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Economic analysis in bell pepper crop on open field production system and under irrigation depths

Richard Alberto Rodríguez Padrón[1], Alexandre Swarowsky[2], Alfredo Schons[3], Pancracio Cánepa[4], Pablo Gamazo[4]

[1]Center of Rural Science, Postgraduate Program in Agricultural Engineering, Federal University of Santa Maria.

[2]Department of Environmental Engineering, Franciscan University, Santa Maria, RS, Brazil.

[3]Asistente Técnico Regional da EMATER-Regional de Santa Maria, RS-Brasil.

[4]Water Department, North Littoral Regional University Center, Universidad de la República, Uruguay.

rarpadron@gmail.com, aleswar@gmail.com, aschons@emater.tche.br, pancracio.canepa@gmail.com, gamazo@unorte.edu.uy

Abstract: In agriculture, the search for higher net profit is the main challenge in the economy of the producer. This study aims at the economic analysis in the bell pepper crop on open field production system and under different irrigation depth. Irrigation treatments consisted in 0.25, 0.50, 0.75 and 1.0 (rate of crop evapotranspiration) and the control (no-irrigation). Two trials were conducted in the 2013-2014 and 2014-2015 season from September to March. The determination of the costs of crop production was based on the methodology of the total cost and gross operating revenues calculated based at the producer level. The lowest yield was obtained with the open field treatment and the highest with irrigation rate of 0.75 of evapotranspiration, with internal rate of return of 0.29 and 0.84 respectively. The net profit for rainfed agriculture for a simulated 10 years of study, projections oscillate between R$ 6,000-13,000, and with irrigation rate of 0.75 between R$ 38,000-48,000. The investment of the irrigation system is justified, as a supplementary tool for production, necessary for profitability in the crop. The cultivation is economically profitable and has a fast return of investment.

Key words: *Capsicum annuum*, financial indicators, profitability, rainfed, drip irrigation.

Análise econômica no cultivo do pimentão cultivado em campo aberto e sub lâminas de irrigação

Resumo: Na agricultura, a busca do lucro líquido mais elevado e minimizar os custos de produção é o principal desafio da economia do produtor. O estudo teve como objetivo realizar a análise econômica no cultivo do pimentão cultivado em campo aberto e comparar agricultura de sequeiro com diferentes lâminas de irrigação. Os tratamentos de irrigação consistiam em 0,25, 0,50, 0,75 e 1,0 da taxa de evapotranspiração da cultura e m tratamento controle (sem irrigação). Dois experimentos foram realizados na temporada de setembro a março 2013-2014 e 2014-2015. A determinação dos custos de produção do cultivo, foi baseado na metodologia do custo operacional total e os ingressos brutos foram calculados com base no nível do produtor. A menor rentabilidade foi obtida com o tratamento sem irrigação e a mais alta com taxa de irrigação de 0,75 da evapotranspiração, com taxa interna de retorno de 0,29 e 0,84, respectivamente. O lucro líquido sem irrigação para 10 anos de estudo, oscilam entre R$ 6.000-13.000, e com taxa de irrigação de 0,75 entre R$ 38.000-48.000. Se justifica o

investimento no sistema de irrigação, como uma ferramenta de produção suplementar, necessária para a rentabilidade na cultura. O cultivo é economicamente rentável e rápido retorno do investimento.

Palavras-chave: *Capsicum annuum*, indicadores financeiros, rentabilidade, sequeiro, irrigação por gotejamento.

Introduction

The production of bell pepper (*Capsicum annuum* L.) is a significant activity for the Brazilian agricultural sector, the area cultivated is about 13 thousands hectares annually, approximately 290 thousands of tons of fresh fruit, generally grown on open field, especially during the dry season and irrigation is a fundamental practice to meet the water demand of plants (Marouelli and Silva, 2012). From the economic point of view, it is among the top ten vegetables in the domestic market, being a crop that due to the short period for the start of production provides a rapid return on investment, which is widely exploited by small and medium producers (Marcussi and Boas, 2003).

