Influence of the adoption of phosphogips and seros-containing fertilizers on the microbial population of south chernozem

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Abstract. The following field experiences were performed on the Chernozem southern carbonate: 1.Control, 2. Sulphoammophos – 150 kg/ha, 3. Sulphoammophos – 250 kg/ha, 4.Phosphogypsum – 3 t/ha, 5.Phosphogypsum – 6 t/ha, 6.Phosphogypsum – 12 t/ha, 7. Phosphogypsum – 3 t/ha ammophos –70 kg/ha ammonium nitrate, 100 kg/ha 8. Phosphogypsum – 6 t/ha ammophos –70 kg/ha ammonium nitrate, 100 kg/ha 9. Phosphogypsum – 12 t/ha ammophos-70 kg/ha ammonium nitrate, 100 kg/ha. 10. ammophos-70 kg/ha + ammonium nitrate 100 kg/ha. The determination of the number of microorganisms produced in the phase of milky-wax ripeness of winter wheat on the selective nutrient medium: meat-peptone agar – number of ammonifiers; on starch and ammonia agar – microorganisms that assimilate mineral forms of nitrogen on the Hutchinson medium – calculatorsreal the number of microorganisms on the Czapek-Dox medium – the number of micromycetes on the Ashby medium – the number of aerobic nitrogen-fixing bacteria of the genus Azotobacter. Introduction phosphogypsum, sulphoammophos, ammophos and ammonium nitrate contributes to the increase in the numbers of various physiological groups of microorganisms. The highest values of the studied indicators in comparison with the control was achieved through the joint application of phosphogypsum – 12 t/ha ammophos-70kg/ha and ammonium nitrate-100kg/ha: ammonifiers on 123.4 million CFU/g (or 2.5 times); nitrifiers at 138 million CFU/g (3.3 times), microscopic fungi on 90,0 thousand CFU/g (1.7 times); cellulose-fermenting microorganisms on 250.6 thousand CFU/g (more than 2 times); aerobic nitrogen-fixing bacteria of the genus Azotobacter by 30.7 thousand CFU/g (1.5 times). Thus, the most responsive to the introduction of phosphogypsum and fertilizers microorganisms that convert mineral and organic nitrogen compounds.

1 Introduction

The microbial population plays a special role in formation of soil fertility and productivity of agricultural land. They determine the rate of biological weathering of mineral bases in soils, decomposition of organic mortmass and transform unavailable forms of nutrients available to plants [1, 2]. The number of microorganisms of different physiological groups and their relationship with each other reflect the characteristics of the change in the composition of living matter in a specific period [3].

As a result of agricultural use of the soil, they are constantly depleted due to the removal of nutrients and their alienation along with the harvest [4, 5]. This also applies to mobile sulfur, which determines the quality of the yield. The chernozems of the Central Pre-Caucasus in the middle and at the end of the last century were characterized by an average and sometimes increased content of mobile sulfur [6]. Currently, the availability of soil on this nutrient is estimated as low [7, 8]. According to many scientists [9], the elimination of sulfur deficiency in the soil contributes to obtaining a higher yield of better quality.

2 Material and methods

The aim of the research is to study the effect of phosphogypsum and sulfur-containing mineral fertilizers on the number of main physiological groups of microorganisms in the southern chernozem.

The studies were conducted in the North-Western part of the Central Pre-Caucasus on the southern chernozem. The field experience was laid with the separate and combined use of phosphogypsum, sulfoammophos, ammophos and ammonium nitrate according to the following scheme: 1. Control, 2. Sulphoammophos – 150 kg/ha, 3. Sulphoammophos – 250 kg/ha, 4. Phosphogypsum – 3 t/ha, 5 Phosphogypsum – 6t/ha, 6. Phosphogypsum – 12 t/ha, 7. Phosphogypsum – 3t/ha + ammophos-70 kg/ha + ammonium nitrate-100 kg/ha, 8. Phosphogypsum – 6t/ha + ammophos-70 kg/ha + ammonium nitrate-100kg/ha, 9. Phosphogypsum – 12 t/ha + ammophos –70 kg/ha + ammonium nitrate-100 kg/ ha, 10.ammophos – 70 kg/ha + ammonium nitrate-100 kg/ha.

