Tropentag 2013
Stuttgart-Hohenheim, September 17-19, 2013
"Agricultural development within the rural-urban continuum"

Production Function of Irrigated Eggplant in Protected Environment

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Introduction

Eggplant (*Solanum melongena* L.) is a solanaceous plant that originates in eastern tropical regions and has been cultivated over 1500 years by Chinese and Arabs. In recent years there has been an increasing demand for eggplants due to their medicinal characteristics and richness of vitamins and minerals. The biggest limitation to eggplant cultivation is inadequate soil moisture during its cycle, as occurs with most vegetables (Vieira, 1994; Marouelli et al. 1996). Irrigation can be used to supplement and retain soil rain water ideal for crop development, thus increasing plant growth, product quality and yield (Reichardt, 1987). Proper irrigation management can maximize efficiency of water use, minimize energy consumption (Marouelli et al. 1996) and promote optimum economic productivity. The point of maximum physical productivity can be achieved with results of agricultural experiments to obtain production functions, which evaluate the effects of input variation on production variation. This study aimed to establish optimal irrigation strategies for eggplant crop, Napoli cultivar, grown in a greenhouse in the South of Minas Gerais, considering water as a limiting production factor and different values for product price and electricity cost.

Material and Methods

The experiment was conducted in a greenhouse at the University of Lavras, state of Minas Gerais, April to October 2008. The municipality is located in the southern region of Minas Gerais, 918 m altitude, 21°14' south latitude and 45° 00' west longitude, where the soil is classified as Oxisol Typical (EMBRAPA, 1999). According to the Köppen classification, the region has a climate Cwa, i.e. mild temperate, rainy, with dry winters (DANTAS et al., 2007). We used a completely randomized design with 6 replicates. Treatments comprised 5 different irrigation depths (50, 75, 100, 125 and 150% replacement water depth to field capacity). Seedlings of eggplant, Napoli hybrid were transplanted to polyethylene pots capacity 21 L filled with Oxisol Typical (EMBRAPA, 1999). We used gravity drip irrigation system with emitters inserted on the line. Irrigation management was carried out with tension reading on tensiometers installed at 0.125 m depth in the experimental units with replacement of 100% of the recommended depth.
Using tension results, we calculated the corresponding humidity levels based on soil water retention curve. With these humidity levels and that one corresponding to field capacity, and also considering the volume of soil in the pots, we calculated replacement volume according to each

treatment. Product price was obtained in CEASA - MG (2008) while price of water was based on variable costs of energy, labour, maintenance and repairs of a pumping system. The study considered typical conditions of regional family farming, such as greenhouse cultivation, area 200 m²; spacing of plants 1 x 0.6m (0.6 m²); head height 60 m; performance of pump set 0.6; labour 5% of energy cost; maintenance and repairs 5% of energy cost (Vilas Boas, 2006); and consumer classified in group B of the Brazilian electric system (Carvalho & Oliveira, 2008). Variation in price of water was performed by varying energy cost (current rate R $ 0.279 kWh^{-1}) provided by the Energy Company of Minas Gerais - Cemig.

Results and Discussion

Maximum physical productivity of eggplant was found with a volume of 229 litters. Considering product price (Py) R$ 0.30 kg^{-1} and price of water (Pw) R$ 0.08 m^{-3}, maximum economic efficiency was obtained with a volume of 227 litters. There was a small difference (0.87%) between the amount required to achieve maximum technical efficiency and that required to achieve maximum economic efficiency. A similar result was found by Villas Boas (2006) for lettuce crop, i.e. water depths corresponding to maximum physical and economical productivity were very close. Total revenue (R$. $cycle^{-1}$) showed a quadratic function in relation to treatments, while total variable cost (R$. $cycle^{-1}$) showed a linear response, as shown in Figure 1.

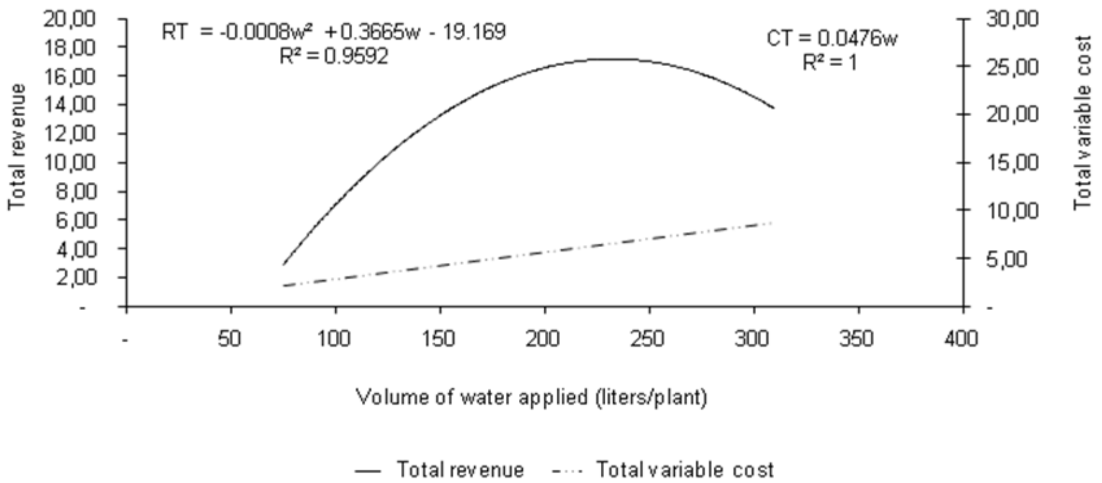

Figure 1. Effect of different irrigation depths on total revenue (R$) and total variable cost (R $) of eggplants subjected to different irrigation depths. UFLA Lavras / MG, 2008.

