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CO_2 at introduction of fallow into circulation on gray forest soil

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Abstract. The work is devoted to research of CO_2 emission dynamics on fallow lands of 5-10 years of age. The purpose was to study the amount of CO_2 emission from gray forest soil at different technologies of fallow land introduction into agricultural turnover in the sub-boreal forest of Western Siberia. Technologies of fallow land introduction into turnover have a significant influence on CO_2 emission. Spring wheat was cultivated on experimental plots under 2 technologies (methods) of fallow land introduction into turnover. In comparison with fallow land, CO_2 emission increased by 1.35 times at agrotechnical technology (with pre-sowing tillage). At combined technology (direct sowing) - 1.18 times. The agrotechnical technology of fallow land restoration contributed to higher CO_2 emission (than the combined technology), probably due to higher intensity of soil tillage during fallow land restoration with this technology and increased aeration and microbiological activity in the soil layer. On the basis of the data obtained on carbon dioxide emission from gray forest soils in the sub-boreal forest, models of soil CO_2 emission depending on the applied technology of fallow land conversion were developed.

1 Introduction

At present, as a result of anthropogenic activities, the concentration of greenhouse gases is increasing. The formation of fallow lands leads to changes in the fluxes of biogenic elements in the plant-soil-atmosphere system due to the accumulation of carbon dioxide in soils and plants, and the introduction of such lands into agricultural turnover leads to an increase in soil carbon dioxide emissions [1-4]. The development of technologies for the introduction of fallow land should be based on monitoring data of carbon dioxide concentration and take into account climatic and soil characteristics, topography, as well as the technologies themselves [5-8]. Monitoring data will make it possible to assess the carbon balance and the contribution of set-aside land to the storage of climate-active gases.

The purpose of the research is to study the magnitude of CO_2 emission from the gray forest soil under different technologies of introducing fallow land into agricultural turnover.

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2 Methods and Materials

Field experiments studying different technologies for introducing fallow lands into turnover in sub-boreal forests of the south of Western Siberia for monitoring soil carbon dioxide emissions in 2023 were conducted.

The soil cover is represented by gray forest thick and medium thick soils with Sorgh content in A1 and A1A2 horizons of 2.1-2.55%. Differences in properties of gray forest soils on deposits of different ages were revealed. On deposits of 20-30 years the soil is light loamy (physical clay 66.1%), with insignificant value of hydrolytic acidity (0.89 mmol/100 g), on deposits of less than 10 and 10-20 years the soil is light loamy (physical clay 21.8-28.1%) with more pronounced acidity (3.4-5.0 mmol/100 g). The content of mineral nitrogen before sowing in the 0-20 cm soil layer in the subtaiga zone was average and high, mobile phosphorus - elevated, potassium - low.

To studying the impact of fallow land introduction technologies on greenhouse gas emissions, field work was carried out in the Tarsky District of Omsk Oblast. The field experiments laid in 2022 with two technologies of fallow lands introduction into turnover: agrotechnical and combined (with the use of chemical means of weed control) were continued. Experiments were conducted on fallow land plots with the age of 5-10 years. The first crop of crop rotation, spring wheat, was cultivated on experimental plots in all zones. The 1st technology provided tillage before sowing, the 2nd one was direct sowing (without pre-sowing tillage), with application of chemical treatment with herbicide during vegetation (combined technology). The area of experimental plots was 200 m^2. Experiment scheme:

1. Control (fallow land).
2. Agrotechnical technology. Tillage: moldboard plowing with plow PLN 3-35 to a depth of 20-22 cm, pre-sowing discing with harrow BDT-3 in two traces to a depth of 10 - 12 cm.
3. Combined technology. Direct sowing, without pre-sowing tillage. Treatment (chemical) with a continuous herbicide "Glyphosate" at a dose of 2 liters/ha on the preparation.

Sowing on May 25 with planter SZZ 2.1, the norm - 5 million/ha, variety Stolypinskaya 2. Treatment with herbicide on July 5. Harvesting September 18.

Repetition of three times. The bases of the chambers were cut into the soil to a depth of 6 cm, before determining the intensity of respiration.

The value of air-dry above-ground mass of plants on fallow plots was determined, it was 1.11-1.64, on average 1.34 t/ha at the end of vegetation of plants. The yield of spring wheat in field experiments was 2.12 t/ha at agrotechnical technology 1 and 1.95 at combined technology.

Repetition on each variant of the field experiment was threefold. Gas sampling for CO_2 content in the chambers was carried out by air sampler in hermetically sealed 30 ml vials during the day at an interval of 3 hours. Soil temperature, soil moisture, soil property parameters were determined by standard methods [9-15].

