Scientific Papers. Series A. Agronomy, Vol. LXIV, No. 1, 2021
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

BIOLOGICAL EFFICACY OF SEGADOR FOR WEED CONTROL IN NON-CROPPED AREAS

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Abstract

The efficacy of Segador (organic fertilizer with a contact herbicide effect), applied alone or in combination with the adjuvant Melamyel for controlling of the invasive weed species Sorghum halepense (L.) Pers., Cirsium arvense (L.) Scop. and Convolvulus arvensis L. in non-cropped areas was studied. Segador at concentration 5%, 8% and 12% indicated high efficiency from 95 to 100%. It proved to be a successful element in a strategy for controlling of invasive weed species (Cirsium arvense (L.) Scop. and Convolvulus arvensis L.) and greatly important for reducing to population density of perennial dicotyledonous weeds. The resistance of Segador was demonstrated to Sorghum halepense (L.) Pers. at all tested rates with or without Melamyel. Segador successfully controlled perennial dicotyledonous weeds, but it was not toxic to Sorghum halepense (L.) Pers.

Key words*: non-cropped areas (stubbles), invasive weeds, organic herbicide, Segador, efficacy.*

INTRODUCTION

Weeds are undesirable plants impeding the use of land and water resources and in this way they affect human life indirectly (Nasim and Shabbir, 2012). According to Oerke (2005), Dimitrova (2009) and Bentsen and Felby (2012) limited acreage 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 the damage of the environment. All this increases the need for study for weed control, especially due to the fact weeds reduce yield of agriculture crops more than other pests. The great diversity of species and their high biological plasticity remain a major problem associated with weeds, allowing their rapid spread and adaptation. Due to the large regenerative capacity of their underground organs and their high seed productivity, some of the perennial weed species such as perennial monocotyledonous (*Sorghum halepense* (L.) Pers.) and perennial dicotyledonous (*Cirsium arvense* (L.) Scop. and *Convolvulus arvensis* L.) spray quickly in arable land (Dimitrova, 2009; Nasim and Shabbir, 2012; Schwinning et al., 2017).

Summary studies of Tonev (2000), Schwinning et al. (2017) and Tiley (2010) determine *Sorghum halepense* (L.) Pers., *Cirsium arvense* (L.) Scop. and *Convolvulus arvensis* L. like some of the one hundred most economically important weeds characterized by high biological and ecological plasticity, and hight allelopathic potential (Golubinova and Ilieva, 2014).

According to studies of (Gyenes et al., 2005; Dimitrova and Serafimov, 2007a; 2007b; Stoimenova et al., 2008; Johnson et al., 2014; Tavaziva et al., 2019) in a non-cropped area (stubble) of conventional agriculture *Sorghum halepense* (L.) Pers., *Cirsium arvense* (L.) Scop. and *Convolvulus arvensis* L. can be controlled by selective herbicides.

At organic farming, however, the use of herbicides for weed control against invasive weed species been banned and the may be used only biological or mechanical methods for weed control (Kropff et al., 2000 and Webber et al., 2012).

The importance of the successful control of the species *Sorghum halepense* (L.) Pers., *Cirsium arvense* (L.) Scop. and *Convolvulus arvensis* L. by using of herbicides attracted the attention of many researchers (Boutin et al., 2012; Schwinning et al., 2017 and Tavaziva et al., 2019). The reports of use of organic products with the herbicide contact action which can be used for weed control in farms in the period of conversion to biological (organic) agriculture production are sporadic and extremely limited (Marinov-Serafimov and Golubinova, 2015; Georgieva et al., 2018).

Many methods were being developed to reduce the use of herbicides and notably organic herbicides were developed to have the same herbicidal effect but without the side effects from the organic herbicides (Cheng, 2014).

The objective of this work was to conduct a biological study of the effectiveness of organic product Segador (organic fertilizer with a contact herbicide effect) in controlling invasive weed species *Sorghum halepense* (L.) Pers., *Cirsium arvense* (L.) Scop. and *Convolvulus arvensis* L. in non-cropped areas (stubbles).

MATERIALS AND METHODS

The study was conducted in a non-cropped area (stubble) after harvest of winter forage pea (*Pisum sativum* L.) grown in conventional production conditions under natural weed infestation pressured at the Institute of Forage Crops in Pleven in the 2014-2016 period. The experiment was set up using the block design method at four replications and the size of the experimental plot of 10 m^2 under non-irrigating conditions. The soil type was leached chernozem of pH 7.3-7.6. Treatments of the trial are shown in Table 1.

