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THE INITIATIVE “4 PER MILLE” – A NEW GLOBAL CHALLENGE FOR THE SOILS OF RUSSIA

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The implementation of the “4 per mille” or “4 per 1000” Initiative in Russia can be one of the instruments mitigating concentration of the greenhouse gases in the atmosphere. It is estimated that the total annual absorption of carbon dioxide (CO_2), including natural dynamics and application of carbon saving technologies in agriculture, can be as much as 23–28 % of annual emission of the gas into the atmosphere. The “4 per 1000” Initiative mechanism will operate successfully for 12–15 years, which corresponds to the time of saturation of arable soil with carbon. The implementation of the “4 per mille” Initiative is not only Russia's positioning among the countries that support sustainable, energy-efficient and environmentally friendly development, but also demonstrates the ability of the country to realize its competitive advantages in demand in the low-carbon world.

Keywords: Initiative “4 per mille”, greenhouse gases, soil carbon, climate change, soil.

INTRODUCTION

On June 18–20, 2019 the city of Poitiers (France) held an international conference on the topic: “Food Security and Climate Change: “4 per 1000” Initiative, New Tangible Global Challenges for Soils” (for details, see the website: https://symposium.inra.fr/4p1000, as well as the information article in the Natural Resource journals (Ivanov, Stolbovoy, 2019). The conference was attended by more than

160 scientists from the European Union countries, the USA, Australia, China, New Zealand and others.

We should remind that the global Initiative “4 per mille” or “4 per 1000” was launched by the international soil community in 2015 after the Climate Conference in Paris. The initiative aims to promote the adoption of cost-effective and environmentally friendly agricultural practices in the direction of carbon sorption. At the same time, the initiative aims to several tasks in sustainable development related to climate change and food security. The initiative is based on the proposal made by the Minister of Foreign Affairs of France to compensate for greenhouse gas emissions by their soil absorption. In this proposal, “4 per mile” is the share of global emissions in the total carbon stock in the two-meter layer of the world soils.

What are the main objectives of the Conference? These were declared partnerships to ensure the quality and sustainability of soils, to promote innovation and the exchange of knowledge, as well as to ensure decision making in the framework of “4 per 1000” Initiative. It should be noted that, as it follows from the list of tasks, the main issues discussed go beyond the scope of “4 per mille” Initiative itself and are associated with the problems of sustainable development. In this sense the topic of the Conference is consonant with the national report “Global climate and soil cover of Russia...” (National Report..., 2018). It is important to emphasize that, despite differences in formulations, thematically the problems of Russian and foreign soil institutes are close.

The conference provided a platform for the views exchange of scientists, decision makers, funding agencies and geopolitical structures to discuss critical issues, real opportunities and challenges for the initiative implementation. Moreover, the Conference often emphasized that cooperation is necessary to balance strong scientific creativity with pragmatic needs in short-term and long-term solutions to reducing risks. Along with that, the necessary representation of the concerned parties is a key factor. A forum with a lot of concerned participants can analyze a good amount of useful ideas, introduce common methods leading to the efficient use of soils in different countries. All of the above is necessary to change the fundamental trajectory of the world community development and to improve the life quality.

The message aims to share the results of the Conference work and express some ideas which we came up with during its work.

RESULTS AND DISCUSSION

The report which we presented on the topic: "Initiative 4 ‰ – Russia's Perspective" (Ivanov et al., 2019) analyzes the ability of Russian soils to compensate for anthropogenic carbon emissions into the atmosphere. The report also noted that Russia has a number of government programs, including the Soil Fertility Program, the Agricultural Land Monitoring Program, where humus (organic carbon) is the main criterion for soil quality. Moreover, in the "Guidelines for the State Cadastral Assessment" approved by Ministry of Economic Development of the Russian Federation (Order of the Ministry of Economic Development No. 226, dated May 12th, 2017), humus content and thickness of humus horizon are some of the criteria for soil quality (Fig. 1).

