The Influence of Technologies for the Introduction of Fallow Lands into Circulation in the Forest-Steppe on the Intensity of Soil Carbon Dioxide Emissions

Igor Bobrenko[a], Natalia Homan[b] Olga Nezhevlyak[c], Elena Bobrenko[d] and Irina Trotsenko[e]
Omsk State Agrarian University named after P.A. Stolypin, 1, Instituskaya Square, Omsk, 644008, Russia
{ia.bobrenko, nv.goman, eg.bobrenko, ov.nezhevlyak, ia.trotsenko@omgau.org}

Keywords: Fallow lands, Forest steppe of Western Siberia, Carbon dioxide emission, Monitoring.

Abstract: The amount of carbon dioxide emissions into the atmosphere increases due to the introduction of large areas of fallow lands into agricultural circulation. Therefore, it is important to investigate this problem, to determine the size of carbon dioxide emissions from fallow lands with various technologies of their introduction into circulation in the conditions of the forest-steppe of Western Siberia. Technologies for introducing fallow lands into circulation have a significant impact on carbon dioxide emissions. Monitoring of soil CO2 emissions at the sites of the studied fallow lands in the South of Western Siberia in 2022 showed a significant variation in the size of the flows, both depending on the time of day, during the season, and depending on the technology of introducing these lands into circulation.

1 INTRODUCTION

Currently, large areas of fallow lands are being introduced into agricultural circulation. At the same time, the amount of carbon dioxide emissions into the atmosphere increases. In particular, it depends on the agricultural technologies that are used in this case. Therefore, it is important to investigate this problem. As a result, criteria for determining the priority of re-development of fallow lands will be justified, taking into account the assessment of the effectiveness of their management, focused on carbon sequestration. The analysis of environmental monitoring data on the dynamics of carbon dioxide flows on the studied land plots will allow calculations of greenhouse gas emissions and runoff on fallow lands put into circulation using various technologies and justify their introduction into the structure of land use. The aim of the research is to determine the size of carbon dioxide emissions from fallow lands with various technologies of their introduction into circulation in the conditions of the forest-steppe of Western Siberia (Bobrenko, Matveychik, Bobrenko, Popova, 2021; Nezhevlyak, Bobrenko, Dolgova, Korolev, 2022).

2 METHODS

To study the impact of technologies for the introduction of fallow lands into circulation on carbon dioxide emissions in the Kormilovsky district of the Omsk region, field experiments were conducted at a site with an age of fallow lands of 5-10 years. The first technology provides only agrotechnical treatments (agrotechnical technology), the second – chemical treatments with herbicide (combined technology). The agricultural equipment at each experimental site is adapted to the research area. The area of the experimental plots is 200 sq. m.

1. Control (without treatments)
2. The main treatment is disking in two tracks to a depth of 10 -12 cm with a BDM 7x2P disk header + the second treatment with a BDM 7x2P disk header to a depth of 12-15 cm.

[a] https://orcid.org/ 0000-0002-2496-0773
[b] https://orcid.org/0000-0001-8959-5888
[c] https://orcid.org/ 0000-0002-8943-5531
[d] https://orcid.org/0009-0005-8219-4869
[e] https://orcid.org/ 0000-0003-0109-8460

3. The main treatment: disking in two tracks with a BDM 7x2P disk header to a depth of 10-12 cm + the second treatment: chemical with herbicide of continuous action "Glyphosate" at a dose of 2 l/ha of the drug.

The first treatment was carried out on July 9, 2022, the second – on September, 9, 2022.

The soil cover of the fallow area is a complex of meadow-chernozem crust-columnar low-sodium heavy loamy and meadow-chernozem moderately deep and shallow medium-humus heavy loamy soil. The density varied from 1.07 g/cm^3 in horizon A $_1$, up to 1.26-1.50 g/cm^3 in saline and sub-saline horizons. Content of C_{org} in horizon A $_1$ and B $_1$ in solonetz is 3.84 and 3.65%, respectively. The number of exchange-absorbed cations in horizon B_1: Ca^{2+} - 22.0, Mg^{2+} - 14.3, Na^+ - 2.04 mmol/100 g. Medium reaction in horizon A $_1$ is close to neutral (pH 6.96), in horizon B $_1$ it is slightly alkaline (pH 7.4), in sub-saline and Sc - alkaline and strongly alkaline (pH 8.44-8.77).

Carbon dioxide emissions were determined monthly with an interval of 10-15 days, starting from July to October. Plastic insulator devices consisting of a base 10 cm high and a cylindrical vessel with a hole for soil air intake 20 cm high and 23.5 cm in diameter were used as chambers (Nezhevlyak, Bobrenko, Korolev, Dolgova, 2022; Voronkova, Bobrenko, Nevenchannaya, Popova, 2020).

