Results of the study of long-term dynamics of microbiological and agro-chemical indexes of the fertility of the meadow-sod soils with the use of fertilization systems of different intensity (Sakhalin Island)

L V Samutenko, V P Slavkina and L V Fedorova
Sakhalin Research Institute of Agriculture
E-mail: lyubiva_1953@mail.ru

Abstract. A decrease of the level of basic elements of plant nutrition in soils regardless of the use of different fertilizer systems was established after the 30-year monitoring. The soil acidity had quite noticeable changes. Conservation of soil acidity indicators at the level of slightly acidic and close to neutral for 5 years was ensured by a calcium-organic complex. The fertilizer system of 200 t per ha of PMC (action and long-term aftereffect) + 2NPK contributed to the increase in the number of pedotrophic microflora in the soil, indicating an increase in the number of labile forms of organic matter involved in the synthesis of humus. The most favourable microbiological regime with balanced processes of nitrogen and humus transformation was formed when lime was combined with organic and mineral fertilizer systems (Ca + 20 or 40 t / ha of manure + 2NPK).

1. Introduction
In conditions of intensification of agriculture, the anthropogenic load on the soil increases, changing its fertility. The main agrochemical indicators of soils, which may vary, include the amount of humus, acidity, the number of absorbed bases, and the content of assimilable forms of nitrogen, phosphorus and potassium [1]. Nitrogen is a limiting element of nutrition in soils that are not fertile, and its deficiency is observed even under the conditions of systematic use of high doses of nitrogen fertilizers [2]. The introduction of low doses of mineral fertilizers that do not cover the removal of nitrogen by the crop yield is accompanied by increased mineralization of organic matter and a decrease in potential fertility to the level of non-fertilized soil [3]. Under conditions of insufficient application of mineral fertilizers and lime, fertility losses are inevitable. This is confirmed by the results of long-term stationary observations, where an increase in acidity, a decrease in the content of phosphorus and potassium [4, 5, 6], humus, total and easily hydrolyzed nitrogen [1] are noted.

The development of effective, scientifically based fertilizer systems has a special place in a complex of measures to increase crop productivity, preserve and improve soil fertility [6, 7]. A long study of the effect and aftereffect of different systems showed that soil fertility created during the long-term use of organo-mineral fertilizer systems has a higher aftereffect than that formed based on using only mineral systems [3, 8]. The most important indicator characterizing soil fertility and the intensity of the processes is biological
activity. Any agrotechnical measures aimed at increasing the yield of plants and reproduction of soil fertility should have a soil microbiological justification [9].

The island Sakhalin includes 15 types of soils; meadow-sod (typical meadow-sod, meadow-gley), brown forest and marsh soils are the most suitable for agronomic use. The peculiarities of island soils are weak morphological differentiation of the profile with a low humus horizon, high acidity, low availability of basic nutrients with significant natural humus content, fulvate type of humus, the presence of a large amount of iron and aluminium in the composition, heavy particle size distribution [10]. So, we can suggest the general nature of changes in physicochemical and chemical properties, taking into account typical soil features. Bringing the soils involved in agricultural use to the required level of cultivation required significant temporary, economic and energy investments.

In the stationary experiment of the Sakhalin Research Institute of Agriculture, a set of research directions included the study of the dynamics of the soil agrochemical parameters to establish the most rational fertilizer systems in crop rotation to preserve and reproduce its fertility. In the process, it was necessary to make corrections for the material and technical security of the experiment.

2. Materials and methods
The station has three replications in space (3 ha) and in time (establishments at 1989, 1990 and 1991), which allows taking into account soil and weather differences and determining mathematical dependencies not only within each experiment but also when combining the obtained results. The alternation of crops in grass-cultivating crop rotation is in time. Despite the unified field massif occupied by the station, the old arable meadow-sod soil is characterized by a heterogeneous granulometric composition (medium loam-light clay) and unequal agrochemical properties.

Initial agrochemical parameters are the following: pH is 3.9-5.9 (potentiometric determination), humus content is 2.9-5.1% (according to Tyurin-Simakov), total nitrogen is 0.27-0.33% (according to Tyurin), easily hydrolyzed nitrogen is 149-184 mg (according to Tyurin-Kononova), mobile forms of phosphorus are 262-622 mg (according to Kirsanov), exchange potassium is 74-138 mg (flame photometrically in a Kirsanov extract) per 1 kg of soil [11, 12]. The microbiological activity was measured according to [13].