Soil is chernozem southern carbonate medium-thick low-humus heavy loam on loess loam. The content of

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humus in the topsoil is 3.8 %, pH – 8.3; amount of exchange bases 25.4 mg-eq/100 g; the content of mobile phosphorus and exchangeable potassium is 24.7 and 370 mg/kg, respectively; the content of mobile sulfur is 3.5 mg/kg. The experience was laid in accordance with the generally accepted methodology, the placement of options was randomized and the repetition was threefold. Culture – winter wheat varieties "Tanya". The studies were conducted in 2018.

Phosphogypsum is a product of chemical flotation of apatite concentrate. It is obtained by irrigation of apatite with sulfuric acid. The resulting phosphoric acid used for making phosphate fertilizers and gypsum goes to the dump. It contains an average of 20 – 22 % Ca, 1.4 % Of Mg; 1.4 % of P_2O_5; 20,2 % S; 0,17 – 0,20 % F; 0,1 % B; 1 % Mn; 0,01 % Cu; 0.05 % of Zn; about 0.03 % Co; 0,05 % Mo. Phosphogypsum was brought in 2 times. First half of the applied dose, then peeling to a depth of 12–14 cm, with subsequent plowing. After that a second half dose with subsequent disking was brought. Thus, the full mixing of phosphogypsum with the soil was achieved. Sulphoammophos and ammophos were brought at sowing, ammonium nitrate fertilizer – in spring. The rate of ammonium phosphate together with nitrate has been recommended for agriculture.

The determination of the number of microorganisms produced in the phase of milky-wax ripeness of winter wheat on the selective nutrient medium: meat-peptone agar – the number of ammonifiers; on starch and ammonia agar – microorganisms that assimilate mineral forms of nitrogen on the Hutchinson medium – the number of calculatorsreal microorganisms on the Czapek-Dox medium – the number of micromycetes; on the Ashby medium – the number of aerobic nitrogen-fixing bacteria of the genus Azotobacter.

3 Results and discussion

The result of the research showed that the introduction of phosphogypsum and fertilizers had an impact on the number of microorganisms of various physiological groups. So, the number of ammonifiers was lowest in the control and 78.8 million CFU/g (Figure 1–2).