The herbide products used in this study (Basta 15 CL and Reglone Forte) are registred for weed control in Bulgaria. Segador is not registered in Bulgaria. Segador is organic fertilizer with a non-selective contact herbicide action against weeds. Segador is a complex natural hydroxyphosphate in the form of an emulsion, and natural surfactant depressor of water activity that and thus causing desiccation of the plant cell. Contains phosphorus (P_2O_5) 25.5% water-soluble and zinc (Zn) water-soluble 0.20%.

Melamyel is organic product consists of an emulsion of ethoxylated castor oil and used as a non-ionic for surface moisturizer. Melamyel is not registered in Bulgaria.

The applied product and standard rates were as recommended by their manufacturers and were applied with a working solution quantity of 500 l/ha.

Table 1. Variants of the study

Treatments	Herbicides	Active Ingredient (s)	Chemical family	Dose (concentration) of commercial product
T$_1$	Control (untreated) K$_u$			-
T$_2$	Basta 15 SL	150 g/l glufosinate-ammonium	bipyridylium	5.0 l/ha
T$_3$	Reglone Forte (Standart)	150 g/l diquat and 150 g/l humidifier		3.0 l/ha
T$_4$	Segador	phosphorus (P_2O_5) 25.5% water-soluble and zinc (Zn) water- soluble 0.20%	natural hydroxyphos-phate	5.0%
T$_5$	Segador			8.0%
T$_6$	Segador			12.0%
T$_7$	Segador	phosphorus (P_2O_5) 25.5% water-soluble and zinc (Zn) water- soluble 0.20%	natural hydroxyphos-phate	5.0%
	Melamyel	emulsion of ethoxylated castor oil	non-ionic surface moisturizer	0.4 l/ha
T$_8$	Segador	phosphorus (P_2O_5) 25.5% water-soluble and zinc (Zn) water- soluble 0.20%	natural hydroxyphos-phate	8.0%
	Melamyel	emulsion of ethoxylated castor oil	non-ionic surface moisturizer	0.4 l/ha
T$_9$	Segador	phosphorus (P_2O_5) 25.5% water-soluble and zinc (Zn) water- soluble 0.20%	natural hydroxyphos-phate	12.0%
	Melamyel	emulsion of ethoxylated castor oil	non-ionic surface moisturizer	0.4 l/ha

Treatment was conducted at the at the growth stage for perennial dicotyledonous (*Cirsium arvense* L.) Scop. (BBCH-12-14) and *Convolvulus arvensis* L. (BBCH–39-42) and perennial monocotyledonous (*Sorghum halepense* (L.) Pers.) (BBCH–12-14) (Hess et al., (1997). The efficacy of the herbicides and the organic products were reported at 7th, 14th

and 21th days after treatment (recommended time for contact herbicides) using the 1-9 scale of the EWRS (European Weed Research Society) (0-100% killed weeds - score from 1 to 9). The experimental data is presented as average values for the period of study because the tendency was the same in the different years.

Ground cover of the weeds was determined visually and was recorded on a scale of 0-100% (0- no plants, 100% very healthy plants - covering the entire surface area) (Fontenot et al., 2015). The growing weeds after treatment with herbicides and the organic product was recorded on the 14th and 21th day after treatment which is recommended time for herbicides or organic products with herbicide effect with contact action. For the characterization of the arid/humid characteristic during the study period was used index De Martonne's (I_{DM}). To determine arid/humid characteristic of a specific month, was calculated by Equation (1) (Coscarelli et al., 2004).

$$I_{DM} = \frac{12P_i}{T_{ai}+10} \quad (1)$$

where P_i is the monthly amount of precipitation (in millimeters) and T_{ai} is the mean monthly air temperature (in degree Celsius) recorded in the considered month, 12 and 10 are constants.

All data were analysed using the Statistica version 10 software. Means separated using Fisher's protected least significant difference when F tests were significant at α=0.05.

RESULTS AND DISCUSSIONS

Analysis of meteorological factors shows that during the study period the monthly amount of precipitation has slight deviations from -7.4% to +27.3% and relatively stronger changes in temperature from 0.6^{0}C to 1.9 ^{0}C compared to multi-annual period from 1961to 2011.