Bell pepper production, permanently faces a series of risks such as: constant variation in prices paid to producers, poor performance due to the heterogeneity of management practices applied, commercial competition produced on open field that generate a permanent imbalance in the productive chain, as well as uncertainties about the real profitability. In addition, it is essential to understand the cost of water, which in the future, will demand that this resource is applied with economic efficiency and effectiveness. According to Roas (2001), the water in its natural conditions has an economic value. Its value derived from direct use (irrigation, industry, recreation, etc.), indirect use value (habitat, contaminants debugger, etc.), non-use value of existence and legacy (scenic beauties, cultural sites, historical sites) and option value (biodiversity habitat, potential use and non-use). The cost of water is composed of capital costs, operation, maintenance, reliability of supply, and the opportunity cost of externalities imposed on society by their use. Also, Harou et al. (2009), say that a key to efficient water allocation concept is that the economic value of water and costs vary according to the amount used. In addition, factors such as location, water use (agricultural, industrial and residential consumption), availability of resources (abundance or shortage), also affect the economic value. Moreover, Booker et al. (2012), state that the use of water by farmers, including irrigated agricultural production and various industrial uses are among the largest in the world. Irrigation in the agriculture processes are one of the most significant factors in water use being even more important in countries with arid and semi-arid regions. Therefore, determining the economic value of water to users is an important tool to support the management of water resources in making decisions about public policies that lead to efficiency in water use and minimize shortage.

The estimation of production profit from the combination of available resources has been the subject of several studies. Frizzone (1993), says that among the factors of production, water and nutrients limit performance more frequently; therefore, control of irrigation and soil fertility are essential criteria for the success of agriculture. Moreover, Paz et al. (2002), is in arid or semi-arid regions where water is scarce and in humid regions, optimization of production depends on the rational use of water resources. Carvalho et al. (2011), state that the management of irrigation system should provide appropriate measures to improve the development and productivity of crop conditions. Therefore, an irrigation project should allow maximizing the efficiency of water use, rational management and minimize costs, investment and operation, so that the activity is economically viable and sustainable.

The use of production functions allows project useful solutions in optimizing the efficient use of water for irrigation and forecasting yields in agriculture (Frizzone, 1987). To determine the economic benefits of irrigation, it is necessary to know the quantity expected in production, according to the depths of water applied (Bernardo, 2006). Graphical or mathematical function of this relationship is called production function (water-culture). According, to Reis et al. (1999), the production function is a technical relationship between a possible specific set of factors included in the production process and the product obtained with the technology used and the analysis of production costs is crucial to determine the efficiency of economic profitability study of the resources used.

Through economic and financial analysis, one can identify strengths and weaknesses in terms of technical and economic performance, allowing decision-making actions of direct investment at any time and in this way constituting a better management of the use of available resources. Due to the above, this study aims to the development of economic analysis of the bell pepper crop, cultivated on open field production system and under different irrigation depth, compared to rainfed agriculture.

Material and Methods

The study was conducted in the experimental area of the Polytechnic School of the Federal University of Santa Maria, located at an altitude of 110 meters and geographically at coordinates 29°41'25"S, 53°48'42"W, for the spring-summer seasons of 2013-2014 and 2014-2015. The soil is classified as loam, types of Ultisols (Streck et al. 2008), and described in the physical-hydric characteristics by (Padrón et al., 2015a). The climate of the region is humid subtropical (Cfa) according to the classification of Köppen.

The experimental design was complete randomized block with four replications. The irrigation treatments were 0.25, 0.50, 0.75 and 1.0 of crop evapotranspiration and a control treatment without irrigation. There were established 20 experimental plots, each one with 5.0 m long and 4 m wide (20 m^2), for a total area of 400 m^2, not including the edge plants. The variety of bell pepper was Arcade, widely used in the region. The seedlings are transplanted on field with two months of age, with a separation of 1.0 m between rows and 0.4 m between plants (plant density of 2.5 plants m^{-2}), on November 16, 2013 and November 23, 2014.