Irrigation strategies are shown in Table 1, considering different prices of product and water. Table 1.

Table 1. Irrigation strategies (W) with different combinations of product price (Py) and price of water (Pw) in four electricity rates.

Month	Seasonal price rates	Py R$.kg^{-1}	Pw R$.litre^{-1} 0,000084	0,000105	0,000125	0,000167
			----Economic Water Depth (litres/plant)---			
Jan	1,01	0,38	227,73	227,34	226,95	226,17
Feb	1,08	0,41	227,83	227,47	227,10	226,37
Mar	1,07	0,41	227,82	227,45	227,08	226,35
Apr	0,92	0,35	227,58	227,15	226,72	225,87
May	1,01	0,38	227,72	227,33	226,94	226,16
Jun	1,00	0,38	227,71	227,32	226,93	226,14
Jul	1,13	0,43	227,89	227,55	227,20	226,50
Aug	1,16	0,44	227,93	227,59	227,25	226,57
Sep	1,05	0,40	227,79	227,41	227,04	226,29
Oct	1,00	0,38	227,71	227,32	226,93	226,14
Nov	0,79	0,30	227,30	226,80	226,30	225,30
Dec	0,81	0,31	227,34	226,86	226,37	225,40

The optimum economic depth is always very close to the depth recommended for maximum physical productivity of 229 litters, even with 100% increase in electricity rates. The percentage of variable cost savings, considering application of the depth necessary to achieve maximum economic efficiency in relation to the depth necessary for obtaining maximum physical yield is shown in Figure 2. By applying the optimum economic depth, variable cost savings varies both with different rates and seasonal index price. The highest percentage was found in November, 1.614%, considering electricity price R$ 0.279 kWh^{-1} and product price R$ 0.30 kg^{-1}, which shows a small influence in price variation in the optimum economic depth.

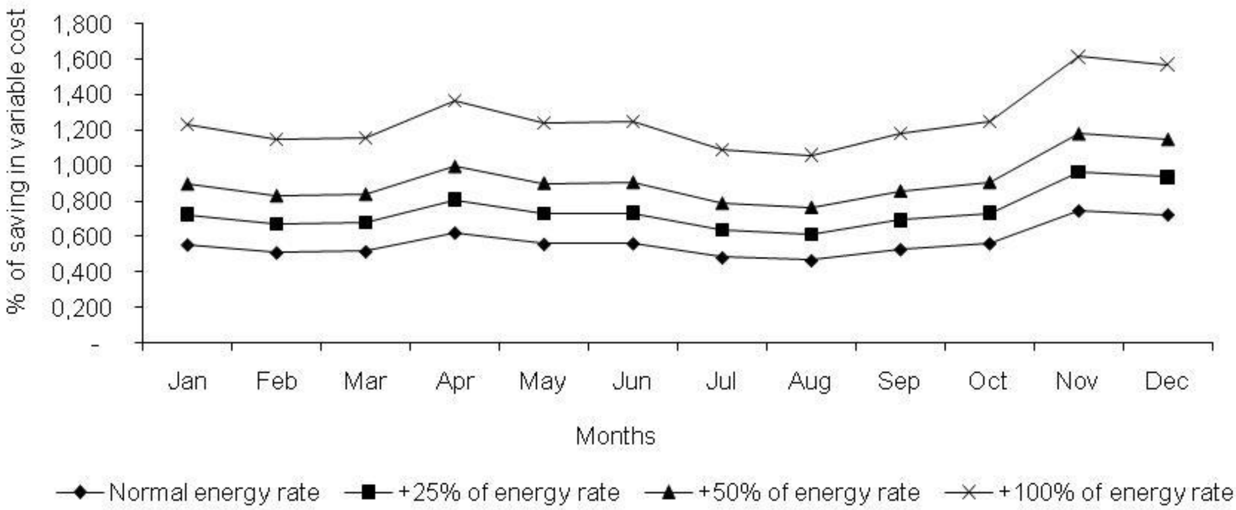

Figure 2. Percentage of variable cost savings, considering application of the depth necessary to achieve maximum economic efficiency in relation to the depth necessary for obtaining maximum physical yield. UFLA Lavras / MG, 2008

Conclusions

The highest yield was estimated by applying the volume of 229 litters of water, while maximum economic efficiency was estimated using 227 litters of water. Variation in price relationship (Pw / Py), considering seasonal price index and increase in power rate, had no proportional influence on the water depth recommended to achieve maximum economic efficiency.

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