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PROFITABILITY OF ORGANIC YELLOW PASSION FRUIT AS A FUNCTION OF IRRIGATION, PROTECTED CULTIVATION AND POLLINATION[1]

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ABSTRACT – Passion fruit production has become an attractive activity due to its social and economic benefits, given the rapid economic return and well-distributed income over most of the year. From this perspective, this study aimed to evaluate the technical and economic indicators of yellow passion fruit cultivation by combining irrigation, protected cultivation, and pollination. The experimental design was in randomized blocks set up in split plots (2 x 2 x 2), with eight treatments and four replicates containing four plants per experimental unit. The protected environment was installed on the upper part of each trellis and consisted of 100 m transparent plastic film as cover material. Irrigation was performed using a micro-sprinkler system, and pollination was either manual or natural (entomophilous). The following parameters were evaluated: commercial yield - estimated for one hectare considering the mass of marketable fruits produced in the plot (30 m^2); production cost - capital depreciation, input prices, and labor used in cultivation; economic indicators - profitability index, family labor remuneration, profitability, net income, benefit/cost ratio, and fixed, variable, and total costs. The results show that artificial pollination increased the yield and provided a 41% higher profitability rate than natural pollination; supplemental irrigation, compared to rainfed cultivation, has no positive effects on profitability indices; protected cultivation increases the total cost and does not increase the yield; organic passion fruit production provides profitability indices ranging from 60% to 70%.

Keywords: Economic analysis. Operational costs. Profitability. *Passiflora edulis* Sims.

RENTABILIDADE DO MARACUJAZEIRO AMARELO ORGÂNICO EM FUNÇÃO DA IRRIGAÇÃO, CULTIVO PROTEGIDO E POLINIZAÇÃO

RESUMO – A passicultura tem se tornado uma atividade atrativa, em decorrência de seus benefícios sociais e econômicos, principalmente devido ao rápido retorno econômico com receita bem distribuída na maioria dos meses do ano. Sendo assim, objetivou-se avaliar os indicadores técnicos e econômicos no cultivo do maracujazeiro amarelo combinando fatores de irrigação, cultivo protegido e polinização. O delineamento experimental foi em blocos casualizados em parcelas divididas (2 x 2 x 2) com oito tratamentos e quatro repetições contendo quatro plantas por unidade experimental. O ambiente protegido foi instalado na parte superior de cada espaldeiras, constituído de filme plástico aditivado transparente de 100 m como material para a cobertura. A irrigação foi do tipo micro aspersão e a polinização manual ou natural (entomófila). Avaliou-se: produtividade comercial - estimada para um hectare considerando a massa de frutos comerciais produzidos na parcela (30 m^2); custo de produção - foram considerados a depreciação do capital, preços dos insumos e da mão de obra empregada no cultivo; indicadores econômicos - índice de lucratividade, remuneração do trabalho familiar, rentabilidade, receita líquida, relação benefício/custo, e custos fixos, variáveis e totais. Conclui-se que: a polinização artificial contribui para aumento da produtividade, proporcionando índice de rentabilidade 41% a mais que o cultivo com polinização natural; a irrigação suplementar, comparada ao cultivo em sequeiro, não apresenta efeitos positivos sobre os índices de lucratividade; o cultivo protegido eleva o custo total e não contribui para aumento de produtividade; a passicultura orgânica gera lucratividade na ordem de 60% a 70%.

Palavras-chave: Análise econômica. Custos operacionais. Lucratividade. *Passiflora edulis* Sims.

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INTRODUCTION

Brazil is the largest producer and consumer of yellow passion fruit in the world (*Passiflora edulis* Sims), with a production of 593,429 tons and a mean yield of 14.3 t ha^{-1} (IBGE, 2020), standing out in the fruit production agribusiness and contributing to the development of the agricultural sector (FALEIRO et al., 2019).

There are several studies attesting to the positive aspects of organic passion fruit farming focusing on the reduction of external inputs and lower production costs (ALVES et al., 2018; ARAÚJO NETO et al., 2014; MOTTA et al., 2008; SILVA et al., 2020; UCHÔA et al., 2021a), in addition to environmental benefits such as improved physical, chemical, and biological soil quality (ALMEIDA et al., 2020) and higher fruit contents of tocopherols and ascorbic acid (PERTUZATTI et al., 2015).