Assessing the complex impact of meteorological factors (rainfall and air temperature) according the De Martonne airdity index *(Iar-DM*) during the study years can be classified conventionally for 2015 and for 2016 are moderately airdity respectively I_{ar}-DM_{2014} - 27.0 and I_{ar}-DM $_{2015}$ – semi – humid and 2016 is semi-dray (*Iar-DM* – 19.5) (Table 2).

Table 2. Rainfall amount, air temperature and index of aridity (*Iar*-DM) for the period from March to September

Year	Monthly rainfall, mm		Average monthly temperature of the air, ^{0}C		Index of airdity (*Iar*-DM) March – September
	For the 1964-2014 period				
	March – September 403.3 mm	Deviation, %	March – September 16.8 ^{0}C	Deviation, ^{0}C	
2014	484.8	120.2	18.1	1.3	25.9
2015	512.9	127.3	17.4	0.6	28.1
2016	373.6	92.6	18.7	1.9	19.5

Species composition within the weed association of experimental area was represented by invasive weed species from different biological groups: perennial monocotyledonous (*Sorghum halepense* (L.) Pers.) and perennial dicotyledonous (*Cirsium arvense* (L.) Scop. and *Convolvulus arvensis* L.) (Table 3a and 3b).

Before treatment, the degree of weed infestation was high during the study years. For *Sorghum halepense* (L.) Pers. From 46.2 stems/m^2 to 64.5 stems/m^2, average for the period 53.8 stems/m^2 For *Cirsium arvense* (L.) Scop. from 41.6 stems/m^2 to 59.3 stems/m^2, average for the period 52. stems/m^2 and for *Convolvulus arvensis* L. from 13.2 stems/m^2 to 18.8 stems/m^2, average for the period 16.5 stems/m^2.

The total weed density varied in the period of the study from 101.0 plants/m^2 to 142.6 plants/m^2, average 123.0 plants/m^2 in the treatment area which is a prerequisite for a realistic assessment to determine the efficacy of the tested herbicides (Table 3a, 3b and Figure 1).

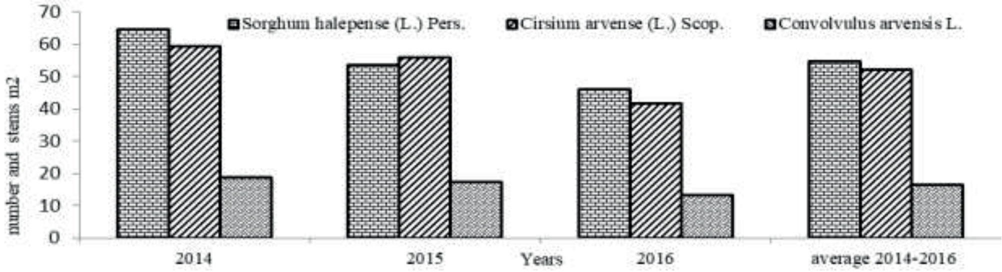

Figure 1. Species composition and density of weeds in a non-cropped area (stubble) after harvest of winter forage pea (*Pisum sativum* L.) during the period of the study

Table 3a. Efficacy of Segador againts weeds in non-cropped area (stubble) average for the period 2014-2016

