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Potential of storage of the *Jatropha curcas* oil for the management of the cabbage aphis

Potencial de armazenamento do óleo de Jatropha curcas *para o manejo dos pulgões da couve*

Anderson Mathias Holtz[1]
Priscila Stinguel[2]
Julielson Oliveira Ataide[2*]
Ronilda Lana Aguiar[1]
Vergilio Borghi Neto[1]
Natália Daros Fienni[1]

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Abstract

The use of oils obtained from plants has been an alternative to pest management, because they are selective, biodegradable and have little effect on non-target organisms. The objective of this work was to evaluate the storage effect on essential oil *Jatropha curcas* L, for a period of 150 days, and its potential on the *Brevicoryne brassicae* (L.) (Hemiptera: Aphididae). Mortality was evaluated in relation to the time after application. The solution was sprayed onto discs of kale leaves containing aphids, with the help of Potter's Tower. Seven oil concentrations were tested, with 10 replicates per treatment. There was no statistical difference between the storage time and the different concentrations of *J. curcas* on *B. brassicae* mortality, all treatments being efficient in the management of *B. brassicae*.

Keywords: *Brevicoryne brassicae*, Alternative Control, Essential oil, Mortality.

Resumo

A utilização de óleos obtidos de plantas tem sido uma alternativa para o manejo de pragas, pois são seletivos, biodegradáveis e têm pouco efeito sobre organismos não-alvo.

1 *Instituto Federal do Espírito Santo – Campus Itapina, BR 259, Km 70, Caixa Postal 256, CEP. 29709-910, Colatina, ES.* E-mail: anderson.holtz@ifes.edu.br, https://orcid.org/0000-0002-1374-1049; ronilda.aguiar@ifes.edu.br, https://orcid.org/0000-0003-0638-0051; vergiliobneto@gmail.com, https://orcid.org/0000-0002-5440-7178; natalia1999.ndf@gmail.com, https://orcid.org/0000-0001-7078-8444

2 *Departamento de Produção Vegetal – NUDEMAFI, Centro de Ciências Agrárias da Universidade Federal do Espírito Santo, Alto Universitário, s/n, CEP: 29500-000, Alegre, ES.* pri_stinguel@hotmail.com, https://orcid.org/0000-0003-4097-2835; *julielsonoliveira@hotmail.com, https://orcid.org/0000-0003-1109-8798

O objetivo deste trabalho foi avaliar o efeito do armazenamento do óleo essencial de *Jatropha curcas* L, por um período de 150 dias, e seu potencial sobre *Brevicoryne brassicae* (L.) (Hemiptera: Aphididae). A mortalidade foi avaliada em relação ao tempo após a aplicação. A solução foi pulverizada sobre discos de folhas de couve contendo pulgões, com auxílio de Potter's Tower. Sete concentrações de óleo foram testadas, com 10 repetições por tratamento. Não houve diferença estatística entre o tempo de armazenamento e as diferentes concentrações de *J. curcas* sobre a *B. brassicae* , sendo todos os tratamentos eficientes no manejo de *B. brassicae*.

Palavras-chave: *Brevicoryne brassicae,* Controle Alternativo, Óleo Essencial, Mortalidade.

Introduction

Cabbage aphis, *Brevicoryne brassicae* (Linnaeus, 1758) (Hemiptera: Aphididae), is widely distributed in temperate and subtropical regions of the world, being that, practically all its host plants belong to the family Brassicaceae. In Brazil, this species is considered a key pest of the kale crop, developing large colonies (Botti, 2015), causing direct damages by the injection of toxins and continuous sucking of sap, affecting the development and commercialization of the plant, due to the presence of totally damaged (Griffin & Williamson, 2015). In addition, it may be vectored of turnip mosaic virus, which attacks kales and other plants of the genus *Brassica* (Souza-Silva & Ilharco, 2008), justifying the search for methods to control of this pest aphid.

Among the methods used to control aphids in agriculture, the chemical is the most usual, with the use of broad spectrum insecticides carried out intensively (Filgueira, 2008), often with products not registered for a particular pest. This can lead to resistance of the target pest as well as the appearance of new pests (Godonou et al., 2009), in addition to environmental and human contamination and the elimination of beneficial insects (Ahamad & Akhatar, 2013).