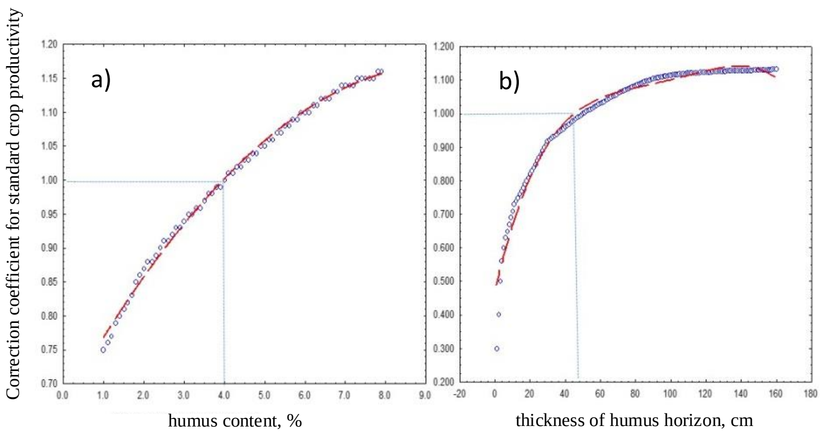


Fig. 1. The dependence of the standard grain crop productivity on the following factors: a) humus content in the soil plough-layer; and b) the thickness of the humus horizon (Ivanov et al., 2019).

The dashed lines in Figure 1a show that the correction coefficient for the standard crop productivity is equal to 1.00 with the humus content of about 4 %. A higher humus content leads to an increase and a lower – to a decrease in the standard grain crop productivity. The dashed lines in Figure 1b illustrate that the correction coefficient for the standard crop productivity is 1.00 at the thickness of the humus layer of about 44 cm. The large thickness of the humus horizon leads to an increase in the standard crop productivity. Upon reaching 100 cm, the thickness of the humus horizon does not affect the standard crop productivity. The thickness of the humus horizon less than 44 cm leads to a decrease in the standard grain crop productivity.

It should be noted that the state programs listed above are aimed exclusively at controlling the organic matter content in soils and do not include measures to increase it, as in the case of the objectives of “4 per mille” Initiative. In other words, the goal of existing national programs is to preserve the carbon stocks in soil humus. Obviously, “4 per mille” Initiative fundamentally complements the existing traditions of state control of agricultural lands conditions and is aimed primarily at increasing the content of organic matter in agricultural soils.

The report also presents the results of scientific and practical work on the study of up-to-date carbon content dynamics in the soils of Russia, the balance of organic matter in plowlands (Fig. 2), etc. In particular, in our report it was noted that from historical perspective Russia has developed humus/carbon saving technologies of agricultural production. This is due to the country's traditional limited use of mineral fertilizers. Humus saving technologies were provided by systems of self-rotation, which maintained the balance of organic matter in soils. We should note that this practice led to relatively small losses of organic matter stocks in arable soils of the country. Thus, in our estimation (Stolbovoi, 2002), the total decrease in organic carbon stocks was about 16 %. For comparison, according to the published foreign data, similar losses could reach 50 % or more.

In assessing the average carbon loss in Russian soils, it must be borne in mind that when forest soils were involved in agricultural activity, which had a thin humus horizon (mainly dwarf sod-podzolic ones) in their original state, organic matter accumulated. Such an increase was noted for soils of 15 non-chernozem regions of Russia.

The increase in organic carbon concentration is associated with the formation of arable organic-accumulative horizon, which was determined by the cultivation of crops with a developed rhizosphere, the use of organic fertilizers, liming, etc.