Treatments	Weed	BBCH	Ground cover of the weed	BBCH	Efficacy, %	EWRS *	Ground cover of the weed	Regrowing, %
		0 DBT		*7 DAT*				
T_1	*Cirsium arvense*	12-14	25	14-16	0^{a}	9	45	-
	S. halepense	12-14	10	12-16	0^{a}	9	15	-
	C. arvensis	39-42	20	42-49	0a	9	30	-
T_2	*Cirsium arvense*	12-14	25	14-16	95^{d}	2	25	0.0
	S. halepense	12-14	10	14-16	90^{d}	2	10	0.0
	C. arvensis	39-42	20	47-59	95^{d}	2	15	0.0
T_3	*Cirsium arvense*	12-14	25	14-16	95^{d}	2	25	0.0
	S. halepense	12-14	10	14-16	95^{d}	2	10	0.0
	C. arvensis	39-42	20	47-59	95^{d}	2	15	0.0
T_4	*Cirsium arvense*	12-14	25	14-16	85^{cd}	3.5	30	0.0
	S. halepense	12-14	10	14-16	45^{b}	7	15	0.0
	C. arvensis	39-42	20	47-59	85^{cd}	3	15	0.0
T_5	*Cirsium arvense*	12-14	25	14-16	95^{d}	2	25	0.0
	S. halepense	12-14	10	14-16	55^{b}	6	15	0.0
	C. arvensis	39-42	20	47-59	95^{d}	2	15	0.0
T_6	*Cirsium arvense*	12-14	25	14-16	95^{d}	2	20	0.0
	S. halepense	12-14	10	14-16	58^{b}	6	15	0.0
	C. arvensis	39-42	20	47-59	95^{d}	2	15	0.0
T_7	*Cirsium arvense*	12-14	25	14-16	95^{d}	2	20	0.0
	S. halepense	12-14	10	14-16	50^{b}	7	15	0.0
	C. arvensis	39-42	20	47-59	95^{d}	2	15	0.0
T_8	*Cirsium arvense*	12-14	25	14-16	95^{d}	2	20	0.0
	S. halepense	12-14	10	14-16	55^{b}	6	15	0.0
	C. arvensis	39-42	20	47-59	95^{d}	2	15	0.0
T_9	*Cirsium arvense*	12-14	25	14-16	95d	2	20	0.0
	S. halepense	12-14	10	14-16	65b^{c}	4	15	0.0
	C. arvensis	39-42	20	47-59	95^{d}	2	15	0.0

*Legend: ** Treatments- see Table 1; DBT - day before treatments; DAT - days after treatment; BBCH scale—general for the descriptions of the growth stages of monocotyledonous and dicotyledonous weeds, Hess et al. (1997); Means with different a ,b, c and d in P=0.05 level of probability by LSD test;* EWRS (European Weed Research System) scale for weed control efficacy (100% (score 1) = total control and 0% (score 9)= no effect on the weeds); Ground cover of the weed were recorded on a scale of 0-100% (0- no plants. 100% very healthy plants - covering the entire surface area); Regrowing weeds on a scale of 0-100% (0- no plants, 100% very healthy plants - covering the entire surface area).*

The studied product Segador is organic fertilizer with a non-selective contact herbicide effect against weeds is total, foliar-applied product with a contact action. Phytotoxicity symptoms on the weeds were typical for this group of herbicides and organic product with contact total actions. As a result of the biological process of contact products for weed control, the active ingredient of the tested organic product exerts a phytotoxic effect on the green leaf mass of all plant parts of the aboveground surface of the weeds species. In the first-second week after treatment, there was chlorosis of the aboveground parts, which changed into necrosis later.

Table 3b. Efficacy of Segador againts weeds in non-cropped area (stubble) average for the period 2014-2016

**Treatments	weeds	BBCH	Efficacy, %	EWRS *	Ground cover of the weed	Regrowing %	BBCH	Efficacy, %	EWRS *	Ground cover of the weed	Regrowing %
		14 DAT					21 DAT				
T_1	*Cirsium arvense*	16-17	0^{a}	9	60	-	17-18	0^{a}	9	70	-
	S. halepense	16-17	0^{a}	9	15	-	21-23	0^{a}	9	20	-
	C. arvensis	59	0^{a}	9	40	-	63	0^{a}	9	65	-
T_2	*Cirsium arvense*	14-16	100^{d}	1	10	6.5	14-16	100^{d}	1	10	15.0
	S. halepense	14-16	98^{d}	1.5	5	5.2	14-16	100^{d}	1	5	10.8
	C. arvensis	47-59	100^{d}	1	5	7.4	47-59	100^{d}	1	5	14.9
T_3	*Cirsium arvense*	14-16	100^{d}	1	10	5.2	14-16	100^{d}	1	10	10.7
	S. halepense	14-16	98^{d}	1.5	5	8.6	14-16	100^{d}	1	5	21.3
	C. arvensis	47-59	100^{d}	1	5	7.8	47-59	100^{d}	1	5	16.9
T_4	*Cirsium arvense*	14-16	89^{cd}	1.5	15	11.3	14-16	90^{d}	2	15	26.5
	S. halepense	14-16	55^{b}	6	15	18.5	14-16	70^{bc}	4	15	58.2
	C. arvensis	47-59	90^{d}	2	10	10.4	47-59	90^{d}	2	10	34.3
T_5	*Cirsium arvense*	14-16	98^{d}	1.5	10	10.9	14-16	100^{d}	1	10	25.8
	S. halepense	14-16	65^{b}	4	10	19.5	14-16	75^{bc}	3.5	10	46.9
	C. arvensis	47-59	96^{d}	1.5	5	16.8	47-59	100^{d}	1	5	33.4
T_6	*Cirsium arvense*	14-16	98^{d}	1.5	10	6.3	14-16	100^{d}	1	10	25.0
	S. halepense	14-16	76^{bc}	3	10	17.4	14-16	75^{bc}	3.5	10	52.3
	C. arvensis	47-59	96^{d}	1.5	5	13.3	47-59	100^{d}	1	5	40.0
T_7	*Cirsium arvense*	14-16	97^{d}	1.5	10	10.6	14-16	100^{d}	1	10	21.9
	S. halepense	14-16	60^{bc}	5	10	32.6	14-16	70^{c}	3	10	64.3
	C. arvensis	47-59	99^{d}	1	5	12.8	47-59	100^{d}	1	5	37.5
T_8	*Cirsium arvense*	14-16	98^{d}	1.5	10	9.4	14-16	100^{d}	1	10	18.9
	S. halepense	14-16	65^{bc}	4	10	28.0	14-16	70^{b}	2	10	62.0
	C. arvensis	47-59	100^{d}	1	5	16.0	47-59	100^{d}	1	5	36.1
T_9	*Cirsium arvense*	14-16	98^{d}	1.5	10	8.6	14-16	100^{d}	1	10	19.1
	S. halepense	14-16	72^{cd}	4	10	26.9	14-16	75^{b}	3.5	10	59.6
	C. arvensis	47-59	100^{d}	1	5	18.6	47-59	100^{d}	1	5	43.0

