Herbicidal efficiency of natural salt in cultivation of spring wheat

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Abstract. The studies were carried out in order to assess the effect of the herbicidal activity of a 30% solution of natural salt in the cultivation of spring wheat. In a field experiment under the conditions of the Krasnoyarsk forest-steppe, crude natural brines of the Troitsk deposit of the Krasnoyarsk Territory were used, containing in their composition, g/l: sodium - 77.07; magnesium - 0.49; iron - 3.67; calcium - 2.56; potassium - 2.36; chlorides - 131.00; sulfates - 1.51. The concentration of natural salt was obtained by diluting the original base brine. Studies have established that sodium chloride, being the main component of brines from the Troitskoye deposit, has herbicidal activity on the weed component and selectivity of action. The maximum efficiency of the natural salt solution was noted for the variant with a 30% solution of natural salt with the Satellite, Zh. A decrease in the total weediness of crops for harvesting wheat by 84% in terms of the number of weeds and by 89% in terms of biomass indicates the effectiveness of this technology of using natural salt. The natural herbicide was found to be highly effective against perennial root-shedding weeds Sonchus arvensis and Cirsium arvense and the annual weed Chinochloa crus-galli.

Keywords: Natural brine, Troitskoye deposit, herbicide, weeds, spring wheat, agrochernozem.

Introduction

The creation of favorable conditions for the growth and development of agricultural crops during their growing season is determined by a set of agrotechnical measures [Purlaur et al., 2009; Strizhkov et al, 2018; Nikolaichenko, 2019; Kurdyukova, 2021], among which the main role is assigned to the fight against weeds. Weeds, being a constant component of agroecosystems, determine yield losses from 10 to 50%. Therefore, the use of chemical herbicides in the technology of cultivation of agricultural crops is several times higher than the amount of other plant protection products [Aktar et al, 2009; Cantrell et al, 2012]. At the present stage of the development of agriculture, a completely new concept is being formed, the essence of which is not in the complete destruction of the weed component in agrocenoses with the

growing threat of environmental pollution by pesticides, but in the regulation of their number [Korneva et al., 2014; Yan et al, 2016; Cressey, 2015, Bruhal et al., 2017]. In this regard, the issue of a fundamental change in approaches to the development of new herbicides is being resolved. They must be safe for the environment and have a different mechanism of action from existing drugs. One of these compounds, which is proposed to be used as a natural herbicide, is the brine from the Troitskaya salt deposit (Krasnoyarsk Territory). The rationale for the possibility of using natural salts of various concentrations for weed control and its effect on soil properties was discussed by us earlier [Kurachenko et al, 2020; Vlasenko et al, 2020].

The purpose of the sudy – to evaluate the herbicidal efficiency of natural salt in the cultivation of spring wheat in the conditions of the Krasnoyarsk forest-steppe.

Objects and Methods

The studies were carried out in 2021 in the conditions of the Krasnoyarsk forest-steppe, located on the southwestern outskirts of Central Siberia. This territory receives 350-450 mm of precipitation per year. The average annual air temperature in the region varies from 0.5 to 3.0°C, sometimes dropping to -2°C. The duration of the period of biological activity varies within 90-155 days. The sum of active temperatures is 1550-1800°C, soils freeze to a depth of 1.5-3.0 m.

The study of the herbicidal effectiveness of natural salt was carried out in a field experiment in wheat agrocenosis according to the scheme: 1) control (without treatment); 2) treatment of plants with a 30% solution of natural salt; 3) treatment of plants with a 30% solution of natural salt with an adhesive Satellite, J.

In the experiment, we used crude natural brines from the Troitskoye deposit, geographically located in the Krasnoyarsk Territory and having explored reserves of the mineral halite of about 1 billion tons. Crude natural brines of this deposit in their composition contained in g/l: sodium - 77.07; magnesium - 0.49; iron - 3.67; calcium - 2.56; potassium - 2.36; chlorides - 131.00; sulfates - 1.51. The concentration of natural salt was obtained by diluting the original base brine. The choice of concentration of natural salt as herbicide is based on preliminary field experiments.

The total area of the plot is 15 m^2, the registration area is 10 m^2, the location is systematic. Each variant is repeated four times. The crops of spring wheat variety Novosibirskaya 31 were sprayed using a professional battery-operated telescopic sprayer (CAIMANTELESCOPIC 150 EW) during the beginning of tillering with a massive appearance of weeds. The consumption rate of the working fluid was calculated on the basis of a hectare rate of 300 l/ha.

The soil of the experimental plot is clay-illuvial agrochernozem typical of heavy loamy granulometric composition, characterized by a high humus content (6.0-6.5%), a very high

amount of exchange bases (53.2-62.0 mmol/100g), and a neutral reaction of the soil solution (pHn_2o 6.8-6.9), a very high content of mobile phosphorus (343-316 mg/kg) and exchangeable potassium (228.6-220.1 mg/kg).

