Eriochloa villosa in the Primorsky Territory of Russia and the search for soil herbicides to combat it in soybean crops

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Abstract. The work analyzes the results of monitoring the weed field flora of the Primorsky Territory. A tendency has been revealed to increase the occurrence and density of the woolly cupgrass *Eriochloa villosa* (Thunb ex Murray.) Kunth, which is difficult to control due to a number of competitive biological advantages and morphological features that determine its resistance to many herbicides. In experiments conducted in 2021–2022. in the Far Eastern Scientific Research Institute of Plant Protection, it was revealed that according to the main indicator - a decrease in the wet above-ground mass of experimental weed plants compared to the control, the most effective herbicides were Dual Gold 1.6 l/ha, Proponit 3.0 l/ha and tank mixtures Dual Gold 1.5 l/ha + Gesagard 2.5 l/ha, Dual Gold 1.5 l/ha + Zenkor Ultra 0.5 l/ha, Dual Gold 1.5 l/ha + Command 0.7 l/ha.

1 Introduction

Currently, soybean production is associated with technological and environmental problems. In the world, the crop is grown on an area of 131 million hectares, production has reached 258 million tons. Of the 15 leading soybean-producing countries, cultivation of the crop is mainly concentrated in the United States, Brazil and Argentina [1-2].

Weeds are one of the most important factors limiting crop yields worldwide. They are characterized by high seed productivity, rapid germination, early growth, long life span, compete with crops for resources such as light, water, air, space, and if agrochemical, chemical and other work is not carried out in a timely manner, the yield shortfall can reach 45–95 % [3–5].

Among the wide range of weed species growing in soybean and other crops, the hairy woolly cupgrass Eriochloa villosa (Thunb. ex Murray) Kunth, a representative of the *Poaceae family*, or Poaceae Barnhart (Gramineae, Juss.) [6-7]. This is an annual plant 30–200 cm high with dark green and densely pubescent leaves that are velvety to the touch. Hairy woolly cupgrass not only infests agricultural land, but also successfully penetrates

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into open natural habitats. The plant's homeland is the Far East. In Russia, this species is currently also widespread and is found in the Voronezh and Belgorod regions, in western Siberia (Altai Territory), and in the Caucasus [8–11]. Outside the Russian Federation, *E. villosa* is widespread in many regions of Asia: eastern China, Japan, Mongolia, North Korea, Republic of Korea, Taiwan. In Europe, the weed has penetrated into the territory of Eastern Austria, the Czech Republic, Romania, and Hungary. In the United States, woolly cupgrassly is steadily becoming an economically significant pest in corn and soybean production areas. In Canada, this species has been a nationally regulated quarantine species since 2011 [8, 12–14].

E. villosa seeds can germinate and emerge over a wide range of soil temperatures and depths. Significant germination, more than 80%, is observed at temperatures from 15 to 40 ºC, with an optimum of 20–35 ºC. The action of variable temperatures (heat and cold) increases seed germination. The density of weeds of this species can reach more than 200 pieces/m^2. By competing with agricultural plants, woolly cupgrass significantly reduces their productivity. One *E. villosa* plant can produce 3,000–164,000 seeds that remain viable for up to three years. This species is difficult to control due to its biological characteristics (early appearance and subsequent “waves” of seedlings; flexible nature of plant growth, their resistance to drought and soil waterlogging) and complete or partial immunity to many herbicides [6, 13]. Therefore, the strategy of integrated protection against hairy woolly cupgrass includes the use of mechanical methods and compliance with crop rotation, and the necessary effectiveness of the chemical method is achieved by using one or more herbicides with high toxicity for this dangerous weed [6, 8].

In our opinion, in the case of hairy woolly cupgrass weed, as well as other weeds that are difficult to control in soybean crops using herbicide treatments on vegetative plants, the success of protection should mainly be ensured by the use of soil preparations with confirmed high activity against problem species. Effective use of herbicides before sowing or before soybean emergence also allows you to protect the crop at the initial stages of ontogenesis, which are most vulnerable to the harmful effects of weeds.

