An FAO type crop factor modification to SWB for inclusion of crops with limited data: Examples for vegetable crops

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Abstract

There is a lack of information on crop water requirements of vegetables in South Africa. Six winter and 10 summer irrigated vegetable species were grown in a field trial at Roodeplaat (Gauteng Province) during the 1996/97 season. The objectives were to determine seasonal water requirements of vegetables and to develop a simple, generic crop, irrigation scheduling model that would not require time-consuming and therefore expensive growth analysis data to determine model parameters. Weather data were recorded with an automatic weather station, canopy cover (C) was measured weekly with a sunfleck ceptometer and soil water with a neutron meter. A simple C-based procedure was used to determine FAO (Food and Agriculture Organisation of the United Nations, Rome, Italy) type basal crop coefficients (Kcb) and growth periods for the following stages: initial, development, mid-season and late-season. In addition, initial and maximum rooting depths and crop heights were determined. An FAO-based crop factor approach was combined with the mechanistic irrigation scheduling SWB (Soil-Water Balance) model, thereby allowing evaporation and transpiration to be modelled as supply- and demand-limited processes. FAO type crop parameters were included in SWB and simulations performed. SWB predicted soil-water deficit and canopy cover well. The crop parameters should be extremely useful to irrigators, but caution should be exercised against blind acceptance of these empirical parameters as local conditions, management and cultivars are likely to influence crop growth periods and Kcb's.

Introduction

Interest in the application of computer models in agriculture is rapidly increasing, particularly since PCs have become accessible to crop producers. Crop models have been developed with different levels of complexity depending on the specific requirements (Whisler et al., 1986). For irrigation scheduling purposes, models should simulate growth and development of the crop well. Several mechanistic irrigation scheduling models are available (Bennie et al., 1988; Campbell and Stockle, 1993; Singels and De Jager, 1991a, b and c; Hodges and Ritchie, 1991). Mechanistic crop growth models, however, require specific crop growth input parameters which are not readily available for all crops and conditions. The Food and Agriculture Organisation (FAO) of the United Nations recommended a semi-empirical approach for calculating crop water requirements, based on the fact that crop yield depends on climatic conditions, genetic potential of the crop and irrigation water management (Doorenbos and Pruitt, 1992). The FAO approach was used to develop the crop water requirement models CROPWAT (Smith, 1992a) and, in South Africa, SAPWAT (Crosby, 1996). Doorenbos and Pruitt (1992) give a comprehensive database of FAO crop coefficients (Kc) for different climatic conditions and phenological stages (initial, mid-season and late-season stages). They also stressed the need to collect local data on growing season and rate of crop development of irrigated crops. Green (1985a and b) reviewed Kc values empirically related to pan evaporation and growth periods for crops grown in South Africa.

The Kc's published by the FAO represent mean values for a given irrigation cycle and strongly depend on wetting frequency, wetted area and soil type. Allen et al. (1996) defined Kc as the sum of the basal crop coefficient (Kcb) and the time-averaged effects of evaporation from the soil surface layer. They also reported Kcb values and maximum crop height (Hc_{max}) for a wide range of species. The Kcb values, however, depend on cultivars, management and climatic conditions, in particular during incomplete canopy cover (Jagtap and Jones, 1989). Van Zyl and De Jager (1994) recommended climate-adjusted upper limits of Kcb for potato and maize grown at several locations in South Africa. Very little literature is available on Kcb's for vegetables grown in South Africa. In this study, 6 winter and 10 summer vegetable species were grown at Roodeplaat (Gauteng Province). The objectives were to determine what seasonal crop water consumption growers could expect in that area, and to generate a database of Kcb values, growth periods, root depths (RD) and crop heights (Hc) from the limited data available. A further objective was to develop a simple computer model making use of this database for real time mechanistic irrigation scheduling of vegetables.

Materials and methods

Field trial

A field trial was established at Roodeplaat (Department of Agriculture - Directorate of Plant and Quality Control; 25°35' S, 28°21' E, altitude 1 165 m), 30 km NE of Pretoria. The climate of the region is one of summer rainfall with an average of about 650 $mm \cdot y^{-1}$ (October to March). January is the month with the highest average maximum temperature (30°C), whilst July is the month with the lowest average minimum temperature (1.5°C). Frost occurs frequently during winter months. The soil is a 1.2 m deep clay loam Red Valsrivier (Soil Classification Working Group, 1991), with a clay content of between 27% and 31% and a water-holding capacity of about 300 $mm \cdot m^{-1}$.

Six winter vegetable species were grown during the 1996

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