Improving the efficiency of using Russian soil resources

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Abstract. Russia’s soil is degraded by simplified agricultural production technologies, lack of fertilizers, plant protection products, irrigation, improper use of crop rotations or their absence, and weakening of state control over the use and protection of agricultural land. There is a depletion of available land. The average annual deficit of humus in the arable layer is 0.52 tons per hectare, and the applied doses of organic and mineral fertilizers do not compensate for the loss of soil nutrients. 46% of the surveyed area is characterized by a low content of organic substances. The renewal and preservation of fertility of Russia’s soils suitable for vegetable growing is possible in a scientifically sound combination of organic and mineral fertilizers, use of crop rotations with inclusion of break crops and perennial grasses, technological, agricultural and technical parameters of the technology, the organization of control over use and protection of agricultural land from the state and regional authorities.

1. Introduction

Soil is the most important component of the natural resources of the Russian biosphere. It is a critical non-renewable resource, as the process of its natural formation takes several thousand years [1]. Soil is an independent natural-historical natural body formed on the surface of the Earth, consisting of mineral substances of the rock underlying the soil, organic substances formed during the reproduction of dead remains of animals and plants, water, air, living organisms and their products, having fertility and having specific genetic and morphological characteristics and properties that create appropriate conditions for the growth and development of plants [2].

By 2050, the potential increase in the world’s arable land area to the current 1,550 million ha could reach a maximum of 500 million ha, with up to 900 million ha will decrease their fertility due to increased degradation processes. These areas will be partially removed from crop rotation or completely excluded from agricultural turnover. In the end, the balance will remain close to zero or become negative [3,4].

The problem of increasing the efficiency of existing arable land and putting new land into circulation is extremely urgent at the present stage of economic development. Some aspects of the problem under consideration today need to be solved comprehensively, including the use of scientific developments in the field of agriculture, soil science and agrochemistry.

2. Materials and methods

In the process of work, the methods used in economic science are used: general scientific (dialectical, analysis and synthesis, comparison and analogy, tabular, graphic); special (system, comparative analysis, statistical-economic, economic-mathematical). The information base of the study was state
statistics; normative legal acts of Federal and regional levels; data from the Ministry of Agriculture of the Russian Federation; reference materials of specialized publications on the subject under study; materials received from participants in the market of protected soil vegetables, their own research; Internet data (industry portals, sites of producers of protected soil products, articles and reviews).

3. Results

Russia is the only country in the world that has a real opportunity to expand the area of agricultural crops. However, these opportunities have not been fully realized yet, there is a reduction in arable land and their transfer to other categories, and a decrease in soil fertility. If in 1990, the sown area was 120 million square meters and bare fallow -12 million ha (in total 132 million ha of arable land), then in 2017 – 122 million ha, in 2018 – 117 million ha. Agricultural land within the borders of the Russian Federation for the period from 1990 to 2017 decreased from 222409.2 to 222012.6 thousand hectares, arable land – from 132304.2 to 122727.4 thousand hectares, the area of deposits increased – from 347.2 to 4896.4 thousand hectares, hayfields and pastures – from 87899.5 to 92479.2 thousand ha.

Today, Russian soils are degraded by simplified agricultural production technologies, lack of irrigation, lack of fertilizers, plant protection products, lack of crop rotation, weakening of state control over the use and protection of agricultural land, etc. A large number of land owners and agricultural producers of various forms of ownership have appeared.

In the pre-perestroika period, agricultural land was mainly owned by the state and community 25-29 thousand of collective farms and state farms. During the reforms, 11.6 thousand of agricultural cooperatives, 3.2 thousand of state unitary and municipal organizations, 5.4 thousand of joint-stock companies, and 6.7 thousand of limited liability companies were created on their basis, 11.9 million of Russian farmers received conditional land shares (10-15 ha per person). By 2006, a multi-layered agricultural sector was formed, consisting of agricultural organizations, peasant farms and individual entrepreneurs, and personal subsidiary farms.

According to the 2006 agricultural census, there were 58901 agricultural organizations, 253236 peasant (farm) farms, and 31789 individual entrepreneurs in the agricultural sector of the economy. After 10 years, the number of agricultural organizations decreased by 22.8 thousand (38%), peasant farms decreased to 136.6 thousand (53.5%), and personal subsidiary farms remained 16.2 million (decreased by 20%), there are 3.2 million private households left, or three times less than in 2006. Only 67.6% of agricultural organizations, 49.3% of peasant farms and 66% of individual entrepreneurs carried out agricultural activities [5].

The 2016 census showed that in the 10 years since the previous census, the area assigned to agricultural organizations decreased from 82.2 mln ha to 64.8 mln ha (20%), increased in peasant farms from 14.9 to 23.6 mln ha (51%), and in individual entrepreneurs from 1.7 to 3.2 mln ha (85%) [6].

According to Rosstat, as of January 1, 2018, 255.5 mln ha, or 66.7% of agricultural land was in state and municipal ownership, in private ownership -127.8 million hectares (28.3%), including in the ownership of citizens – 108.5 mln ha (28.3%), in the ownership of legal entities – 19.3 mln ha (5%) [7].

