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Differences in biological efficiency of one- and two-component graminicide on sugar beet crops in Tula region

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Abstract. One of the most urgent tasks in sugar beet production for Russia today is irregularities in cultivation technology and a low-efficiency crop protection. It leads to a high level of weed infestation of agricultural fields. Developing and identifying the most efficient, selective and accessible herbicides, which have low phytotoxicity, do not have a negative effect on soil chemical characteristics and can be used in sugar beet cultivation is relevant today. The aim of this study was to examine and compare biological efficiency of various doses and concentrations of one- and two-component graminicides on sugar beet crops against the following weeds: Cockspur grass — *Echinochloa crusgalli* (L.) Beauv., Wild millet — *Setaria glauca* (L.) Beauv. and Couch Grass — *Elytrigia repens* (L.) Nevski. The experiment was conducted on the territory of the Tula region in 2020. The total field experiment area was 480 m². Application of clethodim + quizalofop-P-ethyl (0.5 l/ha) resulted in reducing the number and weight of annual weeds by 64...71 %, reducing the number and weight of perennial weeds by 54...58 %, which had the same efficiency as clethodim (0.6 l/ha). The efficiency of clethodim + quizalofop-P-ethyl (1.0 l/ha) was higher than Clethodim (0.6 l/ha) and amounted to 73...87 % of reduction in the number of weeds compared to the control, but was lower than Clethodim (1.8 l/ha), which resulted in 89...95 % reduction in the number of weeds compared to the control. The highest sugar beet yields were obtained in the variants with clethodim (1.8 l/ha) and two-component herbicide (1 l/ha), which amounted to 28 and 25 % yield increase, in comparison with the control.

Keywords: sugar beet, biological efficacy, pesticide, herbicide, graminicide, clethodim, quizalofop-P-ethyl

Conflict of interest. The authors declare that they have no conflict of interests.

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Introduction

Sugar beet is one of the most important industrial crops in Russia and has a great national and economic importance. The main advantage of sugar beet is high yields and productivity, which can reach 50 t/ha, depending on the region, the cultivation technology and cultivar characteristics [1, 2].

Sugar beet is a highly weed-sensitive crop. There are over 75 species of weeds that cause significant damage to sugar beet production. In turn, human economic activity leads to changes in the stable species composition of weeds in a field community [3–5].

Nowadays, highly profitable sugar beet production is impossible without the integrated crop protection system against weeds. Integrated protection includes a complex of agrotechnical, biological, chemical and other methods of weed control. First of all, the main task is to regulate the number of harmful objects on sugar beet crops to the threshold of economic harmfulness [6].

In Russia, there is a high weed infestation of fields, which is associated with a violation of crop rotation rules, soil cultivation systems, a decrease in the use of chemical herbicides, and, the number of such fields is growing [3–5]. According to various sources, there are no production fields in the country without weeds. About 75 % of the area requires constant weed control and a lot of appropriate measures [5].

Number of weed seeds in the arable soil layer increased 1.5 fold in beet-growing regions [1]. The number and species composition of weeds is also increasing, including perennial and harmful weeds [7–11].

In this study, a field experiment was carried out on sugar beets using graminicides based on clethodim and a mixture of clethodim with quizalofop-P-ethyl [12]. These active substances have proven effectiveness in many countries, have a high biological efficiency and do not harm sugar beet plants [13–19].

Thus, developing and identifying the most efficient, selective and accessible herbicides, which have low phytotoxicity, do not have a negative effect on soil chemical properties and can be used in sugar beet cultivation is relevant today [1, 5, 6].

The aim of this study was to examine and to compare biological efficiency of various doses and concentrations of one- and two-component graminicides against annual and perennial cereal weeds on sugar beet crops in the Tula region (active substances: clethodim; clethodim + quizalofop-P-ethyl).

Materials and methods

The objects were plots and weeds in the sugar beet field in the Tula region. The research subjects were the following harmful objects:

1. Couch Grass — *Elytrigia repens* (L.) Nevski.
2. Cockspur grass — *Echinochloa crusgalli* (L.) Beauv.
3. Wild millet — *Setaria glauca* (L.) Beauv.

The cultivated plants were sugar beets (*Beta vulgaris* L.) of one-seeded mid-ripening sugary hybrid — ‘Okean’.

Seeding rate: 1.1 sowing unit. Plant growth stage treated: 4–6 true leaves. Forecrop: winter wheat. Tillage: in autumn — plowing to a depth of 25 cm, in spring — presowing harrowing and cultivation.

The experiment has variants:

1. Control (without any chemical graminicide treatment).
2. Graminicide with active ingredient of clethodim (120 g/l). Application rate: 0.6 l/ha.
3. Graminicide based on clethodim (120 g/l). Application rate: 1.8 l/ha.
4. Graminicide based on clethodim and quizalofop-P-ethyl (140 g/l + 70 g/l, respectively). Application rate: 0.5 l/ha.
5. Graminicide based on clethodim and quizalofop-P-ethyl (140 g/l + 70 g/l, respectively). Application rate: 1.0 l/ha.

