

Incorporating a water-logging routine into CERES-Maize, and some preliminary evaluations

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Abstract

The inability of CERES-Maize v3.0 to simulate a fluctuating water table has been identified as a major constraint in using this particular model in South Africa and in Kenya. Information regarding fluctuating water tables under specific conditions, and their influence on maize production, has been presented in South African literature. The objective of this study was to construct a simple water-logging subroutine based on these mechanisms, using the existing input data structure of CERES-Maize. Results indicate that it is possible to simulate the impact of water logging on maize plants in this way. Further studies are needed to evaluate the assumptions made in this study and, if necessary, to make some refinements to the water-logging subroutine.

Introduction

In recent years it has become increasingly difficult to increase agricultural production by means of current methods of information transfer (Uehara, 1998). Most field trials conducted over the past decade have been aimed at refinement of recommendations made to the producer. It may be possible to stabilise African maize production if recommendations can be tailored to particular soil, plant and climatic conditions. In this respect the use of simulation models may serve to improve recommendations pertaining to variety selection, fertiliser use, irrigation scheduling, and optimum planting times (Acock, 1982; Thornton, 1990; Piper and Weiss, 1990).

The CERES-Maize model may be used for management decision making by the producer, provided that the model is evaluated and calibrated for various regions (Ritchie et al., 1998). This is an internationally-recognised maize model, highly acclaimed by researchers in the field (De Vos and Mallett, 1987; Du Pisani, 1987; Carberry et al., 1989; Piper and Weiss, 1990). The model was designed to use a minimum set of soil, weather, genetic and management information. It is a daily-incrementing model and therefore requires daily weather data consisting of maximum and minimum temperature, solar radiation and rainfall. It calculates crop phasic and morphological development using temperature, day length and genetic characteristics. Leaf area index, plant population and row width provide information for determining the amount of light interception, which is assumed to be proportional to biomass production. The biomass is partitioned into the various plant parts by means of a priority system. Water and nitrogen balance submodels provide feedback that influences the development of growth processes.

During a project to develop an integrated approach to assessing soil fertility and climatic interactions in pilot maize-producing

areas in Kenya, it became evident that CERES-Maize v3.0 could not simulate the impact of water logging on maize growth (a relatively common occurrence in certain parts of Kenya), a conclusion supported by Hensley et al. (1997) and Hensley (2000).

Hensley et al. (1997) and Hensley (2000) describe the water-table logic for sandy soils as follows. There is an upward linear decrease in water content from the water table, where the soil water is at saturation, to the drained upper limit (DUL) of the layer approximately 600 mm above the water table. If the water-table depth is less than about 600 mm from the soil surface, aeration stress occurs for maize with a consequent decrease in yield. It can be expected that the number of live roots will decrease with an increase in time of water logging, and thus the uptake of nutrients will also decrease.

The objective of this study was to incorporate the Hensley logic into the water uptake and drainage subroutines of CERES-Maize. It simulates the rise and fall of the water table, with the concomitant effects of water logging on the growth of the maize plant.

Material and methods

Crop growth simulation model

The CERES models for maize, sorghum, wheat, millet and barley were combined to provide a generic multi-crop model which runs with a single set of code, incorporating the development and growth sections for each individual model into a single module with a single soil component (Tsuji et al., 1994; Ritchie et al., 1998). According to Ritchie (1991), generic models should allow users to have more uniform procedures for validating models and for linking with components not included in the generic model. The generic CERES-Maize model (Hoogenboom et al., 1994), with modifications made by Du Toit (1996) to simulate secondary ears and tillering under low plant populations, was used for the simulations. An experimental approach to water-table simulation was used to simulate the results as reported in Hensley et al (1997). The results reported as "without water-table simulation" in this paper do not include the experimental approach.

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