The objectives of the work are to summarize long-term monitoring data of the woolly cupgrassly moth in the Primorsky Territory of the Russian Federation; to study the biological effectiveness of a number of herbicides (and their tank mixtures) with soil activity and recommended for the protection of soybeans against this species.

2 Materials and methods

An assessment of crop infestation in the Primorsky Territory was carried out in 1996–2023. The effect of herbicides with soil activity on woolly cupgrass was studied in 2021–2022. in growing conditions using methods generally accepted in herbology and plant growing [15-16].

Herbicides based on seven active ingredients and their tank mixtures were studied. Individually, herbicides were used at the maximum permitted consumption rates.

3 Results

Between 1996 and 2023. annual monitoring of weed infestation in industrial crops of soybeans, corn and early grain crops in the steppe, forest-steppe, southern taiga and northern taiga was carried out on an average area of 4.6 thousand hectares. We first found hairy woolly cupgrass weed in soybean crops in 2007. Every year, every field season, this weed began to be found in soybean crops and other agricultural crops starting in 2013 (Table 1).

Table 1. Infestation of agricultural crops with woolly cupgrassly grass in the Primorsky Territory in 2013–2023.

Year	Occurrence of *Eriochloa villosa*, %		Abundance of *Eriochloa villosa*, pcs./m²	
	in crops of all agricultural crops	including in soybean crops	in crops of all agricultural crops	including in soybean crops
2013	25.7	23.0	2.7	4.3
2014	45.0	50.0	8.3	10.2
2015	69.8	60.0	6.6	2.9
2016	70.5	70.3	12.8	15.7
2017	82.1	85.4	8.7	8.5
2018	89.7	94.4	7.9	6.8
2019	94.9	94.9	11.3	13.1
2020	85.2	81.0	4.5	3.2
2021	85.4	83.6	6.3	6.3
2022	88.0	87.1	5.8	5.9
2023	83.7	78.4	7.5	6.3

The sensitivity of shaggy woolly cupgrass to the soil herbicides and their tank mixtures used in the experiments was determined (Figures 1 and 2).

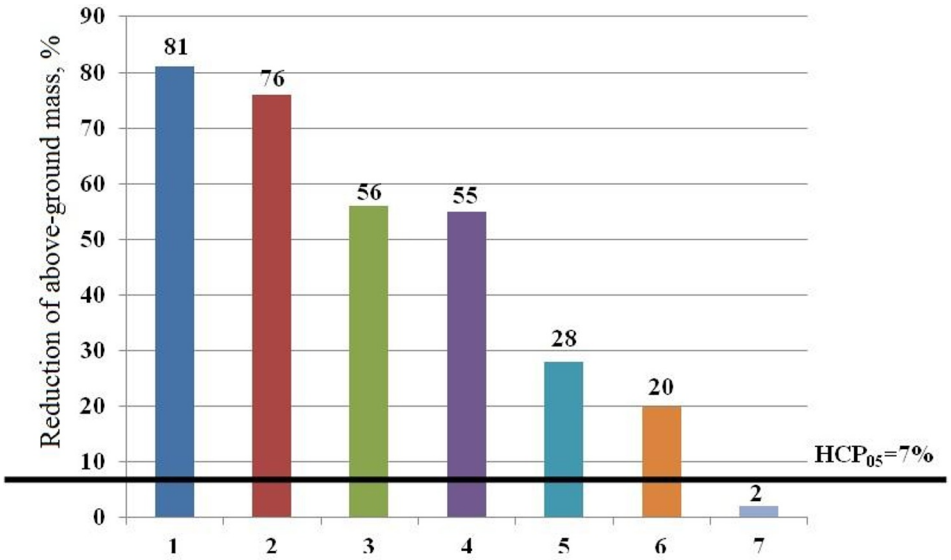

Fig. 1. Sensitivity of *Eriochloa villosa* to soil herbicides, average of two experiments.