Weed counts were carried out by a quantitative method on 4 accounting plots with a size of 0.25 m^2 on each plot of the experiment, where the total number of weeds was counted by species. The biological effectiveness of natural salt was determined in comparison with the original contamination. Weed counts were carried out before the treatment of experimental plots, two weeks later, and before harvesting the crop.

Results and discussion. The formation of weeds in the crops of spring wheat took place under optimal conditions for their growth and development. During the period of emergence of spring wheat seedlings, the amount of precipitation exceeded the average annual level by 75%. Sowing of spring wheat on a layer of perennial grasses (forage mixtures) and warm weather conditions determined a strong degree of contamination of the agrocenosis of wheat before the start of its tillering. In the summer period, 17 species of weeds from 10 botanical families were recorded in wheat crops (tab. 1). The weed coenosis is represented by plants from the family Amaranth, Lebed, Cabbage, Madder, Lamb, Bluegrass, Pink, Compositae, Lipoaceae and Bindweed. The biomorphological spectrum of weed species indicates that 10 species are juvenile weeds and 7 species are perennial. Representativeness of biological groups of weeds, according to L.D. Protasova et al. [2008] is determined by weather conditions. So in the control variant in extreme years, 15-16 species were observed, and in years favorable for plant growth, it reached up to 39 species.

Table 1 – Species composition of weeds in the agrocenosis of spring wheat

Species	Latin name	Family	Biological group
annual			
Amaranthus retroflexus	*Amaranthus retroflexus*	Amaranthaceae	spring annual
Shepherd's Purse	*Capsella bursa pastoris*	Mustards	spring annual
White goosefoot	*Chenopodium album*	Chenopodioideae	spring annual
Cleavers	*Galium aparine*	Chenopodioideae	wintering annual
Galeopsis tetrahit	*Galeopsis tetrahit*	Mints	spring annual
Annual bluegrass	*Póa ánnua*	Pooideae	spring annual
Spear saltbush	*Atriplex patula*	Amaranthaceae	spring annual
Common wild oat	*Avena fatua*	Pooideae	spring annual
Setaria pumila	*Setária*	Pooideae	spring annual
Cockspur grass	*Chinochloa crus-galli*	Pooideae	spring annual
perennial			
Dandelion	*Taraxacum*	Compositae	tap-root perennial
Silverweed	*Potentilla anserina*	Rosaceae	perennial

Field bindweed	*Convolvulus arvensis*	Convolvulaceae	root-scion perennial
Perennial sow thistle	*Sonchus arvensis*	Compositae	root-scion perennial
Leonurus	*Leonurus quinquelobatus*	Labiatae	tap-root perennial
Creeping thistle	*Cirsium arvense*	Compositae	root-scion perennial
Timothy	*Phleum pratense*	Pooideae	perennial

The account of weediness of spring annual wheat crops showed that a strong degree of weediness was manifested in the first half of the growing season of the crop (tab 2). The rapid growth and development of spring annual wheat in the stemming phase resulted in the suppression of the weed component. The average degree of contamination of the culture (22 pcs/m^2) in the control variant was noted during the ripening of the culture.

Table 2 – Dynamics of weed infestation of spring annual wheat crops

Option	30.06*		13.07**		17.08***	
	pcs/m^2	g/m^2	pcs/m^2	g/m^2	pcs/m^2	g/m^2
Control (without treatment)	60	56.4	60	58.0	22	24.4
Natural salt 30%	92	82.4	52	34.4	22	27.2
Natural salt 30% +adhesive	88	108.0	60	32.0	14	12.0

* - before treatment
** - two weeks after treatment
*** - before harvesting

A strong degree of contamination of the wheat agrocenosis was also noted in the variants of the experiment with the use of a 30% solution of natural salt. Before the treatment of crops with a natural herbicide, the number of weeds reached 88-92 pcs/m^2. A weed phytocenosis has formed here, consisting mainly of perennial weeds (52-61%). The dominant perennial species in these variants of the experiment were dandelion (*Taraxacum*), perennial sow thistle (*Sonchus arvensis*), and field bindweed (*Convolvulus arvensis*). The use of a 30% solution of natural salt and its use in conjunction with an adhesive made it possible to reduce the competition between weeds and the crop for the main factors of growth and development by the beginning of spring annual wheat stemming. Despite the growth of "second wave" weeds, the natural herbicide in all variants of the experiment led to a reduction in their number. The calculation of the biological effectiveness of a natural herbicide, determined two weeks after its application on vegetative plants, showed that the different form of its application affected the weed component at a similar level (44 - 32%) (fig.). The weeds that retained their viability were in a depressed state, as

evidenced by their low biomass. The average weight of weeds on the variants of the experiment with the use of natural salt decreased 2.4-3.4 times and did not exceed 34 g/m^2.

