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METHOD OF STUDYING THE REDUCTION AND SEQUESTRATION OF GREENHOUSE GASES ON CARBON FARMS

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Abstract

Methodological approaches to the formation of a unified National system for monitoring and recording the balance of carbon and greenhouse gas emissions are considered, as well as the purpose, typification, requirements for the spatial distribution of "carbon" landfills, assessment of the carbon absorption capacity of forests and agricultural ecosystems of the Russian Federation, a standard methodology recommended by the international community for assessment of carbon stocks in soils, which should be applied in the Russian Federation to ensure comparability of greenhouse gas accounting results between countries, determination of carbon absorption capacity of natural ecosystems and soils. The carbon uptake potential of agricultural soils is shown. A list of indicators for assessing soil carbon according to the methodology of the Intergovernmental Panel on Climate Change (IPCC Guidelines for National Greenhouse Gas Inventories) is given.

Keywords: carbon polygons, greenhouse, carbon farms, agricultural ecosystems, environmental protection, carbon dioxide

I. Introduction

Carbon farming is an effective strategy for more sustainable production of food and other related products. It aims to simultaneously produce a variety of natural farming practices and marketable products[1]. According to the Food and Agriculture Organization (FAO), agriculture, forestry and other land uses account for 24% of global greenhouse gas (GHG) emissions, and total global emissions from livestock production are 7.1 gigatonnes of CO2 equivalent per year, which is 14 .5 gigatons. % of total anthropogenic GHG emissions [2]. For example, an agroforestry system that deliberately combines trees and crops with livestock in agricultural production has the potential to increase carbon sequestration and reduce greenhouse gas emissions from terrestrial ecosystems, thereby helping to mitigate global climate change. In addition, agroforestry has the potential to generate vast amounts of biomass and is considered particularly suitable for replenishing soil organic carbon (SOC). SOC is an important indicator of soil fertility, as change in SOC can explain whether land-use patterns of soil fertility are deteriorating or improving [2,3]. What's more, SOC, found in soil as soil organic matter (SOM), directly or indirectly helps improve soil health. Thus, efforts must be made to convince farmers to improve resource efficiency and soil conservation in order to maximize the benefits of agriculture. Therefore, this review aimed to clarify the issues of carbon farming, changes in the carbon cycle and carbon sequestration during agricultural development, and the benefits of agroforestry. A clear trend towards bringing climate change issues to the forefront of the global political and economic agenda has emerged in the past few months. The growing consensus in global economic centers on the legitimacy of trade restrictions on goods with a high carbon footprint is a real threat to Russian exports. Already today, some world exchanges require issuers to report on greenhouse gas emissions. The mining and metals industries, fertilizer producers, and subsequently other sectors of the economy, including agriculture, are at risk of constantly shrinking export markets as more countries move to the standards of the leaders in the climate race. We are talking about the prospect of erecting barriers not only in the EU or US markets, but also in all markets that are actively trading with them [4]. However, natural and climatic conditions allow Russia to be not an object, but an active subject of the global carbon policy. The vast forest areas of our country, tens of millions of hectares of agricultural land taken out of circulation, with proper preparation (fire prevention, building protective forest belts, etc.) can become huge carbon storage factories capable of absorbing, according to some estimates, hundreds of millions of tons of carbon dioxide in year. The transition of agriculture to resource-saving practices, the introduction of carbon farming methods will significantly reduce the carbon footprint of Russian agricultural products, turn the Russian agricultural producer, land user into a provider of carbon absorption services [3]. Russia can and should become a leader in carbon credit trading within the global sequestration industry. The introduction of new management methods will also require new approaches to the selection of agricultural and forest plants, reorientation of breeding work to new characteristics, including increasing the ability to absorb atmospheric carbon and reducing the need for the use of fertilizers and plant protection products. The invitation of the authors of the report to talk about Russia's possible strategy in the new "carbon reality" can only be welcomed. The spread of carbon farming and forest management practices will directly contribute to the achievement of this goal by enhancing the protection, protection and reproduction of forests, reducing the area of forest fires, and increasing the absorption capacity of forests. The organization in Russia of carbon farms, adapted to the characteristics of specific territories and ecosystems, will make it possible to work out forestry and agricultural technologies aimed at the most active absorption of carbon dioxide from the atmosphere.

