The effect of the timing of shungite application on the agrochemical properties of sod-podzolic soil and potato yield

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Abstract. The shungite effect on potato growth and yield and on the main agrochemical properties of agro sod-podzolic soil under conditions of small-scale field experiment was studied. Shungite fractions of 0.5 mm and shungite-dolomite mixture in a dosage of 0.5 kg/m^2 were used. Meliorants were introduced in two periods – first during the autumn digging of the plots and in the spring immediately before planting. It was found that the uniform pre-sowing application of shungite led to an increase in potato yield by 28-48% and contributed to a decrease in the proportion of rotten tubers. A greater effect is manifested from the application of pure shungite compared with shungite-dolomite, as well as from pre-sowing application compared with autumn one. With pre-sowing application, the effect of meliorants begins to manifest only after 1.5-2 months. In case of autumn application of meliorants, by the beginning of the sowing season, an increase in the pH level is observed when applying a shungite-dolomite mixture or an increase in the carbon content when applying pure shungite.

1 Introduction

In the practice of agricultural production, it is relevant to study the possibility of using various rocks and agronomic ores, as well as fertilizers based on them. The introduction of chemically rich rocks has a significant effect on the effective fertility of soils [1].

In this regard, shungite slats are of undoubted interest. Due to their specific structure and heterogeneous composition, as well as a wide range of changes in the amount of carbonaceous shungite, these rocks are widely used in almost all production areas [2-4].

One of the promising areas is the use of shungites in agriculture. In their composition, shungites contain silicon oxide, potassium oxide, phosphorus oxide, magnesium, copper, zinc, and other trace elements, which can improve the mineral nutrition of plants [5]. It was also noted in [6] that shungite rocks mixed with other substances in the composition of fertilizers can have very different effects on plants.

When using various meliorants, the question of the timing of their application to the soil is important. For example, dolomite flour is very effective, but it does not work immediately, only after a season. That is, it is needed to bring it in for the winter if we want

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to plant in the spring. When applied right before planting, it will not have time to give effect [7].

The purpose of the work is to study the effect of various application periods of shungite both in pure form and as part of a shungite-dolomite mixture on the carbon content and acidity level of agro sod-podzolic soil, as well as the effectiveness of the shungite effect on potato yields.

2 Objects and Methods

The small-scale field experiment was laid in the vicinity of the city of Petrozavodsk on the territory of the agrobiological station of the Karelian Research Center. The soil type is agric soddy podzolic.

The crop used in the field experiment is potato of the Nevsky variety. Screening of shungite (0.5 mm fraction) and shungite-dolomite (SD) mixture were used as meliorants. Meliorants were applied evenly in two periods: during autumn digging and in the spring before planting. The control option is without the application of shungite and without the use of fertilizers. The repetition of the experiments is threefold.

The dose of meliorants 0.5 kg/m^2 was selected based on our preliminary studies in 2017-2022 [8]. The experiment was laid down by analogy with other studies conducted earlier on the territory of Karelia [9, 10].

During the growing season, germination and plant height measurements were carried out. Also, throughout the season, soil samples were taken from each plot for subsequent analysis. In the first decade of September, potato harvesting was carried out manually with a separate weighing of tubers. In soil samples, the exchange acidity pH(KCl) was determined potentiometrically and the content of organic carbon by high-temperature catalytic combustion.

3 Results and Discussion

The highest germination was observed in areas with spring pre-sowing application of shungite-containing meliorants (Table 1). The preliminary autumn application of shungite to the soil also contributed to the earlier appearance of potato seedlings.

Table 1. Potato germination, %.

