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Economic analysis for oregano under irrigation considering economic risk factors

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ABSTRACT

The oregano is a plant, rich in essential oil and very used as spice in the preparation of foods. The objective of this paper was to analyze the viability of irrigation for oregano in Presidente Prudente, São Paulo state, Brazil, including economic risk factors, their effect on irrigation total cost, as well as the different pumping kinds. The Monte Carlo simulation was utilized to study the economic factors: fixed cost, labor, maintenance, pumping and water. The use of irrigation for the oregano in the region of Presidente Prudente is indicated because of its economic feasibility and the reduced risks. The average values of the benefit/cost for all water depths tested were higher than 1, indicating viability. The use of irrigation promoted lower risks compared to the non irrigated crop. The micro irrigation system presented greater sensitivity to changes of prices of the equipment associated to the variation of the useful life of the system. The oregano selling price was the most important factor involved in annual net profit. The water cost was the factor of lesser influence on the total cost. Due to the characteristic of high drip irrigation frequency there was no difference between the tariffs based in use hour of electric energy classified as green and blue, which are characterized by applying different rates on the energy consumption and demand according to the hours of day and times of the year. For the studied region it was recommended drip irrigation water management of oregano with the daily application of 100% of pan evaporation Class A using electric motor with tariffs blue or green.

Keywords: *Origanum vulgare*, pumping, economic viability, risk analysis, medicinal plants.

RESUMO

Análise econômica do orégano irrigado considerando fatores de risco econômico

O orégano é planta rica em óleo essencial, muito usada como tempero na preparação de alimentos. O objetivo deste trabalho foi a análise da viabilidade econômica do uso da irrigação em orégano para a região de Presidente Prudente (SP), com a inclusão do risco econômico e a análise do efeito dos fatores econômicos sobre o custo total da irrigação, bem como as diferentes formas de bombeamento. Utilizou-se a simulação por Monte Carlo para os fatores econômicos estudados: custo fixo, mão de obra, manutenção, bombeamento e água. Baseado neste estudo concluiu-se que o uso da irrigação para o orégano na região de Presidente Prudente é indicado devido a sua viabilidade econômica e redução dos riscos. Os valores médios obtidos da relação benefício/custo para todas as lâminas de irrigação testadas foram superiores a 1, indicando viabilidade. O uso da irrigação promoveu riscos inferiores aos do cultivo de sequeiro. A irrigação localizada apresentou maior sensibilidade à variação dos custos de aquisição associado à variação da vida útil do sistema. O preço de venda do orégano foi o fator que mais influenciou na receita líquida anual. O custo da água foi o fator de menor influência no custo total. Devido à característica de alta frequência da irrigação localizada não se observou diferenças entre as tarifas horosazonais verde e azul. A tarifa horosazonal é caracterizada pela aplicação de valores de tarifas diferenciados de consumo de energia elétrica e de demanda de acordo com as horas de utilização do dia e dos períodos do ano. Para a região estudada o manejo adequado da irrigação do orégano por gotejamento é a aplicação diária de 100% da evaporação medida no tanque Classe A com motor elétrico utilizando tarifa verde ou azul.

Palavras-chave: *Origanum vulgare*, bombeamento, viabilidade econômica, análise de risco, plantas medicinais.

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The oregano (*Origanum vulgare*), a small aromatic plant of *Lamiaceae* family, is originated from the Mediterranean region (Mastro *et al*., 2004). Since it is rich in essential oil, its use is very common in food preparation. As medicinal plant, it is used for stomachache and diuretic. Several medicinal, aromatic and spice plants are produced through the use of supplemental irrigation, like oregano, chamomile, sage and peppermint. In his study, Hadid *et al.* (2004) obtained the yield of 7,000 kg ha^{-1} using the supplemental irrigation and observed that the oregano, when irrigated, showed economic benefits higher than the ones obtained in big crops, giving 24 times more payback than the wheat cultivated in arid regions of Syria.

The irrigation is justified as an essential economic resource to increase the yield of the crops in regions where the insufficiency or poor distribution of rainfall affects the farm income. However, the economic viability is an indispensable factor for its adoption among farmers (Silva *et al*., 2003; Mousinho *et al.,* 2008). According to Almeida *et al.* (2004) and Oweis & Hachum (2009), the viability of a production system depends on the appropriate management, and it needs economic analysis. Silva *et al.* (2007) add that the promising prospect of the adoption of the irrigation should be studied and analyzed carefully, according to planning, design, management and development of the crop. They also believe that irrigation can help the farmers a great deal. However, the risks of the adoption of an irrigated agriculture should be carefully planned, always aiming a gross income higher than the expenses.

