡
Pacifica WG + Biopower	175 + 350	4	1	5	3	6	3	6	6	6	7
	350 + 700	4	9‡	6	9‡	7	9‡	8	9‡	9	9‡
	525 + 1050	5	9‡	6	9‡	7	9‡	8	9‡	9	9‡
Ally Max	17.5	1	1	1	1	1	1	1	1	1	1
	35	1	1	1	1	2	1	2	1	2	1
	52.5	1	1	2	2	3	2	3	2	3	2
Eagle 75 WG	10	1	1	3	2	4.5	3	5	2	5	2
	20	2	2	5	3	7	3	7	3	7	3
	30	2	2	5	3	7	3	7	3	7	3
Basis 75 DF	12	1	1	3	3	4	4	4	4	4	4
	24	2	2	3	3	5	5	5	5	5	5
	36	3	3	5.5	9‡	7	9‡	7	9‡	7	9‡

Legend: EWRS logarithmic scale (1–9): score 1 – without damages, score 9 – the crop is completely destroyed; A[1] – during the establishing year of the stand, B[2] – during seed production year, DAT – day after treatment, ‡ – the plants died after treatment with the herbicide in the establishing year

yl + 500 g/kg rimsulfuron) with three doses. Phytotoxicity is expressed in a retardation of the growth of culture and presence of chlorosis. Higher phytotoxicity was caused by Eagle 75 WG (750 g/kg chlorsulfuron) in comparison Basis 75 DF (250 g/kg thifensulfuron methyl + 500 g/kg rimsulfuron). Fourteen days after the treatment with the herbicides (14 DAT) the damages were expressed as inhibition and weaker tillering of the plants about by Eagle 75 WG (750 g/kg chlorsulfuron) – EWRS score from 3 to 5.5 (average 4.5) and Basis 75 DF (250 g/kg thifensulfuron methyl + 500 g/kg rimsulfuron) – score 3–5 (average 3.7) during the year of stand establishment. By increasing the vegetation period of perennial ryegrass to 21, 30 and 45 DAT phytotoxicity effects from herbicides Eagle 75 WG (750 g/kg chlorsulfuron) and Basis 75 DF (250 g/kg thifensulfuron methyl + 500 g/kg rimsulfuron) increases from 1.3 to 1.7 times (EWRS score 5–7) and the observed symptoms remain.

As a result of expressed phytotoxicity of the herbicides to complex action against annual and broadleaf weeds Eagle 75 WG (750 g/kg chlorsulfuron), including wild oat (*Avena fatua* L.) Basis 75 DF (250 g/kg thifensulfuron methyl + 500 g/kg rimsulfuron) these characteristics were significantly reduced: according to fresh biomass after treatment by Eagle 75 WG (from 11.3 to 63.0%) and by Basis 75 DF (from 26.5 to 79.9%), and according formated dry biomass by 4.8 to 53.6 and 22.0 to 77.0%, respectively (Table 4).

Very strong phytotoxicity (score 6–7) was established 14 DAT with herbicides Axial One (45 g/l pinoxadene + 5 g/l florasulam) and Pacifica WG (30 g/kg mesosulfuron-methyl + 10 g/kg odosulfuron-methyl sodium + 90 g/kg mefenpyr-diethyl) + Adjuvant Biopower at optimal and one half to the higher doses expressed in chlorosis and strong suppression of growth and development of plants (Table 3 and 4). However, for experimental field and agrometeorological conditions, the amount of fresh and dry biomass accumulated from perennial ryegrass at m^2 formed after treatment with Axial One (45 g/l pinoxadene + 5 g/l florasulam) low doses (350 ml/ha) elicited a stimulating effect from 4.5 to 23.4%, while the applied increased dose causes a lethal effect at the perennial ryegrass.

Similar results in experimental work had been reported by Thomas et al. (2005), Belz et al. (2011) and Velini et al. (2010), according to which the applied low rates of glyphosate sulfometuron-methyl, dicamba and 2,4-D also can stimulate plant growth (this effect is called hormesis). At low doses, triazine herbicides stimulate growth through beneficial effects on nitrogen metabolism and through auxin-like effects. When applied at recommended rates for weed control are effective, low-cost plant growth regulators and

Table 4. Influence of herbicides on productivity of perennial ryegrass (*Lolium perenne* L.) during harvesting of 1-st cut in the year of establishing of the sward and seed yield

