Agrochemical characteristics of soils in the vicinity of the village of Mishkino, Mishkinsky district of the Republic of Bashkortostan

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Abstract. The article is devoted to the analysis of the dynamics of the content of such important elements of fertility as phosphorus and potassium and the acidity of arable soils in the vicinity of the Mishkino Mishkinsky district of the Republic of Bashkortostan is determined. The data on the content of phosphorus and potassium and the determination of acidity in the soils of the Mishkinsky district of the Republic of Bashkortostan from 1976 to 2000 were compared. Studies on the phosphorus content in the soils of the Mishkino district conducted in 1976 showed an average level of phosphorus availability. Studies conducted in 1992 showed a slight increase in the availability of phosphorus in the soil. Studies conducted in 1992 and 2000 showed a continuing trend of increasing the availability of phosphorus in the soil. Studies conducted to study the potassium content showed a fairly low potassium content in 1976. In 1992, in general, there were changes in the classes of security and in the amount of potassium content in the soil. Studies conducted in 1992 and 2000 showed a steady trend towards an increase in potassium content in the soils of the district and the presence of soils only with an increased and high potassium content. Studies on soil acidity conducted in 1976 showed that the area of arable soils is mainly represented by medium-acid and slightly acidic soils. Studies in 1992 showed an increase in soil acidity. In the following years, the farm undertook methods of agrochemical effects on soils in order to reduce acidity. Research 2015 and 2020 showed a significant decrease in the acidity of arable soils. It has been established that due to the use of methods of rational nature management of territories, the area of agricultural soils with an average and increased content of mobile phosphorus and exchangeable potassium increases, processes of neutralization of strongly acidic soils occur.

1. Introduction
Intensification of agricultural production processes requires agrochemically competent, scientifically-based application of organic and mineral fertilizers and pesticides. Farmers need to know the level of provision of the used soils with nutrients throughout the growing season, taking into account the characteristics of biological cultivated crops and varieties and their removal of nutrients. Only taking into account all these features, it is possible to preserve the fertility of the soil and achieve its increase. When planting plants, it is necessary to correctly calculate the need for different types of fertilizers, taking into account the planned harvest, determine the dosage of fertilizers and pesticides, the timing and methods of...
their application, i.e. reliably and scientifically plan out all methods of agrochemical soil maintenance and the entire system of fertilizer application.

Soil properties are a very dynamic indicator and depend on the level of agricultural culture. However, today there is a steady trend of soil deterioration. The basis of modern strategies for increasing the productivity of agroecosystems is the restoration of soil fertility. The state of the ecological environment in certain landscapes and the biosphere as a whole significantly depends on the general state of soils, which is largely determined by the attitude of a person.

The ecological state of agroecosystems under anthropogenic influence depends on the level of soil fertility and on the number of basic plant nutrition elements. The study of changes in agroecosystems in order to increase soil fertility and prevent the removal of nutrients is a very urgent task. Therefore, the study of the most important agrochemical indicators is very important.

In this work, the dynamics of the content of such important elements of fertility as phosphorus and potassium was analyzed and the acidity of arable soils in the vicinity of Mishkino Mishkinsky district of the Republic of Bashkortostan was determined.

2. Methods

Mishkinsky district is located in the northern forest-steppe zone of the Republic of Bashkortostan. The total area of Mishkinsky district is 168,900 ha.

The specificity of the structures of the soil cover is associated with the peculiarities of natural conditions in the area where the predominant type of gray forest soils. Subtypes of gray forest soils are represented by light gray, gray and dark gray forest soils. There are also podzolized chernozems [1].

The lands of the Mishkinsky district of the Republic of Bashkortostan by structure include gray forest soils 93.3% of the total area of the district (bonitirovka, 80). Arable lands include gray soils - 43.7%, dark gray forest soils - 36.8%, podzolized chernozem - 4.6% of the total area of arable land [2].

