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Economic feasibility of use soil cover in organic lettuce crops in the semiarid region of the state of Alagoas, Brazil

Viabilidade econômica do uso da cobertura do solo em culturas orgânicas de alface na região semiárida do estado de Alagoas, Brasil

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ABSTRACT
Lettuce is a species widely cultivated in the world and, in the production process, soil

covers have been used to reduce water loss and production costs. The geotextile blanket, solid waste generated in water treatment plants, has potential as an alternative mulching. To maintain competitiveness, knowing the economic parameters through financial indicators will allow defining the feasibility of the rural enterprise. Therefore, this study aimed to evaluate the economic feasibility of use soil covers in four production periods on organic lettuce crops in the semiarid region of the state of Alagoas - Brazil. Four experiments were carried out in a completely randomized design, with four treatments (geotextile blanket, white white polypropylene mulching, black polypropylene mulching, and uncovered soil - control) and five replicates. Costs related to labor (weeding control), materials, inputs, energy and depreciation were estimated, in which the operation with harvest and post-harvest (33.7%) and the acquisition of the irrigation system, in the 1st production period were the most expressive (44.9%). Manual weeding increased costs in the control treatment by 38.6%. The economic indicators gross and net revenue, profitability index (PI), minimum attractiveness rate (MAR), discounted payback (DP) and net present value (NPV) were estimated, in which the lowest and highest gross (US\$ 32,072.3 and 37,903.61 ha^{-1}) and net (US\$ 24,652.0 and 33,504.1 ha^{-1}) revenues were observed in the 1st and 3rd production periods in black and white mulches, respectively. PI, MAR, DP and NPV indicated economic feasibility already in the 2nd production period.

Keywords: discounted payback, minimum attractiveness rate, net present value, profitability index.

RESUMO

A alface é uma espécie cultivada em todo mundo e, no processo de produção, as coberturas do solo vêm sendo utilizadas para reduzir a perda de água e os custos de produção. A manta geossintética, resíduo sólido gerado nas estações de tratamento de água, tem potencial como mulching alternativo. Porém, para manter a competitividade, conhecer os índices econômicos, por meio de indicadores financeiros, permitirá definir a viabilidade do empreendimento rural. Portanto, esta pesquisa objetivou avaliar a viabilidade econômica do uso de coberturas do solo em quatro períodos de cultivo de alface orgânica na região semiárida de Alagoas - Brasil. Foram realizados quatro experimentos no delineamento inteiramente casualizado, com quatro tratamentos (manta geossintética, mulching de polipropileno branco, mulching de polipropileno preto, e solo descoberto - controle) e cinco repetições. Foram estimados os custos relacionados com mão de obra, materiais, insumos, energia e depreciação, em que as operações com colheita e pós colheita (33.7%) e a aquisição do sistema de irrigação, no 1º plantio foram os mais expressivos (44.9%). As capinas manuais aumentaram em 38.6% os custos no tratamento controle. Os indicadores econômicos receitas bruta e líquida, o índice de lucratividade (IL), a taxa mínima de atratividade (TMA), o payback descontado (PD) e o valor presente líquido (VPL) foram estimados, em que as menores e maiores receitas bruta (US\$ 32,072.3 e 37,903.61 ha^{-1}) e líquida (US\$ 24,652.0 e 33,504.1 ha^{-1}) foram observadas no 1º e no 3º plantio nas coberturas preta e branca, respectivamente. O IL, TMA, PD e VPL indicaram viabilidade econômica já no 2º período de plantio.

Palavras-chave: payback descontado, taxa mínima de atratividade, valor presente líquido, índice de lucratividade.

1 INTRODUCTION

Lettuce (*Lactuca sativa* L.) is a species widely cultivated in the world, with China, the United States of America and India as the largest producers, with 16.3, 3.7 and 1.3 million tons in 2019, respectively (FAO, 2019). Brazil, with 108.4 thousand establishments cultivating lettuce, produced 671.5 thousand tons, with the Southeastern regions standing out for concentrating 64.1% of national production (IBGE, 2020).

