Agricultural Water Management 192 (2017) 294–305

Contents lists available at ScienceDirect

Agricultural Water Management

journal homepage: www.elsevier.com/locate/agwat

Research paper

Effective management of irrigation water for carrot under constant and optimized regulated deficit irrigation in Brazil

B.C. Léllis [a], D.F. Carvalho [b,*], A. Martínez-Romero [a], J.M. Tarjuelo [a], A. Domínguez [a]

[a] Universidad de Castilla-La Mancha (UCLM), Centro Regional de Estudios del Agua (CREA), Ctra. de Las Peñas, km 3.2, 02071 Albacete, Spain
[b] Departamento de Engenharia, Universidade Federal Rural do Rio de Janeiro, BR 465, km 7, 23890-000 Seropédica, RJ, Brazil

ARTICLE INFO

Article history:
Received 1 March 2017
Received in revised form 20 June 2017
Accepted 21 July 2017

Keywords:
MOPECO
Water productivity
Profitability
Harvest quality

ABSTRACT

The optimized regulated deficit irrigation (ORDI) determines the level of deficit (ratio between actual and maximum evapotranspiration "ET_a/ET_m") to be applied at each development stage of a crop in order to reach the maximum yield for a certain global deficit at the end of the cropping period. One of the weaknesses of this methodology is its inability to forecast the effect of deficit irrigation on the quality of the harvest, which may affect the profitability of the crop. A research conducted in Seropédica (Brazil) during 2013 and 2014, aimed to assess the effect of deficit irrigation on the yield, quality, water productivity, and profitability of a carrot crop "Brasilia cv.". Ten strategies of irrigation management were applied to the crop: full irrigation, 90, 80, 70, and 60% of ET_m using constant deficit irrigation (CDI) (the ET_a/ET_m ratio was the same at all the development stages), 90, 80, 70, and 60% of ET_m using ORDI, and rainfed. The experimental design was composed of random blocks equipped with a drip irrigation system. The moment and the amount of water applied to each treatment were determined by the soil water balance module of the MOPECO model, and corroborated by the monitoring of soil moisture samples. "Full irrigation" treatments achieved the highest yield, quality, and profitability per unit of the cropped area, while ORDI increased the water productivity and reached the highest profitability per unit of volume of irrigation water supplied to the crop (average up to 12.26 € m^{-3} for the "0.6 ORDI" treatment vs. 8.38 € m^{-3} for the "full irrigation"). CDI and ORDI treatments reached similar total yields. However, the marketable yields were 26.6% average higher for ORDI, advising against using the CDI strategy. Consequently, in areas where water is not scarce, the use of regulated deficit irrigation strategies is not justified. Nevertheless, in areas where water is the limiting factor, but not the irrigable land, ORDI may increase the total gross margin of a farm by supplying the same volume of irrigation water to a greater area.

© 2017 Elsevier B.V. All rights reserved.

1. Introduction

Worldwide, agriculture is the main user of water (FAO, 2016). Notwithstanding, the increasingly competitive use of water resources for other sectors (Imtiyaz et al., 2000b) forces to increase the efficiency in the use of water. Regulated Deficit Irrigation (RDI) reaches this objective by improving the water productivity of the crops at the expense of decreasing the yield per unit of area (Chai et al., 2016; English, 1990).

In addition to the yield, the use of RDI techniques affects other physiological parameters of the plant during its development. This fact may be relevant if the quality of the harvest is modified and decreases the price perceived by the farmer (Carter and Stoker, 1985; Chai et al., 2016). Consequently, it is necessary to establish strategies of regulated deficit irrigation that maximize the productivity of irrigation water while maintaining a high level of crop quality.

The MOPECO model (Ortega et al., 2004) was conceived for maximizing the gross margin (GM) of irrigated farms through an optimized use of both available volumes of water and irrigable area. For the management of the irrigation water, the model uses the optimized regulated deficit irrigation (ORDI) methodology (Domínguez et al., 2012b) to determine the level of deficit to be reached at each development stage of the crops in order to get the maximum yield for a certain global deficit. One of the weaknesses of MOPECO is its inability to simulate the effect of ORDI on the quality of harvests.

Carrot (*Daucus carota* L.) is the main root vegetable in terms of economic value in Brazil (Luz et al., 2009) with a production area of over 28,000 ha and more than 750,000 tons of roots (Silva et al.,

* Corresponding author.
E-mail address: daniel.fonseca.carvalho@gmail.com (D.F. Carvalho).

http://dx.doi.org/10.1016/j.agwat.2017.07.018
0378-3774/© 2017 Elsevier B.V. All rights reserved.