The repetition is threefold. The bases were cut into the soil to a depth of 6 cm, before determining the intensity of respiration. The plants were cut at the soil level. Thus, the determined carbon flow determined the total respiration of soil microflora, roots, etc. without taking into account the respiration of the ground layer of phytomass.

Gas sampling for carbon dioxide content in the chambers was carried out with an air sampler for the soil chamber in hermetically sealed vacuumated glass vials (volume 30 ml) during the day (24 hours) at an interval of three hours. The exposure time was 5, 10, 30 minutes with the sampling of control samples after 5, 10, 30 minutes. The analysis of gas samples was carried out using a Crystal 5000.2 gas chromatograph.

Temperature, soil humidity (every 10 cm to 100 cm), air temperature and nitrogen, phosphorus and potassium content (0-20 cm) were determined simultaneously with gas sampling at the sites selected for the study of carbon dioxide emissions during the entire measurement period. Soil temperature was determined using soil thermometers, soil moisture was determined by the weight method, the content of macronutrients by standard methods corresponding to the type of soil (Nevedrov, Sarzhanov, Protsenko, Vasenev, 2022; Meshalkina, Yaroslavtsev, Vasenev, Valentini, 2015).

The emission rate of CO_2 from the soil was calculated using the formula (Panikov, Gorbenko, 1992; Larionova et al, 1998):

$$ER\ CO_2 = (C2-C1) * H/t,$$

where ER CO_2 is the emission rate of CO_2, mg S/m^2 /hour; C2 and C1 are the final and initial concentrations of CO_2 inside the insulator, mg S/m^3; H is the height of the insulator above the soil surface, m; t is the exposure time, hour.

3 RESULTS

Soil carbon dioxide emission is a highly variable parameter depending on the natural and climatic zone, time of year (season), day (Kurganova, 2010; Komarova, 2019).

Daily dynamics of soil carbon dioxide carbon flows. The most pronounced daily dynamics of soil carbon dioxide emissions was on fallow lands when introduced into circulation using agrotechnical technology in July and varied from 44.7 g to 66.9 g of CO_2 /m^2 * day-1), in August – from 22.9 g to 43.3 g of CO_2/m^2 * day-1); for fallow lands when put into circulation using a combined technology: in July from 39.7 g to 52.4 g, in August – from 21.4 g to 40.3 g CO_2/ m^2 * day-1 with strongly contrasting night and day air and soil temperature indicators with greater intensity of CO_2 soil flows in the morning and afternoon hours and less - in the evening and at night (Figure 1).

Seasonal dynamics of soil carbon dioxide carbon flows. Monitoring of soil carbon dioxide emissions during the warm season for fallow lands when introduced into circulation using agrotechnical technology showed a significant variation in its size (Figure 2) with the highest rates in July (53.1 g of CO_2/m^2 * day-1) and the lowest in September (27.1 g); for fallow lands when introduced into turnover with the use of combined technology, respectively, 45.8 and 17.4 of CO_2/m^2 * day-1. The reason for this is seasonal variability of air temperature, soil temperature and humidity. The agrotechnical technology of introducing fallow lands into circulation contributed to a greater emission of carbon dioxide than the combined one. At the same time, the differences in the intensity of flows are less than in the subtaiga zone.

Technologies for introducing fallow lands into circulation have a significant impact on carbon dioxide emissions. Compared with the control, it increased from 31.4 g in the control to 41.2 g of CO

$_2/m^2$ * day-1 with agrotechnical technology (tillage), and with combined (tillage + herbicide treatment) - up to 33.9 g of CO_2/m^2 * day-1 (on average for the period after the beginning of treatments).

