The effect of azotovit and phosphatovit on the yield of vetch oats

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Abstract. In the Novgorod region, the effectiveness of the integrated use of new microbiological preparations of Azotovit, Phosphatovit and mineral fertilizers has been investigated. The purpose of the experiment was to increase the yield of green mass of oatmeal mixture. Field experiment took place in 2017-2019 on sod-podzolic light loamy, clay-laden soil. Of the varieties recommended for cultivation in the North-West region, the following objects of research were used: spring vetch Lyudmila and oats of spring variety Borrus. Three methods of applying micronutrient fertilizers were tested: presowing treatment of seeds; foliar treatment in the phase of branching the wiki and tillering of oats; seed treatment presowing + foliar in the phase of branching the vetch and tillering of oats on two backgrounds of mineral nutrition - background 1 – N82P105K70 and background 2 – N41P53K35. The highest yield of green mass of oatmeal mixture (on average over 3 years) – 42.4 t/ha (6.8 t. units/ha) and digestible protein of 0.85 t/ha were obtained with a dose of mineral fertilizers per calculated yield N82P105K70 during seed treatment before sowing with microbiological fertilizers (Azotovit, Phosphatovit), as well as spraying the ground vegetative part of the vetch (in the branching phase) and oats (in the tillering phase). Doses: Azotovit – 1.0 l/ha + Phosphatovit – 1.0 l/ha. At the same time, the energy intensity of production of one ton of feed units in this embodiment was 2.2 GJ. In addition, energy efficiency was 4.7 units, and the increase in soil energy potential was 15 GJ/ha.

1. Introduction

The use of new microbiological preparations Azotovit (A) and Phosphatovit (Ph) in the cultivation of crops promotes the use of macro and micronutrients that are found in the soil in unapproachable forms. Used new microbiological fertilizers significantly increases the yield and improves the ecological situation. In addition, the effective soil fertility is significantly increased.

Azotovit (active substance: Azotobakter chroococcum). Mechanism of action: free-living nitrogen-fixing bacteria that fix nitrogen from the atmosphere and make it available for absorption by plants. It stimulates seed germination, synthesizes the fungistatic antibiotic of the anisomycin group, and forms an additional crop by increasing the intensity and efficiency of the use of nutrients by plants.

Phosphatovit (active substance: Bacillus mucilaginosus). Mechanism of action: bacteria dissolve silicate minerals (triphosphates, phosphorites, apatites, mica) and release phosphorus and potassium from complex compounds, converting them into accessible forms that are easily digestible for plants and form an additional crop due to the supply of more nutrients to plants.

Oats and vetch can be used for feed purposes in various phases of plant development. Prior to milk-wax ripeness of grain in beans, biomass increases and digestibility of the immature part of the crop decreases [1].
During the harvesting of spring vetch as a green phytomass for fodder for cattle and hay, weed vegetation does not bloom yet, and weeds are destroyed before flowering, which makes it possible to effectively combat weeds [2]. It is the best predecessor for many crops.

Vetch is a moisture-loving culture and cannot tolerate even a short moisture deficit. This is due to the fact that nodules die off due to a lack of carbohydrate.

Vetch as green fodder is sown not in its pure form, but more often in a mixture with oats. Oats act as a supportive culture. Vetch has a weak stem, easily lays and needs support. Oats are unpretentious when cultivated, but loves moisture and is well eaten by various animals. The protein content in vetch is significantly higher than that of oats. Depending on the predominance of one or another component in the oatmeal mixture, the nutritional value of the mixture of vetch and oats is obtained.

However, the knowledge of agricultural technology of cultivating the green mass of the oatmeal mixture in the conditions of the Novgorod region is insufficient. The development of the main technological methods for the integrated use of new microbiological and mineral fertilizers in the cultivation of the green mass of oatmeal mixture will allow to obtain stable yields of high-quality feed.

The purpose of the research is to study the effect of new microbiological fertilizers Azotovit and Phosphatovit, together with mineral ones, on the productivity of biomass of the oatmeal mixture and preservation of soil fertility.

The research objectives include: to establish the optimal way to use microbiological fertilizers; calculate the humus balance of the soil according to the options of the experiment and the energy-economic efficiency of technologies for cultivating the oatmeal mixture into green mass.

2. Objects and research methods

In 2017-2019, studies were conducted on sod-podzolic clay loamy clay soil, which contains: mobile phosphorus 240 mg/kg and exchange potassium 185 mg/kg; 2.8% soil organic matter and pH_{salt} = 6.0.

