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Assessing the Sustainability of a Wheat-Based Cropping System under Mediterranean Conditions

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Abstract

In this study, we demonstrate the usefulness of the Agricultural Production Systems Simulator (APSIM) in examining prospects for enhancing the sustainability and productivity of a wheat-chickpea rotation at Tel Hadya, northwest Syria. The analysis included daily weather data from 1979 to 2002 and 5 nitrogen (N) fertiliser (0, 30 to 120 kg N ha^{-1} to wheat only) x 3 tillage/residue management combinations (CT, conventional tillage: deep ploughing at 30 cm depth; MT, mulch-tillage: non-inversive with a residue mulch left on the soil surface; CT, conventional tillage with stubble burning after wheat).

Ecological and economical indicators for monitoring changes in the sustainability of the system were yield, water use efficiency (WUE, ratio of yield to evapotranspiration), soil organic matter (SOM) and gross margin (GM). A management system was considered sustainable if the values of the selected indicators were maintained or enhanced over the simulated timeframe of 23 years and relative to a baseline system.

Mulch-tillage outperformed CT and BCT for all selected sustainability indicators. This indicates that MT has the potential to enhance the sustainability of a wheat-based system in northwest Syria. Simulated soil water was higher under MT compared to CT and BCT, which resulted in improved yield and WUE. The mean gain in wheat (60 kg N ha^{-1} applied) and chickpea yield was about 0.5 t ha^{-1} and about 0.4 t ha^{-1}. Stubble burning after wheat (BCT) had no effect on SOM, but led to lower GM compared to CT and MT as there was no revenue from sold straw or benefit from soil water conservation. Both the amount of N fertiliser and retained crop residues increased SOM, though the long-term response of SOM to management did not exceed 0.3 % (0–30 cm depth).

APSIM proved suitable for monitoring and quantifying changes in selected sustainability indicators. However, the choice of indicators is predefined by the capabilities of the model. Pests and diseases, for example, are not simulated. Despite this limitation, systems simulation allows us to objectively examine long-term, future impacts of alternative interventions across the range of expected weather variability in a manner that is not possible with empirical approaches.

Keywords: APSIM, chickpea, rotation, sustainability, wheat

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