The influence of the surfactant sodium laureth sulfate on the obstacles of lupine seedlings

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Abstract. As a result of the conducted laboratory experiment, the negative effect of increasing doses of sodium laureth sulfate on the formation of lupin seedlings was established. The effect of sodium laureth sulfate on the germination rate of lupin seeds was established, which was accompanied by a consistent decrease in the number of seedlings as the concentration of the toxicant in the soil increased and reached its maximum value in the fifth variant with the highest concentration of detergent in the soil. Sodium laureth sulfate reduced the germination of seeds and the dynamic characteristics of plants by the end of the experiment. Metric indicators of lupin: total weight, weight of leaves, stems; roots, stem length and total leaf surface area were below the control values. The analysis of allometric coefficients confirmed the high sensitivity of lupin seedlings to the phytotoxic effect of sodium laureth sulfate, which was most pronounced in the fifth version of the experiment. The data obtained from the results of a laboratory experiment can be used in the practice of cultivating crops with possible soil contamination with detergents. Currently, the effects and behavior of surfactants in the soil horizons of fields irrigated by wastewater have not been sufficiently studied.

1 Introduction

The modern level of agro-industrial production involves the use of a wide range of chemicals of artificial origin, which allow to intensify production processes in agrocenoses. The chemicalization of agricultural lands to sustainably grow the country's food supply requires a special approach to soil as a basic means of production and a key factor in the sustainability of the natural environment.

Chemical pollution of the environment belongs to the category of existential factors leading to disruption of the stability of ecosystems at all levels, dangerous not only for wild flora and fauna, but also for human society. Cumulative effects are characteristic of many toxicants and xenobiotics, which, without participating in organisms in either plastic or energy metabolism, enter organisms through food chains, causing pathological changes of various etiologies in them.

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The main source of inorganic and organic pollutants entering natural and agricultural facilities is human economic activity, and the place of their biospheric localization is water bodies, soil and higher plants. The most dangerous pollutants of ecosystems include heavy metals, surfactants, carcinogens and mutagenic compounds. Xenobiotics with mutagenic and carcinogenic effects belong to the category of the most dangerous environmental pollutants.

Surfactants (surfactants) are substances that are part of detergents and cosmetics and are used in various production areas. They can be absorbed at the interface of the two phases and form a layer with an increased concentration.

The use of this group of compounds leads to a sharp decrease in the surface tension between the media due to the high adsorption of solutions of these substances, which causes a decrease in the interaction and exchange of gases such as oxygen and carbon dioxide. Some surfactants are considered less safe because their breakdown products are carbohydrates. But when adsorbed on microparticles of soil and sand, the rate of their degradation is noticeably reduced. This applies to all surfactants. All have positive adsorption on microparticles, and are also capable of introducing heavy metal ions, which affects the health of the environment and, accordingly, humans. The study of the effects of these substances on living organisms is currently increasingly relevant.

A distinctive feature of the modern stage of agricultural production is the complex loading of soil with chemicals. At the same time, surfactants (surfactants) detergents are included in the composition for any variant of soil chemical load in conditions of intensification of all branches of agriculture. Depending on the degree of chemicalization in uncultivated lands, the concentration of surfactants is 1-10 mg/kg in fertilized soil – up to 100 mg/kg.

All soils with the adsorption activity of anionic detergents are divided into two groups: strongly adsorbing with low cationic activity, high content of clay and free iron oxides, and weakly adsorbing with high cationic activity, high clay content, but low concentration of iron oxides.

Currently, the effects and behavior of surfactants in the soil horizons of fields irrigated by wastewater have not been sufficiently studied. So, for a more complete understanding of the extent of the influence of surfactants, it is necessary to establish concentration standards for their safe use for various types of soils, the number of irrigations, and irrigation standards. The available data does not allow us to create predictive models of the distribution, utilization and translocation of detergents in soil biota.

The question of the effect of surfactants on other toxic substances such as heavy metals, nitrates and organochlorine compounds remains open. There is preliminary evidence that the excessive presence of metals such as copper, zinc, cadmium, and calcium in the soil blocks the process of biodegradation of surfactants. In addition, the negative effect of surfactants has been found to reduce the availability of nutrients by plants when using mineral fertilizers and reduce their protein content.

Thus, there is every reason to assume that the synergism of surfactants with other chemical compounds can enhance the adverse effects on the soil-biotic complex and the quality of agricultural products.

The relevance of studying the effect of detergents on the soil-biotic complex is related to the fact that crop cultivation technologies involve the use of chemical plant protection products, mineral fertilizers, sewage sludge, which include surfactants.

We analyzed morphometric indicators of the stability of the formation of lupin seedlings at different levels of sodium laureth sulfate in the soil. We determined the effect of the detergent on the germination and dynamic characteristics of the formation of lupin seedlings; establishing the relationship between the metric values of lupin and the dose of

sodium laureth sulfate introduced into the soil; analyzed the phytotoxic effect of the detergent on the allometric characteristics of lupin seedlings.