The Novgorod region belongs to the zone of excessive moisture and it is advisable to cultivate legumes in it. Legumes grow poorly on acidic and sandy soils. They need soil: medium, slightly acidic, neutral loamy and loamy sand with a good content of phosphorus, potassium and calcium.

In general, the soil and climatic conditions of the Novgorod region correspond to the biological requirements of the spring vetch and other legumes and provide high grain yields and green masses of these crops.

Vetch and oats cultivated for green mass during the years of research were sufficiently provided with moisture. For this, we used a conditional indicator of hydration - hydrothermal coefficient (HTC). The hydrothermal coefficient was calculated as follows. The total amount of precipitation for the entire period with a temperature above 10°C was divided by the sum of the temperatures for the same period, which was reduced by 10 times. During the field experiments, the HTC of the vegetation periods was 1.6; 1.3 and 1.5 units, respectively, which indicates sufficient soil moisture. Vetch-oatmeal mixture is a moisture-loving culture. In the flowering phase, spring vetch is particularly demanding on moisture. During this period, the largest growth of stems occurs and the mass of plants increases. Crop is significantly reduced if moisture is insufficient [3]. In our studies, in the flowering phase, soil moisture was good, and the HTC was 1.6; 1.8 and 2.0 units, respectively, by year of research.

The research was carried out on the crops of the vetch of the sowing variety Lyudmila mixed with oats of the Borrus variety.

Spring vetch Lyudmila has the growing season of 87-100 days from seedling to bean ripening. Sowing vetch with oats and barley gives high yields. The yield of green mass in crops with oats reaches 38-40 tons per hectare, including vetch - 20-21 tons per hectare. The vetch Lyudmila is resilient to stressful cultivation conditions. It tolerates heat and waterlogging. Recommended regions are North-West, Central, Volga-Vyatka.

Spring oats Borrus medium early. Drought tolerance is above average. The main features of the variety: plastic, responsive to high agricultural background and irrigation. The protein content in the
Grain is 13-19%, lysine in the protein is 2.6-4.2%, fat is 4.5%. In addition to grain use, it is sown in a mixture with legumes for green feed. Tolerance region: North-West, Central.

Microbiological fertilizers in the cultivation of spring vetch were used in conjunction with mineral fertilizers to study their effectiveness. The first dose of mineral fertilizers (N₁P₁K₁) was calculated for the planned yield, taking into account the removal of the main nutrients from the soil with the crop and the availability of basic macronutrients available for plants. The second dose of mineral fertilizers (N₂P₂K₂) was reduced by 50% to study the effectiveness of the interaction of mineral and microbiological fertilizers. In addition, the use of microbiological preparations is not expensive.

The scheme of the experiment 2×4.

Factor B – doses of mineral fertilizers: B₁– N₁P₁K₁ for the planned yield; B₂ – N₂P₂K₂ reduced by 50% of the dose of factor B₁.

Factor H – methods of using Azotovit and Phosphatovit: H₀ - control (without using A+Ph); H₁ - seed treatment before sowing Azotovit and Phosphatovit at 2 liters per hectare of each; H₂ – in the phase of branching the vetch and tillering of oats, foliar treatment with microbiological preparations of one liter per hectare; H₃ - pre-sowing seed treatment with Azotovit and Phosphatovit + in the phase of branching the vetch and tillering of oats foliar treatment with micronutrient fertilizers.

Scheme of experience:
1. N₁P₁K₁ – background 1;
2. background 1 + seed treatment: A (2.0 l/t) + Ph (2.0 l/t);
3. background 1 + foliar treatment A (1.0 l/ha) + Ph (1.0 l/ha);
4. background 1 + seed treatment A (2.0 l/t) + Ph (2.0 l/t) + foliar treatment A (1.0 l/ha) + Ph (1.0 l/ha);
5. N₂P₂K₂ – background 2;
6. background 2 + seed treatment: A (2.0 l/t) + Ph (2.0 l/t);
7. background 2 + foliar treatment A (1.0 l/ha) + Ph (1.0 l/ha);
8. background 2 + seed treatment: A (2.0 l/t) + Ph (2.0 l/t) + foliar treatment A (1.0 l/ha) + Ph (1.0 l/ha).

In addition, oat seeds were sown before treatment (sample) with a treater Bunker, VKS (60 g/l) at a dose of 0.5 l/t. The oatmeal mixture did not require special care during the growing season, since the crops drowned the weeds.

