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Research Article

Dependence of proportions and seasonal application of saponite water suspension as ameliorant on acidic properties of soil

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Abstract

Increased soil acidity remains one of the important problems in world agriculture, especially relevant for the Northern territories, Traditionally, it is solved using lime ameliorants. Searching for new ameliorants that are just as effective, but at the same time are more are more accessible to certain areas is a promising direction for the development of agricultural science. Saponite water suspension can become effective ameliorant to improve acidic properties of soil on the territory of the Arkhangelsk region (Russia). This is possible due to the unique properties of saponite, its availability and the presence of large reserves in the region. This article presents the results of an experiment conducted in the Kholmogorsky district of the Arkhangelsk region (Russia) on sod-weak podzolic loam tame soil to identify the effect of saponite water suspension on acidic properties of soil under a naked fallow condition. The experiment proves the dependence of the seasonality of application, the different proportions of saponite water suspension and changes in pH and hydrolytic acidity, as well as the estimation of the most effective proportions of saponite water suspension to improve acidic properties of soil and revealed differences in the influence of seasonal application on the manifestations of the deoxidizing ability of saponite water suspension.

Keywords

ameliorant, field experience, hydrolytic acidity, saponite water suspension, soil acidity

Introduction

Today, one of the world's problems in soil fertility is soil acidification (Montanarella et al. 2015). Reducing soil acidity is especially important for agricultural land, because increased soil acidity contributes to a decrease in crop yield (Trubnikov 2011). The major method of reducing soil acidity is liming (Potatueva and Ignatov 2011, Maltsev et al. 2011). But, in addition to lime, other agrochemicals containing calcium carbonate can be applied. For example, agriculture organizations can use various clay minerals to increase soil fertility (Korolev 2007, Kozlov et al. 2017, 2019, Tsykalov and Bobreshov 2013), such as saponite (Bosak and Sachivko 2016, Bosak et al. 2016a, b, Streltsova et al. 2016, 2017).

Saponite is a clay mineral, a layered silicate from the montmorillonite group. In the North of Russia saponite is a by-product of diamond mining at the Lomonosov Deposit, which is located in the Arkhangelsk region. It is reported that the annual production of this Deposit is more than 3 million tons of rock, which contain about 90 % saponite and is distributed evenly not changing in percentage with cover thickness (Shpileva 2008). This overstock of saponite demands looking for its application in various spheres of human activity, including agriculture.

A unique feature of the technological process of diamond mining in the Lomonosov deposit is the dilution of saponite with water, turning it into water suspension.

The high moisture-absorbing and water-retaining capacity of this mineral (Tarasevich et al. 2011) is explained by the structure and size of its particles (Korshunov and Nevzorov 2007, 2009). This feature as well as the ability of saponite to absorb H+ ions can reduce the acidity of soil waters and even neutralize them (Telminov et al. 2011, Nakvasina et al. 2015, Gusakov 2016). These findings suggest the use of saponite water suspension as ameliorant.

It has to be noted, however, that the yield of crop depends not only on the proportions of ameliorant but on its seasonal application. Therefore, the aim of this article is to analyze the effect of proportions and seasonal application of saponite water suspension on the acidic properties of soil.

First, we provide methods for collecting data on the deoxidizing properties of saponite water suspension during spring and autumn application. Secondly, we analyze the collected data characterizing the acidic properties of soil, namely pH and hydrolytic acidity of the soil. Finally, we propose the optimal proportions and season of application of saponite water suspension.

Materials and methods

The field experiment was carried out at the production site "AGROFIRM "KHOLMOGORSKAYA" (Kholmogorsky district, Arkhangelsk region, Russia). The geographical coordinates of the site are 64°11'41"N, 41°37'38"E. The total area of the site is 7.1 hectares.

The experiment was carried out by a randomized two-row method, the location of plots in 4-fold repetition. Thus, the total number of plots was 36. Each plot had a size a total area of 18 m2. The distance between the plots was 0.5 m.

To minimize the possible impact of plants on soil acidity the experiment was held on a naked fallow, that is, without planting crops and with the use of all necessary agrotechnical measures for killing of weeds.

