REDUCING SPRAY VOLUME FOR THE CONTROL OF *Leucoptera coffeella* (Lepidoptera: Lyonetiidae) IN COFFEE PLANTS

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ABSTRACT: The present work evaluated reducing on spray volume for the control of *Leucoptera coffeella* (Guérin-Mèneville & Perrottet, 1842) (Lepidoptera: Lyonetiidae) in coffee. Were used a conventional sprayer to apply the volumes 200 and 400 L ha^{-1} and an ultra-low-volume (ULV) sprayer to apply 46, 67 and 92 L ha^{-1}. Sprays utilized 800 mL ha^{-1} of the insecticide profenofos+lufenuron. The tracer $MnSO_4$ was mixed to the spraying liquids at 20 g L^{-1}. Leaves were collected from different parts of the coffee tree to evaluate the volume of insecticide spraying liquid deposited. For the *L. coffeella* control, leaves were collected before and 7, 14, and 21 days after spraying (DAS) to evaluate the number of live and dead *L. coffeella* larvae. Data were subjected to variance analysis and the means compared by Tukey's test ($p<0.05$). There was no significant difference for spraying liquid deposit between the volumes of 200 and 400 L ha^{-1}, as well as among the ULVs at 46, 67 and 92 L ha^{-1}, however with lower deposit for the latter, compared to the two higher volumes. The estimated insecticide volume deposited was significantly higher for the 200 L ha^{-1}. The untreated control had higher number of live *L. coffeella* larvae compared to the sprays at 7 and 21 DAS, as exception for the 14 DAS. The volume of 200 L ha^{-1} by the conventional sprayer and 92 L.ha^{-1} by the ULV sprayer may be adopted for coffee plantations providing insecticide deposit and control of *L. coffeella* with efficiency above 80%.

Index terms: Leaf miner, low volume, pneumatic nozzle, atomizer.

VOLUME DE PULVERIZAÇÃO REDUZIDO PARA CONTROLE DE *Leucoptera coffeella* (Lepidoptera: Lyonetiidae) EM PLANTAS DE CAFÉ

RESUMO: *Avaliou-se, no presente trabalho, a redução do volume de calda no controle de Leucoptera coffeella (Guérin-Mèneville & Perrottet, 1842) (Lepidoptera: Lyonetiidae, no café. Foi utilizado um pulverizador convencional nos volumes de 200 e 400 L ha^{-1} e um pulverizador de ultrabaixo volume (UBV) a 46, 67 e 92 L ha^{-1}. As pulverizações utilizaram 800 mL ha^{-1} do inseticida profenofós+lufenuron. O marcador $MnSO_4$ foi adicionado às caldas, na proporção de 20 g L^{-1}. Folhas foram coletadas em diferentes partes da planta para avaliar a quantidade de calda inseticida depositada. Para o controle de L. coffeella, folhas foram coletadas antes e depois de 7, 14 e 21 dias após pulverização (DAP), para a avaliação do número de larvas de L. coffeella vivas e mortas. Os dados foram submetidos à análise de variância com médias comparadas pelo teste de Tukey ($p<0,05$). Não houve diferença significativa na quantidade de calda depositada entre 200 e 400 L ha^{-1}, bem como entre os UBVs 46, 67 e 92 L ha^{-1}, porém estes últimos tiveram depósitos significativamente menores, comparados aos dois maiores volumes. O volume estimado de inseticida depositado foi significativamente maior para 200 L ha^{-1}. O controle sem pulverização teve maior número de larvas vivas de L. coffeella comparado às pulverizações aos 7 e 21 DAP, com exceção para 14 DAP. O volume de 200 L ha^{-1}, por meio do pulverizador convencional, e 92 L ha^{-1}, com o pulverizador UBV, podem ser adotados em plantações de café, proporcionando depósito de inseticida e controle de L. coffeella com eficiência acima de 80%.*

Termos para indexação: *Bicho-mineiro, baixo volume, bico pneumático, atomizador.*

1 INTRODUCTION

Coffee cultivation in Brazil extends over large areas, favoring harmful host insect populations. Controlling these pests requires inspection and population control measures to ensure successful coffee production (MATIELLO; GARCIA; ALMEIDA, 2006). Among the major coffee crop pests, *Leucoptera coffeella* (Guérin-Mèneville & Perrottet, 1842) (Lepidoptera: Lyonetiidae), an exotic pest that thrives in plantations throughout the world, is a primary pest in the major coffee-producing regions of Brazil and must be periodically culled (SCALON et al., 2011). Chemical control is predominantly used to control *L. coffeella* in the plantation and represents approximately 10–15% of production costs, which varies with the type of sprayer used, the crop yield and the coffee price (AGRIANUAL…, 2012).