1. Proponit (3.0 l/ha); 2. Dual Gold (1.6 l/ha); 3. Gardo Gold (4.5 l/ha); 4. Gesagard (3.5 l/ha); 5. Command (1.0 l/ha); 6. Zenkor Ultra (1.0 l/ha); 7. Pledge (0.12 kg/ha)

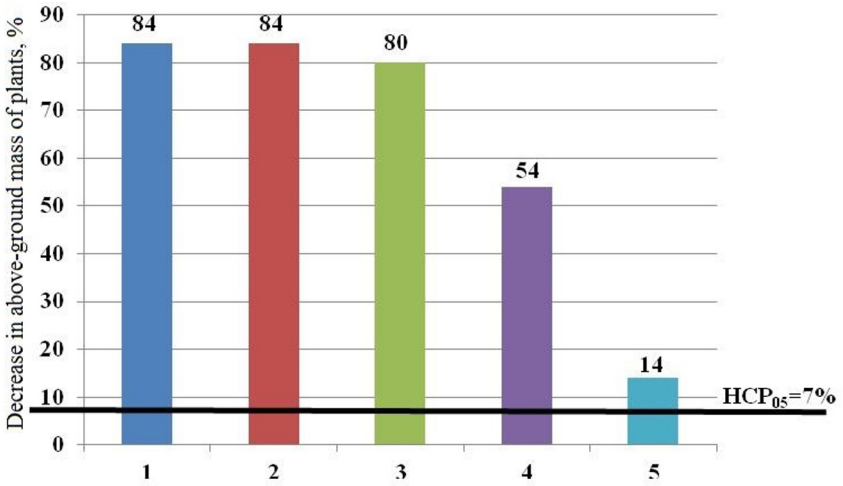

Fig. 2. Sensitivity of *Eriochloa villosa* to tank mixtures of soil herbicides, average of two experiments.

1. Dual Gold (1.5 l/ha) + Gesagard (2.5 l/ha); 2. Dual Gold (1.5 l/ha) + Command (0.7 l/ha); 3. Dual Gold (1.5 l/ha) + Zenkor Ultra (0.5 l/ha); 4. Proponit (2.0 l/ha) + Pledge (0.1 kg/ha); 5. Command (0.7 l/ha) + Pledge (0.1 kg/ha)

4 Discussion

In the next five years after the first discovery of woolly cupgrassly moth in 2007, it was only discovered again in 2010 in soybean crops. The occurrence of the weed on average over two years was 4.4% with a low growth density of 2.3 pcs./m^2. Between 2013 and 2016 The prevalence of *E. villosa* on average over four years reached 52.8% of all surveyed areas of soybeans, corn and early grain crops, and the abundance increased to 7.6 pcs./m^2. Directly for soybean crops, these figures were respectively 50.8% and 8.3 units/m^2. Over the next seven years (2017–2023), the average density of woolly cupgrassly in the crops of the surveyed crops did not change or increased slightly, but the occurrence increased to 82.1–94.9%. The infestation of soybean crops with woolly cupgrass this period varied from 2.9 pcs./m^2 in 2015 to 15.7 pcs./m^2 in 2016, and the prevalence ranged from 78.4% in 2023 to 94.9% in 2019 (Table 1) . In the conditions of the Primorsky Territory, bluegrass weeds (common barnyard grass Echinochloa crusgalli (L.) Beauv., green bristle grass *Setaria viridis* (L.) Beauv.; low-growing bristle grass - *Setaria pumila* (Poir.) Schult. and hairy woolly cupgrass) in soybean crops By the bean filling phase, depending on the weather conditions of the year, from 0.23 to 1.45 kg/m^2 of green mass is formed, which mainly determines their high harmfulness to the crop. The contribution of woolly cupgrass to this volume can reach 58.0% (on average - 19.0%). In 2021–2023 in soybean agrocenoses, the share of woolly cupgrass in the above-ground mass accumulated by cereal weeds was in the range of 22.8–33.2%.