Although the North region of Brazil offers favorable edaphoclimatic conditions for passion fruit cultivation, the annual rainfall is distributed asymmetrically throughout the year, with a drought period from May to September (INMET, 2020), limiting passion fruit cultivation since the crop requires 86 mm month^{-1} of water during flowering and fruit setting (DUTRA et al., 2018). Water availability is indispensable to reaching higher fruit yields and quality (CAVALCANTE et al., 2020; UCHÔA et al., 2021b), justifying the use of complementary irrigation as a profitable technique while observing the amount and moment of water application (ARAÚJO et al., 2013).

Pollination is an important factor for many fruit species. Artificial pollination can triplicate the fruit yield of passion fruit (KRAUSE et al., 2012) and provide up to 90% of fruit establishment (ESASHIKA; FALEIRO; JUNQUEIRA, 2019). However, even in environments with large populations of pollinating bees of the genus *Xylocopa* spp., entomophilous pollination can be low due to the presence of pest bees that damage flowers and/or extract pollen. Therefore, artificial pollination is indispensable in passion fruit cultivation since, in addition to preventing the loss of pollen to pests, this practice deposits higher amounts of pollen and provides its better distribution on the stigmas in relation to insect activity, resulting in higher fruit biomass values (LAGE et al., 2018; SILVEIRA et al., 2012).

On the other hand, protected cultivation environments represent a potential alternative for passion fruit production due to the anticipation of harvest in the off-season and the production of fruits with fewer physical damage in relation to cultivation under direct sunlight (KOETZ et al., 2010), protecting plants from direct solar radiation and excessive rainfall. Therefore, this practice maintains the integrity of grain pollens and increases flower fertilization and fruit production.

Although some studies highlight the technical and economic viability of organic passion fruit production in Acre (ALVES et al., 2018; ARAÚJO NETO et al., 2014; GALVÃO et al., 2020; REZENDE et al., 2017; SILVA et al., 2020; UCHÔA et al., 2021a), fruit production in that state is still insufficient to supply the local market (IBGE, 2020) due to the lack of studies and cultivation technologies.

In this scenario, the adequacy of crop management practices, allied to cost reduction and/or revenue increase, are essential for the success of passion fruit production. From this perspective, this study aimed to quantify the technical and economic indicators of yellow passion fruit production by combining irrigation, protected cultivation, and pollination.

MATERIAL AND METHODS

The experiment was conducted at the Seridó Ecological Station in Rio Branco, Acre, located at the geographic coordinates 9º 53’ 16’’ S and 67º 49’ 11’’ W, at an elevation of 170 m above sea level. The soil of the area where the project was development is classified as a Plinthic Lithic RED YELLOW ULTISOL with a slightly undulating topography, no apparent erosion, and moderate drainage (SANTOS et al., 2013a). The chemical attributes of the 0 to 20 cm depth layer are as follows: pH = 6.3; P = 1.0 mg.dm^{-3}; K = 1.1 mmolc.dm^{-3}; Ca = 24 mmolc.dm^{-3}; Mg = 11 mmolc.dm^{-3}; Al+H = 31 mmolc.dm^{-3}; O.M. = 17 g.dm^{-3}; SB = 36.1 mmolc.dm^{-3}; CEC = 67.1 mmolc.dm^{-3}; V = 53.8%.

The regional climate is hot, humid, and classified as *Am* according to the Köppen classification, with mean annual temperatures around 24.5 ºC, relative air humidity of 84%, and annual rainfall ranging from 1,700 mm to 2,400 mm (INMET, 2020).

The experimental design was in randomized blocks and set up in split plots (2 x 2 x 2) with eight treatments and four replicates containing four plants per experimental unit. The plot was composed of irrigation or rainfed cultivation, in which two other factors were distributed: cultivation environment (protected or direct sunlight) and pollination (artificial or natural).

