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ЭКОЛОГИЧЕСКАЯ ОЦЕНКА ПРИМЕНЕНИЯ ГЕРБИЦИДА ЛЮМАКС

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Изучены чувствительность сельскохозяйственных культур к гербициду Люмакс, состоящего из трех действующих веществ (д.в.): С-метолахлора, тербутилазина и мезотриона, длительность их сохранения в лугово-бурой почве и определено последействие препарата на культуры севооборота. Исследования проведены в Приморском крае в 2019, 2020 гг. в условиях вегетационного домика. На опытных делянках до всходов кукурузы применяли гербицид Люмакс в дозах 4,0 л/га (рекомендованная) и 8,0 л/га (двукратная от рекомендованной). Осенью 2019 г. и весной 2020 г. с опытных участков и с контрольного (без гербицидов) отобраны образцы лугово-бурой почвы с глубины пахотного слоя, содержащего 3,5% гумуса. Образцы использованы для установления длительности сохранения действующего начала и последействия гербицида Люмакс. Предварительно отобраны растения индикаторы остаточных количеств препарата в лугово-бурой почве. Рассчитаны дозы гербицида, снижающие надземную массу тест-растения на 50%, и его предельно-допустимые концентрации в почве. Определено, что к концу вегетационного сезона при норме внесения препарата 4,0 л/га в лугово-бурой почве сохраняется 0,7–3,0% д.в. гербицида Люмакс, при норме 8,0 л/га – 0,6–3,9%. К началу следующего полевого сезона препарат, примененный в рекомендованной норме расхода, полностью разлагается, в двукратной норме от рекомендованной остается 0,8–1,7% гербицида. Через 8 мес после внесения гербицид Люмакс в норме расхода 4,0 л/га безопасен для последующих культур севооборота. В случае передозировки или двойного наложения (8,0 л/га) он способен оказывать последействие на чувствительные культуры. Определены культуры, высокочувствительные к препарату Люмакс: капуста, редис, рапс, свекла, томаты, огурец и рис; чувствительные: пшеница, гречиха и соя; относительно устойчивые: овес и ячмень. Установлена безопасная норма расхода гербицида Люмакс (4,0 л/га) для последующих культур севооборота.

Ключевые слова: гербицид, препарат, Люмакс, норма расхода, доза, культура, почва

ENVIRONMENTAL ASSESSMENT OF THE USE OF THE HERBICIDE LUMAX

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The sensitivity of agricultural crops to the Lumax herbicide, consisting of three active agents C-metolachlor, terbutylazine and mesotrione, the duration of their action in meadow-brown soil, and the aftereffect of the herbicide on the plants of the crop rotation were determined. The study was conducted in the conditions of the greenhouse in the Primorsky Territory in 2019 and 2020. The herbicide Lumax was used on experimental plots before corn germination at doses of 4.0 l/ha (recommended) and 8.0 l/ha (twice the recommended). In the autumn of 2019 and in the spring of 2020, samples of meadow-brown soil were taken from the experimental plots and from the control (without herbicides) from the depth of the arable layer containing 3.5% humus. The samples were used to establish the duration of the action of active agents and the aftereffect of the herbicide Lumax. Prior to this, plants indicating residual amounts of the chemical in meadow-brown soil were preselected. The doses of the herbicide which reduce the above-ground mass of the test plant by 50% were calculated, as well as its maximum permissible concentration in the soil. It was determined that by the end of the growing season, 0.7–3.0% of the active agent of the herbicide Lumax is retained in meadow-brown soil at a rate of application of 4.0 l/ha, and 0.6–3.9% – at a rate of 8.0 l/ha. By

the beginning of the next field season, the preparation applied at the recommended rate completely decomposed, while when it was applied at a double rate of the recommended rate, 0.8–1.7% of the herbicide remained. Eight months after the application at a rate of 4.0 l/ha, the herbicide Lumax is safe for subsequent crops of the crop rotation. In case of overdose or double application (8.0 l/ha), it can have an aftereffect on sensitive crops. The crops that are highly sensitive to the Lumax preparation were identified: cabbage, radish, rapeseed, beetroot, tomatoes, cucumber and rice; sensitive: wheat, buckwheat and soybean; relatively resistant: oats and barley. A safe consumption rate of the Lumax herbicide (4.0 l/ha) for subsequent crops of the crop rotation was established.

