

Type of sowing and weed control in organic carrot cultivation

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Abstract

Weed interference is a great problem in olericulture, requiring viable techniques for their control. From this perspective, the present study aimed to evaluate the use of mulching and different sowing methods on the yield of organic carrot. The experiment was conducted in the state of Acre from July to September 2018 using the carrot cultivar Brasília Irecê. The experiment was set up in a randomized block design under a 4 x 3 factorial arrangement with four weed control methods: bare ground, organic mulching, plastic mulching, and solarization; and three types of sowing: direct sowing, indirect sowing, and pre-germinated seeds. The evaluations were performed after 81 days. The highest organic commercial yield was obtained using plastic mulching in direct sowing (44.87 t ha⁻¹) and pre-germinated sowing (44.39 t ha⁻¹). Solarization and organic mulching were efficient to favor the conventional commercial yield. Weed suppression was higher in the soil protected by organic and plastic mulching. The use of plastic mulching allied to direct and pre-germinated sowing increases the yield of organic carrot.

Keywords: agroecology, *daucus carota*, mulching

Introduction

Carrot (*Daucus carota* L.) is the Apiaceae family vegetable with the highest commercial importance in Brazil. This crop is one of the most important due to its worldwide consumption, the extent of planted areas, and its role in favoring socioeconomic development among rural producers. Also, carrot is one of Brazil's five most consumed crops (per capita 4.29 kg year⁻¹) and can be grown in the entire national territory (Matos et al., 2011).

As a profitable crop for production in family and organic agriculture, carrot cultivation requires alternatives that combine the use of family labor, good agronomic performance, environmental sustainability, and economic viability.

However, one of the leading technical and economic problems of vegetable cultivation is weed control, often performed by manual methods that increase production costs due to the high labor demand

(Muoni et al., 2013). In this scenario, the coexistence between agricultural crops and weeds causes damage to the amount, quality, and economy of products regardless of the production system (Gibson et al., 2017).

Even if necessary for ecological benefits in organic agriculture, weeds cause significant damage, especially by reducing crop yield, competing for resources (water, nutrients, and light), and being allelopathic or hosts to pests and diseases (Oliveira Júnior et al., 2011).

One the ways to achieve efficient weed control is the type of sowing performed at the beginning of cultivation, aiming to provide the crop with a greater competition potential against weeds, thus allowing the species to establish first than the invaders, populating the soil surface and thus preventing sunlight from reaching the seeds, triggering the germination process (Silva et al., 2010).

The use of mulching is another technique widely

used in organic agriculture for weed control. However, the benefits of this technique, depending on the material used, also include the improvement of edaphoclimatic conditions, reduction in transpiration, reduction in weed reinfestation, and the supply of organic matter and nutrients, culminating in the increase of productivity and cost reduction (Bucki & Siwek, 2019; Hashimi et al., 2019; Santos et al., 2011; Silva et al., 2013).

From this perspective, this study aimed to evaluate the use of soil mulching and types of sowing on the yield of organic carrot.

Material and Methods

The experiment was conducted from June to September 2018 at the Seridó Ecological Station, located on the Porto Acre Highway, km 04, Branch José Rui Lino, km 1.7, in the municipality of Rio Branco, Acre, located at the geographic coordinates 09° 48'18" S and 67° 39' 11" W. The property has been used to grow fruit and vegetable species under organic cultivation since 2008.

The climate of the region is hot and humid, classified as *Am* according to the Köppen classification, with annual temperature means of 25.2 °C, relative humidity of 85.7%, and rainfall of 2,247 mm (Inmet, 2018). The soil is classified as a plinthic yellow Ultisol with a sandy-loam texture, showing the following chemical characteristics: pH= 7.0; O.M.= 17 g dm⁻³; P= 49 mmol_c dm⁻³; K= 1.1 mmol_c dm⁻³; Ca= 49 mmol_c dm⁻³; Mg= 11 mmol_c dm⁻³; SB= 61.1 mmol_c dm⁻³; CEC= 72.2 mmol_c dm⁻³; V= 84.6%.