The practical significance lies in the assessment of the possible consequences of detergent contamination of the soil during the cultivation of agricultural crops.

2 Materials and methods

Experimental studies were conducted in the laboratory of Agrobiotechnology of the Faculty of Agronomy.

To carry out the model experiment, polyethylene containers were used in which soil samples were placed. Aqueous solutions of sodium laureth sulfate 70% were introduced into the soil, the concentration of which is shown in Table 1 according to the variants.

Table 1. The content of sodium laureth sulfate in the soil.

Active ingredient	Options				
	Control	2	3	4	5
Sodium laureth sulfate 70%, mg/kg	-	62.5	125	250	500

After careful mixing of the soil, the containers with the soil were left for two weeks to establish soil equilibrium, and then lupin seeds were sown. Watering of the soil and seedlings was carried out after 2-4 days, as the soil dried out, with the same volume of water for each variant of the experiment. The duration of the experiment was 14 days.

Phenological observations and measurements of the length of the seedlings were carried out after 2 days according to generally accepted methods. Plant growth was measured by the height of the aboveground part. At the end of the experiment, the metric characteristics of the seedlings were determined: the mass of plants, leaves, roots and stems. The total area of the leaf surface was determined by the weight method. Calculated coefficients were used to evaluate allometric indicators: relative leaf area (leaf area/plant weight), photosynthetic effort (leaf weight/phytomass unit), root weight ratio per phytomass unit, stem weight ratio per phytomass unit

3 Results and Discussion

3.1 The effect of sodium laureth sulfate on seed germination and lupin growth dynamics

The emerging seedling is a multifunctional system, the development of which is determined by metabolic dependencies on the intake of substances from the seed, on the other hand, from external factors. Functioning seedlings are characterized by a maximum need for organic and mineral substances that ensure their growth, which explains their high dependence on environmental factors.

The effect of sodium laureth sulfate on the germination rate of lupin seeds was accompanied by a consistent decrease in the number of seedlings as the concentration of the toxicant in the soil increased: in the second variant by 3; in the third by 5; in the fourth by 8 and in the fifth by 15% relative to the control (Figure 1).The results of the effect of different doses of sodium laureth sulfate on the dynamics of the formation of lupin seedlings are presented in Table 2.

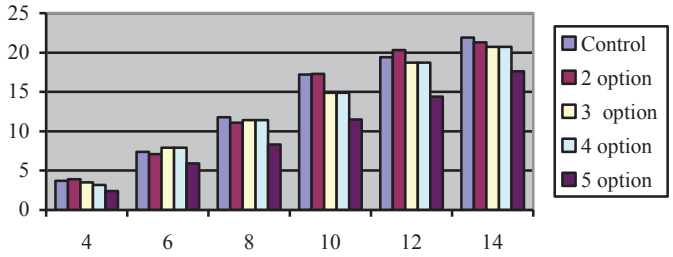

Fig. 1. Germination of lupine seeds, %.

Table 2. Dynamics of development of lupin seedlings under the influence of sodium laureth sulfate, cm.

Day	Option				
	Control	2	3	4	5
4	3.7	3.9	3.5	3.2	2.4
6	7.4	7.1	7.9	6.3	5.9
8	11.8	11.1	11.4	10.6	8.3
10	17.2	17.3	14.9	13.2	11.5
12	19.4	20.3	18.7	17.6	14.4
14	21.9	21.5	20.7	19.9	17.6

Tabular data, in general, indicate a negative effect of the detergent on the growth dynamics of lupin. In all variants of the experiment, except for the second, on day 4, the length of the seedlings turned out to be lower than the control indicators: in the third variant by 0.2 or 5.4; in the fourth – by 0.5 or 13.5; in the fifth – by 1.3 cm or 35.1%. With further observations, the dynamics of lupin growth did not change (Figure 2). By the end of the experiment, the length of the seedlings in the second variant was 0.4 or 1.8; in the third - 1.2 or 5.5; in the fourth – 2.0 or 9.1 and in the fifth 4.3 cm or 19.6% lower than the control values. The average daily increase over the entire period of the experiment was 1.6 cm in control; 1.5 cm in the second and third variants; 1.4 cm in the fourth and 1.2 cm in the fifth.