Keywords: herbicide, preparation, Lumax, consumption rate, dose, crop, soil

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INTRODUCTION

Weed infestations of crops is one of the factors that hinder getting high and stable corn grain yields. Modern agriculture has a wide range of ways to combat weeds, the most effective of which is the use of herbicides [1]. At present, about half of the world's agricultural crops are obtained from plant protection products, therefore it is practically impossible to provide the growing population of the planet with food and raw materials without the use of pesticides. Under these conditions, there is a high urgency of the problems associated with the control of the behavior of chemicals in the environment. [2–4].

New technologies of agricultural production are used, the safety of plant protection products is studied, environmental standards for their permissible residual content are being developed to solve phytosanitary problems [5, 6].

According to various estimates, 70–90% of pesticides enter the soil at the time of application. Their residual amounts inhibit soil biota, have a negative aftereffect on cultivated plants and pollute surface and ground waters [7].

The problem of contamination of arable soils with modern herbicides is associated with the food security of the country, since it can lead to significant losses in crop yields as a result of uncontrolled use of herbicides [8].

One of the requirements for herbicides during registration tests is environmental safety. It is determined by a number of indicators: decomposition during one growing season, the absence of aftereffect on the next crop rotation, etc. [9, 10]. The absence of negative aftereffect is one of the most important properties of selective herbicides. Most of the drugs used have this property if the regulations for their use are observed. If the technology is violated (overestimation of the consumption rate, uneven distribution over the area, etc.), many drugs become dangerous and can cause damage not only to the processed, but also to subsequent crops of the crop rotation [11].

New generation herbicides have high phytotoxicity and retain herbicidal activity in environmental objects, in particular in soil, for a long time. In connection with the contamination of arable soils with residues of modern persistent herbicides, new ways of solving this problem are required [12–14].

Residual amounts of herbicides or their metabolites affect the subsequent crop. It had no practical significance for field crop rotations, since the share of such herbicides in production was insignificant [15].

The number of chemicals is increasing by about a thousand names every year. However, many of them are insufficiently studied from

the point of view of ecological safety in various soil and climatic conditions [16].

The evaluation of the pesticides detoxification rate is carried out by the following methods: direct determination of the dynamics of the compound of substances in the soil using physicochemical analyzes and indirectly using biotests. The first method, in some cases, is not sensitive enough to detect traces of herbicides, in particular those used in low doses. The phytotest on sensitive plants is recognized as the most accessible and sufficiently informative in this case [17].

The aim of the research is to study the sensitivity of agricultural crops to the Lumax herbicide, which consists of three active substances: C-metolachlor, terbutylazine and mesotrione to establish the duration of their preservation in meadow-brown soil and to determine the aftereffect of the drug on crop rotation crops.

MATERIALS AND METHODS

The studies were carried out in a vegetation house (2019, 2020), as well as on the experimental field of the Far Eastern Research Institute of Plant Protection in 2019. The soil of the site is meadow-brown podzolized medium loamy, containing 3-4% humus in the arable horizon, pH_{sal} 5, 0-5.9. In 2019, in a growing house, the sensitivity of 12 agricultural crops to the Lumax herbicide was determined. A weighed portion of meadow-brown soil, 1.5 kg, was treated with herbicide solutions at doses: 4.0; 3.0; 2.0; 1.0; 0.5; 0.25; 0.125; 0.063 and 0.0315 l / ha. The application of the drug solutions was carried out using an OL-5 laboratory sprayer designed by the All-Russian Research Institute of Phytopathology. One day after thorough mixing, the treated soil was placed in 300 g cups. Seeds of the following test cultures were sown in them: wheat, barley, oats, rice, rapeseed, radish, cucumbers, buckwheat, soybeans, cabbage, beetroot, and tomatoes.

