ACTIVITY OF INSECTICIDES ON COFFEE BERRY BORER, *Hypothenemus hampei* (Coleoptera: Curculionidae, Scolytinae).

ATIVIDADE DE INSETICIDAS SOBRE A BROCA-DO-CAFÉ, Hypothenemus hampei *(Coleoptera: Curculionidae, Scolytinae).*

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ABSTRACT: The objective of this work was to evaluate the topical, residual and agronomic effects of the insecticides Voliam Targo, Benevia, Lorsban 480 BR, Curbix 200 SC, Sperto, Verismo, Polytrin 400/40 CE, Curyom 550 EC, Polo 500 SC and Vertimec 18 EC in the control of the berry borer of coffee (*H. hampei*). The experimental design was completely randomized and four replicates were used in the trials. In the laboratory, a direct spray was sprayed on the insect (topical effect) and applied to the fruits of the coffee (residual contamination). In both experiments, each plot consisted of a Petri dish lined with filter paper, 10 fruits in the green stage and 10 adult females of the berry borer, originating from artificial breeding. Two field experiments were carried out at Campus Glória Experimental Farm. The first one was carried out with the objective of evaluating the residual effect of the insecticides on artificial infestation of the berry borer after applying the products to fruits at the beginning of maturation. The number of perforated fruits, dead females, number of eggs and larvae were evaluated in laboratory and field experiments. The second field experiment had as objective to evaluate the effectiveness in controlling the natural population of the berry borer. Two applications were performed with a 30-day interval, using a motorized turbocharger. The number of fruits bored in 50 fruits per plot and percentage of seeds bored in a sample of 250 seeds per replicate were evaluated. In the laboratory, all insecticides provided mortality higher than 80% in topical application and greater than 73% by residual contamination, except the insecticide Polo 500 SC, which provided a 55% mortality. In the field experiment with artificial infestation, all the insecticides differed from the control, maintaining residual control until 30 days after application and with mortality higher than 70%, reaching up to 100% of mortality. In the test with natural berry borer females infestation the insecticides differed from the control in all evaluated parameters, showed efficacy higher than 75% at 35 days after the second application. The insecticides Voliam Targo, Lorsban 480 BR, Curbix 200 SC, Sperto, Polytrin 400/40 CE and Verismo presented the best control results, being indicated for use in the management of the berry borer of coffee.

KEYWORDS: *Coffea arabica*, IPM, chemical control.

INTRODUCTION

World coffee production forecast for the 2017/2018 harvest is estimated at 159.66 million 60 kg sacks, a volume that represents a growth of close to 1.2% over the previous harvest. This positive performance is attributed directly to the 12.1% increase in robust coffee production, which offset, to some extent, a slight reduction of 4.6% in the volume of Arabica coffee produced compared to the previous period (CONAB, 2018).

Brazil is the largest producer and exporter of coffee, accounting for 33.73% of world exports (USDA, 2017). The cultivated species are *Coffea arabica* L. and *Coffea canefora*, with total planted area around 2,156,500 hectares. The states of Minas Gerais, Espírito Santo and São Paulo are the main producers. The total estimate of Brazilian production in the 2017/2018 harvest is 59.9 million sacks, of which 76% is Arabica coffee, with gross revenues of around R$ 22.9 billion (CONAB, 2018).

In spite of these high yields, several phytosanitary problems affect coffee cultivation, being the coffee berry borer (*Hypothenemus hampei*) (Ferrari) (Coleoptera: Curculionidae: Scolytinae), one of the main ones, because it attacks fruits at all stages of development, compromising the production and altering coffee quality due to opportunistic microorganisms. In this way, the losses caused to the crop affect the economy of more than 25 million small farmers in the world (SOUZA, 2014).

In Brazil, the berry borer of coffee was introduced in the state of São Paulo, probably in 1913, along with seeds imported from Africa and Java. From 1913 to 1924 the insect spread through

Received: 08/04/19
Accepted: 20/12/19

http://dx.doi.org/10.14393/BJ-v36n4a2020-46735

many coffee plantations in Campinas and several neighboring municipalities. In the harvest harvested in 1924 the first losses were observed. From then on, the berry borer spread throughout the coffee regions of Brazil (SOUZA; REIS; SILVA, 2007).

For the management of coffee borer, it is necessary to know the bio-ecology of the insect and its interaction with the environment to determine its management, integrating several forms of control (MICHAEL; PORTILLAR, 2018). The application of insecticides is the most widely used method of control and is responsible for the 1940 revolution in insect control, as it has been the most efficient and economical means of combating insects, especially if the objective is to maximize crop productivity in large areas (SOUSA, 2013). This method is recommended for the management of coffee beery borer when 3 to 5% of brocaded fruits are observed, however, most producers do not follow this recommendation, making applications without any criterion (SOUSA, 2013).

Although chemical control is the main method used by farmers to manage *H. hampei*, it has been shown to be of low efficiency due to the natural selection of resistant insect strains, which can also cause environmental problems such as the elimination of natural enemies and contamination of the soil (MOURA; CARVALHO; BOTTON, 2012) The chemical control with the insecticide endosulfan was the most efficient for the control of the berry borer in coffee cultivation, however, due to its toxicology, certifiers and government banned its use. In addition, the indiscriminate use of this insecticide, without proper monitoring and manage

Laboratory Experiments

Two experiments were realized in the Laboratory of Entomology of the Federal University of Uberlândia, Brazil, to evaluate the effect of insecticides on the insect, the first one on top of the insect (shock effect) and the second on the fruits, to verify the residual effect of insecticides. Each plot consisted of a Petri dish of 10 cm diameter, lined with filter paper. For the accomplishment of these tests fruits were used from the experimental area of Campus Glória, previously described. Rosettes with fruits in the green grain stage were collected using pruning shears and the material was packed in a thermal box and transported to the laboratory. The fruits were washed in running water and then left in 5% hypochlorite solution for 10 minutes. After this period, the fruits were washed in running water and left at room temperature for drying. For the tests were used adult females of *H. hampei*, originating from artificial diet, provided by the Laboratory of Entomology of the agronomic institute of Paraná (AIPAR). The insects were kept in petri dishes containing artificial diet and during the whole period of the tests were kept in an air-conditioned room (25ºC ± 1ºC and photo-phase of 12 hours).

ment, has diminished its effectiveness. Proof of this is the increase in the number of applications and the doses practiced in recent years (PARENTI; SOUZA; MEDEIROS, 2013).

With the exit of the endosulfan insecticide from the Brazilian market in 2013, there was a great concern on the part of the researchers, consultants and producers regarding the options available for the control of the coffee borer (*H. hampei*), being an important pest in the crop of coffee, there was a strong demand for research of new assets to control this pest (MENDONÇA; MATTIELLO, 2017).

New insecticides can replace endosulfan with less environmental impact in chemical control, but without the strategic management of this pest, new technologies will have short efficiency and high cost for producers. The solution to the population control of this pest in a sustainable way consists in the frequent monitoring of the plots with historical of the pest, to treat them with the insecticides punctually well at the beginning of the infestation and only where it is necessary. In addition, the rotation of the chemical groups of insecticides corroborates the longevity of the efficiency of the new insecticides. In this context, it is important to carry out studies to evaluate the activity of insecticides available in the market for coffee cultivation (SILVA et al., 2010). Thus, this study aimed to evaluate the topical, residual and agronomic effects of the insecticides Voliam Targo, Benevia, Lorsban 480 BR, Curbix 200 SC, Sperto, Verismo, Polytrin 400/40 CE, Curyom 550 EC, Polo 500 SC and Vertimec 18 EC in the control of the berry borer of coffee (*H. hampei*).

MATERIAL AND METHODS

The work was developed during the 2017/2018 harvest, in two stages, two laboratory tests and two field tests. The products used are shown in Table 1. The control treatment consisted only of water. The experimental study was a completely randomized design with 11 treatments and 4 replicates.

The first stage of the experiment was conducted from March to May at the UFU Entomology Laboratory (Federal University of Uberlândia) located at the Umuarama Campus of Block 4C. The field stage was conducted from March to June 2018, at the Experimental Farm of Campus Glória of the Federal University of

Uberlândia, in the Coffee Sector, geographical coordinates: 18 ° 57'34.6 "S 48 ° 12'20.2" W, Altitude: 883m accuracy: 7m.

Table 1. Trade name, active ingredient, chemical group, concentrations of the active ingredients and doses of insecticides, tested in mortality, population and reproduction control, under laboratory and field conditions. (Sistema de agrotóxicos fitossanitários - AGROFIT, 2015). Uberlândia - MG, 2018.

