Effect of natural salt solutions on grass-wheatgrass association phytomass

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Abstract. When spraying a herb-wheatgrass association, it was found that there was no toxic effect on phytomass 20 and a 40% solution of the natural salt of the Troitskoye deposit at a dose of 30 ml/m². A solution of natural salt at a dose of 300 ml/m² at a concentration of 20% has a partial toxic effect on some plant species, which manifests itself in the death of aerial organs within 24 hours after spraying. A solution of natural salt at a dose of 300 ml/m² at a concentration of 40% has a toxic effect on most species of forbs, manifested in the drying and death of aerial organs within 24 and 72 hours after spraying. Leaves of creeping wheatgrass (Elytrigiarépens) were highly resistant to the action of natural salt. Within 30 days after spraying, overgrowth of aerial organs occurred in all variants of the experiment, which indicates the absence of the effect of natural salt solutions on the root systems of plants during surface treatment.

1. Introduction
The search and comprehensive study of natural compounds with herbicidal activity is an urgent and timely direction of scientific research, since obtaining environmentally friendly products becomes important in the context of the growing chemicalization of agricultural production. One of these compounds, which is proposed to be used as a natural herbicide, is the brine from the Troitskoye salt deposit (Krasnoyarsk Territory). Substantiation of the possibility of using natural brines from the Troitskoye salt deposit, the effect of various concentrations of brines on the physical and chemical properties of agricultural soils was discussed by us earlier [1; 2; 3]. This report examines the possibility of using natural brines as a herbicidal agent on the slopes of roads, railways and highways, for laying mineralized strips in forests and municipalities when organizing fire-fighting measures.

The assumption that the solutions of natural Troitskoye salt, which are used for spraying the aboveground phytomass, have a herbicidal effect, is based on the proven fact of inhibition of a high concentration of Na⁺ and (or) Cl⁻ on the photosynthesis process. This is due to the sensitivity of phosphorylation and carboxylation processes to high salt concentrations. An increased concentration of salts inactivates the work of proteins, inhibits their synthesis [4; 5]. External signs of the toxic effect of salts in aerial organs are growth inhibition, twisting and wilting of leaves. At high concentrations of salts, yellowing and browning of plant leaves is observed, salt spots appear on them, and then these leaves usually fall off [6; 7]. At the same time, the mechanisms of the effect of surface application of salt solutions on the root systems of plants are practically not studied. Due to the fact that the root systems of perennial plants are an additional factor that strengthens the slopes of roads, and in forest and other landscapes, herbaceous vegetation ensures the stability of phytocenoses, the purpose of this study is to determine the concentration and dose of natural salt solutions, under the surface action of...
which the aboveground phytomass will die off, and the underground organs of plants will retain their vitality.

2. Research objects
A series of experiments to identify the herbicidal effect of natural salt on plants was carried out on herbaceous communities located on chernozem soils within the Krasnoyarsk forest-steppe zone (56.1 N, 92.8 E). Chernozems are widespread in the forest-steppe zone of the Krasnoyarsk Territory; among them, leached chernozems and ordinary chernozems dominate [8]. Among the ordinary chernozems, with a close occurrence of carbonate parent rocks, there is a genus of ordinary carbonate chernozems, which, as a rule, are confined to the upper and middle parts of the southern and south-eastern slopes of watersheds with low moisture and high heat supply. Such soils are characterized by a low thickness of the humus horizon (5–15 cm), low and medium humus content (2–5%), and occurrence of carbonates within the humus-accumulative horizon A, which is accompanied by “boiling” of these soils from the surface [9]. The vegetation on such soils is close in its botanical composition to the vegetation of meadow and stony steppe, where, along with plants belonging to the ecological group of mesophytes: creeping wheatgrass (Elytrigia repens), field sow thistle (Sonchus arvensis), field bindweed (Convolvulus arvensis), common dandelion (Taraxacum officinale), common yarrow (Achillea millefolium), xerophytic plants are found: gray wormwood (Artemisia glauca), gray-headed wormwood (Veronica incana), gray fescue (Festuca valesiaca) stemless cinquefoil (Potentilla acaulis) [10]. Mesophytic plants of such open, well-lit habitats, with a lack of moisture, acquire obvious xeromorphic features: they have a denser network of veins, a greater frequency of stomata and hairs, a more powerful wax coating, leaf pulp cells are smaller than those of the same plants from shady and humid habitats [11]. The effect of natural salt as a herbicide on such plants can be difficult since the penetration of Na+ and (or) Cl- ions into the cells of the leaf blade in xerophytes is partial due to the presence of wax plaque and the abundance of hairs. In this regard, the determination of the dose and concentration of natural salt, which will have a herbicidal effect on the plants of natural grass communities on the southern slopes, will make it possible to determine the maximum level of such an effect.

3. Research methods and experimental design
The description of the floristic composition of plants was carried out according to the method of A.S. Bogolyubov and A.B. Pankov, assessment of plant abundance according to Druda (with additions by A.A. Uranov), determination of phenophases according to V.V. Alekhine [12]. The NaCl concentration in the starting brine was 245 g / L. The plots were sprayed with 20 and 40% solutions of the original brine with a working fluid volume of 30 and 300 ml / m² using a professional battery telescopic sprayer (CAIMANTELESCOPIC 150 EW) over the vegetative organs of plants in the first decade of July. Plants were observed at 24 hours, 72 hours and 30 days after treatment. The effect of the salt solution on plants was tested according to the following experimental scheme: 1) Control; 2) 30 ml / m² of 20% solution; 3) 30 ml / m² 40% solution; 4) 300 ml / m² of 20% solution; 5) 300 ml / m² 40% solution.