Despite being a species with C_3 photosynthetic metabolism, lettuce has thermotolerant genes in its germplasm (YOONG *et al.*, 2016), making it possible to develop early-cycle cultivars, adapted to the Northeastern climate, with low occurrence of pests and diseases and good acceptability by the consumer market (SOUZA *et al.*, 2019). However, the high temperatures and irregular rainfall distribution observed in this region increase evapotranspiration, which can make the water balance negative, so that the water management and use of techniques aimed to minimize its loss are key factors to guarantee high productivity (SANTOS; BRITO, 2016).

Synthetic and organic soil covers have been widely used in agriculture with the aim of reducing soil water losses by evaporation, controlling weeds, facilitating harvesting and marketing, since the product is cleaner and healthy (GONÇALVES *et al.*, 2005). They also allow to reduce production costs, with savings of water and electricity, in addition to labor (AZIZ *et al.*, 2019).

Solid waste has been used as alternative to synthetic mulching (BARBOSA *et al.*, 2014; OLIVEIRA *et al.*, 2020; BARROS *et al.*, 2023), with the advantage of transforming disposable materials into value-added co-products (TEODORO; PEREIRA, 2021), preserving natural resources, making the crop an ecologically correct activity, by mitigating environmental damage, increasing the useful life of sanitary landfills, in addition to reducing costs. The geotextile blanket, used in water filtration and sludge dehydration in water treatment plants, takes 25 years to degrade if directly discarded into the environment (GUIMARÃES *et al*., 2017). Due to its physicochemical characteristics, it has potential for use in agriculture as soil cover (OLIVEIRA *et al*., 2020).

The increase in production costs due to the scarcity of international agricultural inputs, especially fertilizers, and disruptions in the supply chain caused by the COVID-19 pandemic, becomes advantageous for sustainable production systems (Hassen & Bilali, 2022), such as agroecological and organic systems, as it does not depend on synthetic inputs. However, even in this scenario, it is essential for producers to minimize costs. For this, knowing the economic indices and managing production costs are essential to maintain competitiveness. According to García-Zertuche *et al*. (2021), the analysis of the economic profitability is used as a basis for decision-making on the feasibility of the rural enterprise through financial indicators (net profit margin, net present value, internal rate of return).

Considering that 82.2% of lettuce producers in Brazil are classified as family farmers (Law No. 11,326/2006), with low education and technical assistance problems (IBGE, 2020), they are unaware of rural property accounting. In addition, there are few studies that have analyzed economic parameters in multiple production periods. Therefore, the aim of this study was to evaluate the economic viability of use soil covers in lettuce ‘Veneranda’ cultivar cultivated in four production periods, in the organic system, in the semiarid region of Alagoas.

2 MATERIAL AND METHODS

The research was carried out between 2020 and 2021 on a commercial property that adopts the organic production system, certified by the Ministry of Agriculture, Livestock and Supply (MAPA No. 13,966), located in the village of Flexeiras (9º 47’ 50.92” S; 36° 36’ 14.63” W), 237 m a.s.l., rural area of the municipality of Arapiraca, Alagoas - Brazil. The climate is ‘BSh’ (hot semiarid), according to the Köppen classification (CLIMATE-DATE, 2023). The soil of the experimental area was classified as Anionic Acrudox. The minimum and maximum average temperatures are 20.6 and 30.8ºC, respectively (INMET, 2023).

Four experiments were carried out on the farm: Experiment 1) from 13 June to 17 July 2020 (autumn-winter); Experiment 2) from 07 August to 14 September 2020 (winter); Experiment 3) from 2 December 2020 to 5 January 2021 (summer); and Experiment 4) 04 February to 10 March 2021 (end of summer). All experiments were installed in the same area, with the mulching treatments remaining in the same positions (plots) for the entire period of the four experiments. The climatic information during the experimental period is shown in Table 1.

Table 1. Mean climatic data from experimental periods in Arapiraca, Alagoas - Brazil.

Variables	Production periods			
	13 Jun to 17 Jul/20	07 Aug to 14 Sep/20	02 Dec/20 to 05 Jan/21	04 Feb to 10 Mar/21
Rainfall (mm)[1]	24.1	0.4	0.0	0.0
Minimum temperature (ºC)[2]	19.2	18.7	21.9	22.7
Maximum temperature (ºC)[2]	27.9	28.5	33.3	34.8
Global solar radiation (Mj m^{-2})[2]	1.16	1.32	1.65	1.66

Source: [1]Department of Agriculture of Arapiraca, Alagoas - Brazil; [2]INMET (2023).