3 Results

Soil CO_2 emission is an indicator that varies greatly with climate, time of year and day, and cultivation technology [2-3, 16].

Monitoring of soil emission of carbon dioxide on the fallow land when introduced into rotation with the use of agrotechnical technology revealed a significant variation in its size (Figure 1), with the highest values in early August (104.5 g $CO_2/m^{-2} \cdot day^{-1}$), and the lowest in October (20.8 g $CO_2/m^{-2} \cdot day^{-1}$); on the fallow land when introduced into rotation with the use of combined technology, 85.0 and 19.5 g $CO_2/m^{-2} \cdot day^{-1}$, respectively. The reason for this is the dynamics of air temperature, soil temperature and moisture. Differences in flux

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intensity under different technologies become significantly smaller by September and October.

The studied technologies of fallow lands introduction into turnover have a significant impact on CO_2 emission. Compared to the control, it increased with agrotechnical technology (with pre-sowing treatment) from 37.4 g $CO_2/m^{-2} \cdot day^{-1}$ in the control to 50.5 g $CO_2/m^{-2} \cdot day^{-1}$, with combined technology (with direct sowing) to 44.0 g $CO_2/m^{-2} \cdot day^{-1}$. The maximum flux increase is observed in the period after sowing until early August.

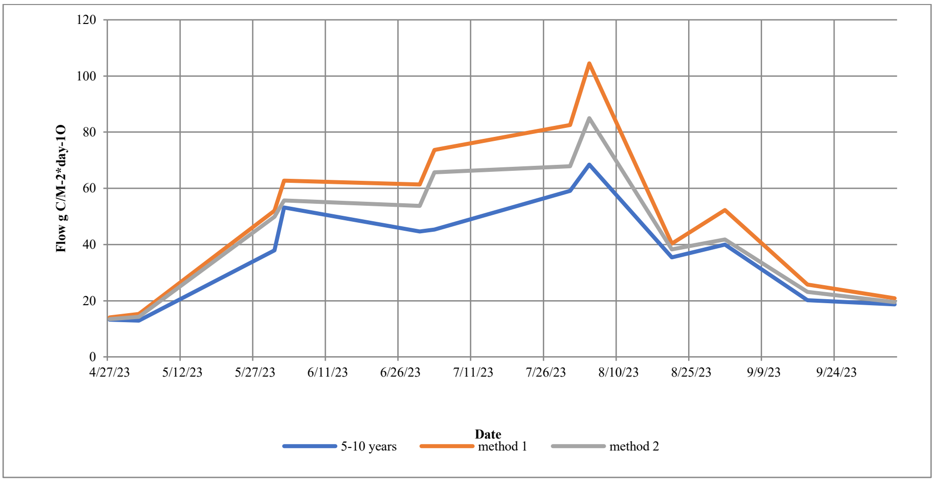
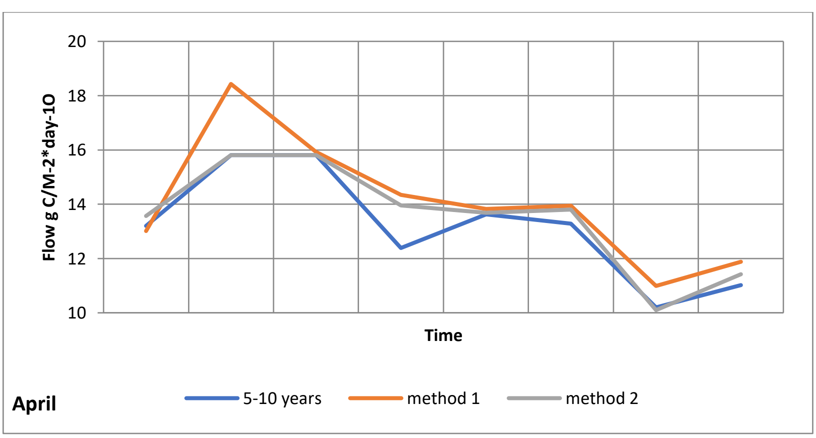


Fig. 1. Seasonal changes in CO_2 emission by gray forest soil when fallow lands put into circulation on (April-October, 2023)

The studied key areas of fallow lands were characterized by certain daily dynamics of carbon dioxide emission: it has an increased level in the morning and daytime hours, decreased in the evening and night hours (Figure 2) which is generally characteristic of this process due to the corresponding changes in the temperature regimes of soil and air [3-5].