Fertilizer systems included zero (0NРК), organic (100, 200 and 400 t / ha of peat-manure compost (PMC)), mineral (1 and 3NК, 1-3NРК) and organomineral (100-200 t / ha PMC + 1-3NРК) backgrounds. Basic single doses in the 1st rotation of the crop rotation (kg/ha of active substance): for potatoes - 60NРК, for annual fodder mixtures and perennial herbs - 60N90Р90К, for fodder root crops - 90N120Р180К - consistent with general regional recommendations. In the 2nd rotation, the basic dose of mineral fertilizers was changed to 30N108РК, in the 3rd - to 60N108PK. The introduction of organic fertilizers was not provided. The remote aftereffect of PMCs was monitored in the 2nd and 3rd rotations. In the 3rd rotation effect and aftereffect Ca + H (lime at 1.5 GK (Ca) + 20 and 40 t / ha of manure (N)) were monitored since 2010.

In plant samples, the content of NPKCa, fibre ash, sugars, and nitrates were determined according to methods generally accepted in feed production. Based on the analytical data, the yield of feed units, crude and digestible protein, gross and metabolic energy was calculated. The mathematical processing of materials was carried out according to BA Dospekhov [14].

3. Results and discussion
The results of 30-year monitoring showed that during the indicated period significant changes occurred in the soil, although their nature was not identical in all the points of the experiment. Soil pH had very noticeable changes (table 1).
Table 1. Dynamics of soil acidity depending on different fertilizer systems.

| Fertilizer system | pH | 1st point | 2nd point | 3rd point |
|-------------------|----|-----------|-----------|-----------|
|                  |    | 1989      | 2019      | 1990      |
| 0NPK             | 5.38 | 3.71      | 4.37      | 3.82      | 4.34 | 3.76 |
| 1NK              | 5.32 | 4.27      | 4.30      | 3.88      | 4.33 | 3.61 |
| 3NPK             | 5.19 | 3.94      | 4.14      | 3.71      | 4.55 | 3.96 |
| 1NPK             | 4.83 | 4.13      | 4.26      | 3.88      | 4.50 | 3.78 |
| 2NPK             | 4.71 | 3.88      | 4.16      | 3.82      | 4.42 | 3.65 |
| 3NPK             | 5.26 | 3.63      | 4.04      | 3.68      | 4.66 | 4.03 |
| 100 t\ha^{-1} PMC (aftereffect)+2NPK | 4.91 | 3.81 | 4.18 | 3.72 | 4.49 | 4.00 |
| 200 t\ha^{-1} PMC (aftereffect)+2NPK | 4.98 | 3.86 | 4.14 | 3.72 | 4.54 | 4.02 |
| 400 t\ha^{-1} PMC | 4.91 | 4.31 | 4.62 | 3.53 | 4.68 | 3.60 |

The maximum decrease in pH (by 0.60-1.67 units, depending on the system) occurred in the soil of the 1st experiment point, characterized by the best initial level of fertility. Indicators of soil pH in the 2nd and 3rd points, corresponding to the very acidic category, had smaller changes: -0.34, -0.77. The pH dynamics corresponded to a change in the values of hydrolytic acidity, exchange aluminium, and the number of absorbed bases: the parameters of the first two increased (aluminium was especially activated), the third, on the contrary, decreased (table 2).

The peculiarity of the soil reaction to a lime application (2005-2007) after a long break (1989-1991) was that there was a very rapid decrease in the effect of the ameliorant: in the 1st year of aftereffect a decrease in pH by 0.7-0.8 units was noted in the soil of the 2nd and 3rd points and by 0.4 - in the 1st. Probably, this can be explained by several reasons, including the unsaturation of the soil complex, the fulness of humus, the presence in the soil of a significant amount of exchangeable aluminium, manganese, and iron [10].

Repeated lime treatment combined with the introduction of organic matter, for 5 years ensured the preservation of soil acidity in most of the options at the level of slightly acidic and even close to neutral. In 2016, observations showed that the aftereffect of this complex began to weaken, although favourable conditions with a pH of more than 5.0 remained in the soil of a significant part of the options.