What carbon amount are we talking about in “4 per mille” Initiative in terms of Russia? Obviously, without an answer to this question, it is difficult to discuss the possibility to set the national task “4 per mille”. We should note that in our opinion the key aspect of answering to the above question is the decision about which soils have anthropogenically regulated carbon storage potential. Thus, in the widely cited Minasny’s study (Minasny et al., 2017), all daytime soils of the world are assigned to such soils. At the same time, some co-authors of the Minasny’s article (Savin and Stolbovoy) in the section devoted to Russia express the view that the closest potential for the country is agricultural soils, for which there are real carbon regulation tools that are widely used in humus saving production technologies. The authors noted above stated this in the national report “Global Climate and Soil Cover of Russia...” (National Report..., 2018) and in the article: “Can Agricultural Soils of Russia Affect Climate Change?” (Stolbovoy, Savin, 2018) However, it will be fair to admit that the possibilities to affect the reservoir of soil carbon in different countries are not the same. Therefore, regarding the implementation of “4 per mille” Initiative, national approaches and priorities should be used.

So, the common goal within the meaning of “4 per mille” Initiative is to compensate for the total annual emission of CO_2 into the atmosphere by soils. This emission in Russia is estimated approximately 2 500 million tonnes of CO_2 equivalents (The Seventh National Report..., 2017), which, recalculated for carbon, is about 681 million tonnes of C. Thus, the latter is the national goal of “4 per mille” Initiative. Knowing the amount of emission, we can calculate how many per mille it will be for our country. For this, it is necessary to correlate the total annual CO_2 emission (681 million tonnes of C) with the carbon stocks in the 2-meter soil layer in Russia, which, according to our data (Stolbovoi, 2002), are equal to 373 billion tonnes of C. Calculations show that the desired fraction is less than two ppm. In other words, the global CO_2 absorption rate of “4 per 1000” is translated into the national goal of “2 per 1000”, i.e. twice less.

The explanation for a significant decrease in the rate of CO_2 absorption lies in the fact that the soils of Russia are characterized by an increased, compared to other countries of the world, reserve of soil organic carbon (Table 1). It was previously shown (Stolbovoi, 2002) that the stock of organic carbon in the country soil layer of 0.3 m is about 23 % of the global reserves and almost 19 % – in the soil layer of 1.0 m, while the country's share in the soil cover of the world is about 12 % The increased stocks of soil organic carbon in the soils of Russia are associated with intense accumulation of organic carbon in the conditions of cold and humid climates domination.

For wildlands the total reserves of organic carbon in the at-ground and underground biomass of Russia amounted to about 51.3 billion tonnes of C (Table 1). Organic carbon reserves in a meter-deep soil layer of the country were almost 297 billion tonnes of C. The total reserve of organic carbon (vegetation plus soil) in Russian at-ground ecosystems was approximately 349 billion tonnes of C. The ratio of organic carbon stock in the biomass to organic matter stocks in the soils, averaged for natural zones of Russian at-ground ecosystems, was about 1/6.

Table 1. Carbon stock in both soils and plant biomass calculated for wildlands in each natural zone of Russia (based on Nilsson et al., 2000; Stolbovoi, 2002).

Natural zone		Stocks, 10^9 tC		Sum	The ratio of stocks in soils to stocks in plants
Name	Area*, 10^6 ha	Soils, layer 1.0 m	Vegetation**		
Polar deserts	0.7	0.1	1.0	1.1	n\s
Tundra	266.9	44.2	2.0	46.2	22
Forest tundra and north taiga	233.0	62.6	5.3	67.9	12
Middle taiga	683.6	111.3	29.1	140.4	4
South taiga	211.5	40.9	10.7	51.6	4
Forests of temperate climates	60.4	8.7	3.8	12.5	2
Steppes	148.8	27.3	1.2	28.5	23
Semi deserts and deserts	25.4	2.4	0.2	2.6	12
Total	***1 629.8***	***297.4***	***51.3***	***348.7***	***6***

Note: * excluding the area of inland waters and hard rocks extraction;
**a coefficient of 0.5 was used at calculating plant dry matter content into carbon.