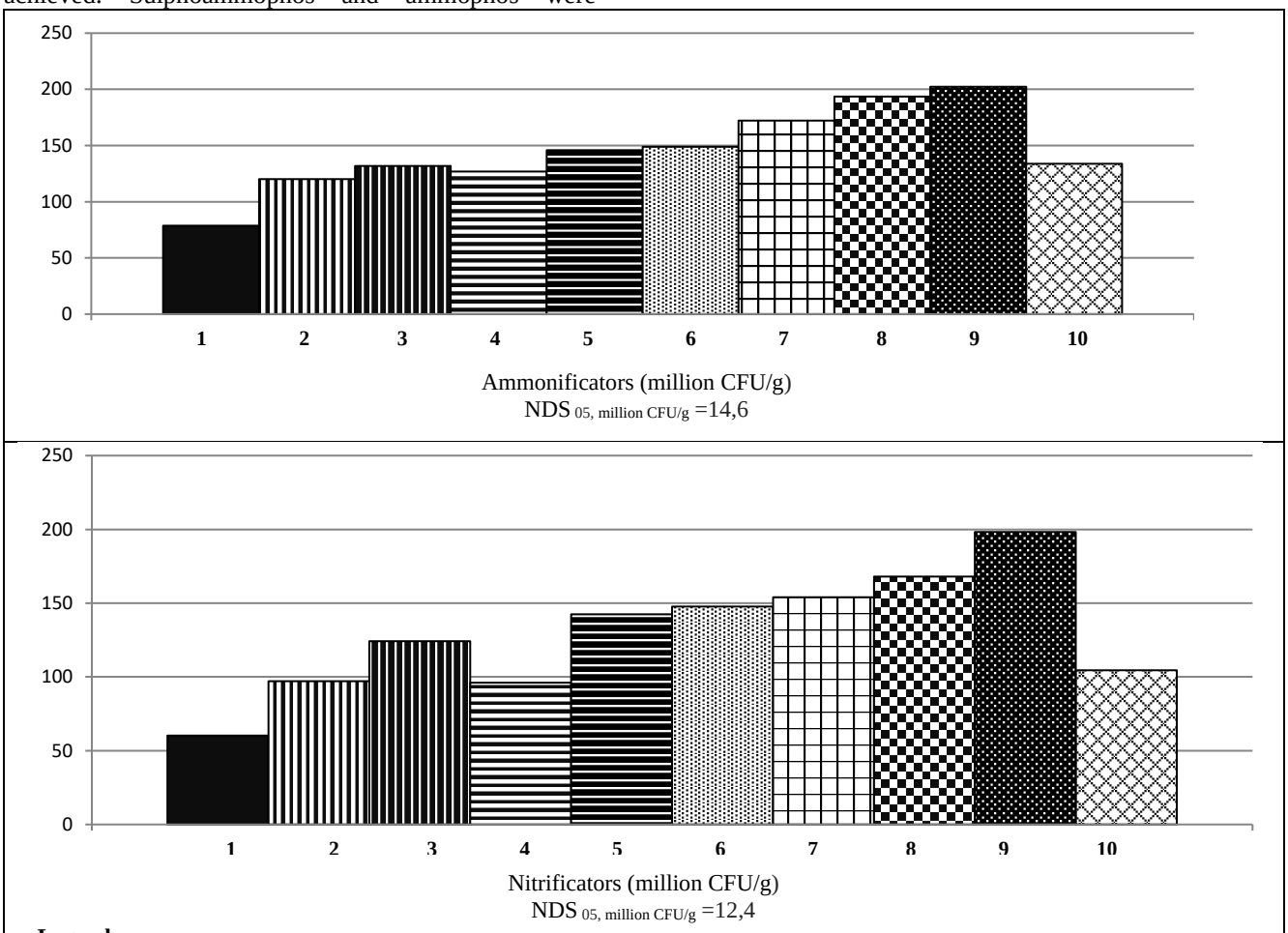
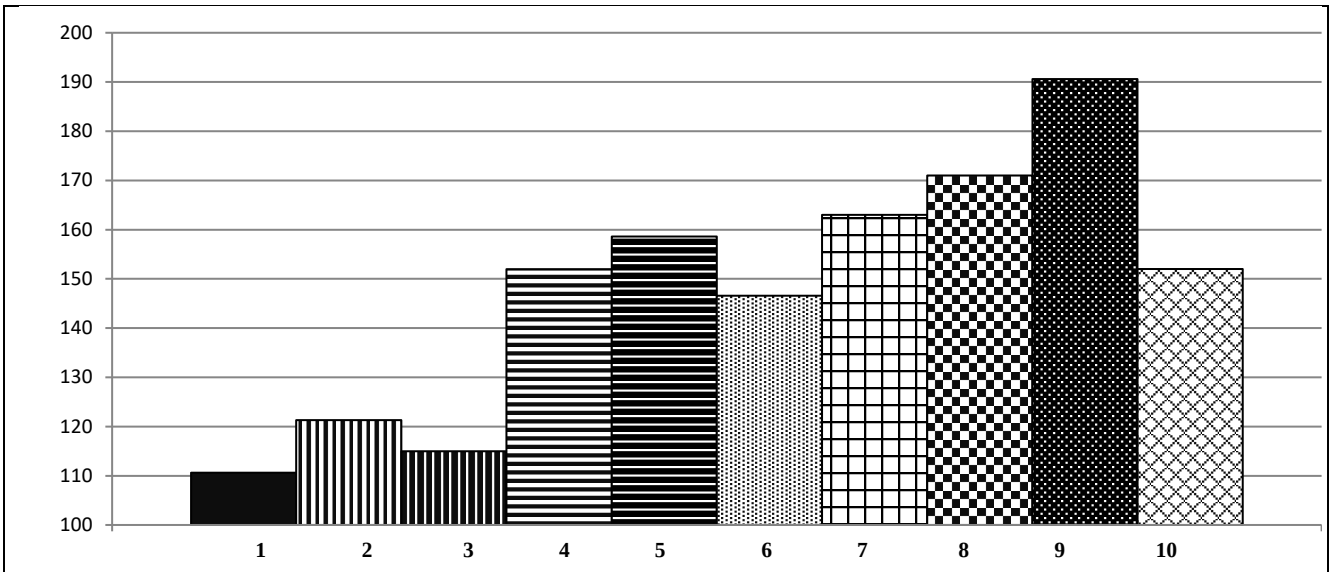
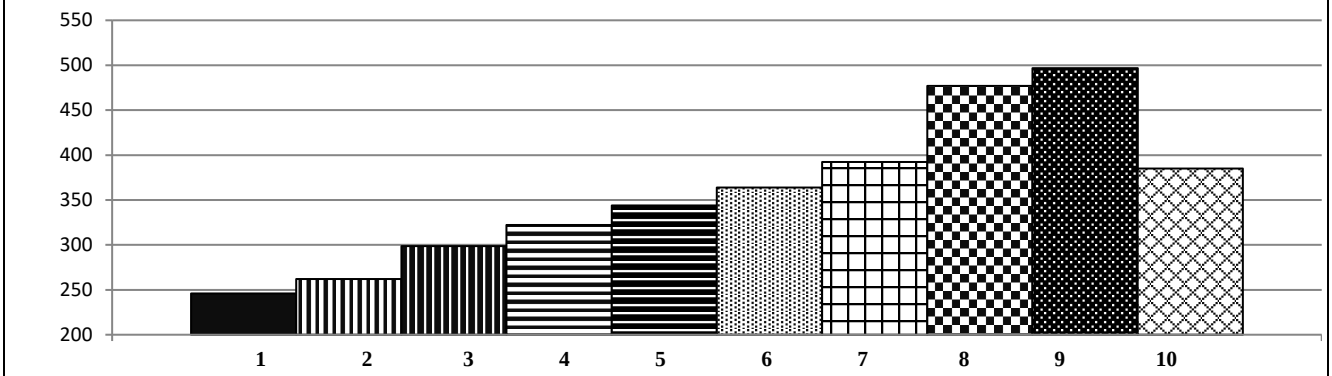