The duration of the field experiment was 16 months, from May, 2018 to August, 2019. The soil of the experimental site was scryptopodzol illuvial-ferruginous sandy loam. According to the agrochemical survey conducted by the Federal state budgetary institution station agrochemical service "Arkhangelsk" in 2016 the site had a medium acid reaction of the soil environment, had a very high degree labile phosphorus, an average-mobile potassium, an average degree of humus.

The water suspension of saponite used contained 78% water. In this regard, it was necessary to recalculate the of water suspension per the content of dry saponite.

Scheme of the experiment consisted of 9 combinations: 1 option-control (nil treatment); 2, 3, 4 and 5 options with the introduction of saponite water suspension in May, 2018 at the rate of 27 liters/plot

(3.6 t / ha), of 48 liters/plot (7.3 t / ha), of 61 liters/plot (9.7 t / ha), and of 82 liters/plot (12 t / ha), respectively. 6, 7, 8 and 9 options present introduction of saponite water suspension in September, 2018 in the same proportions.

The field experiment consisted of 4 stages. The first stage was produced (from May to September, 2018) included preparation of naked fallow, division of the site into plots, soil sampling, introduction of saponite water suspension according to the scheme of the experiment and application of the agrotechnical measures. The second stage (September, 2018) included restoration of boundaries of the experimental plots, soil sampling, introduction of saponite water suspension according to the scheme of the experiment and applications of necessary agrotechnical measures. The third and fourth stages were performed to assess the aftereffect of saponite water suspension on the acidic properties of the soil. They were held from May to July, 2019 and in August, 2019 respectively. They included the restoration of the boundaries of the experimental plots, soil sampling and carrying out the necessary agrotechnical measures.

Chemical analysis of soil samples was carried out on the basis of the accredited testing laboratory of Federal state budgetary institution station of agrochemical service "Arkhangelsk". Determination of pH in the soil was carried out according to GOST 26483-85 (Valid from 01.07.1986). Hydrolytic acidity was determined according to GOST 26212-91 (Valid from 01.07.1993).

Results

The dynamics of changes in the average acidity index during the introduction of saponite water suspension in May, 2018 is presented in the graph (Figure 1).

The option-control (nil treatment) has demonstrated a continual gradual decrease in the average values of soil acidity by 0.25 pH for the entire period of observation. All other options (2, 3, 4 and 5) have demonstrated an increase in pH for September, 2018 and decrease for May, 2019 and another increase for August, 2019.

The selection of the period of soil sampling have proved to be statistically significant for soil acidity index as P-value 0.007 < α 0.05. The different proportions of saponite water suspension has not proved statistically important for soil acidity index as P-value 0.88 > α 0.05. At the same time there is no mutual influence of saponite proportions and the frequency of soil sampling on soil acidity index as P-value 0.99 > α 0.05.

Data on the change in the average value of hydrolytic acidity on the plots with the introduction of sa-