Herbicides	Dose of commercial product, ml(g)/ha	Productivity in the year of establishing				Seed yield	
		fresh biomass		dry biomass			
		kg/m²	% K_U	kg/m²	% K_U	kg/ha	% K_U
Untreated control (K_U)		2.601[ab]	100.0	0.688[a]	100,0	70.4[d]	100.0
Accurate 60 WG	5	2.971[b]	114.2	0.889[b]	129.2	73.0[d]	103.7
	10	2.842[b]	109.3	0.880[b]	127.9	64.5[cd]	49.0
	15	2.201[a]	84.6	0.621[a]	90.3	45.9[ab]	22.6
Axial One	350	2.717[b]	104.5	0.849[b]	123.4	74.0[bc]	105.1
	700	2.274[b]	87.4	0.674[b]	98.0	43.5[abc]	61.8
	1050	0.000[a]	–	0.000[a]	0.0	0.0[a‡]	–
Pacifica WG + Biopower	175 + 350	2.224[b]	85.5	0.463[a]	67.3	3,6[a]	5.1
	350 + 700	0.000[a]	–	0.000[a]	–	0.0[a‡]	–
	525 + 1050	0.000[a]	–	0.000[a]	–	0.0[a‡]	–
Untreated control (K_U)		0.994[ef]	100.0	0.209[ef]	100,0	65,0[d]	100.0
Ally Max	17.5	0.801[de]	80.6	0.198[e]	94.7	60.9[d]	93.7
	35	0.810[de]	81.5	0.201[ef]	96.2	60.7[d]	93.4
	52.5	0.484[bc]	48.7	0.137[bcd]	65.6	47.3[cd]	72.8
Eagle 75 WG	10	0.882[e]	88.7	0.199[e]	95.2	36.1[bc]	55.5
	20	0.853[e]	85.8	0.200[e]	95.7	18.9[ab]	29.1
	30	0.368[ab]	37.0	0.097[ab]	46.4	14.5[ab]	22.3
Basis 75 DF	12	0.731[cd]	73.5	0.163[cd]	78.0	12.2[a]	18.8
	24	0.577[bc]	58.0	0.130[bc]	62.2	8.1[a]	12.5
	36	0.200[a]	20.1	0.048[a]	23.0	0.0[a‡]	–

Legend: Means with different letters differ at $P < 0.05$ level of probability by LSD test; ‡ – the plants died after treatment with the herbicide in the establishing year

can inhibit rust diseases in many crops (barley, coton, soybean, sugar cane, wheat, vigna, and others crops) (Velini et al., 2010; Correia & Leite, 2012; Georgiev et al., 2014; Georgiev, 2014, 2015; Rana & Rana, 2015). The selectivity of the applied herbicides to perennial ryegrass sensitivity is in positive correlation with the dose (*r* ranging from 0.938 to 0.997) in negative dependence on vitality (*r* is within the limits -0.087 to -0.981).

In seed productive years on perennial ryegrass selectivity of herbicides Accurate 60 WG (600 g/kg metsulfuron methyl), Ally Max (143 g/kg metsulfuron + 143 g/kg tribenuron methyl) for the control of only broadleaf weeds was confirmed, while herbicides with complex action against annual and broadleaf weeds Eagle 75 WG (750 g/kg chlorsulfuron), including wild oat (*Avena fatua* L.) Axial One (45 g/l pinoxadene + 5 g/l florasulam), Basis 75 DF (250 g/kg thifensulfuron methyl + 500 g/kg rimsulfuron) and Pacifica WG (30 g/kg mesosulfuron-methyl + 10 g/kg odosulfuron-methyl sodium + 90 g/kg mefenpyr-diethyl) + Adjuvant Biopower caused higher phytotoxic effects (Table 4).

Seven days after treatment (7 DAT) Accurate 60 WG (600 g/kg metsulfuron methyl) and Ally Max (143 g/kg metsulfuron + 143 g/kg tribenuron methyl) applied in optimal and over dosed provoked very weak phytotoxity effect (score 2) on growth and development on perennial ryegrass. With increasing vegetation period 14, 21, 30 and 45 days after treatment herbicides are very weak and established phytotoxic changes on the plants observed (score 2) which do not affect the growth of the perennial ryegrass.

The herbicides Eagle 75 WG (750 g/kg chlorsulfuron) and Basis 75 DF (250 g/kg thifensulfuron methyl + 500 g/kg rimsulfuron) applied during the seed productive years on perennial ryegrass expressed a relatively higher selectivity from 14 DAT (score 2–3), 21, 30 and 45 DAT (score 5-7) with chlorosis and necrotic parts on the leaf mass with negative reflection on the seed formation.

