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Profitability of organic carrot influenced by weed control and sowing methods

Geazí Penha Pinto[1], Regina Lucia Félix Ferreira[2], Sebastião Elviro de Araújo Neto[2], Luís Gustavo de Souza e Souza[2]*, Thays Lemos Uchôa[2], Lucas Machado[2]

[1]Federal Institute of Acre, Rio Branco, Brazil
[2]Federal University of Acre, Rio Branco, Brazil
*Corresponding author, e-mail: gustavo_souza_fj@hotmail.com

Abstract

The economic assessment of the agricultural activity is essential to determine its viability. In this scenario, this study aimed to assess the economic profitability of organic carrot cultivation under different weed control and sowing methods. The experiment was conducted in Rio Branco, AC, from June to September 2018, and was followed a randomized block design set up in 4 x 3 split-plots corresponding to four control methods: dead plant mulching, plastic mulching, solarization, and bare ground. There were also three types of sowing: direct, indirect, and pre-germinated. Harvest was performed 81 days after planting and, after the yield evaluation, the following economic indicators were evaluated: costs, revenues, profitability, profit margin, family labor remuneration, and production to cover costs. Considering the costs with inputs and services as of 2018 and the technical coefficients obtained during the experiment, the profit margin was higher than other investments, such as savings accounts. All treatments showed positive profitability, and the B/C ratio was higher than 1,0. Plastic mulching resulted in the highest revenues. The daily wage paid for family labor reached R$ 621.26. Solarization with indirect sowing demanded the highest yield to cover total costs. Regardless of the control method and type of sowing, the profitability is positive and shows a supernormal profit. Plastic mulching allied to direct and pre-germinated sowing increase the revenues.

Keywords: agroecology, *Daucus carota,* financial analysis, soil protection

Introduction

The Brazilian production of carrots in 2017 was 714.5 thousand tons, with 66.7% of this total concentrated in the Southeast region. On the other hand, carrot production in the North region was estimated at only 19 tons (IBGE, 2018). In this scenario, with an incipient production but significant appreciation by the consumer market, carrot is still imported from other states in the Brazilian state of Acre.

The current challenges to olericulture include weed control and crop management practices aiming to reduce environmental impacts, minimize costs, and increase revenue. From this perspective, organic agriculture is an adequate system for vegetable production since it can merge technologies to prevent or reduce the main bottlenecks of the activity, including the control of spontaneous plants (Sediyama et al., 2014).

This system shows reduced costs since there is no use of agrochemicals and highly soluble chemical fertilizers (Tomio et al., 2021), instead prioritizing internal inputs from the property itself and contributing to improving soil fertility with the increase in organic matter using organic materials (Fortini et al., 2020).

Given the edaphic balance provided by the organic system, vegetable crops tend to present more tolerance to the interference caused by spontaneous plants (Santos et al., 2020). Moreover, the protection provided by soil cover is another common practice in organic production. In addition to suppressing weeds, this practice standardizes soil temperature and moisture and provides better crop responses (Lemos et al., 2013).

Financial analysis is an important aspect in agriculture since only the agronomic efficiency of the production technology is not sufficient for its recommendation, requiring the assessment of costs and revenues in order to establish whether the production

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system adopted is viable. For carrot production, agronomic efficiency has also been expressed through economic efficiency, demonstrating that this crop responds positively to sustainable practices (Bezerra Neto et al., 2014; Favacho et al., 2017; Oliveira et al., 2012).

From this perspective, this study aimed to assess the economic profitability of organic carrot cultivation under different weed control and sowing methods.

Material and methods

Carrot cultivation was established in an organic property named Seridó Ecological Station and located on the road to Porto Acre, highway 04, branch José Rui Lino, Rio Branco, Acre, from June to September 2018. The local climate is equatorial, humid hot, and classified as *Am* according to Köppen.

The experiment was set up in a 4 x 3 split-plot following a randomized block design with four blocks. The first factor consisted of weed control methods: plant mulching, plastic mulching, solarization, and bare ground. The second factor consisted of different sowing methods: direct sowing, indirect sowing, and pre-germinated seeds.

