Geophysical Research Abstracts
Vol. 18, EGU2016-3365, 2016
EGU General Assembly 2016

Dynamics of pedogenic carbonate accumulation in soils under different land use as an impulse to simulation study of water flows in their profiles

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Little is known about changes in pedogenic carbonate accumulation under different land use in forest-steppe ecosystems. This work was conducted to investigate the dynamics of pedogenic carbonate accumulation in cultivated Gray-Forest soils (Luvisols). These soils together with the Chernozems belong to typical soils for the forest-steppe area of the Central Russian Upland. The studied soils were formed on calcareous loess-like loam parent material in well-drained position with groundwater level at 8–10 m depth. Soils were sampled at four sites: a broadleaf forest and an adjacent 50-year continuously cropped field under corn monoculture (first plot), bare fallow (second plot) and crop rotation which includes clean fallow every fourth year (third plot) at the Experimental Station of the Voronezh Institute of Corn in the Voronezh oblast of Russia. All plowed soils are now classified as arable Chernozems (Mollisols). The carbonate status of four soils was studied using hierarchical morphological observation (macro-, meso-, micro- and sub-micro levels) and radiocarbon dating of carbonate pedofeatures. Then, the simulation of soil hydrology for two plots, under corn monoculture and bare fallow, was performed for the vegetation period.

Significant differences in the down-profile carbonates distribution were apparent between pairs of soil pits: under monoculture of corn and forest on the one hand, and under bare fallow and crop rotation on the other. In pits under bare fallow and crop rotation, the depth of carbonate occurrence was about 60–80 cm higher than in the profiles under forest and corn. In addition significant differences were observed in micro- and submicrostructure of carbonate pedofeatures in these two pairs of soils. 14C-date of carbonate soft masses (cutans) from 80–90 cm in the soil under bare fallow was 10650±170 yr BP whereas practically the same date, 11100±100 yr BP, was obtained in the soil under corn from 140–160 cm. Presumably, this difference in carbonate depths and status is due to repeating upward water fluxes, which are much greater in soils under fallow than under vegetation.

Mathematical modeling has shown that under the bare fallow the hydrological regime of Chernozems changed dramatically. In the absence of transpiring vegetation, soil moisture increased as compared to the areas under corn in almost the whole profile of the soil under bare fallow. Under corn a significant part of moisture moves up along the plant roots. As a result, under the same weather conditions the plot under bare fallow provides much more favorable hydrological conditions for the rise of carbonates and their accumulation in the upper part of the profile as compared with the plot under corn.

The reported study was funded by RFBR according to the research projects №№14-04-01761-a, 16-05-00669-a