The passion fruit cultivar used in the experiment was an F4 variety of public domain formed by genotypes 2, 22, 23, 35, 37, 33, and 20 from Viçosa (MG, Brazil), the State University of Northern Rio de Janeiro (Campos dos Goytacazes, RJ, Brazil), and the municipalities of Brasiléia and Rio Branco (AC, Brazil) (NEGREIROS et al., 2008).

The seedlings were produced in a plant nursery covered with 100-µm transparent plastic film. The seeds were sown in polystyrene trays and transplanted after emergence to 3-L plastic bags containing a substrate with the following composition: 33% soil, 33% organic compost, 33% ouricuri palm fiber (*Attalea phalerata*), 1.0 kg m^{-3} of dolomitic limestone, 1.5 kg m^{-3} of natural thermophosphate, and 1.0 kg m^{-3} of potassium sulfate, receiving irrigation twice a day.

The seedlings were transplanted to the field in September 2018 using a spacing of 2.5 m between rows and 3.0 m between plants, with evaluations until August 2020.

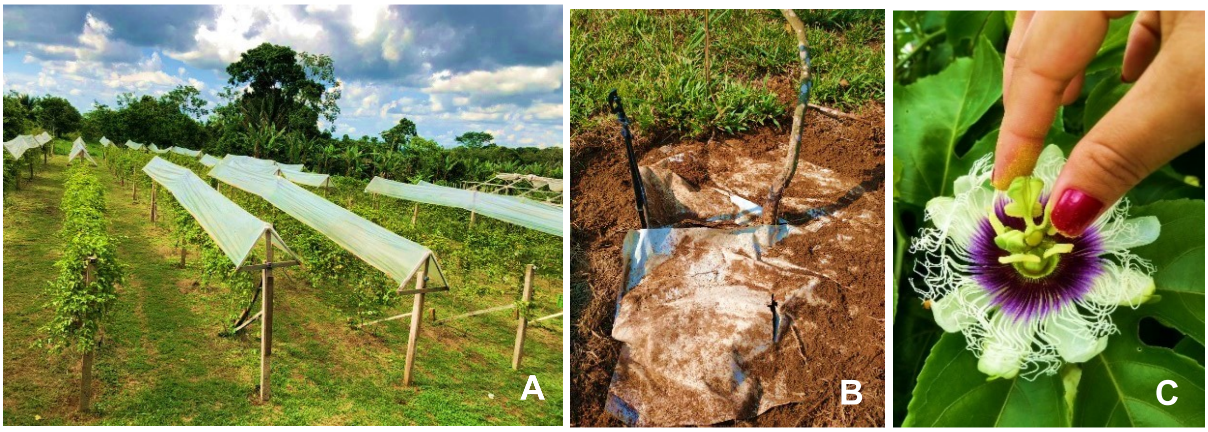
The planting area was cleaned with a backpack brush cutter, and planting holes 80 cm wide and 30 cm deep were opened with a soil drill without inverting the soil layers. Then, the holes were fertilized with 20 L of organic compost, 500 g of limestone, and 200 g of thermophosphate.

The plants were conducted in a vertical trellis system using smooth wire no. 12 at the height of 2 m. The wire was attached to concrete posts spaced six meters apart. Strings were used as trainers during early plant development, and the plants were periodically pruned to conduct them in a single stem (main branch). When exceeding 10 cm above the wire, the plant apex was cut so that the two secondary branches closest to the wire were conducted in opposite directions until they reached 1.5 m in length, after which the tip of the plant was removed. The tertiary branches that emerged from these were then conducted toward the soil and subsequently pruned at 20 cm from the ground, forming the "curtain" where the productive branches are located.

The protected environment was installed above the trellis using 100-µm transparent plastic film as cover material (Figure 1A)

Micro-sprinkler irrigation was performed using one emitter per plant in the row at a flow rate of 67.5 L h^{-1}. The moment of irrigation was defined by the soil water matric potential, measured with a tensiometer fixed at 0.15 m from the plant and a depth of 0.20 m in the soil. When the value was close to 60 kPa, it indicated the moment when supplemental water had to be provided (DUTRA et al., 2018). The readings were performed daily using a digital reader.

Artificial pollination was performed daily between 1:00 p.m. and 5:00 p.m. with naked fingers. Before or during pollination, the plant anthers were collected so that the operator could pass the fingertips with pollen on the surface of the stigmas (Figure 1C).