In vegetation experiments, woolly cupgrass shoots in the control and in most experimental variants appeared simultaneously, five days after sowing. 3–4 days after germination, a visually noticeable negative effect on the woolly cupgrass of the herbicides Dual Gold 1.6 l/ha, Proponit 3.0 l/ha, Gesagard 3.5 l/ha and Gardo Gold 4.5 l/ha was noted, expressed in the growth retardation of experimental plants, chlorosis of leaves and the formation of necrosis on them. After 10–12 days after germination, when the control

seedlings of the woolly cupgrass plant grew to an average of 8 cm and formed three well-developed leaves, up to 40–60% of the plants died in the indicated variants.

A bleaching effect of Command 1.0 l/ha on weed plants was noted without a noticeable delay in growth and development, which, however, did not even lead to partial death of the shoots in the vessels during the experiments.

Plants in the variants using Zenkor Ultra 1.0 l/ha and Pledge 0.12 kg/ha from emergence to cutting did not visually differ from the control.

Also, simultaneously with the control, the emergence of *E. villosa* seedlings was noted when using tank mixtures Proponit 2.0 l/ha + Pledge 0.1 kg/ha and Command 0.7 l/ha + Pledge 0.1 kg/ha. Subsequently, the combination of Proponit with Pledge significantly suppressed the growth of the weed and caused chlorosis of the leaves. The combined use of Command with Pledge manifested itself in the form of lightening of the leaves and a slight lag in growth of the experimental plants. There was no death of woolly cupgrass seedlings in these variants.

As a result of using tank mixtures Dual Gold 1.5 l/ha + Gesagard 2.5 l/ha, Dual Gold 1.5 l/ha + Zenkor Ultra 0.5 l/ha and Dual Gold 1.5 l/ha + Command 0.7 l/ha, shaggy woolly cupgrass seedlings appeared later, than in the control for 3–4 days. On average, 70% of the plants died over the next five days, and the remaining ones were noticeably behind the control seedlings in growth (by 13-25%) and development (phase of 1–2 leaves versus 3 leaves in the control). Signs of damage to the woolly cupgrass were also recorded - chlorosis of the leaves, the presence of small point necrosis on them, drying of the distal edges of the leaf blades.

30 days after sowing and application of herbicides, the raw above-ground plant biomass was cut and weighed. By this time, control plants had developed 4–6 leaves and had a fresh above-ground mass of 12.1 g/vessel (on average in two experiments). In terms of reducing weed mass, good, maximum efficiency in the experiment (80–84%) was shown by tank mixtures of Duala Gold with one of the following herbicides: Gesagard, Command and Zenkor Ultra and separately applied Proponit. Somewhat weaker, but also good, Dual Gold worked 76% independently. Gardo Gold, Gesagard and a mixture of Proponit and Pledge worked satisfactorily (51-75% reduction in weed weight). The application of Zenkor Ultra, Commanda, Pledge and a combination of the last two drugs to the soil to control hairy woolly cupgrass by weight turned out to be ineffective (Figures 1 and 2).

5 Conclusion

In the Primorsky Territory, hairy woolly cupgrass, steadily progressing as a segetal weed, has been among the four most common weed species for the last seven years. Occurrence of woolly cupgrassly moth in soybean crops in 2017–2023. ranged from 78.4 to 94.9% (on average - 86.4%) with an average weed density of 71.8 thousand plants per hectare. Possessing high adaptive and reproductive abilities, species resistance to many widely used herbicides, hairy woolly cupgrassly has become a serious danger to soybeans.

Of all the tested soil preparations, Dual Gold 1.6 l/ha, Proponit 3.0 l/ha and mixtures of Dual Gold 1.5 l/ha + Gesagard 2.5 l/ha, Dual Gold 1.5 l/ha + Zenkor Ultra 0.5 l showed good effectiveness against hairy woolly cupgrass. /ha, Dual Gold 1.5 l/ha + Command 0.7 l/ha. In variants with the use of these drugs and combinations, the early death of the weed reached 70%, and the wet above-ground mass of preserved, surviving plants 30 days after treatment decreased by 76–84% compared to the control. Individual or combined use of effective soil herbicides will allow you to successfully control hairy woolly cupgrass in soybean crops in the early stages of growth and development, and will also create favorable conditions for the subsequent use of herbicides on vegetative plants.

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