II. Methods

New approaches to farming systems and soil management are being developed to manage excess CO2 in the environment while improving water use efficiency and soil quality. Various management practices affect the amount of soil organic matter, composition and water retention capacity [1,2]. However, meeting human needs and protecting environmental resources at the same time is the key to effective planning strategies. Soil quality research aims to understand how to manage soil in order to take advantage of its inherent qualities. Therefore, it becomes necessary to recognize the factors influencing soil health, among which organic matter is crucial [3,4]. Organic matter that is easy to handle in land management can be found in most agricultural land. Since organic matter increases water-holding capacity and strengthens soil structure [5,6], it contributes to increased agricultural productivity as well as reduced incidence of drought and disease [7,8]. In addition, agricultural activities that release organic matter into the soil are necessary to limit CO2 emissions into the environment [9,10].Soil management activities have also been shown to be necessary to conserve and restore soil carbon. However, many agricultural lands, although not all, have a significant carbon deficiency due to erosion and soil destruction [10]. It is widely recognized that various governments are taking possible measures to encourage environmentally sustainable agricultural practices to conserve soil carbon. In low-cost areas, agroforests fight to increase crop productivity and help farmers maintain soil quality. In combination with crops, certain types of trees in agroforest management systems can be suitable for solving numerous agricultural problems [4]. Another government project is the implementation of an environmental policy aimed at reducing the carbon footprint. In addition to traditional tillage, terracing and no-mulching systems, farmers are encouraged to use other systems such as bio-fertilizers, no-till and plant mulch, along with systems operating under agroforestry [6]. Forest density is another important factor influencing soil carbon content. On the other hand, deforestation significantly affects river flow and land use patterns. Agriculture, forestry and other land use practices account for 24 percent of global greenhouse gas (GHG) emissions, with total global livestock emissions of 7.1 gigatonnes of CO2 equivalent per year, representing 14.5 percent of total anthropogenic GHG emissions, according to the Food and Agriculture Organization (FAO) [9]. Forests, however, provide significant opportunities for a net reduction in global warming (as a consequence of greenhouse gas emissions) through CO2 sequestration [10]. Since the injection of flue gases into aquifers to store and utilize CO2 poses a risk of carbon leakage over time, it offers few economic benefits, making the carbon sequestration method more attractive [8]. In addition, the planning and management of forests must also consider how they relate to other aspects of the ecosystem. In addition, microalgae demonstrate highly productive photosynthesis, as a result of which a large amount of CO2 is formed in their cells in the form of organically bound carbon [10]. Therefore, for biomass derived from fossil fuels, CO2 pollution per unit can be reduced by having CO2 recycled and then reused by algae.

