

## THE INFLUENCE OF GREEN-MANURED FALLOW ON SALINE SOIL FERTILITY OF YAKUTIA



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**Abstract:** This article provides results of experiments focusing on determining the effects of green-manured fallow on permafrost saline soils in Central Yakutia. 74,7 thousand hectares or 74% of the explored area of the republic are covered with saline soils. In general, arable land soils are typically chloride-sulfate (45%) and chloride (27%) salinity types. The field works were carried on frozen meadow-chernozem saline soils of agrological company's "Nemyugyu" plot "Moydokh" located on the second inundated terrace of Lena River. For the green manure material, we used the White melilot (*Melilotus albus*) due to its increased drought and salinity resistance compared with other legumes. Additionally, this

species supply upper soil horizons with biogenetic calcium inhibiting the soil salinization. Crop rotations included: 1. Pure steam- barley-oat-pea mix; 2. Green-manured fallow (melilot)- barley-oat-pea mix (post-action of fallow)- oat+ melilot. By several parameters, such as digestible protein amount (up to 0.36t/ha), green mass yield (up to 21,2-23,2 t/ha) and feeding units (up to 2,57-3,99t/ha) in green-manured fallow oat-pea mix was 1.5 times higher than in rotations of pure fallowing. These results indicate the apparent positive effect of the green-manured fallow application on crop yield. The surface tillage of barley resulted in a green-manured fallow seed yield of 1,31t/ha and 1,29t/ha in a pure fallow field. By the end of crop rotations, the number of elements and soil salinity levels improved, except for the phosphorus and potassium levels. Soil pH decreased from initial 7,20 to 6,98; humus increased by 0,59% and total nitrogen in soil increased by 0,03%. In the case of the phosphorus and potassium, the amounts decreased by 32,85 and 8,80 mg per 100g of soil respectively. It is also necessary to point that not only humus content increased, but the amount of humic acids increased by 0,23% (initially 0,64% to 0,87%). Taken all together, the melilot utilization as green manure are beneficial via its ability to desalinize the soils as well as increasing gross humus content and its quality improvement, and lastly by increasing seeding and feeding crops yields.

**Keywords:** *frozen saline soils, yield, soil alkalinity, melilot, green-manured fallow, fertility, feeding crops.*

## Introduction

According to the results from the eighth round of the assessment on arable land soils in the Republic of Sakha (Yakutia) (2006 - 2010), saline soils occupy a significant territory – 74,7 thousand ha or 74% of the surveyed area. Among them, soils with a low degree of salinization predominate with 69% of saline soils, the portion of non-saline soils was 22%, and the remaining proportion was highly saline lands. Chloride-sulfate (45%) and chloride (27%) types of salinization mainly predominated on arable land [1]. According to the State Budgetary Institution “Republican Agrochemical Station of the Ministry of Agriculture and Industrial Development of the Republic of Sakha (Yakutia)”, the half of the grain crops are confined to permafrost taiga soils with mostly slightly saline levels. The other half is located on the soils of the chernozem row of “alas” and floodplain terraces with sufficient heat supply. Feeding crops are found on all types of soil involved in agricultural production. All soil types are characterized by an alkaline pH reaction of the soil environment, except of the South Yakutia. Also, in almost all districts of the republic, a marked deficiency of humus under grain crops is noted.

Generally, saline soils are common in Central Yakutia. The productivity of crops in saline soils decline fluctuates from 20 to 50% [2]. In addition, it is known that increased alkalinity and salinity of soils reduces the efficiency of mineral fertilizers. After summarizing these conditions, we can argue that there is a challenge in the necessity for improving the saline soil's

characteristics. Previously it was proposed that the biologization of agriculture can be applied in reality and is an economically viable way to restore soil fertility [3].

One of the methods for improving the fertility of saline rainfed lands is the use of green-manure crops as an environmentally friendly source of soil enrichment with organic matter. White melilot can be used as a green manure crop culture in Yakutia. It is more drought and salt-tolerant compared to other leguminous crops [4], and was shown to be able to enrich the upper soil horizons with biogenic calcium, and resists soil salinization [5].

Experiments with culturing melilot and alfalfa on arable land in Yakutia have been holding on since the 90s, with the assumption of using melilot as a desalinating agent. Interest in this culture has increased in recent years, especially after the emergence of local varieties of *Nemyugunsky* white melilot and *Alasovsky* sweet clover.

### Materials and methods

Field experiments were conducted at the Moydokh plot of the Nemyugyu agricultural company on the second floodplain terrace of the Lena River, located 3 km from Pokrovsk and 70 km from Yakutsk. The study was focusing on permafrost meadow chernozem saline soils of the studied plot. Agrochemical analysis of the soil of the plot was following: alkaline environment was saline-alkaline with the pH of 7.20; the humus content in the arable horizon was 3.16%, the content of mobile forms of nitrogen N- 0.13-0.16 mg per 100 g of soil; mobile forms of phosphorus P<sub>2</sub>O<sub>5</sub> - 33.79 mg / 100g; potassium K<sub>2</sub>O - 25.14 mg / 100g.