Moreover, this ratio reached its highest values (1/22–23) in bare natural zones such as tundra and steppes. In forest zones of taiga and forests of temperate climates, the ratio of carbon stocks in at-ground and underground biomass to organic carbon stocks in soils ranges from 1/2 to 4. For comparison, the global stocks of organic carbon in plant and soils of at-ground ecosystems are 2 477 billion tonnes of C (466 and 2011 billion tonnes of C, respectively) (IPCC, 2000).

Thus, organic carbon stocks of at-ground ecosystems in Russia make up more than 14 % of the world values. The ratio of organic carbon stocks in plants and the soils of at-ground ecosystems of the world is about 1/4. The differences in the total organic carbon reserves in the plants and the soils of Russia and in the world are determined mainly by the increased accumulation of carbon in soils.

The decrease in the carbon absorption rate mentioned above – the "transformation" of the international "4 per mille" Initiative into the national goal of "2 per mille" – is also associated with a reduction in CO_2 emissions as a result of the industrial production decline in the country. At the same time, a decrease in the rate of carbon absorption in Russian soils compared with the global average does not give practical advantages, since it does not affect the value of the total annual CO_2 emission. Therefore, in order to avoid confusion in the future we will use the internationally accepted term "4 per mille"

How realistic are the objectives of the national goal of "4 per mille" Initiative? To answer this question, first of all, it is necessary to understand the modern dynamics of the carbon content in the soils of Russia, associated with climate change and changes in the reserves of organic matter, determined by the modification of the land use.

Our studies (Stolbovoy, Ivanov, 2014) show that at present the annual carbon balance in Russian soils is positive and amounts to about 76 ± 32 million tonnes of C (Table 2).

Table 1. Carbon balance (1×10^6 tonnes of carbon) in the organogenic horizons and in organic matter profiles of Russian soils (Stolbovoy, Ivanov, 2014).

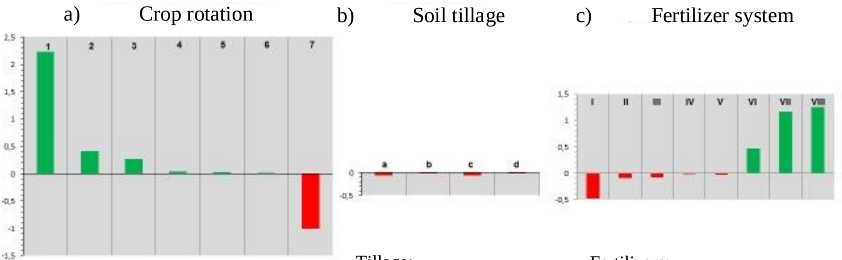
Natural zone	Plowland	Grazing lands	Forests	Waterlogged shallow peatlands	Deep peatbogs	Shrubs and grasses	Altogether in the zone
Organic horizon (O)							
Tundra	0	-3.6	-0.9	19.9	-17.0	17.7	16.1
Forest tundra and north taiga	0	-2.2	-43.5	15.8	-52.4	12.0	-70.3
Middle taiga	0	-16.1	-32.1	-0.4	-43.6	22.7	-69.5
South taiga	0	-12.4	-24.9	-0.5	-31.1	10.6	-58.3
Forests of temperate climates	0	-4.6	17.5	0.6	-0.2	8.4	21.7
Steppes	0	9.5	43.8	3.9	2.4	127.8	187.4
Semi deserts and deserts	0	-0.9	1.1	0.6	0.1	22.4	23.3
Total for the lands	0	-30.3	-39	39.9	-141.8	221.6	50.4