III. Results

The EU's plans to introduce a frontier carbon adjustment mechanism have prompted many manufacturers of carbon-intensive products exported to the EU to rethink their carbon strategy. Over the past few months, it has become clear that the emergence of such a mechanism in one form or another is inevitable. Moreover, similar measures can be taken in the United States: the program of the new president directly provides for the introduction of a "corrective carbon levy" in relation to countries "not fulfilling their obligations on climate and environmental protection." If this scenario materializes, there is a high probability of a domino effect triggering: exporters to these markets will be forced to switch to higher carbon standards of importing countries, and therefore protect their producers with similar measures. Russia's failure to take steps to develop and implement a strategy to reduce greenhouse gas emissions will mean a gradual narrowing of export markets. It may turn out that there will simply be nowhere to switch from the EU market: similar barriers will be erected in other markets [6,7]. Challenging “carbon adjustments” in the World Trade Organization is unlikely to lead to the desired results: if specific forms of implementation of the mechanism can be found to be inconsistent with certain WTO rules (for example, on the prohibition of discrimination), the very idea of such a mechanism is subject to its support economic centers of the world, including the EU and the USA, and the emergence of climate change issues at the forefront of the international agenda - with a high probability will be recognized as legitimate. In addition, the WTO dispute resolution system remains blocked today (the US is preventing the appointment of members of the Appellate Body, citing irregularities in its work; the new administration has not yet demonstrated a willingness to change the situation in the foreseeable future), so filing a complaint in the near future is futile [8]. Thus, having won a dispute with the EU over energy adjustments last year, Russia cannot enforce the decision of the arbitration panel, since the EU filed an appeal with the non-functioning Appellate Body, thereby maintaining the status quo indefinitely. Carbon pricing initiatives—in the form of a carbon tax or an emissions trading system—are on the rise around the world, with about 60 of them now. years before. Africa's first carbon tax was introduced in the Republic of South Africa (SAR), with Singapore pioneering in Asia. On February 1, 2021, the national emissions trading system began to operate in China. In these circumstances, one of the key elements of Russia's response to climate threats and related trade barriers could be agriculture and forestry [8].

Forest farms focus on growing special forest and non-timber forest products, including such valuable ones as mushrooms, ginseng, nuts, herbs and dyes. The activities of such a farm change the forest ecosystem, but do not violate such important functions as soil erosion control, microclimate regulation and the creation of wildlife habitats. Windbreaks are strips of trees and/or shrubs that are maintained to change the wind flow and affect the microclimate. Such strips can protect sensitive crop species, improve water use efficiency, better control wind erosion, and increase bee and pesticide pollination efficiency. These ecosystem services can improve soil health by increasing soil diversity, reducing soil disturbance, and providing year-round soil cover [5,6]. Coastal (tugai) forest buffers consist of strips of grass, shrubs, and trees between the shore, just below the water's edge, and arable land. Trees and shrubs stabilize the coast, improve and protect the aquatic environment, and protect arable land from water erosion and weeding. Grass slows and disperses runoff from arable fields, promoting sedimentation and infiltration of nutrients and pesticides. Finally, silvopasture agriculture is the deliberate use of a forest area as a pasture. Typically, this system includes seeding with native pasture grasses, fertilization and nitrogen-fixing legumes, and rotational grazing. Potential benefits of this system include a cooler environment for livestock, shorter logging cycles due to higher levels of nitrogen fertilizer and control of competition, and more efficient uptake of nutrients by plants. The costs and challenges associated with setting up a silvopastoral irrigation system include the high capital costs associated with planting trees, the need for fencing and monitoring of livestock, and ensuring correlation between livestock and plant species [7,8].

Forests cover about 30% of the total land area and play an important role as carbon sinks in both the atmosphere and soil. The current area of forest cover is dynamic and will be largely affected by land use and climate change in the future. Rising temperatures, more frequent droughts and wildfires are some of the factors that can transform forests from net carbon sinks to net CO2 sources. Natural solutions to climate change will require significant contributions from afforestation, reforestation and the prevention of deforestation. For such measures to be effective, it will be necessary, among other things, to undertake a concerted plant breeding effort. Paulownia, a tree widely used in agroforestry and as a biomass for energy generation, shows the highest rate of carbon sequestration among all species [4]. The volume of its sequestration is about 9 tons of CO2-eq./ha per year. Another plus is the fast growth rate - 3.6-5.0 m per year, a relatively short harvest cycle - starting from 8-10 years in the most favorable conditions. These characteristics require a lot of nutrients and water, which can be costly and affect soil quality and fertility. Paulownia is quite adapted to various climatic conditions: being endemic to Asia, it can tolerate temperatures as low as -15ºC and therefore has the potential to adapt to colder climates. Experimental paulownia plantations have been established in a number of countries of Central Asia - in Uzbekistan, Kyrgyzstan, and Kazakhstan. However, a wide distribution in new regions for this family can lead to consequences that have not been studied so far. In a number of US states, the distribution of paulownia is prohibited by local law [9].