The high investment on irrigated agriculture in works and acquisition of equipment as well as energy costs and labor for the operation of the system, represent important extra expenses, which should be paid by the increase of the yield provided by water supply to the plants (Clark *et al*., 1993; Oweis & Hachum, 2009).

The simulation method by Monte Carlo provides the calculus of different combinations that probabilistically can occur, obtaining as a result not a deterministic value of economic factors but a distribution of frequencies (Frizzone & Silveira, 2000; Iglesias *et al.,* 2003). The combined possibilities of net benefit are calculated, generating a normal distribution in which it is possible to infer about the probabilities of net benefit higher than zero to the analyzed situations.

This study aimed to analyze the economic viability of the use of irrigation in oregano crop for Presidente Prudente region, São Paulo state, Brazil, including the economic risk through the variation of economic factors: fixed cost, labor, maintenance, pumping and water, as well as the different costs of forms of pumping water.

MATERIAL AND METHODS

To analyze the economic viability of the irrigation, the yield obtained in a field research by Marques *et al.* (2009) was used. The experiment was carried out in Presidente Prudente city (São Paulo state, Brazil). The weather is according to Köppen, aw mesothermal, with hot summers and dry winters. In this research, completely randomized design was used, considering 0; 25; 50; 75 and 100% ECA (the Class A pan evaporation). The fresh oregano yields obtained were 3,127.20; 4,985.10; 5,263.80; 5,699.30 and 8,089.70 kg ha^{-1} of fresh oregano respectively for irrigation depths of 0; 54.20; 108.41; 162.62 and 216.82 mm respectively.

The local soil, classified as Arenic Ultic Orthoxic Tropudalf (EMBRAPA, 1999), shows water content at field capacity (ϴcc) = 21.9%; water content to wilting point (ϴpmp) = 6.9%; bulk density = 1.66 g cm^{-3} and total porosity of 37.13%; for the depth of 0-0.20 m and ϴcc = 20.6%; ϴpmp = 4.9%; ds = 1.64 g cm^{-3} and total porosity of 39.97% for the depth of 0.20 – 0.40 m.

The water storage capacity in soil was obtained through the adjusted soil water retention curve (Van Genuchten, 1980) and calculated according to the root system growth in each crop phase.

To calculate the cost of pumping using electric motor, electricity rates prevailing in the year of 2009 were used (green, blue and conventional tariffs) for Presidente Prudente, Caiuá Company (ANEEL, 2009). To calculate the cost of pumping using diesel motor, the price of selling of the diesel oil of R$ 2.40 L^{-1} and a consumption of 170 g cv^{-1} h^{-1} (Marques & Coelho, 2003) were used. The monthly wage used was R$ 550.00 month^{-1}, plus legal fees.

To analyze the viability of irrigation, the cost to produce a dry-farming system of R$ 2,600.00 ha^{-1} (MAPA, 2006) was considered, equivalent to a unit cost of production of produced R$ 0.83 kg^{-1}, calculated according to Bach & Lopes (2007); the purchase price of drip irrigation system is R$ 8,000.00 ha^{-1}, with a rated horsepower of 2 cv ha $^{-1}$, flow of 2.5 m^{3} h^{-1} and application efficiency 90%.

The calculations used followed the computational model to analyze the economic risk in irrigated crops (Marques & Frizzone, 2005), in which simulations of economic factors are performed in Triangular Probability Distribution by Monte Carlo method with values obtained in Marques *et al.* (2006) and Associação Brasileira de Olericultura (2007). The values used for minimum (MIN), modal (MOD) and maximum (MAX) of economic factors were respectively for the oregano selling price of 6.50; 8.40 and R$ 8.60 kg^{-1}; for the irrigation system life span of 10; 13 and 15 years; for the maintenance fee of 2.0; 3.0 and 4.0%; for the interest rate of 8; 12 and 16% per year; for labor a use of 1.0; 2.5 and 4.0 hours ha^{-1} irrigation^{-1}; the water cost 0.00; 0.01 and R$ 0.03 m^{-3}.