Photos: Silva (2019).
Figure 1. Conduction of the yellow passion fruit experiment. A) 100 m transparent plastic film cover; B) Micro-sprinkler irrigation and mulching at the base of the plant; C) manual passion fruit pollination.

Two topdressing fertilization interventions were performed during crop formation, the first 60 days after planting using 176.5 g $plant^{-1}$ of P_2O_5 and 88.2 g $plant^{-1}$ of K_2SO_4, and the second 120 days after planting with 176.5 g $plant^{-1}$ of P_2O_5 and 88.2 g $plant^{-1}$ of K_2SO_4. In both applications, thermophosphate was used as the P source, whereas potassium sulfate was used as the K source.

After topdressing fertilization, a mulch cover measuring 50 cm x 50 cm was laid at the base of the plants (Figure 1B) to prevent weed growth.

Fruit harvest was performed two to three times a week by collecting the fruits on the ground and the ripe fruits attached to the plants. All fruits that showed 55% of yellow peel color were considered ripe (SANTOS et al., 2013b).

The commercial yield was estimated for one hectare by considering the total mass of marketable fruits produced in the plot (30 m^2) during the first (January to August 2019) and second crop years (September 2019 to August 2020), with values expressed as kg ha^{-1}.

The production cost was calculated based on capital depreciation and the prices of the inputs and manpower employed in cultivation, whereas the economic indicators used were the profitability index, family labor remuneration, profitability, net revenue, benefit to cost ratio, and fixed, variable, and total costs (REIS, 2007).

This analysis considered the production costs in the protected environment and under direct sunlight, with irrigation and rainfed conditions, and with natural and artificial pollination estimated for one hectare. The fixed costs comprised the trellis system, irrigation, plastic covers, fruit processing facility, brush cutter, and others. The sale price of fresh passion fruit was R$ 5.00 kg^{-1}, whereas the price of the frozen pulp was R$ 12.00 kg^{-1}.

Fixed and variable costs were calculated based on the interest rate of 6% per year used as alternative costs necessary to compensate the capital employed in the agricultural activity and 3% of administrative costs (CONAB, 2010). The total cost was determined by summing all costs with capital services (depreciation), inputs, and manpower in passion fruit cultivation.

The value of the daily wage paid was calculated according to the Brazilian minimum wage from 2018 to 2020, with due adjustments and charges (CONAB, 2010), divided by 23 working days.

Calculating the depreciation of goods is necessary to know the time for their replacement by physical or economic wear. This parameter was determined using the following equation:

$$D = \frac{V_a - Vr}{V_u} . P$$

D – depreciation (R$/cultivation);
V_a – current value of the good (R$);
V_r – residual value (final value of the good) (R$);
Vu – lifespan (period during which the good is used in the activity);
P – period considered, production cycle.

The benefit to cost ratio was defined by the quotient between the current value of the revenue flow obtained and the current cost flow value, including the investments necessary to develop the production unit.

The net income (RL) represents the income obtained with the activity and is obtained by subtracting the total cost from the total income.

The profit margin (L) was obtained by the quotient between the net income and the total income and was expressed as a percentage. Family labor remuneration (RMOF) was calculated by the ratio between the net income earned by the family and the number of working days.

The profitability index (IR) determined the degree of attractivity of the enterprise and was obtained by the following equation:

$$IR = \frac{RL}{I+CG} .100$$

IR - profitability index;
RL – net income;
I - fixed investment;
CG – working capital.

The working capital was employed to purchase the inputs used in agroecological agriculture, e.g., soil correctors, fertilizers, packages, sulfur, limestone, neem oil, biological insecticide, organic compost, and transportation costs.

The simplified economic analysis was performed using the following indicators: mean total cost (CTMe), operational coverage production (Pcop), and total coverage production (PcT), according to Reis (2007).

The statistical analysis was performed by checking the presence of outliers, normality of errors by the Shapiro-Wilk test, and homogeneity of variances by the Bartlett test. The analysis was variance was also performed, and when the F-value indicated a significant difference between treatments ($p<0.05$), Tukey's test was applied at the 5% level of significance.