The studies were carried out according to the field experiment methodology [6], the bioenergy assessment method for forage crops [7]. Phenological, biometric observations and analysis data of soil and plant samples were performed accordingly to GOST 26205-86. Agricultural technologies of soil cultivation were carried out following the recommendations of YSRIA [8]. Laboratory analyses were conducted in the biochemistry laboratory. The mass-spectral analysis was performed using NIRSCANNER moLCE 4250 spectral analyzer.

In 2001, laboratory of field crop production under the YSRIA, performed the series of experiments on a dehydrator, focusing on the investigating the effect of white melilot as green-manure material and its effect on the yield of forage crops in crop rotations, as well as its effect on the fertility level of meadow chernozem saline soils. Crop rotations included in the following links: 1. Pure steam - barley-oat-pea mixture-oats; 2. green manure fallow- barley-pea mixture (aftereffect of manure) - oats + white melilot. In the second year of life, the clover in the budding phase was embedded in the soil to a depth of 15 cm with disk harrows. Then, deep plowing with dump plows up to 20-22 cm was carried out. In total, with a green mass of clover 140 kg/ha, 33.6 kg/ha of dry matter containing 110.8 kg of potassium, 13.1 kg of phosphorus entered the soil, which is equivalent to adding more than 15 tons of manure [9]. After green manure in the first year, barley was placed according to the crop rotation scheme, and the pea-oat mixture was placed according to barley. Annually, under the barley, and subsequently under the pea-oat mixture, a background was created at a dose (NPK) of 60. Mineral fertilizers were applied before pre-sowing cultivation.

### Results and discussion

Pea-oat mixture provided the highest productivity in the feed crop rotation 1. In terms of dry mass yield of 5.30-5.78 t / ha and exchange energy of 43.6-53.5 GJ/ha, the pea-oat mix

was shown to be superior to other crops. Post-harvest, the pea-oat mix produced the digestible protein (up to 0.36 t / ha), the yield of green mass (up to 21.6-23.2 t / ha) and feed units (up to 2.57-3.99 t / ha) under the green manure fallow exceeded pea-oat mixture in pure steam 1.5 times. This indicates that green manure has a positive effect on the forage crops yield. Barley for subsurface tillage provided grain yield for a green-manure fallow of 1.31 t/ha, for a pure steam - 1.29 t/ha.

We highlighted the high productivity of the pea-oat mixture at the control variety with green-manured fallow, where exchange energy was 43.6-49.7 GJ/ha; feeding units - 2.57-3.18; digestible protein - 0.20-0.24 t/ha. Such characteristics clearly demonstrate the beneficial effect of green-manure fallow. In contrast, other variants demonstrated low productivity.

The results of studies on the fertility of saline soils are as follows: by the end of the crop rotation cycle, the nutrient content and soil salinity in the experimental plots improved, except for phosphorus and potassium contents. At first, the alkaline environment converted to the neutral – pH 6.98, the humus content increased by 0.59%, total nitrogen by 0.03%, and the phosphorus and potassium content decreased by 32.85 and 0.88 mg per 100 g of soil respectively (Table. 1).

Table 1

The influence of green-manure fallow produced from melilot on the agrochemical characteristics of soil (0-20cm)

| Characteristics        | Rotation start | Rotation end |                     |
|------------------------|----------------|--------------|---------------------|
|                        |                | Pure steam   | Green-manure fallow |
| PHsal.                 | 7,20           | 7,19         | 6,98                |
| Humus, %               | 3,16           | 3,35         | 3,75                |
| Phosphorus, mg/100g.   | 33,79          | следы        | 0,94                |
| Potassium, mg/100 g.   | 25,14          | 23,37        | 24,26               |
| Total Nitrogen, %      | 0,21           | 0,22         | 0,24                |
| Humic acids, mg/100 g. | 0,64           | 0,87         | 0,87                |

Such agrochemical characteristics shifts can be explained by the fact that with a decrease in salinity, the mineral nutrition of plants following the green-manure pre-treatment has also improved. Consequently, the utilization of mobile phosphorus from the soil likely increased while cultivating barley and a pea-oat mixture in the experimental plot. The barley productivity reached the 640kg/ha of grain, and the yield of green mass of pea-oat mix (the second crop cultivated after green-manure) was 23.2 t / ha.

It should be noted that not only the amount of humus has increased, but also its quality. Accordingly to the soil agrochemical analysis by the end of the crop rotation cycle, it was demonstrated that the number of humic acids increased by 0.23% (0.87%) compared with the initial dataset (0.64%).

### Conclusion

Our study demonstrated beneficial properties of the white melilot as the green manure the use of white melilot as green-manure contributed to the desalinization and increase in gross humus reserves and an improvement in its quality, as well as to an increase in the yield of grain and fodder crops. White clover, as a sideral culture, can be used to reproduce the fertility of saline lands in Central Yakutia with the obligatory use of mineral fertilizers in subsequent crops.

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