THE NEUTRALIZED PHOSPHOGYPSUM AS GYPSUM-CONTAINING MELIORANT RUSSIAN CASE-STUDY

УДК 631:631.9:631.95

DOI:10.24411/2588-0209-2019-10048

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Summary

Phosphogypsum is not only a valuable meliorant for saline soils, it is also a multicomponent fertilizer that improves the soil structure and physical properties. Long-term research allowed to prove agronomical and economical efficiency of phosphogypsum application, to develop regulations for its application in agriculture. As the greatest result of all research work phosphogipsum was included to the Goverment subsidy program as gypsum-containing meliorants.

Keywords: phosphogypsum, soil fertility, high-alkaline soil, nitrogen, phosphorus, potassium, fertilizers, soil structure, gypsum-containing meliorants

Phosphogypsum has great potential for use in agriculture. Regular phosphogypsum is characterized by an excessive acidity, but at the mineral fertilizer production enterprise «EuroChem-BMU», Krasnodar Region, neutralized phosphogypsum is manufactured with slightly alkaline medium reaction. The product is formed during processing of domestic apatites which are low in heavy and radioactive metals. It is characterized by a high safety and does not cake.

The neutralized phosphogypsum contains 92% CaSO4 and is used for chemical reclamation of saline lands to improve their physical, chemical and water-air soil properties.

Phosphogypsum is not only an ameliorant, but it is also a source of plant nutrients, as one ton contains 25-30 kg of phosphorus (P_2O_5), 200 kg of sulfur (SO_4^{2-}), 370 kg of calcium (CaO) and trace elements[1,2]. The use of phosphogypsum in agriculture can solve quite a range of problems: improving soil fertility and plant productivity, rational use of natural resources and waste management. Currently in Russia phosphogypsum is commonly stored in dumpings near enterprises as a byproduct, and it has a limited use in agriculture[3].

In Soviet times, the practice of using gypsum-containing meliorants was widespread. In the USSR in 1964, a special resolution about activities in liming acid and gypsuming alkaline soils and development of production of limestone flour and raw ground plaster" (dd 10.09.1964 No.776) was accepted, and, according to it, 50%-85% of expenses on ameliorants adding were subsidized from the state budget. This measure has led to a widespread chemical reclamation. In the late Soviet period, the volume of application of gypsum-containing ameliorants was about 1.5 million tons per year. Currently, the use of ameliorants in Russia does not exceed several thousand tons per year (Fig.1) [3,4,5].

The total area of saline lands in Russia is in the range of 35-40 million hectares or about 20 % of the farmland area. The area of saline arable land is about 10 million hectares. Thus we can see, that the necessity for melioration remains very high. The demand for phosphogypsum makes about 1.5-3 million tons per year [3].

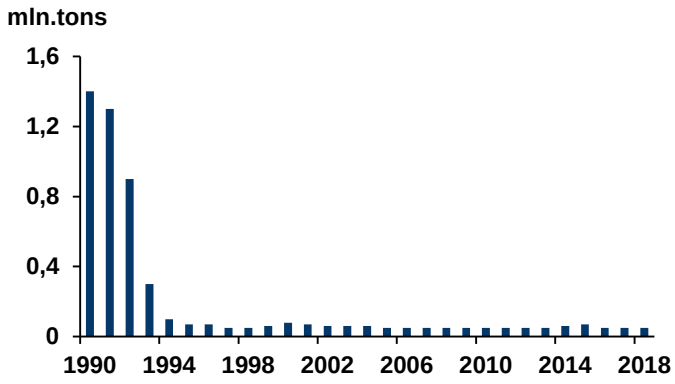

Fig.1 The dynamics of reduction of phosphogypsum fertilizer use in Russia.