Thus, the search for alternative measures to chemical control has been emphasized, through research related to the use of substances obtained from plants, such as vegetable oils, and has shown a satisfactory efficiency in the control of insect-plague, besides being less aggressive techniques (Botti, 2015; Mapeli et al., 2018). Among the advantages are the short residual period, low toxicity, low cost and availability (mainly because Brazil is the country with the greatest vegetable diversity of the planet (BFG, 2015)) (Kathrina & Antonio, 2004; Wiesbrook, 2004) and have secondary metabolites that can exert repellent action, deterrent to feed, and oviposition, growth inhibitors and sterilants (Saxena, 1989).

The Jatropha, which belongs to the family Euphorbiaceae and is cited as a potential biocide plant (Almeida et al., 2009), little attacked by insects due to caustic latex exudation (Arruda, 2004), provoking food inhibition, repellency, inhibitory or suppressive action of oviposition, infertile eggs, inhibition of the development of larvae, nymphs and pupae and inhibition of the mating act, besides interfering in several metabolic routes important for the general metabolism, being able to cause the death of the insect (Ungaro & Regitano Neto, 2007).

However, in general, essential oils in the presence of oxygen, light, heat, moisture and metals become very unstable, suffering numerous reactions of degradation, making its conservation difficult, making its process and time of storage, essential for the maintenance of their quality (Simões et al., 2004).

In this context, the objective of this work was to evaluate the insecticidal activity of Jatropha oil on *B. brassicae* in the kale crop, as well as the duration of this effect for a certain time.

Material and methods

The experiment was carried out at the Instituto Federal do Espírito Santo- (IFES-Campus Itapina). The tests were conducted in heated room at the temperature of 25 ± 1 ºC, relative humidity 70 ± 10% and photophase of 12 h. *Brevicoryne brassicae* was established in kale plants (*B. oleracea* var. Acephala) without any phytosanitary treatment in a greenhouse for the multiplication of this aphid for laboratory tests.

Seeds of Jatropha were collected in the experimental area of the IFES- Campus Itapina, and subjected to the extraction of the oil by cold pressing. After this procedure, the oil was filtered with a fine mesh screen and stored in an amber colored glass container wrapped in foil. The container containing the oil was conditioned in an air-conditioned room with 25 ± 2 ºC, relative humidity 70 ± 10% and photophase of 12 h. The storage time of the oil used in the experiments was 0, 30, 60, 90, 120 e 150 days after extraction.

The concentrations used in the experiment with Jatropha oil were 0.0, 0.5, 1.0, 1.5, 2.0, 2.5 e 3.0% (volume/volume). For the dilution and application of the oil was used distilled water with adhesive spreader **Tween**® 80 (0,05%). The control consisted of distilled water and Tween® 80 (0.05%).

Bioassays

Kale leaves were periodically removed and taken to the laboratory, washed with distilled water, dried on filter paper, and packaged in gerbox plastic boxes.

Subsequently, they were transferred with the aid of a brush of fine bristles, 10 aphids for discs (8 cm diameter) of kale leaves. These were packed in plates Petri (10 x 1.2 cm). Each of the concentrations of the oil of *J. curcas*, which were previously determined, were applied on the kale leaves. The control consisted of disks sprayed with the solution distilled water and Tween® 80 adhesive spreader (0.05%). For application of solutions on insects in plates Petri, was used a Potter tower, whose pressure was 15 Lb/pol² and solution volume of 6/mL. The storage time ranged from 0 to 150 days.

The experiment was conducted in factorial 6 x 7 (6 ages and 7 concentrations), with 10 repetitions (each plates petri being a repetition). The mortality of individuals 24, 48 and 72 hours after spraying was evaluated. The data of the different concentrations, as well as the storage time of the Jatropha oil were submitted to the Tukey test at 5% of significance.

Results

There was no statistical difference between the time of storage and the different concentrations of the oil of *J. curcas* on the mortality of *B. brassicae*, showing to be efficient, presenting mortality rates above 40% in the 0.5% concentration, and reaching values higher than 70% at 3.0% concentration at 72 hours after spraying (Table 1).

In the first 24 hours after spraying, the highest efficiency occurred at concentrations higher than 1.5%, which did not differ among themselves, but with mortality rates higher than 0.5%; 1.0% and the witness, which were statistically the same. This behavior was the same for all storage times of the Jatropha oil (Table 1).

