The Content of Nitrate Nitrogen in the Soil in Biologized Crop Rotations of the Lower Volga Region

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Abstract: One of the factors affecting the yield and grain quality of agricultural crops, in the conditions of the dry–steppe zone of light chestnut soils, is the use of various types of fertilizers, including organic ones. At the same time, the cultivation of crops using organic fertilizers has a significant impact on soil fertility, increasing the efficiency and potential of sown crops. In our research, we studied the effect of various precursors on the content of nitrate nitrogen in the soil. As a result of the conducted studies, it was found that the sowing of crops by pairs of occupied sideral precursors, such as phacelia, sweet clover and oats, was higher than in the control variant, but the content of this nutrient in the soil in the crops was noted as low.

1 INTRODUCTION

The main task of agriculture is the production of competitive products that meet the demand of the modern market. Sustainable agriculture is based on the reproduction of soil fertility, which is one of the main problems of agricultural production (Larionov, Zharnikov, Stukanov, 2020; Yamaltdinova, Zavyalova, Fomin, Vasbieva, 2020; Cheverdin, Cheverdin, Cheverdin, 2022). Intensive use of arable land, improper crop rotation, insufficient or excessive introduction of macro- and microelements into the soil, and others have a negative impact on soil fertility, all this leads to deterioration of soil conditions and a decrease in crop productivity, and in some cases, complete destruction of crops. Reproduction of soil fertility is tied to the return to the soil of energy and nutrients carried out with the harvest (Khrustalev, 2022; Seminchenko, 2019). The strongest biological factor in increasing soil fertility, and consequently crop yields, is sideration. When selecting a sideral crop in the crop rotation, it is necessary to pay attention to the transpiration coefficient, the seeding rate and the ability to rapidly increase biomass, for earlier embedding it in the soil (Minchenko, 2021; Zhloba, Kunanbayev, Zueva, 2020).

The introduction of organic fertilizers in the form of siderates and residues of the non-marketable part of the grain harvest contribute to a more effective increase in soil fertility, compared with other methods (Dedov, Dedov, Nesmeyanova, 2016; Kratko, 2017; Skirukha, Gribanov, Usenya, 2019; Ulanov, 2017; Sokolov, Sokolov, Tymchuk, Larin, 2014).

The purpose of the research was to determine the content of nitrate nitrogen in the soil in field crop rotations, when sowing various siderative crops.

2 RESEARCH METHODOLOGY

The experimental site was located on the territory of the Federal State Budgetary Scientific Institution "Federal Scientific Center for Agroecology, Integrated Land Reclamation and Protective Afforestation of the Russian Academy of Sciences" (FSC Agroecology RAS), the soils of the site are represented by salty light chestnut varieties of heavy granulometric composition in combination with 15-20% of salt. The width of the experiment was 1242

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m, length – 50 m, area – 62100 m2 or 6.2 hectares. Around the experiment was bordered by a road, the width of which was 10 m.

Determination of the nitrate content in the soil was carried out by the colorimetric method according to the methodological materials of Grandval – Liege. To recalculate the content of quantitative nitrate NO3- in the soil into nitrate nitrogen N-NO3, a conversion factor of 0.226 was used. Soil samples were taken in an arable 0-30 cm soil layer diagonally across the accounting plot in ten places by a soil drill during the determination of soil moisture in winter wheat crops during sowing, winter care, spring regrowth and harvesting. In chickpea and spring barley crops – during sowing and harvesting (Mineev, 2004).

3 RESEARCH RESULTS

Studies aimed at studying the effect of precursors and biologization techniques on the content of nitrate nitrogen in the soil under field crops of experimental crop rotations are presented in Figures 1 and 2.

