Agrochemical Characteristics of Soils of Agricultural Lands in the Suburbs of Yakutsk and their Use in Agriculture

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Abstract: The article considers the agrochemical indicator of the composition of soils of agricultural lands in the vicinity of the territory of the city of Yakutsk. The research was carried out as part of an agrochemical tour for the purpose of state accounting of soil fertility indicators, assessment of the state and changes in soil fertility of agricultural lands. In 2021, a soil-agrochemical examination of agricultural lands in the vicinity of Yakutsk was conducted. Agrochemical examination of soils of agricultural lands is carried out according to the methodological guidelines developed by the staff of the All-Russian Scientific Research Institute of Agrochemistry named after D.N. Pryanishnikov, soil analyses were performed in the testing laboratory of the SBI Agriculture Service of the Republic of Sakha (Yakutia) according to industry standards. On permafrost sod-meadow soils, the humus content is average. The reaction of the environment is slightly alkaline. The content of mobile phosphorus is average. The availability of exchangeable potassium is average. On permafrost taiga pale-yellow soils, the humus content is low. The reaction of the environment is neutral, the content of mobile phosphorus is average. The availability of exchangeable potassium is average. On permafrost taiga soils, the humus content is low. The reaction of the environment is from neutral to slightly alkaline. The content of mobile phosphorus is very high. The availability of exchangeable potassium is average. On permafrost chernozems, the humus content is low. On these soils, the reaction of the environment is from neutral to slightly alkaline. The content of mobile phosphorus is low. The availability of exchangeable potassium is average.

1 INTRODUCTION

Soil fertility is one of the objective conditions for obtaining a crop. However, the size of the harvest also depends on the plant, climate, historical time and the activities of the landowner. To realize its potential, each crop requires specific soil conditions, the duration of the growing season with certain heat and moisture availability, timely and high-quality implementation of technological methods of plant cultivation, taking into account the level of development of the scientific and technical process. Therefore, soil fertility is not always characterized by the level of yield. At the same time, all other things being equal, the crop yield will be determined by the fertility of the soil. (Barashkova, Neustroeva, Ustinova, Slepcova, Zaharova, 2019; Kozlov, Selickaya, 2015; Lukina, Isaeva, Ustinova, 2018). The Federal Law of the Russian Federation and the Law of the Republic of Sakha (Yakutia) No. 563-3 of

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October 11, 2005 "On state regulation of ensuring the fertility of agricultural lands" the conduct of agrochemical and ecological-toxicological surveys, monitoring of soil fertility of agricultural lands is defined as one of the main directions of agrochemical services.

2 CONDITIONS AND METHODS OF RESEARCH

The studies were conducted in the conditions of Central Yakutia. The main feature of the climate of Central Yakutia is a sharp continentality, manifested in large annual temperature fluctuations and a relatively small amount of precipitation. These features of the climate of Central Yakutia are determined by the factors of its climate formation, which, in turn, are associated with the geographical location of this region in relatively high latitudes and in the northeastern part of the vast Eurasian continent (Gavrilova, 1973). The soils of Yakutia are permafrost, so they are easily damaged and difficult to recover.

Permafrost pale-yellow, meadow-chernozem, chernozem-meadow, sod-meadow, saline, swamp and floodplain soils are the most common in Central Yakutia (Elovskaya, 1991; Ohlopkova, Ustinova, 2022; Prokop'ev, Ustinova, 2022).

The main objects of the study are soil samples taken by a soil drill from a depth of 0.20 m. The samples are labelled according to the statement, a register is made and handed over to the testing laboratory where the analyses are carried out. The determined indicators of humus, the actual acidity, the mobile form of phosphorus and potassium.

Soil analyses are performed according to industry standards:

- actual acidity by the potentiometric method as per GOST 26423-85
- determination of organic matter by the Tyurin method as per GOST 26213-84
- mobile phosphorus and exchangeable potassium according to the Egner-Riem method – (DL-method) as per GOST 26209-91.

Study Results. In the conditions of risky farming in Yakutia, the importance of fertilizers that can increase crop productivity by 1.5-2.5 times increases significantly, especially in conditions of a short growing season. According to the law of agriculture, each food element fulfills its specific role and cannot be replaced by another element (Slepcova, 2021). Nitrogen and potassium have a major role in the growth of biomass: nitrogen during the unfolding of the leaf surface (photosynthetic apparatus), potassium during the growth of stems. Phosphorus is necessary for the synthesis of macro-energetic substances that provide energy for the processes occurring in the plant organism, is part of the nucleic substances that carry genetic information. Nitrogen stretches the growth period, delays the onset of maturation. Phosphorus accelerates the processes of plant growth and development, the harvest turns out to be ripe, but loses in magnitude (Korovin, 1972; Mamontov, 2021).

