Tropentag, September 16-18, 2026, hybrid conference

"Towards multi-functional agro-ecosystems
promoting climate resilient futures"

Effects of long-term reduced tillage on greenhouse gas emissions, soil C and N dynamics and crop-weed responses under ambient and reduced rainfall

Jilan Long[1], Antonios Apostolakis[2], Christiane Muenter[3], Stefan Siebert[4], Klaus Dittert[5], Haitao Wang[6]

[1] *University of Göttingen, Department of Crop Sciences, Germany*
[2] *University of Göttingen, Department of Crop Sciences,*
[3] *University of Göttingen, Department of Crop Sciences,*
[4] *University of Göttingen, Dept. of Crop Sciences; Division Agronomy / Crop Science, Germany*
[5] *University of Göttingen, Crop Sciences, Section of Plant Nutrition and Crop Physiology, Germany*
[6] *University of Göttingen, Department of Crop Sciences, Germany*

Abstract

Reduced tillage (RT) is widely promoted to enhance soil organic carbon sequestration, yet its long-term effects on greenhouse gas (GHG) emissions and crop performance remain uncertain under climate change. We used the long-term Garte-Süd field experiment, established in 1970 in Göttingen, Germany, to compare RT with conventional tillage (CT) on a silt loam Luvisol. In 2023, rainout shelters (2 m × 2 m) were installed to exclude 50 % of rainfall. Crop yield, soil CO_2 and N_2O emissions, soil mineral nitrogen (N), microbial biomass carbon (MBC), and dissolved organic carbon (DOC) were quantified under RT and CT at two soil depths (0–10 cm and 10–30 cm). These variables were measured from March to August 2025 under Faba bean, and from October 2025 onward under Winter wheat. Our results showed that rainfall exclusion did not significantly affect cumulative CO_2 and N_2O fluxes, likely because high soil water retention buffered the moderate water deficit. Instead, gas fluxes were mainly regulated by soil temperature, water-filled pore space, and mineral N, with emission peaks following management events. RT did not affect soil CO_2 efflux but tended to increase N_2O emissions. RT also decreased soil mineral N availability, particularly NO_3-, while reduced rainfall further constrained N dynamics and accelerated leaf senescence, with limited effects on plant growth. However, RT showed slightly higher chlorophyll than CT under reduced rainfall, suggesting improved buffering of soil water and nutrient availability. RT was associated with greater labile C availability in the topsoil (0–10 cm), as indicated by the highest MBC and relatively high DOC, suggesting enhanced microbial activity and substrate turnover in topsoil. In 2025, RT did not significantly affect Faba bean yield or yield components, but it consistently increased weed biomass and weed proportion, suggesting a potential shift in crop-weed competition with implications for crop productivity and nutrient use efficiency over time. Overall, long-term RT reshaped topsoil C and N dynamics more strongly than reduced rainfall, while the main agronomic trade-off was increased weed pressure rather than yield loss. These findings highlighted the need to combine conservation tillage with integrated weed management under variable rainfall conditions.

Contact Address: Jilan Long, University of Göttingen, Department of Crop Sciences, Carl-Sprengel-Weg 1, 37075 Göttingen, Germany, e-mail: jlong@uni-goettingen.de

Keywords: Greenhouse gas emissions, long-term reduced tillage, rainfall exclusion, soil carbon and nitrogen cycling