The soil had a sandy-loam texture and the following chemical characteristics: pH= 7.0; O.M.= 17 g dm^{-3}; P= 49 mmolc dm^{-3}; K= 1.1 mmolc dm^{-3}; Ca= 49 mmolc dm^{-3}; Mg= 11 mmolc dm^{-3}; SB= 61.1 mmolc dm^{-3}; CEC= 72.2 mmolc dm^{-3}; V= 84.6%. The area where the experiment was established was previously cleaned with a backpack brush cutter and a manual hoe, and the soil was then turned with a compact tractor. The plant beds measured 1.20 m in width and 0.20 m in height and were fertilized with organic compost (15 t ha^{-1}).

Direct sowing was performed directly in the plant beds, whereas the pre-germinated seeds were kept in moist paper towels until radicle emergence. In indirect sowing, the seedlings were produced in paper tubes 2.0 cm high and 7.4 cm high filled with organic substrate and transplanted after four days.

The plastic mulching treatment used a black and white mulch film, whereas the dead plant cover was formed by distributing a 5.0 cm thick grass layer. For soil solarization, the soil was previously covered with 50 µm transparent plastic film for 45 days.

All treatments received irrigation, thinning, and weeding. The evaluations and the yield were determined when the plants reached the harvest point after 81 days.

The economic analysis was performed by determining the carrot yield (kg m^{-2}) and the cultivation costs based on the values of inputs and services as of 2018. The following parameters were calculated: production cost, net revenue, rate of return, break-even point, and residual point (Silva et al., 2020; Reis, 2007; Tomio et al., 2021).

The production costs correspond to the fixed costs with the depreciation of facilities and equipment. Variable costs included expenses with inputs and services. Opportunity costs included the cost of land, alternative costs (6% p.y.), and administrative costs (3%) (Conab, 2010; Reis, 2007).

Depreciation is the cost to replace goods damaged by either physical or economic wear. This parameter is calculated by the following equation:

$$D = \frac{Va - Vr}{Vu}$$

D - depreciation, R$/cultivation; Va – current value of the resource; Vr – residual value (final value of the resource); Vu - lifespan (period during which the resource is used in the activity).

The lifespan of materials was determined based on the table of agricultural production costs developed by Conab (2010). The technical coefficients such as time for planting, crop management practices, and harvest were obtained while the experiment was being conducted.

The services were calculated based on the value of labor corresponding to the daily wage expressed as man/day (HD). The calculation considered the minimum wage as of 2019 (R$ 998.00) plus payroll taxes of 45.59% (vacations, 13th salary, FGTS, INSS). As a result, the daily wage value was R$ 63.17 HD, working 23 days per month and 8 hours per day.

The costs with organic certification were not considered since producers performed the social control through the direct sale to customers, without a certifying seal but still as an organic product, as established by current regulations (Brasil, 2003; Brasil, 2014).

According to the methodology proposed by Reis (2007), the economic indicators analyzed were the total cost (CT), calculated based on the total fixed cost (CFT) and the total variable cost (CVT); total mean cost (CTm); mean fixed operational cost (CopFm); mean variable operational cost (CopVm); mean total operational cost (CopTm); profitability index (IR); total revenue (RT); net revenue (RL); benefit to cost ratio; family labor remuneration (RMOF); and profit margin (L). Furthermore, the yield to cover production costs was also considered based on the yield to cover total costs (PCT) and the yield to cover operational costs (PCop).

The data were evaluated for normality of residuals and homogeneity of variances. The F-test was used for the analysis of variance, and the Tukey test was used to compare the means at 5% of probability. Some data were not subjected to statistical analysis since there was no variability.

Results and Discussion

The profit margin ranged from 56.65% to 78.98% (Table 1), highlighting the viability of continuing this activity rather than investing in a savings account (3.15% p.y.) or investments based on the Selic interest rate (4.5% p.y.). Since this profit is based on cycles and considering that up to three cycles are possible per year, the annual profitability could then be tripled.

All treatments showed positive profitability, reaching up to 448.34% with direct sowing and plastic mulching (**Table 1**). This indicates that, for every R$ 1.00 invested, the return was R$ 4.48.

The economic indicators were also positive for carrot cultivation with organic fertilization, with a profitability index of 49.40% (Oliveira et al., 2012). For organic chive production in another study, the profitability index was 267% (Souza et al., 2015), attesting to the economic viability of organic olericulture.

The benefit to cost ratio (B/C) highlights the economic viability of the activity, remaining above 1 in organic carrot cultivation regardless of the treatment, with a maximum of 5.10 in direct sowing with plastic mulching (**Table 2**).