Poplar (Populusspp) and its hybrids have been identified as a promising species for carbon sequestration in colder, northern and continental climates. Poplar is distributed throughout most of Russia and is found in many Russian cities. It has a relatively high carbon sequestration potential of 1.8–6.35 tCO2-eq/ha per year, high growth rates of 1.524–3.6 m/year, and a short productive cycle of 10–15 years [10]. Poplar can be used in agroforestry, bioenergy, pulp production. Several hybrids have been created in Russia: Breeze, Voronezh Giant, Veduga, Surprise. To maximize the effectiveness of future poplar afforestation and reforestation initiatives, selection of genotypes with high growth, biomass and disease resistance will be required. The specificity of the planting region is also an important characteristic for the selection of the genotype [6]. A number of foreign forestry companies, such as Alberta-Pacific (ALPAC) in Canada, are experimenting with poplar-aspen hybrid plantations. In the process of experimental cultivation, not only positive, but also a number of negative points were revealed - for example, a high degree of damage to poplars by various phytopathologies [7]. Before widespread introduction into practice, it is necessary to conduct experimental plantings of this kind of plantings. Although the range of eucalyptus (Saligna) and bamboo (Phyllostachys pubescens) is far from cold regions, they deserve attention due to their extremely high potential for carbon sequestration. Eucalyptus is a fast growing species (1.8–3.6 m/yr) with a high carbon sequestration potential (8 tCO2e/ha/yr), a short harvest cycle (8–12 years) and reusability of its wood [9]. The homeland of eucalyptus is Australia, the local habitat is from tropical to subtropical. The paper describes the crossing of Eucalyptus grandis with Eucalyptus urophylla, which allows the plant to be resistant to freezing. Such studies offer interesting opportunities for adapting eucalyptus to carbon sequestration initiatives in colder regions. Several decades ago, eucalyptus trees were planted in the Colchis lowland in Georgia, took root and became an element of the natural environment. Due to the low resistance to frost, further expansion of common eucalyptus to the north did not occur. As for bamboo, several of its species are cold-resistant (Phyllostachys Aurea, Phyllostachys bissetii) and can tolerate temperatures up to 15°C. Bamboo has an extremely fast growth rate (5.0–10.0 m/year) with a high carbon sequestration potential (8.5 tCO2-eq/ha/year) and can be used as a raw material for production as well as for food [3,4]. Not classified as a tree, bamboo reaches a height comparable to a tree (up to 15–20 m) and also has a biomass structure similar to trees. Bamboo reforestation initiatives have been observed to promote the accumulation of organic matter in the soil, counteract erosion, promote the restoration of exploited landscapes, reduce sedimentation and pollution from agricultural runoff, and even filter sewage. It should be noted that the rate and magnitude of growth of forest stands depend not only and even not so much on the presence of fast-growing species, but on the quality of care. Forestry requires planting a much larger number of seedlings than the total number of mature trees per unit area. So, based on the rules of reforestation, it is necessary to plant at least 3,000 seedlings per 1 ha, while about 250–300 survive to the age of 100 years. This means that 90% of trees die due to natural causes - due to competition or as a result of natural death.