In 2019, the herbicide Lumax was used in the sowing of maize before germination at rates of 4.0 l / ha (recommended) and 8.0 l / ha (two times the recommended). In the fall (after 3 months) and in the spring of 2020 (after 8 months), samples of meadow-brown soil were taken from these plots, as well as from the control variant, from the depth of the arable layer (0–20 cm). The soil was dried, crushed, then the cups were filled with it, after which the seeds of sensitive test cultures were sown in them. At the same time, a weighed portion of pure (without herbicides) meadow-brown soil, 1.5 kg, was treated with Lumax solutions. After the preparation described above, the same selected sensitive cultures were sown. The experiments were repeated five times. The soil moisture in the cups was maintained at the level of 60–70% WFC (water field capacity) by irrigation with tap water. After 30 days, the plants were cut and weighed. The calculation of ED_{10} and ED_{50} (a toxic dose that reduces the green mass of plants by 10 and 50%), as well as residual amounts of active substances in the soil was carried out using a computer. The aftereffect of the Lumax herbicide was determined by the decrease in the aboveground mass of the test plants in comparison with the control.

All studies were carried out in accordance with the approved methodological guidelines[1], and the digital material was processed according to B.A. Dospekhov[2].

RESULTS AND DISCUSSION

Crops reacted differently to the application of the Lumax herbicide to the soil. The complete death of beetroot was observed from the presence in the soil of 0.063 l / ha of the drug, cabbage and cucumber - from 0.25 l / ha, tomatoes, rice, rapeseed and radish - from 0.5 l / ha, buckwheat and wheat - from 2.0 l / ha, and soybeans, oats and barley - from 4.0 l / ha (see table. 1).

The calculation of the toxic dose of the herbicide Lumax, which reduces the green mass of plants by 50%, showed that for beetroot it is equal to 0.004 l / ha, for cabbage, rice, tomatoes, cucumber, rapeseed and radish - 0.045–0.166 l / ha. These crops are identified as highly sen-

[1]Spiridonov Yu.Ya., Larina G.E., Shestakov V.G. Methodical guidelines for the study of herbicides used in crop production. M.: Pechatny gorod, 2009.252 p.

[2]Dospekhov B.A. Field experiment technique. Moscow: Kolos, 1979.416 p.

sitive. Wheat, buckwheat and soybeans turned out to be sensitive crops to this herbicide, while oats and barley were relatively resistant. Plants that indicate residues of the Lumax herbicide in meadow brown soil include highly sensitive and sensitive agricultural crops. According to the ED_{10} indicator of the drug in the soil, the test crops are arranged in descending order as follows: barley → oats → soybean → buckwheat → wheat → radish → rapeseed → cucumbers → tomatoes → rice → cabbage → beetroot.

By the end of the growing season (3 months after treatment) from the application rate of 4.0 l / ha (2.152 kg r.a. / ha), 0.016–0.064 kg r.a. / ha, or 0, remained in the meadow-brown soil. 7-3.0%, herbicide Lumax, from the application rate 8.0 l / ha (4.304 kg r.a. / ha) - 0.024-0.170 kg / ha, or 0.6-3.9%, (see. Table 2).

Almost all of the selected plants showed the presence of the studied preparation in the soil. By the beginning of the next field season (8 months after application), Lumax, applied at the recommended consumption rate, completely decomposed. When the drug was applied in two times the recommended dose, the herbicide remained 0.035–0.072 kg / ha, or 0.8–1.7%. Residual amounts of Lumax in the soil were noted in the crops of cucumbers, soybeans, rice, tomatoes and wheat.

The studies carried out to determine the aftereffect of the herbicide Lumax indicate that, at the recommended consumption rate of 4.0 l / ha, tomatoes slightly (by 1.5%) reduced the aboveground mass (see Table 3).