By 2019, the manifestation of the active aftereffect of lime-organic complexes on the physicochemical properties of the soil was almost completed, however, in cases with the combined use of lime and organic fertilizer (manure), the acidity and the properties changing in parallel with it corresponded to a slightly better level of soil conditions compared to indicators of ordinary backgrounds.

Table 2. The effect of re-liming and organo-lime complex on changes in soil acidity, the content of absorbed bases and exchange aluminium (8th year of aftereffect).

| Fertilizer system (aftereffect) | Hydrolytic acidity | The number of absorbed bases | Al$^{3+}$ |
|--------------------------------|--------------------|----------------------------|----------|
|                                | nmole per 100 g of soil | mg per 100 g of soil | background | Ca+H | ordinary | Ca+H | ordinary | Ca+H | ordinary | Ca+H | ordinary |
| 0NPK                           | 14.0               | 7.6                        | 7.3       | 14.0  | 23.1     | 2.0 |
| 1NPK                           | 13.9               | 12.9                       | 8.2       | 15.8  | 23.4     | 6.7 |
| 2NPK                           | 16.7               | 19.7                       | 5.8       | 8.7   | 39.7     | 17.2 |
| 3NPK                           | 10.6               | 5.1                        | 11.5      | 22.7  | 9.0      | 0.7 |
| 100 t\ha^{-1} PMC (aftereffect) + 20 t\ha^{-1} H** | 15.3 | 13.8 | 7.3 | 7.8 | 32.8 | 27.4 |

The peculiarity of the soil reaction to a lime application (2005-2007) after a long break (1989-1991) was that there was a very rapid decrease in the effect of the ameliorant: in the 1st year of aftereffect a decrease in pH by 0.7-0.8 units was noted in the soil of the 2nd and 3rd points and by 0.4 - in the 1st. Probably, this can be explained by several reasons, including the unsaturation of the soil complex, the fulness of humus, the presence in the soil of a significant amount of exchangeable aluminium, manganese, and iron [10].

Repeated lime treatment combined with the introduction of organic matter, for 5 years ensured the preservation of soil acidity in most of the options at the level of slightly acidic and even close to neutral. In 2016, observations showed that the aftereffect of this complex began to weaken, although favourable conditions with a pH of more than 5.0 remained in the soil of a significant part of the options.

By 2019, the manifestation of the active aftereffect of lime-organic complexes on the physicochemical properties of the soil was almost completed, however, in cases with the combined use of lime and organic fertilizer (manure), the acidity and the properties changing in parallel with it corresponded to a slightly better level of soil conditions compared to indicators of ordinary backgrounds.
The results of changes in the content of the main elements of plant nutrition in the soil when using different-intensity fertilizer systems are shown in table 3.

Table 3. The dynamics of the basic elements of plant nutrition in the soil, depending on different fertilizer systems over 30 years, mg / kg.