The area, without history of agriculture and livestock use, after being systematized, no factors promoting external variation were observed, being, therefore, considered homogeneous, installing experiments in a completely randomized design, with four treatments (SoilTain DW® geotextile blanket, white polypropylene mulching, black polypropylene mulching and uncovered soil) and five replicates. The experimental plot consisted of 42 plants, of which 20 were considered as useful area and the others as borders.

Lettuce 'Veneranda' cultivar, looseleaf type, for being widely cultivated in the region, was used. geotextile blanket, solid residue made of polypropylene with 14 mm in thickness, permeable, of high resistance and tenacity, with UV protection, inert to biological degradation and resistant to chemical attacks, was used without alteration in its original physicochemical constitution. Synthetic covers of 20 µm in thickness, waterproof, made of white and black polyethylene are used by producers without previous research in the region. Uncovered soil, used as control treatment, predominates in regional crops.

Soil chemical analysis was performed (0 to 20 cm), presenting the following characteristics: pH 6.8 (H_2O); P: 106 mg dm^{-3}; Na, K, Ca + Mg and H + Al: 0.22, 0.23, 5.7 and 0.6 $cmol_c$ dm^{-3}, respectively; organic matter: 21.8 g kg^{-1}; Fe, Cu, Zn and Mn: 162.7, 7.23, 45.55 and 75.94 mg dm^{-3}, respectively. Following recommendations of Cavalcanti (2008), 30 and 40 kg of N ha^{-1} were applied at planting and topdressing, respectively, and 60 kg K_2O ha^{-1} at planting to meet the crop's demand, using organic compost consisting of castor bean cake and tanned bovine manure (1:1), which presented the following chemical characteristics: organic matter: 428.0 g kg^{-1}; N: 3.12%; P_2O_5: 0.57%; K_2O: 0.43%; Ca: 1.36%; Mg: 0.81%; Fe, Zn, Cu, Mn with concentrations of 5,200, 93, 25 and 105 mg dm^{-3} respectively.

Soil preparation was carried out with the aid of a rotary hoe coupled to a 6.5 CV tractor, at depth of 0.15 m. Subsequently, beds were leveled and prepared using an EH500 trencher, with dimensions of 1.0 x 2.8 m, and 0.10 m in height, adopting 0.25 x 0.25 m of spacing between plants, equivalent to the initial plant density of 123,200 plants ha^{-1}. Seedlings were produced in 200-cell trays, in Bioplant 401® commercial substrate. Transplanting to the field took place 25 days after planting, in all four plantations.

Fertilization was carried out by casting over the beds. The irrigation system was drip irrigation, with two 16-mm thick polyethylene drippers distributed in beds, with drip pipes spaced at 0.2 m and flow rate of 1.6 L h^{-1}, twice a day (morning and afternoon) for 20 minutes, except on rainy days. Drip pipes were placed under soil covers. Weed control was manual in the control treatment.

The initial investment for 1.0 ha included the acquisition of the drip irrigation system with the following characteristics: Standart 7.5 CV 60 HZ motor pump, 0.2 m (6,000 microns) drip pipes, DN 75 and 50 pipes (6.0 m, PN 80), DN 75 x 50 mm reduction, initial valve with ring (16 mm) for dripperline, DN 50 weldable gloves for irrigation, valve for weldable tube (DN 50), 3" disc filter (50 m^3 flow), weldable cap (DN 50 PN 80), weldable PVC valve (50 mm) and PVC foot valve with threadable socket.

Labor operations involved soil preparation (harrowing), preparation of beds, application of soil covers, seedling transplanting, fertilizer application, irrigation management, manual weeding, harvest and post-harvest operations and pro-labor payment. Materials and inputs were the acquisition of the irrigation system, organic sources of fertilizers (bovine manure and castor bean cake), sampling and analysis of organic compost and soil (sent to the laboratory), acquisition of lettuce seedlings, acquisition of mulching coils (1,200 m^2) and its disposal (for white and black mulching treatments), according to the final plant density of each treatment, for each plantation.

