



# Modification of maize simulation model for predicting growth and yield of winter wheat under different applied water and nitrogen



Mehdi Mahbod, Shahrokh Zand-Parsa\*, Ali Reza Sepaskhah

Irrigation Department, Shiraz University, Shiraz, Islamic Republic of Iran

## ARTICLE INFO

### Article history:

Received 6 October 2013

Accepted 20 November 2014

### Keywords:

Wheat modeling

Grain yield

Water and nitrogen application

Evaporation

Transpiration

## ABSTRACT

Model WSM (Wheat Simulation Model) was developed based on the previous model (MSM, Maize Simulation Model). The planted cultivar was Shiraz with five irrigation treatments (1.2, 1.0, 0.8, and 0.5 ratios of the potential irrigation requirement under surface irrigation system and rain-fed) and four applied nitrogen treatments (0, 46, 92, 136 kg N ha<sup>-1</sup>). The irrigation water requirements were estimated by measuring the differences between soil field capacity and measured soil water content at root depth in the full irrigation treatment before irrigation. In the WSM model, dynamic flow of water, nitrogen, and heat through the soil were simulated numerically in an unsteady state condition at soil profile. Water and nitrogen transfer in the soil are governed by the Richard's equation and the diffusion convection equation, respectively. Emergence time of seed after sowing was simulated using soil water content, temperature, sowing depth, and soil particle diameters using beta function. Plant growth stages were simulated considering photoperiod, vernalization and air temperature. Hourly simulation of actual evaporation from soil surface and transpiration were simulated using the Penman–Monteith method based on atmospheric conditions and soil water content at root depth. Nitrogen uptake was simulated through mass flow and diffusion processes during the growing season. Produced dry matter was simulated as a function of hourly corrected intercepted radiation (based on air temperature) by plant leaves, maximum and minimum plant top N concentration and the amount of N uptake. Wheat grain yield was simulated by the ratio of grain N uptake and grain N concentration that were estimated by an empirical equation as a function of simulated top N uptake. Obtained experimental data in 2009–2010 were used to calibrate the model. The experimental results from 2010 to 2011 validated favorably the proposed model.

Crown Copyright © 2014 Published by Elsevier B.V. All rights reserved.

## 1. Introduction

Wheat is one of the major cereal crop that is strategic for food security across the world (FAOSTAT, <http://faostat.fao.org>). Soil moisture deficit during the growing period (from double ridge to anthesis) and around the anthesis causes yield and top dry matter losses (Cossani et al., 2009). Similarly, nitrogen (N) nutrition deficiency has been found responsible for cereal yield loss (Passioura, 2002). The understanding of the interactive effects of water and N availability, along with the crop ability to efficiently use these resources is of crucial importance for management of cereal production (Albrizio et al., 2010). Many investigators indicated that proper fertilizer, crop, water and soil management can minimize leaching of nitrates and increase crop yields (Perego et al., 2012).

Crop simulation models have widely been used to assess and understand the effects of environmental parameters, fertilizer application, and irrigation regimes on plant growth and yield. They also help to manage resources, maximize returns to producer and reduce impacts on water quality. They can be used to optimize sowing time, fertilizer rate and water application in a way with maximum yield and minimum environmental pollution. These models differ in the complexity and the theory that have been used in their development (Hoogenboom, 2000).

Many crop simulation models like STICS (Brisson et al., 2003) use water balance methods and non-dynamic water flow through soil for prediction of evapotranspiration and grain or relative yields. Water balance and soil water content is without doubt one of the crucial points in the application of any crop simulation model. Crop models including water balance calculations should be tested prior to application in different sites and environments (Eitzinger et al., 2004). Some models use Richards' equation to simulate soil water flow and consequently soil water pressure head, water content, and root water uptake. In these models crop dry matter production,

\* Corresponding author.

E-mail address: [zandparsa@yahoo.com](mailto:zandparsa@yahoo.com) (S. Zand-Parsa).