| Fertilizer                        | 1st point | 2nd point | 3rd point |
|-----------------------------------|-----------|-----------|-----------|
|                                   | 1989      | 2019      | 1990      | 2019      | 1991      | 2019      |
|                                  | N-NO₃ + N-NH₄ |          |           |           |           |           |
| 0NPK                              |           |           |           |           |           |           |
| 1NK                               | 96.3      | 6.2       | 46.7      | 7.4       | 61.9      | 9.4       |
| 3NK                               | 46.4      | 5.9       | 49.5      | 6.6       | 32.0      | 6.2       |
| 1NPK                              | 61.3      | 4.8       | 36.3      | 6.1       | 41.0      | 5.2       |
| 3NPK                              | 48.6      | 7.7       | 51.8      | 10.6      | 63.6      | 7.0       |
| 2NPK                              | 71.6      | 6.1       | 70.3      | 6.2       | 41.9      | 6.8       |
| 3NPK                              | 83.4      | 9.2       | 64.8      | 6.2       | 42.0      | 7.2       |
| 100 t ha⁻¹ PMC (aftereffect) + 2NPK | 92.1      | 8.8       | 66.3      | 12.6      | 45.6      | 7.8       |
| 200 t ha⁻¹ PMC (aftereffect) + 2NPK | 93.3      | 11.2      | 76.4      | 16.5      | 58.4      | 6.8       |
| 400 t ha⁻¹ PMC (aftereffect)      | 34.4      | 5.4       | 67.3      | 13.4      | 41.8      | 7.4       |
|                                  | P₂O₅      |           |           |           |           |           |
| 0NPK                              |           |           |           |           |           |           |
| 1NK                               | 664.0     | 374.0     | 383.0     | 179.0     | 290.0     | 224.0     |
| 3NK                               | 620.0     | 356.0     | 300.0     | 241.0     | 306.0     | 276.0     |
| 1NPK                              | 610.0     | 348.0     | 352.0     | 276.0     | 308.0     | 234.0     |
| 3NPK                              | 638.0     | 606.0     | 316.0     | 264.0     | 310.0     | 270.0     |
| 2NPK                              | 528.0     | 641.0     | 286.0     | 303.0     | 323.0     | 250.0     |
| 3NPK                              | 639.0     | 633.0     | 360.0     | 357.0     | 351.0     | 351.0     |
| 100 t ha⁻¹ PMC (aftereffect) + 2NPK | 591.0     | 533.0     | 319.0     | 314.0     | 461.0     | 328.0     |
| 200 t ha⁻¹ PMC (aftereffect) + 2NPK | 660.0     | 615.0     | 298.0     | 284.0     | 381.0     | 324.0     |
| 400 t ha⁻¹ PMC (aftereffect)      | 637.0     | 491.0     | 342.0     | 224.0     | 297.0     | 181.0     |
|                                  | K₂O       |           |           |           |           |           |
| 0NPK                              | 124.0     | 74.0      | 140.0     | 68.0      | 137.0     | 98.0      |
Observations showed that, regardless of the use of different fertilizer systems, the production process of crop rotation during the 2nd and 3rd rotations proceeded under conditions of a significant nitrogen deficiency.

A very high supply of soil with mobile forms of phosphorus was maintained throughout the entire period of research. The largest soil losses of this element during three rotation of the crop rotation (at the 30th year of observations) occurred in the control version (0NPK) and the variants using phosphorus-free fertilizer systems. The removal of phosphorus is small and therefore the introduction of a large amount of it in the composition of multicomponent fertilizers leads to unproductive use and excessive accumulation in the soil. However, based on the data in table 3, despite the significant content of phosphorus in the soil, its inclusion in the composition of the fertilizer (1-3 NPK) brought an obvious positive effect.

The soil at the experimental points on the station had different content of exchange potassium and its changes. The most significant in the process of preserving and increasing the amount of potassium (by 18-60 kg/ha) was the effect of 3NK in the 1st and 2nd tabs; in the 3rd, this trend was disrupted.

In general, an analysis of the action of various fertilizer systems indicated an obvious decrease in the availability of soil with the basic elements of plant nutrition. Probable reasons include, first of all, the cessation of the intake of the required volumes of organic and the use, judging by the result, of insufficient doses of mineral fertilizers, the absence of top-dressing of perennial herbs for several years.

The results obtained allowed us to evaluate different quantitative variants of fertilizers and come to the conclusion that their moderate and even high doses do not always bring the desired stability effect.

The use of doses of mineral fertilizers with a nitrogen content of 30-60-90 and potassium 108 kg/ha active substance for the main crop rotation caused a stable decompensation balance of the named nutrients.

According to microbiological observations, the fertilizer system, which included a complex of 200 t / ha TNK (effect and aftereffect) + 2NPK, is most favourable for humus conservation. This background caused
an increase in the number of pedotrophic microflora in the soil, indicating an increase in the number of labile forms of organic matter involved in the synthesis of humus (table 4).