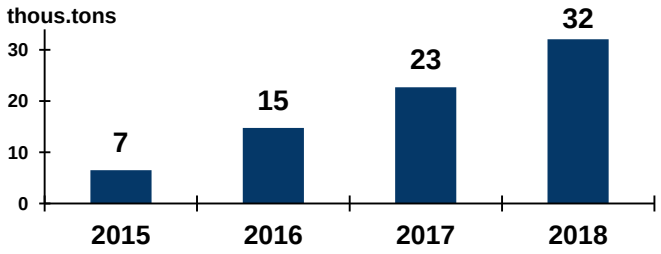

Fig.2 Volumes of of phosphogypsum sales, EuroChem-BMU

Russia produces about 14 million tons of phosphogypsum per year, of which 1 million tons is accounted for by EuroChem-BMU. Consumption of neutralized phosphogypsum produced at EuroChem-BMU remains insignificant, despite a relative sales growth (Fig.2), as EuroChem-BMU has accumulated reserves of more than 30 million tons. This situation is typical for the whole territory of the Russian Federation, and it roots deeply into economic and social transformations of the 90s.

To research the possibility of using neutralized phosphogypsum in agriculture, since 2015, EuroChem-BMU jointly with the key agricultural research institutions of Russia, has conducted a number of field experiments confirming phosphogypsum effectiveness in agricultural production. Actualy there are three effective way to apply phosphogypsum:

1. Gypsum containing soil ammeliorant for alcaline soil

Calcium (Ca^{2+}) contained in phosphogypsum displaces sodium (Na^{+}) from the soil absorbing complex, which in the form of sulfate salts is washed out of the soil [6,8].

2. Ammeliorante to increase physicle characteristic of irrigated land

The phosphogipsum improves soil structure, increases its water-holding capacity, promotes the formation of soil aggregates and improves water-air soil regime[9].

3. Nutrients containing (P, S) ammeliorant for poor or bad structured soils.

The phosphogipsum contains P – 4-6%, but as well it is sulfur contain product, content of S - 21-22%. This element is extrimely nesessery for cereal and oil produse crop due to its high effect on quality characterestics and yield [4,6,7].

The experiments have shown high efficiency of phosphogypsum application for each of these methods.

Nutrients sourse and ammeliorant for irrigated soils. Krasnodar Region is the main agricultural regin in Russia, more than 80% of rice is groing here. It is well known that rice growing system is very specific because of periodical fludding. One of the biggest problem for this fields type is deterioration of soil structure (crust formation, soil compaction) In 2015, the Company held a demonstration field trial with the purpose of evaluating effective dosages and application period for phosphogypsum neutralized in rice growing sustem. The phosphpgypsun was applied as P sourse and soil ammeliorante. The dominated soil type was chernozem leached (pH – 7,4, humus content – 2,5%). The most effective option was autumn treatment at the rate of 4 t/ha (Fig.3), which increased the productivity by 5 kg/ha (or 6%). In this case we have even higher effectivnese than in traditional fertilization system with conventional P-contain fertilizer (typically MAP 12-52). The phosphogypsum (in figure below – "PG") had an impact in increasing yield of subsequent crops – alfalfa by 47% in spring and by 76% in autumn after fertilizer treatment.