Mineral fertilizers were applied under pre-sowing cultivation according to the experimental design. The cultivation of the chill was carried out as the physical ripeness of the soil occurred. Seeder CH-16 sowed vetch and oats for green mass: vetch – 2 and oats – 3 million seeds of germinating seeds per hectare.

Microbiological fertilizers Azotovit and Phosphatovit were used in the experiment; nitrogen fertilizers and azofos N – 16%; P₂O₅ – 16%; K₂O – 16% TU 113-03-466-91 (granules), potassium chloride – 60% K₂O, GOST 4568-95 (powder); double superphosphate – 43% P₂O₅ TU 82-176-00209438-00.

Harvest accounting was carried out according to test sheaves, the research results were processed by dispersion [4] and energy-economic methods [5].

3. The results of the study
The mowing ripeness of the green mass of the oatmeal mixture in the years of research came on the 70-80th day after sowing.

Harvest accounting was carried out in the phase of the formation of green shoulder blades at vetch in mid-July. The highest yield (on average over 3 years) – 42.4 t/ha (table 1) was obtained in option 4. In this case, a synergistic effect is most likely obtained as a result of the optimal combination of several components (factor B₁ + factor H₃ against background 1 for mineral fertilizers). The volume of use of the working solution is 200 l/ha. In this version, the increase in green mass harvest from the use of micronutrient fertilizers is the highest and amounted to 5.2 t/ha (14%) in relation to option 1, where bacteria were not used, which is consistent with the results of studies of other researchers [6, 7, 8, 9].
Table 1. The productivity of the green biomass of the vetch oat mixture, depending on the chemicals used (on average for 2017-2019).

| Option No. | Factor | Dose of mineral fertilizers, kg a.a./ha | Factor | Productivity, t/ha | Crude protein, t/ha | Average factor B (HCP_{05}=1.2 t/ha) |
|------------|--------|------------------------------------------|--------|-------------------|-------------------|-------------------------------------|
| 1          | \(B_1\) | \(\Phi_{OH} 1, N_82P_{105}K_{70}\)     | \(H_0\) | 37.2              | 1.01              |                                     |
| 2          | \(B_1\) | \(\Phi_{OH} 1, N_82P_{105}K_{70}\)     | \(H_1\) | 40.2              | 1.09              | 39.9                                |
| 3          | \(B_1\) | \(\Phi_{OH} 1, N_82P_{105}K_{70}\)     | \(H_2\) | 39.6              | 1.07              |                                     |
| 4          | \(B_1\) | \(\Phi_{OH} 1, N_82P_{105}K_{70}\)     | \(H_3\) | 42.4              | 1.15              |                                     |
| 5          | \(B_2\) | \(\Phi_{OH} 2, N_41P_{53}K_{35}\)     | \(H_0\) | 32.1              | 0.87              |                                     |
| 6          | \(B_2\) | \(\Phi_{OH} 2, N_41P_{53}K_{35}\)     | \(H_1\) | 35.9              | 0.97              |                                     |
| 7          | \(B_2\) | \(\Phi_{OH} 2, N_41P_{53}K_{35}\)     | \(H_2\) | 35.8              | 0.97              | –                                   |
| 8          | \(B_2\) | \(\Phi_{OH} 2, N_41P_{53}K_{35}\)     | \(H_3\) | 37.3              | 1.01              |                                     |

HCP_{05} = 1.0 t/ha on factor H
HCP_{05} = 2.0 t/ha for comparison of private medium

A similar increase in the yield of green mass of oatmeal mixture 5.2 t/ha (16%) was obtained in option No.8 to background 2 (option 5), where microbiological fertilizers were used twice and mineral in half dose, calculated on the planned yield \(N_41P_{53}K_{35}\), introduced under cultivation before sowing. When using microbiological fertilizers, once (seed treatment before sowing and foliar treatment), the yield increase was 2.4-3.8 t/ha (with HCP_{05}=2.0 t/ha) and did not depend on the used doses of mineral fertilizers. Mathematical processing of crop data showed that the effect of the joint interaction of mineral and microbiological fertilizers (Azotovit and Phosphatovit) on the yield of green mass of oatmeal mixture was not obtained. The green mass yield increase with a doubling in the dose of mineral fertilizers amounted to 5.1 t/ha (option 1 in relation to option 5), which is consistent with the results of studies conducted by the Novgorod Scientific Research Institute of Agricultural Sciences [10].