In order to demonstrate the profitability of the activity, an increasing number of producers tend to adhere to the organic system due to its high viability. This represents an alternative for diversifying production in family agriculture and ensuring the financial return of the activity, in addition to socio-environmental and health benefits since no agrochemicals are used (Machado Neto et al., 2018).

Family labor remuneration (RMOF) reached R$ 621.26 per day of work (Table 2), higher than the daily wage typically paid in the region, around R$ 50.00. Ensuring jobs and income in organic production is one of the most important aspects of the theory of sustainability (Araújo Neto et al., 2012) and was achieved by carrot cultivation, making the activity a socially sustainable practice.

The total and net incomes (Table 2) reflect the yield of each treatment as a function of price. Even in the lowest yields, such as with dead mulch and paper tubes, the economic profitability is guaranteed with a margin for a possible price reduction.

Plastic mulching increased the net revenue by 188% compared to traditional cultivation (bare ground with direct sowing) **(Table 3**). Although the plastic represents a cost increase, the yield compensates for this expense since soil protection favors the production of marketable carrot roots and increases the yield (Wozniak et al., 2019).

Table 1. Profit margin and profitability index of organic carrot grown under different weed control and sowing methods. Seridó Ecological Station, Rio Branco, AC, 2018

Control methods	Profit margin (%)			Profitability index (%)		
	Indirect sowing	Direct sowing	Pre-germinated	Indirect sowing	Direct sowing	Pre-germinated
Dead mulch	63.38Ab	75.79ABa	73.58Aab	207.96Ab	361.10ABa	310.41Aab
Bare ground	66.68Ab	66.01BCb	78.98Aa	228.92Ab	233.56BCb	441.80Aa
Solarized	56.65Aa	59.21Ca	58.27Ba	155.40Aa	178.42Ca	160.39Ba
Plastic mulch	58.08Ab	78.83Aa	78.48Aa	176.80Ab	448.34Aa	420.88Aa
CV (%)		9.66			19.53	

Means followed by the same uppercase letters in the columns and lowercase letters in the rows do not differ (p>0.05) by the Tukey test.

Table 2. Benefit to cost ratio (B/C) and family labor remuneration (RMOF) of organic carrot grown under different weed control and sowing methods. Seridó Ecological Station, Rio Branco, AC, 2018

Control methods	B/C ratio			RMOF (R$ day^{-1})		
	Indirect sowing	Direct sowing	Pre-germinated	Indirect sowing	Direct sowing	Pre-germinated
Dead mulch	2.90Ab	4.30ABa	3.84Aab	179.50Bb	318.52Bab	481.69Aa
Bare ground	3.09Ab	3.13BCb	5.04Aa	403.01Aa	351.34Ba	432.51ABa
Solarized	2.42Aa	2.63Ca	2.46Ba	432.50Aa	315.87Ba	270.38Ba
Plastic mulch	2.62Ab	5.10Aa	4.85Aa	417.66Ab	621.26Aa	557.06Aab
CV (%)		19.53			26.17	

Means followed by the same uppercase letters in the columns and lowercase letters in the rows do not differ (p>0.05) by the Tukey test.

The highest mean fixed and variable operational costs were observed in solarized cultivation and plastic mulching (**Table 4**), caused by the plastic materials used in solarization and mulching but also by the drip irrigation system used in these treatments.

The use of dead plant mulching reduced operational costs since this material can be obtained from the production area itself, implying only costs for harrowing, collection, and distribution, which are much lower than with external inputs.

Both plant and plastic mulching reduce water consumption for irrigation by increasing the irrigation efficiency and reducing evapotranspiration, thus resulting in higher profitability (Berça et al., 2019; Carvalho et al., 2018; Lima et al., 2017).

Although no additional costs are initially required with bare ground cultivation, these are increased during cultivation due to weed control.

The increase in the total operational cost with indirect sowing was due to the need for seedling production, considering the paper tubes and the substrate for their filling (**Table 5**). In lettuce cultivation, seedling acquisition is one of the main inputs that increase production costs, representing around 23.5% of the total operational cost (Vendruscolo et al., 2017).

The mean total cost in all treatments was lower than the carrot marketing price of R$ 5.00 kg^{-1} (RMe > CTMe), providing a supernormal profit (Reis, 2007). In addition, since it is a profitable activity, carrot cultivation can be expanded and attract new producers, increasing the supply of the product and generating jobs and income (Tomio et al., 2021)

Even if the supply of organic carrot increased and consequently reduced the price, the activity would still be attractive since the highest CTMe was R$ 2.16 kg^{-1}. It should also be noted that the sale of organic products occurs in market niches and represents unique products (Araújo et al., 2018), thus ensuring the elasticity of their prices.