Electricity consumption involved connection to the irrigation system and drilling of the geotextile blanket. Due to the natural wear and ease of damage of plastic covers, following the manufacturer's recommendation, 30% were purchased, equivalent to two coils, to renew the soil cover from the 2^{nd} to the 4^{th} production periods. Depreciation of the irrigation system was estimated at 10% per year.

Economic evaluation (US$ 1.00 = R$ 4.98; May/2023) was carried out for the soil covers and plantations, considering total operating cost (TOC; US$), from labor, materials and inputs, energy and depreciation, calculated according to CONAB's adaptation (2010), and gross revenue (GR; US$) projections were calculated according to Equation 1:

$$\text{GR (US\$)} = \text{harvested lettuce (units)} \times \text{unit price (US\$)} \quad (1)$$

The price of the lettuce unit was established at US$ 0.33 (R$ 1.65, average 05/2023), based on the marketing value of organic lettuce paid by the Arapiraca Food Acquisition Program.

Net revenue (NR; US$) was calculated using Equation 2:

$$\text{NR (US\$)} = (\text{GR - total operating cost}) \quad (2)$$

The profitability index (PI; %) was calculated using Equation 3:

$$\text{PI (\%)} = \frac{\text{NR}}{\text{GR}} \text{ x } 100 \quad (3)$$

The minimum attractiveness rate (MAR) was established at 13.75% per year (Jun/2023), with 2.25% intended to cover the opportunity cost and 8.0% referring to the premium paid for the risk. The percentage defined for the opportunity cost is equivalent to the reference rate target of the Special System for Settlement and Custody (SELIC), established by the Monetary Policy Committee (COPOM) of the Central Bank of Brazil, on May/2023. MAR was calculated in relation to the total cost of each treatment, in each plantation, according to Equation 4:

$$MAR\ (\%) = \frac{13.75}{366} \times 100 \qquad (4)$$

MAR indicates the economic attractiveness for the activity being explored, in which there will be attractiveness when the profit obtained is equal to or greater than the minimum attractiveness rate.

The internal rate of return (IRR; %) was calculated using Equation 5:

$$IRR\ (\%) = \frac{GR}{TOC} \times 100 \qquad (5)$$

The discounted payback (DP; plantation) was obtained by Equation 6:

$$DP = \frac{\text{Initial investment}}{\frac{NR}{1+0.1^{n}}} \qquad (6)$$

Where:

"n" is the number of each experiment. This relationship expresses the number of production periods that will be required to economically return the initial investment.

The net present value (NPV; US$), which shows the performance of cash flows in relation to the initial investment, was estimated by Equation 7:

$$NPV\ (US\$) = \frac{\sum_{t=1}^{n} FC_t}{(1+r)^t} - FC_0 \quad (7)$$

Where

"t" is the period, "n" is the total period of the project, FC_t is the present value (net cash flow), FC_0 corresponds to the initial investment and "r" is the capital cost, and when the capital cost is high, accepting the investment project is recommended.

3 RESULTS AND DISCUSSION

In general, costs with labor were more expressive with harvest and post-harvest operations (with 68 h/d), fertilizer application and pro-labor payment, representing 33.7, 15.8 and 14.9%, respectively (Table 2). When lettuce was cultivated under uncovered soil, it was observed that manual weeding increased production costs in the four experimental periods, being more expressive in the 1st production period (increase of 38.6%) due to the greater number of operations performed, evidencing the influence of covers on weed suppression. Freitas *et al*. (2021) also observed that polyethylene films were efficient in controlling weeds due to the formation of a physical barrier, impermeable to light, which prevented seed germination. Gheshm and Brown (2020) found that mulching application costed US\$ 0.08 m^{-2}, while manual weeding costed US\$ 0.36 m^{-2}. Therefore, soil cover presents itself as an important cost-reducing practice, making the production system more competitive, especially those of family-based agroecological production.

Table 2. Effective operating cost (EOC) and total operating cost (TOC) for each experimental treatment in four production periods of lettuce 'Veneranda' cultivar (US$ ha^{-1}).