*Legend: ** Treatments - see Table 1; DBT - day before treatments; DAT - days after treatment; BBCH scale—general for the descriptions of the growth stages of monocotyledonous and dicotyledonous weeds, Hess et al. (1997); Means with different a ,b, c and d in P=0.05 level of probability by LSD test;* EWRS (European Weed Research System) scale for weed control efficacy (100% (score 1) = total control and 0% (score 9)= no effect on the weeds); Ground cover of the weed were recorded on a scale of 0-100% (0- no plants. 100% very healthy plants - covering the entire surface area); Regrowing weeds on a scale of 0-100% (0- no plants, 100% very healthy plants - covering the entire surface area).*

The organic product Segador at concentration 5.0%, applied alone or with the adjuvant Melamyel in a dose 0.4 l/ha causes a rapid initial effect of desiccation of the above-ground biomass of the perennial dicotyledonous weeds *Cirsium arvense* (L.) Scop. and *Convolvulus arvensis* L. several hours after treatment, regardless of the change meteorological conditions (Table 2 and 3).

Regarding perennial dicotyledonous weeds (*Cirsium arvense* (L.) Scop. and *Convolvulus arvensis* L.). 7 days after treatment (DAT) was established a fast initial effect of the herbicide on the weeds. 95% of them were killed (score 1.0÷1.5) at the lower concentration of 5.0% of Segador were observed without deviations from the standards Reglon Forte in a dose 3.0 l/ha and Basta 15 CL in a dose 5.0 l/ha. In the perennial monocotyledonous (*Sorghum halepense* (L.) Pers.), the efficacy of the same herbicide rate on organic product Segador was slighter to insignificant, the killed weeds accounting for 45-65% (score 4÷7).

With increasing the growing period to 14 and 21 days after treatment (DAT), the organic product Segador was studied again with Reglon Forte (150 g/l diquat and 150 g/l humidifier) as the standard and Basta 15 CL (150 g/l glufosinate-ammonium) herbicide (Table 3a and 3b). The low rate of the Segador (5.0% solution) successfully killed all perennial dicotyledonous weeds from 90 to 100% efficiency (score - 1÷2), but from *Sorghum halepense* (L.) Pers. was not sufficiently efficient from 55.0 to 70.0% solutions). The high rate (12.0 % solution) achieved 100% efficacy against *Cirsium arvense* (L.) Scop. and *Convolvulus arvensis* L., while in *Sorghum halepense* (L.) Pers. it remains relatively low from 75.0 to 76.0% (score - 4÷6).