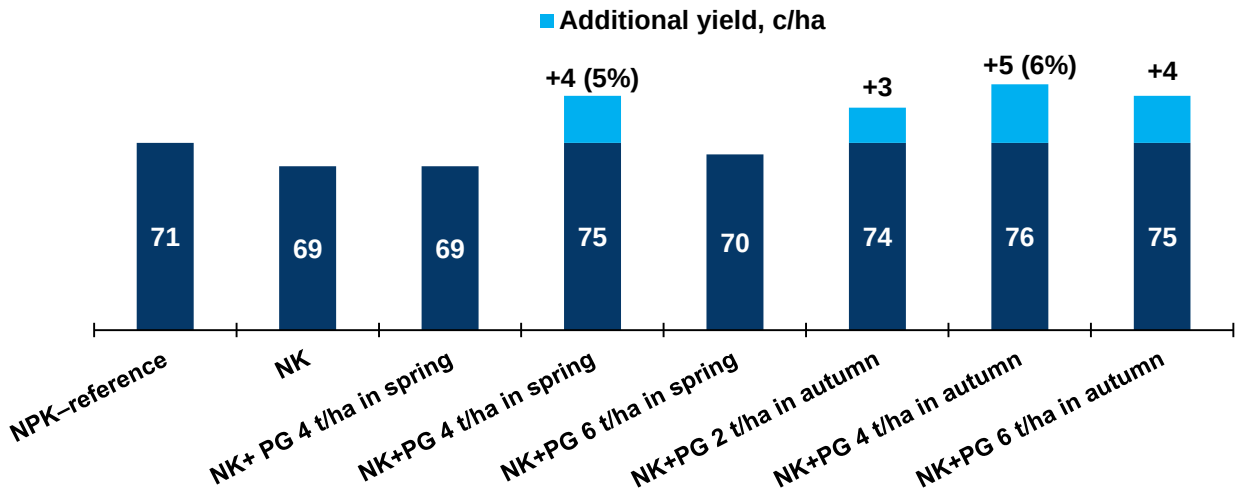

Fig.3 Efficiency evaluation of rates and periods of phosphogypsum application in rice cultivation

In 2017, a similar experiment was held to research the effect of neutralized phosphogypsum on rice productivity in the Republic of Adygea. The soil of the experimental site was rice meadow-marsh (pH – 6,3, humus content – 2,9%). As in the previous experiment, the best result was shown with the rate of application of 4 t/ha jointly with nitrogen potassium fertilizer. The increase in yield was +3.7 c/ha with an additional profit of +8 thousand rubles/ha compared to NPK reference.

To research the effectiveness of neutralized phosphogypsum aftereffect on the yield of winter wheat, another field experiment was held in Krasnodar Region in 2015 (Fig.4). The dominated soil type was chernozem leached (pH – 6,7, humus content – 3,5%). Pre-sowing treatment with neutralized phosphogypsum combined with mineral fertilizers for previous crops – soy and corn for grain contributed to an increase in concentration of water-soluble forms of nitrogen, phosphorus and potassium in soil and had a positive effect on growth and development of subsequent crop – winter wheat. The highest additional yield due to phosphogypsum aftereffect was recorded for an option with the application rate of 4 t/ha related to NPK reference, and amounted to 3.9 c/ha (5%).