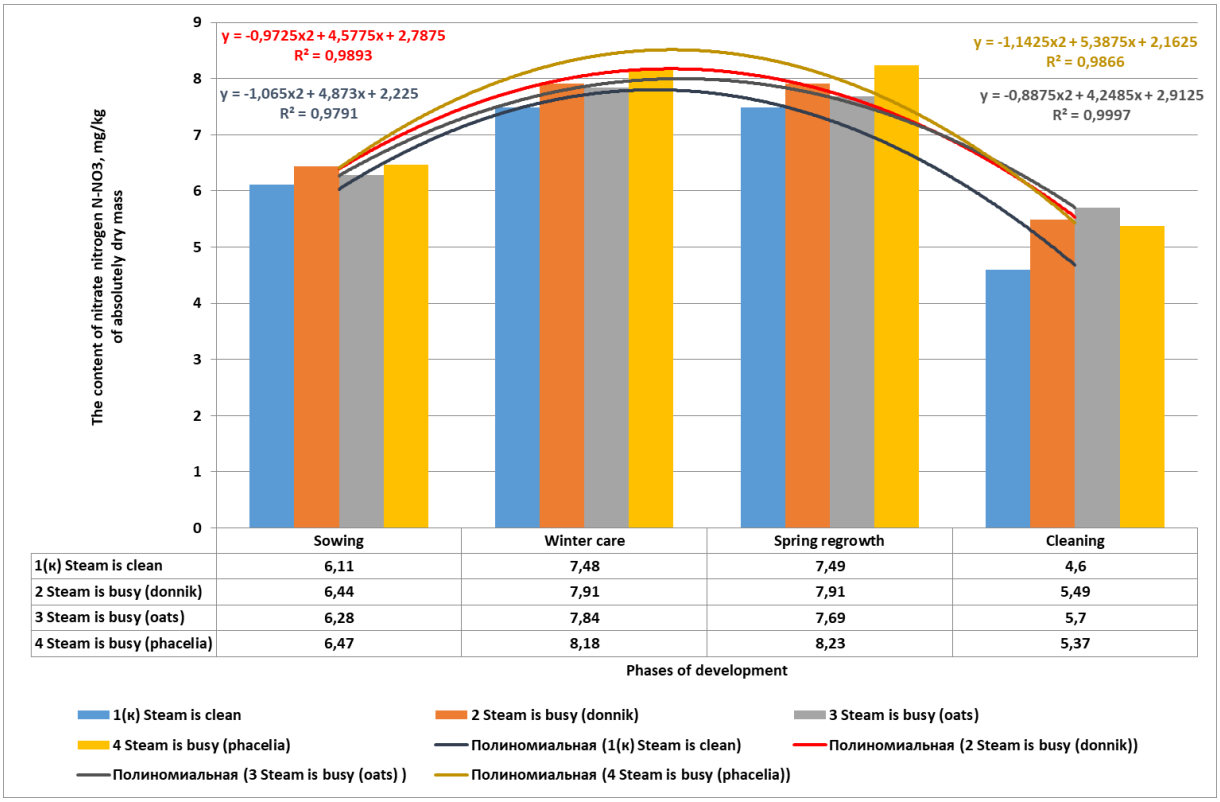

Figure 1: Content of nitrate nitrogen N-NO_3 in winter wheat crops in the arable soil layer, mg/kg of absolutely dry soil (average data for 2017-2020).

From the data shown in Figure 1, it can be seen that by the beginning of winter wheat sowing, the highest levels of nitrate nitrogen in the soil layer of 0.0 – 0.3 m were observed in the seven–field crop rotation for a couple occupied by phacelia on siderate - 6.47 mg/kg of absolutely dry soil, which was 5.9% higher than the control variant, where winter wheat was located on pure steam. Sowing of winter wheat after sideral steam, on which sweet clover and oats were sown, increased the content of N-NO3 in the arable layer compared to the control by 5.4 and 2.8%, respectively.

During the period from sowing to the transition of winter wheat to wintering, the process of humus mineralization and accumulation of nitrate nitrogen occurs in the soil. The highest content of the last component of nutrition was noted when sowing winter wheat in a seven–field crop rotation after the steam occupied by phacelia on sederate - 8.18 mg/kg of soil, this indicator exceeded the control by 0.7 mg/kg or 9.4%. In the variants of placing winter

wheat on the occupied pairs of sederates - oats and sweet clover, the nitrate nitrogen content was above the control, by 0.36 and 0.43 mg/kg of soil, respectively, or 4.8 and 5.7 %.

By the spring regrowth of winter wheat plants, the content of nitrate nitrogen in the arable soil layer was higher than during sowing, and approximately the same as during winter care. This is explained by the fact that in addition to the mineralization of humus, which leads to the accumulation of this nutrient in the soil, the processes of consumption of nitrate nitrogen by winter wheat plants took place in parallel, as well as as a result of the loss of this element from the soil due to infiltration and denitrification. The content of nitrate nitrogen in the arable soil layer in all biologized variants according to the precursors occupied by phacelia, sweet clover and oats per siderate pair was higher than in the control for pure steam, respectively, by 9.9; 5.6 and 2.7 %.

In all variants of the experiment, by the time of harvesting winter wheat, the nitrate nitrogen content decreased to the minimum values – 4.6-5.7 mg/kg of absolutely dry soil due to the loss of this nutrient from the soil, as well as consumption by plants as a result of crop formation..

Analyzing the results of correlation and regression analysis, it can be stated that according to the content of nitrate nitrogen N-NO3 in the arable soil layer in winter wheat crops, a direct linear correlation of a strong degree was observed, which had a polynomial function: for a pure steam У = -1,065X2 + 4,873X + 2,225, (r2 = 0,98); steam busy (donnik)У = -0,9725X2 + 4,5775X + 2,7875, (r2 = 0,99); steam busy (oats) У = -0,8875X2 + 4,2485X + 2,9125, (r2 = 0,99) and steam busy (phacelia) У = -1,1425X2 + 5,3875X + 2,1625, (r2 = 0,99).

Figure 13 shows that the highest amount of nitrate nitrogen was observed in the arable layer of the five–field crop rotation at the time of sowing chickpeas on winter wheat, the straw of which was plowed into the soil - 5.8 mg/kg of soil, and exceeded the control by 1.8 mg/kg or 44.6%. When growing chickpeas on spring wheat and mustard, the straw of which was plowed into the soil, the content of nitrate nitrogen was higher than the control, respectively by 0.6 and 1.7 mg / kg of absolutely dry soil or 15.2 and 41.9%.

