

Soil, vegetation and total organic carbon stock development in self-restoring abandoned vineyards

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Abandoned vineyard's soil and vegetation development was studied on Tokaj Nagy-Hill, which is one of the traditional wine-producing regions of Hungary, it is declared as UNESCO World Heritage site as cultural landscape. Spatial distribution and pattern of vineyards were changing during the last several hundreds of years, therefore significant part of abandoned vineyards were subjected to long-term spontaneous secondary succession of vegetation and self-restoration of soils in absence of later cultivation.

Two chronosequences of spontaneously regenerating vineyard abandonments, one on south (S-sequence) and one on southwest (SW-sequence) slope with differing times since their abandonment (193, 142, 101, 63, 39 and 14 years), were compiled and studied. The S-sequence was 25-35% sloped and strongly eroded, and the SW-sequence was 17-25% sloped and moderately eroded. The sites were investigated in respect of vegetation characteristics, soil physico-chemical characteristics, total organic carbon stocks (TOC stocks), accumulation rates of total organic carbon (TOC accumulation rates), and soil profiles, which were classified according to the World Reference Base (WRB) 2014.

Vegetation development resulted in shrub-grassland mosaics, supplemented frequently by protected forb species and forest development at the earliest abandonment in S-sequence, and predominantly to forest vegetation in SW-sequence, where trees were only absent at the 63 and 14 years old abandonment sites.

In all sites soils on level of reference groups according to WRB were classified, and Cambisols, Regosols, Calcisols, Leptosols, Chernozems and Phaeozems were found. Soils of the S-sequence show shallow remnants of loess cover with colluvic and redeposited soil materials containing 15-65% skeletal volcanic rock of weathering products coated by secondary calcium carbonates. The SW-sequence profiles are developed on deep loess or loess derivatives. The calcium-carbonate content was higher in profiles of the S-sequence ($18.1 \pm 10.4\%$) than in the SW-sequence ($6.7 \pm 2.7\%$); consequently. The pH of the topsoil was higher in the S-sequence, and correlated significantly negatively with the age of abandonment in both sequences ($r = -0.893$; $p = 0.01$ in S, and $r = -0.739$; $p = 0.05$ in SW). TOC stocks of the top 6 cm soil layers were higher in the S-sequence ($1.82 \pm 0.71 \text{ kg m}^{-2}$) than in the SW-sequence ($0.95 \pm 0.49 \text{ kg m}^{-2}$), and correlated significantly positively with the duration of self-restoration. When calculated for the whole profile, TOC stocks were similar in both S- and SW-sequences (S: $8.21 \pm 3.31 \text{ kg m}^{-2}$; SW: $8.24 \pm 6.01 \text{ kg m}^{-2}$). The TOC accumulation rates of the top 6 cm soil layers exhibited $18.9 \pm 10.0 \text{ g C m}^{-2} \text{ y}^{-1}$ in the S and $7.0 \pm 4.2 \text{ g C m}^{-2} \text{ y}^{-1}$ in the SW-sequence.

Sites with the same age of abandonment developed to different vegetation and had different soil features in both chronosequences, indicating that duration of self-restoration is only one of the directive factors in soil development and carbon sequestration processes after abandonment of viticulture on Tokaj Nagy-Hill, which was significantly affected by lithology, slope steepness and exposition as well.

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