**Table 4.** The effect of the lime application of meadow-sod soil on the abundance and ratio of the main and trophic groups of microorganisms (a thousand per 1g of soil).

| Soil Agar Total (Pedotrophs) | Soil Agar Total (Pedotrophs) |
|------------------------------|------------------------------|
|                              |                              |
| Pedotrophic coefficient      | Pedotrophic coefficient      |
| Mineralization coefficient   | Mineralization coefficient   |
| Oligonitrophilous coefficient| Oligonitrophilous coefficient|
| Actinomycetes                | Actinomycetes                |
| Starch-and-ammonia agar      | Starch-and-ammonia agar      |
| Meat-and-peptone agar bacteria | Meat-and-peptone agar bacteria |
|                              |                              |
| 0NPK                         | 8601                         |
| + Ca                         | 4572                         |
| 1NPK                         | 4113                         |
| + Ca                         | 3050                         |
| 3NPK                         | 2200                         |
| + Ca                         | 3811                         |
| 100 t·ha⁻¹ PMC (aftereffect) | 7371                         |
| +20 t·ha⁻¹ H                 | 2750                         |
| 200 t·ha⁻¹ PMC (aftereffect) | 1300                         |
| +40 t·ha⁻¹ H + Ca            | 6900                         |
| 100 t·ha⁻¹ PMC (aftereffect) | 7672                         |
| +40 t·ha⁻¹ H + Ca            | 4752                         |
| 200 t·ha⁻¹ PMC (aftereffect) | 7420                         |
| +40 t·ha⁻¹ H + Ca            | 4020                         |
| 100 t·ha⁻¹ PMC (aftereffect) | 5145                         |
| +1NPK + 20 t·ha⁻¹ H + Ca     | 3050                         |
| 200 t·ha⁻¹ PMC (aftereffect) | 6240                         |
| +1NPK + 40 t·ha⁻¹ H + Ca     | 3950                         |
| 100 t·ha⁻¹ PMC (aftereffect) | 7810                         |
| +2NPK + 20 t·ha⁻¹ H + Ca     | 4860                         |
| 200 t·ha⁻¹ PMC (aftereffect) | 6200                         |
| +2NPK + 40 t·ha⁻¹ H + Ca     | 5125                         |

The introduction of 100 t / ha of TNC during the laying of the hospital led to the activation of microbial cenosis, mobility of organic matter, but less accumulation of humus in the soil with low fertility potential. An increase in the humus content with the above fertilizer system was noted only in highly fertile soil (+0.55% in the 1st point).

In the process of rotation of grass-cultivating crop rotation in the soil, there was a nitrogen deficit, which indicates a qualitative change in the composition of humus. A significant level of mineralization of organic matter is indicated by the depletion of the species composition of indicator spore bacteria. The diversity in the composition of cellulose-destroying microorganisms has been lost: vibrios, some species of myxobacteria and fungi have disappeared. Less diversity is noted in the composition of actinomycetes. It indicates the uniformity of the plant matter entering the soil, a decrease in the qualitative composition of the material from which the organic matter of the soil is synthesized.

Over the years, under the influence of different fertilizer systems, the ratios of ecological and trophic groups of microorganisms in the meadow-sod soil of the station have changed (figures 1 a-c).
Figure 1. The ratio of ecological and trophic groups of microorganisms: a - before experiment establishment (1989); b - after the use of mineral fertilizers (2019); c - after the use of organic and mineral fertilizers (2019).

Strengthening mineralization processes is confirmed by mineralization coefficients. Their highest intensity was observed in the soil with the aftereffect of a triple dose of NPK.

The use of ameliorant led to an increase in the number of ammonifying bacteria, microorganisms that assimilate the mineral forms of nitrogen, provoked the activity of nitrifying agents, oligonitrophils, denitrifying agents, which led to a significant loss of nitrogen by the soil. Increased biological activity contributed to the rapid mineralization of fresh organic matter entering the soil with plant debris. A consequence of the further action of lime was a sharp decrease in the diversity of micromycetes, non-spore forms of microorganisms, oligonitrophils.

The cellulolytic activity of microorganisms is reduced due to a lack of free nitrogen (table 5).