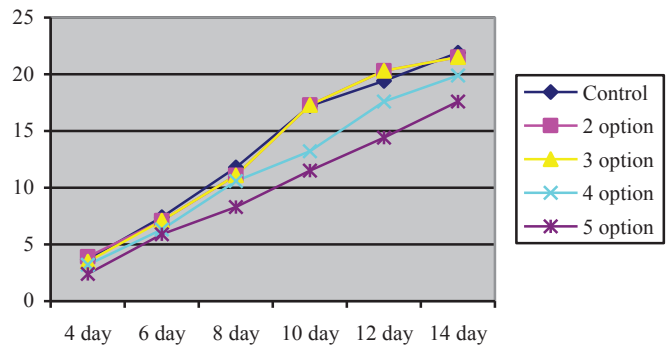

Fig. 2. Dynamics of lupin growth under the influence of sodium laureth sulfate, see.

3.2 Metric indicators of lupin seedlings

The analysis of morphometric parameters of lupin seedlings under the influence of increasing doses of sodium laureth sulfate introduced into the soil (Table 3) showed a negative effect of the detergent on plants.

Table 3. The effect of sodium laureth sulfate on the metric values of lupin.

No. p/p	Indicators	Option				
		Control	2	3	4	5
1	Plant weight, g	1.55	1.39	1.24	1.15	0.99
2	Leaf weight, g	0.47	0.46	0.41	0.39	0.34
3	Weight of stems, g	0.85	0.73	0.66	0.61	0.52
4	Root weight, g	0.23	0.2	0.17	0.15	0.13
5	Stem length, cm	21.9	21.5	20.3	19.9	17.6
6	Number of leaf blades	5	5	5	5	5
7	The total area of the leaf surface, cm^2	15.67	15.33	13.67	13.0	11.33

The negative effect of sodium laureth sulfate on the total weight of lupin seedlings was manifested in all variants of the experiment (Figure 3). The average weight of plants in the second variant decreased by 0.16 or 10.3; in the third – by 0.31 or 20.0; in the fourth – by 0.40 or 25.8 and in the fifth by 0.56 g or 36.1%.

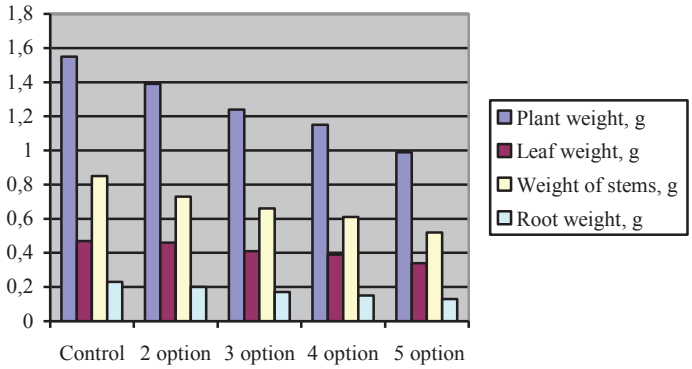

Fig. 3. Mass of vegetative organs of plants, g.

The weight of the leaves according to the variants (Figure 3). was distributed as follows: in the second variant, it was lower than the control values by 0.01 or 2.1; in the third – by 0.06 or 12.8; in the fourth – by 0.08 or 17.0 and in the fifth – by 0.13 g or 27.7%.

The effect of increasing detergent doses on the change in the average weight of stems (Figure 3) was negative and in the second variant the decrease was 0.12 or 14.1; in the third – 0.19 or 22.4; in the fourth – 0.24 or 28.2 and in the fifth 0.33 g or 38.8% compared with the control.

The response of the root system (Figure 3) of lupin seedlings to the action of sodium laureth sulfate was also accompanied by a decrease in its weight in the second variant by 0.03 or 13.0; in the third by 0.06 or 26.1; in the fourth by 0.08 or 34.8 and in the fifth by 0.10 g or 43.5% relative to the control.

For the stem length indicator (Figure 4), the phytotoxicity of the detergent was obvious and in the second variant it decreased compared to.

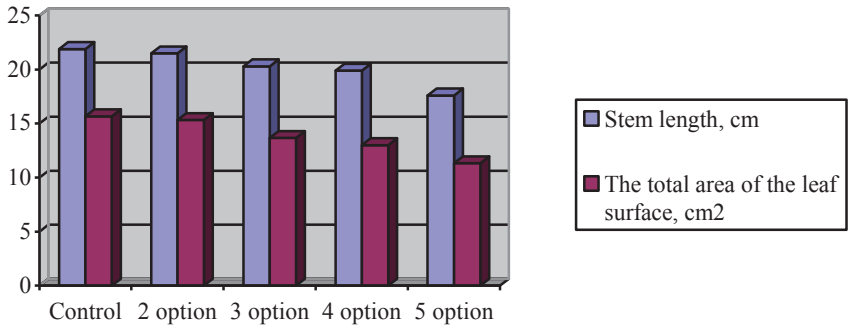

Fig. 4. Stem length, cm and total leaf surface area, cm2.

The total area of the leaf surface was no exception to the revealed patterns and in the second variant there was a decrease of 0.34 or 1.0; in the third - by 2.0 or 12.8; in the fourth – by 2.67 or 17.0 and in the fifth by 4.37 cm^2 or 27.9%.