On the rest of the crops, the green mass of plants was registered by 0.7–7.9% more than on the herbicide-free variant. At a dose of 8.0 l / ha, two times the recommended dose, reliably (LSD 05 = 11.7 and 9.1%, respectively),

Табл. 1. Токсичная доза гербицида Люмакс для сельскохозяйственных культур в лугово-бурой почве, л/га

Table 1. Toxic dose of the Lumax herbicide for agricultural crops in meadow brown soil, l/ha

Crop	Complete death of plants	Reduction of green mass of plants	
		by 50%	by 10%
Barley	4,0	1,193 (1,020 ÷ 1,394)	0,595
Oats	4,0	1,087 (0,994 ÷ 1,188)	0,399
Soy	4,0	0,712 (0,611 ÷ 0,829)	0,201
Buck-wheat	2,0	0,357 (0,308 ÷ 0,413)	0,178
Wheat	2,0	0,336 (0,247 ÷ 0,456)	0,132
Radish	0,5	0,166 (0,126 ÷ 0,219)	0,070
Rapeseed	0,5	0,104 (0,089 ÷ 0,122)	0,042
Cucum-bers	0,25	0,070 (0,057 ÷ 0,085)	0,031
Tomatoes	0,5	0,068 (0,051 ÷ 0,091)	0,020
Rice	0,5	0,067 (0,053 ÷ 0,086)	0,020
Cabbage	0,25	0,045 (0,033 ÷ 0,062)	0,017
Beetroot	0,063	0,004 (0,001 ÷ 0,018)	0

Табл. 2. Динамика содержания действующих веществ гербицида Люмакс в лугово-бурой почве

Table 2. Dynamics of the content of active agents of the herbicide Lumax in meadow-brown soil

Test-crop	Consumption norm, l/ha		Active agents content in the soil layer 0–20 cm			
	acc. to the prep-ara-tion	acc. to a.ag.	in 3 months		in 8 months	
			kg / ha	% of the deposited amount	kg / ha	% of the de-posited amount
Soy	4	2,152	0,060	2,8	0	0
	8	4,304	0,064	1,5	0,040	0,9
Wheat	4	2,152	0,064	3,0	0	0
	8	4,304	0,090	2,1	0,072	1,7
Buck-wheat	4	2,152	0	0	0	0
	8	4,304	0,110	2,6	0	0
Radish	4	2,152	0,016	0,7	0	0
	8	4,304	0,038	1,0	0	0
Rapeseed	4	2,152	0,025	1,2	0	0
	8	4,304	0,056	1,3	0	0
Cabbage	4	2,152	0	0	0	0
	8	4,304	0,026	0,6	0	0
Cucum-bers	4	2,152	0,045	2,1	0	0
	8	4,304	0,050	1,2	0,035	0,8
Tomatoes	4	2,152	0,058	2,7	0	0
	8	4,304	0,062	1,4	0,047	1,1
Rice	4	2,152	0,046	2,1	0	0
	8	4,304	0,064	1,5	0,046	1,1

the smallest increase in green mass was observed on wheat - 12.5% and soybeans - 10%. The aboveground weight of tomatoes, cucumber and rice was also 8.0–9.7% less than in the control.

CONCLUSIONS

1. According to the results of the studies carried out under the conditions of a vegetation house in meadow-brown soil, the sensitivity of agricultural crops to the herbicide Lumax was established. The following highly sensitive crops have been identified: cabbage, radish, rapeseed, beetroot, tomatoes, cucumbers, rice; sensitive: wheat, soy, buckwheat; relatively resistant: barley, oats. Plants that are indicative of Lumax herbicide residues include highly sensitive and sensitive crops.

2. 8 months after the application of the herbicide Lumax in the recommended (4.0 l / ha) consumption rate is safe for subsequent crops of the crop rotation. In case of overdose or double overlapping (8.0 l / ha), it can have an aftereffect. In meadow-brown soil, up to 0.8-1.7% of the active substance of the drug is retained.

Табл. 3. Последействие гербицида Люмакс на культуры севооборота

Table 3. Aftereffect of the herbicide Lumax on the plants of crop rotation

Crop	Green mass of plants in control, g	Reduction of green mass of plants from consumption rates, % to control		LSD_{05}, %
		4,0 l / ha	8,0 l / ha	
Wheat	1,52	+ 0,7	12,5	11,7
Rice	0,86	+ 1,2	9,3	11,6
Soy	2,57	+ 4,7	10	9,1
Buck-wheat	3,64	+ 4,4	0	14,6
Cucum-bers	3,32	+ 6,3	8,7	11
Tomatoes	1,37	1,5	8,0	14
Rapeseed	1,51	+ 7,9	0	12

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