Treatments /Trade name	Active ingredient / Chemical group	Concentrations[2]	Doses[1] c.p./ha
1. Control	-	-	-
2. Voliam Targo[3]	Chloranthraniliprole / Anthranilamide + Abamectin / Avermectin	45 + 18	100 mL
3. Benevia	Cyantraniliprole / anthranilamide	150	1500 mL
4. Lorsban 480 BR	Chlorpyrifos / organophosphorus	1200	2500 mL
5. Curbix 200 SC	Ethylole / phenylpyrazole	500	2500 mL
6. Sperto	Acetamiprid / Neonicotinoid + Bifenthrin / Pyrethroid	125 + 125	500 g
7. Verismo	Metaflumizone / Semicarbazone	480	2000 mL
8. Polytrin 400/40 CE	Cypermethrin / Pyrethroid + Profenofos / Organophosphorus	32 + 320	800 mL
9. Curyom 550 EC	Lufenuron / Benzoylurea + Profenofos / Organophosphorus	40 + 400	800 mL
10. Polo 500 SC	Diafentiuron / Phenylthiourea	400	800 mL
11. Vertimec 18 EC[3]	Abamectin / Avermectin	18	1000 mL

[1]Doses (mL or g commercial product.ha^{-1}); [2] Concentrations (g a.i. kg or L^{-1} c.p.). [3]Adjuvant: Assist. 0, 25%v/v.

The cultivar used in the two stages of the experiment was the *Coffea arabica* L, at 14 years of age, planted at a spacing of 3.5 m x 0.70 m with 4081 plants / ha. In the experimental field, all the cultural treatments necessary for the good development of the culture (liming, fertilization, irrigation and weed management) were carried out. Priori Top + Nimbus® (0.5 L.ha^{-1} + 1L.ha^{-1}) and two applications with a 30-day interval with the fungicide Priori Xtra + Nimbus® (0.75 L.ha^{-1} + 1 L.ha^{-1}).

To evaluate the mortality by the effect of the topical application of the insecticides, 10 active and adult females of the breeding drill were transferred to Petri dishes. Soon after the transfer of the females, the application, with manual sprayer, was carried out in the proportion of 300 L.ha^{-1}. After spraying and drying the syrup, 10 fruits were added per dish.

To evaluate the mortality by the residual effect of the insecticides, the fruits were immersed in the syrup containing the insecticide for 10 minutes and were dried. Two hours after application 10 fruits were transferred to Petri dishes lined with filter paper and soon thereafter, 10 active females of the borer, from the rearing on artificial diet, were transferred to Petri dishes

The evaluations were performed 6, 12 and 24 hours, 3, 5, 7 days after application. The evaluated parameters were mortality and number of fruits bored. At 15 days after application, the bored fruits were dissected to count the number of eggs and larvae.

Field Experiments

Two field experiments were carried out at the Campus Glória Experimental Farm, in adjacent areas of the same coffee plantation, and a volume of 400 liters/ha^{-1} was used.

Evaluation of the residual effect.

First, an experiment was carried out to verify the residual effect of insecticides applied on coffee fruits. For this, parcels with five plants were demarcated and in the central plants were marked 10 branches containing at least five rosettes with 11 fruits on mean. These branches were sprayed at the same application concentration as the first test using a hand sprayer. Two hours after application, ten active females from artificial breeding were infested. To control the bored fruits, an organza cage measuring 30x50 cm was used. A total of four infestations were performed with a 10-day interval between each infestation. Before each infestation, any broached fruits were removed from the branch to be infested.

Ten days after each infestation (DAI), the infested branch was removed per plot with the help of pruning shears and taken to the laboratory, where the total number of fruits, number of fruits drilled, number of live drills, and number of fruits were counted. Thus the bored fruits were dissected to count the number of eggs and larvae.

Evaluation of the efficacy of insecticides in natural infestation.

An area was selected in the coffee-farms of UFU, which was monitored weekly for natural infestation of the berry borer. The experiment was demarcated following a completely randomized design. Each plot consisted of a 15 meter long crop line, with 21 plants, and the evaluations were carried out in 12 central plants. Two applications were performed with a 30-day interval. The applications were performed with motorized turbocharger sprayer (Stihl SR 420), with volume of syrup corresponding to 400L.ha^{-1}. To evaluate the quality of the application, water sensitive paper was used in the control plots to evaluate the size and distribution of the drops in the sprayed plants, the equipment being calibrated with water.

In this way, it was tried to approach the normal conditions executed in the experimental farm (UFU - Campus Glória). At the time of application the wind speed and temperature ranged from 3 to 8 km.h^{-1} and 22 to 30^{0}C, respectively (time between 16:00 and 18:00).

Efficacy evaluations were performed at 0 (pre-evaluation), 15 and 30 days after the first application (DAPA) and at 7, 14, 21, 28 and 35 days after the second application (DASA), by counting the number of fruits attacked in 50 fruits per plot, being 25 fruits of each side of the line, always in the central plants. The evaluation methodology followed the standard recommended by EPAMIG (COMPANY OF AGRICULTURAL RESEARCH OF MINAS GERAIS - EPAMIG, 2014).

At the end of the evaluations 35 days after the second application, the fruits were approximately 90% maturation. Thus, to evaluate the final infestation of the drill, approximately four liters of fruits were collected per plot, half of each side of the line, always in the central plants. The collected fruits were packed in individual bags (onion bag) and dried in a natural environment until reaching approximately 13% moisture. After drying the fruits were benefited. After the processing, an aliquot of 200 g per plot was separated from this aliquot were randomly separated 250 seeds and counted the number of grained grains.

Statistical analysis

Data were submitted to Shapiro-Wilk and Bartlett tests in order to verify normality of distribution and homoscedasticity. On confirmation of these assumptions, data were submit ted to analysis of variance (ANOVA), and means were compared using the Tukey test. In all tests, the level of statistical significance was set at 5%.

RESULTS AND DISCUSSION

Topical application in laboratory

In the first evaluation (6 HAA) of the topical effect of insecticides in the laboratory, it was observed that almost all the insecticides tested provoked mortality of the larger coffee borer than the control, except Verismo and Polo 500 SC. Also, it was possible to observe high mortality of adult females of *H. hampei* for some of the insecticides tested (Table 2). The insecticides Lorsban 480 BR and Sperto caused the highest mortalities (100% and 93% respectively), six hours after the application, characterizing knock down effect. In the second evaluation (12 HAA) only the insecticide Polo 500 SC showed no mortality higher than the control and the insecticides Curbix 200 SC, Curyom 550 EC, Polytrin 440/40 CE and Vertimec 18 EC presented the same mortality as Lorsban 480 BR and Sperto (Table 2). Similarly, at 7DAA days after application, only the insecticide Polo 500 SC showed no mortality (38%) higher than the control, however, the other insecticides presented mortality results higher than 80%. The insecticides Voliam Targo and Benevia presented lower mortality values than those of Lorsban 480 BR, Curbix 200 SC, Curyom 550 EC, Sperto, Lorsban 480 BR, Vertimec 18 EC and Polytrin 400/40 CE (Table 3).

Differently, Dieperi et al. (2010) verified that the application of Lorsban 480 BR with the direct spray on the berry borer, resulted in low mortality, that is, only 9% higher than the control. However, the work done by Ribeiro (2012) resulted in a higher mortality of the coffee borer with Lorsban 480 BR among the five insecticides tested by the author in the control of *H. hampei*.

Table 2. Mean accumulated mortality (± SE) and percentage of efficiency (% E) in each evaluation period, after application of insecticides on the berry borer of coffee (*H. hampei*) in laboratory. Uberlândia - MG, 2018.

Treatments	6 HAA[1]		12 HAA		1 DAA[2]		2 DAA		3 DAA		5 DAA		7 DAA	
	Mean	E%[3]	Mean	E%	Mean	E%	Mean	E%	Mean	E%	Mean	E%	Mean	E%
Control	0.0± 0.0 a[4]	-	0.0 ± 0.0 a	-	0.0 ± 0.0 a	-	0.0 ± 0.0 a	-	0.0 ± 0.0 a	-	0.0 ± 0.0 a	-	0.0 ± 0.0 a	-
Voliam Targo	3.5 ± 0.9bc	35	5.7 ± 1.6 c	70	7,2 ± 0.9cd	73	7.2 ± 0.9 bc	73	7.2 ± 0.9 cd	73	8.2 ± 0.7 c	83	8.2 ± 0.7 b	83
Benevia	3.0± 1.5 bc	25	4.0 ± 1.0 b	40	4.0 ± 1.0 b	40	5.5 ± 1.1 b	55	5.5 ± 1.1 b	55	5.7 ± 0.8 b	58	8.0 ± 0.4b	80
Lorsban 480 BR	10.0 ± 0,0 e	100	10.0 ± 0.0 d	100	10.0 ± 0.0 e	100	10.0 ± 0.0 d	100	10.0 ± 0.0 e	100	10.0 ± 0.0 d	100	10.0 ± 0.0 c	100
Curbix	5.7 ± 0.7 d	65	10.0 ± 0.0 d	100	10.0 ± 0.0 e	100	10.0 ± 0.0 d	100	10.0 ± 0.0 e	100	10.0 ± 0.0 d	100	10.0 ± 0.0 c	100
Sperto	8.5 ± 0.8 e	93	10.0 ± 0.0 d	100	10.0 ± 0.0 e	100	10.0 ± 0.0 d	100	10.0 ± 0.0 e	100	10.0 ± 0.0 d	100	10.0 ± 0.0 c	100
Verismo	1.7 ± 1.7 ab	3	4.5 ± 1.0 b	30	5.0 ± 0.4bc	50	6.2 ± 0.6 b	63	6.2 ± 0.6 c	63	8.7 ± 0.2 cd	85	8.7 ± 0.2 bc	85
Polytrin 400/40 CE	6.5 ± 0.5 cd	55	9.2 ± 0.4 cd	98	9.7 ± 0.2 e	98	9.7 ± 0.2 d	98	9.7 ± 0.2 e	98	9.7 ± 0.2 d	98	9.7 ±0.2 c	98
Curyon 500 EC	4.0± 1.7 bc	20	9.7 ± 0.2 d	95	10.0 ± 0.0 e	100	10.0 ± 0.0d	100	10 ± 0.0 e	100	10.0 ± 0.0 d	98	10.0 ± 0.0 c	100
Polo 500 SC	0.0± 2.5 a	0	0.0 ± 0.0 a	0	1.0 ± 0.2 a	10	1.0 ± 0.2 a	10	2.0 ± 0.2ab	15	2.7± 0.7 ab	28	3.7 ± 0.8 ab	38
Vertimec 18 EC	5.0± 2.1 bc	25	8.2± 0.7 cd	83	8.2 ± 0.7 e	83	9.0 ± 0.5 cd	90	9.0± 0.5 de	95	9.5 ± 0.5d	95	9.5 ± 0.5 c	95
CV%[5]	54.3		53,.2		51.6		49.1		50.6		54.2		48.8	