Consumption of working solution: 200 l/ha. Frequency of treatments: 1. Spraying was carried out in the phase of 2...4 leaves in weeds and regardless of the growth stage of sugar beet plants. The period of herbicide action: during the growing season.

The total field experiment area was 480 m². The size of each experimental plot was 60 m², and the record plot was 24 m². The protective stripes were 3 meters wide and were not counted.

Quantitative-weighting method was used on accounting sites with a size of 1.0 m² on each plot of the experiment. Counting the yield was carried out by a mechanical method from the entire area of the plots, statistical data processing — the technique of analysis of variance (ANOVA). The counts of harmful objects (weeds) were carried out before treatment, 30 and 45 days after treatment, and before harvesting.

Results and discussion

The influence of one- and two-component graminicide with different consumption rates on the total weed infestation of sugar beet crops and on certain types of weeds is shown in Table 1 and 2.

Table 1

Effect of graminicides on weeds (Tula region, 2020)

Variant	Date	Decrease of weeds, % to control		
		Cockspur grass	Wild millet	Couch grass
1. Clethodim, 120 g/l, rate – 0.6 l/ha	17.07	50	67	56
	01.08	68	66	58
	23.09	72	78	67
2. Clethodim, 120 g/l, rate – 1.8 l/ha	17.07	94	97	93
	01.08	99	98	97
	23.09	100	100	98
3. Clethodim, 140 g/l + quizalofop-P-ethyl 70 g/l, rate – 0.5 l/ha	17.07	75	73	61
	01.08	73	73	58
	23.09	82	76	62
4. Clethodim, 140 g/l + quizalofop-P-ethyl 70 g/l, rate – 1.0 l/ha	17.07	96	85	80
	01.08	97	90	81
	23.09	97	93	91
5. Control*	17.07	21	41	23
	01.08	23	42	25
	23.09	20	42	22

*The control contains data on the number of weeds, plants/m²

Table 2

Influence of active ingredients and their rates and concentrations on total weed infestation of sugar beet crops (Tula region, 2020)

Variant	Date	Number of weeds				Weed mass			
		Plants/m ²		Decrease, % to control		G/m ²		Decrease, % to control	
		Annual	Perennial	Annual	Perennial	Annual	Perennial	Annual	Perennial
1. Clethodim, 120 g/l, rate – 0.6 l/ha	17.07	22	10	62	56	63	48	68	59
	01.08	18	9	67	58	59	43	72	64
	23.09	16	8	74	67	–	–	–	–
2. Clethodim, 120 g/l, rate – 1.8 l/ha	17.07	13	4	96	93	23	9	88	92
	01.08	10	2	98	97	18	6	92	95
	23.09	7	1	100	98	–	–	–	–
3. Clethodim, 140 g/l + quizalofop-P-ethyl 70 g/l, rate – 0.5 l/ha	17.07	21	11	74	61	71	54	64	53
	01.08	19	10	73	58	63	51	70	58
	23.09	15	9	79	62	–	–	–	–
4. Clethodim, 140 g/l + quizalofop-P-ethyl 70 g/l, rate – 1.0 l/ha	17.07	15	11	92	80	37	43	81	63
	01.08	11	8	93	81	28	35	87	71
	23.09	7	5	94	91	–	–	–	–
5. Control	17.07	62	23	–	–	195	116	–	–
	01.08	65	25	–	–	212	120	–	–
	23.09	62	22	–	–	–	–	–	–

In variants without any chemical graminicide treatments and using only mechanical treatment of crops, the number of studied annual cereal weeds has reached about 65 or more plants per 1 m², and the number of perennial cereal weeds has reached about 25 plants and more per 1 m².

The initial infestation of sugar beet crops with *Setaria* weeds averaged 41 plants per 1 m², Cockspar grass averaged 21 plants per 1 m², and for Couch Grass the average infestation was 23 weeds per 1 m².

Based on the data obtained, the least effective variants were graminicide based on clethodim, 120 g/l, consumption rate — 0.6 l/ha and graminicide based on clethodim 140 g/l and quizalofop-P-ethyl 70 g/l, consumption rate — 0.5 l/ha. Clethodim at a concentration of 120 g/l, consumption rate 0.6 l/ ha destroyed about 64 % of perennial grasses and about 74 % of annual grasses. Similar results were noted in variant with clethodim 140 g/l and quizalofop-P-ethyl 70 g/l, with a consumption rate of 0.5 l/ha, which destroyed about 59 % of perennial cereal weeds and about 76 % of annual cereal weeds.

The medium efficacy in this study was shown by a herbicide based on clethodim at a concentration of 140 g/l and quizalofop-P-ethyl at a concentration of 70 g/l with a

consumption rate of 1.0 l/ha, reducing the number of studied annual and perennial weeds by 94 and 91 %, respectively. This agent with a consumption rate of 1.0 l/ha is inferior in terms of biological efficiency only to a herbicide based on clethodim, 120 g/l with a consumption rate of 1.8 l/ha.