Agrochemical survey of agricultural lands was carried out on an area of 1316.1 hectares. The surveyed plots are located on permafrost sod-meadow (41.7 ha), permafrost taiga pale-yellow (1122.3 ha), permafrost taiga (77.7 ha) and permafrost chernozem (74.4 ha) soil types (Table 1).

Table 1: Agrochemical characteristics of soils under steam.

Types of permafrost soils	Surveyed area, ha	Indicators			
		Humus, %	P_2O_5, mg/kg of soil	K_2O, mg/kg of soil	pH of the water extract
Permafrost sod-meadow	41.7	5.5	333	291	7.8
Permafrost taiga pale-yellow	1122.3	7.5	158	313	7.6
Permafrost taiga	77.7	3.9	364	100	7.5
Permafrost chernozem	74.4	4.7	79	84	7.4

Permafrost sod-meadow soils develop in the valleys of taiga rivers, in low places of alas, on flat relief elements and less often on the above-floodplain terraces of large rivers. Soils are formed under conditions of moderate and temporarily excessive moisture by meadow vegetation. They are characterized by the periodically flushing nature of the water regime, the developed turf horizon, and the accumulation of organic matter. On the territory of the suburb of Yakutsk, 41.7 hectares of agricultural land are located on this type of soil. The humus content is average – 5.5%, the phosphorus and potassium content is high, phosphorus – 333 mg/kg of soil, potassium – 291 mg/kg of soil. The pH of the soil is slightly alkaline.

Permafrost taiga pale-yellow soils are common in areas with developed agriculture. They are developed on ancient alluvial deposits under the canopy of forest vegetation with a well-developed herbaceous cover. This type of soil is mastered by uprooting for crops of grain and fodder crops. These soils occupy one of the first places among the taiga soils of Yakutia in terms of fertility. Basically, the largest area of agricultural land is located on permafrost taiga pale-yellow soils – 1122.3 hectares. The humus content is high – 7.5%, phosphorus – 158 mg /kg of soil, potassium – 313 mg /kg of soil. The pH of the soil is slightly alkaline.

Permafrost taiga soils are formed under the canopy of larch and pine-larch forests with a well-developed ground cover on a carbonate-free eluvium of sedimentary and bedrock on these soils there are insignificant areas of grain crops - 77.7 hectares. These soils differ from taiga pale-yellow soils in the composition of exchange cations. The humus content is low – 3.9%, phosphorus – 364 mg /kg of soil, potassium – 100 mg/kg of soil. The pH of the soil is slightly alkaline.

On permafrost chernozem soils there are 74.4 hectares of arable land in Yakutsk. These soils are developed on the drier elevated relief elements of the floodplain terraces of rivers. They also occupy high points of above-floodplain landscapes, are characterized by relatively high thermal resources and deep seasonal thawing. The main limiting factor of biological productivity is the lack of soil moisture. The humus content is average – 4.7%, the availability of phosphorus and potassium is low. Phosphorus – 79 mg/kg of soil, potassium – 84 mg/ kg of soil. The pH of the soil is slightly alkaline.

The agrochemical composition of permafrost soils varies depending on the height of the location of the agricultural landscape, agro-climatic conditions and culture. (Table 2,3,4,5). At the time of the survey, there were 528.7 hectares of unused arable land, 366.9 hectares for cereals, 164.7 hectares for potatoes, 53.6 hectares for fodder and 202.2 hectares for fallow.

Table 2: Agrochemical studies of soils under steam.

Name of agricultural land	Crop	pH.	Humus, %	Content of mg/kg of soil		Soil type
				P_2O_5	K_2O	
Mountain 1 cl. A	steam	7.7	2.1	122	114	Permafrost taiga pale-yellow
Zhukovsky right cl. A	steam	6.4	2.3	58	68	Permafrost taiga pale-yellow
Bulgunnyakhtakh cl. C	steam	7.2	3.0	323	174	Permafrost taiga pale-yellow
Bulgunnyakhtakh cl. C-1	steam	7.5	3.0	405	207	Permafrost taiga pale-yellow
Ionic Stumps 1 cl. A	steam	7.3	3.2	169	80	Permafrost taiga pale-yellow
Bulgunnyah 2 cl. A	steam	6.5	3.5	82	92	Permafrost taiga pale-yellow
Nastasyevo 1	steam	6.9	3.7	72	97	Permafrost taiga pale-yellow
Bulgunnyah 3	steam	6.7	6.7	64	80	Permafrost taiga pale-yellow

Mostly permafrost taiga pale-yellow soils were located under the steam. The humus content is low, mainly ranged from 2.1 to 6.7%, the phosphorus and potassium content from 58 to 405 and 68 to 201 mg/kg of soil. The reaction of the soil pH from neutral to slightly alkaline.

Table 3: Agrochemical characteristics of soils for potatoes.

