Facts and figures on 16 years of a comparative study of Conventional and Conservation tillage in Hungary

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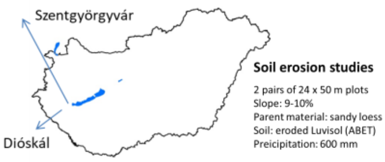
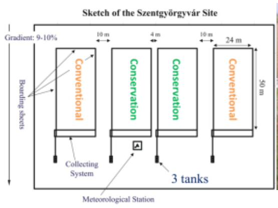
Introduction

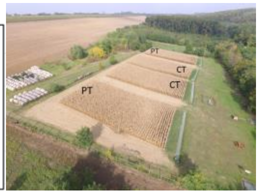
Intensive tillage can lead to severe soil erosion and biodiversity losses. Conservation Tillage (CT) is a sustainable agricultural system. Its main advantages are the protection against erosion and deflation, the improvement of soil and soil fauna, the protection of surface waters and the preservation of biodiversity.

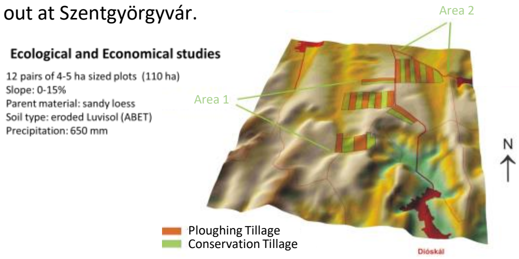
Material and methods

In 2003, an experimental area was set up in Western Hungary for the comparison of the Conventional- (ploughing, inversion tillage; PT) and CT (non-inversion, minimum tillage, with 30% residue cover and combined machines) on hummocky Luvisol (10% slope steepness). 12 pairs of plots (4–5 ha/plot) were created in an area of 107 ha (Dióskál) and 2×2 uniquely designed erosion plots of 24×50 m size were configured (Szentgyörgyvár). During the last 16 years, agroecological and economical experiments took place at Dióskál, while continuous soil and erosion monitoring were carried out at Szentgyörgyvár.









Results

The effect of CT on erosion was favourable compared to PT. The soil loss (SL) on CT could be kept one order magnitude lower than the tolerable amount. The runoff (RO) was reduced by 75%, which increased crop safety in dry periods and decreased pesticide and nutrient loss (Fig. 1-3).

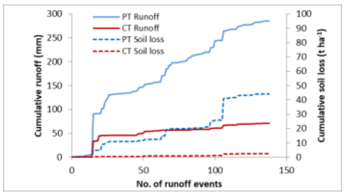


Fig. 1. Cumulative graph of runoff and soil loss at Szentgyörgyvár, 2004–2019. PT: Ploughing-, CT: Conservation Till.

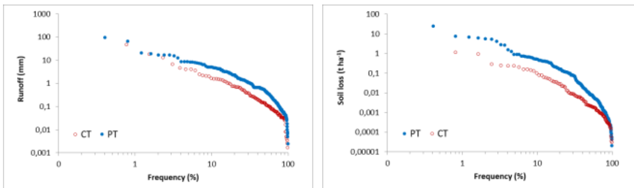


Fig. 2. Amount of runoff and soil loss as functions of their exceedance at experimental plots treated by Ploughing-(PT) and Conservation Tillage (CT) (2004–2019).

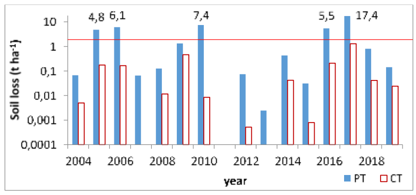


Fig 3. Distributions of annual soil loss under PT and CT treatments. Red line: Soil loss tolerance value (2 t ha^{-1}).

By the end of the study period, significantly higher water-stable aggregates (PT: 20.0%, CT: 30.4%), higher soil organic matter (PT: 1.4%, CT: 1.9%), greater earthworm abundance (4.9 times that in PT plots) was recorded on the CT plots (Fig. 4-5).

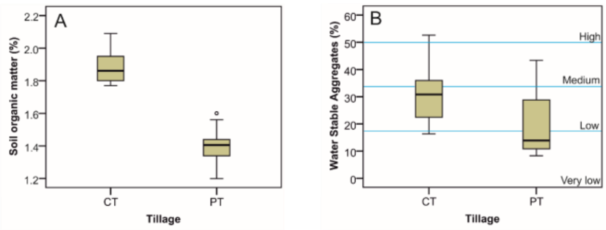


Fig. 4. Distribution of soil organic matter (A) and water stabile aggregates (B) for the experimental plots.

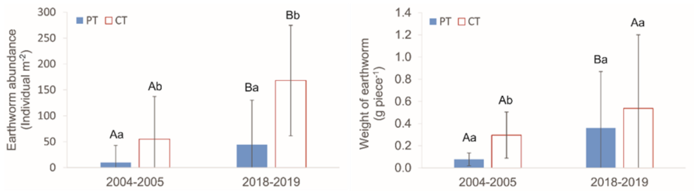


Fig. 5. Mean number and weight of earthworms for the experimental plots in the period of 2004–2005 and 2018–2019. Different letters represent significant differences (p<0.05). Upper case: Comparison of elapsed time effect under fixed tillage; Lower case: comparison of tillage effect in a fixed year.

Conclusions

The present research focussed on the effects of conservation tillage on soil properties and erosion. Here long-term soil erosion data measured on field-scale plots in East-Central Europe are used to determine the key factors of runoff and soil loss. Our data showed that soil organic matter, water-stable aggregates, and earthworm abundance increased significantly in the soil in CT plots after 16 years. This improved soil structure and quality, and a stable gallery network was developed, which facilitated water infiltration and decreased erosion. A stable soil structure is more resistant to erosion by raindrops during storms and less prone to crust development. A large abundance of macropores reduced the likelihood of blockage of the network of channels. The crop residues left on the surface, together with the more rugged soil surface, resulted in a lower rate of RO on CT plots, leaving more time for infiltration. Thus, RO declined by 75% and SL declined by 95% on CT plots, and SL was one order of magnitude lower than its tolerable value. Most of the SL was caused by low-probability, low frequency, high-intensity rainstorms. Both RO and SL depend on the complex interaction of several factors, including antecedent soil quality and condition, soil water content, the mean and maximum intensity of rainfall, and the state of development of the crop canopy. Our results suggest that tillage type, as a factor, was more important, in terms of erosion risk and soil health, than the highly variable climate, plant cover, or crop type (Fig. 6).

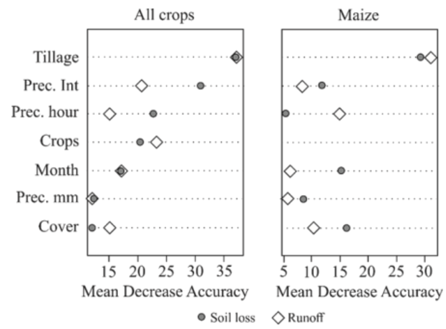


Fig. 6. Overall variable importance, calculated as the mean decrease in accuracy (MDA) for the whole (left), and maize sub-dataset (right), based on the Random Forest classification model with dependent variables runoff and soil loss. Features: Tillage (PT or CT); Cover: plant cover; Month (of event); Prec. mm: precipitation amount; Prec. hour: precipitation duration; Prec. Int.: 30 min precipitation intensity maximum.

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