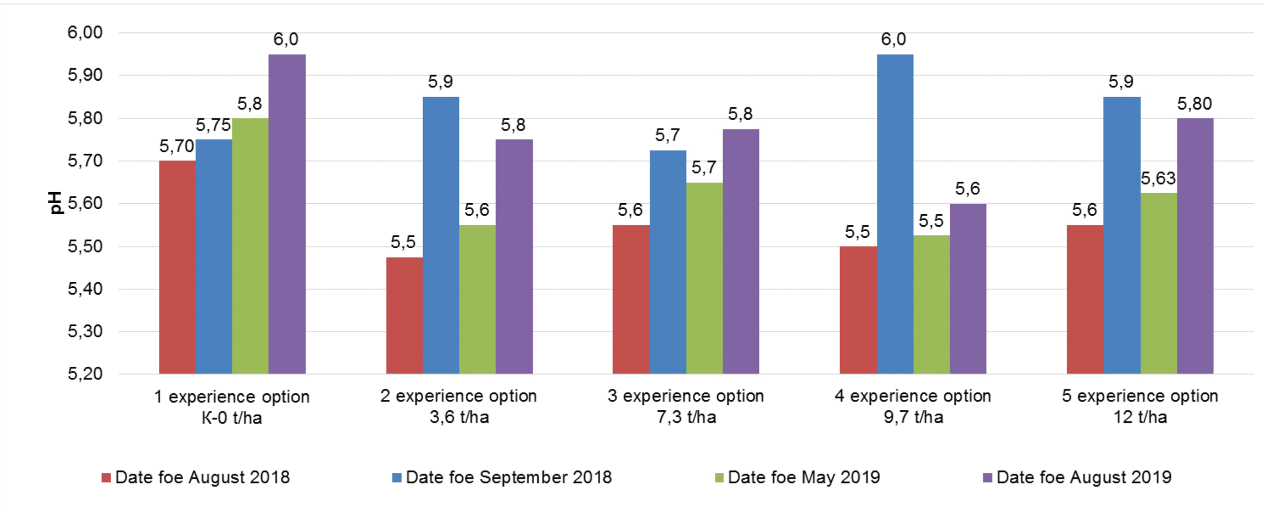

Fig. 1. Dynamics of changes in the average values of soil acidic (May, 2018)

ponite water suspension in May, 2018 are shown in the graph (Figure 2).

The option-control (nil treatment) has demonstrated a continual gradual decrease in the average values of hydrolytic acidity 0.8 mmol/100 g for the entire period of observation. All other options (2, 3, 4 and 5) have demonstrated a decrease in hydrolytic acidity for September, 2018 and increase in May, 2019 and another decrease for August, 2019.

Statistically significant has proved the influence of soil sampling periods for hydrolytic acidity index as P-value 0.007 < α 0.05. The different proportions of saponite water suspension have not proved statistically important for hydrolytic acidity index as P-value 0.98 > α 0.05. Mutual influence of saponite proportions and frequency of soil sampling have proved statistically insignificant as P-value 0.90 > α 0.05.

The dynamics of changes in the average acidity index during the introduction of saponite water suspension in September, 2018 is presented in the graph (Figure 3).

The option-control (nil treatment) and 9 option have demonstrated a continual gradual decrease in

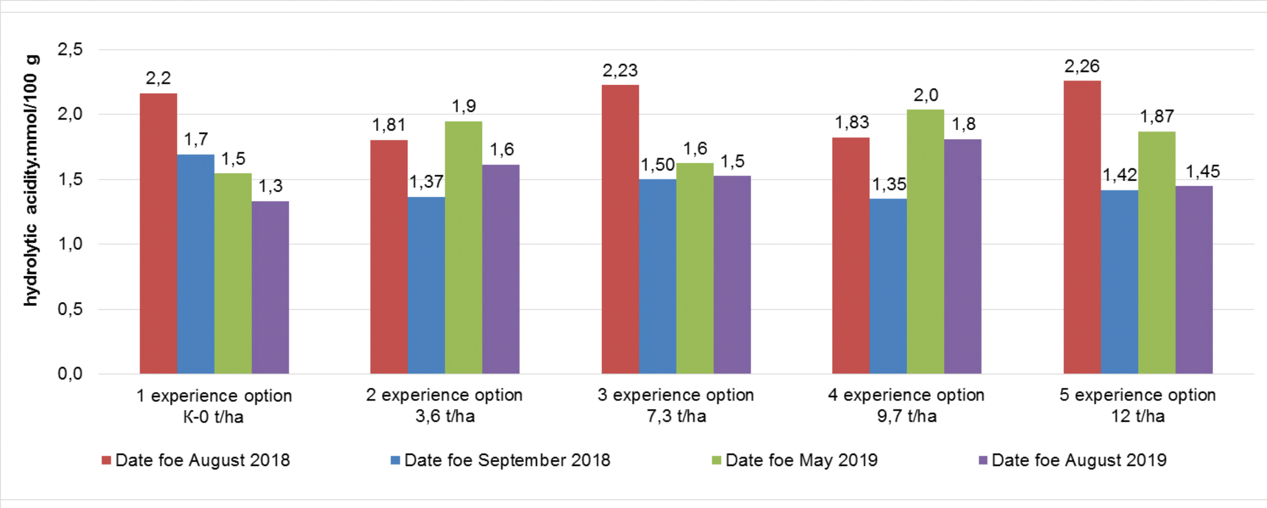

Fig. 2. Dynamics of change of average values of hydrolytic acidity (May, 2018)