RESULTS AND DISCUSSION

There was no significant double or triple interaction on any of the evaluated factors ($p>0.05$) (Tables 1, 2, and 3).

There were significant differences of pollination and plant cover on profitability, benefit to cost ratio, profitability index, net income, total income, and family labor remuneration (Table 1).

The profitability index of organic passion fruit cultivation in this study ranged from 157.94% in protected cultivation to 276.50% in direct sunlight cultivation (Table 1). In other studies with organic passion fruit, Silva et al. (2020) and Uchôa et al. (2021a) obtained the respective indices of 177% and 157%. However, the profitability indicators were unfavorable in conventional cultivation with high input supply, especially due to the high costs of agricultural inputs and disease control practices (FURLANETO et al., 2011).

The profitability of passion fruit cultivation is similar to other significant agricultural activities in Brazil, e.g., soybean production with molybdenum application, which achieved profitability indices ranging from 76.80% to 79.65% (OLIVEIRA et al., 2015). However, several agricultural activities have lower profitability than organic passion fruit cultivation, e.g., cowpea, with which Vieira et al. (2018) obtained a profitability index of 39.02%, and conventional coffee cultivation (*Coffea arabica*), which can be influenced by seasonality during the off-season, alternating between negative (-13.9%) and positive profitability indices (44.8%) (TURCO et al., 2017).

Table 1. Profitability (L), benefit to cost ratio (B/C ratio), profitability index (IR), net income (RL), total income (RT), and family labor remuneration (RMOF) of organic yellow passion fruit as a function of cultivation systems.

Factor	L	B/C ratio	IR	RL	RT	RMOF
	(%)		(%)	(R$ ha^{-1})		(R$ day^{-1})
Artificial pollination	67.44 a	3.33 a	254.25 a	98.363.69 a	142.592.81 a	232.53 b
Natural pollination	59.06 b	2.65 b	180.19 b	66.416.63 b	108.477.73 b	312.09 a
Protected cultivation	56.63 b	2.46 b	157.94 b	72.910.19 a	122.960.68 a	235.60 b
Direct sunlight	69.88 a	3.52 a	276.50 a	91.870.13 a	128.109.86 a	309.03 a
Irrigation	62.44 a	2.88 a	204.69 a	82.882.69 a	128.960.88 a	275.38 a
Rainfed conditions	64.06 a	3.10 a	229.75 a	81.897.63 a	122.109.81 a	269.19 a

Different lowercase letters in the column differ ($p<0.05$) for the factors of pollination, coverage, and irrigation by the Tukey test.

Table 2. Operational coverage production (Pcop), total coverage production (PcT), total commercial yield (ProdCT), and total mean cost (CTMe) of organic yellow passion fruit as a function of cultivation systems.

Factor	Pcop (kg ha^{-1})	PcT (kg ha^{-1})	ProdCT (kg ha^{-1})	CTMe (R$ kg^{-1})
Artificial pollination	9,197.98 a	10,052.07 a	32,407.38 a	1.44 b
Natural pollination	8,745.91 b	9,559.33 b	24,654.06 b	1.80 a
Protected cultivation	10,450.34 a	11,375.09 a	27,945.56 a	1.91 a
Direct sunlight	7,493.54 b	8,236.31 b	29,115.88 a	1.33 b
Irrigation	9,596.44 a	10,472.28 a	29,309.25 a	1.66 a
Rainfed conditions	8,347.44 b	9,139.13 b	27,752.19 a	1.59 a

Different lowercase letters in the column differ ($p<0.05$) for the factors of pollination, coverage, and irrigation by the Tukey test.

Table 3. Total variable cost (CVT), total fixed cost (CFT), and total cost (CT) of organic yellow passion fruit as a function of cultivation systems.

Factor	CVT	CFT	CT
Artificial pollination	31,966.91 a	12,262.00 a	44,229.12 a
Natural pollination	29,798.85 b	12,262.00 a	42,061.04 b
Protected cultivation	31,248.72 a	18,801.50 a	50,050.41 a
Direct sunlight	30,517.04 a	5,722.50 b	36,239.75 b
Irrigation	31,620.14 a	14,4457.50 a	46,078.04 a
Rainfed conditions	30,145.62 b	10,066.50 b	40,212.13 b

Different lowercase letters in the column differ ($p<0.05$) for the factors of pollination, coverage, and irrigation by the Tukey test.