In the pre-perestroika period, Roskomzem, which has an integrated system of subordinate organizations and structures (89 regional, more than 2 thousand city and district committees, a powerful scientific base, a computer center, instrumentation, monitoring system, planning, accounting, etc.), was engaged in the effective use of land resources.

Today, land management issues are spread across 11 ministries and departments, regional and local authorities, which generally do something in their part, but there is no systematic management, no one is seriously engaged in preserving land resources, arable land, acreage, soil fertility.

As a result, various negative processes operate on Russian lands – intensive development of erosion, water logging, salinization, desertification, flooding, overgrowth of agricultural land with low-value forest stands, weeds and quarantine plants, which leads to land degradation, loss of agricultural land fertility, and their withdrawal from economic turnover. [7] Attempts to introduce
additional areas into agricultural turnover are hindered by insufficient provision of agricultural machinery, funds for land reclamation, purchase of fertilizers, plant protection products, seed and planting material. When expanding the acreage, the land has to be purchased or leased, as it already belongs to someone.

According to the Ministry of Agriculture of Russia, the area of unused arable land is 19.4 million hectares, about 9 million hectares of which are overgrown with woody and shrubby vegetation, about 0.5 ml of which were subjected to water logging and flooding. At the same time, the arable land suitable for introduction into agricultural circulation is more than 11 million hectares, or 55% of all unused arable land [8].

Erosion leads to the destruction and demolition of the upper most fertile soil horizon as a result of the action of water and wind. Today in Russia, about 35% of the soil is slightly humid, 51.5 million hectares are acidic, almost 10 million hectares are swampy, 16.1 million hectares are waterlogged, the first deserts appeared, less than 68% of the possible acreage is used.

In 2018, 5-20% of arable land is used for crops in some territories, 25% in the Astrakhan region, 28% in the Smolensk region, 47.3% in the Moscow region and 50% in the Ryazan region. But at the same time, the Krasnodar territory uses 95% of the available arable land for crops, while the Altai territory uses 80.5%. A high percentage of arable land use is in the Stavropol territory, Rostov, Belgorod, Kursk, and Bryansk regions.

Analysis of the current state of agricultural land, assessment of changes in land quality indicators indicate a trend towards deterioration of the overall environmental situation and a decrease in the level of fertility of arable soils and their depletion.

The formation of soil organic matter plays an important role in the sustainable development of agriculture. The degree of humus is traditionally used as a criterion for the level of soil fertility. It is known that humus is a solar energy accumulator and the main regulator of biochemical processes in the soil. The amount of humus, its qualitative composition has a great impact on the biological activity of soils, largely determines the level of its fertility and crop yield [9,10,11,12,13,14,15].

In recent years, the average annual deficit of humus in the arable layer in the Russian Federation has been 0.52 tons per hectare, and the applied doses of organic and mineral fertilizers do not compensate for the loss of soil nutrients (removal with the harvest). Reserves of organic matter are reduced due to increased mineralization of organic soil components due to intensive processing, increased aeration, insufficient supply of root and soil residues, and a sharp reduction in organic fertilizers.

Thirty years ago, according to statistics, 886 million tons of manure was produced in Russia, and 390 million tons (44%) were added to the soil. At present, 315 million manure is produced and 65 million is deposited. More than 15 tons of organic fertilizers were applied to each hectare of the Russian field. Over the 1990-2010 period, the application of organic fertilizers decreased by 7.4 times, including by 1 ha of crops from 1.5 t/ha to 1.1 t/ha. At the same time, organic fertilizers were applied in agricultural organizations for only 8.4% of the total sown area in 2015 and for 9.2% in 2017. In 2017, 2.6 tons of organic fertilizers were applied to each hectare of vegetable and fruit crops. The state monitoring of land in the Russian Federation showed that 46% of the surveyed area is characterized by a very low content of organic substances. The lack of organic matter in the soil, a decrease in its content and quality contributes to the deterioration of agrochemical, agrophysical, biological properties of the soil and a decrease in soil fertility.

According to many scientists, the main factor in the deficit-free balance of humus is the use of organic fertilizers. By minimizing the application of organic fertilizers to the soil, Russia not only get at least 30-50% of agricultural products, but at the same time it suffers significant losses in potential productivity of arable land due to overexploitation of its natural fertility and its decline.

The main need for nutritional elements of vegetable crops is met by mineral fertilizers. Since the mid-1990s, Russia’s arable soils have had a negative balance not only of humus, but also of the main elements of the mineral nutrition of agricultural crops. According to statistics, for 74-81 million hectares of crops and 14-16 million hectares of fallow fields, 1.5-3.0 million of active substances (a.s.)
of mineral fertilizers (NPK) were used annually. For 20 years, there has been an annual negative balance of the main elements of mineral nutrition (over 100 kg of a.s./ha). Trace elements, mobile silicon, and sulfur are also not replenished. The volume of fertilizers and chemical ameliorants did not provide and do not provide even a simple reproduction of the fertility of arable soils. The area and proportion of acidic soils in agricultural land is constantly growing.