3.3 Allometric indicators of lupin seedlings

The allometric analysis method is designed to assess changes in the uniformity of the development of plant organs under the influence of changing conditions of their existence. The ontogenetic essence of allometric growth lies in the fact that under optimal environmental conditions, the relative growth rates of plant organs remain constant throughout the entire life cycle. At the same time, when the values of environmental factors shift to pessimal indicators, it is accompanied by ontogenetic changes in the growth rates of plant organs and subsequently to a change in the survival strategy of the organism. The coefficients of allometric indicators of lupin seedlings, depending on the dose of sodium laureth sulfate introduced into the soil, are shown in Table 4.

Table 4. Effect of sodium laureth sulfate allometric indicators of lupin.

No. p/p	Indicators	Option				
		Control	2	3	4	5
1	Relative leaf area	10.1	11.0	11.0	11.3	11.4
2	Photosynthetic effort	0.30	0.33	0.33	0.34	0.34
3	Weight of roots per unit of phytomass	0.15	0.14	0.13	0.13	0.13
4	The weight of stems per unit of phytomass	0.55	0.52	0.53	0.53	0.52

In relation to plants, the possibility of using these patterns to identify the relationships between linear and weight dimensions in ontogenesis has been established. The assessment of allometric parameters in time and space allows us to observe the process of adaptation of plants to changing conditions of existence, which often goes by changing survival strategies.

The coefficient of relative leaf area, which is the ratio of the total leaf area to the weight of the plant, for lupin of the experimental variants was higher than the control level: for the second and third variants, this difference was 0.9; for the fourth, 1.2 and for the fifth, 1.3.

The introduction of sodium laureth sulfate into the soil had an effect on the photosynthetic effort of plants, in all experimental variants this indicator was higher than the control: in the second and third by 0.03; in the fourth and fifth by 0.04 (Figure 5).

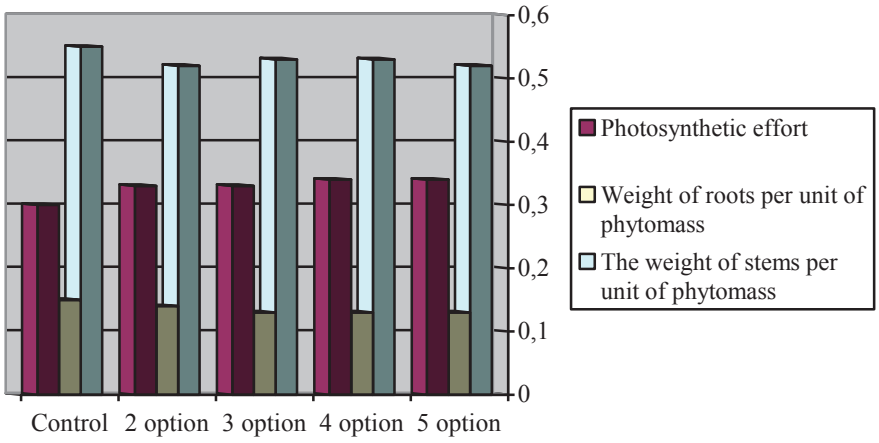

Fig. 5. Photosynthetic force, weight of roots per unit of phytomass, weight of stems per unit of phytomass.

The ratio of the weight of the roots to the total phytomass of lupin was not highly variable and in the second variant was lower than the control level by 0.01; in the third, fourth and fifth by 0.02.

The coefficient characterizing the ratio of the weight of the stem to the total phytomass of plants (Figure 5) in all variants of the experiment was lower than the control values: in the second – by 0.03; in the third and fourth – by 0.02 and in the fifth by 0.03.

4 Conclusion

Based on the results of a laboratory experiment and an analysis of the morphometric characteristics of the formation of lupin seedlings under the influence of increasing doses of sodium laureth sulfate, the following conclusions can be drawn:

- Lupin showed high sensitivity to changes in morphogenesis depending on the dose of sodium laureth sulfate introduced into the soil.
- The maximum phytotoxic effect was recorded in the fifth version of the experiment at a detergent concentration of 500 mg / kg
- Sodium laureth sulfate reduced seed germination by 15% and the dynamic characteristics of plants by the end of the experiment by 19.6%.
- Metric characteristics of lupin seedlings: total weight by 36.1; leaf weight by 27.7; stems by 38.8; roots by 43.5; stem length by 19.6 and total leaf surface area by 27.9% were lower than the control values in the fifth version of the experiment.
- Allometric coefficients under the influence of increasing doses of sodium laureth sulfate indicate a change in the ratios in the formation of vegetative organs of lupin seedlings.
- The data obtained from the results of a laboratory experiment can be used in the practice of cultivating crops with possible soil contamination with detergents.

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