The revenue obtained with the activity accounts for a total monthly income of R$ 7,129.64 and net revenue of R$ 4,918.18 when using artificial pollination. These high values are directly related to the high yield, low production costs, and fruit prices higher than the mean production cost. In this case, the calculation considered short-circuit marketing without intermediaries and with direct sale to the consumer for R$5.00 kg^{-1} of fresh fruit and R$ 12.00 kg^{-1} of frozen pulp.

The profitability of the activity was considered high, with a mean value above 56%. However, rainfed cultivation showed a 12.3% higher profitability than irrigation, whereas cultivation under direct sunlight was 75.1% higher than protected cultivation. Moreover, artificial pollination increased profitability by 41.1% compared to natural pollination (Table 1).

Despite the higher costs caused by manpower, artificial pollination in passion fruit results in higher yields, benefit to cost ratio, profitability index, and net and total incomes than natural pollination (Table 1). This effect is directly related to the significant yield increase (Table 2).

The use of plastic covers reduces the profitability, revenue, and benefit to cost ratio due to costs with the cover structure, plastic film, and manpower for installation. However, this practice shows economic viability despite the lower economic indicators, with a benefit to cost ratio of R$ 2.46 for every R$ 1.00 invested. On the other hand, if considering the energy expenditure and residues generated, cultivation under direct sunlight is more ecologically indicated.

Since there is no significant difference in profitability and revenue between irrigation and rainfed cultivation, the physical and economic planning of the irrigation system for passion fruit is necessary since prolonged water stress periods require supplementary irrigation for this crop (UCHÔA et al., 2021b), otherwise compromising fruit production even with the return of natural water availability due to irreversible stress (GALVÃO et al., 2020). In this case, higher rainfall rates decrease the variable cost (electricity and maintenance) with water supplementation.

Family labor remuneration (RMOF) was considered high for agricultural standards (4.5 times higher than the regional daily wage of R$ 68.86/ man/day), with higher values for natural pollination (R$ 312.09/day), under direct sunlight (R$ 309.03/ day), and using irrigation (R$ 275.38/day). In the case of pollination and direct sunlight cultivation, the lower use of manpower compensated for the lower yield and profitability. However, the investment in irrigation generated higher yields and profitability, increasing the economic return for the manpower employed if using family labor.

One of the characteristics of organic passion fruit cultivation is the low cost of the activity due to fewer external inputs (UCHÔA et al., 2021a). From this perspective, Motta et al. (2008) compared the economic aspects of organic and conventional yellow passion fruit cultivation and verified the superiority of organic cultivation, with a 21.39% higher mean profitability index for this system.

Pollination, protected cultivation, and irrigation showed significant differences in the operational coverage production (Pcop) and total coverage production (PcT), whereas only pollination showed a significant difference in the total commercial yield (Table 2).

The yield necessary to cover operational costs (Pcop) and the total cost (Pct) was lower in rainfed cultivation, with natural pollination, and under direct sunlight (Table 2).

The costs to produce fruits with artificial pollination demanded 452.07 kg ha^{-1} more than natural pollination. On the other hand, the additional commercial yield obtained with this technique was 7,753.3 kg ha^{-1} (Table 2), with a return of R$ 3.33 for every R$ 1.00 invested (Table 1).

The economic viability of organic passion fruit cultivation, considering the low use of inputs, requires low yields to cover production costs, e.g., 3.2 t ha^{-1} when using tall seedlings with long roots (SILVA et al., 2020), increasing to 5.49 t ha^{-1} with irrigation, artificial pollination, and deep planting (FRANCISCO et al., 2020), and to 6.90 t ha^{-1} when using irrigation and a large volume of organic inputs (UCHÔA et al., 2021a). On the other hand, conventional passion fruit cultivation using large volumes of synthetic inputs requires yields above 28.3 t ha^{-1} to cover production costs (FURLANETO et al., 2011).

