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IS THE MIXTURE BETWEEN CASTOR AND JATROPHA OILS EFFICIENT IN THE MANAGEMENT OF PINK HIBISCUS MEALYBUG?

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Abstract: The pink hibiscus mealybug, *Maconellicoccus hirsutus* (Green) (Hemiptera: Pseudococcidae) is a polyphagous pest species that has been reported in about 350 species of host plants worldwide. Usually, the use of synthetic chemicals is still the most used control method for the control of agricultural pests. The objective of this present work was to evaluate the potential of the mixture of oils extracted from the species *Ricinus communis* L. (castor) and *Jatropha curcas* L. (jatropha) (Euphorbiaceae) in the form of direct and indirect application on *M. hirsutus*. The experiments were conducted in air-conditioned chambers at a temperature of 25 ± 1ºC, relative humidity 70% ± 10 and a photophase of 12h. The 3% concentration was used in the tests, with 11 interaction ratios between the oils. Individuals' mortality was assessed at 24, 48 and 72 hours after spraying. The results of the interactions indicated up to 78% mortality of individuals in the ratio 90% castor + 10% jatropha via indirect application, while in the direct application on individuals they presented 53% mortality in the ratio 40% castor + 60% jatropha. The interactions between castor and jatropha oils have demonstrated potential in the management of pink mealybug by direct or indirect application.

Keywords: *Maconellicoccus hirsutus*; *Jatropha curcas*; *Ricinus communis*; alternative control

1 INTRODUCTION

The pink hibiscus mealybug, *Maconellicoccus hirsutus* (Green) (Hemiptera: Pseudococcidae) is a polyphagous pest species that has been reported in about 350 species of host plants worldwide. Native from South Asia or Australia, this species currently has a worldwide distribution, mainly in tropical and subtropical regions (GARCÍA MORALES et al., 2016). In Brazil, the species was detected in 2010, in the Roraima state (MASSARO JUNIOR et al., 2013). In Espírito Santo, its first report occurred in 2012, in the southern region of the state (CULIK et al., 2013). This species is registered as a potential pest for several host plants from 78 botanical families (GARCÍA MORALES et al., 2016; MARTINS et al., 2019), and its feeding habit, which consists of sucking the sap of the plant and injecting a toxic substance, can cause the malformation of the leaves and fruits, as well as withered apical growth, which may directly inhibit the development of some plant species (FORNAZIER et al., 2017; HOLTZ et al., 2019). Considering the damage caused by pest species in crops of economic interest, synthetic chemicals are still the most used control method to combat the main agricultural pests. And, although chemical insecticides are used with relative success in agriculture, the constant application in the field can promote the selection of resistant individuals, making later generations even more problematic (MERCÊS et al., 2018). In addition, the active ingredients that make up these products can interfere in the population of natural enemies, pollinators, and wild animals, as well as bring toxic effects to man, through application, by the residues present in food and persistence in the environment (CARVALHO, 2017; OLIVEIRA et al., 2018; HOLTZ et al., 2020).

In this way, aiming at the search for alternative methods to chemical control, researches related to the use of oils, essential oils and plant extracts are showing satisfactory and proven efficiency in pest control, as they have secondary metabolites present that act in the intoxication of target organisms and rapid degradation in the environment (MERCÊS et al., 2018). Previous studies have shown the potential of botanical insecticides against mealybugs. For example, Holtz et al. (2019) found mortality rate over 80%, using aqueous castor extract *Ricinus communis* L. (Euphorbiaceae) in the *M. hirsutus* control. Another example is the use of *Jatropha curcas* L. (Euphorbiaceae) aqueous extracts, which mortality of 91.6% was found in the concentration of 1.5, 2.0 and 3.0% applied directly to *Planococcus citri* individuals (Risso, 1813) (Hemiptera: Pseudococcidae) (HOLTZ et al., 2016a,b). Knowing the efficacy of *R. communis* and *J. curcas* in the control of mealybug species, this study aimed to evaluate the effectiveness of the mixture of the oils extracted of these plants applied directly and indirectly against *M. hirsutus*.

2 METHODS

The experiment was carried out at the Agricultural Entomology and Acarology Laboratory of the Federal Institute of Espírito Santo - *Campus* Itapina (Ifes-Itapina), in air-conditioned chambers at a temperature of 25 ± 1ºC, relative humidity 70% ± 10, and 12h photophase.

2.1 BREEDING AND MAINTENANCE OF *M. hirsutus*

The breeding technique adopted was an adaptation by Sanches & Carvalho (2011), using pumpkins in an early stage of maturity to feed the pink hibiscus mealybug. To the initial infestation of pumpkins, the individuals were collected in the field on infested *Theobroma cacao* (Malvaceae) plants. After the establishment of the initial colony, the process of multiplication of mealybugs occurred. When it was needed the pumpkins were exchanged, new pumpkins were brought into contact with those infested. The approximation of the fruits favors the transfer of newly hatched nymphs from the mealybug to the new fruit due to its high mobility at this stage.