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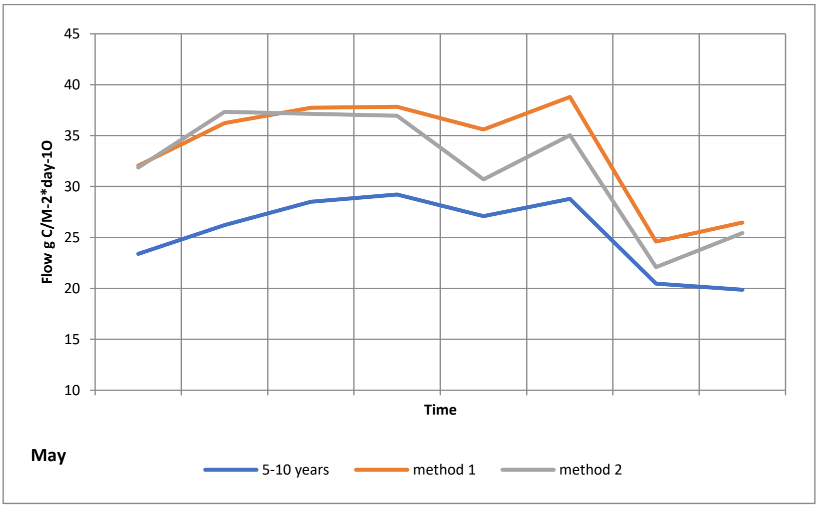