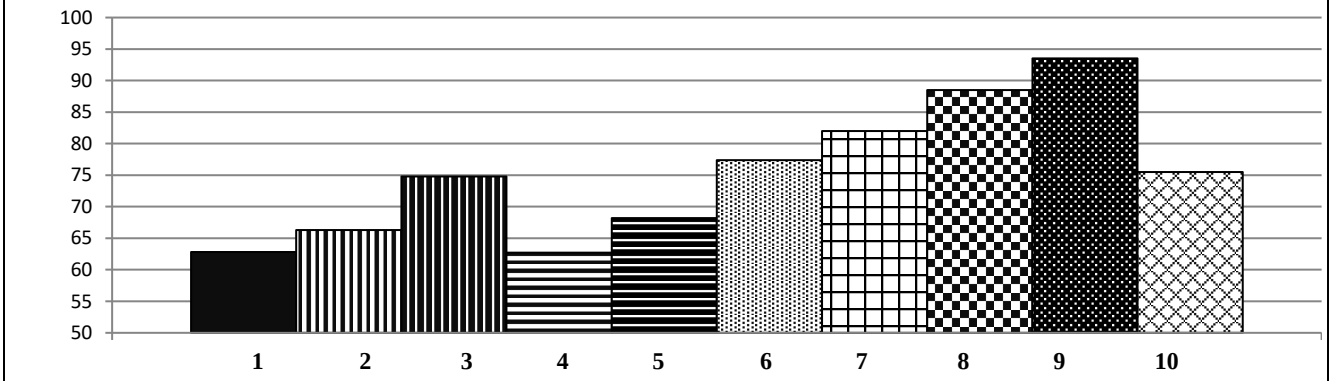
Fig. 1. Number of ammonifiers and nitrifiers by variants of experience



Microscopic mushrooms (thousand. CFU/g)
NDS $_{05,\ \text{thousand. CFU/g}}$ =15,6
LSD =12,4 million CFU/1 g



Cellulose destructive microorganisms (thousand. CFU/g)
NDS $_{05,\ \text{thousand CFU/g}}$ =20,3



Aerobic nitrogen fixers (million CFU/g)
NDS $_{05,\ \text{million CFU/g}}$ =13,7

Legend
1. Control; 2. Sulphoammophos – 150 kg /ha; 3. Sulphoammophos – 250 kg /ha; 4. Phosphogypsum – 3 t /ha; 5 Phosphogypsum – 6 t /ha; 6. Phosphogypsum – 12 t/ha; 7. Phosphogypsum – 3 t/ha + ammophos-70 kg/ha + ammonium nitrate-100 kg/ha; 8. Phosphogypsum – 6 t/ha + ammophos – 70 kg/ha + ammonium nitrate-100 kg/ha; 9. Phosphogypsum – 12 t/ha + ammophos – 70 kg/ha + ammonium nitrate – 100 kg/ha; 10. Ammophos – 70 kg/ha + ammonium nitrate – 100 kg/ha

Fig. 2. Number of microscopic fungi, cellulose-destroying microorganisms and aerobic nitrogen fixators according to the variants of the experiment

The use of sulphoammophos at a dose of 150 and 250 kg/ha increased the studied indicator by 41.3 and 53.0 million CFU/g, respectively. The application of phosphogypsum led to similar result with little difference between the different doses.

