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Biological Efficacy of Herbicides for Weed Control in Noncropped Areas

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SUMMARY

An increasing problem facing agricultural producers is the invasion of weeds, perennial in particular, so that implementation of industrial technologies is impossible without their highly efficient and rational control. For the purpose of studying efficient herbicides for weed control in noncropped areas (stubbles), a biological study of five total systemic herbicides was conducted in areas under natural weed infestation and pressure from other surrounding weeds at the Institute of Forage Crops in Pleven in 2005-2007. The trials were carried out in field conditions using the block method with plot size of 20 m^2. Treatment was conducted at the predominant stage of budding of perennial dicotyledonous weeds and earing of monocotyledonous weeds. Herbicidal efficacy was recorded on the EWRS 9-score scale (0-100% killed weeds = score 9-1).

It was found that treatment of noncropped areas (stubbles) with the total systemic herbicides Touchdown System 4 (360 g/l glyphosate); Cosmic (360 g/l glyphosate); Roundup Plus (441 g/l glyphosate potassium salt); Leon 36 SL (360 g/l glyphosate) and Glyphos Super 45 SL (450 g/l glyphosate) was highly efficient, so that it was a successful element of a strategy for controlling weeds of different biological groups, and was especially effective against perennial weeds.

Keywords: Herbicides; Efficacy; Weeds; Noncropped areas

INTRODUCTION

Weeds are useless and undesirable plants impeding the use of land and water resources and in this way they affect human welfare (Rao, 2000). According to Oerke (2005), population increase, limited acrage for crop cultivation, a need for more special nutrition, increased demand for bioenergy crops and negative consequences of global warming will necessitate greater production in the future, while at the same time reducing to a minimum damage to the environment. All this increases the need for weed studies, especially due to the fact that weeds reduce crop yields more than other pests.

Great species diversity and their high biological plasticity continue to be a major problem connected with weeds, enabling their fast spread and adaptation.

Experience worldwide has shown that the implementation of industrial technologies in agriculture is impossible without highly efficient and rational weed control. An increasing problem is the invasion of perennial weeds due to a great regenerative ability of their underground organs and their high seed productivity, as well as an underestimation of the role of crop rotation and some other cultural practices. The control of weeds in this biological group is difficult, especially during the growing season of crops. On the one hand, possibilities to apply efficient methods are more limited, while on the other weeds exert their competitive effects on cultivated plants over longer periods.

Some authors (Jeffery, 1981; Sheppard, 1984; Hallgren, 1985) have recommended in their studies the application of glyphosate herbicides before soybean, maize, wheat and barley harvests. In those cases, however, weeds have already exerted their negative effect but their reduced density will have a positive role in the following harvest year.

Integrated management was recognized as a preferred strategy in the programme of the United Nations Conference on Environment and Development (UNCED, 1992). According to Fetvadzhieva et al. (1982), Lyubenov (1987), Baeva (1994), Fetvadzhieva and Milanova (2002), Rogers (1981) and Sarpe (1982), integrated management combining a complex of methods and means, depending on the species, degree of weed infestation and the specific agro-ecological conditions, is the most efficient approach.

High effectiveness in weed control is achieved when combining conventional methods of soil tillage with treatments of noncropped areas (stubbles) with total systemic herbicides. The most suitable stage for treatment is early earing of grass weeds and budding of broad-leaved perennial weeds. Deep plowing should be conducted after about three weeks, so that herbicide translocation to weed underground organs can take place, while one or two replowings are conducted in autumn as required.

Preliminary control of perennial weeds is particularly important in perennial crops that remain in the same area for several years. Vydrina and Voskresenskaya (1988) achieved successful control of *Agropyrum repens* (L.) Pers. by preliminary treatment of an area for seed production of perennial grasses. The studies conducted in the area with high density of *Sorghum halepense* (L.) Pers. (346 plants/m^2) showed that successful control by an integrated approach, including treatment of an area with a total herbicide (Roundup) following treatment of a preceding crop, resulted in an increase in dry biomass yield of lucerne by 76%, and seed yield by 82% (Dimitrova, 1995), while herbicide effects reached 92-94% (Dimitrova, 2001).