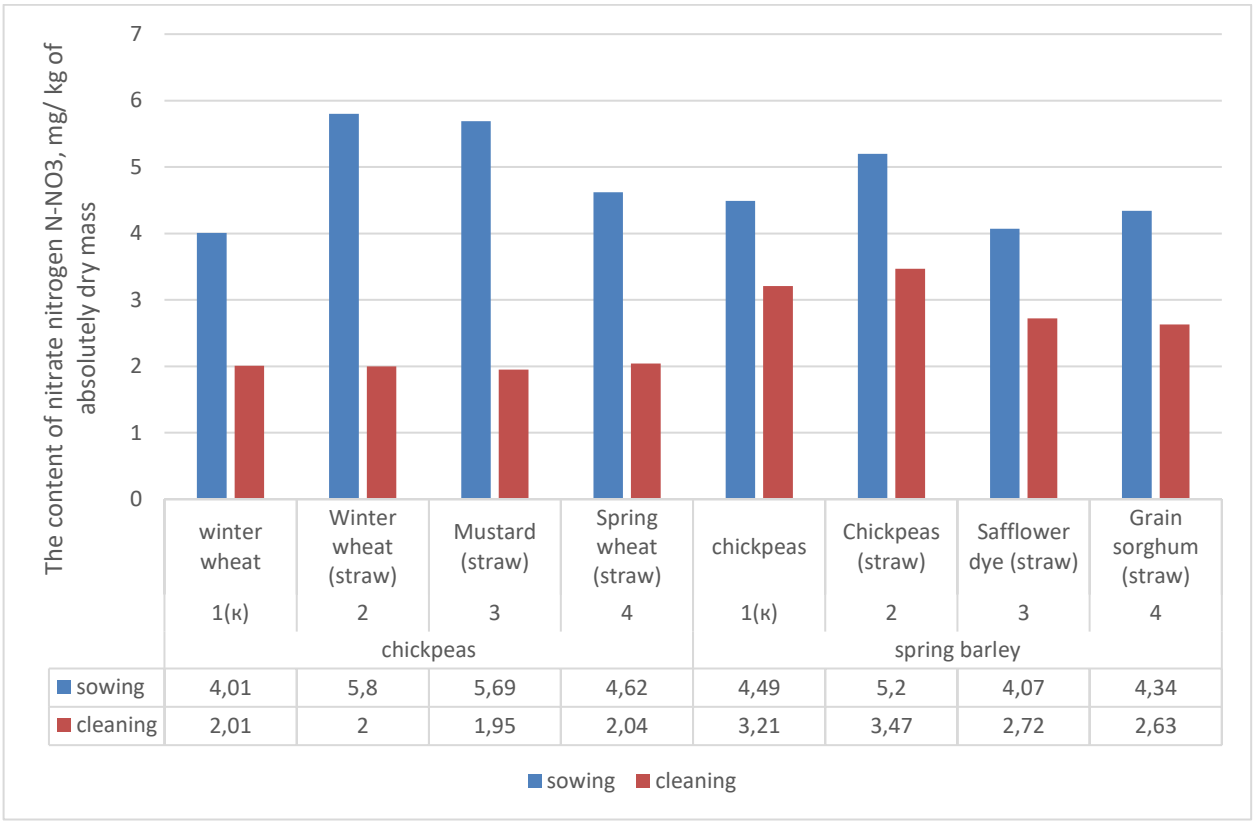

Figure 2: The content of nitrate nitrogen N-NO3 in the arable 0.0-0.3 m soil layer in chickpea and spring barley crops, mg/kg of absolutely dry soil (average data for 2018-2020).

By the beginning of the chickpea harvest, there was a decrease in the nitrate nitrogen content in the arable layer and its change depending on the experiment variant from 1.95 mg/kg of soil according to the mustard precursor in the seven-field crop rotation to 2.04 mg/kg of absolutely dry soil in the seven-field crop rotation for spring wheat.

When sowing spring barley, the presence of nitrate nitrogen in the arable soil layer varied from 4.07 mg/kg of safflower soil in a seven-field crop rotation to 5.2 mg/kg of chickpea soil in a five-field crop rotation. In the four-field control crop rotation, where spring barley was cultivated on chickpeas, the straw of which was alienated from the field, the content of nitrate nitrogen was 4.49 mg/kg of absolutely dry soil.

By spring barley harvesting, the presence of nitrate nitrogen in the soil decreased to 2.63 mg/kg of soil when placed in a seven-field crop rotation for grain sorghum to 3.47 mg/kg of absolutely dry soil for chickpeas in a five-field crop rotation.

4 CONCLUSION

The presence of nitrate nitrogen in the soil varied depending on the precursor, the phase of crop development and crop rotation. The highest quantity of it was noted in the arable layer at the time of sowing the crop, by the harvest period there was a gradual decrease.The content of nitrate nitrogen in winter wheat, chickpeas and spring barley crops in all variants and in various phases of development according to Grandvalle was characterized as very low (less than 10 mg/kg of soil).

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