The best biological efficiency in this study was recorded in variant with clethodim at a concentration of 120 g/l and consumption rate of 1.8 l/ha. The weed decrease was 95 % and more for annual weeds and 98 % and more for perennial weeds compared to the control, i.e. at a given consumption rate of this agent based on clethodim at a concentration of 120 g/l, it almost completely destroys all weeds studied in this research and completely destroys annual weeds. The effect of this formulation and consumption rate was superior in biological effectiveness compared to the effect of other investigated graminicides.

The yield of sugar beet root crops of the ‘Okean’ hybrid, depending on the formulation and the consumption rate used, is shown in Table 3. Date of harvesting: September 23, 2020.

Table 3

**Sugar beet productivity depending on the graminicides and their consumption rates
(Tula region, 2020)**

Variant	Average yield, t/ha	% to control
1. Clethodim, 120 g/l, – 0.6 l/ha	26.4	118
2. Clethodim, 120 g/l, – 1.8 l/ha	28.6	128
3. Clethodim, 140 g/l + quizalofop-P-ethyl 70 g/l, – 0.5 l/ha	26.5	119
4. Clethodim, 140 g/l + quizalofop-P-ethyl 70 g/l, – 1.0 l/ha	27.8	125
5. Control	22.3	100

LSD05 = 1.6 t/ha.

The average yield of sugar beet root crops without the use of the studied graminicides in the control was 22.3 t/ha.

In the variants with the use of the studied graminicides, significant increases in the yield of sugar beet were obtained, which averaged 18...28 %.

The largest increase in the yield of sugar beet reached 28 % for the formulation based on clethodim at a concentration of 120 g/l at a consumption rate of 1.8 l/ha, while the average yield of crops was 28.6 t/ha.

The lowest increase in yield among the studied graminicides was 18 and 19 % for the formulation based on clethodim at a concentration of 120 g/l with a consumption rate of 0.6 l/ha and for the formulation based on clethodim at a concentration of 140 g/l with quizalofop-P -ethyl at a concentration of 70 g/l with a consumption rate of 0.5 l/ha, respectively, and the average yield of sugar beet was 26.4 and 26.5 t/ha, respectively.

The medium result in the increase of sugar beet productivity was 25 % in the formulation based on clethodim at a concentration of 140 g/l with quizalofop-P-ethyl at a concentration of 70 g/l with a consumption rate of 1.0 l/ha. The average yield of sugar beet was 27.8 t/ha.

Conclusions

The most effective was a herbicide formulation based on clethodim at a concentration of 120 g/l with a consumption rate of 1.8 l/ha. Also, an effective result was shown by clethodim 140 g/l with quizalofop-P-ethyl 70 g/l with a consumption rate of 1.0 l/ha. The lowest biological effectiveness among studied agents was noted in graminicides based on clethodim, 120 g/l with a consumption rate of 0.6 l/ha and Clethodim, 140 g/l with Quizalofop-P-ethyl 70 g/l with a consumption rate of 0.5 l/ha. The use of pesticides was safe for the protected crop and did not have any negative visual effects.

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Изучение различий биологической эффективности применения одно- и двухкомпонентного граминицида на сахарной свекле в условиях Тульской области

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Аннотация. Одна из наиболее актуальных проблем при возделывании сахарной свеклы в России — нарушение технологии выращивания и низкоэффективная защита данной культуры, что приводит к высокой засоренности полей. Разработка и подбор наиболее высокоэффективных, селективных и доступных гербицидов, которые обладают низкой фитотоксичностью и не ухудшают химических свойств почвы, для применения на посевах сахарной свеклы остается актуальной по сей день. Цель данного исследования — изучить биологическую эффективность применения различных доз одно- или двухкомпонентных граминицидов на посевах сахарной свеклы против таких сорных растений, как пырей ползучий (*Elytrigia repens* (L.) Nevski), куриное просо (*Echinochloa crusgalli* (L.) Beauv.), щетинник сизый (*Setaria glauca* (L.) Beauv.). Исследование проводилось на территории Тульской области в 2020 г. Общая площадь опыта составила 480 м². Использование нормы расхода действующих веществ клетодим + хизалофоп-П-этил с нормой расхода 0,5 л/га снижало количество и массу однолетних злаковых сорняков на 64...71 %, количество и массу многолетних злаковых сорняков на 54...58 %, что было на уровне эффективности использования нормы расхода действующего вещества клетодим 0,6 л/га. Эффективность нормы расхода 1,0 л/га препаративной формы на основе клетодима + хизалофоп-П-этила была выше эффективности нормы расхода 0,6 л/га препаративной формы на основе клетодима, но ниже эффективности нормы расхода 1,8 л/га препаративной формы на основе клетодима. Наибольшую прибавку урожайности получили при использовании норм расхода 1,8 л/га препаративной формы на основе клетодима — 28 % и 1 л/га двухкомпонентного гербицида — 25 %.

Ключевые слова: сахарная свекла, биологическая эффективность, пестицид, гербицид, граминицид, клетодим, хизалофоп-П-этил

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