With regard to the total efficacy of Segador, expressed as a percentage, applied alone or with an adjuvant Melamyel in a dose 0.4 l/ha at all studied concentrates 5.0%, 8.0% and 12.0% against perennial dicotyledonous weeds it ranges from 95 to 100% (score 1). Under the the conditions of the study the efficiency of Segador is almost the same like the efficiency of Reglon Forte in a dose 3.0 l/ha used as a standard. The insignificant differences in the values of this indicator between the single application of the organic product Segador and that with the addition of adjuvant (Melamyel - 0.4 l/ha) justifies the assumption that it is self-application (Table 3a and 3b). In this case, the additive of the adjuvant increases the initial effect of Segador, but has little effect on the final herbicidal effect.

As a result of the phytotoxic effect of Reglon Forte in a dose 4.0 l/ha accepted for the standard and Basta 15 CL in a dose 4.0 l/ha 14 days after treatment, the lower regrowing of the perennial dicotyledonous species is in a range from 5.6% to 7.6% while for monotyledonous *Sorghum halepense* (L.) Pers. it varied from 5.2% to 8.6%. After treatment with the organic product Segador, the regrowing varied in the range from 6.3 to 13.3 for *Cirsium arvense* (L.) Scop. and for *Convolvulus arvensis* L. and for *Sorghum halepense* (L.) Pers. the range is from 17.4 to 19.5%.

21 days after treatment (DAT), the weed species regrowing capacity increased from 0.94 times for *Sorghum halepense* (L.) Pers. up to 2.68 times for *Cirsium arvense* (L.) Scop. and *Convolvulus arvensis* L.. It is more pronounced after treated with the organical product Segador with or without the adjuvant Melamyel from 2.06 times to 3.27 times compared to the standard (Reglon Forte in in a dose 4.0 l/ha) and Basta 15 SL in a dose 5.0 l (Table 3a, 3b and Figure 2).

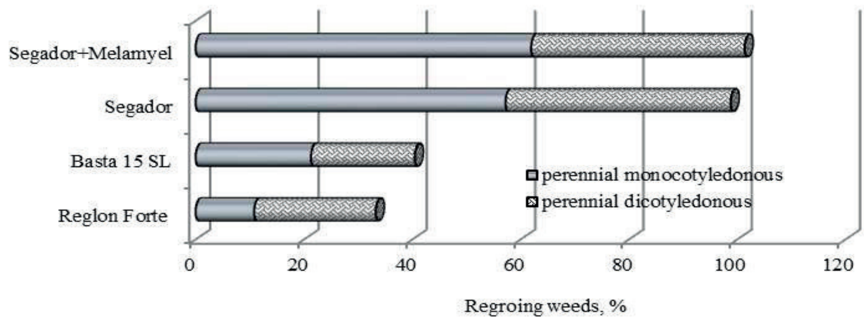

Figure 2. Regrowing of perennial monocotyledonous and dicotyledonous weeds after treatment with herbicides or Segador

The results obtained with respect to the weed species' recovery after treatment of the test areas with Segador in the applied concentrates (5.0%, 8.0% and 12.0%) with additive adjuvant (Melamyel - 0.4 l/ha) are similar. At the end of the three-week period after treatment of non-cropped areas (stubbles), which is sufficient for translocation of total herbicides and organic product Segador, 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 non-cropped areas, 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; Dimitrova, 2001; Schwinning et al., 2017 and Tiley, 2010).

CONCLUSIONS

Treatments of non-cropped areas (stubbles) with Segador at concentrations 5.0%, 8.0% and 12.0% indicated high efficiency from 95% to 100%. It is proved to be a successful element in the strategy for controlling of invasive weed species (*Cirsium arvense* (L.) Scop. and *Convolvulus arvensis* L.). and greatly important for reducing to population density of perennial dicotyledonous weeds.

Resistance of the organic product Segador are demonstrated for *Sorghum halepense* (L.) Pers. at all tested rates. Segador with or without ajuvant Melamyel in a dose 0.4 l/ha has efficiency only from 50% to 70% and strong growing capacity from 58.2% to 64.3%.

Segador has high efficiency against perennial dicotyledonous weeds, but it is not toxic for monocotyledonous *Sorghum halepense* (L.) Pers.

Segador like organic fertilizer with contact herbicidal effect can be used successfully for control against *Cirsium arvense* (L.) Scop. and *Convolvulus arvensis* L. in non-cropped areas (stubbles) during the conversion period from conventional agriculture to organic (biological) one.

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