The largest increase in the number of microorganisms that use organic forms of nitrogen noted in the mixed introduction of phosphogypsum with mineral fertilizers. The number of ammonifiers increased by 93.4 million CFU/g with the introduction of phosphogypsum – 3t/ha ammophos-70 kg/ha and ammonium nitrate- 100 kg/ha. the highest values of the studied indicator was achieved as a result of the application of phosphogypsum – 12 t/ha ammophos – 70 kg/ha and ammonium nitrate 100 kg/ha. Increase compared to control was is 123.4 million CFU/g (or 2.5 times). A similar result, but with slightly smaller values was obtained in the variant with application of phosphogypsum – 6 t/ha ammophos – 70 kg/ha and ammonium nitrate-100 kg/ha. In the variant with application of monoammonium phosphate and ammonium nitrate the effect was at the level of the sulphoammophos.

Nitrifiers are in close metabolic relationship with ammonification. The wastes of the first provide food for the second. For this reason, changes in the number of microorganisms that convert mineral forms of nitrogen in variants of the experiment, similar changes in the number of microbiota that converts organic forms of nitrogen. The only difference is that the number of nitrifiers is slightly lower than ammonifiers.

Figure 2 shows the number of microorganisms under winter wheat depending on application of phosphogypsum and fertilizers.

When taking into account the number of fungi microflora, it was established that it was the smallest at the control and amounted to 110.6 th. CFU /g.

The use of sulfoammophos led to a slight increase in the quantity under study, which was within the limits of experimental error.

The introduction of phosphogypsum significantly increased the studied indicator (by 36-48 thousand CFU/g) with a slight difference between the doses used. With the joint introduction of phosphogypsum with mineral fertilizers, the number of microscopic fungi tends to increase with a reliable difference with the control and an insignificant difference between them. The highest indices of the number of introduction of phosphogypsum and mineral fertilizers.

In the study group were 179.6 thousand. CFU/g, achieved as a result of using phosphogypsum – 12 t/ha, ammophos – 70 kg/ha and ammonium nitrate – 100 kg/ha. The difference with the control was 90.0 thousand CFU/g or 1.7 times.

On the application of ammophos and ammonium nitrate, the number of fungi is reduced compared to the maximum figures by 27.6 thousand. IUE/g and is 152.0 thousand IEE/g. Consequently, the use of phosphogypsum has a primary effect on the number of this group of microorganisms. Similar values were obtained for the variant with the use of phosphogypsum at a dose of 3 tons/ha.

Among cellulose-fermenting microorganisms, quantitative changes are similar to fungi, but with some peculiarities. There is also the smallest number of microorganisms in control (246.0 thousand CFU/g). When making sulfoammophos in a dose of 150 kg/ha, there was an insignificant increase in the studied parameter. With the introduction of this fertilizer in a dose of 250 kg/ha, the number of cellulite increased to 298.6 thousand CFU/g, which is higher than the control by 52.6 thousand CFU/g.

As a result of the use of phosphogypsum in doses of 3, 6 and 12 t/ha, the number of microorganisms in comparison with the control increased by 76.2; 98 and 118 thousand CFU/g, respectively. In our opinion, this may occur due to an increase of the sulfur content in the soil. This group of microorganisms creates mainly sulfur-containing proteins.

The combined use of phosphogypsum with mineral fertilizers leads to an even greater increase in the number of cellulose-fermenting microorganisms. The largest amount was recorded on the variant with the use of phosphogypsum – 12 t/ha, ammophos-70 kg/ha and ammonium nitrate-100 kg/ha. Compared to the control, the studied indicator was increased by 250.6 thousand, more than 2 times. Therefore, the optimization of nitrogen, phosphorus nutrition and the content of mobile sulfur most favorably affect the population of this group of microorganisms.

In the number of aerobic nitrogen fixers of the genus Azotobacter, the picture is a little different. Significant changes in the number of options for the experience are not observed. The use of sulfoammophos in various doses and phosphogypsum at a dose of 3 and 6 t/ha did not lead to a significant increase in the number of nitrogen fixers and was within the limits of experimental error. Only the introduction of phosphogypsum at a dose of 12 t/ha had a significant impact on the studied indicator, although it was insignificant. The increase compared to the control was 14.6 thousand CFU/g at NDS 13.7 thousand CFU/g.