The total cost of irrigation (equation 1) was divided into fixed and variable costs. To obtain the annual fixed irrigation costs, the Capital Recovery Factor (Ortiz Romero *et al*., 2006) was used. The Capital Recovery Factor means sufficient quantity of money in each year to enable the replacement in a number of years plus the charges of interests on the capital investment (Frizzone & Silveira, 2000; Frizzone *et al.*, 2001; Bach & Lopes, 2007). In the calculation of annual variable irrigation costs, the pumping cost, maintenance, labor and water costs (Frizzone *et al.*, 2001; Marques & Coelho, 2003) were used. The annual pumping cost of electric motor was calculated through the total annual billing demand and the total annual billing of consumption (Ortiz Romero *et al.*, 2006). The annual net return of irrigated crop (equation 2) was obtained for the yields of each irrigation levels. The crop net return with no irrigation was calculated using equation 3. The annual liquid profit of the irrigation (equation 4) is referred to the economic profit obtained through the use of irrigation, which is considered in the calculus of B/C relationship that evaluates how much the project pays per unit of investment (equation 5), according to Almeida *et al*. (2004); Marques & Frizzone (2005) and Oweis & Hachum (2009).

$$CI = CF + Cb + Cm + Cmo + Cw \quad (1)$$

$$RLi = [Yi \cdot Pp - (CP \cdot Yi) + CI] \quad (2)$$

$$RLs = [Ys \cdot Pp - (CP \cdot Ys)] \quad (3)$$

$$BL = RLi - RLs \quad (4)$$

$$B/C = \frac{BL}{CI} \quad (5)$$

where: CI is the annual irrigation cost (R$ ha^{-1} year^{-1}); CF is the annual fixed cost (R$ ha^{-1} year^{-1}); Cb is the annual pumping cost (R$ ha^{-1} year^{-1}); Cm is the annual maintenance cost (R$ ha^{-1} year^{-1}); Cmo is the annual labor cost (R$ ha^{-1} year^{-1}); Cw is the annual water cost (R$ ha^{-1} year^{-1}); RLi is the annual net return of the irrigated crop (R$ ha^{-1} year^{-1}); RLs is the annual net return of the non-irrigated crop (R$ ha^{-1} year^{-1}); Yi is the yield of the irrigated oregano for several tested irrigation levels (kg ha^{-1} year^{-1}); Pp is the price paid for the producer (R$ kg^{-1}); CP is the oregano yield cost without considering the irrigation costs (R$ kg^{-1}); Ys is the oregano dry-farming crop yield (kg ha^{-1} year^{-1}); BL is the annual liquid profit (R$ ha^{-1} year^{-1}) and B/C is the cost-benefit rate.

According to Zocoler (2003), for the electric motor, it is important to consider the tariff system of electric energy. This way, four pumping systems are considered (electric motor with green, blue and conventional tariff and diesel motor). Three different tariffs (conventional, blue and green) can be used and two basic components define the price: One is related to the power demand, and the other one is related to the energy consumption. The annual pumping cost for the electric motor is calculated by the total billing demand and total billing consumption related to the type of season tariff. In the calculation of blue and green season tariff prices, some differences are based on the use of the electric energy during the day hours and during the season of the year (Marques & Frizzone, 2005). The day hours are divided into peak hour (in state of São Paulo, three consecutive hours, from 6 to 9 p.m.) and the non-peak hour corresponding to the rest of the hours of the day but the peak ones defined by ANEEL, 2009. Each modality of pumping resulted in 31,250 combined values of annual liquid profit (R$ ha^{-1} year^{-1}) which were separated into 10 classes of frequency for adherence analysis by Kolmogorov-Smirnov to the normal probability density function with level of 5% of significance. After the confirmation of the adherence, the calculus of the probability of irrigation feasibility was done. That means, liquid profit higher than zero.

RESULTS AND DISCUSSION

For all tested pumping modalities with all the irrigation levels, the probability of liquid profit obtained was 100% higher than zero, that means, annual net returns higher than the net returns of the non-irrigated oregano and consequently all of them showed cost-benefit relationship higher than 1. (Tables 1 and 2). For non-irrigated oregano, the annual net return was R$ 21,907.66 ha^{-1} year^{-1} with a standard deviation of 1,468.9 ±6.7%.

These results show that irrigation is viable for oregano, according to Frizzone & Silveira (2000) a project should present a cost/benefit rate higher than one to be viable and, the higher this relationship, more attractive is the project (Clark *et al*., 1993). Concerning this information, the most attractive irrigation depth was the one 100% using electric motor with blue or green tariff with a cost-benefit rate of 4.97. Better results for yield and net return for oregano were obtained by Hadid *et al*. (2004) irrigation depth, corresponding to 100% ECA in Syria. For irrigated coffee using drip irrigation in Lavras (Silva *et al*., 2003), the replacement of 100% of Class A pan evaporation also showed the best economic viability. Kirnak & Dogan (2009) studied different irrigation depth based on Class A pan, in semi-arid conditions, also observed that the higher yield was obtained using 100% ECA.