The application of Axial One (45 g/l pinoxadene + 5 g/l florasulam) at the dose of 350 ml/ha on perennial ryegrass in seed productive years has a weak stimulating statistically no significant effect on seed yield. With increase in the dose to 700 ml/ha, the yield of seeds decreased by 38.2% compared to the control variant (Table 3 and 4).

Similar are the results obtained in the experimental work of Dimitrova and Katova (2011) according to which the herbicides which controle broadleaf weeds as Arat (500 g/kg dicamba + 250 g/kg tritosulfuron), Korida 75VDG (750 g/

kg tribenuron-methyl) and Cambio SL (320 g/l bentazone + 90 g/l dicamba) do not cause a phytotoxic effect, but the treatment of ryegrass crops with herbicides with complex action against annual and broadleaf weeds, including wild oat (*Avena fatua* L.): Grasp 25SK (250 g/l tralkoxydim) + Atplus 463 and Topik 080EK (80 g/l clodinafop-propargyl + antidote) provoked phytotoxic effect and had negative reflection on the growth and development of perennial ryegrass (*Lolium perenne* L.) and seed formation.

The realization of the biological potential concerning seed and dry mass yield of perennial ryegrass imposes use of selective herbicides Accurate 60 WG (600 g/kg metsulfuron methyl) and Axial One (45 g/l pinoxadene + 5 g/l florasulam) in control of broadleaf weeds. Applied low dose of Axial One (45 g/l pinoxadene + 5 g/l florasulam) – 350 ml/ha had stimulation effect (hormesis) and can be used for stimulation the accumulation of fresh and dry biomass during the year of stand establishment, as well as in the years of seed formation.

These results confirmed perennial ryegrass (*Lolium perenne* L.) breeding programs would greatly benefit from screening new variety with high productivity for tolerance to key herbicides and developing an herbicide-tolerance catalog (Leon & Tillman, 2015). This information can be used in new breeding programs to reduce the risk of developing cultivars with low herbicide tolerance especially considering that perennial ryegrass had lower tolerance than herbicides with complex action (for weed control against annual monocotyledonous and dicotyledonous weeds).

Conclusions

The herbicides Accurate 60 WG (600 g/kg of metsulfuron-methyl) – 10g/ha, Ally Max (143 g/kg tribenuron methyl + 143 g/kg metsulfuron methyl) – 35 g/ha and Eagle 75 WG (750 g/kg chlorsulfuron) – 20 g/ha showed high selectivity to perennial ryegrass (*Lolium perenne* L.) and can be applied at the growth stage BBCH 12–14 on the crop, during establishing year of the stand for control of broadleaf weeds. Accurate 60 WG (600 g/kg of metsulfuron-methyl) – 10g/ha and Ally Max (143 g/kg tribenuron methyl + 143 g/kg metsulfuron methyl) – 35 g/ha applied at the growth stage (BBCH 28–30) in the year of seed production had a high selectivity to perennial ryegrass (*Lolium perenne* L.) and can be applied for control of broadleaf weeds.

Applied low dose of Axial One (45 g/l pinoxadene + 5 g/l florasulam) – 350 ml/ha had hormesis effect to perennial ryegrass (*Lolium perenne* L.) and can be used for stimulation the accumulation of fresh and dry biomass during the year of stand establishmentand, as well as in the years of seed formation.

Pacifica WG (30 g/kg mesosulfuron-methyl + 10 g/kg odosulfuron-methyl sodium + 90 g/kg mefenpyr-diethyl) + Adjuvant Biopower showed high phytotoxic (score 7) and lethal effect (score 9) on perennial ryegrass – reduced fresh and dry biomass.

The herbicide tolerance of perennial ryegrass to key herbicides with complex action (for weed control against annual monocotyledonous and dicotyledonous weeds) has been determined, which could serve as a means of increasing the efficiency of the breeding process.

References

Abraha, A., Truter, W., Annandale, J. & Fessehazion, M. (2015). Forage yield and quality responses of annual ryegrass (*Lolium multiflorum*) to different water and nitrogen levels. *African Journal of Range and Forage Science*, *32*(2), 125-131.

Belz, R., Cedergreen, N., & Duke, S. (2011). Herbicide hormesis – can it be useful in crop production? *Weed Research*, *51*, 321–332.

Correia, N. & Leite, G. (2012). Selectivity of the plant growth regulators trinexapac-ethyl and sulfometuron-methyl to cultivated species. *Scientia Agricola*, *69*(3), 194-200.