2.2 OBTAINING AND MIXING OILS

Castor seeds provided by Brazilian Agricultural Research Corporation (Embrapa – Algodão), and jatropha seeds collected in the productive areas of the Ifes-Itapina were used to obtain the oils. After this procedure, the castor and jatropha seeds were subjected to oil extraction by cold pressing. The concentration used in the bioassays was 3%. The treatments were represented by mixtures containing different proportions of the two oils, as shown in Table 1, and the dilutions of the solutions in solvent (100 mL of distilled water and 0.05% of Tween® 80 adhesive spreader). Following, the mixtures remained under agitation on a mechanical stirrer for 12 hours, being stirred again, by magnetic stirrer, at the time of applications, at room temperature.

Table 1. Mixtures between castor (*Ricinus communis*) and jatropha (*Jatropha curcas*) oils used in the experiment in percentage (%) and concentration [C] (v v^{-1}).

Treatments	Castor (%)[C]	Jatropha (%)[C]
T1*	0 [0.0]	0 [0.0]
T2	0 [0.0]	100 [3.0]
T3	100 [3.0]	0 [0.0]
T4	10 [0.3]	90 [2.7]
T5	20 [0.6]	80 [2.4]
T6	30 [0.9]	70 [2.1]
T7	40 [1.2]	60 [1.8]
T8	50 [1.5]	50 [1.5]
T9	60 [1.8]	40 [1.2]
T10	70 [2.1]	30 [0.9]
T11	80 [2.4]	20 [0.6]
T12	90 [2.7]	10 [0.3]

* Control: Solvent, distilled water and Tween® 80 adhesive spreader (0.05%)
Source: Author

2.3 MORTALITY TEST

In order to evaluate the toxicity of castor and jatropha oils and their mixtures in different proportions, direct and indirect exposures were adopted. For both, 10 repetitions per treatment were used, containing 10 adult female mealybugs each (100 insects per treatment). The repetitions consisted of Petri dishes (10.0 x 1.2 cm), where arenas were built with discs of coffee leaves (4 cm in diameter). The disks were adhered to the Petri dish over a 0.5 cm layer of agar solution (x%) and around the disks solid petroleum jelly was used to prevent the escape of insects.

In direct exposure tests, mealybugs were previously deposited in the arenas. Then, 2 ml of solution of the mixtures were sprayed with a 1.3 psi airbrush.

In the indirect exposure bioassays, the coffee leaf discs were immersed for 5 seconds in glass flasks containing X mL of the mixtures. Subsequently, they were placed on paper towels for drying, for 45 minutes, to eliminate excess solution. After this procedure, the disks were fixed to the Petri dishes, as described above and the pink hibiscus mealybugs were transferred to the arenas.

As a control, distilled water and the adhesive spreader Tween® 80 (0.05%) were used. The individuals' mortality was assessed at 24, 48 and 72 hours after spraying or transferring the insects in the indirect exposure test.

2.4 STATISTICAL ANALYSIS

Mortality data collected in 72h, obtained from exposure to mixtures of castor and jathopha oils, were subjected to analysis of variance to verify significance between the routes of exposure and the means of each treatment compared by the Tukey test at the level of 5% probability. All analyzes were performed using ‘software’ R version 3.6 (R Core Team, 2019).

3 RESULTS AND DISCUSSION

The results indicated that the indirect exposure route obtained higher percentages of *M. hirsutus* mortality than the direct route (Table 2). Treatments 9 (60% Castor + 40% Jatropha) and 12 (90% Castor + 10% Jatropha) showed mortality of 78 and 77%, respectively, in the indirect application test. In this type of route, high mortality rates were observed in the first 24 hours, possibly due to the direct contact of the mixture of oils with the leaf, with a greater amount of the substance in the leaf (Results not shown). Celestino et al. (2015)

found mortality levels of approximately 34% when using castor oil at a concentration of 3% on individuals of *Hypothenemus hampei* (Ferrari) (Coleoptera: Curculionidae: Scolytinae) in the form of indirect application, however, the same author states that probably due to the cryptic habit of the insect, this form of application would not be the most efficient, however, for the pink mealybug, this form of application proved to be more effective, considering that it was not given as an option of choice for the insect in the indirect way, so, possibly, the highest mortality is occurring due to the ingestion of the interaction by *M. hirsutus*, acting directly on the internal physiology of the same, which would not occur immediately through the direct route. This mode of action can probably be related to the presence of ricinoleic acid in castor seeds, this is a highly toxic compound. This toxin is called a ribosome inactivating protein (RIPs), that is, protein synthesis does not occur causing cell death, as it is poorly absorbed in the gastrointestinal tract (WANG et al., 2019). However, interactions may act on individuals in different ways, and may penetrate the organism in addition to ingestion (through the digestive system), it may also, by contact, cross the integument and through the airways (HOLTZ et al., 2016a). The mode of action may also be associated with the presence of secondary metabolites from the seeds of *J. curcas*, increasing the mortality rates presented in the study.