Option and term of shungite application	Number of days after planting		
	12	15	20
Control	12.5	75.0	93.8
Autumn, SD	31.3	68.8	93.8
Autumn, shungite 0.5 mm	43.8	87.5	100.0
Spring, SD	75.0	100.0	100.0
Spring, shungite 0.5 mm	50.0	100.0	100.0

In case of pre-sowing application of shungite, a positive effect on potato yield is observed. In the option with pre-sowing spring application of pure shungite, the average weight of one tuber increased slightly, but due to an increase in the number of tubers in the locule, the yield from the bush increased 1.5 times compared with the control option (Table 2). During the autumn application of shungite, the increase in yield from the bush occurred mainly due to a significant increase in the mass of one tuber. During the autumn application of the SD mixture, there is no significant change in yield from the bush.

Table 2. Biometric indicators of potato plants.

Option and term of shungite application	Total number of tubers in the locule, pcs.	Weight of tubers from 1 bush, g	Average weight of 1 tuber, g	Tuber length, cm	Transverse diameter of the tuber, cm
Control	4.6	183.7	34.8	4.3	3.3
Autumn, SD	5.5	195.3	28.9	4.1	3.2
Autumn, shungite 0.5 mm	4.5	243.7	48.3	5.1	3.8
Spring, SD	4.6	236.9	45.6	4.7	3.7
Spring, shungite 0.5 mm	6.1	271.4	38.7	4.6	3.5
$LSD_{0.5}$		22.0	5.9	0.6	0.4

The introduction of shungite contributed to a decrease in the proportion of rotten potatoes in the crop compared with the control. When applying pure shungite, rotten potatoes are not detected or their proportion is minimal. When applying shungite in the form of a shungite-dolomite mixture, the proportion of rotten potatoes increased, but still remained significantly lower than in the control version without shungite. In this case, a greater effect is also observed from the spring application of ameliorants (Table 3).

Table 3. Potato yield.

Option and term of shungite application	Proportion of rotten one, %	Yield, t/ha	Increase to control	
			t/ha	%
Control	9.2	9.2	-	-
Autumn, SD	5.3	9.8	0.6	6.5
Autumn, shungite 0.5 mm	1.5	12.2	3.0	32.6
Spring, SD	2.8	11.8	2.6	28.3
Spring, shungite 0.5 mm	0.0	13.6	4.4	47.8
$LSD_{0.5}$		0.9		

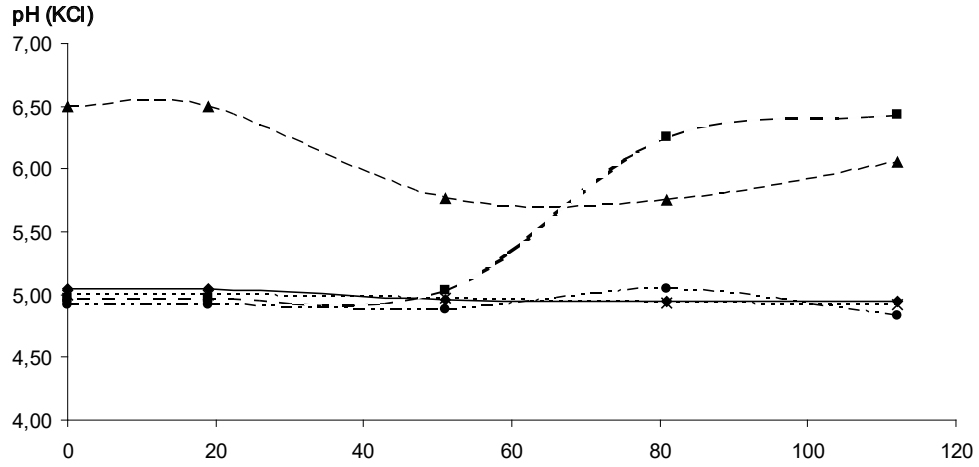
When applying shungite in its pure form, a significant (almost 50%) increase in yield was noted both in case of spring and autumn application, nevertheless, a greater effect is observed with pre-sowing application. When using a shungite-dolomite mixture, the greatest effect is also observed during spring application. Although the increase was noted in the autumn option, it is already insignificant (6.5%).