Cui, Y., Wang, J., & Wang, X. (2015). Phenotypic and Genotypic Diversity for Drought Tolerance among and within Perennial Ryegrass Accessions. *HortScience, 50*(8), 1148-1154.

Dimitrova, Ts. (1984). Study on weeds and their control in seed production of perennial legumes and grasses. Doctoral dissertation, Institute of Forage Crops, Pleven, Bulgaria (Bg).

Dimitrova, Ts. (1995). Study of the weed and their control in seed production of perennial ryegrass (*Lolium perenne* L.). *Rastenievadni Nauki*, 32, 168-170 (Bg).

Dimitrova, Ts. (2002). Selectivity of some herbicides to perennial ryegrass (*Lolium perenne* L.). *Rastenievadni Nauki*, *39*, 72-76 (Bg).

Dimitrova, Ts. (2007). Study concerning the selectivity of some herbicides to standard wheatgrass (*Agropyron desertorum* (Fisch. Schultes), cocksfoot (*Dactylis glomerata* L.) and perennial ryegrass (*Lolium perenne* L.). *Rastenievadni Nauki*, *44*, 162-166 (Bg).

Dimitrova, Ts., & Katova, A. (2010). Effect of growing conditions and weed control on the seed productivity of perennial ryegrass (*Lolium perenne* L.). *Herbologia, 11*, 21-31.

Dimitrova, Ts., & Katova, A. (2011). Selectivity of some herbicides to crested wheatgrass *(Agropyron cristatum* (L.) Gaertn*)* grown for seed production, *Herbologia, 12*(3), 73-81.

Georgiev, M. (2014). Influence of some herbicides and herbicide combinations on yield and harvest index in common wheat variety "Diamond". *Science & Technologies*, *4*(6), 280-286.

Georgiev, M. (2015). Investigation on wheat and barley weeds infestation in the Stara Zagora region and effective solutions for chemical weed control. Doctoral dissertation, Institute of Field Crops, Chirpan, Bulgaria.

Georgiev, M., Atanasova, D., & Delchev, Gr. (2014). Influence of some herbicides and herbicide combinations on grain yield and harvesting index in brewing barley. *Scientific Papers of the Institute of Agriculture – Karnobat*, *3*(1), 253-260.

He, L., Hatier, B., & Matthew, C. (2017). Drought tolerance of two perennial ryegrass cultivars with and without AR37 endophyte. *New Zealand Journal of Agricultural Research*, *60*(2), 173-188.

Humphreys, M. W., Feurstein, U., Vandewalle, M., & Baert, J. (2010). Raygrasses. In: B. Boller et al. (eds.), Fodder Crops and Amenity Grasses, Handbook of Plant Breeding 5, Springer Science Business Media, LLC 2010, 211-260.

Katin-Grazzini, L. (2018). Analyzing The Role of Gibberellin in Dwarfism and Shade Tolerance in Perennial Ryegrass (*Lolium perenne* L.). PhD thesis, University of Connecticut, https://opencommons.uconn.edu/cgi/viewcontent.cgi?article=8102andcontext=dissertations

Katova, A. (2011). New perennial ryegrass variety (*Lolium perenne* L.) IFK Harmoniya. *Journal of Mountain Agriculture on the Balkans*, *14*(4), 721-739.

Katova, A. (2015a). Intergeneric and intraspeific comperative progeny testing of perennial grasses. *Journal of Mountain Agriculture on the Balkans*, *18*(5), 802-815.

Katova, A. (2015b). Development of tetraploid perennial ryegrass varieties I. Colchicine treatment. *Proceedings of the Union of Scientists – Ruse*, *Agrarian and Veterinary Sciences*, *7*(3), 83-89 (Bg).

Katova, A. (2015c). Development of tetraploid perennial ryegrass varieties II. Flow cytometric analyses. *Proceedings of the Union of Scientists – Ruse*, *Agrarian and Veterinary Sciences*, *7*(3), 90-95 (Bg).

Katova, A. (2016a). Species and varieties of perennial grasses for high quality forage in Bulgaria. *Chinese Journal Heilongjiang Agricultural Sciences*, *1*, 138-145.

Katova, A. (2016b). Study on the productive potential of perennial ryegrass grown in pure stand and in mixtures with alfalfa. *Journal of Mountain Agriculture on the Balkans*, *19*(2), 85-100.

Katova, A. (2016c). Seed yield and its elements at competitive variety testing tetraploid perennial ryegrass. *Ecology and Future*, *15*(4), 29-35.