Components of production costs	N°	Un.	Production periods															
			13 Jun to 17 Jul/2020				07 Aug to 14 Sep/2020				02 Dec/2020 to 05 Jan/2021				04 Feb to 10 Mar/2021			
			GB	BM	WM	US	GB	BM	WM	US	GB	BM	WM	US	GB	BM	WM	US
1. Operations			2,028.1	2,028.1	2,028.1	2,761.0	1.706.8	1,706.8	1,706.8	2,228.9	1,706.8	1,706.8	1,706.8	2,228.9	1,706.8	1,706.8	1,706.8	2,228.9
Soil preparation (harrowing)	05	h/m	150.6	150.6	150.6	150.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Preparation of beds	04	h/m	120.5	120.5	120.5	120.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fertilizer application	32	h/d	321.3	321.3	321.3	321.3	321.3	321.3	321.3	321.3	321.3	321.3	321.3	321.3	321.3	321.3	321.3	321.3
Irrigation management	24	h/d	241.0	241.0	241.0	241.0	241.0	241.0	241.0	241.0	241.0	241.0	241.0	241.0	241.0	241.0	241.0	241.0
Seedling transplanting	38.5	h/d	160.6	160.6	160.6	160.6	160.6	160.6	160.6	160.6	160.6	160.6	160.6	160.6	160.6	160.6	160.6	160.6
Manual weeding	78	h/d	0.0	0.0	0.0	783.1	0.0	0.0	0.0	522.1	0.0	0.0	0.0	522.1	0.0	0.0	0.0	522.1
Harvest and post-harvest	68	h/d	682.7	682.7	682.7	682.7	682.7	682.7	682.7	682.7	682.7	682.7	682.7	682.7	682.7	682.7	682.7	682.7
Pro-labor payment	30	h/d	301.2	301.2	301.2	301.2	301.2	301.2	301.2	301.2	301.2	301.2	301.2	301.2	301.2	301.2	301.2	301.2
2. Materials and inputs			4,435.4	5,366.8	5,366.8	4,433.0	2,386.2	2,667.4	2,667.4	2,386.2	2,386.2	2,667.4	2,667.4	2,386.4	2,386.2	2,667.4	2,667.4	2,386.2
Irrigation system	01	un	1,999	1,999	1,999	1,999	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

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			1.6	1.6	1.6	1.6												
Organic fertilizer - bovine manure	1,848	kg	74.3	74.3	74.3	74.3	74.3	74.3	74.3	74.3	74.3	74.3	74.3	74.3	74.3	74.3	74.3	74.3
Organic fertilizer – castor bean	1,848	kg	556.6	556.6	556.6	556.6	556.6	556.6	556.6	556.6	556.6	556.6	556.6	556.6	556.6	556.6	556.6	556.6
Soil analysis	01	un.	7.0	7.0	7.0	7.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Analysis of compound	01	un.	48.2	48.2	48.2	48.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Geotextile blanket	8,400	m²	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lettuce seedlings	678	trays	1,496.7	1,496.7	1,496.7	1,496.7	1,496.7	1,496.7	1,496.7	1,496.7	1,496.7	1,496.7	1,496.7	1,496.7	1,496.7	1,496.7	1,496.7	1,496.7
Coil	07	un.	0.0	913.7	913.7	0.0	0.0	261.0	261.0	0.0	0.0	261.0	261.0	0.0	0.0	261.0	261.0	0.0
Mulching discard	04	un.	0.0	20.1	20.1	0.0	0.0	20.1	20.1	0.0	0.0	20.1	20.1	0.0	0.0	20.1	20.1	0.0
3. Energy			260.9	258.6	258.6	258.6	258.6	258.6	258.6	258.6	258.6	258.6	258.6	258.6	258.6	258.6	258.6	258.6
Irrigation	1,894	kWh	258.6	258.6	258.6	258.6	258.6	258.6	258.6	258.6	258.6	258.6	258.6	258.6	258.6	258.6	258.6	258.6
Blanket perforation	17	kWh	2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
EOC (1+2+3)			6,463.5	7,394.9	7,394.9	7,194.1	4,093.1	4,371.2	4,374.2	4,615.1	4,093.1	4,374.2	4,371.2	4,615.1	4.093,1	4,374.2	4,374.2	4,615.1

4. Depreciation cost	25.38	25.38	25.38	25.38	25.38	25.38	25.38	25.38	25.38	25.38	25.38	25.38	25.38	25.38	25.38	25.38
TOC (1+2+3+4; US$ ha^{-1})	6,488.9	7,420.2	7,420.2	7,219.4	4,118.4	4,399.6	4,399.6	4,640.5	4,118.4	4,399.6	4,399.6	4,640.5	4,118.4	4,399.6	4,399.6	4,640.5

Notes: GB: geosynthetic blanket; BM: black mulching; WM: white mulching; US: uncovered soil; Un. Unit. Source: Authors' elaboration.