The analysis of soil properties was carried out after the completion of the field experiment. The change in soil acidity during the application of the shungite-dolomite mixture depended on the period of ameliorant application. In case of autumn application of shungite-dolomite, by the time planting began in spring, soil acidity decreased by almost 1.5 units from 5.0 to 6.5 pH. By the end of the growing season, this value decreased to 6.0, but still remained significantly higher than in the control option or with pure shungite introduction. In the option with pre-sowing application of shungite-dolomite, the effect of applying meliorant begins to manifest only after 1.5 months. The pH values reach their maximum value about two months after application (Fig. 1a). Shungite, introduced in its pure form, did not change the level of soil acidity.

Similarly, with the autumn application of shungite to the soil, by the time planting begins, the carbon content in the soil increases by 1%, but in case of pre-sowing

application, the effect also begins to manifest only after 1.5-2 months. The effect of shungite-dolomite on the carbon content in the soil is significantly lower, since with equal doses of application, the content of shungite in the mixture is only 50% (Fig. 1a).

a



b

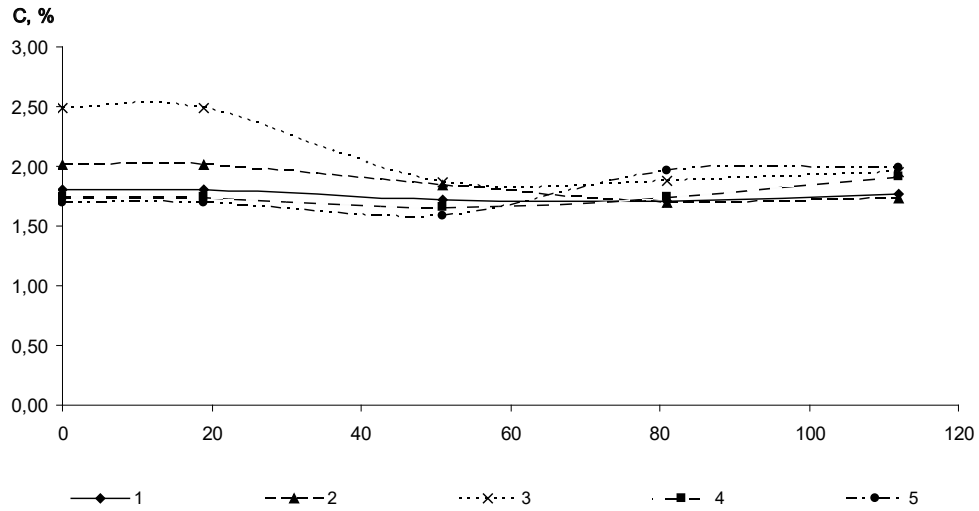


Fig. 1. Dynamics of soil acidity (a) and organic carbon content in the soil (b) depending on the number of days after planting when growing potatoes in areas with different periods of application of shungite: 1 – control; 2 - SD, autumn; 3 - shungite 0.5 mm, autumn; 4 - SD, spring; 5 - shungite 0.5 mm, spring.

4 Conclusions

During the field experiments conducted, it was found that the effectiveness of shungite effect on potato yield and the main agrochemical properties of the soil depends not only on the form, but also on the timing of shungite application.

The results showed that the use of pre-sowing shungite application is most effective in growing potatoes. The introduction of shungite into the soil immediately before planting contributed to the earlier appearance of potato seedlings, and also led to an increase in yield by 28-48% and contributed to a decrease in the proportion of rotten tubers. A greater effect is manifested from the introduction of pure shungite than from the shungite-dolomite mixture.

In case of autumn application of meliorants, by the beginning of the sowing season, an increase in the pH level is observed when applying a shungite-dolomite mixture, and when applying pure shungite, an increase in the carbon content is observed. With pre-sowing application, the effect of meliorants begins to manifest only after 1.5-2 months.

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