Treatment of noncropped areas (stubbles), combined with other cultural practices, is a successful element of a weed control strategy, which has directed the attention of both researchers and manufacturing companies to total herbicides.

The objective of this work was to conduct a biological study of the effectiveness of herbicides in controlling weeds in noncropped areas (stubbles).

MATERIAL AND METHODS

The study was conducted in a noncropped area under natural weed infestation pressured also by infestation from the surrounding area at the Institute of Forage Crops in Pleven in the 2005-2007 period. The soil type was leached chernozem of pH 7.3-7.6. Regarding rainfall, the amounts over the January – December period of the study years can be conventionally arranged in the following ascending order 2007<2006<2005 and air temperature in the ascending order 2005<2006<2007 (Figure 1).

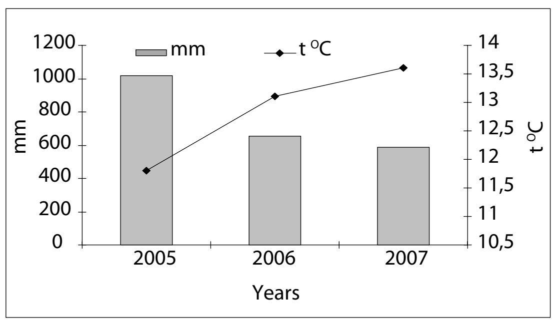

Figure 1. Dynamics of some meteorological factors in the period of study

The following total herbicides were studied: Touchdown System 4 (360 g/l glyphosate) at 1.5 and 4.0 l/ha rates with Roundup Bioforce (360 g/l glyphosate + 160 g/l surfactant) used as a standard at 3.0 and 5.0 l/ha rates; Cosmic (360 g/l glyphosate) at 12.0 l/ha with the standard Roundup (360 g/l glyphosate) at 12.0 l/ha; Roundup Plus (441 g/l glyphosate potassium salt) at 3.0, 4.0, 5.0, 6.0 and 8.0 l/ha with the standard Roundup (360 g/l glyphosate) at 3.0, 4.0, 5.0, 6.0 and 8.0 l/ha; Leon 36 SL (360 g/l glyphosate) at 4.0 and 12.0 l/ha with the standard Roundup (360 g/l glyphosate) at 4.0 and 12.0 l/ha; Glyphos Super 45 SL (450 g/l glyphosate) at 3.2 and 9.6 l/ha with the standard

Roundup (360 g/l glyphosate) at 4.0 and 12.0 l/ha. The applied product and standard rates were as recommended by their manufacturers and were applied with a working solution quantity of 500 l/ha. The trials were carried out using a block method with 4 replications and experimental plot size of 20 m^2. Treatment was conducted at the predominant stage of budding of perennial dicotyledonous weeds and earing of grass weeds.

The efficacy of herbicides was recorded several times and this publication presents the efficacy on the 21st day after treatment (recommended time for systemic herbicides). The EWRS 9-score scale (0-100% killed weeds = score 9-1) was applied. The experimental data is presented as average values for the period of study (Tables 1 to 5) because the tendency was the same in the different years.

RESULTS AND DISCUSSION

Species composition within the weed association of experimental area was represented by different biological groups: annual monocotyledonous; annual dicotyledonous; perennial monocotyledonous; and perennial dicotyledonous. Before treatment, the degree of weed infestation was high, and the weed species found were as follows: *Setaria spp.* – 111 n/m^2; *Panicum crus galli* L. – 42 n/m^2; *Amaranthus spp.* – 32 n/m^2; *Chenopodium album* L. – 21 n/m^2; *Portulaca oleraceae* L. – 17 n/m^2; *Sorghum halepense* (L.) Pers. – 39 n/m^2; *Cynodon dactylon* (L.) Pers. – 26 n/m^2; *Cirsium arvense* L. – 14 n/m^2; *Convolvulus arvensis* L. – 24 n/m^2; *Sonchus arvensis* L. – 12 n/m^2; *Euphorbia cyparissias* L. – 9 n/m^2; *Aristolochia clematitis* L. – 7 n/m^2.

