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# Evaluation of the RZWQM-CERES-Maize hybrid model for maize production

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**Abstract**

The root zone water quality model (RZWQM) was developed primarily for water quality research with a generic plant growth module primarily serving as a sink for plant nitrogen and water uptake. In this study, we coupled the CERES-Maize Version 3.5 crop growth model with RZWQM to provide RZWQM users with the option for selecting a more comprehensive plant growth model. In the hybrid model, RZWQM supplied CERES with daily soil water and nitrogen contents, soil temperature, and potential evapotranspiration, in addition to daily weather data. CERES-Maize supplied RZWQM with daily water and nitrogen uptake, and other plant growth variables (e.g., root distribution and leaf area index). The RZWQM-CERES hybrid model was evaluated with two well-documented experimental datasets distributed with DSSAT (Decision Support System for Agrotechnology Transfer) Version 3.5, which had various nitrogen and irrigation treatments. Simulation results were compared to the original DSSAT-CERES-Maize model. Both models used the same plant cultivar coefficients and the same soil parameters as distributed with DSSAT Version 3.5. The hybrid model provided similar maize prediction in terms of yield, biomass and leaf area index, as the DSSAT-CERES

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model when the same soil and crop parameters were used. No overall differences were found between the two models based on the paired *t* test, suggesting successful coupling of the two models. The hybrid model offers RZWQM users access to a rigorous new plant growth model and provides CERES-Maize users with a tool to address soil and water quality issues under different cropping systems.


*Keywords:* RZWQM; CERES; DSSAT; System modeling; Agricultural management; Plant growth modeling; Water stress; Nitrogen stress

## 1. Introduction

The root zone water quality model (RZWQM) was first released in 1992 (Ahuja et al., 2000a) and has been extensively evaluated for soil water movement (Ahuja et al., 2000b), soil heat transport (Ma et al., 1998a), pesticide transport (Malone et al., 2004), nitrogen (N) management (Ma et al., 1998b), and crop growth (Ma et al., 2003). The strengths of the RZWQM include macropore flow, tile drainage simulation, water table fluctuation, soil microbial population simulation, plant population development, and management effects (Ahuja et al., 2000a; Ma et al., 2000). It has a detailed soil water balance routine using the Green-Ampt equation for water infiltration and the Richards' equation for water redistribution (Ahuja et al., 2000b). Surface crusting and soil macropore flow are also considered (Ahuja et al., 2000b). The detailed soil carbon/nitrogen dynamics module contains two surface residue pools, three soil humus pools, and three soil microbial pools. It simulates N mineralization, nitrification, denitrification, ammonia volatilization, urea hydrolysis, methane production, and microbial population. These processes are functions of soil pH, soil $O_2$, soil microbial population, soil temperature, soil water content, and soil ion strength (Shaffer et al., 2000). RZWQM has an extended Shuttleworth–Wallace potential evapotranspiration (PET) module that considers the effects of surface crop residue cover on aerodynamics (Farahani and DeCoursey, 2000). The generic plant growth model simulates crop yield, biomass, leaf area index, root biomass, and rooting depth (Hanson, 2000); however, it does not simulate leaf number, phenological development, and other yield components. As a greater number of RZWQM applications focused on crop production under different management conditions, there existed a need to improve the generic plant growth model in RZWQM for simulating detailed plant growth components (Ma et al., 2000; Ahuja et al., 2002).

Another widely used model is the DSSAT (Decision Support System for Agrotechnology Transfer) family of models (Tsuji et al., 1994; Ritchie et al., 1998; Hoogenboom et al., 1999; Jones et al., 2003). It contains two crop specific plant growth models (CERES and CROPGRO). These crop models simulate detailed yield components, leaf numbers, and phenological development. In addition, they have been evaluated all over the world. Many crop modelers are continuously working on these models to improve and extend their applicability (Pedersen et al., 2004; Sau et al.,