Table 2. Mortality of *Maconellicoccus hirsutus* treated with different mixing ratios between castor oil and jatropha oil, in different routes of exposure, after 72h.

Treatments		Exposure routes			
		Direct		Indirect	
T1	**Control**	10.00 A	c	3.00 A	d
T2	**Jatropha**	19.00 B	bc	50.00 A	abc
T3	**Castor**	34.00 B	abc	72.00 A	ab
T4	**Castor(10%)-Jatropha(90%)**	32.00 A	abc	49.00 A	abc
T5	**Castor(20%)-Jatropha(80%)**	48.00 A	ab	29.00 A	cd
T6	**Castor(30%)-Jatropha(70%)**	48.00 A	ab	40.00 A	bc
T7	**Castor(40%)-Jatropha(60%)**	53.00 A	a	61.00 A	abc
T8	**Castor(50%)-Jatropha(50%)**	24.00 A	abc	40.00 A	bc
T9	**Castor(60%)-Jatropha(40%)**	38.00 B	abc	78.00 A	a
T10	**Castor(70%)-Jatropha(30%)**	32.00 B	abc	69.00 A	ab
T11	**Castor(80%)-Jatropha(20%)**	36.00 B	abc	64.00 A	ab
T12	**Castor(90%)-Jatropha(10%)**	39.00 B	abc	77.00 A	a
CV (%)		25.12			

Means followed by the same letter, uppercase on the line and lowercase on the column, do not differ by the F and Tukey test, respectively at the level of 5% probability.
Source: Author.

In direct application, the most effective mixture in mealybug mortality was treatment 7 (40% castor oil and 60% jatropha oil) with 53% mortality, despite being statistically similar to treatments 3, 4, 5, 6, 8, 9, 10, 11 and 12 (Table 2).

The efficiency of Jatropha in insect control is probably due to the presence of secondary compounds, known to provide defense to plants against pest attack, presenting a deleterious effect to these herbivores (CARDOSO et al., 2001; CAVALCANTI et al., 2005). The contact action of jatropha oil acts on the insect's central nervous system, preventing the transmission of nerve impulses. Probably due to the inhibition of the enzyme acetyl cholinesterase or by disturbances in acetylcholine, or in GABA. In the channels of Na^+ and K^+ it may also affect cellular respiration by preventing electron transport and inhibitors of ATP synthesis (HOLTZ et al., 2016a). Babarinde et al. (2019) under study found a large number of saturated acids present in jatropha seeds, mainly palmitic acid and linoleic acid. In addition to presenting effective toxicity, long-chain saturated fatty acids such as palmitic and linoleic have groups that interfere with the mechanism of action of growth and development of pest insects (RABAIOLI & SILVA, 2016).

Sabbour & Abd-El-Raheem (2013) observed that the essential oil of jatropha showed high repelling power against *Callosobruchus maculatus* (F.) (Coleoptera: Bruchidae) and *Callosobruchus chinensis* (L.) (Coleoptera: Bruchidae) in common bean grains treated with oil. In the same study, it also showed a high mortality rate of adult insects, as well as an adverse influence on the fecundity of eggs and on the reduction of laying by number of females. The interaction of jatropha oil was also studied by Pant et al. (2014), who tested the insecticidal activity of *Eucaliptus globulus* essential oil against *Tribolium castaneum* (Coleoptera: Tenebrionidae), obtaining a mortality rate of 88 to 100%. However, the interaction of eucalyptus oils and jatropha extract was also studied and in test they stated that the interaction was more toxic and effective for insects compared to the essential oil used separately.

In addition to the oil of *J. curcas* in the studied interaction, castor oil and its chemical components may have contributed to the insecticidal effect. Celestino et al. (2015) found high mortality rates of *H. hampei* in direct application using castor oil, obtaining an LC_{50} of 2.05%, showing high suspension efficiency. In the present study, the interaction applied directly did not cause greater efficiency among treatments, probably because the mealybug has a powdery layer that could be delaying the absorption of toxins by the mealybug and reducing the action on the insect.

Based on the results obtained in the present study, we observed that the mixture between castor and jatropha oils did not provide significant increases in mealybug mortality compared to castor oil alone. However, it provided a reduction in the percentage of castor oil used, which suggests that, in terms of quantities, the composition of the T9 treatment (60-40) is promising in toxicity studies on mealybug. Furthermore, in order to Integrated Pest Management for mealybug, the use of the mixture associated with another method of control may be contributing to mortality in the pest. For this, research regarding the insecticidal effect and the toxic substances present in the tested oils should be further studied in order to produce a commercial product that is safe for farmers and the environment.

4 CONCLUSIONS

It is concluded that the mixture between castor and jatropha oils demonstrates potentiality in the management of *M. hirsutus* via indirect application, mainly with higher percentages of castor oil. However, studies must be carried out to elucidate the toxicological molecules of the oils that act in the organism and the physiology of *M. hirsutus*, as well as the performance of tests in greenhouse and field.

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