Controlled Traffic Farming on steep arable land near Nitra, Slovakia

Year of issue

2025

Summary

This case study documents a long-term Controlled Traffic Farming (CTF) experiment on a 16 ha steep arable field operated by the Slovak University of Agriculture near Kolíňany, Nitra Region, Western Slovakia. CTF was introduced in 2009 and the field-scale layout was established in 2010 using a 6 m machinery module with permanent tramlines. The design confines wheel traffic to fixed lanes so that about half the field remains traffic-free. Slopes are mostly 3 to 7 % on silt-loam soils in a continental climate.

The objective was to test whether confining traffic reduces rainfall-induced runoff and soil loss under Central European conditions. The team combined erosion risk mapping using USLE and RUSLE with targeted field measurements. In 2021 they used a rainfall simulator on three locations representing different traffic intensities. They also assessed soil physical condition using a cone penetrometer.

Results show that the no-traffic area showed the lowest runoff, with runoff intensity after 20 min about ten times lower than in the multiple-traffic area. Total sediment collected after 35 minutes was about 70 % lower in no-traffic than in single-pass, and only a quarter of the multiple-pass loss. Across the 16 ha field, modelling indicated that roughly 30 % of the area has a potential annual soil loss of 5 to 15 t ha^{-1}, which aligns with Slovak regulatory thresholds. The traffic-free strips consistently exhibited better structure and infiltration, confirming the mechanism behind reduced runoff.

Implementation factors that supported performance include permanent tramlines perpendicular to slope, a consistent 6 m module, and continuity of the layout over more than a decade. The study also notes that European adoption often follows a tiered pathway, from low-cost layout conversion using existing machinery to wider modules that require equipment changes. While detailed costs for this site are not provided, prior European analyses show potential payback from yield and tillage savings as systems scale. Overall, the case provides robust, Central Europe-specific evidence that CTF can substantially reduce runoff and soil loss on sloping cropland when tramlines are maintained and operations are aligned to the layout.

Photo Gallery



Location

18.2066, 48.3559

Sector

Agriculture

Installation Date

2009

Implementation status

Completed

Contact

Institute of Agricultural Engineering, Transport and Bioenergetics, Faculty of Engineering, Slovak University of Agriculture in Nitra

Overview

Location of the project

University Farm area near Kolíňany, Nitra District, Nitra Region, Slovakia

Country

Slovakia

NUTS2 Code

Západné Slovensko

Sponge measures implemented in the case study

Controlled traffic farming

Objectives

Reduce water runoff and soil loss on steep arable land by confining traffic to permanent lanes and improving infiltration.

Involved partners

Authority type	Authority name	Authority role	Comments	Authority responsibility
Research institute / University	Slovak University of Agriculture in Nitra (SUA)	Initiation of the measure	research lead, design, monitoring	Responsible
Farmers	SUA University Farm Kolíňany	Implementation	site operation and implementation	Responsible
Research institute / University	Czech University of Life Sciences Prague (CZU)	Monitoring	research collaboration in CTF studies	Supporting

Site Information

Climate Zone

Cool temperate moist

Precipitation

416.00 mm

Temperature (°C)

10.29 °C

Elevation range

196–212 m a.s.l.

Slope range

Mostly 3-7 % ; field range about 1-12 °

WFD Ecological status

Moderate

WFD Chemical status

Failing to achieve good

Design and Implementation

Project scale

Micro

Project scale specifications

site experiment on a single field.

Project area

16 ha

Principles

Permanent tramlines confining traffic to about 24 percent of the area; single-pass strips about 39 percent; no-traffic area about 55 percent. Tramlines laid perpendicular to slope. 6 m machinery module.

Factor constraints

Steep arable field with 3-7 % slopes, silt-loam soils, continental climate; orientation of tramlines relative to slope influences runoff. Matched machinery widths and permanent tramlines to confine traffic; layout perpendicular to slope at this site.

Financing

Financing authorities

Authority name	Type of funding	Comments
European Union	EU-funds: Cohesion and regional development funds	Operational Programme Integrated Infrastructure, project “Sustainable smart farming systems…” 313011W112.
Grant Agency of Slovak University of Agriculture in Nitra	Other	—

Policy and Governance

Policy description

Slovak legislation referenced maximum allowable soil loss 15 t ha^{-1} yr^{-1} in analysis. Wider EU policy links not specified.

Land ownership

University Farm Kolíňany (SUA).

Target remarks

Reduce rainfall-induced runoff and soil loss on steep arable land under Central European conditions.

Pressure remarks

Water erosion on cultivated slopes.

Part of a wider plan

Yes

Public consultation

No

Has contractual arrangements

No

Impacts and Monitoring

Monitoring System

Monitoring parameters

Targeted field campaigns using a rainfall simulator and runoff collection, plus USLE/RUSLE modelling and cone-penetrometer surveys in 2021.

Impact Assessment Methodology

Biophysical impact assessment method

USLE and RUSLE for potential soil loss mapping; in situ runoff and sediment sampling; cone-penetrometer measurements with ANOVA.

Socio-economic Impacts

Direct benefits

Reduced soil loss for farming land.

Biophysical impacts: Hydrology

Information on retained water

In rainfall-simulator tests, no-traffic area had the lowest runoff; after 20 min runoff intensity was about 10 times lower vs multiple-traffic area. Onset of runoff was delayed in no-traffic area.

Biophysical impacts: Water & Soil Quality

Information on water quality overall

Total sediment yield after 35-40 min was 70 % lower in no-traffic area vs single-pass, and 75 % lower vs multiple-traffic area.
Lower cone-penetrometer resistance in topsoil under no-traffic area; statistical differences at $p < 0.05$.

Lessons Learned

Key lessons

CTF on steep Central European arable land can markedly reduce runoff and soil loss when permanent tramlines are maintained.

Drivers

Driver type	Driver role	Comments
Organisation committed to it	Main driver	Research need to address erosion

Success factors

Success factor type	Success factor role	Comments
Conducted assessments (incl. economic)	Secondary factor	Long-term continuity of the layout
Available support tools	Main factor	Availability of GNSS and machinery layout enabling CTF.

Flexibility / Adaptability

Tiered adoption pathway in Europe from low-cost conversion to full 8 m modules suggests transferability; results align with UK and Australia studies. In Europe adoption is limited and often requires machinery coordination or replacement.

Sources

Sources

Reduction in Water Erosion and Soil Loss on Steep Land Managed by Controlled Traffic Farming

University Farm Ltd., Kolíňany