The experimental design was in randomized blocks (DBC) in split plots under a 4 x 3 factorial arrangement with four replications. The plots consisted of different weed control methods: bare soil, organic mulching, and plastic mulching with solarization. The sub-plots consisted of the sowing methods: direct sowing, indirect sowing, and pre-germinated seeds. Each experimental plot consisted of five planting rows with twelve plants each, with the two central rows forming the experimental unit.

The carrot cultivar Brasília Irecê, belonging to the Brasília group, was used in the experiment. This cultivar is adapted to hot climate regions, showing resistance to heat, *Alternaria* leaf blight (*Alternaria dauci*), and lodging. Its roots are cylindrical and have a uniform orange color, with sizes ranging from 18 cm to 22 cm, and a low incidence of green and violet tops.

Sowing was performed in planting beds in 2-cm deep holes opened transversally using a spacing of 30 cm x 10 cm.

In the direct sowing treatment, three seeds were deposited per hole. The pre-germinated seeds were

previously placed on moistened paper towels until radicle emergence, which occurred in four days on average, after which the seeds were sown in the planting beds.

The seedlings (indirect sowing) were produced in cylindrical paper tubes made with reused A4 paper, measuring 2 cm in width and 7.4 cm in height. The tubes were filled with an organic compost substrate, and the seedlings were transplanted four days after sowing without causing root damage.

The growing area was initially cleaned with a brush cutter and a hoe. Then, the soil was turned with a micro tractor, after which the planting beds measuring 1.20 m in width, 18.0 m in length, and 0.20 m in height were constructed, later fertilized with 15 t ha⁻¹ of organic compost (dry basis).

The plots with soil solarization were covered with a plastic film of 50 microns for 45 days. The organic mulch was distributed to each plot according to the treatments, with a thickness of 5 cm (Souza & Resende, 2014). Plastic mulching was performed using a double-sided film. The bare soil treatment followed the recommendations of organic carrot cultivation.

The crop management practices common to all treatments were irrigation, thinning, hilling, and weed cleaning.

Harvest was performed at the beginning of the cycle, after 81 days, by removing all plants when they reached the harvest point, determined by the bending of new leaves and the yellowing of older leaves.

The evaluations performed were: conventional commercial root mass (MRCC) (g root⁻¹) – following the commercial classification of carrot; organic commercial root mass (MRCO) (g root⁻¹) – considering the MRCC and carrots outside the conventional pattern but marketable as organic; conventional and organic commercial yields, expressed as t ha⁻¹ – considering the mass and stand; root diameter (mm) and root length (cm); weed biomass (g m⁻²) - evaluated after 22 days in each plot using a square (50 cm x 50 cm), with later oven drying; and the presence of defects (%).

The statistical analysis consisted of the evaluation of errors and homogeneity of variances, followed by analysis of variance by the F-test. When significance was observed, the means comparison test was performed by the Tukey's test at 5% of probability.

Results and Discussion

The plastic mulching increased the mass and organic yield of carrot regardless of the sowing method compared to the other mulching types. However, direct and pre-germinated sowing provided superior results.

There were similar results in the treatments with solarization with direct and indirect sowing, bare soil with indirect sowing, and organic mulching with pre-germinated seeds (**Table 1**).

Table 1. Organic yield (PCO) and organic commercial root mass (MRCO) of carrot under different weed control and sowing methods. Rio Branco, AC, UFAC, 2018

Control methods	PCO (t ha ⁻¹)			MRCO (g roots ⁻¹)		
	SI	SD	PG	SI	SD	PG
Solarization	30.06 Aab	33.92 ABa	25.62 Bb	62.10 Bb	78.47 BCb	114.17 ABa
Bare soil	25.13 ABa	24.17 Ca	28.03 Ba	75.37 ABa	72.50 Ca	84.08Ca
Organic mulch	20.70 Bc	26.16 BCb	38.06 Aa	90.16 Aa	101.75 Ba	92.22 BCa
Plastic mulch	30.04 Ab	44.87 Aa	44.39 Aa	90.12 Ab	134.60 Aa	133.18 Aa
C.V. (%)		1.36			13.27	

Means followed by the same uppercase letter in the column and lowercase letter in the row do not differ ($p>0.05$) by the Tukey test. SI= indirect sowing; SD= direct sowing; PG= pre-germinated seeds.