We compared the data on the content of phosphorus and potassium and the determination of acidity in the soils of the Mishkinsky district of the Republic of Bashkortostan from 1976 to 2000.

Sampling was carried out using a planned basis for land use of a 1:25000 scale farm. Soil sampling should be carried out in accordance with GOST 17.4.4.02-84 [3].

Determination of soil acidity and phosphorus and potassium content was determined according to GOST 26261 [4], GOST R 54650-2011 [5], GOST R 58594-2019 [6].

3. Results

Phosphorus has a significant and versatile effect on the growth and development of plants. Sufficient phosphorus nutrition significantly increases the yield of many plants and improves the quality of agricultural plant products. Phosphorus is important for the normal development of the root system of plants; promotes more economical water consumption, increasing drought resistance in plants; accelerates the processes of plant maturation; increases the content of spare products in fruits and storage organs. The lack of phosphorus suppresses the processes of photosynthesis [7], reduces the productivity of plants [8].

The forms and amount of phosphorus in the soil depend on the type of soil-forming rocks, the amount of humus in the soil and the granulometric composition of the soil. In the process of mineralization of organic substances with the participation of microorganisms, orthophosphoric acid salts are released, which is soluble in water and available to plants.

The availability of phosphorus for plants depends not so much on its content as on the ability of the soil to provide plants with it, i.e. on the level of mobility of phosphorus compounds. Therefore, determining the degree of phosphorus mobility in the soil allows you to accurately predict the effectiveness of the use of phosphorus fertilizers for these soils.

We compared the data on the phosphorus content in the soils of the Mishkinsky district from 1976 to 2000. The data is shown in Figure 1.
There are 6 classes of soils in terms of phosphorus content: 1 – very low (less than 25 P205 mg/kg of soil), 2 - low (26-50 P205 mg/kg of soil), 3 - medium (51-100 P205 mg/kg of soil), 4 – elevated (101-150 P205 mg/kg of soil), 5 - high (151-250 P205 mg/kg of soil), 6 - very high (more than 250 P205 mg/kg of soil).

Studies on the phosphorus content in the soils of the Mishka district conducted in 1976 [1,2] showed that 4.8% of soils (196 ha) belonged to the 1st class of security, 50.5% (2072 ha) to the 2nd, 37.6% (1546 ha) to the 3rd, 5.3% (216 ha) to the 4th, 1.8% (76 ha) of all arable land of the farm belonged to the 5th class. There were no soils belonging to Class 6. Mobile phosphorus has an index of 89 mg/kg.

Figure 1. Phosphorus availability of the soils of the Mishkinsky district. Symbols: vertically – the area of arable land, horizontally - the years of research.

Studies conducted in 1992 [1,2] showed that 0.9% (37 ha) belonged to the 1st class of soil phosphorus availability, 9.8% (406 ha) to the 2nd class, 2804 ha (67.8%) to the 3rd, 806 ha (19.5%) to the 4th, and 2.0% (83 ha) of the farm's arable land area. Soils belonging to Class 6 were also absent. The content of mobile phosphorus according to the weighted average was 84 mg/kg.

In 2015, 35.6% (345 ha) were assigned to Class 3 in terms of the amount of mobile phosphorus, to 4 - 585 ha (60.1%), and to Class 5 40 ha (4.1%). There were no soils belonging to other classes. The content of mobile phosphorus according to the weighted average was 77 mg/kg.

In 2020, 32.9% (380 ha) were assigned to Class 3 in terms of the amount of mobile phosphorus, 4 - 721 ha (62.6%), and 51 ha (4.4%) were assigned to Class 5. There were no soils belonging to other classes. The content of mobile phosphorus according to the weighted average was 81 mg/kg.

Based on the results of the conducted studies, it can be concluded about the effectiveness of agrochemical techniques carried out by the farm, according to the availability of mobile phosphorus in soils. There is a tendency to decrease the areas of soils with very low and low phosphorus content in the soil and an increase in arable areas with medium, high and high P2O5 content.