Favourable changes in the composition of soil microflora were observed with the combined application of organic and mineral fertilizers.
Table 5. The influence of the fertilizer system, lime application on the number of cellulose-destroying microorganisms and the rate of destruction of fibre.

|                      | 2005                          | 2019                          |
|----------------------|-------------------------------|-------------------------------|
|                      | Total number of microorganisms | Total number of microorganisms | Fibre breakdown rate, % | Fibre breakdown rate, % |
| 0NPK                 | 52.9                          | 35.6                          | 10-15                    | 5-10                      |
| 0NPK + Ca            | 51.3                          | 42.5                          | 15-20                    | 10-15                     |
| 1NPK                 | 44.9                          | 24.3                          | 10-20                    | 10-15                     |
| 1NPK + Ca            | 46.1                          | 20.1                          | 20-25                    | 5-10                      |
| 3NPK                 | 39.8                          | 35.8                          | 25-30                    | 15-20                     |
| 3NPK + Ca            | 42.6                          | 38.7                          | 25-30                    | 10-15                     |
| 100 t ha\(^{-1}\) PMC (aftereffect) + 20 t ha\(^{-1}\) Н | 46.6                          | 36.6                          | 10-15                    | 10-20                     |
| 100 t ha\(^{-1}\) PMC (aftereffect) + 20 t ha\(^{-1}\) Н + Ca | 48.6                          | 26.7                          | 20-25                    | 15-20                     |
| 200 t ha\(^{-1}\) PMC (aftereffect) + 40 t ha\(^{-1}\) Н | 56.1                          | 32.9                          | 25-35                    | 20-25                     |
| 200 t ha\(^{-1}\) PMC (aftereffect) + 40 t ha\(^{-1}\) Н + Ca | 59.7                          | 35.8                          | 30-35                    | 15-20                     |
| 100 t ha\(^{-1}\) PMC (aftereffect) + 1NPK + 20 t ha\(^{-1}\) H + Ca | 56.2                          | 20.1                          | 10-15                    | 10-15                     |
| 200 t ha\(^{-1}\) PMC (aftereffect) + 1NPK + 40 t ha\(^{-1}\) H + Ca | 57.3                          | 28.3                          | 15-20                    | 15-20                     |
| 100 t ha\(^{-1}\) PMC (aftereffect) + 2NPK + 20 t ha\(^{-1}\) H + Ca | 81.0                          | 45.8                          | 80                      | 40-50                     |
| 200 t ha\(^{-1}\) PMC (aftereffect) + 2NPK + 40 t ha\(^{-1}\) H + Ca | 86.3                          | 55.5                          | 90-100                   | 40-45                     |

The aftereffect of this complex caused a similarity in the qualitative composition of spore-bearing microflora with the composition of bacilli at the beginning of the laying of the stationary experiment: the total number of spore-forming bacteria increased by 1.5 times, especially Bac. Subtilis; bacilli of the genus Bac. megatherium appeared.

The spore forms of the main 5 species of bacilli are Bac. cerius, Bac. micoides, Bac. virgulus, Bac. subtilis, Bac. megatherium in the composition of ammonifying bacteria occupied 10-30%. A large proportion of spore-forming bacteria among the soil micro population is characteristic of well-cultivated soils and indicates intensive mineralization processes. The greatest diversity in the composition of the bacilli was observed with the combined application of ameliorant, organic matter (20 and 40 t / ha N), single and double doses of mineral fertilizers (in action and aftereffect) (figure 2).
9

In the variants without organic fertilizers (NPK, lime), the variety of microorganisms of agronomically valuable physiological groups was significantly smaller.

The most favourable microbiological regime with balanced processes of nitrogen and humus transformation was formed when using lime with organomineral systems of 20 and 40 t / ha of manure + 2NPK.

4. Conclusion

Thus, the results of microbiological observations and determination of the productivity of crop rotation let the most optimal fertilizer systems: 100-200 t / ha PMC (effect and long-term aftereffect) + 2 NPK (in the 1st and 2nd rotation) + 20-40 t / ha of manure + lime (in the 3rd rotation). They provided a high yield of agricultural plants, helped to preserve the most favourable properties of meadow-sod old arable soil. Due to long-term agrochemical and microbiological studies, it was possible to identify features of the action of the ameliorant, which was evaluated ambiguously. The effect of lime without organic support was found to be ineffective and short-term.

The use of doses of mineral fertilizers with a nitrogen content of 30-60-90 and potassium 108 kg per ha active substance under the main crop rotation conditions, a stable decompensation balance of the named nutrients was determined.

Figure 2. The effect of different fertilizer and liming systems on the species composition of bacilli (2019).

In the variants without organic fertilizers (NPK, lime), the variety of microorganisms of agronomically valuable physiological groups was significantly smaller.

