The implementation of the FAO Carbon Protocol (GSOC-MRV) in the experimental farm of the Ural State Agrarian University

Nadezhda Vashukevich[1,2,*]

[1]Ural State Agrarian University, 620075,42, Liebknecht str., Ekaterinburg, Russia
[2]Ural Federal University, 620002,19, Mira str., Ekaterinburg, Russia

Abstract. The introduction of various methods of conservation and maintenance of soil organic carbon (SOC) reserves in soils is directly related to the active development of carbon trading markets, the evidence base for which is, in particular, the GSOC-MRV Protocol. This article presents the first results of the practice of implementing the carbon protocol on the territory of the educational farm of the Ural State Agrarian University. In particular, sites were selected to assess the carbon pool in soils under conventional agricultural production practices (BAU), as well as when implementing Sustainable Soil Management (SSM) practices. The first studies showed that as a result of applying the soil-protective agriculture practice in the form of sideration, 64 tons of Sorghum ha-1 for a layer of 0-10 cm and 48 tons for a layer of 10-20 cm were accumulated in 5 years on experimental plots. The approximate rate of soil organic carbon accumulation for the conditions of the Middle Urals when using sideral crops is about 11 carbon units per year. The work was carried out within the framework of the State Task of the Ministry of Science and Higher Education of the Russian Federation, number FEUZ-2023-0023 Ural-Carbon project.

1 Introduction

The concept of "carbon agriculture" appeared in the Kyoto Protocol of 2004, it is associated with farming and animal husbandry practices that minimize greenhouse emissions and contribute to the atmospheric carbon sequestration [1].

The Food and Agriculture Organization of the United Nations (FAO) has defined Conservation Agriculture (CA) as an approach to managing agroecosystems that promotes sustainable agricultural production, reduces energy and labor costs, and increases the efficiency of using soil and water resources.

In 2019, FAO's Global Soil Partnership launched the RECSOIL (recarbonization of soils) program [2], the main goal is to stimulate soil health through soil-protective agriculture. 2 projects were part of the RECSOIL initiative: the GSOCseq global carbon sequestration map, as well as technical guidelines on best practices for the conservation and maintenance of soil

* Corresponding author: vashukevich@urgau.ru

organic carbon (SOC) reserves in soils. The introduction of these best practices is directly related to the active development of carbon trading markets, in which farmers receive compensation payments only when greenhouse emissions are actually reduced. The evidence base is MRV protocols (Measurement, Monitoring, Reporting, Verification). With the help of these documents, the amount of carbon deposited in the soils of farms is measured, and on this basis carbon credits are allocated for sale on the market.

In 2020, FAO's Global Soil Partnership has published the document "A protocol for measuring, monitoring, reporting and verification of soil organic carbon in agricultural landscapes – GSOC-MRV Protocol" [3]. The purpose of the document, which is sometimes called the "carbon protocol", is to provide a standard methodology for measuring the reporting and verification of SOC and greenhouse gases (GHG) emissions during the implementation of agricultural projects.

This article presents the first results of the practice of implementing the GSOC-MRV carbon protocol on the territory of the educational farm of the Ural State Agrarian University. The work was carried out within the framework of the Ural-Carbon project"[4]. Ural SAU is a member of a consortium of universities and research institutes within the framework of the direction "assessment of landscape, weather, climatic, and anthropogenic factors of carbon deposition by ecosystems and the development of predictive models based on this"[5].

2 Materials and methods

The GSOC-MRV Protocol methodology is based on the requirement of phased implementation. A brief description of the stages is given below [6].

At stage 1, the time and territorial framework of the project is determined. According to the Protocol, the project is possible both on the scale of an entire farm and in "Intervention Areas (IA)", i.e., sections of one or more fields, plots, or pastures. It is mandatory to study the history of land use, as well as differences in soil cover, which determines the soil carbon reserves.

At stage 2, it is necessary to identify the general boundaries of the project and identify individual areas where conventional agricultural production is carried out – BAU (Business as Usual), as well as areas with soil-saving agriculture or SSM (Sustainable Soil Management) practice.