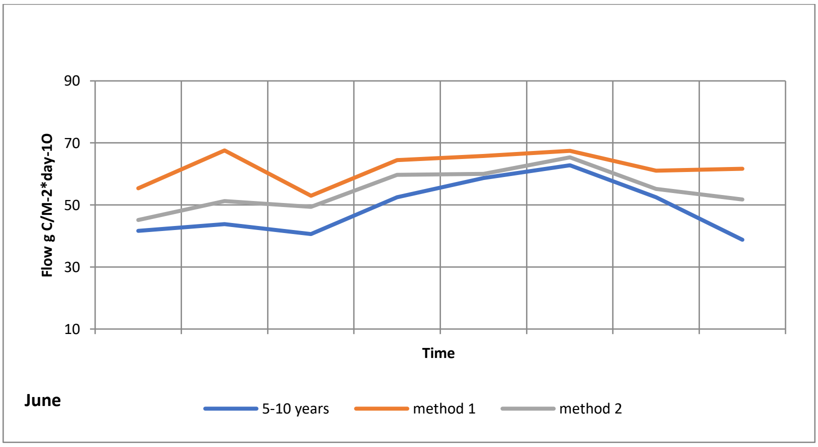

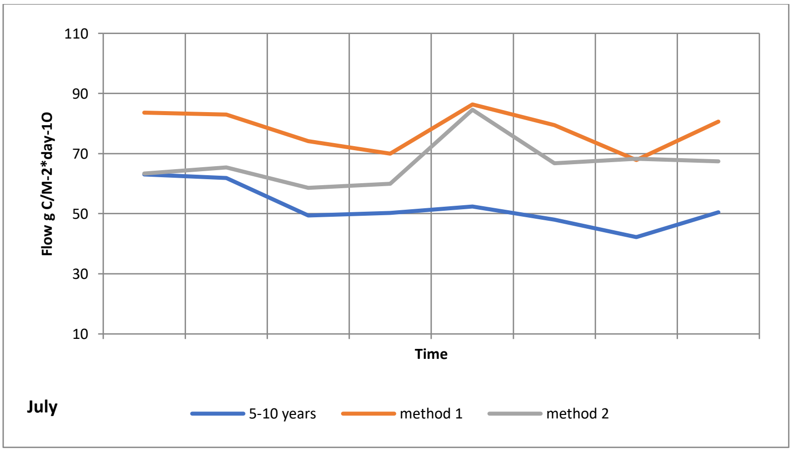

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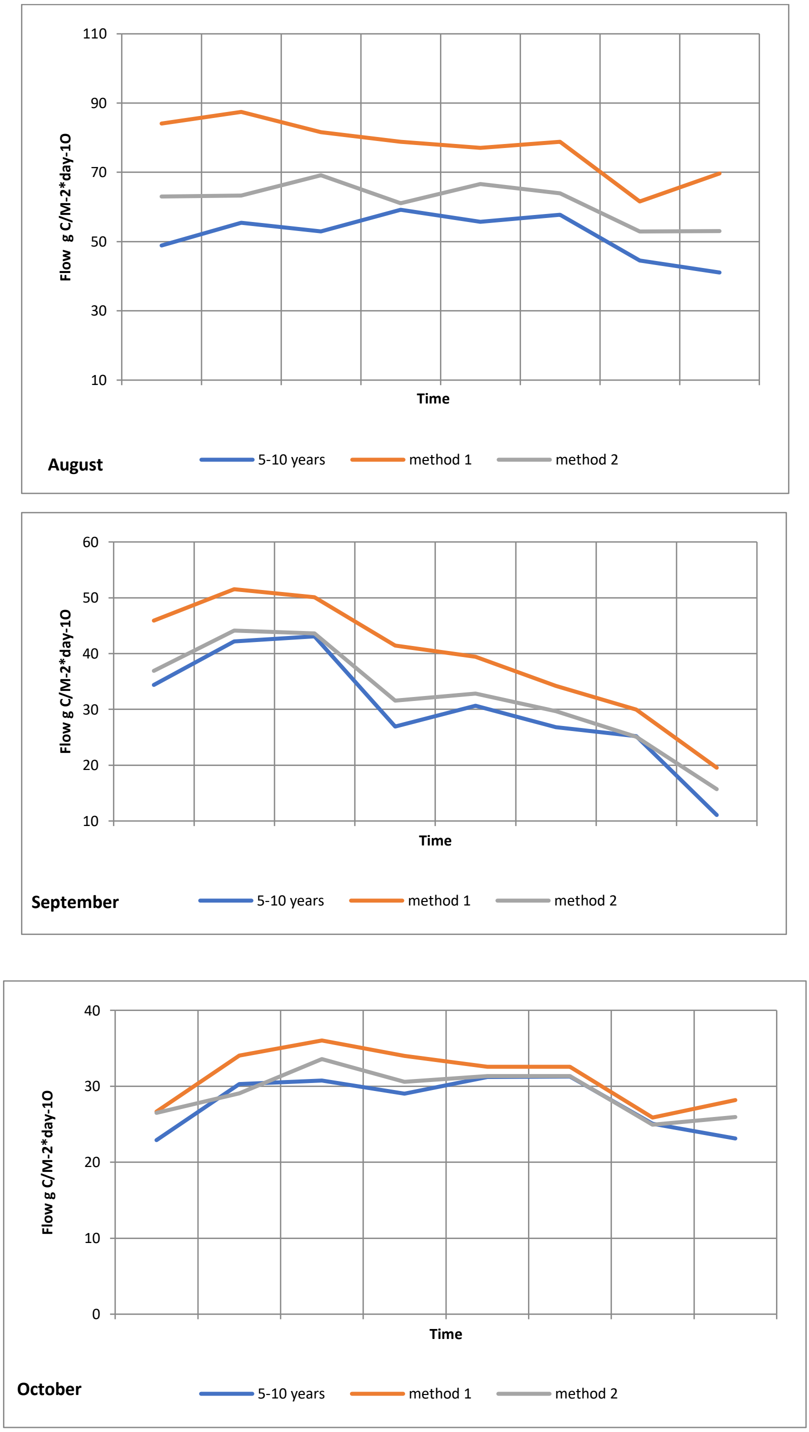

Fig. 2. Daily change of CO_2 emission by gray forest soil when fallow lands put into turnover (April-October, 2023).

Based on the data obtained for carbon dioxide emission from gray forest soil in sub-boreal forest, models of soil CO_2 emission were developed depending on the applied fallow land entry technology. Significant correlations ($r > 0.40$) during the research period were obtained for the emission (C) of soils of key sites with soil temperature (T), its moisture acted on the emission to a lesser extent. For this reason, in the models the emission size dependence was established only on soil temperature (°C) at a depth of 10 cm (x):

1. Control, fallow 5-10 years $C = 2.68T - 1.13$ ($r = 0.59$);
2. Agrotechnical method $C = 2.08T + 19.3$ ($r = 0.40$);
3. Combined method $C = 3.09T + 6.67$ ($r = 0.58$).

4 Conclusions

The technologies of fallow land introduction into sales have a significant impact on CO_2 emission. In comparison with fallow land, it increased by 1.35 times at agrotechnical technology (with pre-sowing tillage). With combined (direct) sowing - 1.18 times. The agrotechnical technology of fallow land restoration contributed to higher CO_2 emission (than the combined technology), probably due to higher intensity of soil tillage during fallow land restoration with this technology and in this connection increased aeration and microbiological activity in the arable layer.

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