For protected cultivation, it was necessary to produce 11.4 t ha^{-1} to cover production costs (Table 2). Even with no significant difference ($p>0.05$) in the commercial yield of plants conducted under direct sunlight, these produced 1.2 t ha^{-1} more than the plants under protected cultivation (Table 2), which, allied to the lower cost, contributed to higher profitability and revenues (Table 1).

The lowest mean total cost to produce organic passion fruit was R$1.44 kg^{-1} for artificial pollination and R$1.34 kg^{-1} for direct sunlight cultivation, below the industrial purchase price in the state (R$ 2.00 kg^{-1}) and below the fresh fruit price during the off-season in the municipalities of Feijó (R$ 14.80 kg^{-1}) and Rio Branco (R$ 7.80 kg^{-1}). According to IBGE (2020), the mean cost per kilogram of passion fruit produced in the country is R$ 2.02 kg^{-1}, above the value estimated in this study.

Fixed and variable costs are higher with irrigation, manpower for pollination, and protected cultivation (Table 3). The use of irrigation makes this activity more expensive without significantly increasing the yield of yellow passion fruit in relation to rainfed cultivation. However, the costs with irrigation are diluted over time since its lifespan is about ten years, being used in three to four crop cycles.

On the other hand, artificial pollination increased the total cost by 5% (Table 3) but increased the speed of return on invested capital by 41% (Table 1), thus showing the profitability of this technique in passion fruit cultivation.

CONCLUSIONS

Artificial pollination increases the yield, providing a profitability index 41% higher than natural pollination.

Compared to rainfed cultivation, supplemental irrigation has no positive effects on the profitability indices.

Protected cultivation increases the total cost and does not contribute to increasing the yield. Therefore, it is not recommended for yellow passion fruit cultivation in the southwestern Amazonian region.

Organic passion fruit cultivation generates profits ranging from 60% to 70%, with indicators reinforcing the importance of this activity as an alternative source of family income.

REFERENCES

ALMEIDA, W. A. Et al. Chemical soil and leaf properties in yellow passion fruit cultivation with organic fertilization. **Comunicata Scientiae**, 11: e3342, 2020.

ALVES, L. E. V. et al. Analysis of the economic feasibility of organic polyculture. **Revista Verde de Agroecologia e Desenvolvimento Sustentável**, 13: 1-7, 2018.

ARAÚJO, H. F. et al. Technical and economic indicators of the yellow passion fruit tree irrigated with underground water supply. **Engenharia Agrícola**, 34: 940-951, 2013.

ARAÚJO NETO, S. E. et al. Organic polyculture of passion fruit, pineapple, corn and cassava: the influence of green manure and distance between espaliers. **Ciência e Agrotecnologia**, 38: 247-255, 2014.

CAVALCANTE, A. G. et al. Physiology and production of yellow passion fruit with hydroabsorbent polymer and different irrigation depths. **Revista Ceres**, 67: 365-373, 2020.

CONAB - Companhia Nacional de Abastecimento. **Custo de produção agrícola**: a metodologia da Conab. Brasília, 2010. 60 p.

DUTRA, A. F. et al. Photochemical and productive performance of yellow passion fruit irrigated in the brazilian semiarid. **Engenharia Agrícola**, 38: 901-909, 2018.

ESASHIKA, D. A. S.; FALEIRO, F. G.; JUNQUEIRA, N. T. V. Number of carpels in the pollination efficiency of sour passion fruit. **Revista Brasileira de Fruticultura**, 41: e-451, 2019.

FALEIRO, F. G. et al. Advances in passion fruit (*Passiflora* spp.) propagation. **Revista Brasileira de Fruticultura**, 41: e-155, 2019.

FRANCISCO, W. de M. et al. Productivity and quality of irrigated organic yellow passion fruits in deep planting in Southeastern Amazon. **Revista Brasileira de Fruticultura**, 42: e-584, 2020.

FURLANETO, F. P. B. et al. Custo de produção do maracujá-amarelo (*Passiflora edulis*). **Revista Brasileira de Fruticultura**, 33: 441-446, 2011.

GALVÃO, R. O. et al. Organic compost as a conditioner of soils cultivated with yellow passion fruit. **Comunicata Scientiae**, 11: e3398, 2020.