The studied products were total, foliar-applied herbicides with a systemic effect. Phytotoxicity symptoms on the weeds were typical for this group of herbicides. As a result of the biological process of translocation, the active ingredient of the herbicides tested moved from the green leaf mass to all plant parts, reaching underground organs. In the first-second week after treatment, there was chlorosis of the aboveground parts, which changed into necrosis later on, and the weeds died completely at the end of the third week. These processes took a relatively more accelerated course in annual weeds as they are more sensitive.

The results of the study on Touchdown System 4 are presented in Table 1, using Roundup Bioforce (360 g/l glyphosate +160 g/l surfactant) as a standard. Regarding annual weeds from both groups (monocotyledonous and dicotyledonous) and *S. halepense* from seeds, a fast initial effect of the herbicide on weeds and a 100% kill at the lower dose of 1.5 l/ha were observed without deviations from the standard. In the perennial group of weed species, the efficacy of the same herbicide rate was slighter to insignificant, the killed weeds accounting for 25-75%. The efficacy of the standard at its low rate was 23-25% higher in some weeds (*C. arvense*, *C. dactylon* and *S. halepensis*). Herbicide efficacy reached 98-100% (score 3-1) at the applied product rate of 4.0 l/ha, but it was insufficient against *C. arvense* as merely 50% of those weeds were killed.

Herbicidal efficacy of the product Cosmic was identical to that of the standard Roundup (360 g/l glyphosate) – Table 2. This was probably due to the same active ingredient of the two herbicides studied at the rate of 12.0 l/ha. They achieved perfect efficacy (score 1) against the weeds present. Greater resistance was again shown by *C. arvensis* with a 95% kill (score 4). The high herbicide effect at this studied rate indicates a need to chose rate based on predominant weeds.

Biological study of the product Roundup Plus (Table 3) involved rates from 3.0 to 8.0 l/ha, using Roundup (360 g/l glyphosate) as a standard.

The lowest herbicide rate achieved 100% efficacy against species in the group of annual weeds and *S. halepense* from seeds. In the perennial weed group, *S. halepense* from rhizomes was the most sensitive, the killed weeds reaching 95-100% at the rate of 4.0-5.0 l/ha. However, these rates were insufficient for some more resistant perennial weeds (*C. dactylon*, *C. arvense*, *C. arvensis* and *S. arvensis*), which were found to develop necrosis of aboveground parts. Evidentlly, the basipetal translocation of the herbicide towards underground organs was insufficient. A high herbicidal effect (90-100%) was observed at the rates of 6.0 to 8.0 l/ha as anthocyan colouration was observed with internode maceration and complete dying of roots located near the central stem. Even at maximum rate, efficacy was very slight to slight (25-50%) against some perennial weeds that showed very high resistance (*E. cyparissias* and *A. clematitis*).

The product Leon 36 SL was studied again with Roundup (360 g/l glyphosate) as the standard, both having the same active ingredient (Table 4). The low rate of the herbicides (4.0 l/ha) successfully killed all annual weeds and *S. halepensis* from the seed, but it was not sufficiently efficient (25-75%) against species in the perennial weed group. The high rate (12.0 l/ha) achieved 100% efficacy against *S. halepense* from rhi-

Table 1. Efficacy of the herbicide Touchdown System 4 (360 g/l glyphosate) and standard Roundup Bioforce (360 g/l glyphosate + 160 g/l surfactants)

