Simulating Tillage Strategies with DSSAT

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Conservation tillage strategies are increasingly being used in cropping systems throughout the world. Improved soil moisture and structural stability leading to higher yields are widely recognized advantages of reduced and zero-tillage systems. In a bid to offset greenhouse gas emissions, conservation tillage is also being promoted as a management option to sequester potentially large amounts of organic C into stable soil organic matter pools.

A carbon credit system which rewards farmers who increase organic C in their soils through improved management is considered a significant mitigation mechanism by the global climate change community. Monitoring of these changes will be an expensive exercise considering the need for extensive soil sampling to reduce variability and ensure accountability. A less expensive option is to use simulation models to provide the relevant information.

The DSSAT (Decision Support System for Agrotechnology Transfer) suite of crop simulation models is widely recognized for its accuracy in predicting yields across a wide range of climate and soil environments in response to crop residue and N fertilizer management in conventionally-tilled systems i.e. with residue incorporation. Without changing the original residue decomposition structure (Figure 1) and data requirements, we have modified DSSAT (v 3.5) to simulate both short and long-term water and soil C responses to residue management strategies directly associated with reduced and zero-till practices.

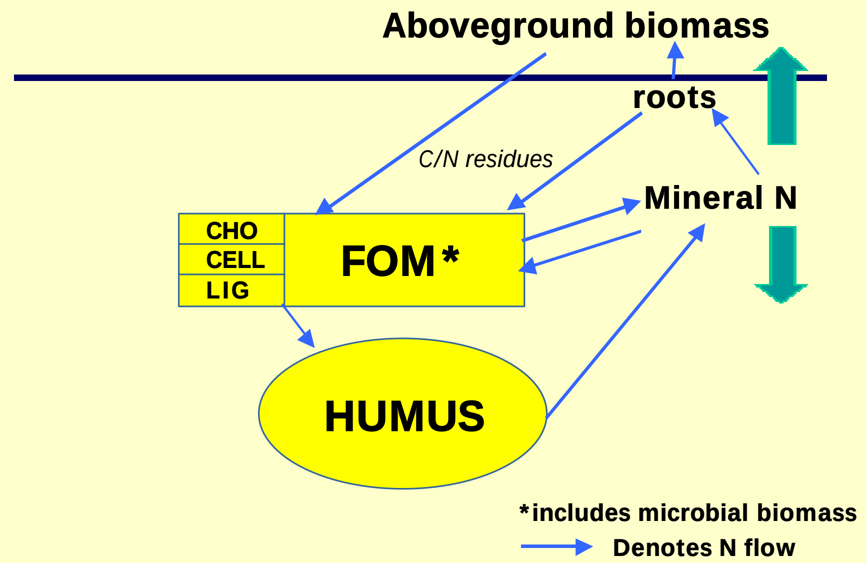

Figure 1. Structure of soil C/N transformations in DSSAT 3.5

Modifications included:

- **Addition of a surface residue (mulch) layer**
- **Evaporation routines for residue covered soils (Dadoun and Ritchie, Agronomy Abstracts, 1991)**
- **Partitioning of C and N from decomposing surface residues into the topsoil.**

We calibrated the surface residue decomposition routine using the data of Stott et al. (SSSAJ, 1990) (Figure 2).

We calibrated the C dynamics of the topsoil and lower layers in response to residue management using data from an 8-year tillage trial on clay-loam from El Batan, Mexico.