[1]HAA = hours after application. [2]DAA = days after application. [3]E% = ((control-treatment) / control) * 100 (ABBOTT 1925). [4]Means followed by the same letter in the column are not statistically different according to the Tukey test (P < 0.05). [5]CV% - coefficient of variation.

Table 3. Mean (± SE) of bored fruits and percentage of efficiency (% E) in each evaluation period, after application of insecticides on berry borer of coffee *(H. hampei)* in laboratory. Uberlândia - MG, 2018.

Treatments	6 HAA[1]		12 HAA		1 DAA[2]		2 DAA		3 DAA		5 DAA		7 DAA	
	Mean	E%[3]	Mean	E%	Mean	E%	Mean	E%	Mean	E%	Mean	E%	Mean	E%
Control	10.0 ± 0.0 a[4]	--	10.0 ± 0.0 a	--	10.0 ± 0.0 a	--	10.0 ± 0.0 a	--	10.0 ± 0.0 a	--	10.0 ± 0.0 a	--	10.0 ± 0.0 a	--
Voliam Targo	1.0 ± 0,4 b	90	1.2 ± 0.4 bc	88	1.2 ± 0.4 bcd	85	1.5 ± 0.6 cd	83	1.5 ± 0.6 bc	83	1.7 ± 0.6 bc	80	2.7 ± 1.1 bc	70
Benevia	1.0 ± 0.7 b	95	1.2 ± 0.6 bc	90	1.2 ± 0.6 cd	90	1.2 ± 0.6 cd	90	1.2 ± 0.6 bc	90	1.2 ± 0.6 cd	90	1.2 ± 0.6 cd	88
Lorsban 480 BR	0.0 ± 0.0 b	100	0.0 ± 0.0 c	100	0.0 ± 0.0 d	100	0.0 ± 0.0d	100	0.0 ± 0.0c	100	0.0 ± 0.0d	100	0.0 ± 0.0 d	100
Curbix	1.5 ± 1.1 b	97	1.5 ± 1.1 c	98	1.5 ± 1.1 d	98	1.5 ± 1.1 d	98	1.5 ± 1.9 c	98	1.5 ± 1.1 d	98	1.5 ± 1.1 d	98
Sperto	0.0 ± 0.0b	100	0.0 ± 0.0c	100	0.0 ± 0.0d	100	0.0 ± 0.0d	100	0.0 ± 0.0c	100	0.0 ± 0.0d	100	0.0 ± 0.0d	100
Verismo	1.0 ± 0.7 b	95	2.0 ± 1.9 bc	85	4.2 ± 1.01bc	70	4.2 ± 1.1 bcd	68	4.2 ± 1.1 b	68	4.2 ± 1.1 b	68	4.2 ± 1.1b	68
Polytrin 400/40 CE	1.0 ± 0.7 b	95	2.1 ± 1.9 bc	95	2.2 ± 1.9 cd	95	2.2 ± 1.9 d	95	2.2± 1.9 c	95	2.2 ± 1.9 d	98	2.2 ± 1.9 d	98
Curyon 500 EC	2.2 ± 2.2 b	97	2.2 ± 2.2 c	97	2.2 ± 2.2 cd	97	2.2 ± 2.2 d	97	2.52± 2.2 c	97	2.2 ± 2.2 d	97	2.2 ± 2.2 d	97
Polo 500 SC	4.0 ± 2.1 b	82	6.2 ± 1.7b	53	6.2 ± 1.7 c	53	6.2 ± 1.7 cd	53	6.2 ± 1.7 b	53	6..2± 1,7 b	53	6.2 ± 1.7 b	53
Vertimec 18 EC	2.7 ± 2.6 b	95	2.7 ± 2,6 bc	95	2.7 ± 2,7 cd	95	2.7 ± 2,7 d	95	2.7 ± 2,7 c	95	2.7 ± 2,7 d	95	2.7 ± 2,7 d	95
CV%[5]	54.3		53.2		51.6		49.1		50.6		54.2		48.8	

[1]HAA = hours after application. [2]DAA = days after application [3]E% = ((control-treatment) / control) * 100 (ABBOTT, 1925). [4]Means followed by the same letter in the column are not statistically different according to the Tukey test (P < 0.05).[5]CV% - coefficient of variation.

In Colombia, Tabares-Carrillo (2013) in field conditions and in the laboratory, found that Curbix 200 SC and Voliam Targo presented mortality efficiency between 87 and 92% in the control of *H. hampei*, being almost twice as high as the other insecticides tested. The reduction of the pest population in evaluation of the natural infestation in field was of 3 to 10% by the two insecticides respectively. In the plots infested artificially with the adult female drill, the two insecticides presented control of 88 and 87% of the pest mortality, respectively. It was verified that from 82 to 93% of agronomic efficiency was calculated by ABBOTT (1925) after two sprays in the interval of 35 days using different equipment.

As for the number of fruits bored, it was possible to verify that 100% of the fruits were bored in the control in the first evaluation (6 HAA) and that all the insecticides tested reduced the percentage of fruits bored in comparison to the control, from 6 HAA to 7 DAA (last evaluation) (Table 3). In the first evaluation, no difference was observed in the number of fruits borne by the *H. hampei* females among the evaluated insecticides, and all the insecticides presented agronomic efficiency above 80% (Table 4). In the subsequent evaluations, mainly from 5 DAA, the number of fruits bored in the sprayed treatments with Verismo and Polo 500 SC was only lower than in the control, similar to those with Benevia and higher than Voliam Targo, Lorsban 480 BR, Curbix 200 SC, Curyom 550 EC, Sperto, Vertimec 18 EC and Polytrin 400/40 CE (Table 3). From 1 DAA, Verismo and Polo 500 SC were the only ones with agronomic efficiency lower than 80% and Lorsban 480 BR and Sperto remained with no fruit bored until the end of the evaluations (Table 4).

Souza (2014) comparing the efficiency of Curbix 200 SC and Lorsban 480 BR with endosulfan at appropriate doses in the laboratory found that the control was greater than 90% E, same level found for endosulfan.

The number of coffee-borer eggs in the fruits at 15 DAA was similar to the results of number of bored fruits, with the presence of bromate eggs only in Verismo and Polo 500 SC treatments, and the presence of larvae was also observed in Vertimec 18 EC, in addition to Verismo and Polo 500 SC. In the other insecticides, fruits with eggs or larvae of *H. hampei* were not found (Table 4).

Table 4. Mean (± SE) of the number of eggs and larvae of berry borer of coffee *(H. hampei*) per fruit and percentage of efficiency (% E) 15 days after application of insecticides on 10 females of berry borer of coffee in the laboratory. Uberlândia - MG, 2018.