It was used a localized irrigation system (drip), by installing a lateral row, the emitters with a spacing of 0.2 m and flow rate of 0.8 L h^{-1}. In each experimental plot size, were installed: a ball valve to regulate the irrigation time and pressure control valves for uniformity. The irrigation strategy were: during the first 20 days after transplantation were applied 100% of crop evapotranspiration to all irrigated treatments to ensure the establishment of plants. The irrigation depth was applied from 20 days to 119 days after transplantation and the frequency of daily irrigation was established. The evaporation of reference crops is calculated based on the method of Penman-Monteith/FAO. The crop evapotranspiration was calculated with the method of crop coefficients for each phenological stage (kcini= 0.6; kcmid= 1.15; kcend= 0.8) (Allen et al., 2006). The meteorological data were obtained from the automatic weather station located 1.0 km from the experimental area, on a daily basis; weather station recorded maximum and minimum temperature; relative humidity of air maximum and minimum; wind speed; insolation and rainfall.

The crop was harvest weekly for two months (from 60 days to 120 days after transplantation) in the years of study. The yield was determined in 20 plants per experimental plot size, located in the middle row. The methodology used in the production cost structure and total operating cost of production, was proposed by (Matsunaga et al., 1976; Rezende et al., 2009). This structure takes into account the actual disbursements made by the producer during the production cycle covering the costs of labor, repairs and maintenance of machinery, implements and specific inputs, machinery operations and the amount of depreciation machinery, instruments and specific improvements used in the production process.

To obtain the function of net profit margin is used the regression analysis between the dependent variables (net profit) and the independent variable (depth of irrigation applied), adjusted by the quadratic equation (Equation1) as follows.

$$y = a + b\,x + c\,x^2 \qquad (1)$$

where: y= net profit (R$); x= depths of water applied (mm); a, b, c= equation parameters. Also, is calculated the point of maximum economic efficiency of irrigation water to maximize net profit (Equation 2) as follows.

$$X_{max} = \frac{-\,b}{2\,c} \qquad (2)$$

The profit of production is determined from the difference in value of commercial yield, irrigation water costs and fixed costs of production system, in this item is included in the cost of the irrigation system (Equation 3) as follows.

$$L(x) = P_y\, y - P_x\, x - c \tag{3}$$

where: L(x)= profit (R\$ h^{-1}); P(y)= price of the product (R\$ kg^{-1}); y= yield (kg ha^{-1}), P(x)= price of irrigation water (R\$ mm^{-1}); x= total depths water applied (mm), c= cost of fixed factors (R\$ ha^{-1}).

To determine the maximum profit was calculated the first order derivative (Equation 3), with respect to (x) was calculated and the equation obtained is equalized in relation to the price of water (Px) and production (Py). In this way, the optimum depths that maximizes profit (Equation 4) as follows.

$$x_{\text{opt}} = \frac{P_x - P_y\, b}{2\,P \quad c} \tag{4}$$

The average price of production was obtained at the producer level, referring to periods of crops, stipulating R\$ 2.0 kg^{-1}. The cost of water for irrigation was obtained according to the company of Technical Assistance and Rural Extension (EMATER-RS), the value of water in the central region of Rio Grande do Sul, is considered as follows; (a) to supply water for irrigation to the agricultural property by gravity, it is charged around 8-10% of the yield per hectare; (b) to supply irrigation water to the agricultural property, requires pumping system, it is charged around 14% of the yield per hectare. The variable costs were obtained considering: workmanship of the irrigation system, fertigation, application of fungicides and insecticides and agronomic crop management. Fixed costs include: cost drip irrigation system, staking, reinforced concrete pole, poles, wire 12 and 20. The input prices were collected from both agricultural harvests and the dollar for calculations was established at a rate of R\$ 3.5.

The analysis was performed from the economic and commercial point of view in the different irrigation depths. To set the project's profitability, it was determined: the net present value (NPV), internal rate of return (IRR), the cost-benefit ratio (B/C) calculated for 10 years of analysis and assuming annual interest rate of 10%.