The 1st planting had the highest costs with materials and inputs, in which the acquisition of the irrigation system, seedlings and organic fertilizer were the most expressive in treatments with geotextile blanket and uncovered soil, corresponding to 44.9, 33.7 and 12.5%, respectively. (Table 2). In synthetic covers, coils increased costs by 20.6%. It is an input that can undergo thermal degradation and photodegradation due to photo-oxidation caused by ultraviolet rays; mechanical degradation due to damage caused by handling, wind and chemical degradation, caused by sulfur and chlorine-based compounds, as well as excess water (FARIA JÚNIOR; HORA, 2018). For this reason, following the manufacturer's recommendations, an additional coil purchase of 30% was planned to replace damaged ones, impacting costs in 9.5% from the 2nd to the 4th production period. Due to its low degradability, this input can generate large amounts of waste and environmental pollution (LIU *et al.*, 2014). Therefore, the cost of US$ 20.1/cultivation was stipulated for the disposal of plastic in a sanitary landfill, avoiding its burning and the so-called white pollution in the field.

Costs related to manual force (weeding control) corresponded to 38.0% (general average) of the total operational cost (TOC). However, comparing soil covers with control treatment, 35.7% and 44.7% were observed (average of the four plantations), respectively, evidencing reduction in the need for force with the adoption of covers. Souza *et al*. (2019) observed similar contribution when lettuce 'Babá de Verão' cultivar was cultivated under uncovered soil in the spring (49.8%) and autumn-winter (52.5%), in Serra Talhada/PE, under organic fertilization.

Organic agriculture does not use synthetic inputs (pesticides, fertilizers), making it a demanding activity in terms of labor, which is increasingly scarce (FROEHLICH *et* *al*., 2018). Therefore, the use of soil covers can minimize the demand for manual force in agriculture, making food cheaper. On the other hand, the organic production system is recognized for job creation (MORAES; OLIVEIRA, 2017), which promotes improvement in income and quality of life of workers, keeping the man in the countryside, with reduction in rural exodus, mainly of young farmers.

Materials and inputs contributed with 61.5% of total operating costs (general average), in which the geotextile blanket had the lowest value in the four plantations (Table 3), mainly because it is a free input, without the need for replacement due to mechanical damage, in addition to promoting soil protection against weeds, without the need for manual weeding. On the other hand, synthetic films presented the highest values due to the acquisition of coils and disposal of films.

The lowest and highest gross (US$ 32,072.3 and 37,903.61 ha^{-1}) and net (US$ 24,652.0 and 33,504.1 ha^{-1}) revenues were observed in the 1st and 3rd periods, using black and white mulching, respectively, period in which the smallest and largest plant density were observed (Table 3). In the 1st period, accumulated rainfall was 131.5 mm (Table 1), sufficient to meet the lettuce demand (MAGALHÃES *et al*., 2015). However, rainfall distribution was irregular, in which, in the first four days, it rained 53% of the total (66 mm), promoting seedling mortality and plant density reduction. In the 3rd period, despite the low accumulated rainfall, water demand was supplemented by drip irrigation.

Table 3. Plant density and economic indices of lettuce 'Veneranda' cultivar under different soil covers in four growing seasons.

Production periods	Soil covers	Plant density	Gross revenue	Net revenue	Profitability index	MAR	IRR	Discounted payback Periods	NPV
		-- Plants ha^{-1} --	-------- US$ ha^{-1} -------		---------- % ----------				US$
13 Jun to 17 Jul/2020 (autumn-winter)	Geotextile blanket	107,250	35,534.6	31,338.6	88.2	1.00	2.6	1.46	-2,842.2
	White mulching	98,450	32,619.0	27,491.5	84.3	1.00	2.2	1.49	-3,607.2
	Black mulching	96,800	32,072.3	26,944.8	84.0	1.00	2.1	1.85	-3,7