Treatments	Number of eggs		Number of Lavae	
	Mean ± SE	E%[1]	Mean± SE	E%
1. Control	2.2 ± 0.4 a[2]	--	9.0 ± 2.3 a	--
2. Voliam Targo	0.0 ± 0.0 c	100	0.0 ± 0.0 c	100
3. Benevia	0.0 ± 0.0 c	100	0.0 ± 0.0 c	100
4. Lorsban 480 BR	0.0 ± 0.0 c	100	0.0 ± 0.0 c	100
5. Curbix 200 SC	0.0 ± 0.0 c	100	0.0 ± 0.0 c	100
6. Sperto	0.0 ± 0.0 c	100	0.0 ± 0.0 c	100
7. Verismo	1.2 ± 0.6 c	89	1.0 ± 0.7 b	44
8. Polytrin 400/40 CE	0.0 ± 0.0 c	100	0.0 ± 0.0 c	100
9. Curyon 550 EC	0.0 ± 0.0 c	100	0.0 ± 0.0 c	100
10. Polo 500 SC	6.7 ± 0.4 b	67	3.0 ± 1.1 b	67
11. Vertimec 18 EC	0.0 ± 0.0 c	89	1.0 ± 1.0 c	100
CV%[3]	37.94		24.63	

[1]E% = ((control-treatment) / control) * 100 (ABBOTT, 1925). [2]Means followed by the same letter in the column are not statistically different according to the Tukey test ($P < 0.05$). [3]CV% - coefficient of variation.

Residual contact in laboratory

When the insects were exposed to the sprayed fruits, there was no difference in the mortality of the coffee borer for the tested insecticides and the control at 6 HAA. On the other hand, 12 HAA were found to be higher in Lorsban 480 BR, Curbix 200 SC, Sperto, Curyon 550 EC and Polytrin 400/40 CE insecticides than in the control and other treatments, with 70 to 100% mortality (Table 5).

In the evaluation at 1 DAA almost all insecticides except Polo 500 SC differed from control and 2 DAA and until the last evaluation (7 DAA) the mortality of coffee borer was higher in the treatments with the application of the insecticides than in the control (Table 5). It was possible to observe a difference in the mortality of the coffee borer among the insecticides in the evaluations 1, 2, 3 and 4 DAA, with special mention for the insecticides Lorsban 480 BR, Curbix 200 SC, Sperto, Curyon 550 EC and Polytrin 400/40 CE however, at 7 DAA, there was no difference between insecticides, with the same percentage of efficiency ranging from 75 to 100% (Table 5).

All the insecticides tested had a mean of broached fruit smaller than the control and no difference between them in all evaluations (Table 6). Efficacy when evaluated the number of fruits bored was 80% or greater for almost all insecticides, showing high protection of fruits for the attack of the berry borer, except for Benevia 480 EC (70%) (Table 6). Thus, even if the insecticides did not cause high mortality in the first evaluations, as occurred with topical application, the drill was unable to drill the pulverized fruits. Similar results, with lower insect mortality on the application of insecticides to fruits than topical, but with great protection of fruits, were observed by several authors (DEPIERI; MARTINEZ, 2010; MARTINEZ; VAN-EMDEN, 2010; FETTING; HAYES, 2012; VIJAYALAKS; TIMTUMOL; VINODKUMAR, 2014).

The number of coffee-borer eggs in the fruits at 15 DAA in all treatments was lower than in the control and no insect eggs were observed in the fruits sprayed with the insecticides Voliam Targo, Benevia, Lorsban 480 BR, Curbix 200 SC, Sperto, Verismo and Polytrin 400/40 CE, which presented lower number of eggs per fruit than Curyon 550 EC, Polo 500 SC and Vertimec 18 EC (Table 7). As for the number of larvae of the borer per fruit, the insecticides Lorsban 480 BR, Curyon 550 EC and Polo 500 SC did not differ from the control, while the other insecticides did not present berry borer larvae (Table 7)

Residual contact in the field

All insecticides caused high mortality of the berry borer differing from the control (Table 8) 10 days after infestation of berry borer females, and due to the high mortality, the results obtained in the evaluation of the percentage of fruits bored in the artificial infestation were also significantly lower than in the control, during all the evaluations carried out at 0 day after application of products and, 10, 20 and 30 after infestation of berry borer females (Table 9), demonstrating a high residual effect of insecticides in the field.

In the evaluation performed 10 days after the first infestation, the insecticides that caused mortality above 80% were Curbix 200 SC (96%), Sperto (93%), Curyon 550 EC (93%), Voliam Targo (85%) and Lorsban 480 (85%), and the treatments with the lowest number of bored fruits differed from the control, due to the high mortality of the insect caused by the insecticides (Tables 8 and 9).

After 10 days of the second infestation (Tables 8 and 9), all insecticides differed from the control, with the highest mortality rates in the treatments with Sperto (100%), Curbix 200 SC (89%), Lorsban 480 BR), Polytrin 400/40 CE (85%), Polo 500 SC (85%) and Vertimec 18 EC (85%). Regarding the percentage of fruits bored, only the treatments with Voliam Targo and Curyon 550 EC did not differ from the control, however, there was no difference between the insecticides.

In the evaluation performed 10 days after the third infestation, high insect mortality was observed in the control, but the percentage of broached fruits was not affected (Tables 8 and 9). The insecticides that caused the greatest mortality were Benevia 480 EC (100%), Curbix 200 SC (100%), Sperto (100%), Verismo (93%) and Voliam Targo (89%), and there was no difference between insecticides and only the insecticides Benevia, Curbix 200 SC and Sperto provoked higher mortality and lower percentage of bored fruits than the control.

In the last infestation, the lowest mortality in the control was observed, consequently, the highest mean of broached fruits (36.1%) was obtained among all infestations. All insecticides caused mortality above 80%, except for the Curyon 550 EC insecticide (74%), but all of them differed from the control. Regarding the percentage of fruit bored, Curyon 550 EC and Polo 500 SC did not reach a minimum efficiency of 80%, but did not differ from the other insecticides.

The residual effect of insecticides, which cause high mortality of the borer and the percentage of fruits attacked, was much lower than those of the control, even in the infestation 30 days after the application. In the experiment two more infestations were scheduled with a 10-day interval to confirm the residual effect of the insecticides and corroborate with the recommendations, which indicate the accomplishment of at least two applications with a 30-day interval, according to Souza et al. (2014), but were not carried out due to the lack of insects for infestation and also due to the marked fall of fruits, due to the advanced maturation stage.

Table 5. Mean accumulated mortality (± SE) of the berry borer of coffee (*H. hampei*) and percentage of efficiency (% E) in the laboratory at each evaluation period, after application of the insecticides on the coffee fruits. Uberlândia - MG, 2018.

Treatments	6 HAA[1]		12 HAA		1 DAA[2]		2 DAA		3 DAA		5 DAA		7 DAA	
	Mean	E%[3]	Mean	E%	Mean	E%	Mean	E%	Mean	E%	Mean	E%	Mean	E%
Control	0.0 ± 0.0 a[4]	-	0.0 ± 0.0 a	-	0.0 ± 0.0 a	-	0.0 ± 0.0 a	-	0.0 ± 0.0 a	-	0.0 ± 0.0 a	-	0.0 ± 0.0 a	-
Voliam Targo	0.0 ± 0.0 a	0	2.5 ± 0.2 a	23	5.0 ± 1.0 cd	50	6.0 ± 0.4 bc	60	6.0 ± 0.4 bc	60	7.2 ±1.0 bc	73	7.3 ± 1.1 bc	78
Benevia	0.0 ± 0.0 a	0	2.7 ± 0.6 a	28	4.5 ± 0.5 bc	45	5.7 ± 0.9 bc	58	6.7 ± 0.2 de	68	6.8 ± 1.0 bc	75	7.7 ± 0.7 bc	78
Lorsban 480 BR	2.7 ± 1.3 a	28	7.7 ± 1.8 b	78	7.5 ± 0.8 de	75	8.2 ± 0.7 cd	83	8.2 ± 0.7 ef	83	8.2 ± 1.1bc	83	8.2 ± 0.1 bc	83
Curbix	1.5 ± 0.0a	15	7.0 ± 1.2 b	70	7.7 ± 1.0de	78	9.2 ± 0.4 cd	93	9.2 ± 0.4 ef	93	9.1 ± 0.7c	90	9.2 ± 0.4 c	93
Sperto	0.0 ± 0.0 a	0	10.0 ± 0.0 b	100	10.0 ± 0.0 e	100	10.0 ± 0.0 d	100	10.0 ± 0.0 f	100	10.0 ± 0.0 c	100	10 ± 0.0 c	100
Verismo	0.0 ± 0.0 a	0	0.7 ± 0.4 a	8	5.0 ± 1.2 cd	50	5.2 ± 1.2 bc	53	6.2± 0.6 cd	63	7.3 ± 0.6bc	75	7.5 ± 0.6 bc	75
Polytrin 400/40 CE	0.0 ± 0.0 a	0	7.5 ± 0.2 b	75	9.5 ± 0.2 e	95	9.5 ± 0.2 d	95	9.5 ± 0.2 ef	95	9.3 ± 0.3c	95	9.5 ± 0.2 c	95
Curyon 500 EC	0.0 ± 0.0 a	0	9.0 ± 1.0 b	90	9.1 ± 0.7 e	93	9.2 ± 0.5 d	95	9.5 ± 0.5 ef	95	9.5 ± 1.2c	90	9.5 ± 1.5 c	95
Polo 500 SC	0.0 ± 0.0 a	0	0.2 ± 0.2 a	3	1.5 ±1.5 ab	15	3.2 ± 1.3 b	33	3.2 ± 1.3 b	33	5.5 ± 1.1bc	55	5.8 ± 0.8 ab	83
Vertimec 18 EC	0.5 ± 0.5 a	5	3.0 ± 0.4 a	30	6.0 ± 0.5 cd	60	7.0 ± 0.4 bc	70	7.0± 0.4 ef	70	7.3 ± 0.2 bc	73	7.3± 0.3 bc	82
CV%[5]	40.2		48.6		49.4		44.2		48.6		46.4		48.8	

[1]HAA = hour after application. [2]DAA = days after application. [3]% E = ((control-treatment) / control) * 100 (ABBOTT, 1925). [4]Means followed by the same letter in the column are not statistically different according to the Tukey test ($P < 0.05$). [5]CV% - coefficient of variation.