Organic-accumulative horizon (A1)							
Tundra	0	0	0	0.1	0.2	0.5	0.8
Forest tundra and north taiga	0	0	0.7	0.1	0.2	0.1	1.1
Middle taiga	0	0	4	0.2	0.4	0.8	5.4
South taiga	0.1	0	1.6	0.3	0	0.2	2.2
Temperate forests	0.1	0	0.5	0	0	0.1	0.7
Steppes	0.7	0.3	0.5	0	0	0.8	2.3
Semi deserts and deserts	0	0	0	0	0	0.2	0.2
Total for the lands	0.9	0.3	7.3	0.7	0.8	2.7	12.7
Organic-illuvial horizon (Bh)							
Tundra	0	-0.1	-0.2	0.7	-0.2	-4.9	-4.7
Forest tundra and north taiga	0	0	-2	0.7	-0.6	-0.2	-2.1
Middle taiga	-0.2	-0.2	11.9	1.7	0.3	0.6	14.1
South taiga	-0.6	-0.2	3.5	0.2	0.4	0.3	3.6
Forests of temperate climates	-0.5	-0.1	-0.4	0	0	-0.1	-1.1
Steppes	0.4	0.1	1.3	0.1	0.1	1.8	3.8
Semi deserts and deserts	-0.1	-0.2	0	0	0	-0.4	-0.7
Total for the lands	-1.0	-0.7	14.1	3.4	0	-2.9	12.9

Natural zone	Plowland	Grazing lands	Forests	Waterlogged shallow peatlands	Deep peatbogs	Shrubs and grasses	Altogether in the zone
Organic Profile (O + A_1 + Bh)							
Tundra	0	-3.7	-1.1	20.7	-17.0	13.3	12.2
Forest tundra and north taiga	0	-2.2	-44.8	16.6	-52.8	11.9	-71.3
Middle taiga	-0.2	-16.3	-16.2	1.5	-42.9	24.1	-50.0
South taiga	-0.5	-12.6	-19.8	0	-30.7	11.1	-52.5
Forests of temperate climates	-0.4	-4.7	17.6	0.6	-0.2	8.4	21.3
Steppes	1.1	9.9	45.6	4.0	2.5	130.4	193.5
Semi deserts and deserts	-0.1	-1.1	1.1	0.6	0.1	2.0	22.8
Total for the lands	-0.1	-30.7	-17.6	40.0	-141.0	221.4	76.0

Such dynamics is associated with an increase in average annual temperatures and precipitation, which stimulates an increase in the productivity of vegetation and leads to an increase in the supply of plant residues to the soil. As noted above, the mass of carbon absorbed by soils is 76 ± 32 million tonnes of C per year, which is about 11 % of the national goal of "4 per mille" initiative.

An additional part of organic carbon can be found in agriculture transition to carbon-saving production technologies, including manipulations with crops, fertilizers, processing technologies (Fig. 2) and others. According to our estimations (National Report..., 2018; Stolbovoy, Savin, 2018), considering the accumulation of organic carbon by fallow lands (0.8–1.2 billion tonnes of C), the potential of arable and pasture soils for carbon sequestration in Russia is about 2.4 billion tonnes of C.



Crops:
1 – perennial grasses
2 – autumn-sown rye
3 – autumn-sown wheat
4 – oat
5 – spring wheat
6 – barley
7 – potato

Tillage:
a – moldboard
b – combined energy-saving
c – combined layer
d – anti-erosion

Fertilizers:
I – no fertilizer (control)
II – $N_{30}P_{30}K_{30}$
III – $N_{60}P_{60}K_{60}$
IV – $N_{90}P_{90}K_{90}$
V – $N_{120}P_{120}K_{120}$
VI – manure 40 tonnes
VII – manure 40 tonnes + N_{40}
VIII – manure 40 tonnes+ N_{60}

Fig. 2. The annual carbon balance (tonnes of C per ha) in the arable gray forest soil of the Vladimir Opol'e depending on: a) crop rotation; b) the method of soil tillage; c) fertilizer systems applied.