Weeds	Product Touchdown System 4				Standard Roundup Bioforce			
	1.5 l/ha	4.0 l/ha	3.0 l/ha	5.0 l/ha				
	1*	2**	1*	2**	1*	2**	1*	2**
Annual monocotyledonous								
Setaria spp.	100	1	100	1	100	1	100	1
Panicum crus-galli L.	100	1	100	1	100	1	100	1
Annual dicotyledonous								
Amaranthus spp.	100	1	100	1	100	1	100	1
Chenopodium album L.	100	1	100	1	100	1	100	1
Portulaca oleraceae L.	100	1	100	1	100	1	100	1
Polygonum aviculare L.	100	1	100	1	100	1	100	1
Perennial monocotyledonous								
Sorghum halepense (L.) Pers.								
- from seed	100	1	100	1	100	1	100	1
- from rhizomes	75	6	100	1	98	3	100	1
Cynodon dactylon (L.) Pers.	25	8	98	3	50	7	100	1
Perennial dicotyledonous								
Cirsium arvense L	50	7	100	1	75	6	100	1
Convolvulus arvensis L.	25	8	50	7	25	8	75	6
Sonchus arvensis L.	50	7	100	1	50	7	100	1

1* - % killed weeds; 2** - score according to EWRS scale

Table 2. Efficacy of the herbicide Cosmic (360 g/l glyphosate) and the standard Roundup (360 g/l glyphosate)

Weeds	Product Cosmic 12.0 l/ha		Standard oundup 12.0 l/ha	
	1*	2**	1*	2**
Annual monocotyledonous	100	1	100	1
Annual dicotyledonous	100	1	100	1
Perennial monocotyledonous				
Sorghum halepense (L.) Pers	100	1	100	1
Cynodon dactylon (L.) Pers.	100	1	100	1
Perennial dicotyledonous				
Cirsium arvense L.	100	1	100	1
Convolvulus arvensis L.	95	4	95	4
Sonchus arvensis L.	100	1	100	1
Rumex crispus L.	100	1	100	1
Carduus acanthoides L.	100	1	100	1

1*- % killed weeds, 2**- score according to EWRS scale

zomes, *C. arvense*, *S. arvensis* and *R. crispus*, while the efficacy against *C. arvensis* and *C. dactylon* was 90% and 95%, respectively.

The active ingredient of the herbicide Glyphos Super is glyphosate, but its concentration was higher (450 g/l) than that of the standard Roundup (360 g/l glyphosate). The rates of the studied products (Table 5) were conformed. There was no difference in product efficacy at the lower rates and it reached 100% against annual weeds and *S. halepense* from seeds, and 95% against the same weed from rhizomes. However, the efficacy of this rate was slight to unsatisfactory (50-75%) against the other species in the perennial weed group. A 100% mortality was achieved at the rate of 9.6 l/ha of Glyphos Super 45 SL against *C. arvense*, *S. arvensis* and *R. crispus,* and 90-95% against *C. dactylon* and *C. arvensis* that demonstrated the highest resistance.

Table 3. Efficacy of the herbicide Roundup Plus (441 g/l glyphosate potassium salt) and the standard Roundup (360 g/l glyphosate)

