

Evapotranspiration and Irrigation Scheduling



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Evaluation of Irrigation Scheduling Techniques for Processing Tomatoes in Brazil

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ABSTRACT

In Brazil processing tomatoes production is one of the most important agricultural activities. Despite many irrigation scheduling techniques available, processing tomatoes growers keep managing irrigation empirically. The objective of this work was to evaluate four irrigation scheduling techniques for processing tomatoes based on a) soil water tension; b) soil water balance with variable irrigation frequency; c) soil water balance with fixed irrigation frequency and; d) empirical technique recommended by farmers' association. Total and marketable yields ranged from 78 to 88 t/ha and from 46 to 60 t/ha, respectively, with the lowest yield corresponding to the empirical technique. Soluble solids content, pH and acidity were also evaluated. Both pH and acidity were considered in the normal range. Soluble solids content however, resulted low because irrigation continued until the first harvest. The results indicate the need for using sound techniques for scheduling irrigation.

Keywords: Tomatoes, Irrigation management, Soil water tension, Matric potential

INTRODUCTION

Production of processing tomatoes is one of the most important agricultural practices in Brazil. About 50,000 ha are cropped annually, most of which are grown under irrigation, especially sprinkler systems. In spite of its importance irrigation has been performed empirically and inadequately, affecting both fruit yield and quality for industrialization.

Both shortage and excess of soil water induce severe development problems to tomato crop. High water content in the soil, mainly before blossom, favor excessive vegetative growth without an increase in production (Bonet et al., 1981). On the other hand, water deficit mainly during flowering and frutification, which are critical growing stages, causes reduction in the number of fruits per plant and, consequently, results in reduced fruit yield (Cannel and Asbell, 1974; Bonet et al., 1981).

Processing characteristics are also influenced by irrigation management. Excess soil water during maturation affects fruit color, reduces soluble solids content and acidity (Giardini et al., 1988). Soil water shortage during maturation results in problems with fruit consistency and color (Varga, 1987).

Incidence of blossom-end rot, which is related to low calcium content in the soil, may also increase for either high or low soil water content (Cerdeira et al., 1979; Nashe-Esfahani and Bradley, 1981).

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Irrigation scheduling basically involves predicting when to irrigate and how much water to apply to meet crop water requirements. Among existing irrigation scheduling methods none can be considered as standard for all situations. To one extent or another all methods present advantages and disadvantages.

According to Marouelli et al. (1990), who worked in the Federal District of Brazil, high yield of processing tomatoes can be obtained when irrigation is applied at a soil water tension of 400 kPa at 0.10 m depth during vegetative period and 100 kPa at 0.20 m depth during reproductive stage. Based on these results, the use of tensiometers for processing tomatoes is not indicated because the optimum potential falls out the working range of these instruments.

Soil water balance techniques which require daily values for precipitation, irrigation, crop evapotranspiration and losses by runoff and deep percolation, provide an efficient method for managing irrigation (Roque et al., 1986a, 1986b; Tan, 1988).

Crop evapotranspiration can be estimated indirectly from daily Class A pan evaporation data and crop coefficients (Kc). This is a very simple, reliable and practical method because it integrates the major factors affecting crop evapotranspiration (Doorenbos and Pruitt, 1977).

Furthermore, Roque et al. (1986b) pointed out that the water balance method utilizing Class A pan evaporation reduced the number of irrigations and the total amount of applied water, when compared to the traditional method in which irrigation frequency is fixed in advance.

In Brazil, most farmers growing processing tomatoes in relatively large areas irrigated with center pivots, usually do not employ a sound technique to manage irrigation because they perceive that all of the available technologies are either very expensive or too cumbersome to use.

The main objective of this work was to evaluate the effect of four irrigation scheduling techniques on yield and quality parameters of processing tomatoes.

METHODS AND MATERIALS

This work was carried out in 1992 at the National Vegetable Crop Research Center (CNP/EMBRAPA) located in Brasília, Federal District of Brazil. The local altitude is about 1,100 m above the sea level and the climate is dry (20-30% R.H.) with mild temperatures (12-25°C) during the growing season (April to September). The soil is a dark latosol, with an average 47.3% clay, 44.9% silt and 7.8% sand. The soil moisture release curve data were obtained from undisturbed soil samples and fitted to the van Genuchten (1980) model shown in Eq. (1):

$$\theta = 0.05 + \frac{0.5}{[1 + (1.109h)^{1.142}]^{0.125}} \quad r^2 = 0.945 \quad (1)$$

where h is the soil water tension in kPa and θ is the volumetric water content in cm^3/cm^3 .