In options 4 and 8, a high yield of crude (1.15; 1.01 t/ha) and digestible (0.85; 0.75 t/ha) protein was obtained, respectively. The effect was obtained from the use of mineral fertilizers and the double use of microbiological fertilizers: seed treatment before sowing with microfertilizers of 2 liters per hectare and foliar treatment in the phase of branching the vetch and tillering of oats with Azotovit and Phosphatovite, one liter per hectare.

When cultivating crops, it is necessary to use such technologies in order to maintain or improve soil fertility. After spring vetch, many crops can be sown. This is due to the fact that during the growth process it accumulates a lot of nitrogen in the soil, as well as a larger amount of crop and root residues. When cultivating the oatmeal mixture on green mass on sod-podzolic soil using new microbiological and mineral fertilizers, the humus balance of the soil in all the technologies studied is positive and the increase in soil humus was 0.43 - 0.64 t/ha (table 2), as previously confirmed conducted research at the Novgorod Scientific Research Institute of Agricultural Sciences [10].

Table 2. The effect of growing oatmeal mixture on green mass using microbiological and mineral fertilizers on soil quantitative parameters (average for 3 years).

| Option | Humification of organic fertilizers, | Humification of crop-root residues, | Mineralization of humus, t/ha | Humus balance, ± t/ha |
|--------|------------------------|-------------------------------|-----------------------------|----------------------|
| 1      | 0                      | 0.89                          | 0.34                        | +0.56                |
| 2      | 0                      | 0.96                          | 0.34                        | +0.62                |
| 3      | 0                      | 0.95                          | 0.34                        | +0.61                |
| 4      | 0                      | 0.98                          | 0.34                        | +0.64                |
The results of the studies showed that the best energy and economic indicators of the green mass cultivation of the oatmeal mixture were obtained in options 4 and 8. At the same time, a low energy intensity of production per ton of feed units (2.2 and 1.8 GJ) was achieved, as well as a high productivity of 6.8 and 6.0 t. units/ha. Received an increase in soil fertility by 15 and 13 GJ/ha and the profitability of production was 144 and 153% (respectively). In these options, they reduced the energy intensity of the production of a ton of feed units of the weighing mixture by 8% and 5% and increased the energy efficiency of the production of basic products by 0.3 units compared to options 1 and 2, respectively (table 3).

Table 3. Energy and economic efficiency of technologies for cultivating the green mass of the oatmeal mixture on average over 3 years.

| Option No. | Productivity, feed. units/ha, t | Profitability, % | Main products | Soil energy potential increase, GJ/ha |
|------------|-------------------------------|------------------|---------------|--------------------------------------|
|            |                               |                  | Energy efficiency, units | Energy intensity, GJ/t, units. |                                |
| 1          | 6.0                           | 132              | 4.4           | 2.4                                  | +13                              |
| 2          | 6.4                           | 105              | 4.6           | 2.3                                  | +14                              |
| 3          | 6.3                           | 129              | 4.5           | 2.3                                  | +14                              |
| 4          | 6.8                           | 144              | 4.7           | 2.2                                  | +15                              |
| 5          | 5.1                           | 143              | 5.6           | 1.9                                  | +10                              |
| 6          | 5.7                           | 150              | 5.8           | 1.8                                  | +12                              |
| 7          | 5.7                           | 145              | 5.7           | 1.8                                  | +12                              |
| 8          | 6.0                           | 153              | 5.9           | 1.8                                  | +13                              |

In options 4 and 8, they obtained high energy and economic indicators in the production of green phytomass of a mixture of oats and vetch due to the low cost of micronutrient fertilizers and their combined use with pesticides.

4. Conclusion
The cultivation of the vetch-oatmeal mixture on sod-podzolic soil in the Novgorod region using new microbiological fertilizers Azotovit and Phosphatovit twice (seed treatment before sowing and foliar cultivation up to a plant height of 30 cm) and introduction of mineral fertilizers under cultivation, based on the planned yield and reduced by 50% allowed to obtain a yield of green mass of more than 6.0 t. units/ha. The content of digestible protein was more than 0.75 t/ha. The content of digestible protein was more than 0.75 t/ha. It should also be noted that the specific energy consumption of production has significantly decreased (dropped below 2.2 GJ/tk unit). In addition, a high energy efficiency ratio (over 4.7 units) was achieved. In the variants with recommended technology elements, a steady increase in soil fertility was obtained — the balance of soil humus increased by 0.64 and 56 t/ha, respectively.
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