Summary of the doctoral dissertation

Carbon dioxide emission from soils in conditions of differentiated tillage technology for sugar beet

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This dissertation presents the results of empirical and model studies of CO_2 fluxes between the sugar beet agroecosystem and the atmosphere during the growing season under the conditions of conventional and reduced pre-winter tillage.

The justification for conducting these studies was the need to search for soil tillage technologies that would improve the carbon balance of arable soils and the balance of CO_2 exchange of agro-ecosystems with the atmosphere.

The general objective of the research was to determine the magnitude and dynamics of CO_2 emission and absorption fluxes of sugar beet crop, and to determine, on their basis, the balance of net CO_2 exchange between this agroecosystem and the atmosphere during the growing season on variants of conventional and reduced pre-winter tillage. The practical aim of the research was to indicate the most favorable cultivation system from the point of view of protecting carbon resources in the soil and the most favorable from the perspective of the atmosphere.

The research was carried out in 2010-2016 on a farm located in the Kujawy region, in Więcławice (52°50' N, 18°18' E). The field experiment was located in a complex of soils classified as black earths (Phaozems). The two-factor field experiment included 2 variants of traditional (typical ploughing, subsoiling preceded by ploughing) and reduced tillage (subsoiling, zero tillage) associated with 2 variants of catch crop cultivation (white mustard) and mulching of the soil surface. Variants of pre-winter tillage were the superior factor, and variants of catch crop cultivation were the subordinate factor.

Field measurements included: CO_2 flux from soil (soil respiration, Sr), total agro-ecosystem respiration (TER), net CO_2 ecosystem exchange (NEE) and supplementary characteristics (soil temperature and moisture, meteorological parameters, leaf area index, plant root biomass). Field measurements of CO_2 fluxes were carried out using the method of closed ventilated chambers. Model research and analyzes included the calculation of the above-mentioned fluxes using semi-empirical models and the DNDC mathematical model.

The main hypothesis assumes that the magnitude of net CO_2 exchange with the atmosphere (NEE) and soil respiration (Sr) of the sugar beet agroecosystem are different under the conditions of conventional and reduced pre-winter tillage preceding cultivation of this crop.

Experimental studies and analyzes showed that the net CO_2 ecosystem exchange (NEE) and soil respiration (Sr) of the sugar beet agroecosystem differed under the conditions of conventional and reduced pre-winter tillage. The use of reduced tillage resulted in a favorable change of NEE flux during the growing season from the perspective of the atmosphere as well as from the perspective of the agroecosystem compared to conventional tillage. The cumulative seasonal value of NEE (from the perspective of the atmosphere) on the conventional tillage variants ranged on average from -3.2 t $CO_2 \cdot ha^{-1}$ on the variant with subsoiling and plowing to -4.8 t $CO_2 \cdot ha^{-1}$ on the variant with typical plowing, while on the variants of reduced tillage it was lower and ranged from -8.5 t $CO_2 \cdot ha^{-1}$ on the variant without tillage to -10.5 t $CO_2 \cdot ha^{-1}$ on the variant with subsoiling.

The use of reduced tillage resulted in a beneficial change in the amount of CO_2 flux from soil respiration from the point of view of protecting carbon resources in the soil in comparison to conventional tillage. The cumulative seasonal value of Sr on conventional tillage variants ranged on average from 36.3 t $CO_2 \cdot ha^{-1}$ on the variant with plowing preceded by subsoiling

to 36.9 t $CO_2 \cdot ha^{-1}$ on the variant with a typical plowing. On the variants of reduced tillage it was lower and ranged from 29.3 t $CO_2 \cdot ha^{-1}$ on the variant without tillage to 30.3 t $CO_2 \cdot ha^{-1}$ on the variant with subsoiling.
It was also shown that the performance of pre-winter tillage treatments for sugar beets induced a strong impulse of CO_2 emission from the soil immediately after tillage, which varied in the type of treatment. The highest cumulative CO_2 emissions from the soil surface in the periods of up to 24, 48 and 72 hours from the moment of pre-winter tillage was most often recorded on variants with traditional pre-winter tillage, i.e. typical plowing and plowing preceded by subsoiling. In the period up to 72 hours from the moment of the tillage, they were on average 489.5 kg $CO_2 \cdot ha^{-1}$ on the variant with typical plowing and 356.7 kg $CO_2 \cdot ha^{-1}$ on the variant with ploughing after subsoiling. In the variant with subsoiling, the cumulative CO_2 emission was on average 260.9 kg $CO_2 \cdot ha^{-1}$, and on the variant without pre-winter tillage 182.4 kg $CO_2 \cdot ha^{-1}$.
The DNDC model was calibrated and the correct simulations of soil respiration in the sugar beet agroecosystem was carried for the conventional cultivation system.

Key words:

soil respiration, net ecosystem exchange, total ecosystem respiration, gross primary production, reduced tillage, pre-winter plowing, subsoiling, phaeozem, DNDC model