Available online at www.sciencedirect.com
SCIENCE DIRECT
Agricultural water management
ELSEVIER
Agricultural Water Management 79 (2006) 113–136
www.elsevier.com/locate/agwat

Subsurface drain flow and crop yield predictions for different drain spacings using DRAINMOD

X. Wang [a], C.T. Mosley [b], J.R. Frankenberger [c,*], E.J. Kladivko [d]

[a] *Texas Agricultural Experiment Station, Blackland Research Center, 720 East Blackland Road, Temple, TX 76502, USA*
[b] *Agri-Waste Technology, Inc., Raleigh, North Carolina, NC, USA*
[c] *Department of Agricultural and Biological Engineering, 225 S University Street, Purdue University, West Lafayette, IN 47907-2093, USA*
[d] *Department of Agronomy, Lilly Hall of Life Sciences, 915 W. State Street, Purdue University, West Lafayette, IN 47907-2054, USA*

Accepted 2 February 2005
Available online 13 March 2005

Abstract

DRAINMOD was run for 15 years to predict and compare drain flow for three drain spacings and crop yield for four drain spacings at the Southeastern Purdue Agricultural Center (SEPAC). Data from two continuous years of daily drain flow from one spacing were used to calibrate the eight most uncertain parameters using a multi-objective calibration function and an automatic calibration method. The model was tested using the remaining field data for the 5, 10, and 20 m drain spacings for drain flow and the additional 40 m spacing for yield predictions. Nash–Sutcliffe efficiency (EF) for daily drain flow simulations for the calibration years and drain spacing ranged from 0.62 to 0.79. The daily EF for model testing ranged from −0.66 to 0.81, with the average deviations of 0.01 to 0.07 cm/day and standard errors of 0.03–0.17 cm/day. On a monthly basis, 91% of plot years had EF values over 0.5 and 76% over 0.6 for years with on-site rainfall data. The total yearly drain flow was predicted within ±25% in 71% of plot years, and within ±50% in 93% of plot years with on-site rainfall data. Statistical tests of daily drain flow EF values for three spacings and percent errors of crop relative yield for four spacings indicated that the reliability of the model is not significantly different among different spacings, supporting the use of DRAINMOD to study the efficiencies of different drain spacings and to guide the drain spacing design for specific soils. In general, the model

* Corresponding author. Tel.: +1 765 494 1194; fax: +1 765 496 1356.
E-mail address: frankenb@purdue.edu (J.R. Frankenberger).

0378-3774/$ – see front matter
doi:10.1016/j.agwat.2005.02.002

correctly predicted the pattern of yearly relative yield change. The relative corn (*Zea mays* L.) and soybean (*Glycine max* L.) yields were well predicted on average, with percent errors ranging from 1.3 to 9.7% for corn and from −3.3 to 10.3% for soybean.

Keywords: DRAINMOD; Subsurface drainage; Modeling; Automatic calibration; Multi-objective; Yield

1. Introduction

Artificial drainage has been an important water management practice for farming some of the most productive soils of the Midwest. The need to have guidelines for drainage design and water management for different soils and climates has driven both the experimental field research and computer modeling. Computer-based simulation models, such as DRAINMOD, can predict subsurface drain flow, water table fluctuations, and crop yields in a greater variety of conditions than what is feasible through monitoring, which allows timely decisions to be made about complex problems when field data are both difficult and expensive to obtain (Haan and Skaggs, 2003). Computer models are also needed to predict the influence of subsurface drain flow on stream water quality for total maximum daily loads (TMDLs) and other water quality management plans. Models provide a synthesis of understanding that is increasingly important in the policy arena (Bobba et al., 1995). It is necessary to determine the capability of a computer model to simulate the changes in the soil water regime brought about by a drainage system at its geographical location. Therefore, field testing and evaluation of existing models over a wide range of soils, climatic and agricultural conditions is an essential part of model evaluation and application.

DRAINMOD (Skaggs, 1978), a hydrologic model, was developed to simulate the performance of drainage and related water table management systems on subsurface drainage, water table fluctuations, and yields. Skaggs and Gilliam (1981) and Breve et al. (1998) applied the model to study effects of design of drainage and subirrigation systems and management on crop productivity, profitability, and nitrate transport. While Agricultural Drainage and Pesticide Transport model (ADAPT) (Ward et al., 1988), and Soil Water Infiltration and Movement (SWIM) (Ross, 1990) have been used for similar purposes, comparative studies (Barkle et al., 1998; Sands et al., 2002; Workman and Skaggs, 1989) showed that DRAINMOD has equal or better accuracy than those hydrology models, with fewer and simpler input requirements and faster running time.

The reliability of DRAINMOD predicting water table elevations and subsurface drain flow has been tested in many parts of the world for different soils, crops and climates (Amatya and Skaggs, 2001; Borin et al., 2000; Helwig et al., 2002; Luo et al., 2001; Oztekin et al., 1999; Northcott et al., 2001; Zhao et al., 2000). The expected goodness of fit of DRAINMOD depends on the amount of field-specific input data (John et al., 2001). Reported average deviations for drain flow predictions range from 0.06 to 0.14 cm/day, and standard errors from 0.08 to 0.36 cm/day. There has been limited testing and comparison of the crop yield by using DRAINMOD.