The most favourable microbiological regime with balanced processes of nitrogen and humus transformation was formed when using lime with organomineral systems of 20 and 40 t / ha of manure + 2NPK.

4. Conclusion

Thus, the results of microbiological observations and determination of the productivity of crop rotation let the most optimal fertilizer systems: 100-200 t / ha PMC (effect and long-term aftereffect) + 2 NPK (in the 1st and 2nd rotation) + 20-40 t / ha of manure + lime (in the 3rd rotation). They provided a high yield of agricultural plants, helped to preserve the most favourable properties of meadow-sod old arable soil. Due to long-term agrochemical and microbiological studies, it was possible to identify features of the action of the ameliorant, which was evaluated ambiguously. The effect of lime without organic support was found to be ineffective and short-term.

The use of doses of mineral fertilizers with a nitrogen content of 30-60-90 and potassium 108 kg per ha active substance under the main crop rotation conditions, a stable decompensation balance of the named nutrients was determined.
Long-term stationary observations showed that a decrease in the organomineral replenishment of soil costs for the plant production process and the formation of high-level fertility leads to a tendency to lose the favourable physicochemical properties inherent in cultivated meadow-sod soil.

The results obtained allowed us to evaluate different quantitative variants of fertilizers. The conclusion is that the moderate and high doses of fertilizers not always bring the desired stability effect.

References
[1] Kirillova G B and Zhukov Yu P Soderzhanie gumusa i dostupnost’ form azota v poche v zavisimosti ot razlichnykh doz udobreniy Izvestiya of Timiryazev Agricultural Academy 2 3–9 [In Russian]
[2] Panniikov V D and Mineev V G 1977 Pochva, klimat, udobrenie i urozhay (Moscow: Kolos) [In Russian]
[3] Efremov V F 2004 Deystvie i posledeystvie sistem udobreniya v zernovom sevooborote Plodorodie 4 10–1 [In Russian]
[4] Smirnov B A and Shchukin S V 2005 The efficiency of different depth soil cultivation system in turf-podzol soils of excessive moisture Izvestiya of Timiryazev Agricultural Academy 1 34–43 [In Russian]
[5] Vaulin A V, Kovalenko A A and Varlamov V A 2010 Dynamics of available phosphorus in loamy soddy-podzolic soil at the applications of high rates of phosphoric fertilizers Plodorodie 4 28–30 [In Russian]
[6] Merzlaya G E, Devyatova T A, Ponomareva E V and Rumyantseva I V 2010 Effect of long-term application of organic and mineral fertilizers Plodorodie 4 31–2 [In Russian]
[7] Konova A M 2010 Produktivnost’ sevooborota pri kompleksnom primeneni sredstv khimizatsii Plodorodie 4 15–6 [In Russian]
[8] Merzlaya G E and Shevtsova L K 2006 Gumus i organicheskie udobreniya kak osnova plodorodiya Plodorodie 5 (32) 27–9 [In Russian]
[9] Polyakova N V, Platonycheva Yu N, Volodina E N and Narchev M A 2010 Ispol’zovanie biologicheskih parametrov dlya otsenki okul’turennosti serykh lesnykh pochv Plodorodie 4 40–1 [In Russian]
[10] Ivlev A M 1977 Osobennosti genezisa i biogeokhimiya pochv Sakhalina (Moscow: Nauka) [In Russian]
[11] Sokolov A V 1975 Agrokhimicheskie issledovaniya pochv (Moscow: Nauka) [In Russian]
[12] Arinushkina E V 1962 Rukovodstvo po khimiceskomu analizu pochv (Moscow: Izd-vo MGU) [In Russian]
[13] Tepper E Z 2004 Praktikum po mikrobiologii (Moscow) [In Russian]
[14] Dospekhov B A 1985 Metodika polevogo opyta (s osnovami statisticheskyh obrabotki rezul’tatov issledovanyi) (Moscow: Agropromizdat) [In Russian]
[15] Sokolov O A, Shmyreva N Ya and Ivashikina N V 2007 Agrokhimicheskie i ekologicheskie osnovy regulirovaniya potokov azota v agrosistemakh Aktual’nuye problemy agrokhimichesky nauki. K 75-letiyu Vserossiyskogo NIH agrokhimii im. D.N. Pryanishnikova (Moscow) 35–46 [In Russian]