Cultivation in a protected environment offers a favorable space for plant growth, producing more vigorous, healthy, and resistant plants, reducing soil temperature, and increasing the moisture content, which increases plant growth (Mazed et al., 2015).

There is no available literature on the production of carrot seedlings. Thus, it is suggested that the lower yield observed was due to the salt stress caused by the environment change after transplanting since the seedlings had a height of 3-4 cm at the occasion.

The mass and commercial yield of conventional organic carrot cultivation were higher in the solarized soil (**Table 2**). This soil management can inhibit plant pathogens, pest insects, and control weeds, an adequate method for organic production that minimizes or prevents agrochemicals (Khan et al., 2012). In carrot cultivation, solarization is a widespread practice in early crop management to reduce or prevent the appearance of plant pathogens (Bezerra Neto et al., 2014).

Like solarization, cultivation under plant mulching promoted higher yields (Table 2), attributed to soil protection under the straw, maintaining moisture, promoting biological soil activity, and preventing the loss of minerals (Wozniak et al., 2019).

Root length showed an isolated effect of the factors, not differing for the different types of mulching, with a mean of 16.79 cm (Table 2). This variable is mainly influenced by the type and preparation of the soil, which,

Table 2. Conventional commercial root mass (MRCC), conventional commercial yield (PCC), and root length of organic carrot under different weed control methods. Rio Branco, AC, UFAC, 2018

Control methods	MRCC (g root ⁻¹)	PCC (t ha ⁻¹)	Root length (cm)
Solarization	67.93 a	21.30 a	16.24 ^{ns}
Bare soil	47.22 b	15.74 b	16.48
Organic mulch	48.67 b	16.22 ab	17.12
Plastic mulch	45.82 b	15.27 b	17.31
C.V. (%)	32.13	31.93	6.51

Means followed by the same letter do not differ ($p>0.05$) by Tukey's test. ^{ns} Not significant.

when adequate, favored the root development of carrot.

Direct and pre-germinated sowing resulted in the highest root length and diameter (**Table 3**). In these treatments, sowing is performed directly in the plant

Table 3. Growth and root diameter of organic carrot grown under different types of sowing. Rio Branco, AC, UFAC, 2018

Types of sowing	Root length (cm)	Root diameter (cm)
Indirect sowing	14.62 b	3.35 b
Direct sowing	17.59 a	3.52 ab
Pre-germinated	18.17 a	3.61 a
C.V. (%)	6.51	7.38

Means followed by the same letter do not differ ($p>0.05$) by the Tukey test.

bed, with the only difference being that, in the second treatment, radicle emission has already occurred. However, root growth is not interfered with in the initial moment.

However, in the seedlings produced in paper tubes, the growth of the main root had already begun when the seedlings were transplanted, which may have affected root growth since the plants were adapted to the tube substrate, and the soil of the planting bed could be an initial physical barrier.

The root diameters observed are within the organic and conventional cultivation patterns. However, this variable is intimately related to the root mass, and its variation can also affect the internal color, especially in the xylem (Carvalho et al., 2017; Mazed et al., 2015).

Organic and plastic mulching resulted in the lowest mass of weeds (**Figure 1**), collaborating to the better performance of these treatments in the production components, especially PCO, since both types of mulching reduce the incidence of weeds, thus decreasing the competition for nutrients and water and increasing the crop yield (Butler et al., 2016).

Weed interference in carrot cultivation can range from 38% to 87% of losses in the commercial root yield due to the competition for resources, negatively affecting plant height and the root mass, diameter, and length (Colquhoun et al., 2017; Soares et al., 2010).