Soil solarization applied to indirect sowing demanded a higher yield to cover total (1.42 kg m^{-2}) and operational costs (1.30 kg m^{-2}) (**Table 6**), intensified by costs with solarization plastic and paper tubes. Nevertheless, the yield obtained in this treatment (3.0 kg m^{-2}) is sufficient to cover the costs.

The break-even point obtained by Miguel et al. (2011) for organic carrot was 1.78 kg m^{-2}, with a yield of 3.3 kg m^{-2}, ensuring the profitability and economic sustainability of the activity.

Conclusions

Regardless of the weed control and sowing methods, the profitability is positive and results in a supernormal profit.

Plastic mulching allied to direct or pre-germinated sowing increase the revenues. The production to cover total costs is higher in solarized soils.

Table 3. Total and net revenues of organic carrot cultivated under different weed control and sowing methods (R$.m^{-2}). Seridó Ecological Station, Rio Branco, AC, 2018

Control methods	Total revenue (R$ m^{-2})			Net revenue (R$ m^{-2})		
	Indirect sowing	Direct sowing	Pre-germinated	Indirect sowing	Direct sowing	Pre-germinated
Dead mulch	10.35Bb	14.50Bab	17.93ABa	6.78Ab	11.13Bab	13.26ABa
Bare ground	12.56ABa	14.07Ba	15.99Ba	8.50Aa	9.58Ba	12.82ABa
Solarized	17.17Aa	15.03Ba	14.48Ba	10.09Aa	9.32Ba	8.62Ba
Plastic mulch	15.02ABb	22.43Aa	22.19Aa	9.28Ab	18.04Aa	17.62Aa
CV (%)		18.03			25.61	

Means followed by the same uppercase letters in the columns and lowercase letters in the rows do not differ (p>0.05) by the Tukey test.

Table 4. Mean fixed operational cost (CoFm) and mean variable operational cost (CoVm) of organic carrot cultivated under different weed control and sowing methods. Seridó Ecological Station, Rio Branco, AC, 2018

Control methods	CoFm (R$ m^{-2})			CoVm (R$ m^{-2})		
	Indirect sowing	Direct sowing	Pre-germinated	Indirect sowing	Direct sowing	Pre-germinated
Dead mulch	0.05Ba	0.03Ca	0.027Ca	1.63Aa	1.07BCb	1.18Bab
Bare ground	0.03Ba	0.03Ca	0.030Ca	1.48Aa	1.52ABa	0.93Bb
Solarized	0.10Ba	0.12Ba	0.12Ba	1.88Aa	1.75Aa	1.79Aa
Plastic mulch	0.41Aa	0.27Ab	0.26Ab	1.51Aa	0.70Cb	0.72Bb
CV (%)		27.35			20.42	

Means followed by the same uppercase letters in the columns and lowercase letters in the rows do not differ (p>0.05) by the Tukey test.

Table 5. Mean total operational cost (R$ m^{-2}) of organic carrot cultivated under different weed control and sowing methods. Seridó Ecological Station, Rio Branco, AC, 2018

Control methods	Sowing		
	Indirect	Direct	Pre-germinated
Dead mulch	1.67Aa	1.10Bb	1.21Bab
Bare ground	1.52Aa	1.55ABa	0.96Bb
Solarized	1.98Aa	1.87Aa	1.91Aa
Plastic mulch	1.91Aa	0.97Bb	0.98Bb
CV (%)		20.40	

Means followed by the same uppercase letters in the columns and lowercase letters in the rows do not differ (p>0.05) by the Tukey test.

Table 6. Yield to cover total (PCT) and operational costs (PCO) of organic carrot cultivated under different weed control and sowing methods. Seridó Ecological Station, Rio Branco, AC, 2018

Control methods	PCT (kg m^{-2})			PCO (kg m^{-2})		
	Indirect sowing	Direct sowing	Pre-germinated	Indirect sowing	Direct sowing	Pre-germinated
Dead mulch	0.65	0.62	0.85	0.58	0.85	0.77
Bare ground	0.81	0.90	0.63	0.74	0.87	0.58
Solarized	1.42	1.14	1.17	1.30	1.04	1.07
Plastic mulch	1.15	0.88	0.91	1.08	0.80	0.84

Data obtained in the experiment without repeatability and without variance.

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