Weeds	Rate, l/ha									
	3.0		4.0		5.0		6.0		8.0	
	1*	2**	1*	2**	1*	2**	1*	2**	1*	2**
Product Roundup Plus										
Annual monocotyledonous										
Setaria spp.	100	1	100	1	100	1	100	1	100	1
Panicum crus-galli L.	100	1	100	1	100	1	100	1	100	1
Annual dicotyledonous										
Amaranthus spp.	100	1	100	1	100	1	100	1	100	1
Chenopodium album L.	100	1	100	1	100	1	100	1	100	1
Solanum nigrum L.	100	1	100	1	100	1	100	1	100	1
Portulaca oleracea L.	100	1	100	1	100	1	100	1	100	1
Perennial monocotyledonous										
Sorghum halepense (L.) Pers.										
- from seed	100	1	100	1	100	1	100	1	100	1
- from rhizomes	75	6	95	4	100	1	100	1	100	1
Cynodon dactylon (L.) Pers.	25	8	50	7	75	6	95	4	98	3
Perennial dicotyledonous										
Cirsium arvense L.	50	7	75	6	90	5	95	4	99	2
Sonchus arvensis L.	50	7	75	6	90	5	98	3	100	1
Convolvulus arvensis L.	0	9	25	8	50	7	90	5	98	3
Euphorbia cyparissias L.	0	9	0	9	0	9	25	8	50	7
Aristolochia clematitis L.	0	9	0	9	0	9	0	9	25	8
Standard Roundup										
Annual monocotyledonous										
Setaria spp.	100	1	100	1	100	1	100	1	100	1
Panicum crus-galli L.	100	1	100	1	100	1	100	1	100	1
Annual dicotyledonous										
Amaranthus spp.	100	1	100	1	100	1	100	1	100	1
Chenopodium album L.	100	1	100	1	100	1	100	1	100	1
Solanum nigrum L.	100	1	100	1	100	1	100	1	100	1
Portulaca oleracea L.	100	1	100	1	100	1	100	1	100	1
Perennial monocotyledonous										
Sorghum halepense (L.) Pers.										
- from seed	100	1	100	1	100	1	100	1	100	1
- from rhizomes	75	6	95	4	100	1	100	1	100	1
Cynodon dactylon (L.) Pers.	0	9	25	8	50	7	75	6	95	4
Perennial dicotyledonous										
Cirsium arvense L.	25	8	50	7	75	6	90	5	98	3
Sonchus arvensis L.	25	8	90	5	95	4	98	3	99	2
Convolvulus arvensis L.	0	9	25	8	50	7	75	6	95	4
Euphorbia cyparissias L.	0	9	0	9	0	9	0	9	25	8
Aristolochia clematitis L.	0	9	0	9	0	9	0	9	25	8

1*- % killed weeds; 2**- score according to EWRS scale

At the end of the three-week period after treatment of noncropped areas (stubbles), which is sufficient for translocation of systemic total herbicides, preparation of the areas for next crops could begin. In order to achieve a long-term effect of the investment made in controlling perennial weeds in noncropped areas,

Table 4. Efficacy of the herbicide Leon 36 SL (360 g/l glyphosate) and the standard Roundup (360 g/l glyphosate)

Weeds	Product Leon 36 SL				Standard Roundup			
	4.0 l/ha		12.0 l/ha		4.0 l/ha		12.0 l/ha	
	1*	2**	1*	2**	1*	2**	1*	2**
Annual monocotyledonous								
Setaria spp.	100	1	100	1	100	1	100	1
Panicum crus-galli L.	100	1	100	1	100	1	100	1
Annual dicotyledonous								
Amaranthus spp.	100	1	100	1	100	1	100	1
Chenopodium album L.	100	1	100	1	100	1	100	1
Portulaca oleracea	100	1	100	1	100	1	100	1
Polygonum aviculare L.	100	1	100	1	100	1	100	1
Perennial monocotyledonous								
Sorghum halepense(L.) Pers.								
- from seed	100	1	100	1	100	1	100	1
- from rhizomes	95	4	100	1	95	4	100	1
Cynodon dactylon (L.) Pers.	50	7	95	4	50	7	95	4
Perennial dicotyledonous								
Cirsium arvense L.	75	6	100	1	75	6	100	1
Sonchus arvensis L.	50	7	100	1	50	7	100	1
Convolvulus arvensis L.	25	8	90	5	25	8	90	5
Rumex crispus L.	50	7	100	1	50	7	100	1

1* - % killed weeds; 2** - score according to EWRS scale

Table 5. Efficacy of the herbicide Glyphos Super 45 SL (450 g/l glyphosate) and the standard Roundup (360 g/l glyphosate)