For risk values measured by the standard deviation (Table 2), all the irrigation depth provided percentage values lower to production risk of the dry-farming crop (±6.7%), which is only linked to changes in market prices. With the use of the irrigation the distribution of the probabilities of the other simulations diluted the wide variation promoted by the selling price of the oregano. In a sensitivity analysis, the result obtained was that the selling price of the oregano when submitted to a percentage variation of ±20%, promoted an average variation of ±26.5% in annual net return. The other economic factors showed values always lower than ±1.5%. The factor that promoted a lower influence was the water cost with values always lower than ±0.5%.

The annual fixed cost of the irrigation equipment considering all the combinations resulted in an expected value of R$ 1,262.60 a year. The average expected values obtained using the four types of pumping for irrigation in the oregano crop, in the region of Presidente Prudente, for the different irrigation depths, are shown in Table 3.

In this work, the irrigation cost represented 35.8; 36.1; 35.1 and 28.4% of the total production cost. These values agreed with Pavlov *et al.* (2006), which consider that the irrigation costs are high, it can reach 40% of the total production cost. On the other hand, a

Table 1. Annual net received (RLi) and annual net benefit (BL) expected (R$ ha^{-1} yr^{-1}) for the four water depths tested considering four pumping kinds (receita líquida e benefício líquido esperados anuais (R$ ha^{-1} ano^{-1}) para quatro lâminas em quatro modalidades de bombeamento). Presidente Prudente, UNOESTE, 2009.

Pumping kind	Water depth (%ECA)	RLi	BL
Diesel oil	25%	32,472.60	10,564.94
	50%	34,193.31	12,285.65
	75%	37,009.21	15,101.55
	100%	53,494.18	31,586.52
electric motor tariffs blue and green	25%	32,589.00	10,681.34
	50%	34,489.54	12,581.88
	75%	37,481.64	15,573.98
	100%	54,139.98	32,232.32
electric motor tariffs conventional	25%	10,553.17	32,460.83
	50%	34,352.38	12,444.72
	75%	37,335.43	15,427.77
	100%	53,984.69	32,077.03

1 US$ = R$ 2.35

Table 2. Average expected values (E(X)) obtained for the four water depths considering four pumping kinds (valores médios esperados (E(X)) obtidos para quatro lâminas de irrigação considerando quatro modalidades de bombeamento). Presidente Prudente, UNOESTE, 2009.

	Water depth (%ECA)			
	25%	**50%**	**75%**	**100%**
	Diesel motor			
CI	2427.65	2654.44	2881.92	3116.71
B/C	3.10	3.19	3.39	4.53
σ	897.5 ±2.8%	1.025.8 ±3.0%	1.213.2 ±3.3%	2.340.2 ±4.4%
P(%)	100%	100%	100%	100%
	Electric motor, tariffs green and blue			
CI	2311.25	2358.18	2409.44	2467.38
B/C	3.19	3.42	3.74	4.97
σ	897.5 ±2.8%	1.025.8 ±3.0%	1.213.2 ±3.3%	2.340.2 ±4.4%
P(%)	100%	100%	100%	100%
	Electric motor, tariffs conventional			
CI	2439.43	2495.35	2555.66	2622.68
B/C	3.09	3.31	3.62	4.86
σ	897.5 ±2.8%	1.025.8 ±3.0%	1.213.2 ±3.3%	2.340.2 ±4.4%
P(%)	100%	100%	100%	100%

E(X)= average expected values (valores esperados médios); CI= annual irrigation cost in R\$ ha^{-1} year^{-1} (custo anual da irrigação em R\$ ha^{-1} ano^{-1}); B/C= benefit/cost relation (relação benefício custo); σ= standard deviation used as a risk measuring in % (desvio padrão usado como medida do risco em %); P(%)= probability of annual net benefit >0 (probabilidade de benefício líquido anual >0).

detailed study on the irrigation costs is necessary, in order to identify the most important factors in the formation of the annual irrigation cost.

Studying the annual cost of irrigation, the participation of involved economic factors (Table 3) was evaluated separately. The fixed and variable costs remained around 50% share of the annual cost of irrigation, for all kinds of pumping and all irrigation levels. The high share of the fixed cost is due to the high value of the acquisition of the drip irrigation system, which requires fixed system in the field, good filtering and multiple records. Blanco *et al.* (2004) also observed that the cost of the equipment acquisition associated to the life span are the higher sensitivity factors in the fixed irrigation costs.

Evaluating the kinds of pumping, the diesel motor provided lower net returns followed by the conventional electric tariff. The study in order to choose the kind of pumping and the electric tariff is an important step in this project. Andrade Júnior *et al.* (2001) considered that among the variable costs of an irrigation system, the electricity consumption is one of the most important components.