The experimental design consisted of four treatments arranged in randomized blocks, with six replications. Each experimental plot had four 8-meter long rows spaced 1.0 m apart. Treatments were irrigation scheduling techniques as follows: 1) soil water tension; 2) soil water balance with variable irrigation frequency; 3) soil water balance with fixed irrigation frequency; and 4) farmers' empirical method.

For treatments purposes the crop effective rooting depth was considered to be 0.20 m until flowering and 0.40 m from flowering to harvest. For treatment 1 irrigations were performed when soil water tension at 0.10 m depth reached about 400 kPa during vegetative period, and 100 kPa at 0.20 m depth from flowering to the final irrigation. Soil water tension was evaluated

CONCLUSION

It is concluded from this work that good processing tomatoes yields can be obtained when irrigation is scheduled based on sound techniques such as monitoring soil water content or estimating crop evapotranspiration. These techniques require reliable, relatively precise and rather simple equipment like neutron probe and Class A pan. Furthermore, for similar soil and climatic conditions, irrigation can be applied on a fixed interval of 5 to 7 days, applying the amount of water lost from the soil during that period.

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MARKVAND: A Decision Support System for Irrigation Scheduling

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ABSTRACT

MARKVAND is a PC-based decision support system, which gives daily information on the timing, the amount and the economical net return of irrigation for a wide range of agricultural crops in Denmark. In general, tests have shown a good performance of the MARKVAND system and at present, 100 licenses of the software have been sold and it is used by at least 200 farmers in Denmark.

The MARKVAND system includes conceptual and empirical sub models for crop development, water balance and crop yield. The model for crop development is calculated from temperature sums. The water balance model is based on the field and wilting capacity concept. The empirical models, using the stress day concept, are included for the calculation of crop yield. A priority module ranks the crops with respect to their economic net return of irrigation and thus makes recommendations on the priority of crops for irrigation. Calculations in the priority module are based on model calculated yield increase from irrigation, cost of irrigation and crop prices. The irrigation demand is calculated for a five-day forecast period to help farmers in planning their activities.

At the beginning of a new irrigation season, data describing the fields, soil types and crops to be grown have to be given as input to the MARKVAND system. Daily climatic input to the system is potential evapotranspiration and air temperature calculated in a national (40 by 40 km) climate grid and precipitation measured at farm level. A seven-day forecast for precipitation can be given as optional input, which is a valuable option enabling a better planning of irrigation and the possibility of saving water.

Keywords. Models, Water balance, Crop yield, Microcomputer systems

INTRODUCTION

In recent years several models for use on micro-computer have been developed to support decisions on irrigation management (Jensen and Wright, 1978; Bala et al., 1988; King and Busch, 1993). As the models in general are simple and typically developed to local conditions (climate, crops, etc.) there is a need for adjustments of existing models or development of new models for use in other conditions and locations.

In Denmark, the timing and need for irrigation have previously been based on local experience, simple rules and calculated figures for precipitation deficit (potential evapotranspiration minus precipitation). Supplemental irrigation is needed nearly every year on sandy soils to maintain a stable production and, at present, about 15,000 irrigations plants are used to irrigate 15 % or 420,000 ha of the agricultural land. Along with the increased demand for water in different sectors of the society and because of the need to balance the cost and income in agricultural production, it was found necessary to focus on more efficient methods of irrigation management.

Irrigation in Denmark is mostly carried out using moving rain-guns and the water is supplied from ground water pumping. At present, constraints on supply of irrigation water are mostly caused by a scarce irrigation capacity, however, restrictions on the use of ground water are becoming increasingly important.

During the period 1988-1994 common efforts from Danish Institute of Plant and Soil Science and Danish Agricultural Advisory Centre resulted in the development of the MARKVAND system, a PC-based decision support system for use in irrigation management (Plauborg and Olesen, 1991;

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