Results and Discussion

Evapotranspiration and effective rainfall in the 2013-2014 season were 560.0 mm and 345.1 mm respectively, for the 2014-2015 season were 500.7 mm and 543.8 mm respectively, showing a difference of 60.7 mm and 198.7 mm, respectively. The maximum interval between rainfalls in the

2013-2014 season was 13 days and in the 2014-2015 season was 11 days. Furthermore, in both seasons the minimum interval was 1 day, with 9 and 8 frequencies, respectively.

Investment costs for the production of bell pepper in rainfed and under irrigation, are shown in (Table 1). Overall, comparing the variables that influence production, excluding the value of land, inputs represent 47%-54%, services 29%-23% and harvesting 24%-23% of total cost in rainfed and under irrigation, respectively. The supplies represent the largest percentage of investment, in both cases, requiring greater investment in staking and irrigation system, with 53%-39%, respectively. This is also, affected by devaluation, availability and scarcity of products, among others. The costs in the work of harvesting are next to services; the concentrated harvest requires more labor in a short time and the highest cost services is the work of staking. Rainfed plots showed higher percentage of investment in the work of services and irrigation plots on inputs because it is included the cost and management of the irrigation system. Fixed costs represent 35%-44% and variable costs 65%-56% in rainfed and irrigation, respectively. Variable costs are affected by the change in the value of inputs and fixed costs are affected by depreciation, lack of maintenance and/or deterioration, and therefore the replacement of the equipment. McCoy et al. (2013), conducted economic analysis of the bell pepper crop under shade net, reported that variable costs represented 75% of total costs and fixed costs are responsible for the remaining 25%, also, conclude that in general, the economic sustainability of netting under cultivation shadow seems profitable and it is more attractive to producers with adverse climate risk. Also, Sreedhara et al. (2013), reports that among the tools for implementation, the cost of network structure shading was the main cost item, accounting for 66.4%, the value of land 20.3%, the structure of irrigation 6.2%, the electrical structure 5.4% and soil preparation 1.7%.

Table 1. Investment costs for one hectare of bell pepper cultivated on open field in rainfed and under irrigation.

Variable	Rainfed		Under irrigation	
	R$ ha^{-1}	US$ ha^{-1}	R$ ha^{-1}	US$ ha^{-1}
Supplies	14,230.0	4,065.7	25,350.0	7,242.9
Services	8,898.0	2,542.3	10,698.0	3,056.6
Harvest	7,350.0	2,100.0	10,950.0	3,128.6
Cost total	30,478.0	8,708.0	46,998.0	13,428.0
Fixed costs	10,530.0	3,008.6	20,530.0	5,865.7
Variable costs	19,948.0	7,048.0	26,468.0	7,562.3

The yield, average irrigation depths, gross profit and net profit, are shown in (Table 2). The irrigation rate that maximizes yield in bell pepper crop is 69.4% of evapotranspiration and technical efficiency maximum of yield of 33,534.2 kg ha^{-1} with irrigation depths of 239.2 mm (Padrón et al., 2015b). From these results, the net profit is determined by selecting irrigation rates, showing higher yield (69.4% and 75% of evapotranspiration), not including the value of water, obtaining R$ 40,600.4 and R$ 43,732.0 respectively. The difference in net profit between irrigation rates is R$ 3,131.6 and the average depth of irrigation of 43 mm. The minimum profit was obtained without irrigation with R$ 11,852.0, including the value of water to the difference of the average depths it was obtained R$ 1,064.7 and R$ 1,862.9, when the irrigation water is supplied properly by using gravity and pumping system, respectively. Determining the maximum technical efficiency of irrigation on crops, savings obtained in irrigation water consumption, increased yield and net profits. Rezende et al. (2005), obtained similar results, reporting net profit of R$ 48,847.98, in intercropping bell pepper and lettuce, where yield of these items individually was 61% and 72% lower, respectively. In addition, it was reported on monoculture of bell pepper a net profit of R$ 19,060.34. As well as Rezende et al. (2009), reported net profit associated to bell pepper and lettuce of R$ 44,138.34. In order to maximize productivity and net profit, the producer need to improve crop management practices.