Name of agricultural land	Crop	pH.	Humus, %	Content of mg/kg of soil		Soil type
				P_2O_5	K_2O	
Bulgunnyakhtakh cl. D	potato	6.6	2.6	475	142	Permafrost taiga pale-yellow
Bulgunnyakhtakh cl. F	potato	7.3	3.0	337	96	Permafrost taiga pale-yellow
Bulgunnyakhtakh cl. E	potato	6.8	3.4	401	146	Permafrost taiga pale-yellow
Bulgunnyah 2	potato	6.5	4.3	60	78	Permafrost taiga pale-yellow
Cotrus arable land	potato	7.8	5.5	333	291	Permafrost sod-

						meadow

Under potatoes, permafrost taiga pale-yellow soils with a low content of the fertile layer also occupy a large part. In permafrost sod-meadow soils, the average humus content is 5.5%, phosphorus content is 333 mg/kg of soil, potassium content is 291 mg/kg of soil.

Table 4: Agrochemical characteristics of soils for oats

Name of agricultural land	Crop	pH.	Humus, %	Content of mg/kg of soil		Soil type
				P_2O_5	K_2O	
Obryvistaya	oats	7.5	4.4	171	149	Permafrost taiga pale-yellow
Old Magan 1	oats	7.4	4.7	79	84	Permafrost chernozem
Behind the farm	oats	7.0	2.6	138	110	Permafrost taiga
Ionic Stumps 1	oats	7.0	3.1	140	136	Permafrost taiga pale-yellow
Ionic Stumps 2	oats	7.3	3.3	131	178	Permafrost taiga pale-yellow
Varietal Field	oats	7.4	3.5	242	145	Permafrost taiga pale-yellow
Yargalaah	oats	7.6	7.5	158	313	Permafrost taiga pale-yellow

Oats enrich the soil with valuable organic matter, phosphorus, potassium, therefore, humus content from 2.6 to 7.5% is observed in oat crops, phosphorus and potassium content from 79 to 242 mg/kg of soil and 84 to 313 mg/kg of soil, reaction of soil pH - from neutral to slightly alkaline, relative to agrochemical indicators of other agricultural lands, which proves the correct decision to use oat crops as fertilizer. The mown shallowly buried mass after rotting significantly increases the quality component of the soil. With the help of oats, you can restore fertility in a couple of years – the cereal is unpretentious and grows on different soils and you can not be afraid to actively sow it on both sandy and clay soils.

Table 5: Agrochemical characteristics of soils for wheat.

Name of agricultural land	Crop	pH.	Humus, %	Content of mg/kg of soil		Soil type
				P_2O_5	K_2O	
Mountain 1	wheat	7.9	2.7	114	121	Permafrost taiga pale-yellow
Ionic Stumps 1 cl. B	wheat	6.9	3.1	136	99	Permafrost taiga pale-yellow
Old Magan 2	wheat	7.5	3.9	364	100	Permafrost taiga
Old Magan	wheat	7.2	4.8	286	128	Permafrost taiga pale-yellow

Wheat is very demanding of soils. They should be highly fertile, according to agrochemical indicators of soils for wheat, the humus content is not enough for sowing wheat from 2.7-4.8%, the phosphorus and potassium content is sufficient P 2 O 5 from 114 to 364 mg/kg of soil, K 2 O from 99 to 128 mg/kg of soil. Therefore, in the fields in the vicinity of Yakutsk, we recommend enriching the soil for wheat crops.

3 CONCLUSIONS

According to the research results, low and average organic matter content was found in most agricultural lands, which is the main source of mineral nitrogen in the soil. The shortage of humus in the soil of agricultural lands is an indicator that prolonged use of soils without sufficient application of organic and mineral fertilizers leads to depletion of permafrost soils. The content of organic matter in the soil can be increased by:

Introducing high rates of organic fertilizers for crops, after which there are few organic residues on the field (vegetables, row crops);

Expanded reproduction of organic matter residues (crop residues, underground phytomass) on arable land under grain, fodder crops, on hayfields and pastures;

Sowing legumes and oats for green manure crop.

Thus, the analysis of the agrochemical composition of the studied permafrost soils convinces that they are formed under the influence of the sod soil-forming process in combination with the illuvial-carbonate and leaching process against the background of permafrost (CHevychelov, Barashkova, Zaharova, Ustinova, Arzhakova, 2018; CHevychelov, Skrybykina, Vasil'eva, 2009). Fertilizers, being a source of available mineral food for plants, performing a trophic function, are the main means of increasing crop productivity, especially in conditions of short summer. In the conditions of the North, due to the rational use of fertilizers, it is quite possible to improve the fertile soil layer (Ivanov, Vinokurova, Ignat'eva, 2008; Ustinova, Barashkova, 2022).

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