In recent years, there has also been a slight increase in phosphorus by the weighted average.

It is necessary to replenish the phosphorus content in arable soils and increase the degree of mobility for phosphates by additional application of organic and phosphorus-containing mineral fertilizers. Full (calculated) doses for phosphorus fertilizers should be applied on arable soils with an average supply of nutrients; 80% of the norm should be applied to soils with a high phosphorus content, and 50-60% of the application rate should be applied to soils with a high phosphorus content. Such agricultural practices will allow you to maintain the level of phosphorus content in an optimal amount.

Potassium is the most important, irreplaceable element of plant nutrition. Potassium reduces the negative effect of oxidative stress caused by drought [9], has a positive effect on the regulation of
osmotic pressure, promotes the normal course of photosynthesis, increases the content of spare products in fruits and storage organs, increases the resistance of plants to pathogenic microorganisms [10]. With a lack of potassium, the development of plants and the ripening of fruits slows down.

Different agricultural crops need different amounts of potassium and, accordingly, are characterized by different amounts of this element. Therefore, the potassium content in the diet of agricultural plants deserves great attention.

We compared the data on the potassium content in the soils of the Mishka district from 1976 to 2000. The data is shown in Figure 2.

There are 6 classes of soils in terms of potassium content: 1 – very low (less than 40 K₂O mg/kg of soil), 2 - low (41-80 K₂O mg/kg of soil), 3 - medium (81-120 K₂O mg/kg of soil), 4 – elevated (121-170 K₂O mg/kg of soil), 5 - high (171-250 K₂O mg/kg of soil), 6 - very high (more than 251 K₂O mg/kg of soil).

Studies conducted in 1976 [1,2] showed that there are no soils with a very low potassium content in the farm. 226 ha (5.5%) belonged to the 2nd class of potash availability, 2904 ha (70.7%) belonged to the 3rd class, and 953 ha (23.2%) belonged to the 4th class. High potassium content was observed on 24 hectares of soils, which is only 0.6% of arable land. The weighted average indicator for the content of exchangeable potassium was 138 mg/kg.

Figure 2. Potash availability of soils of Mishkinsky district. Symbols: vertically – the area of arable land, horizontally - the year of the study.

In 1992, in general, there were changes in security classes and in the amount of potassium content in the soil. The measures carried out have made it possible to improve the condition of the soil in terms of the content of this element. The results showed that soils with a low potassium content began to be absent, the number of soils with an average content of this element decreased to 598 hectares (14.5%), the area of soils with an increased potassium content increased to 3081 hectares (74.5%), and a high potassium content was already noted on 457 hectares of soils, which was 11% of arable land. The weighted average indicator for the content of exchangeable potassium practically did not change and amounted to 139 mg/kg [1,2].

Studies in 2015 showed a steady trend towards an increase in potassium content in the soils of the district and the presence of soils only with an increased and high potassium content: 95.9% (933 hectares of arable land) were assigned to Class 4, and 4.1% (40 hectares) to class 5 soils with a high potassium content. Compared with previous agrochemical studies, the level of exchangeable potassium increased by 18 mg/kg of soil and amounted to 157 mg/kg.

Studies in 2020 confirmed the tendency to increase the potassium content in the soils of the district. The study showed the presence of soils with only high and high potassium content: 94.5% (1012 hectares of arable land) were assigned to Class 4, and 5.5% (59 hectares) to class 5 soils with high potassium content. Compared with previous agrochemical studies, the level of exchangeable potassium increased slightly to 158 mg/kg.
When applying potash fertilizers, it is necessary to take into account that the removal of potassium by agricultural plants is much higher than for other elements, therefore, an imbalance of this element is often observed in the soil.

In addition, potassium nutrition in plants decreases with liming of acidic soils, because there is a containment of a decrease in the activity of potassium ions in the soil solution and inhibition of their absorption into plants. Therefore, the application of potash fertilizers during liming of soils is especially important. To improve the saturation of the soil with potassium, organic and mineral potassium-containing fertilizers can be applied.