In the evaluation of 48 hours, there was difference between the oil concentrations, in all ages evaluated. The highest mortality rates were obtained in concentrations higher than 1.5%, being that, from this concentration there was no difference between them (Table 1). In the 72-hour spray powders evaluation there was a statistical difference between the concentrations within the storage ages of the Jatropha oil (Table 1).

Table 1. Mortality average (%) ± SE of *Brevicoryne brassicae* submitted under different concentrations and ages of storage of Jatropha oil with 24, 48 and 72 hours after spraying.

24 hours

Concentration (%)	Oil ages					
	0	30	60	90	120	150
0,0	2,00 ± 1,50 aA1	3,00 ± 2,00 aA	4,00 ± 2,00 aA	5,00 ± 1,00 aA	5,00 ± 3,00 aA	4,00 ± 2,40 aA
0,5	8,00 ± 2,90 aA	7,00 ± 2,70 aA	10,00 ± 3,80 aA	7,88 ± 4,90 aA	6,90 ± 2,00 aA	7,00 ± 5,50 aA
1,0	4,00 ± 1,63 aA	10,00 ± 1,90 aA	9,00 ± 2,50 aA	8,00 ± 2,62 aA	12,00 ± 3,23 aA	8,60 ± 4,56 aA
1,5	32,00 ± 10,41 bA	31,00 ± 9,80 bA	32,50 ± 8,00 bA	27,00 ± 7,00 bA	29,00 ± 6,05 bA	28,00 ± 5,80 bA
2,0	41,33 ± 10,97 bA	42,00± 10,00 bA	41,00 ± 6,80 bA	40,00 ± 8,80 bA	41,00 ± 5,85 bA	39,00 ± 7,80 bA
2,5	34,19 ± 5,85 bA	35,00 ± 5,95 bA	33.44 ± 5,80 bA	36,50 ± 5,85 bA	36,50 ± 6,00 bA	33,40 ± 8,00 bA
3,0	38,58 ± 4, 19 bA	40,02 ± 4, 00 bA	37,67± 4, 30 bA	40,00 ± 6, 30 bA	40,00 ± 5,60 bA	38,00 ± 6,00 bA

48 hours

Concentration (%)	Oil ages					
	0	30	60	90	120	150
0,0	5,00 ± 2,01 aA1	6,00 ± 1,80 aA	4,50 ± 2,50 aA	6,00 ± 1,75 aA	6,80 ± 3,00 aA	5,60 ± 3,20 aA
0,5	22,52 ± 7,58 bA	18,20 ± 7,00 bA	17,00 ± 4,50 bA	23,40 ± 6,48 bA	23,00 ± 5,43 bA	22,00 ± 8,45 bA
1,0	31,96 ± 7,38 bA	30,00 ± 6,80 bA	29,90 ± 4,56 bA	28,80 ± 5,30 bA	32,76 ± 5,00 bA	29,00 ± 6,00 bA
1,5	54,65 ± 9,88 cA	50,00 ± 7,50 cA	54,00 ± 9,00 cA	55,80 ± 6,00 cA	53,30 ± 7,80 cA	56,00 ± 6,01 cA
2,0	55,94 ± 9,94 cA	57,30 ± 8,80 cA	53,25 ± 4,54 cA	50,00 ± 6,90 cA	54,00 ± 5,00 cA	52,10 ± 6,35 cA
2,5	58,28 ± 6,62 cA	58,00 ± 5,00 cA	55,40 ± 4,30 cA	52,00 ± 3,00 cA	54,00 ± 7,80 cA	59,00 ± 4,50 cA
3,0	63,73 ± 7,56 cA	60,00 ± 5,40 cA	61,00 ± 4,45 cA	58,90 ± 6,80 cA	64,50 ± 5,00 cA	62,00 ± 8,00 cA
3,0	38,58 ± 4, 19 bA	40,02 ± 4, 00 bA	37,67± 4, 30 bA	40,00 ± 6, 30 bA	40,00 ± 5,60 bA	38,00 ± 6,00 bA