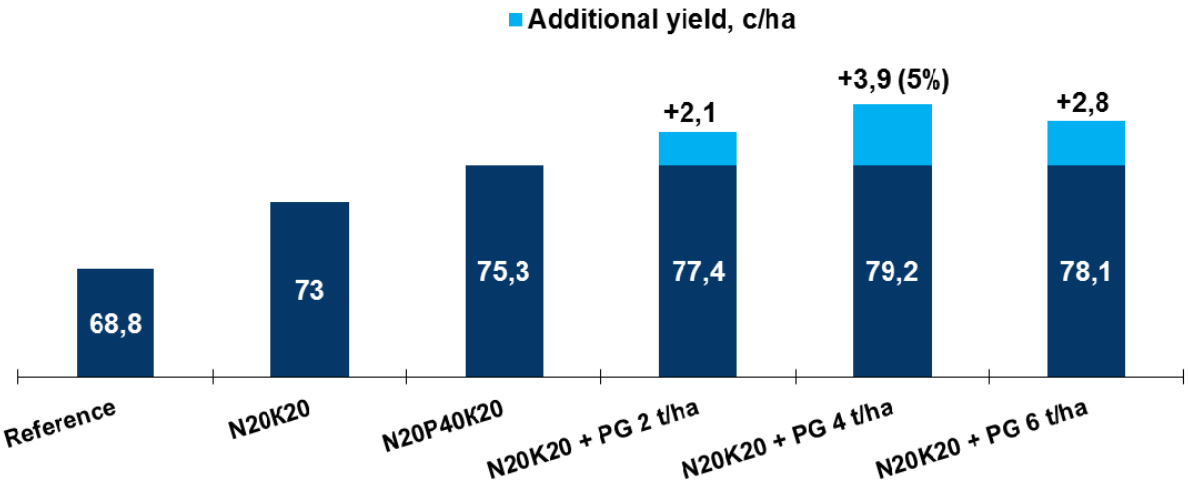

Fig. 4 Efficiency of neutralized phosphogypsum impact on winter wheat crops

Nutrients source, soil pH correction In 2016, an experiment was held to examine the effects of neutralized phosphogypsum on productivity of oil-bearing flax under conditions of Rostov Region. The dominated soil type was typical chernozem (pH – 8,3 humus content – 3,4%) In the variant with the phosphogypsum treatment at the dosage 5 t/ha, the additional yield made +4 t/ha with an additional profit of +3 thousand rubles (or 24%) compared against the reference without any phosphogypsum. Good effect for treatments containing phosphogypsum is the result of soil pH correction effect (phosphogypsum reduced the acidity from the meaning 8,3 to 7,7)

Soil pH correction. An experiment was conducted in Stavropol region at a spring barley field to research the effect of neutralized phosphogypsum impact on such an important soil fertility indicator as reaction of the medium (pH) and to assess the direct effect of phosphogypsum as an ameliorant of alkaline saline soils (Fig.5). The dominated soil type was typical chernozem (pH – 7,7-8,0 humus content – 4,6%). Phosphogypsum treatment reduced the acidity from 0.6 to 1.2 units per one vegetative season. As a result of increasing the nutrients availability in options with

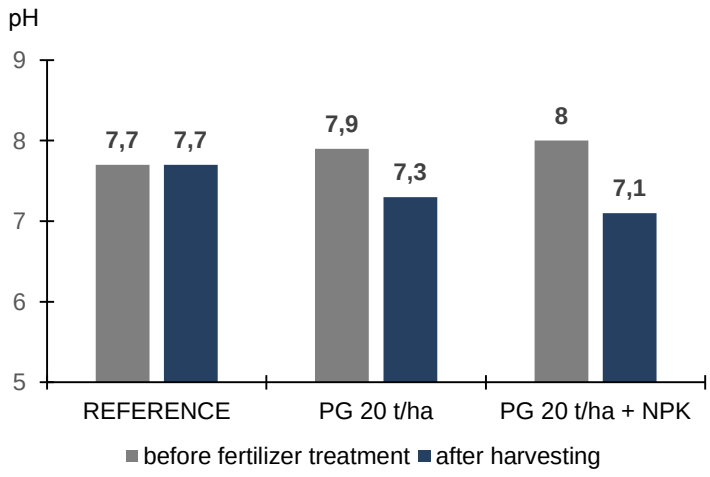

Fig.5 Application of neutralized phosphogypsum for melioration of alkaline soils in Stavropol Region in 2017

phosphogypsum treatment, the productive bushiness, grain weight and barley yield increased.

Therefore, EuroChem-BMU confirmed that phosphogypsum can be used as an effective ameliorant based on its own field experiments.

Chemical melioration can involve in new lands in the turnover in areas with favorable thermal conditions that are the most suitable for cultivation of high-margin crops. According to data of Pryanishnikov All Russian Research Institute of Agriculture and Soil Science, phosphogypsum use in 4 major agricultural regions of the Russian Federation (in

Krasnodar and Stavropol Regions, in Rostov and Vologda Regions) can provide an increase in yield by 5 million tons of grain units, which is an equivalent to 50 billion rubles of additional profit.

From an economic point of view, gypsuming is a large financial investment, of which transportation costs to the site of application make the largest share. Financial support from the state to gypsum delivery can extend amelioration to much larger areas of saline soils.

To solve the problems with phosphogypsum application was made following steps:

1. To increase the phosphogypsum and other ameliorants use, EuroChem-BMU appealed to governmental agencies with relevant proposals. The Ministry of Agriculture of the Russian Federation supported the initiatives of EuroChem-BMU in including phosphogypsum chemical amelioration activities of saline soils in the "National program of export of agricultural products" to improve the land fertility. Under instructions of the RF Ministry of Agriculture, EuroChem-BMU prepares targeted commercial proposals for southern regions of Russia.