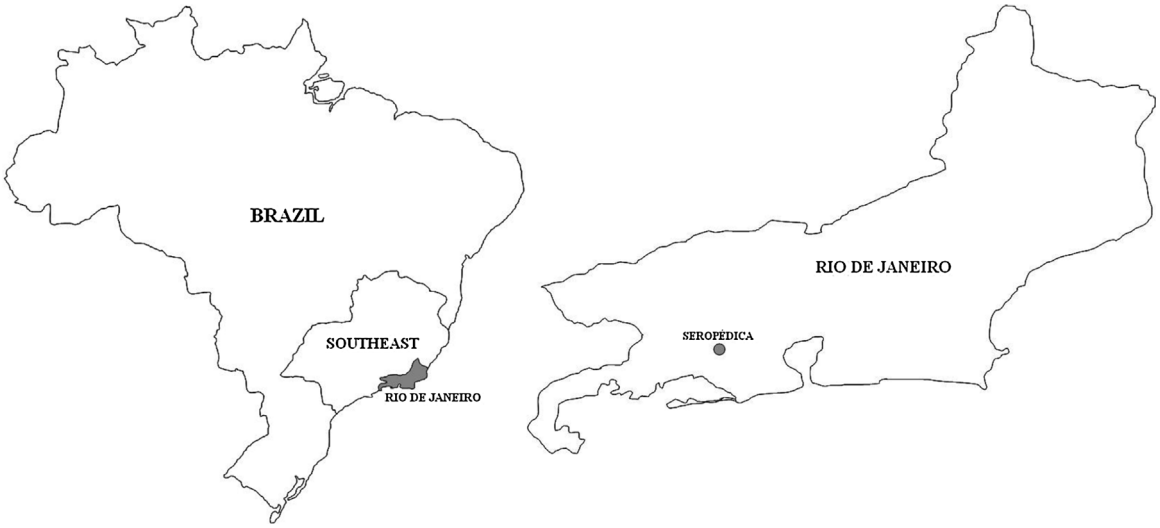

Fig. 1. Location of the experimental farm.

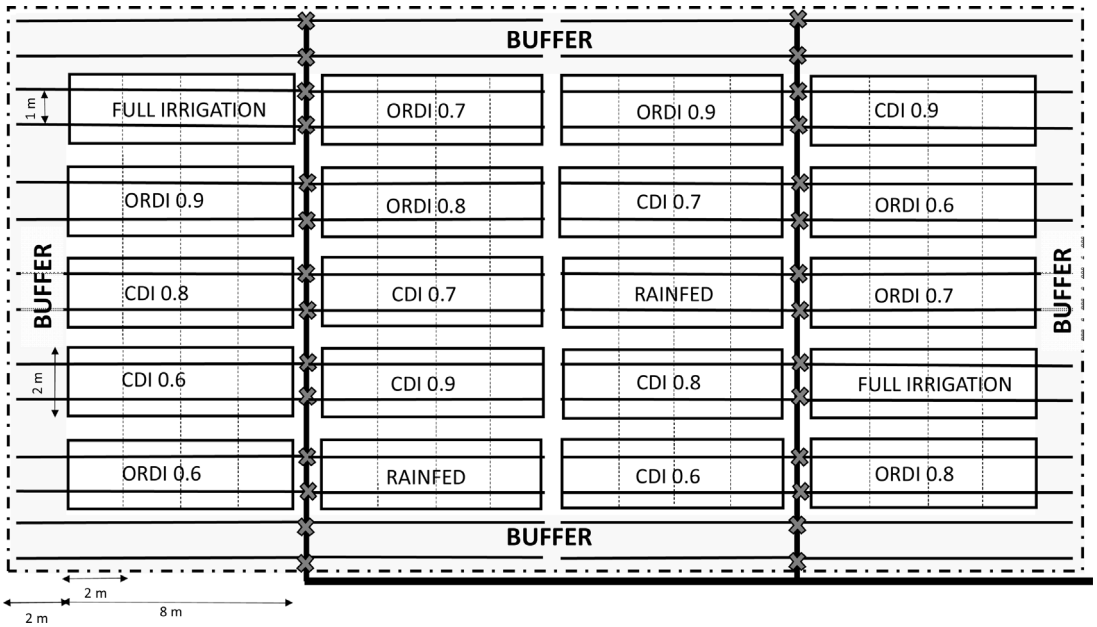

Fig. 2. Comparison between the ET_a/ET_m rate objectives and the rates reached by carrots during the irrigation seasons (a: full irrigation; b: rainfed; c: 0.9 CDI; d: 0.9 ORDI; e: 0.8 CDI; f: 0.8 ORDI; g: 0.7 CDI; h: 0.7 ORDI; i: 0.6 CDI; j: 0.6 ORDI).

2012). Since carrot is a crop with high economic value, the irrigation management schedule is designed to obtain the maximum yield (Nagaz et al., 2012). Nevertheless, low availability of irrigation water may lead to the use of deficit irrigation, which must be analyzed to determine the most suitable irrigation strategy for the purpose of reaching the highest water productivity without decreasing the quality of the final product.

Several authors have demonstrated that RDI may lessen the harvest quality of carrots, being cracks and malformations the main causes in the decrease of the harvest sale price (Carvalho et al., 2014; Silva et al., 2011; Teodoro et al., 2002). Determining the most sensitive stages of the crop to water deficit, as well as planning the irrigation schedule that increases the water productivity maintaining the quality of the harvests, will allow to reach suitable profitability in water scarcity areas by using RDI techniques.

Carvalho et al. (2014) calibrated the parameters required for the simulation of a carrot crop in Brazil by using MOPECO model. Moreover, these authors used ORDI for determining the theoretical deficit rates to be applied at each phenological stage that reaches the maximum marketable yield for a certain global deficit objective. This term indicates the rate between accumulated actual (ET_a) and maximum evapotranspiration (ET_m) at the end of the growing period.

The main aims of this study are to assess both the effect of deficit irrigation on the yield and quality of a carrot crop, and the ability of ORDI to increase the productivity of irrigation water by maintaining the quality of the harvest. The specific objectives of this work are: (1) to determine the yields reached by a carrot crop subdued to 10 strategies of irrigation management: full irrigation, 90, 80, 70, and 60% of irrigation requirements applying constant deficit irrigation (CDI), 90, 80, 70, and 60% of irrigation requirements applying optimized regulated deficit irrigation (ORDI), and rainfed; (2) to analyze the quality of the harvests in terms of length of roots and marketable criteria; and (3) to value the results depending on the total yield obtained by each treatment and the different price of the roots, according to their quality.

Download English Version:

https://daneshyari.com/en/article/5758438

Download Persian Version:

https://daneshyari.com/article/5758438

Daneshyari.com