Table 6. Mean number (± EP) of fruits borer by the berry borer of coffee *(H. hampei*) and percentage of efficiency (% E) in laboratory at each evaluation period, after application of insecticides on coffee fruits. Uberlândia - MG, 2018.

Treatments	6 HAA[1]		12 HAA		1 DAA[2]		2 DAA		3 DAA		5 DAA		7 DAA	
	Mean	E%[3]	Mean	E%	Mean	E%	Mean	E%	Mean	E%	Mean	E%	Mean	E%
Control	10.0 ± 0.0 a[4]	-	10.0 ± 0.0 a	-	10.0 ± 0.0 a	-	10.0 ± 0.0 a	-	10.0 ± 0.0 a	-	10.0 ± 00 a	-	10.0 ± 0.0 a	-
Voliam Targo	2.2 ± 1.1b	78	2.2 ± 1.1 b	78	2.2 ± 1.1 b	78	2.2 ± 1.1 b	78	2.2 ± 1.1 b	78	2.2 ± 1.0 b	78	2.2 ± 1.0 b	78
Benevia	2.2 ± 1.1 b	78	2.2 ± 1.1 b	78	2.2 ± 1.1 b	78	2.2± 1.1 b	78	2.2 ± 1.1 b	78	2.2 ± 1.1b	78	2.2 ± 1.1 b	78
Lorsban 480 BR	0.0 ± 0.0 b	100	1.8 ± 0.6 b	85	1.7 ± 0.7 b	83	1.7 ± 0.7 b	83	1.7 ± 0.7 b	83	1.7 ± 0.7 b	83	2.2 ± 1.0 b	80
Curbix.	0.0 ± 0.0 b	100	1.7 ± 1.6 b	85	1.7 ± 1.6 b	85	1.7 ± 1.6 b	85	1.7 ± 0.6 b	85	1.7 ± 0.6 b	85	1.7 ±0.6 b	85
Sperto	0.0 ± 0.0 b	100	0.0 ± 0.0 b	100	0.0 ± 0.0 b	100	0.0 ± 0.0 b	100	0.0 ± 0.0 b	100	00 ± 0.0 b	100	0.0 ± 0.0 b	100
Verismo	0.0 ± 0.0 b	100	2.2 ± 0.6 b	78	2.2 ± 0.7 b	78	2.2 ± 0.7 b	78	2.2 ± 0.6 b	78	22 ± 0.6 b	78	2.2 ± 0.6 b	78
Polytrin 400/40 CE	0.5 ± 0.2 b	95	0.5 ± 0.2 b	95	0.5 ± 0.2 b	95	0.5 ± 0.2 b	95	0.5 ± 0.2 b	95	0.5 ± 0.2 b	95	0.5 ± 0.2 b	95
Curyon 500 EC	0.0 ± 0.0 b	100	0.7 ± 0.7 b	93	0.7 ± 0.7 b	93	0.7 ± 0.7 b	90	1.0 ± 1.0 b	90	1.0 ± 1.0 b	90	1.0 ± 1.0 b	90
Polo 500 SC	1.7 ± 0.7 b	83	1.7 ± 0.7 b	83	1.7 ± 0.7 b	83	1.7 ± 0.7 b	83	1.7 ± 0.7 b	83	1.7 ± 0.7 b	83	1.7 ± 0.7 b	83
Vertimec 18 EC	0.0 ± 0.0 b	100	1.7 ± 0.7 b	83	1.7 ± 0.7 b	83	1.7 ± 0.7 b	83	1.7 ± 0.6 b	83	1.7 ± 0.6 b	83	1.7 ± 0.6 b	83
CV%[5]	40.2		48.6		49.4		44.2		48.6		46.4		48.8	

[1]HAA = hour after application. [2]DAA = days after application. [3]% E = (control-treatment) / control) * 100 (ABBOTT 1925)[4]Means followed by the same letter in the column are not statistically different according to the Tukey test ($P < 0.05$).[5]CV% - coefficient of variation.

Table 7. Mean (± SE) of the number of eggs and larvae berry borer of coffee *(H. hampei*) per fruit and percentage of efficiency (% E), 15 days after application of insecticides on coffee fruits. Uberlândia - MG, 2018.

Treatments	Number of eggs		Number of larvae	
	Mean	E%[1]	Mean	E%
1. Control	3.2 ± 0.2 a[2]	-	0.0 ± 0.4 a	-
2. Voliam Targo	0.0 ± 0.0 c	100	0.0 ± 0.0 b	100
3. Benevia	0.0 ± 0.0 c	100	0.0 ± 0.0 b	100
4. Lorsban 480 BR	0.0 ± 0.0 c	100	0.5 ± 0.2 ab	50
5. Curbix 200 SC	0.0 ± 0.0 c	100	0.0 ± 0.0 b	100
6. Sperto	0.0 ± 0.0 c	100	0.0 ± 00 b	100
7. Verismo	0.0 ± 0.0 c	100	0.0 ± 0.0 b	100
8. Polytrin 400/40 CE	0.0 ± 0.0 c	100	0.0 ± 0.0 b	100
9. Curyon 550 EC	0.7 ± 0.2 b	77	0.7 ± 0.2 ab	25
10. Polo 500 SC	0.2 ± 0.2 b	77	0.2 ± 0.2 ab	75
11. Vertimec 18 EC	0.6 ± 0.3 b	77	0.0 ± 0.0 b	100
CV%[3]	15.72		22.31	

[1]E% = ((control-treatment) / control) * 100 (ABBOTT 1925). [2]Means followed by the same letter in the column are not statistically different according to the Tukey test (P < 0.05). [3]CV% - coefficient of variation.

Table 8. Mean percentage (SE) of bored fruits and percentage of efficiency (%E) in the field, with artificial infestation 0, 10, 20 and 30 days after application (DAA) of the products and evaluation at 10, 20, 30 and 40 DAA (10 days after each infestation of the berry borer of coffee). Uberlândia - MG, 2018.

Treatments	10 DAA		20 DAA		30 DAA		40 DAA	
	Mean% (± SE)	E%[1]	Mean% (± SE)	%E	Mean%(± SE)	E%	Mean%(± SE)	E%
1. Control	29.6 ± 6.5 a[2]	--	27.7 ± 6.0 a	--	32.1 ± 7.7 a	--	36.1 ± 7.5 a	--
2. Voliam Targo	3.6 ± 1.0 bc	88	9.8 ± 3.0 ab	65	5.4 ± 1.5 cd	83	5.7 ± 1.5 bc	84
3. Benevia	11.5 ± 3.5 b	61	7.5 ± 2.0 bc	73	0.0 ± 0.0 d	100	6.7 ± 1.2 bc	81
4. Lorsban 480 BR	6.0 ± 1.5 bc	80	5.3 ± 1.2 bc	81	15.7 ± 2.7 ab	51	3.5 ± 0.7 bc	90
5. Curbix 200 SC	4.2 ± 1.0 bc	86	6.9 ± 1.7 bc	75	0.0 ± 0.0 d	100	3.9 ± 0.5 bc	89
6. Sperto	0.8 ± 0.2 c	97	0.0 ± 0.0 c	100	0.0 ± 0.0 d	100	0.0 ± 0.0 c	100
7. Verismo	3.8 ± 0.2 bc	87	6.1 ± 1.7 bc	78	2.4 ± 0.7 cd	93	4.1 ± 1.2 bc	89
8. Polytrin 400/40 CE	4.0 ± 1.2 bc	86	5.6 ± 1.7 bc	80	9.9 ± 3.5 bc	69	5.5 ± 1.2 bc	85
9. Curyon 550 EC	4.8 ± 1.2bc	84	11.9 ± 1.7 ab	57	6.6 ± 1.7 bc	79	14.5 ± 2.2 b	60
10. Polo 500 SC	9.4 ± 1.2 bc	68	8.6 ± 1.7 bc	69	9.5 ± 1.5 bc	70	11.1 ± 2 b	69
11. Vertimec 18 EC	5.0 ± 2.5 bc	83	6.4 ±1.5 bc	77	7.5 ± 2.2 bc	77	7.2 ± 1.7 b	80
CV%[3]	69.4		74.3		67.50		61.48	

[1]% E = (control - treatment) / control) * 100 (ABBOTT, 1925) .[2] Means followed by the same letter in the column do not differ by Tukey's test (p <0.05). [3]CV% - coefficient of variation.