IV. Discussion

It is very likely that in the future, agricultural products will somehow fall under the EU's corrective mechanism [8]. Given that the agricultural sector is the subject of special protection in the EU, there is no reason to believe that, by protecting competition in its market with a carbon corrective mechanism, the European Commission will refuse to use this tool to protect the European agricultural producer. Moreover, at the international level, an understanding is beginning to form that, in the issue of climate change, agricultural production "is not only the source of the problem, but also a key element of the solution [9]." If earlier agriculture was perceived, on the one hand, as one of the causes of climate change, and on the other hand, as one of its main victims, and the question was raised only about reducing the impact of climate change on agricultural production and its adaptation to a changing climate, today it is that agriculture can become a source of technologies that ensure the removal (sequestration) of greenhouse gases from the atmosphere. Farming methods aimed at capturing carbon from the atmosphere are known as carbon (or carbon) farming (carbon farming). The essence of carbon farming is to increase soil carbon by increasing the amount of carbon put into the soil and reducing the rate of carbon loss through respiration and soil erosion. The reduction of greenhouse gas emissions associated with agriculture is achieved, among other things, by minimizing the use of agrochemicals (fertilizers, plant protection products).In recent years, along with the active spread of state regulation systems for greenhouse gas emissions (including emission trading systems in Europe, China, California and carbon taxes in European and Asian countries), as well as various sectoral emission regulation systems (including the system Corsia on the basis of ICAO), voluntary carbon offsetting schemes are rapidly developing based on the implementation of investment projects. Voluntary carbon markets are platforms for transactions for the sale and purchase of greenhouse gas emission reduction units. Companies come to participate in voluntary emission reduction schemes both out of a desire to increase their attractiveness for investors, and based on some associated benefits, including to strengthen their positions in certain local markets where the company's products are supplied 7,8]. Projects cover a range of activities, from reducing agricultural emissions by reducing the amount of chemical fertilizers used, to improving the energy efficiency of production and switching to cleaner energy sources. Recently, projects in the field of forestry and land use have become increasingly popular. Your projects have a fairly wide geography and are being implemented in more than 80 countries, but the majority are concentrated in India, China, the USA, Turkey and Brazil.

In many ways synonymous with carbon farming is the concept of "regenerative" (i.e. restorative) agriculture (regenerative agriculture), which is understood as a set of non-destructive agricultural practices that ensure soil restoration in the process of managing. With the help of modern breeding methods, it is possible to obtain regenerative varieties with the appropriate characteristics and technical characteristics [8,9]. As part of the new climate agenda, it is necessary to develop varieties and types of agricultural plants, including fundamentally new ones, that would have the ability to suppress weeds, resist pests and diseases without the help of agrochemistry. Breeding these kinds of varieties and species is more complex than breeding for homogeneous, manageable, high-yielding systems. But it is necessary in the face of declining global resources with a growing population of the planet, as well as taking into account the inevitable introduction of strict carbon standards, fines, and quotas into the agricultural industry. The subject of breeding work should be non-obvious properties and point effects on molecular mechanisms, and not simple formulas like "yield / cost". Forests, in turn, are the main natural sink of greenhouse gases in terrestrial ecosystems in the world. As the world's leading forest power, Russia has natural capital in the form of forests accumulating 625 million tons of greenhouse gases annually. This gives Russia significant competitive advantages, since the absorption of greenhouse gas emissions by forests occurs without significant costs from the state, the cost of measures to reduce emissions - for example, to extinguish forest fires - is moderate (3 billion rubles per year) compared to other types of measures, for example, to improve energy efficiency in industry [7]. In general, in Russia there is a huge and still not used reserve for reducing the carbon footprint of products due to the existing protective and other categories of forests on agricultural lands. Forests located on agricultural land are of great importance for the absorption of greenhouse gases. If 1 hectare of forests on the lands of the forest fund absorbs on average about 1 ton of greenhouse gases per year, then 1 ha of protective and anti-erosion forests on agricultural lands - about 7 tons per year, i.e. 7 times more. At the same time, according to various estimates, from 40 to 90 million hectares of agricultural land in Russia are overgrown with forests, which are not yet taken into account in the national statistics of greenhouse gas absorption due to the fact that they do not belong to managed forests. Forest breeding should be aimed at obtaining varieties and species with high growth rates and high potential for carbon sequestration in the climatic conditions of Russia.

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