The combined use of phosphogypsum and mineral fertilizers leads to a more significant increase in the number of aerobic nitrogen-fixers. Nevertheless, the maximum values of the indicator on the 9 th variant of 93.5 thousand CFU/g surpass the control only 1.5 times. For a population of soil microorganisms, this difference is not considered significant.

When applying ammophos and ammonium nitrate, the amount of this physiological group of microorganisms is reduced compared to the option of mixed application of phosphogypsum and fertilizers to a value close to unreliable from a mathematical point of view. Therefore, Azotobacter reacts poorly to fertilization, and especially nitrogen. This is evidenced in the results of research by many scientists [10].

4 Conclusion

Thus, the introduction of phosphogypsum, sulphoammophos, ammophos and ammonium nitrate contributes to the increase in the numbers of various

physiological groups of microorganisms. The highest values of the studied indicators in comparison with the control was achieved through the mixed application of phosphogypsum – 12 t/ha, ammophos-70 kg/ha and ammonium nitrate-100 kg/ha: ammonifiers on is 123.4 million CFU/g (or 2.5 times); nitrifiers on 138 million CFU/g (3.3 times), microscopic fungi on 90,0 thousand CFU/g (1.7 times); cellulose-fermentingmicroorganisms on of 250.6 thousand CFU/g (more than 2 times); aerobic nitrogen-fixing bacteria of the genus Azotobacter by 30.7 thousand CFU/g (1.5 times). Therefore, the microorganisms that convert mineral and organic nitrogen compounds are the most responsive to the introduction of phosphogypsum and fertilizers.

References

1. V.S. Tskhovrebov, V.I. Faizova, A.N. Mar'in, D.V. Kalugin, A.A. Novikov, *Changing Population by Aerobic Nitrogen-Fixing Bacteria in Natural and Anthropogenically Transformed Chernozems Biogeocenoses Central Ciscaucasia*, Res. J. of Pharmaceut., Biolog. and Chem. Sci., **7(4)**, 2178 (2016)
2. O.I. Vlasova, V.M. Perederieva, I.A. Volters, A.I. Tivikov, L.V. Trubacheva, *Change in microbiological activity under the effect of biological factors of soil fertility in the central forecaucasus chernozems,* Biol. and Med., **7(5)**, 146–150 (2015)
3. V.S. Tskhovrebov, V.I. Faizova, A.N. Mar'in, A.A. Novikov, A.M. Nikiforova, *Changing In Ammonifiers of Virgin Land and Black-Earth Ploughland to Central Ciscaucasia*, Res. J. of Pharmaceut., Biolog. and Chem. Sci., **7(4)**, 2174 (2016)
4. S.A. Emelyanov, Y.A. Mandra, O.Y. Gudiev, L.V. Maznitsyna, S.A. Korostylev, *Effects of Anthropogenic Environmental and Food Safety*, Res. J. of Pharmaceut., Biolog. and Chem. Sci., **7(3)**, 2562–2569 (2016)
5. S.I. Kolesnikov, A.A. Kuzina, K.Sh. Kazeev, T.V. Denisova, Yu.S. Kozun, Yu.V. Akimenko, *The Influence of Soil Contamination of The Black Sea Coast of The Caucasus By Heavy Metals and Oil on The Abundance of Azotobacter Genus Bacteria*, Res. J. of Pharmaceut., Biolog. and Chem.l Sci., **7(6)**, 718–724 (2016)
6. T.D. Hooker, J.E. Compton, *Forest ecosystem carbon and nitrogen accumulation during the first century after agricultural abandonment*, Ecol. Appi, **13**, 299–313 (2003)
7. A.N. Esaulko, M.S. Sigida, E.A. Salenko, S.A. Korostylev, E.V. Golosnoy, *Agrochemical Principles of Targetting Winter Wheat Yield on Leached Chernozem of the Stavropol Elevation*, Biosci. Biotechnol. Res. Asia, **12(1)**, 301–309 (April 2015)
8. P.V. Prudnikov, *Use of local agroores for liming and fertilization of soils of the Bryansk region*, Fertility, **5**, 25 (2007)
9. A.S. Yakovlev, M.A. Kanaikin, V.A. Terekhova, *Environmental assessment of soil exposed to phosphogypsum*, Soil science, **6**, 737 (2013)