4. Research results
On the trial plots laid on the southern slope of the III above-floodplain terrace of the Kachavid River, edificators are cereals: creeping wheatgrass, meadow bluegrass, forbs is represented by common yarrow, common dandelion, small field grass, pink sow thistle, white clover, gray wormwood, stemless cinquefoil, yellow lupine, etc. are found singly (table 1, figure 1). In relation to moisture, the plant community is mainly represented by mesophytic species, however, xerophytes are also abundant; in general, xerophytization of vegetation is noted on the southern slope. The soils of the site are represented by ordinary thin medium loamy chernozems on red-coloured carbonate diluvium. The humus content is incredibly low (1.6 - 1.9%), the provision of the soil with nitrate nitrogen is average (14.4 mg / kg), ammonia is low (7.7 mg / kg), exchangeable potassium is remarkably high (733.9 mg / kg), and mobile phosphorus is very low (52.3 mg / kg). Rockiness is noted in some places. Despite the slope of the
surface (about 5-80), there are no signs of water erosion since the slope on which the trial plot is located is well sodded. The projective cover is 95%.

Table 1. Floristic composition of herbage on ordinary carbonate thin medium loamy chernozems.

| Species                        | Abundance according to Druda | Occurrence, % | Phenophase |
|-------------------------------|------------------------------|---------------|------------|
| Creeping wheatgrass (Elytrigiarépens) | Cop3                         | 100           | Veg        |
| Meadow bluegrass (Poa praténsis)  | Cop1                         | 85            | Veg        |
| Yarrow (Achilléamillefólium)   | Sp                           | 50            | Veg        |
| Dandelion (Taráxacumofficinále) | Sp                           | 45            | Veg        |
| Sow thistle (Sónchusarvénsis)  | Sol                          | 20            | Veg        |
| Sow-thistle pink (Cirsium arvense) | Sol                         | 20            | Veg        |
| Clover white (Trífolium repens) | Sol                          | 15            | Budding    |
| Stemless cinquefoil (Potentilla acaulis) | Sol                      | 5             | Veg        |
| Field bindweed (Convólulusarvénis)  | Sol                          | 5             | Fading     |
| Alfalfa yellow (Medicago falcata) | Sol                          | 5             | Full bloom  |
| Lupine yellow (Lupinus luteus)  | Sol                          | 3             | Fading     |
| Gray wormwood (Artemisia glauca) | Sol                          | 2             | Veg        |
| Lanceolate plantain (Plantagolanceolata) | Sol                     | 2             | Veg        |

![Figure 1](image1.png)

Figure 1. Forb-grass association of the southern slope of the Kacha River valley (control plot).

Treatment of plots with 20 and 40% solutions of natural salt at a volume of working fluid of 30 ml / m² (Option 2 and Option 3) did not lead to the expected effect of herbicidal effect on plants. This dose was found to be insignificant and did not have a toxic effect (figures 2; 3). The concentration of a natural salt solution of 20% with a working fluid volume of 300 ml / m² (Option 4) partially had a herbicidal effect on some plant species (white clover, yarrow, yellow alfalfa), which manifested itself in yellowing, drying, dying off, leaves of clover and yarrow and blackening and withering away of clover flowers and yarrow leaves during the first three days of exposure. Then, within 30 days, there was a secondary growth of dead organs, which indicates the absence of herbicidal effect on the plant roots by surface spraying with natural salt (figures 4; 5).
Figure 2. Option 2 (30 ml / m$^2$ 20% salt solution).

Figure 3. Option 3 (30 ml / m$^2$ 40% salt solution).

Figure 4. Option 4 (300 ml / m$^2$ 20% salt solution).

Figure 5. Option 5 (300 ml / m$^2$ 40% salt solution).
Creeping wheatgrass turned out to be resistant to a high concentration of salt; leaf death of this plant practically did not occur, only a slight yellowing of their tips was noticeable. Perhaps this is due to the presence of a waxy coating and an abundance of hairs on the leaves of wheatgrass, which prevented the salt solution from sticking to the leaves and the penetration of salt into the tissues of the leaf plate. After 30 days of exposure on the site of Option 5, secondary regrowth of all plants also occurred, which indicates that there is no effect on the root systems of the surface application of this dose and the concentration of the natural salt solution. The concentration of a natural salt solution of 40% with a working fluid volume of 300 ml / m2 had a significant effect on the aerial vegetative organs of plants, which manifested itself in the inhibition of their growth, yellowing, dying off, leaf twisting of most plant species, the appearance of brown spots along the edge of the leaf blade (common dandelion, field sow thistle), the death of flowers.

5. Conclusion
Analysis of the herbicidal activity of a solution of natural salt sprayed on the surface on the herb-wheatgrass association of the southern slope showed:

- A solution of natural salt with a concentration of 20 and 40% with a volume of working fluid of 30 ml / m2 has no toxic effect on plants.
- A solution of natural salt with a concentration of 20% with a working fluid volume of 300 ml / m2 has a partial toxic effect on some plant species (white clover, yellow alfalfa, yarrow), which manifests itself in the death of aerial organs within 24 hours after spraying.
- A solution of natural salt with a concentration of 40% with a working fluid volume of 300 ml / m2 has a pronounced toxic effect on most species of herb plants, which manifests itself in drying and death of aboveground organs within 24 and 72 hours after spraying.
- Leaves of common wheatgrass have a high resistance to the action of natural salt, which did not die off even after spraying a 40% salt solution in a working fluid volume of 300 ml / m2.
- In 30 days after spraying solutions of natural salt in all variants of the experiment, secondary regrowth of aboveground organs occurred, while the vitality of plants did not suffer (flowering and fruiting were observed), which indicates the absence of the effect of surface spraying on the root systems of plants.

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