Weeds	Product Glyphos Super 45 SL				Standard Roundup			
	3.2 l/ha		9.6 l/ha		4.0 l/ha		12.0 l/ha	
	1*	2**	1*	2**	1*	2**	1*	2**
Annual monocotyledonous								
Setaria spp.	100	1	100	1	100	1	100	1
Panicum cruss-galli L.	100	1	100	1	100	1	100	1
Annual dicotyledonous								
Amaranthus spp.	100	1	100	1	100	1	100	1
Chenopodium album L.	100	1	100	1	100	1	100	1
Portulaca olerasea L.	100	1	100	1	100	1	100	1
Polygonum aviculare L.	100	1	100	1	100	1	100	1
Perennial monocotyledonous								
Sorghum halepense (L.) Pers.								
- from seed	100	1	100	1	100	1	100	1
- from rhizomes	95	4	100	1	95	4	100	1
Cynodon dactylon (L.) Pers.	50	7	90	5	50	7	95	4
Perennial dicotyledonous								
Cirsium arvense L.	75	6	100	1	75	6	100	1
Sonchus arvensis L.	50	7	100	1	50	7	100	1
Convolvulus arvensis L.	50	7	95	4	25	8	100	5
Rumex crispus L.	75	6	100	1	50	7	100	1

1* - % killed weeds; 2** - score according to EWRS scale due to an abundance of weed seeds present in the soil, it is necessary to continue their control also during the growing season with crop cultivation by including selective herbicides (Dimitrova, 1995, 2001).

CONCLUSIONS

Treatments of noncropped areas (stubbles) with the total systemic herbicides Touchdown System 4 (360 g/l glyphosate); Cosmic (360 g/l glyphosate); Roundup Plus (441 g/l glyphosate potassium salt); Leon 36 SL (360 g/l glyphosate) and Glyphos Super 45 SL (450 g/l glyphosate) achieved high efficiency, so they proved to be a successful element in a strategy for controlling weeds of different biological groups and greatly important for reducing population density of perennial weeds.

High resistance to the herbicides and rates applied were demonstrated by the species *Euphorbia cyparissias* L. and *Aristolochia clematitis* L.

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Biološka efikasnost herbicida u suzbijanju korova na strništu

REZIME

Poljoprivredni proizvođači se sve češće suočavaju sa problemom invazije korova, naročito višegodišnjih, tako da je primena industrijske tehnologije nemoguća bez njihovog efikasnog i racionalnog uklanjanja. Da bi se ispitala efikasnost herbicida u suzbijanju korova na neobrađenim površinama (strništima), tokom perioda 2005-2007. godine, u Institutu za krmno bilje u Plevenu sproveli smo biološko istraživanje pet totalnih sistemskih herbicida na površinama sa prirodnom infestacijom i drugim korovima u okruženju. Ogledi su izvedeni u polju, a korišćen je blok sistem sa veličinom elementarne parcele od 20 m^2. Tretmani su izvedeni u stadijumu pupoljka kod višegodišnjih dikotiledonih korova i u stadijumu klasanja kod monokotiledonih korova. Efikasnost herbicida je merena na skali EWRS od 9 poena (0-100% uništenih korova = ocene 9-1).

Rezultati pokazuju da su tretmani neobrađenih područja (strništa) totalnim sistemskim herbicidima Touchdown System 4 (360 g/l glifosat); Cosmic (360 g/l glifosat); Roundup Plus (441 g/l glifosat kalijumova so); Leon 36 SL (360 g/l glifosat) i Glyphos Super 45 SL (450 g/l glifosat) postigli visoku efikasnost, tako da predstavljaju uspešan element u strategiji suzbijanja korova iz različitih bioloških grupa, s tim da je najznačajniji rezultat postignut kod višegodišnjih korova.

Ključne reči: Herbicidi; efikasnost; korovi; neobrađene površine