The pumping cost using diesel represented an average of 2.64 times the pumping cost of the electric motors. Similar values were obtained by Marques & Frizzone (2005) for sugar cane of 2.61 and for tomato of 2.35 times.

In electric motor, the conventional tariff, which does not contemplate different tariffs for season of year (dry and humid seasons) and for working hours (peak hours, from 6 p.m. to 9 p.m., and non-peak hours), showed the higher irrigation costs (Table 3). The green and blue tariff showed similar values, due to non-use during the peak hours in the analyses, like in the studies by Souza & Frizzone (2003). This fact is because drip irrigation use a short irrigation period (normally lasting less than 21 hours) due to the high frequency, it is not necessary to use during the peak hours.

A decrease in the percentage share of fixed costs and an increase of variable costs were observed (Table 3), as the irrigation depth was developed, due to the increase of the water and pumping costs. Similar results were obtained by Silva *et al.* (2007) for sunflower harvesting period.

Among the variable costs, the labor participation highlights (24 to 29% of the irrigation cost). The high frequency of irrigation, during 75 days in a 90-day cycle, leaded to a constant use of labor during the period, resulting in higher costs. Another factor to be considered is that trickle irrigation requires a more technified labor, which receives a better wage than the field laborers.

Concerning the pumping cost, a high share was expected, just like the one obtained by Andrade Júnior *et al.* (2001) for watermelon grown by drip irrigation in semi-arid region where the use of deficit irrigation showed higher net returns. Marques & Frizzone (2005), for sugar cane irrigated by central pivot and self-propelled obtained values higher than 50%. However, in this experiment, maximum values of 28.37% were observed for the use of diesel motor only due to the high cost of the liter of diesel and the impossibility of special values use during the non-peak hours just like for the electric motor. For the electric motor the values were always lower than 15%. These results were obtained due to the use of low pressure and high frequencies, common characteristics of the trickle irrigation systems that require a low power pump and little time of irrigation.

The maintenance rate showed average values from 7 to 10% of the annual irrigation cost. The charge for the use of the water was the factor that most influenced in the annual net return with values always lower than 1.2% of the total irrigation cost, the same results obtained by Blanco *et al.* (2004) and Marques & Frizzone (2005).

Thus, this study concluded that the average values of cost-benefit rate for all tested irrigation depths were higher than 1, indicating economic viability. The use of irrigation promoted economic risks lower than the use of dry-farming system. For the risks, the indicators obtained confirm that the use of trickle irrigation showed higher sensitivity to the variation of the acquisition costs associated to the variation of

Table 3. Percentage share of irrigation costs in the total cost of irrigation obtained for the four irrigation depths considering the four pumping kinds (participação percentual dos custos advindos da irrigação no custo total da irrigação obtidos para quatro lâminas de irrigação considerando as quatro modalidades de bombeamento). Presidente Prudente, UNOESTE, 2009.

Total anual irrigation cost		% do CT			
		Water depth (%ECA)			
		25%	50%	75%	100%
Pumping Diesel oil					
CF		52.00	47.50	43.75	40.50
CV		48.00	52.50	56.25	59.50
	Cmo	28.74	26.25	24.16	22.56
	Cm	9.85	9.08	8.36	7.64
	Cb	9.11	16.64	22.98	28.37
	Cw	0.30	0.53	0.75	0.93
Electric motor, tariffs blue and green					
CF		54.62	53.46	52.32	51.09
CV		45.38	46.54	47.68	48.91
	Cmo	30.35	29.55	28.90	28.45
	Cm	10.35	10.22	10.00	9.77
	Cb	4.37	6.18	7.90	9.53
	Cw	0.31	0.59	0.88	1.16
Electric motor, tariffs conventional					
CF		51.75	50.52	49.33	48.07
CV		48.25	49.48	50.67	51.93
	Cmo	28.75	27.93	27.27	26.76
	Cm	9.81	9.66	9.43	9.19
	Cb	9.39	11.33	13.16	14.88
	Cw	0.30	0.56	0.81	1.10

CT= total irrigation cost (custo total da irrigação); CF= fixed irrigation cost (custo fixo da irrigação); CV= variable irrigation cost (custo variável da irrigação); Cb= pumping cost (custo do bombeamento); Cm= maintenance cost (custo da manutenção); Cmo= labor cost (custo da mão de obra); Cw= water cost (custo da água).

the life span of the system. Due to the characteristics of the high frequency of the trickle irrigation, no differences were observed between green and blue season tariffs. So the use of the irrigation for the oregano in Presidente Prudente region is indicated due to the economic viability and the decrease of risks, considering the appropriate management for drip irrigation to the application of 100% ECA with electric motor using the green or blue tariff.

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