The greatest positive balance (+ 2.4 tonnes of C per ha) is noted under the perennial grass culture (Fig. 2a). A negative balance (– 1.4 tonnes of C per ha) is found under the potato culture. A positive balance (+ 1.2 tonnes of C per ha) is also formed when higher doses of manure are introduced (Fig. 2c). The applied soil treatment did not have a significant effect on the soil organic matter balance (Fig. 2b). The study of carbon balance (Fig. 2) illustrates the practical ability to control the carbon content in soils.

According to the long-term field experiments conducted by R. Petrosyan on the experimental fields of Vladimir Opol'e of the Verkhnevolzhsky Agrarian Center (Ivanov et al., 2019), for example, the production of spring wheat from manured fallow allows statistically significant annual accumulation of 1.08–1.41 tonnes of C per ha in the soil. Calculating for the arable lands in Russia (about 80 million hectares), the total volume of sequestration can reach 80.64–112.8 million tonnes of C. This value of sequestration is 12–17 % of the volume required by the national goal of "4 per mille" Initiative.

Thus, the total annual absorption (natural dynamics and carbon-saving technologies) can be about 23–28 % of the national target, i.e. can reach a quarter of the total annual CO_2 emissions by Russia. We believe that the "4 per mille" Initiative mechanism will operate successfully for 12–15 years, which corresponds to the time of arable soils saturation with carbon.

The international goal of "4 per mille" Initiative cannot be fully achieved in Russia. This conclusion should not be dramatized, since it only confirms the fact that regulating the concentration of greenhouse gases in the atmosphere is a very difficult task. Its solution requires a comprehensive approach, including the transformation of the energy and the industrial sectors of the economy, as well as the environmental management. It is naive to believe that the regulation of the concentration of greenhouse gases in the atmosphere can be carried out by simple one-step approaches.

We should note that "4 per mille" Initiative both contributes to a decrease in the concentration of greenhouse gases in the atmosphere and coincides with the idea of sustainable development of agricultural production and works for it. In other words, the "4 per mille" initiative has a clear double effect. It should be noted that increasing humus content of soils not only concerns greater carbon content, it also involves the accumulation of nutrients, such as nitrogen, phosphorus, potassium, leads to improved water-physical properties, structural state of soils, their aeration, water retention capacity and etc. All of the above will contribute to increasing soil fertility, increasing crop yields while reducing the consumption of mineral fertilizers. As a result, an increase in humus content will contribute to promoting production of environmentally friendly products in Russia, improving quality of the natural environment and the people's life.

However, the international Initiative "4 per mille" is not only Russian positioning among the countries that have chosen energy-efficient environmental development. It is important that the country finds and realizes its competitive advantages, demanded in the low-carbon world. These advantages are associated with vast territory and significant land resources that allow manipulating land use systems in order to absorb greenhouse gases by soils. Diversification of the country's economy is designed to mitigate social-economic consequences of lower energy exports in the future. In other words, the Paris Agreement sets a wider range of tasks for Russia than just the need to reduce greenhouse gas emissions. We agree with those experts who believe that Russia needs to adapt to the new energy landscape and gradually switch to a new model of economic growth that defines the country's new position in the world economy. Russia has a globally significant potential for intensifying agricultural production. In the modern world, the questions of what with and how we should begin to realize this potential capacity to complete our global food mission remain topical.

CONCLUSIONS

In conclusion we would like to note that we expressed a restrained opinion about the possible contribution of Russian soils (23–28 % of the annual total carbon dioxide emissions) to achieving the national goal to reduce greenhouse gases concentration in the atmosphere. Obviously, the soils can solve only part of the problem, and it seems important to determine the size of this part.

Another significant conclusion of the Conference should be the fact that the soil resources of the world are the subject of sharp scientific and practical debate. Russia, which has a huge reserve of soil resources, including climate control ones, should not keep out of these discussions, reflecting the trends of modern global development processes. As the experience of our participation in the Conference on "4 per 1000" Initiative shows we have something to propose on the issue under discussion and we have a lot of things to do in scientific and practical terms.

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