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Changes in organic carbon pools and C sequestration potential in abandoned Chernozems

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Land use system in Russia has been significantly changed since 1990. More than quarter of croplands (about 34 M ha) including soils of southern regions (Chernozems. Kastanozems) was abandoned. The abandonment of cultivated lands and successive establishment of natural vegetation led to carbon (C) accumulation in soil, qualitative changes in organic C pools and microbial community. This study was aimed (1) to quantify the different C organic pools (total, labile, recalcitrant, and microbial) in the former arable Chernozems depending on the abandonment period and (2) to estimate C sequestration potential of soils after land use change from crops to natural vegetation.

Our investigations were carried out on arable soil under winter wheat and soils abandoned 5, 11, 21 and 77 years ago after land use change from crops to permanent grassland (Haplic Chernozems, Rostov region, Russia, 47o27'N, 39o35'E). The total soil organic C (Ctotal, dichromate oxidation method), labile and recalcitrant C (after 7 week incubation at 20 oC and 60% of water holding capacity) were determined in the former plough-layer (0-20 cm). A first order two-component model was used for the analysis of cumulative CO2-C evolution, calculation of mineralization rate constants for labile and recalcitrant C-pools, and estimation of their mean residence time (MRT). Carbon immobilized in microbial biomass (Cmic) was estimated by fumigation-extraction method before and after 10 weeks of incubation without and following addition of glucose at rate of 730 μg/g of soil. Carbon sequestration potential of soils (CSP, %) was calculated using the ratio between extra C-CO2 release induced by glucose addition and amount of C applied to soil.

Our results showed that the establishment of perennial vegetation after land use change from arable Chernozems to permanent grassland resulted in the significant C-accumulation in soils. The SOC-content (0-20 cm layer) increased from 2.08±0.03 to 2.24±0.04% for the first 5 years of abandonment and reached 2.87±0.07% in the 77-yr grassland. The C-stock increased linear with the period of abandonment and changed from 4330 g C/m2 in arable Chernozems to 6650 g C/m2 after 77-yr of permanent grassland. The average C accumulation rate was maximal (280 g C/m2yr) during the first 5 years of abandonment and then soils sequestered C at a rate of 41 and 5 g C/m2•yr for the following 16 and 56 yr, respectively. The average C accumulation rate for entire 77-yr period amounted to 30 g C/m2•yr.

Content of microbial C was the lowest in arable and the highest in the 77-yrs grassland as well. The share of Cmic in SOC was minimal in arable soil and 5-yr grassland (1.17-1.21%), and reached to 1.55% after 77 yr of abandonment. The abandonment of arable Chernozems resulted in increase of recalcitrant fraction in the soil organic C pool: 20.6 mg C/g in arable soil vs. 28.6 mg C/g in 77-yrs old abandoned land. The MRT of recalcitrant C in soils after 11-77 years of abandonment was 1.9-2.2 times higher than that in arable soil. The labile C was decreased from 0.25 mg C/g in arable soil to 0.12 mg C/g in soil after 77 years of abandonment. The total C-CO2 release during 10 weeks of incubation decreased from 1.01-1.12 mg C/g in arable soil and young grassland (5 yrs after abandonment) to 0.74-0.77 in old grasslands. Addition of glucose induced the extra C-CO2 release that amounted to 0.22-0.41 mg C/g of soil depending on land use. The extra C-release was maximal in arable soils. It was found that applying of glucose resulted in more significant increase of Cmic in arable soil and 5-yrs grassland in comparison with soils of forest belt, 21- and 77-yrs grasslands. Carbon sequestration potential varied from 44%

in arable to 70% in the 77-yrs grassland.

We conclude that land use change from crops to natural vegetation leads to organic C accumulation, increase of microbial C, and increase of C sequestration potential in soils. The C accumulation in soils is mainly caused by the sequestration of recalcitrant C pools. The conversion of arable Chernozems to permanent grassland will promote C sequestration in soils.

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