									15.9
	Uncovered soil	111,100	36,810.2	31,883.6	86.6	1.00	2.7	2.12	-2,733.8
07 Aug to 14 Sep/2020 (winter)	Geotextile blanket	103,950	34,441.3	30,624.0	88.9	1.00	3.4	0.55	5,971.3
	White mulching	102,850	34,076.8	29,978.4	87.9	1.00	3.0	0.61	5,844.2
	Black mulching	108,900	36,081.3	31,983.0	88.6	1.00	3.0	057	6,238.9
	Uncovered soil	113,850	37,721.4	33,382.1	88.5	1.00	3.6	0.57	6,166.9
02 Dec/2020 to 05 Jan/2021 (summer)	Geotextile blanket	103,400	34,259.0	30,441.8	88.9	1.00	3.6	1.28	5,877.8
	White mulching	114,400	37,903.6	33,805.3	89.2	1.00	3.2	0.79	6,553.7
	Black mulching	108,900	36,081.3	31,983.0	88.6	1.00	3.2	0.85	6,178.4
	Uncovered soil	109,450	36,263.6	31,924.2	88.0	1.00	3.2	1.24	6,166.9
04 Feb to 10 Mar/2021 (end of summer)	Geotextile blanket	99,550	32,983.4	29,166.2	88.4	1.00	3.6	1.12	5,574.4
	White mulching	112,750	37,356.9	33,258.6	89.0	1.00	3.3	0.79	6,364.8
	Black mulching	104,500	34,623.5	30,525.1	88.2	1.00	3.3	0.98	5,836.9
	Uncovered soil	108,350	35,899.1	31,559.8	87.9	1.00	3.7	0.90	6,036.7

Notes: MAR: minimum attractiveness rate of; IRR: internal rates of return; NPV: net present value.
Source: Authors' elaboration.

The profitability index (PI) presented minimum value of 76.9% and maximum of 88.4% for black and white mulching treatments, respectively (Table 3), that is, for every US$ 1.0 that was invested, the operation returned US$ 0,769 and 0,884 of profit. Therefore, it is considered that treatments were economically feasible, according to this index and the minimum attractiveness rate (MAR = 1.0). Similar result was observed by Lacerda *et al*. (2017), in Pombal/PB, with PI = 88.7%, using bovine manure. Under the 0.25 x 0.30 m spacing, the study conducted by Vendruscolo *et al*. (2019), in Goiânia/GO, indicated that the control treatment presented PI (59.9%) higher than white mulching (52.8%) due to lower productivity and film costs.

The highest internal rates of return (IRR) were observed in the 3rd and 4th production periods. The geotextile blanket promoted IRR of 3.3% in both periods, indicating that, for every US$ 1.00 invested in lettuce cultivation, there is an economic return of US$ 3.3. This was due to the larger plant density, with consequent higher gross revenue, directly impacting net revenue, profitability index and IRR. According to Moraes and Silva (2020), when IRR is higher than MAR, there is financial feasibility. In hydroponic lettuce, Leite *et al*. (2016) also observed the superiority of IRR, recommending it to family farmers, as it is a quick investment with good rate of return.

The discounted payback refers to the period of time required for the capital investment to be recovered (LEITE *et al*., 2016). In the 1st production period, period with the highest cost, due to the acquisition of permanent materials and labor (Table 2), the discounted payback presented the highest values (average of the four treatments = 1.73 periods) which, compared to the net present value (NPV), indicates unattractiveness (Table 3). On the other hand, when considering the 2nd production period, lower payback values and positive NPV values were observed, indicating economic feasibility. The variation observed between treatments is a function of the plant density in each production period. Therefore, when carrying out the economic analysis with only one production period, it can lead to wrong decisions on the part of the investor.

In general, all treatments showed economic feasibility. However, as it is a free solid waste, the geotextile blanket presents itself as an alternative as mulching, with reduction in the total operating cost, possibility of reuse for several production cycles, ease of storage, change of cultivation site without altering its physicochemical properties, directly benefiting family farmers, mainly in organic production.

4 CONCLUSION

The costs with harvesting and post-harvest operations and the acquisition of the irrigation system are those that most impact the total operating cost. In the control treatment, manual weeding increases costs by 38.6%; in synthetic films, the purchase of polyethylene coils increased costs by 20.6%. The financial indicators indicate the economic feasibility of soil covers, starting from the 2nd production period.

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