72 hours

Concentration (%)	Oil ages					
	0	30	60	90	120	150
0,0	5,00 ± 3,44 aA[1]	7,00 ± 3,35 aA	10,00 ± 4,42 aA	12,00 ± 5,23 aA	9,00 ± 6,42 aA	7,00 ± 8,41 aA
0,5	47,11 ± 7,44 bA	46,00 ± 6,99 bA	45,00 ± 6,41 bA	44,00 ± 7,44 bA	46,00 ± 6,5 bA	43,00 ± 6,90 bA
1,0	65,87 ± 8,19 bA	64,00 ± 8,10 bA	63,00 ± 8,10 bA	63,00 ± 8,19 bA	65,00 ± 7,3 bA	63,00 ± 8,00 bA
1,5	69,93 ± 8,31 bA	68,10 ± 8,20 bA	67,00 ± 7,69 bA	69,00 ± 8,31 bA	70,00 ± 4,6 bA	64,30 ± 8,00 bA
2,0	68,89 ± 7,88 bA	68,00 ± 7,00 bA	68,80 ± 7,10 bA	68,45 ± 7,88 bA	71,00 ± 7,2 bA	67,00 ± 6,80 bA
2,5	72,49 ± 6,09 bA	70,20 ± 5,30 bA	71,30 ± 5.98 bA	72,00 ± 6,09 bA	73,00 ± 6,20 bA	69,20 ± 6,20 bA
3,0	75,24 ± 7,59 bA	76,21 ± 6,53 bA	70,00 ± 6,88 bA	76,45 ± 7,59 bA	74,00 ± 7,10 bA	70,30 ± 7,00 bA

[1] Means (± SE) followed by the same uppercase letter in the column and lowercase letter in the row do not differ statistically from each other by the Tukey test (P> 0,05).

Discussion

As observed at all storage times, when there is increased concentration, the mortality of the pest aphid is increased. Probably, there is a reduction in the detoxification capacity of insects in the highest concentrations, because there are more molecules of the active principle of the plant per volume of the solution, acting jointly in the digestive tract, nervous and respiratory system of the pest, simultaneously (Celestino, 2011). In addition, the solutions were applied on the aphid (contact path) and the food (leaf disc) (route of ingestion), making it more difficult for this pest to escape the insecticidal action of the plant. Several authors argue that the action by contact is faster than the mode of action by ingestion, because the latter to act on the target organism depends on the digestion process for incorporation and action on the vital systems of the pest (Isman et al., 2006).

However, the action by contact of the oil, probably, acts on the central nervous system of the insect, preventing the transmission of nerve impulses, due to inhibition of the enzyme Acetylcholinesterase or by disturbances in acetylcholine, or GABA, and / or Na + and K + channels. These could also affect cellular respiration by preventing the transport of electrons and / or inhibitors to ATP synthesis (Holz et al., 2016).

The toxicity of *J. curcas* is attributed mainly to the presence of two components in the seeds: a ribosome inactivating protein (curcine) and diterpene esters (Holz et al., 2016). Besides these, the seeds present other bioactive molecules, such as inhibitors of proteases, saponins, phytates and tannins. Curcina resembles ricin, a toxic protein isolated from castor bean seeds (*Ricinus communis*), which has two polypeptide chains, one with lectin function and another capable of inhibiting protein synthesis (Stirpe et al., 1976). Thus, mortality of *B. brassicae* is probably associated with the joint action of anti-food effects and protein insecticides contained in the oil extracted from the seed of *J. curcas* (Darby et al., 2001).

The digestion and absorption of starch by insects is prevented by the action of α-amylase protein inhibitors, whereas, (Olsnes & Kozlov, 2001), the insecticidal activity occur when ribosome inactivating proteins (RIP_S) are ingested and cause death of the cells of the gastrointestinal tract (Audi et al., 2005).

The storage time did not affect the potential of the Jatropha oil on the aphid. Probably, this fact is related to absence of the light incidence in the oil, because it was stored in amber glass, wrapped in foil. Secondary compounds from plants can be oxidized when they are exposed directly to light, pH and inadequate storage temperatures (Constantine & Karchesy, 1998).

Jatropha seeds are orthodox and at room temperature may remain viable for one year, however, for extraction of its oil, a long period of storage is not recommended because these oleaginous ones are more susceptible to the attack of pathogens, which can cause a rancification of the fatty acids that compose the oil (Mello et al., 2005; Goldfarb, 2010).

The results showed that Jatropha oil presents insecticidal activity and persistence, even though it was stored for a period of 150 days, proving to be efficient in handling the cabbage aphis. We conclude that Jatropha oil is efficient in the management of *Brevicoryne brassicae* in kale culture, even after a predetermined period of storage.

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Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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