Katova, A. (2017a). Tetrany – the first Bulgarian tetraploid perennial ryegrass variety (*Lolium perenne* L.). *Journal of Mountain Agriculture on the Balkans*, *20*(1), 110-122.

Katova, A. (2017b). Tetramis – new tetraploid perennial ryegrass variety. *Journal of Mountain Agriculture on the Balkans*, *20*(1), 123-134.

Katova, A., & Dimitrova, D. (2013**).** Selectivity of some herbicides to standard wheatgrass (*Agropyron desertorum* (Fisch.) Schultes) during stand establishment and seed production. *Pesticides and Phytomedicine*, *28*(2), 125-131.

Katova, A., Marinov-Serafimov, Pl., Golubinova, I. & Dimitrova, Ts. (2018). Handbook for the seed production of perennial and annuals cereals forage crops. In press, IFC Pleven, 22 pp.

Keren, Z. (2017). Growth and feed quality of five perennial ryegrass (*Lolium perenne* L.) cultivars under three water treatments. Degree of Master of Applied Science, Lincoln University, Christchurch, New Zealand.

Leon, R., & Tillman, B. (2015). Postemergence Herbicide Tolerance Variation in Peanut Germplasm. *Weed Science*, *63*(2), 546-554.

Matthew, C., Van Der Linden, A., Hussain, S., Easton, H. S., Hatier, J. H. B., & Horne, J. (2012). Which way forward in the quest for drought tolerance in perennial ryegrass? In: *Proceedings of the New Zealand Grassland Association, 5-8 November 2012, Gore, New Zealand* (Vol. 74, pp. 195-200).

Mueller-Warrant, G. W., & Rosato, S. (2002a). Weed control for stand duration perennial ryegrass seed production: I. Residue removed. *Agronomy Journal*, *94*, 1181-1191.

Mueller-Warrant, G. W., & Rosato, S. (2002b). Weed control for stand duration perennial ryegrass seed production: II. Residue retained. *Agronomy Journal, 94*, 1192-1203.

Ramel, F., Sulmon, C., Serra, A. A., Gouesbet, G., & Couée, I. (2012). Xenobiotic sensing and signalling in higher plants. *Journal of Experimental Botany*, *63*(11), 3999–4014.

Rana, S., & Rana, M. (2015). Advances in Weed Management. Department of Agronomy, College of Agriculture, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur, 55 pp.

Sampoux, J. P., Baudouin, P., Bayle, B., Béguier, V., Bourdon, P., Chosson, J. F., De Bruijn, K., Deneufbourg, F., Galbrun, C., Ghesquière, M. & Noël, D. (2013). Breeding perennial ryegrass (*Lolium perenne* L.) for turf usage: an assessment of genetic improvements in cultivars released in Europe, 1974–2004. *Grass and Forage Science*, *68*(1), 33-48.

Sanna, F., Franca, A., Porqueddu, C., Piluzza, G., Re, G. A., Sulas, L., & Bullitta, S. (2014). Characterization of native perennial ryegrasses for persistence in mediterranean rainfed conditions. *Spanish Journal of Agricultural Research*, *12*(4), 1110-1123.

Smit, H. J., Tas, B. M., Taweel, H. Z., Tamminga, S., & Elgersma, A. (2005). Effects of perennial ryegrass (*Lolium perenne* L.) cultivars on herbage production, nutritional quality and herbage intake of grazing dairy cows. *Grass and Forage Science, 60*, 297-309.

Stoyanova, Sv., Ilieva, D., & Dochev, V. (2016). A studyind about the selectivity of a herbicide group of the wheat cultivar „Venka 1“ in conditions of Northeast Bulgaria. *Proceedings of University of Ruse, 55*(1.1), 47-51.

Tanetani, Y., Ikeda, M., Kaku, K., Shimizu, T., & Matsumoto, H. (2013). Role of metabolism in the selectivity of a herbicide, pyroxasulfone, between wheat and rigid ryegrass seedlings. *Journal of Pesticide Science*, *38*(3), 152-156.

Thomas, W. E., Burke, I. C., Robinson, B. L., Pline-Srnić, W. A., Edmisten, K. L., Wells, R., & Velini, E. D., Trindade, M. L., Barberis, L. R. M., & Duke, S. O. (2010). Growth regulation and other secondary effects of herbicides. *Weed Science, 58*(3), 351-354

Wilcut, J. W. (2005). Yield and physiological response of nontransgenic cotton (*Gossypium hirsutum*) to simulated glyphosate drift. *Weed Technology, 19*, 35-42.

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