Table 9. Mean number of dead drills (± SE) and percentage of corrected mortality (MC %) in the field, with artificial infestation 0, 10, 20 and 30 days after application (DAA) of the products and evaluation at 10, 20, 30 and 40 DAA (10 days after each infestation of the coffee-borer). Uberlândia - MG, 2018.

Treatments	10 DAA		20 DAA		30 DAA		40 DAA	
	Mean ± SE	CM%[1]	Mean ± SE	CM%	Mean ± SE	CM%	Mean ± SE	CM%
1. Control	0.0 ± 0.8 a[2]	--	0.0 ± 0.5 a	--	0.0 ± 1.0 a	--	0.0 ± 0.5 a	--
2. Voliam Targo	6.3 ± 0.3 b	89	2.2 ± 0.8 b	52	5.0 ± 0.5 ab	89	6.0± 0.4 b	85
3. Benevia	3.0 ± 1.1 b	56	2.8 ± 0.6 bc	74	4.5 ± 0.0 b	100	7.8± 0.3 b	93
4. Lorsban 480 BR	2.7 ± 0.4 b	85	7.8 ± 1.0 bc	85	7.5 ± 0.5 ab	63	8.3 ± 0.3 b	96
5. Curbix 200 SC	7.5 ± 0.3 b	96	7.0 ± 0.5 bc	89	10.0 ± 0.0 b	100	9.3 ± 0.3 b	96
6. Sperto	9.0 ± 0.5 b	93	10.0 ± 0.0 c	100	10.0 ± 0.0 b	100	10.0 ± 0.0 b	100
7. Verismo	6.0 ± 0.5 b	81	0.8 ± 1.2 bc	78	9.5 ± 0.5 ab	93	6.0 ± 0.4 b	85
8. Polytrin 400/40 CE	6.0 ± 0.4 b	85	7.5 ± 0.6 bc	85	5.0 ± 1.5 ab	56	7.8 ± 0.3 b	89

9. Curyon 550 EC	7.0 ± 0.5 b	93	6.0 ± 1.4 bc	74	6.5 ± 0.5 ab	78	6.1 ± 1.1 b	74
10. Polo 500 SC	3.0 ± 1.4 b	67	4.6 ± 1.0 bc	85	6.2 ± 0.6 ab	74	9.5 ± 0.3 b	93
11. Vertimec 18 EC	3.5 ± 0.7 b	70	3.0 ± 0.6 bc	85	6.4 ± 1.0 ab	67	5.9 ± 0.3 b	81
CV%[3]	8.98		10.83		9.47		5.99	

[1]Where Mo = observed mortality, Mt = mortality at the control (Abbott, 1925). [2] Means followed by the same letter in the column do not differ by Tukey's test ($p < 0.05$). [3]CV% - coefficient of variation.

The protection of coffee fruits from the pest attack is very important, since it is known that the pest can negatively affect the weight and quality of the coffee, if the pest is not controlled (SOUZA; REIS; SILVA, 2011). Tatagiba (2012) evaluated in the field the agronomic efficiency of the insecticides Voliam Targo and Curbix 200 SC. Two applications were carried out with application interval 43 days, and observed a significant reduction in comparison with the control of 89.4% of broached fruits, that is, with damage caused by *H. hampei* in coffee seed. At 30 days after the second spray, only 3.7% of the live individuals were found inside the dissected fruits, while 35.7% of the alive individuals were found in the control.

The average number of eggs and number of *H. hampei* larvae in the bored fruits were significantly lower in all treatments compared to the control (Tables 10 and 11), reflecting the high mortality of adult females caused by insecticides, together with the possible effect on larval reproduction and development, in treatments where the mortality of adult females did not reach 100%.

Some insecticides can significantly alter insect reproduction, acting as a growth regulator, due to the developmental paralysis, damaging oviposition of the pest, larvae hatching and mortality (ZAMBOLIM et al., 2014). Thus, these surviving insects may not produce offspring, which in combination with cultural management can reduce the population of the drill in well-managed areas. The climatic conditions and sub dosage concentration of an insecticide can adversely affect survival and reproduction, which was verified by Martinez and Van-Emden (2010) in a work comparing the field and laboratory results of some of the tested insecticides.

In this way the effects resulting from the residual evaluation in the field, indicate a real perspective of population reduction of the berry borer of coffee. It is either by direct action of said active principle or by indirect action, predisposing the surviving individuals of *H. hampei* to the action of the residual effect of insecticides. On the other side that was not verified in this work, the action of natural enemies (parasitoids, predators and pathogens).

Table 10. Mean (± SEM) of the number of eggs of *H. hampei* and percentage of efficiency (% E) in the field, with artificial infestation at 0, 10, 20 and 30 days after (DAA) of the products and evaluation at 10, 20, 30 and 40 DAA (10 days after each infestation of the coffee-borer). Uberlândia - MG, 2018.

Treatments	10 DAA		20 DAA		30 DAA		40 DAA	
	Mean (± SE)	E%[1]	Mean (± SE)	E%	Mean (± SE)	E%	Mean (± SE)	%E
1. Control	4.0±0.0 a[2]	-	4.8 ± 0.5 a	-	3.5 ± 1.5 a	-	2.5 ± 0.5 a	-
2. Voliam Targo	0.3±0.3 b	94	1.0 ± 0.4 b	77	0.2 ± 0.3 c	96	0.0 ± 0.0 b	100
3. Benevia	0.5±0.3 b	88	0.0 ± 0.0 b	100	0.0 ± 0.0 c	100	0.0 ± 0.0 b	100
4. Lorsban 480 BR	0.0±0.0 b	100	0.5 ± 0.5 b	91	1.2 ± 0.8 b	81	0.0 ± 0.0 b	100
5. Curbix 200 SC	0.3±0.3 b	94	0.0 ± 0.0 b	100	0.0 ± 0.0 c	100	0.0 ± 0.0 b	100
6. Sperto	0.0±0.0 b	100	0.0 ± 0.0 b	100	0.0 ± 0.0 c	100	0.0 ± 0.0 b	100
7. Verismo	0.3±0.3 b	94	1.5 ± 0.9 b	91	0.0 ± 0.0 c	100	0.8 ± 0.8 ab	70
8. Polytrin 400/40 CE	0.8±0.3 b	75	0.8 ± 0.5 b	91	1.2 ± 0.9 b	85	1.4 ± 0.8 ab	60
9. Curyon 550 EC	0.3±0.3 b	94	0.3 ± 0.3 b	98	0.5 ± 0.5 c	92	0.5 ± 0.5 b	80
10. Polo 500 SC	0.5±0.5 b	88	0.5 ± 0.5 b	93	0.0 ± 0.0 c	100	0.0 ± 0.0 b	100
11. Vertimec 18 EC	0.5±0.5 b	88	0.5 ± 0.5 b	93	1.7 ± 1.0 b	89	0.0 ± 0.0 b	100
CV%[3]	30.6		41.3		39.8		47,6	

[1]% E = (control - treatment) / control) * 100 (ABBOTT, 1925. [2]Means followed by the same letter in the column do not differ by Tukey test ($p < 0.05$) [3]CV% = coefficient of variation.

Table 11. Mean (± SE) of the number of coffee borer larvae (*H. hampei*) and percent efficiency (% E) in the field, with artificial infestation at 0, 10, 20 and 30 days after application (DAA) of the products and evaluation at 10, 20, 30 and 40 DAA (10 days after each infestation of the berry borer of coffee. Uberlândia - MG, 2018.

Treatments	10 DAA		20 DAA		30 DAA		40 DAA	
	Mean (± SE)	E%[1]	Mean (± SE)	E%	Mean (± SE)	E%	Mean (± SE)	%E
1. Control	9.0 ± 1.0 a[3]	--	11 ± 3.7 a	--	6.5 ± 1.9 a	--	3.3 ± 1.6 a	--
2. Voliam Targo	1.0 ± 1.0 b	89	2.5 ± 1.8 b	79	0.2 ± 0.3 b	96	0.0 ± 0.0 b	100
3. Benevia	0.0 ± 0.0 b	100	0.0 ± 0.0 b	100	0.0 ± 0.0 b	100	0.0 ± 0.0 b	100
4. Lorsban 480 BR	2.3 ± 0.3 b	75	1.0 ± 1.0 b	90	1.2 ± 0.8 b	81	0.0 ± 0.0 b	100
5. Curbix 200 SC	0.8 ± 0.8 b	92	0.0 ± 0.0 b	100	0.0 ± 0.0 b	100	0.0 ± 0.0 b	100
6. Sperto	0.0 ± 0.0 b	100	0.0 ± 0.0 b	100	0.0 ± 0.0 b	100	0.0 ± 0.0 b	100
7. Verismo	1.8 ± 0.9 b	81	1.0 ± 0.4 b	68	0.0± 0.0 b	100	1.5 ± 1.5 ab	54
8. Polytrin 400/40 CE	1.5 ± 0.9 b	89	1.3 ± 0.9 b	79	1.2 ± 0.9 b	85	1.0 ± 1.0 ab	69
9. Curyon 550 EC	1.8 ± 0.6 b	81	0.3 ± 0.3 b	95	0.5 ± 0.5 b	92	1.0 ± 1.0 ab	69
10. Polo 500 SC	1.8 ± 1.8 b	81	0.8 ± 0.8 b	90	0.0 ± 0.0 b	100	0.0 ± 0.0 b	100
11. Vertimec 18 EC	2.3 ± 0.8 b	75	0.8 ± 0.8 b	100	0.7 ± 0.5 b	89	0.0 ± 0.0 b	100
CV%[3]	29.8		34.5		30.6		32.6	

[1]Efficiency% E = ((observed - control) / control) * 100 (ABBOTT, 1925). [2]Means followed by the same letter in the column do not differ by Tukey's test ($p < 0.05$). [3]CV% = coefficient of variation.