Depending on the weed species, greater competition with carrot plants may occur, resulting in a loss of up to 98% in the yield when these plants remain during the whole crop cycle due to the greater interference on

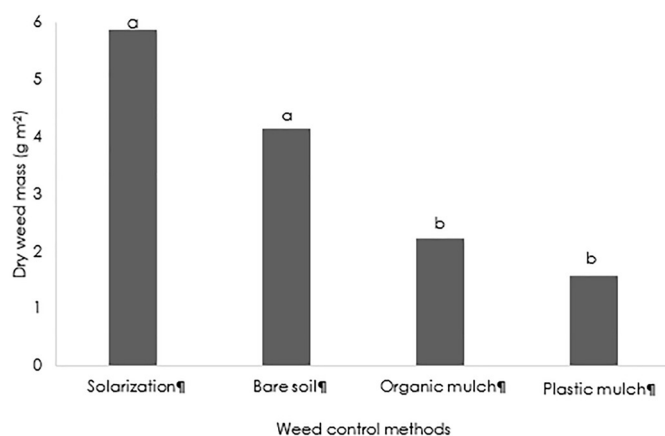


Figure 1. Dry mass of weeds (MPE) under different control methods. Rio Branco, AC, UFAC, 2018. Means followed by the same letter do not differ ($p > 0.05$) by the Tukey test.

root development (Reginaldo et al., 2021).

Solarization was inefficient for weed control (Figure 1), possibly because the 45-day period was insufficient to observe the expected effect. However, this method was positive for the PCC and did not interfere drastically with the other variables.

The mean plant height was 54.93 cm and was not influenced by weed control or sowing methods. Nevertheless, this parameter achieved the average of other studies with organic cultivation. This variable is intimately related to root growth by influencing the photosynthetic capacity of plants (Resende & Braga, 2014; Paulus et al., 2012).

Length classes 14 and 18 were the most frequent. This classification is recommended by the Brazilian Program for the Modernization of Horticulture, which establishes a national standard for the conventional system. The values are within the range expected for the cultivar (16-18 cm) and meet the preferences of Brazilian consumers (Resende et al., 2016).

The higher incidence of green and violet tops in the roots was observed in the treatments with plastic and/or organic mulching (Figure 2), resulting from the absence of hilling, which is not possible when the soil is covered.

The presence of forked roots was observed in indirect and pre-germinated sowing, possibly due to the initial form of cultivation.

It should be noted that there is no organic commercial classification, and this is performed according to local sales and consumer acceptability. However, root length and mild defects (green and violet tops and forking) are not considered in the direct or market sale of organic products since these are merely physical defects that do not interfere with the product's quality.

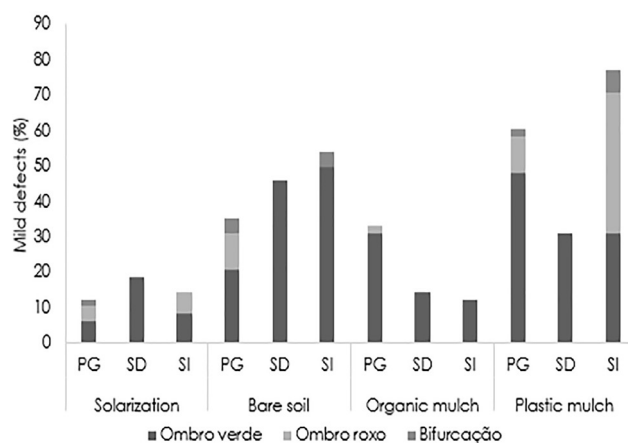


Figure 2. Percentage of incidence of green and violet tops and forking in organic carrot roots. Rio Branco, AC, UFAC, 2018. Data not subjected to statistical analysis. PG - Pre-germinated; SD - Direct sowing; SI - Indirect sowing.

Conclusions

Plastic mulching resulted in the highest yield of organic carrot, especially allied to direct or pre-germinated sowing. Along with organic mulching, this technique is efficient in controlling weeds. Moreover, although achieving lower values, indirect sowing provides a similar carrot yield to the Brazilian average.

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Conflict of Interest Statement: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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