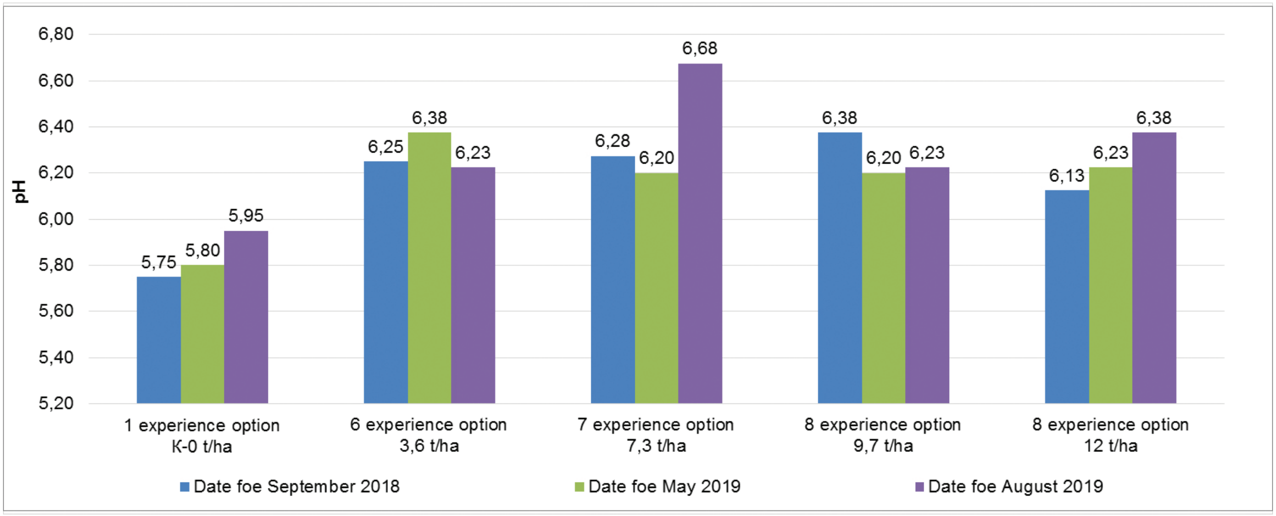

Fig. 3. Dynamics of changes in the average values of soil acidic (September, 2018)

the average values of soil acidity index by 0.20 pH and by 0.25 pH for the entire period of observation. Fluctuations in the acidity index in 6 and 8 options do not exceed ± 0.2 pH. The greatest decrease in soil acidity was demonstrated by option 7 by 0.4 pH.

The different proportions of saponite water suspension have proved to be statistically significant for soil acidity index as P-value 0.002 < α 0.05. The selection of the period of soil sampling has not proved statistically important for soil acidity index as P-value 0.60 > α 0.05. No mutual influence of saponite proportions and the frequency of soil sampling on soil acidity index was registered as P-value 0.77 > α 0.05.

Data on the change in the average value of hydrolytic acidity on the plots with the introduction of saponite water suspension in September, 2018 are shown in the graph (Figure 4).

The option-control (nil treatment) has demonstrated a continual gradual decrease in the average values of hydrolytic acidity 0.36 mmol/100 g for the entire period of observation. At the same time, the 7 option recorded a decrease in hydrolytic acidity by 0.39 mmol / 100 g during the observation period. In the remaining options of the experiment, the hydrolytic acidity index either remained virtually unchanged (9 option by 0.04 mmol / 100 g.), or increased (6 option by 0.37 mmol/100 g., 8 option by 0.23 mmol/100 g.).

Statistically significant has proved the influence of different proportions of saponite water suspension soil for hydrolytic acidity index as P-value 0.0003 < α 0.05. The sampling periods have not proved statistically important for hydrolytic acidity index as P-value 0.54 > α 0.05. Mutual influence of saponite proportions and frequency of soil sampling has proved statistically insignificant as P-value 0.78 > α 0.05.