Stage 3 - selection of the model needed to calculate the volumes of organic carbon that will be deposited when implementing SSM practice. Modeling is performed for a period of up to 20 years. In modeling, it is important to consider not only the carbon content in the soil, but also greenhouse gas emissions.

Stage 4 - monitoring of changes in the soil organic carbon (SOC) content. The most preferred method of selection of soil samples according to the MRV protocol is a stratified, static synchronous method with fixed points provided with geodata.

Stage 5 - Monitoring reports (initial, two-year, and subsequent during the project implementation).

The studies of the soil samples presented in this work were carried out in the ecoanalytic laboratory of the Komi Institute of Biology of the Scientific Center of the Ural Branch of the Russian Academy of Sciences, which in 2018 was accredited in the Global Network of Soil Laboratories (GLOSOLAN) and recognized as the national reference laboratory of the Russian Federation "[7].

The determination was carried out using the soil organic content (SOC) Measurement Method on the element analyzer EA 1110 (CHNS-O), 88-17641-004-2016 [8].

3 Results and Discussion

We will present the first results of the practice of implementing the FAO carbon protocol (GSOC-MRV) at the sites of the training and experimental farm of the Ural SAU.

The territorial scope of the project and the choice of plots. The GSOC-MRV Protocol adaptation project at the first stage was carried out on sites where basic land use practices and SSM practices are used.

As BAU plots (Figure 1), production fields 4 and 9 are selected, which differ by soil types (4 - agro-gray soil; 9- agrochernozem clay-illuvial, podzolized), as well as plots under perennial grasses (5 - haymaking; 7 - pasture). Figure 2 shows the scheme of selection and binding of soil samples taken at the base sites in October 2022.

Fig. 1. Cartography of BAU plots under arable land, hayfields, and pastures of the educational and experimental farm of the Ural SAU (AgroMon digital platform).

Fig. 2. Cartography of soil sampling with geodata for plot 4 (BAU) entered into the AgroMon digital platform database

The selection of soil samples, according to the requirements of the GSOC-MRV protocol, was carried out using a stratified, static synchronous method with constant points provided with geodata. Sampling depth is from 0 to 10 cm. Soil density and organic carbon will be determined in the samples.

The second block of plots was chosen to characterize the SSM practice. Experimental plots were used, where in 2017-2022, Associate Professor of the Department of Soil Science, Agroecology, and Chemistry V.A. Chulkov conducted research to assess the effect of siderates on the biological properties and yield of grain crops.

The soil of the experimental site is clay-illuvial, podzolized agrochernozem. The humus horizon contains a large number of exchange bases, has an actual acidity neutral or close to neutral. The link of the field crop rotation: green-manured fallow – spring barley. Pea + oat, spring rapeseed, white mustard, lupin, phacelia, fodder beans were grown as siderates according to generally accepted technologies. The experiment was carried out in three-fold repetition by the method of systematic placement of variants. Mineral fertilizers were not applied for the sowing of siderates. Sowing was carried out in the first half of May. The planting of green mass into the soil was carried out during the flowering of legumes, cruciferous crops and during the earing of bluegrass, the green mass was considered from plots of 10 m2.

The condition of soils under various siderates variants was assessed by microbiological activity (laying of linen cloths), considering the number and mass of earthworms, the volume mass, humidity, and soil structure were determined. The research results are presented in the papers [9,10].

In the summer of 2022, mixed soil samples were selected (from depths of 0-10 and 10-20 sm) under various variants of sideral crops and on a dead fallow plot. In parallel, samples were also taken from the 20-year-old deposit adjacent to the experimental field (control), as well as the initial background soils (gray forest soils) from the site of the indigenous forest located next to the experimental field.

The analysis of soil samples (fig. 3) for the soils of SSM plots was carried out according to the requirements of the standard operating procedure for SOC adopted in GLOSOLAN.