The full (calculated) dose of potash fertilizers must be applied on arable soils in conditions of high security - 60%; at a very high degree - 50-50% of the full norm. With a low and medium level of soil availability, the dose of potash fertilizers should be increased by 30-50%.

The growth and normal development of plants depends on the reaction of the soil solution. With an acidic reaction in the soil, biological activity decreases, because there is a weakening or complete cessation of the activity of microorganisms (a group of nitrificates, nitrogen-fixing bacteria) and earthworms. The acidity of the soil is an indicator for the processes of reproduction of soil fertility, the full use of fertilizers and increasing the yield of agricultural plants. If there is a predominance of hydrogen ions in the soil solution, then such soil is considered acidic. With an increased concentration of OH, the soil is alkaline. Both strongly acidic and strongly alkaline soils are unfavorable for plants. In such soils, plants worsen the growth and branching of the root system, therefore, the normal processes of mineral intake into the plant are disrupted, which causes significant disturbances in carbohydrate and protein metabolism and negatively affects the development of generative organs. In a highly acidic environment, processes such as nitrogen fixation, ammonification, nitrification decrease and active reproduction of pathogenic fungi is observed [11].

We compared the data on the study of soil acidity of the Mishkinsky district, from 1976 to 2000. The data is shown in Figure 3.

![Figure 3](image.png)

**Figure 3.** Acidity of the soils of the Mishkinsky district. Symbols: vertically – the area of arable land, horizontally - the year of the study.

Studies conducted in 1976 showed that the area of medium acidic arable soils with a pH of 4.6-5.0 was 9.4% (386 ha), slightly acidic (pH 5.1-5.5) - 63.8% (2619 ha), and the area of soils with a pH of 5.6-6.0 was 26.8% of the total area (1102 ha) [1,2].

Studies in 1992 [1,2] showed an increase in soil acidity. The area of very acidic soils with a pH of less than 4 was 2.6% (106 ha), strongly acidic soils (pH 4.1-4.5) were 35.7% (1,476 ha), the area of medium acidic soils (pH 4.6-5.0) increased markedly, which amounted to 10.7% (444 ha) of all arable land. The area of slightly acidic soils (pH 5.1-5.5) decreased to 51% (2110 ha) of all arable land. Thus, during this period there was an increase in acidification of arable soils.
In the following years, the farm undertook methods of agrochemical influence on the soil in order to reduce acidity, such as liming, the use of mineral fertilizers, etc. Studies in 2015 showed a significant decrease in the acidity of arable soils. The area of slightly acidic soils (pH 5.1-5.5) increased to 44.1% (429 ha), the area of soils with a pH of 5.6-6.0 was 19.1% of the total area (186 ha) and neutral soils with a pH of more than 6.1 appeared among arable soils, the area of which was 358 ha (36.8%).

Studies in 2020 have shown the preservation of the acidity of arable soils in the area. The area of slightly acidic soils (pH 5.1-5.5) was 49.9% (521 ha), the area of soils with a pH of 5.6-6.0 was 20.2% of the total area (211 ha), and the area of neutral soils with a pH of more than 6.1 was 312 ha (29.9%).

To eliminate excess acidity, one of the most common methods is liming of soils. Agrochemical analysis is necessary for more effective ways of conducting agricultural activities, maintaining a favorable ecological situation and the environment. Violations of the natural balance of agrocenoses can lead to the destruction of the humus layer, a significant removal of plant nutrition elements, and consequently to a decrease in crop yields, a violation of soil acidity and the appearance of dangerous infectious plant diseases.

Monitoring studies of arable soil in the vicinity of the village of Mishkino, Mishkinsky district, have shown an improvement in soil conditions in recent years. It has been established that due to the use of methods of rational nature management of territories, the area of agricultural soils with an average and increased content of mobile phosphorus and exchangeable potassium increases, processes of neutralization of strongly acidic soils occur.

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