Discussion

Changes in soil acidity and hydrolytic acidity in the option-control (nil treatment) demonstrate natural fluctuations, against which the influence of different proportions of saponite water suspension is determined. Introduced in May, 2018, saponite water suspension over the summer contributed to a significant decrease in the concentration of H^+ ions, which is proved by an increase in pH and a decrease in hydrolytic acidity. Similar results were obtained by other authors (Kozlov et al. 2019, Nakvasina et al. 2015). The effect can be exploited by the sorption capacity of saponite particles. Further decrease in acidity and increase in hydrolytic acidity in May, 2019 is probably due to the release of hydrogen ions due to the influence of meltwater. Then in August, 2019 to decrease

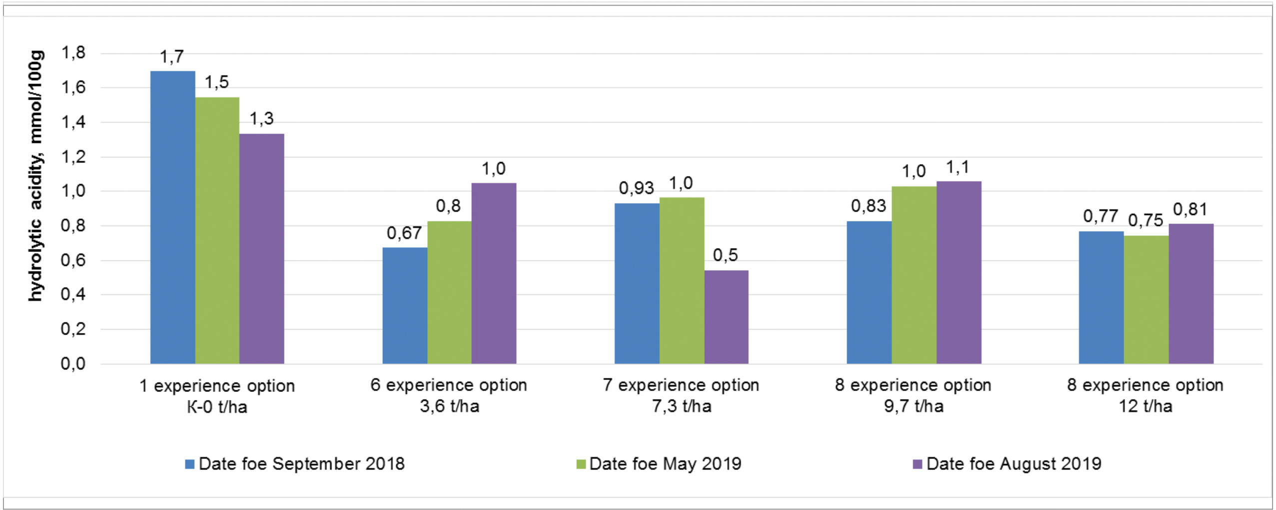

Fig. 4. Dynamics of change of average values of hydrolytic acidity (September, 2018)

hydrogen ion which might be caused by hydrogen ion sorption, but to a lesser extent.

The introduction of saponite water suspension in September, 2018 was carried out on plots with a neutral pH, and therefore minor fluctuations in the concentrations of hydrogen ions were observed in comparison with May, 2018. The effect of "leveling" indicators is noticeable when the proportions containing bigger amount of dry saponite were introduced.

It should be noted that during the experiment we were limited to one site with a specific type of soil with different initial acidity. In addition, the size of the allocated area did not allow increasing the area of plots and the number of proportions options and seasonally of application. To expand the spectrum of research of deoxidizing properties of saponite water suspension requires several experiments on sites with different localization and soil conditions. It is recommended to choose a site with initially aligned background

More extensive studies may provide further evidence of the reclamation properties of saponite water suspension as deoxidized capable in certain regions to replace lime.

Conclusion

Our research showed that the use of saponite water suspension affects the pH and hydrolytic acidity of the soil with a single application, regardless of the seasonality of application. At the same time, spring application can be considered more productively in terms of the speed of achieving the deoxidizing effect, and autumn application has a more "leveling" character. Since this experiment tested the effect of different proportions of saponite water suspension, it can be recommended to make the one that showed the best results, namely the proportion of 7.3 t / ha. At this dose, maximum values were achieved, both in the spring and autumn introduction of saponite water suspension.

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