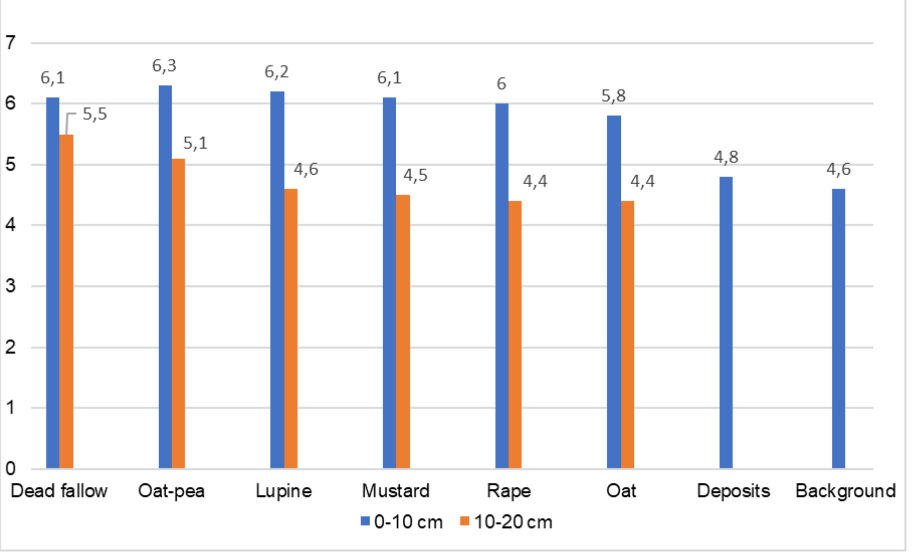

Fig. 3. Organic carbon content (%) in soils of SSM plots

Monitoring of changes in the carbon content in soils. The analysis of the results obtained allows to draw the following conclusions. The relative error of the average in the series of layered distribution of organic carbon was 3.8-4%, which indicates a fairly good accuracy of research. The coefficient of variation in the range of 3-9% shows a weak variability of the data obtained, regardless of the sampling depth and the composition of the sideral crops.

In general, we can talk about a significant effect of the siderates used in the experimental plots on the organic carbon content in the upper 10 cm layer, where it is 5.8-6.3%, which is more than 1.5% higher than the level of Corg. in the deposits and in the background soil.

An assessment of SOC reserves was also carried out (fig. 4) using data on soil density, which was 1.27 g/cm^2 under the deposit, 1.05 g/cm^2 in the background soil, and 1.21 g/cm^2 under fallow.

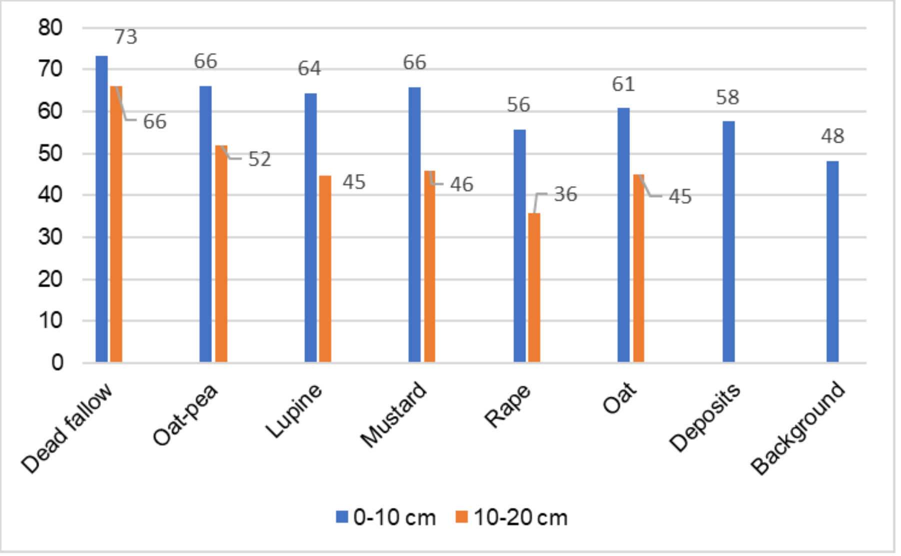

Fig. 4. Reserves of organic carbon in the soils of SSM plots, t/ha

The calculated reserves of organic carbon allow to draw preliminary conclusions about the approximate rate of its accumulation in the experimental field areas where the practice of soil-saving agriculture is applied.