It is known that the factors responsible for the natural mortality of coffee borer was also an inevitable variable that could interfere with the results in particular field evaluations are: parasitism, predatory insects, such as bedbugs, of the Anthocoridae family and ants; the occurrence of physiological disturbances (unviable eggs and incomplete ecdysis in larvae and pupae) and infestation of fungi *Metarhizium anisoliae* and *Beauveria bassiana* (CHEDIAK, 2009).

The number of eggs of the borer found in the dissected fruits was significantly higher in the control in all infestations, and in the last evaluation, only the insecticides Polytrin 400/40 CE and Verismo did not differ from the control (Table 10). There were no differences among the insecticides regarding the number of eggs.

As for the number of larvae in the dissected fruits, all insecticides differed from the control (Table 11). However, at 40 days of evaluation, a lower number of larvae were found in the control, and thus the insecticides Verismo, Polytrin 400/40 CE and Curyon 550 EC were statistically the same as the control, but did not differ from other insecticides. It was verified that during the evaluations the insecticides presented satisfactory results of control, that is, percentage of efficiency superior to 80% in the majority of the evaluations.

Filho-Fernandes, Silva and Paradela (2016) evaluated the agronomic efficiency of the Lorsban 480 BR insecticide in five coffee cultivars, starting applications with 0.5% of brocaded chumbon type fruits 80 days after flowering. In the research the insecticide provided 89% of agronomic efficiency in evaluating the presence of eggs and larvae inside the fruits.

Dutra (2012) and Krohling; Gonring (2016) studying the efficiency of the insecticide Benevia observed a control level of 90% higher in larval control, a result similar to the present research. In addition, Krohling et al. (2011) evaluated the efficiency of the new mixture of Chloranthraniliprole + Abamectin (Voliam Targo) in the control of the berry borer of coffee, showing its efficiency greater than 80% in comparison with the standard insecticide endosulfan.

Efficacy in the field

It was verified that in the previous evaluation performed before the first application there was no significant difference between the treatments, indicating uniform infestation of the berry borer of coffee in the experimental area, corresponding to 4.4% of infested fruits (Table 12). According to Vega et al. (2017), the applications should be started when the index reaches between 3 and 5% of bored fruits, so the first application was made. The infestation observed in the previous evaluation is mainly due to the remaining fruits of the previous harvest, which demonstrates the importance of a well-harvested harvest and the transference when many remaining fruits of the harvest are verified (OLIVEIRA et al., 2017).

In the evaluation performed 15 DAPA, it was verified that the mouth population increased in the experimental area, passing from 9 to 15 fruits bored on average for each 50 evaluated fruits, which is explained by favorable climatic conditions for the borer (OLIVEIRA et al., 2017). Among the insecticides evaluated, only Lorsban 480 BR and Sperto differed from the control, reaching 80% efficiency (Table 12). In the evaluation carried out at the 30 DAPA, the insecticides Voliam Targo and Polytrin 400/40 CE differed from the control, with 75% and 65% efficiency respectively. The other insecticides did not differ from the control. Thus, the second application was performed with a 30-day interval, following the recommendations of the research agencies (SOUZA, 2014).

At 7 DASA the insecticides had an effect on the borer, keeping the insect infestation practically at the same levels as the DAPA evaluation, while in the control the level of infestation increased (Table 12). The insecticides Voliam Targo, Curbix 200 SC, Sperto, Polytrin 400/40 CE, Curyon 550 EC and Polo 500 SC differed from the control, but with efficiency below 67%. In the DASA 14 count, only the insecticide Sperto differed from the control, and the infestation rates remained similar to that of the 7 DASA.

At 21 DASA the insect population increased in the control. The insecticides Curbix 200 SC, Sperto, Polytrin 400/40 CE and Curyon 550 EC differed from the control, but only the insecticide Sperto reached efficacy higher than 80%, which is the minimum value agreed for a pesticide (Table 12). In the evaluation carried out at the 28 DASA, all insecticides differed from the control, with Lorsban 480 BR, Verismo and Polytrin 400/40 CE reaching efficacy above 80%.

It was observed in the last evaluation carried out at 35 DASA that all treatments differed from the control, with only the Lorsban 480 BR insecticide not reaching 80% efficacy. The insecticides with the highest control rates were Sperto (98%), Polytrin 400/40 CE (96%), Benevia (93%), Curyon 550 EC (91%), Voliam Targo (88%) and Verismo 88%), Curbix 200 SC (87) and Polo 500 SC (87) and Vertimec 18 EC (85%) (Table 12).

The number of fruits bored in the previous evaluation increased considerably in the control during the conduction of the test, whereas in the treatments with the insecticides the infestation did not increase, and in some treatments, the rate of infestation decreased, being clear the influence of the insecticides. In the case of the control, it is possible that the peak of infestation occurred in the last evaluation, because the insect would have found fruits with a dry matter content more adequate for the biological development of the pest (PÉREZ; INFANTE; VEJA, 2015).

In studies conducted in Rondônia, the behavior of the berry borer populations was similar. The population increased between September and May, culminating almost before harvest (May) (ARISTIZABAL, 2005). In the state of Minas Gerais, in surveys conducted from 2009 to 2012, it was observed that infestation in arabica coffee also increased during fruit development and peaked between June and July (SILVA et al., 2013). These studies demonstrate that the insect shows a high population growth, as observed in the control without application of the present study, where the infestation started from 4.5%, reaching 44.4% of fruits attacked, proving that the insecticides have a positive effect on the control of the insect.

In the evaluation of the final infestation of bored grains, after fruiting, there was no difference between the insecticides and almost all had a lower number of broached fruits than the control, except for the insecticides Benevia, Polo 500 SC and Vertimec 18 EC. Which did not differ from the control (Table 13).

Other authors have evaluated the performance of some of the insecticides tested in the present study in the control of the berry borer of coffee (KROHLING; GONRING, 2016; MENDONÇA; MATTIELLO, 2017). Mendonça and Mattiello (2017) tested in the field the insecticides Verismo, Benevia and Voliam Targo, applied with use of different adjuvants and verified a reduction in the rate of infestation corroborating the data obtained in the present research. Krohling and Gonring (2016) evaluated the insecticide Voliam Targo and concluded that the insecticide provided an average efficiency of 77.36%, and may be an option to control the *H. hampei*.

Borges et al. (2016) conducted a field study with the insecticides Benevia, Verismo, Lorsban 480 BR and Voliam Targo and concluded that all insecticides provided a significant reduction in the infestation of the berry borer, but all were below 80%, a fact explained by the high initial infestation. The authors report that to obtain good results, especially in situations of high infestation, at least two applications are necessary, corroborating with the results of the present research.

Table 12. Mean (± SE) of number of fruits bored and percentage of efficiency (% E), at 0 (previous), 15 and 30 days after the first application (DAPA) and 7, 14, 21, 28 and 35 days after the second application (DASA) on natural berry borer infestation by (*H. hampei*) in the field. Uberlândia - MG, 2018.