2. Eurochem in cooperation with main soil research institution has developed government standard for gypsum-containing soil ameliorants application based on numerous trials results

3. After this initiative, government standard development and phosphogypsum effectiveness approvement made by Eurochem and Russian Association of Fertilizer Producers and within the framework of support of food security policy, the RF Ministry of Agriculture announced the necessity to conduct chemical soil amelioration. The decision was made to subsidize 30% of agricultural enterprise costs on soil liming, phosphoriting and gypsuming. This subsidy starts in 2019, and it is expected to increase it to 50% next year

At the moment, agricultural manufacturers of Russia come to conclusion about the necessity of ameliorants use to increase production efficiency. In its turn, the government jointly with fertilizer producers, shall provide a support to encourage use of ameliorants, including phosphogypsum.

Testimonials

We are actively exploring the possibility of using neutralized phosphogypsum as a multicomponent fertilizer. Phosphogypsum can be used as a complex fertilizer, because it consists of dozens of essential and even indispensable nutrients for plants. We have developed and approved the full application technology - timing, dosages, application methods - and also shown the real need for the phosphogypsum application in agriculture.

Askhat Khazritovich Sheudzhen
Doctor of biological Sciences
Head of the Department of precision technology Rice research Institution, corresponding member of RAS

Long-term experiments conducted on the basis of the all-Russian Scientific Research Institute of Agrochemistry showed significant efficiency of phosphogypsum not only as a meliorant for saline soils, but also as a fertilizer with soil-improving properties. There is no need to prove the importance of phosphorus application, but in the product there is another important element for plant nutrition - sulfur! Farmers all over the world in the last decade are paying more attention to the necessity of application this element and looking for its effective sources. Together with EuroChem, The Institute has developed comprehensive regulations for the phosphogypsum use technology both for saline lands and as a source of nutrients. Now detailed information on the method of application and efficiency is available to any farmer.

Akanova Natalia Ivanovna
Doctor of biological Sciences
Professor, Institute of Agrochemistry named after D. N. Pryanishnikov

We grow from 5 to 7 agricultural crops in our fields. Active use of irrigation systems leads to the appearance of spots in the fields with high salt content – or processes of soil salinization. Irrigation also leads to over-compaction of the upper horizons. It reduces soils fertility. To get rid of excess salt concentrations and improve soil structure we apply 2-6 tons of phosphogypsum per hectare. To develop phosphogypsum application system we based on soil analysis results, crop yields, and visual examination of the fields. We apply phosphogypsum once or twice in the crop rotation, on average. Special attention is paid to rice fields, where phosphogypsum is extremely needed.

With the use of phosphogypsum, phosphorus nutrition is improved, the lack of calcium in our soils is removed, the soil forms a more structured humus horizon. Following our technology we plane to apply phosphogipsum in the fall of 2019. The total amount of the order of 10 000 tonnes.

Rothko Anatoliy Viktorovich
The Director of "Manych-agro» company, Rostov region.

- Phosphogypsum is needed due to the fact that we have soil destructuring, it is necessary to stabilize soil water-air regime, it will improve plant nutrition. That's the most important thing for our soils. Yes, phosphogypsum will slightly increases yields, but its main role is to improve the structure of the soil - due to this, the soil will be less destroyed after mechanical operation and rainfall, conditions for plant growth will be better.

- Phosphogypsum - is highly effective for lands with saline soil. In the Krasnodar region as a whole, we have about 10% of saline land, but in the Bagaevsky district I have about 30%. Although the farm consists of 7 thousand hectares. Now I start to apply irrigation system, and situation only gets worse. In my conditions, the use of phosphogypsum becomes mandatory, but first the product should be tested, what we plan to do in the nearest future.

The independent experts opinion (agricultural producers). The survay in the framework of Focus groups for assessment of consumer demand for phosphogypsum (6 groups, 30 persons in total)

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