According to Rosstat, in 1972, up to 1000 kg/ha of mineral fertilizers were applied to vegetables, in the 90s of the last century – 400-450 kg/ha, in 2006 – 131, in 2015 – 166, in 2017 – 198 kg/ha, in 2019 – 228.4 kg/ha (table). Recently, fertilizers were applied to 48-58% of the area. The specific weight of the sown area of vegetable crops fertilized with mineral fertilizers is 33.7% in agricultural organizations, 19.5% in peasant farms and individual entrepreneurs.

Such amounts of mineral fertilizers do not cover 40-50% of the removal of nutrients from the soil. According to ARSRIVG data, the annual removal of nutrients from the soil for some vegetable crops (medium cabbage-822 kg/ha, medium-late cabbage-742 kg/ha, beet-690 kg/ha, cucumber-575 kg/ha) is 4.5 times higher than their age [16,17].

In modern vegetable growing, mainly focused on chernozems, floodplain and peat soils, mineral fertilizers are the main element of the fertilizer system of vegetable crops. However, the greatest effect in obtaining the maximum yield and preserving soil fertility is achieved by the combined use of mineral and organic fertilizers.

In 2015-2017, the production of mineral fertilizers was 20.1-20.8 million tons. Sales of mineral fertilizers on the national market for Russian agricultural producers did not exceed 23-25% of those produced in the country. If one of the guarantees for maintaining soil fertility and stable growth of crop production, including vegetable production, in Russia is a rational combination and use of mineral and organic fertilizers, then to provide agricultural crops with mineral fertilizers, it is necessary to sharply reduce their exports and provide national producers with the opportunity to purchase them.

Table 1. Introduction of mineral and organic fertilizers for agricultural crops in the Russian Federation for sowing in 2019 (according to Rosstat).

| Added mineral fertilizers | Added organic fertilizers |
|---------------------------|---------------------------|
| **in terms of 100% of nutrients-total, thousand C** | **per 1 ha of seeding, kg** | **thousand ha** | **total, thousand tons** | **per 1 ha of seeding, t** | **thousand ha** |
| potato | 535.0 | 404.6 | 123.4 | 464.6 | 3.5 | 13.5 |
| vegetable crops | 155.8 | 228.4 | 58.2 | 211.4 | 3.1 | 8.4 |
| melon crops | 0.8 | 23.4 | 0.5 | 1.0 | 0.3 | 0.1 |
| fodder crops - total | 2203.2 | 22.0 | 3272.5 | 20602.9 | 2.1 | 548.0 |
| of them: | | | | | | |
| corn for silage and green feed | 844.0 | 74.0 | 837.5 | 11281.1 | 9.9 | 232.8 |
| seeded grasses (annual and perennial) | 1319.9 | 15.3 | 2340.5 | 8829.4 | 1.0 | 280.8 |
| under perennial plantings | 52.8 | - | 42.4 | 42.3 | - | 4.6 |
| under natural hayfields and pastures | 6.7 | - | 12.5 | 180.7 | - | 11.2 |
| in protected soil | 187.8 | - | 2.3 | 11.7 | - | 0.2 |
The resumption of the fertility of vegetable-suitable soils (and all other crops) can only be carried out by a well-thought out scientifically-based combination of two measures – the introduction of fertilizers and the correct crop rotation. [16,17,18]

The role of rotation is mainly to improve soil fertility through control of soil organic matter and mineral nutrients, maintaining satisfactory structural condition of the soil; prevention of erosion and deflation; limiting the development of weeds; the regulation of phytosanitary condition of the soil, increasing the productivity and quality of agricultural products, including vegetable crops. Many years of ARSRIVG research in cooperation with vegetable experimental stations located in the main areas of commercial vegetable, on seven soil differences with a humus content of 0.6% to 6.6% and a humus layer of 15-20 cm to 100-120 cm, showed that maintaining high soil fertility in vegetable production, optimizing their nutrient status, increased physicochemical, agrophysical and agrochemical properties of the soil is possible only with application of organic and mineral or organic and mineral and biological systems of fertilizers in vegetable fodder or vegetable break crop rotations. [19,20,21,22,23,24]

Scientists and practitioners of agricultural production are constantly searching for and developing the most rational and economically acceptable technologies for the production of agricultural products, including vegetables. Currently, a number of alternative farming systems, including biological (ecological) farming, have been developed and exist in practice. The system of agriculture involves the correct use of crop rotations, organic fertilizers, plant residues, straw, break crops, etc.; natural soil fertility, which allows solving the problem of providing nutrition elements; improved nitrogen assimilation due to legumes; complete rejection of the use of mineral fertilizers and pesticides. A valuable and attractive feature of biologization is the ecological purity of products and the absence of environmental pollution, increasing the natural fertility of soils.

4. Summary
The preservation and restoration of fertility of Russia’s soils suitable for vegetable growing is possible by rational combination of organic and mineral fertilizers, use of crop rotations with inclusion of break crops and perennial grasses, technological and agrotechnical parameters of the technology, the organization of control over use and protection of agricultural land from the state and regional authorities.

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