Table 2. Yield, average irrigation depth, gross profit and net profit in bell pepper cultivated on open field by each crop cycle.

Irrigation rate (ETc)	Irrigation depth applied (mm)	Yield[z] (kg ha^{-1})	Gross profit		Net profit	
			R$	US$	R$	US$
0	-	15,900.0	31,800.0	9,086.0	11,852.0	3,386.3
0.25	85.4	24,460.0	48,920.0	13,977.0	22,452.0	6,414.9
0.50	170.8	32,370.0	64,740.0	18,497.0	38,272.0	10,934.9
0.75	256.2	35,100.0	70,200.0	20,057.0	43,732.0	12,494.9
1.00	341.7	28,130.0	56,260.0	16,074.0	29,792.0	8,512.0

[(z)]Font: (Padrón et al., 2015b).

The estimation of the economic value of irrigation water, are shown in (Table 3). According to the methodology established for the value of water, when lower irrigation depths are applied and lower yield is obtained, greater are the value of water, regardless of the water supply system for this study. Carvalho et al. (1996), calculated the value of water depth (R$ mm^{-1}), obtained from the average of the experimental data, considering the value of the energy for irrigation, calculating the value of the unitary water depths applied at R$ 1.10 per mm^{-1}. Also, the component costs of irrigation water will be used by employees (Melo, 1993 cited by Carvalho, 1995), reporting the costs of pumping of 1.0 mm of water depth: demand at 1.14%, energy at 46.2%, labor at 31.48% and maintenance and repairs at 21.77%.

Table 3. The estimating the economic value in different irrigation depth.

Irrigation rate (ETc)	Pumping system R$ mm^{-1}	Gravity system R$ mm^{-1}
0.25	80.18	45.82
0.50	53.06	30.32
0.75	38.35	21.92
1.00	23.05	13.17

The net profit including the value of proper irrigation water supply by using gravity and pumping system, are shown in (Figure 1). The maximum economic efficiency, with gravity system showing net profit of R$ 37,548.3, and the pumping system showing a net profit of R$ 33,375.7, with a difference of R$ 4,172.7, excluding the cost of fuel and electricity. The methodology established in the region, regarding the value of water, is an alternative without impairing the profit of the producer. Other methodologies could also, be tested, as volumetric meter installed in each property, flat rate per hectare or per year fixed rate, among others. In this sense, Roas (2001) mentions different methods to measure the value of water, describing the techniques for resource valuation as intermediate good, highlighting the residual method divided into derivation of the residual value and change in net income; and the alternative cost method. Valuation techniques add water as a commodity, both private and public. On the other hand, it's up to the managers of this income to provide investment to the preservation and conservation of water resources. Also, as an alternative, it is being used in family farming, the use of rainwater as the main source, contributing to income and agricultural profitability.