IBGE - Instituto Brasileiro de Geografia e Estatística. **Produção agrícola municipal – culturas temporárias e permanentes**. Rio de Janeiro: IBGE, 2020. Disponível em: <http://www.sidra.ibge.gov.br/bda/tabela/listabl.asp?c=1613&z=p&o=28>. Acesso em: 06 abr. 2021.

INMET - Instituto Nacional de Meteorologia. **Banco de Dados Meteorológicos para Ensino e Pesquisa**. 2020. Disponível em: <http://www.inmet.gov.br/portal/index. php?r=bdmep/bdmep>. Acesso em: 27 mar. 2021.

KOETZ, M. et al. Qualidade de frutos do maracujazeiro-amarelo em ambiente protegido e natural produzidos sob diferentes regimes de irrigação. **Revista Brasileira de Agricultura Irrigada**, 4: 115-127, 2010.

KRAUSE, W. et al. Produtividade e qualidade de frutos de cultivares de maracujazeiro-amarelo com ou sem polinização artificial. **Pesquisa Agropecuária Brasileira**, 47: 1737-1742, 2012.

LAGE, L. A. et al. Morphometry, floral resources and efficiency of natural and artificial pollination in fruit quality in cultivars of sour passion fruit. **Revista Brasileira de Fruticultura**, 40: e-171, 2018.

MOTTA, I. S. et al. Análise econômica da produção do maracujazeiro amarelo em sistemas orgânico e convencional. **Ciência e Agrotecnologia**, 32: 1927-1934, 2008.

NEGREIROS, J. R. S. et al. Caracterização de frutos de progênies de meios-irmãos de maracujazeiro amarelo em Rio Branco - Acre. **Revista Brasileira de Fruticultura**, 30: 431-437, 2008.

OLIVEIRA, C. O. et al. Custo e lucratividade da produção de sementes de soja enriquecidas com molibdênio. **Pesquisa Agropecuária Tropical**, 45: 82-88, 2015.

PERTUZATTI, P. B. et al. Carotenoids, tocopherols and ascorbic acid content in yellow passion fruit (*Passiflora edulis*) grown under different cultivation systems. **LWT - Food Science and Technology**, 64: 259-263, 2015.

REIS, R. P. Fundamentos de economia aplicada. Lavras, MG: UFLA/FAEPE, 2007. 95 p.

REZENDE, M. I. F. L. et al. Grafting for the recovery of yellow passion fruit stem in organic system. **Revista Brasileira de Fruticultura**, 39: e-745, 2017.

SANTOS, H. G. et al. **Sistema Brasileiro de Classificação de Solos**. 3. ed. Brasília, DF: Embrapa, 2013a. 354 p.

SANTOS, J. L. V. dos. et al. Determinação do ponto de colheita de diferentes cultivares de maracujá. **Revista Brasileira de Engenharia Agrícola e Ambiental**, 17: 750-755, 2013b.

SILVA, N. M. et al. Profitability of organic passion fruit production using tall seedlings and long root system. **Revista Caatinga**, 33: 341-348, 2020.

SILVA, N. M. (Fotógrafo). 2019. **Rentabilidade do maracujazeiro amarelo orgânico em função da irrigação, cultivo protegido e polinização**. Rio Branco/AC, 23 abr. 2019. Fotografia.

SILVEIRA, M. V. et al. Is manual pollination of yellow passion fruit completely dispensable? **Scientia Horticulturae**, 146: 99-103, 2012.

TURCO, P. H. N. et al. Economic profitability in conventional and irrigated coffee production systems in three municipalities in the Marilia region of São Paulo, Brazil. **Ciência Rural**, 47: e20170170, 2017.

UCHÔA, T. L. et al. Economic profitability of yellow passion fruit in organic cultivation under different input levels and irrigation. **Comunicata Scientiae**, 12: e3409, 2021a.

UCHÔA, T. L. et al. Yield and quality of passion fruit under organic cultivation with input levels and irrigation in the state of acre. **Revista Caatinga**, 34: 144-154, 2021b.

VIEIRA, F. A. et al. Technical-economic efficiency of the yield of green grains of cowpea fertilized with roostertree. **Revista Caatinga**, 31: 504-510, 2018.