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Quantification of resilience metrics as affected by conservation agriculture at a watershed scale

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Highlights

- Resiliency of no-till and conventional treatments were evaluated in a large, diverse watershed.
- Resilience metrics included recharge, groundwater table, soil moisture, yield, and net return.
- Crop and groundwater models were integrated to quantify resiliency to droughts.
- The no-till treatment improved overall resilience of the corn-soybean-wheat rotation.

Abstract

It is suggested that conventional tillage operations exacerbate global environmental changes and affect the sustainability of our food production systems. Therefore, no-till has been introduced as one of the conservation agriculture practices to counteract these challenges. No-till has been adopted by a substantial number of farmers in major cropping regions; however, its resilience from large scale implementation has been overlooked. The majority of the studies have reported only a few aspects of the no-till practice (e.g., yield, soil properties, etc.), often with contradicting observations. To fill this gap, we present an approach that integrates long-term field experimental data and modeling to quantify resilience at a watershed scale. The study was conducted in the Kalamazoo River watershed located in Michigan, USA. Recharge, groundwater table, soil moisture, yield, and net return were used as resilience metrics. The DSSAT sequence crop model was developed for a corn-soybean-wheat rotation and calibrated using the yield and soil moisture data from a long-term (1993–2019) experiment for the conventional and the no-till treatment conducted within the study area. Soil moisture, recharge and yield were simulated, and the recharge was fed into a calibrated groundwater model to analyze changes in groundwater heads. The results illustrate clear evidence of higher recharge and net return under the no-till treatment, which were statistically significant for all crops at the watershed scale. Moreover, the no-till treatment consistently retained greater soil moisture than the conventional treatment, thereby helping to mitigate the impacts of droughts. The rise in groundwater table as affected by the adoption of no-till practices in this watershed has ranged between 0.1 and 0.5 m, depending on the underlying groundwater system, and has the potential to beneficially affect the aquifers and groundwater-dependent ecosystems. Therefore, the conservation agriculture could improve the overall resilience of the row crop system.

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