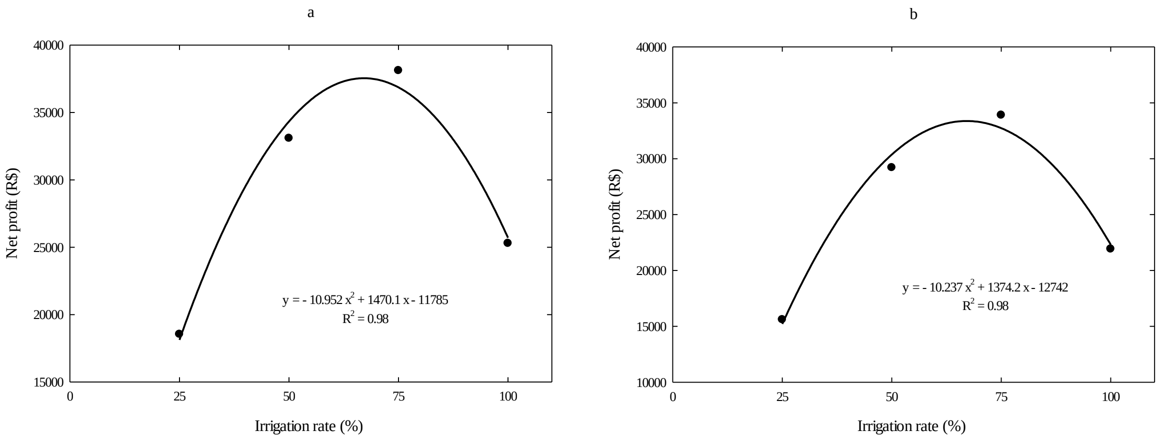

Figure 1. The net profit in bell pepper, when irrigation water is supplied properly by gravity (a) and using pumping system (b) according to irrigation rate.

The financial indicators of bell pepper cultivated on open field and different irrigation depths, are shown in (Table 4). All under irrigation treatments showed net profit and internal rate of return with positive value. The lower economic return was showed by the treatment without irrigation and the greater economic return was showed by the treatment rate of 0.75 of evapotranspiration. With this perspective, it can be estimated that with an investment of R$ 46,998.0, the investment can be recovered in two years under irrigation and under rainfed, in three years, with one crop cycle per year. According to the results of the net present value, the investment would produce earnings above the expected return and the project is profitable. Rezende et al. (2005), reported the internal rate of return of 4.78 in bell pepper monoculture. When associated with lettuce crop, the rate went to 8.2. On the other hand, Ayoola (2014), compared the economic performance of tomato, under irrigation and rain fed systems, with the aim of assessing the determinants of its profitability. The economic efficiencies were 1.380 and 0.986 for irrigated and rain-fed systems respectively and the conclusion was that tomato is more profitable and economically efficient under irrigation. Adewumi et al. (2005), state that tomato farming under small-scale irrigation systems is profitable, with a rate of return to investment greater than 1. Also, Gani and Omonona (2009), confirmed greater profitability and economic efficiency for maize production under irrigation system relative to rain-fed system.

Table 4. Financial indicators calculated for 10 years in bell pepper, cultivated on open field and different irrigation depths.

Irrigation rate (ETc)	NPV	IRR	Benefit (R$)	Cost (R$)	Relation (B/C)
0	31,793.10	0.29	348,201.13	273,692.9	1.27
0.25	72,438.69	0.38	535,660.35	383,295.5	1.40
0.50	177,251.11	0.72	708,884.94		1.85
0.75	213,425.30	0.84	768,670.41		2.01
1.00	121,068.47	0.54	616,031.30		1.61

IRR: internal rate of return; NPV: current net value; B/C: cost/ benefit relation.

The net profit projected in rainfed system with 10 years of simulated study range from R$ 6.000-13.000, and irrigation rate of 0.75 between R$ 38.000-48.000. The difference in net profit between these two hypotheses for 10 years of production represents 45%. In agriculture, the search for the greatest net profit, lower production costs is the main challenge in the economy of the producer. In this regard, it is important to know the risk involved in the acquisition of technology. In irrigated agriculture, it requires investments, primarily in the design, construction, equipment, transportation, control and distribution of water, including energy costs, labor to operate the system, representing additional significant costs. However, investment returns to producer with the product quality and higher yield.

The charge for the use of the water was the factor that most influenced in the annual net return with increase of 12.5% of the net cost. This study sample the average values of cost-benefit for irrigation rate of 0.5 and 0.75 were higher than 2.00, indicating economic viability. The use of the irrigation system for the region under study is indicated due to the economic viability and the decrease economic risks lower than the use of rainfed system, considering the appropriate management for drip irrigation.

Conclusions

The bell pepper crop on open field conditions is economically profitable and has a fast return of investment. Despite the frequent rainfall in the area, the investment is justified from an economic point of view in the drip irrigation system, as a supplementary tool production necessary, to get a cost-effective yield, with management strategy as the frequency of daily irrigation and irrigation rate between 65%-75% of evapotranspiration, optimizing the efficient water use. The producer, to improve crop management practices, achieve higher productivity and maximize the return of profit to the extent possible, may amend the net profits.

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