The average value for a layer of 0-10 cm under various sideral crops is 64 tons of Corg. ha-1 (or 234 tons of CO_2), for a layer of 10-20 cm – 48 tons of Corg. ha-1 (175.9 tons of CO_2). If we assume that the relative accumulation of 16 tons of Corg. ha-1 (58.6 tons of CO_2) was provided due to the active use of siderates over 5 years of experience, then the average accumulation rate per year is about 3 tons of Corg. (11 tons of CO_2) per hectare.

4 Conclusion

The materials obtained for the implementation of methodological approaches of the FAO Carbon Protocol (GSOC-MRV) are primary. In the future, they will be verified both in connection with analytical data on soil samples from the plots of the basic land use option, and with model calculations of carbon sequestration.

The main purpose of implementing the protocol is the implementation of practical projects, for example, the creation of carbon farms, which are defined as "any part of the land surface for which there are documents on the volume of CO_2 absorption by it" [11].

Acknowledgements

The work was carried out within the framework of the State Task of the Ministry of Science and Higher Education of the Russian Federation, number FEUZ-2023-0023 Ural-Carbon project.

References

1. V. Belyaev, A. Varlagin, V. Dridiger, I. Kurganova, L. Orlova, S. Orlov, A. Popov, A. Romanovskaya, A. Toigildin, N. Trots, A. Fomin, D. Khomyakov, IACJ, **1**, 421-441

(2022) URL: https://scholar.google.com/scholar?cluster=5210801106658631653&hl=ru&as_sdt=0,5&as_ylo=2022&as_yhi=2022

2. Recarbonization of global soils - A tool to support the implementation of the Koronivia Joint Work on Agriculture (2019) URL: https://www.fao.org/3/ca6522en/CA6522EN.pdf
3. A protocol for measurement, monitoring, reporting and verification of soil organic carbon in agricultural landscapes, GSOC-MRV Protocol. (FAO. Rome 2020) URL: https://doi.org/10.4060/cb0509e
4. Ural-Carbon URL: https://carbon-polygons.ru/en/polygons/ural-carbon-cmta
5. N. Vashukevich, M. Karpukhin, IACJ, 6 (2022) URL: https://cyberleninka.ru/article/n/otsenka-uglerodsekvestriruyuschego-potentsiala-pochv-agrolandshaftov-srednego-urala
6. G. Peralta, *MRV protocol for measurement, monitoring and verification of soil organic carbon,* (2022) URL: https://agriecomission.com/base/mrv-protokol-po-izmereniu-monitoringu-i-verifikacii-organicheskogo-ugleroda-pochvy
7. E. Shamrikova, B. Kondratenok, E. Tumanova, E. Vanchikova, E. Lapteva, et al., Geoderma, **412**, 115547 (2022) URL. DOI: 10.1016/j.geoderma.2021.115547
8. E. Vanchikova, B. Kondratenok, E. Tumanova E.A E. Measurement procedure, 88-17641-004-2016 (FR.1.31.2016.23502), 29 (2016). (Syktyvkar: IB Komi SC of the Ural Branch RAS, 2016)
9. V. Chulkov, T. Chapalda, AGVU, **4** (207) (2021) URL: https://cyberleninka.ru/article/n/otsenka-vliyaniya-sideratov-na-biologicheskie-svoystva-chernozema-opodzolennogo-v-zvene-polevogo-sevooborota
10. M. Karpukhin, V. Chulkova, V. Chulkov, E. Batyrshina, Vestnik Kurganskoy GSHA, 3 (43) (2022) URL: https://cyberleninka.ru/article/n/biologicheskie-svoystva-chernozyoma-opodzolennogo-pri-ispolzovanii-razlichnyh-sideralnyh-kultur-po-sisteme-organicheskogo
11. L. Efremova, IACJ, **2**, 220-227 (2022) URL: https://cyberleninka.ru/article/n/rol-karbonovoe-zemledelie-v-ekonomicheskoy-stabilnosti-rossii/viewer