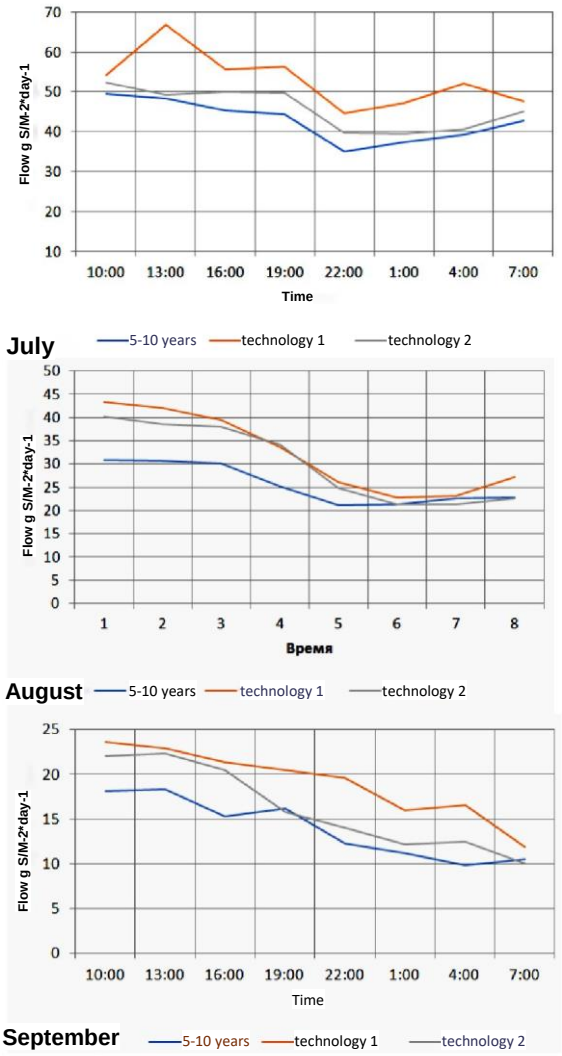

Figure 1: Daily dynamics of soil CO2 emissions during the introduction of fallow lands into circulation in the forest-steppe zone of southern Western Siberia (July-September, 2022).

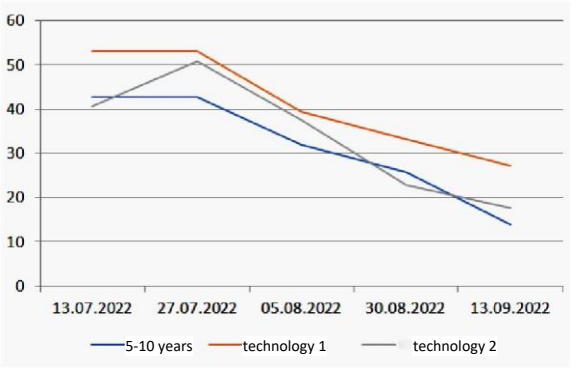

Figure 2: Seasonal dynamics of soil CO2 emissions during the introduction of fallow lands into circulation in the forest-steppe zone of southern Western Siberia (July-September, 2022).

Technologies for introducing fallow lands into circulation have a significant impact on carbon dioxide emissions. Compared with the control, it increased with agrotechnical technology (tillage) by 1.31 times, with combined (tillage + herbicide treatment) by 1.08 times.

Monitoring of soil CO_2 emissions at the sites of the studied fallow lands in the South of Western Siberia in 2022 showed a significant variation in the size of the flows, both depending on the time of day, during the season, and depending on the technology of introducing these lands into circulation.

ACKNOWLEDGEMENTS

The scientific research based on the publication was carried out at the expense of a grant from the Russian Science Foundation in the priority direction "Conducting fundamental scientific research and exploratory scientific research by individual scientific groups" (regional competition), conducted jointly with the authorities of the subject of the Russian Federation (Omsk region) under the scientific project: "Science-based system for monitoring greenhouse gas flows in various technologies for the introduction of fallow lands into circulation", AGREEMENT No. 22-17-20049.

REFERENCES

Bobrenko, I.A., Matveychik, O.A., Bobrenko, E.G., Popova, V.I., 2021. Changes in humus content in

forest- steppe soils of Western Siberia. *Earth and environmental science*, 624. 012219.

Nezhevlyak, O., Bobrenko, E., Dolgova, D., Korolev, A., 2022. Agro-ecological assessment of the soil cover of the forest zone in Omsk region. IOP Conference Series: Earth and Environmental Science. Cep. "International Conference on World Technological Trends in Agribusiness, WTTA" 2022. pages 012052.

Nezhevlyak, O., Bobrenko, E., Korolev, A., Dolgova, D., 2022. Agro-ecological characteristics of arable soils of the forest-steppe and steppe in Omsk region. IOP Conference Series: Earth and Environmental Science. Cep. "International Conference on World Technological Trends in Agribusiness, WTTA". pages 012053

Voronkova, N.A., Bobrenko, I.A., Nevenchannaya, N.M., Popova, V.I., 2020. Efficiency of biologization of agriculture in Western Siberia (on the example of the Omsk region). *IOP Conference Series: Earth and Environmental Science*, № 548(2). 022071.

Nevedrov, N.P., Sarzhanov, D.A., Protsenko, E.P., Vasenev, I.I., 2022. Spatial and Temporal Dynamics of Carbon Dioxide Emission from Al-Fe-Humus Sandy Soils in the Forest-Steppe Zone. Eurasian Soil Sciencethis link is disabled, 55(11). pages 1546–1555

Meshalkina, J., Yaroslavtsev, A., Vasenev, I., Valentini, R., 2015. Seasonal Dynamics of CO2 Fluxes in Two Central-Russian Agroecosystems with Contrasting Ecological and Agronomic Conditions. *Agronomy*, 12(7). pages 1606.