Treatments	Previous	15 DAPA		30 DAPA		7 DASA		14 DASA		21 DASA		28 DASA		35 DASA	
	Mean	Mean	E%[1]	Mean	E%	Mean	E%	Mean	E%	Mean	E%	Mean	E%	Mean	E%
1. Control	9±0.9a[2]	15.0± 0.4 a	--	12,0 ± 2.5 a	--	16.5 ± 4.0 a	--	16.3±6.3 a	--	19 ±6.4 a	--	12±3.0 a	--	23.5± 5,9 a	--
2. Voliam Targo	11.0±1.3 a	7.0± 0.4ab	53	7.0 ± 1.3 bc	75	6.5 ± 1.9 b	61	7.5±1.2 ab	57	6.0±1.4 ab	68	3.0± 1.2 b	75	2.7 ± 0.2 b	88
3. Benevia	9.0 ± 0.8 a	10±0.9ab	33	5.0 ± 1.7 bc	58	8.0 ± 1. ab	52	7.0±1.5 ab	54	7.8±1.0 ab	59	3.3±0,.7 b	73	1,.7 ± 1.0 b	93
4. Lorsban 480 BR	7.0 ± 0.5 a	3.0±0.4 b	80	8.5 ± 3.3 ab	31	8.7 ± 0. 8ab	47	8.3±2.2 ab	57	6.0±0.7 ab	68	3.0± 1.1 b	81	5.2 ± 0.2 b	78
5. Curbix 200 SC	6.0 ±0.5 a	10±1.8 ab	33	6.5 ± 1.6 bc	46	7.2 ± 2.0 b	56	4.0± 1.4 b	66	4.8±1.5 b	75	2.8± 1.2 b	77	3.0 ± 0.4 b	87
6. Sperto	12.0±0.6 a	3.0±0.7 b	80	7.0 ± 1.2 bc	42	6.0 ± 1.0 b	64	8.8±1.6 ab	75	2.3±0.7 b	88	3.5± 1.5 b	71	0.5 ± 0,5 b	98
7. Verismo	8.0 ± 1.4 a	4.0±0.4 ab	73	10.0 ± 2.8 ab	17	9.0 ± 1.3 ab	45	8.7±2.3 ab	46	9.5±1.5 ab	50	1.7± 0.7 b	85	2.7 ± 0.7 b	88
8.Polytrin 400/40 CE	7.0 ± 0.5 a	5.0±0.5 ab	60	4.2 ± 1.7 c	65	5.5 ± 2.2 b	67	8.3±2.3 ab	69	5.0±1.5 b	74	4.0± 1.0 b	92	3.2 ± 0.7 b	96
9. Curyon 550 EC	6.0± 0.8 a	6.0±0.4 ab	40	7.7 ± 0.8 bc	35	6.7 ± 2.7 b	59	8.0±2.3 ab	49	5.5±1.6 b	71	3.3± 0.4 b	73	2.0 ± 0.9 b	91
10. Polo 500 SC	7.0 ± 0.5 a	9.0±0.4 ab	47	9.0 ± 3.6 ab	25	6.0 ± 2.1 b	64	6.0±1.6 ab	51	8.8±2.0 ab	54	4.2± 1.6 b	65	3.0 ± 0.5 b	87
11. Vertimec 18 EC	8.0± 1.1 a	8.0±0.4 ab	73	7.5 ± 0.9 bc	38	8.5 ± 0.6 ab	48	6.8±0.7 ab	58	6.0±0.9 ab	68	5.0± 2.0 b	58	3.5 ± 2.2 b	85
CV%[3]	41.39	50.66		30.76		29.80		29.95		28.36		42.33		38.94	

[1]% E = ((control - treatment) / Witness) * 100 (ABBOTT, 1925). [3]Means followed by the same letter in the column are not statistically different according to the Tukey test (P < 0.05). [4]CV% - coefficient of variation.

Table 13. Mean number (± EP) of coffee beans, *H. hampei*, in four samples of 250 fruits per repetitions and percentage of final infestation (% FI) of the fruits bored by the berry borer. Uberlândia - MG, 2018.

Treatments	Repetitions				Mean ± SE	%FI
	A	B	C	D		
1. Control	14	18	36	14	20.5 ± 4. a[1]	8.2 a
2. Voliam Targo	5	6	8	6	6.3 ± 0.5 b	2.5 b
3. Benevia	6	8	8	14	9.0 ± 1.5 ab	3.6 ab
4. Lorsban 480 BR	1	3	9	1	3.5 ± 1.6 b	1.4 b
5. Curbix 200 SC	2	7	5	5	4.8 ± 0.9 b	1.9 b
6. Sperto	4	8	3	4	4.8 ± 1.0 b	1.9 b
7. Verismo	3	7	8	4	5.5 ± 1.0 b	2.2 b
8. Polytrin 400/40 CE	1	5	2	2	2.5 ± 0.8 b	1.0 b
9. Curyon 550 EC	4	16	7	4	7.8 ± 2.5 b	3.1 b
10. Polo 500 SC	7	8	8	10	8.3 ± 0.5 ab	3.3 ab
11. Vertimec 18 EC	6	7	13	9	8.8 ± 1.3 ab	3.5 ab
CV%[2]					24.56	

[1]% E = ((control - treatment) / Witness) * 100 (ABBOTT, 1925). [3]Means followed by the same letter in the column are not statistically different according to the Tukey test ($P < 0.05$). [4]CV% - coefficient of variation.

CONCLUSIONS

The insecticides Voliam Targo, Benevia, Lorsban 480 BR, Curbix 200 SC, Sperto, Polytrin 400/40 CE, Curyom 550 EC and Vertimec 18 EC increased the mortality of coffee borer when applied topically in the laboratory, causing mortality higher than 80%. On the other hand, the Verismo and Polo 500 SC insecticides did not increase the mortality of the berry borer in topical application.

All the insecticides tested reduced the attack of the fruits by the coffee borer, but the insecticides Benevia, Lorsban 480 BR, Curbix 200 SC, Sperto, Polytrin 400/40 CE, Curyom 550 EC and Vertimec 18 EC reduced by more than 80 % of drilled fruits, while Voliam Targo, Verismo and Polo 500 SC did not reach this reduction index. Due to the high mortality of the borer in topical application, the insecticides prevented the posture, reducing the number of larvae, except Verismo, Polo 500 SC and Vertimec 18 EC;

In the evaluation of the residual effect of insecticides on berry borer mortality in the laboratory, almost all insecticides provided mortality above 70% except Polo 500 SC. The high mortality reflected in the lower number of fruits bored in relation to the control. All the insecticides tested reduced the number of coffee borer eggs in fruits with insecticide application; however, the insecticides Lorsban 480 BR, Curyom 550 EC and Polo 500 SC did not reduce the number of coffee borer larvae in the fruits;

In the evaluation of the residual effect of insecticides in the field, all insecticides maintained high residual power for up to 30 days after application. Due to the high mortality of the coffee borer caused by the insecticides Voliam Targo, Benevia, Lorsban 480 BR, Curbix 200 SC, Sperto, Polytrin 400/40 EC, Verismo and Vertimec 18 EC there was a reduction in the number of fruits attacked by the drill-do -coffee;

All the insecticides showed efficacy in the field, reducing the population and the attack of the coffee borer on the grains; and the insecticides Voliam Targo, Lorsban 480 BR, Curbix, Sperto, Polytrin 400/40 EC and Verismo showed the best control results, being indicated for the use in the handling of coffee beans.

RESUMO: O objetivo deste trabalho foi avaliar em laboratório e em campo os efeitos tópicos, residuais e de eficiência agronômica dos inseticidas Voliam Targo, Benevia, Lorsban 480 BR, Curbix 200 SC, Sperto, Verismo, Polytrin 400/40 CE, Curyom 550 EC, Polo 500 SC e Vertimec 18 EC no controle da broca do café *(H. hampei*). O delineamento experimental foi inteiramente casualizado e quatro repetições foram utilizados nos ensaios. No laboratório foi feita uma pulverização direta sobre o inseto (efeito tópico) e uma aplicação nos frutos do café (contaminação residual). Em ambos os experimentos, cada parcela consistiu de uma placa Petri forrada com papel de filtro, 10 frutos no estágio verde e 10 fêmeas adultas da broca, originários de criação artificial. Dois experimentos de campo foram realizados na Fazenda Experimental Campus Glória. O primeiro foi realizado com o objetivo de avaliar o efeito residual dos inseticidas em infestação artificial da broca após a aplicação dos produtos em frutos no início da maturação. Foram avaliados o número de frutos perfurados, fêmeas mortas, número de ovos e larvas nos experimentos de laboratório e campo. O segundo experimento de campo teve como objetivo avaliar a eficácia no controle da população natural da broca. Foram realizadas duas aplicações com intervalo de 30 dias, utilizando-se um turbo pulverizador motorizado. Foram avaliados o número de frutos perfurados em 50 frutos por parcela e porcentagem de sementes brocadas em uma amostra de 250 sementes por repetição. No laboratório, todos os inseticidas proporcionaram mortalidade superior a 80% em aplicação tópica e maior de 73% por contaminação residual, exceto o inseticida Polo 500 SC, que proporcionou 55% de mortalidade. No experimento de campo com infestação artificial, todos os inseticidas diferiram da testemunha, mantendo o controle residual até 30 dias após a aplicação e com mortalidade superior a 70%, chegando a até 100% de mortalidade. No teste com infestação natural da broca os inseticidas diferiram da testemunha em todos os parâmetros avaliados, mostraram eficácia superior a 75% aos 35 dias após a segunda aplicação. Os inseticidas Voliam Targo, Lorsban 480 BR, Curbix 200 SC, Sperto, Polytrin 400/40 CE e Verismo apresentaram os melhores resultados de controle, sendo indicados para uso no manejo da broca do café.

PALAVRAS-CHAVE: *Coffea arabica,* MIP, controle químico

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