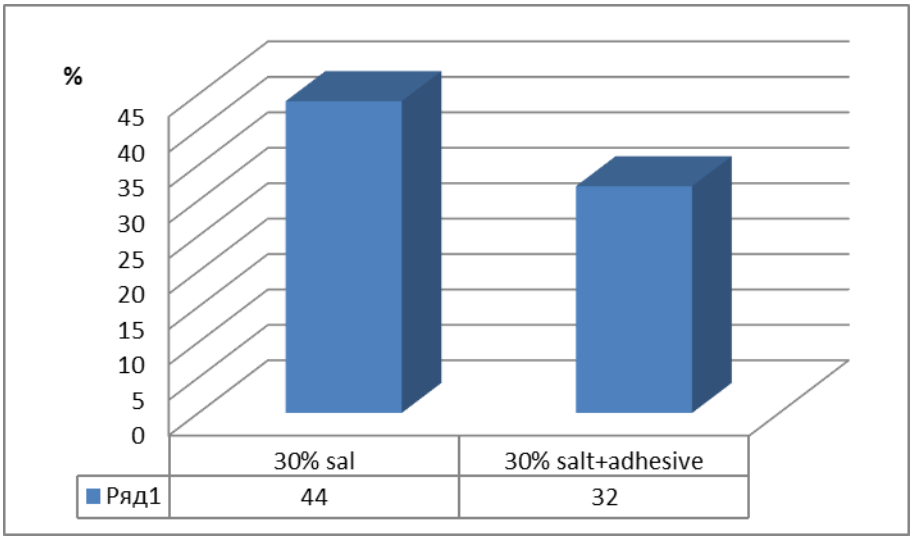

Figure - Biological efficiency of a solution of natural salt on crops of spring annual wheat,% to the initial state

The data of the field experiment showed a decrease in the total weediness of spring annual wheat crops to harvesting on the variant of the experiment using a 30% solution of natural salt with adhesion by 84% in terms of weeds and 89% in terms of biomass.

Evaluation of the effect of a natural salt solution on the main species showed its selectivity in relation to the weed component. In the soil of the control variant, in the July period of counting weeds, their maximum species diversity is noted (tab. 3). In the spring annual sowing of wheat of the control variant, single common wild oat (*Avena fatua*) and silverweed (*Potentilla anserina*) plants disappeared by this period. At the same time, perennial species dominated significantly - field bindweed (*Convolvulus arvensis*), dandelion (*Taraxacum*), creeping thistle (*Cirsium arvense*). Spear saltbush (*Atriplex patula*) prevailed among spring annual crops.

Table 3 – Characteristics of the action of natural salt solution on the main types of weeds (pcs/m^2)

Weed species	Control (without treatment)		Natural salt 30 %		Natural salt 30% + adhesive	
	13.07	17.08	13.07	17.08	13.07	17.08
Perennial						
Dandelion	8	0	20	3	16	0
Field bindweed	12	5	8	4	12	4
Perennial sow thistle	4	12	0	5	0	6

Leonurus	4	0	20	3	16	0
Creeping thistle	16	0	0	0	0	0
Timothy	0	0	4	0	0	0
Spring						
Spear saltbush	8	1	4	8	4	3
Cockspur grass	4	4	0	1	0	1
Winter						
Cleavers	4	0	4	1	12	0

The use of a 30% solution of natural salt to control the weed component on spring annual wheat crops showed high efficacy of the natural herbicide against perennial sow thistle (*Sonchus arvensis*) and creeping thistle (*Cirsium arvense*). The inhibition of the aerial part of perennial root-sprouting weeds in the variants of the experiment using a solution of 30% natural salt, as well as in the case of its use with the Satellite adhesive, is this confirmation. High activity of natural salt against the annual weed cockspur grass (*Chinochloa crus-galli*) was noted. The herbicidal activity of the natural salt solution was maintained until the end of the spring annual growing season of wheat.

Conclusion

The results of the field experiment showed herbicidal activity and selectivity of the action of a 30% solution of natural salt. Under the conditions of strong infestation of spring annual wheat crops, the effectiveness of the natural herbicide manifested itself two weeks after treatment and was accompanied by a decrease in the number of weeds by 44-32% and a decrease in their average weight by 2.4-3.4 times. The maximum efficiency of the natural salt solution was observed in the variant with the Satellite adhesive, which reduced the surface tension of the working solution, ensured the creation of a uniform film on the leaf surface and promoted better adhesion of the natural herbicide and its absorption by the plant. A decrease in the total weediness of crops for harvesting wheat by 84% in terms of the number of weeds and by 89% in terms of biomass indicates the effectiveness of this technology of using natural salt.

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