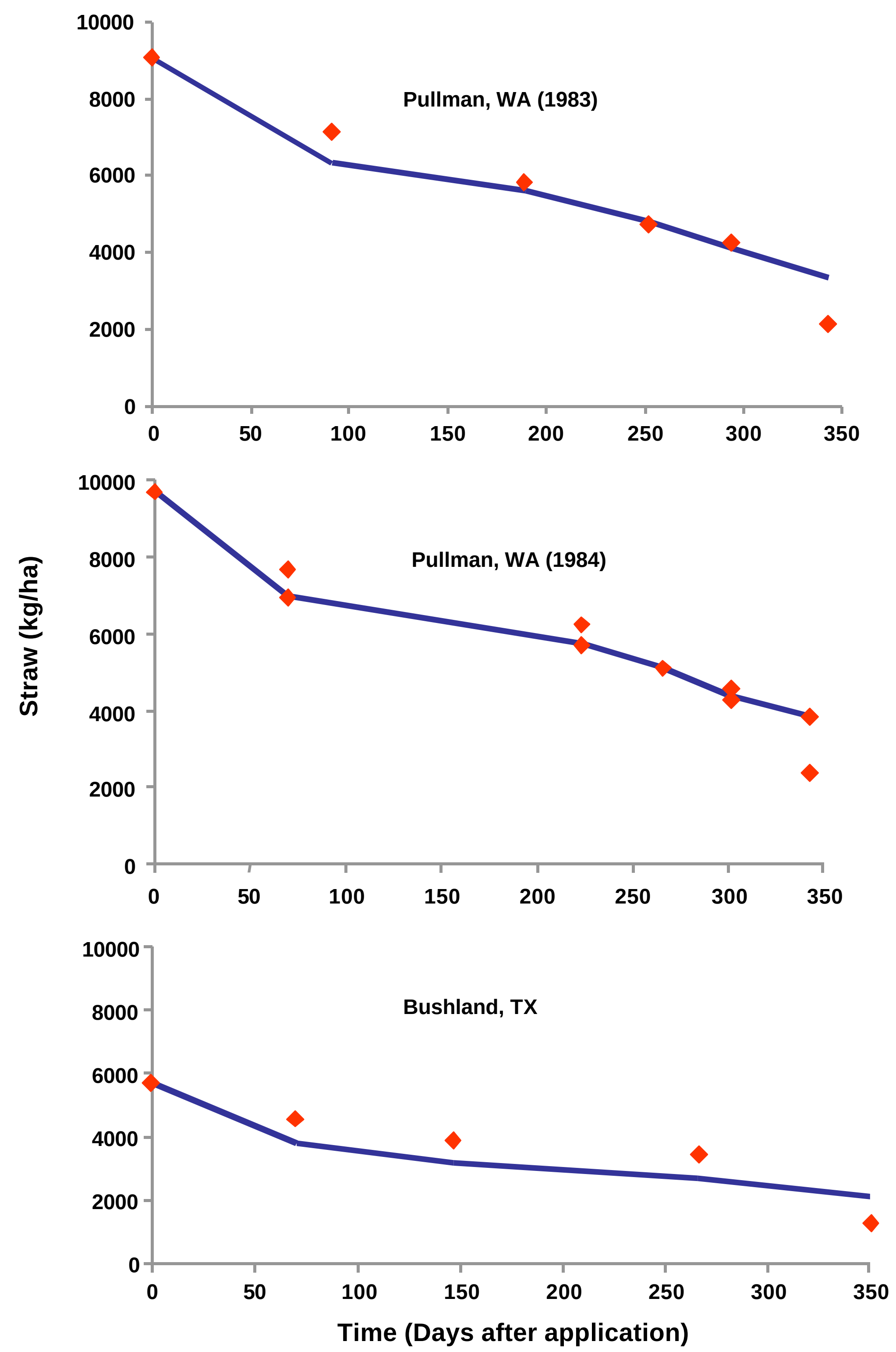

Figure 2. Decomposition of surface applied wheat straw with DSSAT v3.5 modified for zero-till systems (simulated-solid line, observed data-markers)

Treatments included a factorial assessment of zero and conventionally-tilled systems with and without residue retention with continuous maize (MM) and maize-wheat (MW) rotations (Figure 3).

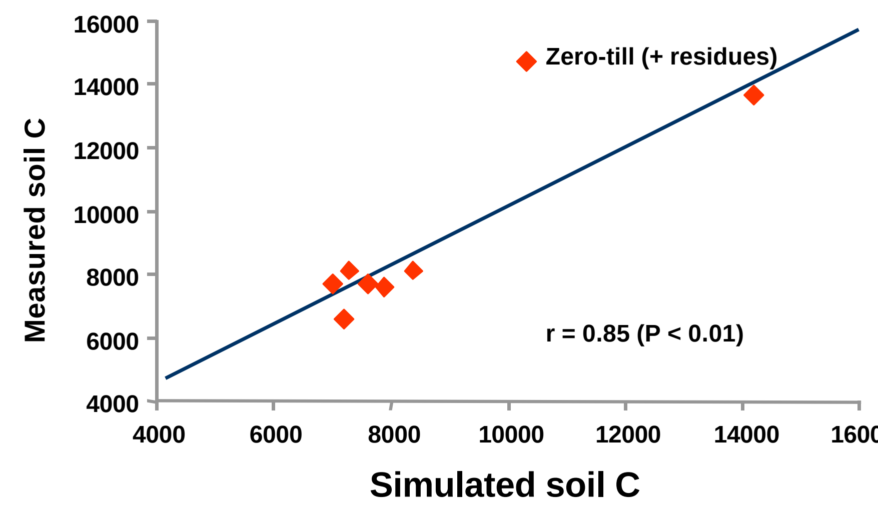

Figure 3. Model calibrated soil C (0-5 cm) after 8 years for MM and MW tillage treatments in Mexico using DSSAT v3.5 modified for zero-till systems.

As a completely independent test of the model's capacity to predict changes in soil C in response to tillage, we then ran the model against a dataset from the Long-Term Ecological Research Site (LTER) at the Kellogg Biological Station in Michigan, USA. Simulations of the conventional and zero-till maize-soybean-wheat rotations on a sandy-loam soil (Treatments 1 and 2 respectively in the trial design) are depicted in Figure 4.

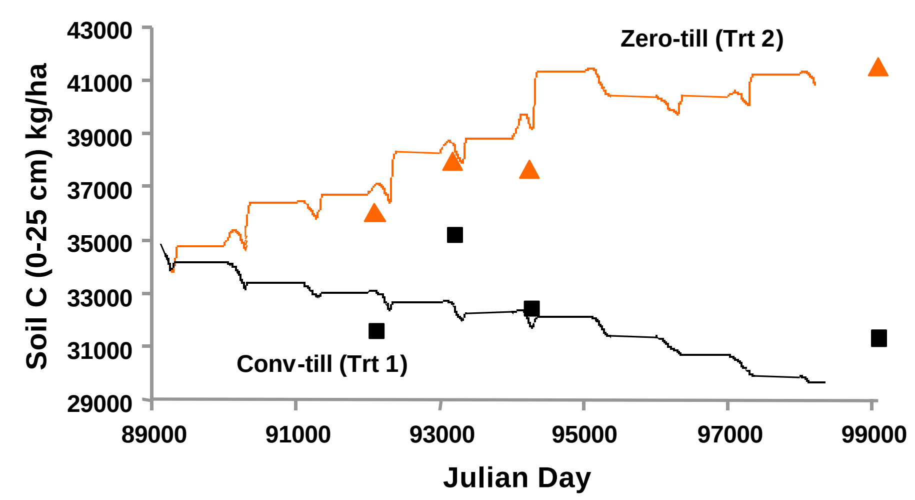

Figure 4. Simulated soil C for the KBS-LTER site using DSSAT v3.5 modified for zero-till systems (simulated-solid line, observed data-markers).

Initial testing of our conservation tillage modifications indicate that it is now possible to accurately simulate the C storage potential of a wide variety of tillage and rotation options with DSSAT 3.5 without the need for additional data requirements.