Due to the high occurrence of *L. coffeella*, approximately 61% of damaged leaves detach themselves from the plants, and regardless of

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lesion size, photosynthetic activity is reduced (TOLEDO FILHO, 1982). As a result, if no control measures are employed, infestations may result in significant loss of coffee bean production (REIS; SOUZA, 1986).

The presence of *L. coffeella* larvae inside mines hampers their contact with plant protection products applied via spraying. To increase the contact of the products with the larvae, spraying is traditionally performed by applying high spraying liquid volumes beyond the point of maximum retention by the leaves (MIRANDA et al., 2012). However, efforts are underway to reduce the application volumes of plant protection products to reduce costs and environmental contamination and to maintain or increase the efficiency of spraying to improve operational capability, allowing work to be performed in larger areas under more favorable weather conditions (DECARO JUNIOR et al., 2014).

Many researches have provided conclusions allowing the application to be performed under reduced spray volumes depending on the target and the application technology. Many tools may be employed to achieve such reduce as the type of sprayer (MIRANDA et al., 2012); outflow type and placement of nozzles (DECARO JUNIOR et al., 2014; FERNANDES; FERREIRA; OLIVEIRA, 2010; SILVA; CUNHA; NOMELINI, 2014); droplets size and its spectra produced (FOURIE et al., 2009; NUYTTENS et al., 2007); air assistance generated (KHOT et al., 2012); use of an adjuvant to protect the droplets from evaporation, particularly under adverse weather conditions (OLIVEIRA et al., 2013; SASAKI et al., 2013); and dimensions of plants (ZHU et al., 2006).

In the present study, was assessed the amount of insecticide deposited and the control of *L. coffeella* in coffee plants by reducing the application volumes in a conventional sprayer, equipped with hydraulic nozzles, and in an ultra-low-volume sprayer, equipped with a pneumatic nozzles.

2 MATERIALS AND METHODS

The experiment was performed in April 2012 at a coffee plantation growing the coffee variety Catuaí Vermelho IAC 99 in the municipality of Altinópolis, São Paulo state, Brazil, with climate classified as humid subtropical with dry winters and warm summers. The coffee plantation was installed in 2001 at a spacing of 0.6 × 3.5 m. Plants had uniform architecture with 3.1 m in height and 1.8 m in diameter of the canopy closer to the ground.

At this property, *L. coffeella* occurred at population levels suitable for the study, with 25% of sampled leaves containing live larvae of *L. coffeella* for this rainy period, thus justifying spraying (GALLO et al., 2002). The chosen parcels contained homogeneous plants that were distributed in a randomized block design of 6 treatments and 4 replications. The efficacy of 5 application volumes of spray and a control without spraying was evaluated. Each parcel contained 5 lines of plants with a spacing of 3.5 m and a length of 15 m. To avoid an influence of the treatments on adjacent, only the central line of plants on each parcel was considered for treatments evaluation.

Rainfall was measured with a rain gauge and there was no rainfall during the experimental period. The rainfall data were noted to determine the effects of rain on the insect population (THUELHER et al., 2003).

Two mounted airblast sprayers were employed in this study. One of the sprayers represented a conventional model (Arbus 400 – JACTO®), capacity of 400 L, utilized by coffee farmers, equipped on both sides with 8 hydraulic hollow cone nozzles, which spray the plants perpendicular to the tractor displacement. This sprayer works with a volume of 400 L ha^{-1} and was equipped with JA-2 hydraulic nozzles operating at 999.7 kPa, producing droplets classified as "Fine", according to the manufacturer. To spray a volume of 200 L ha^{-1}, TXA80-0067VK hydraulic nozzles were used at a pressure of 1,034.2 kPa, and produced droplets classified as "Very Fine". Both hydraulic nozzles spray fine droplet diameter spectra, according to the manufactures, and were assisted with air stream at 11 m^3 s^{-1} generated by the sprayer fan.

In addition, this study employed an Utra-low-volume (ULV) sprayer model (SMART UBV 400) developed by PulsFog® Pulverizadores Ltda Enterprise in Diadema city, São Paulo State, Brazil. This ULV sprayer had 12 flat fan nozzles (UBV PulsFog model), 6 on each side of the sprayer, which sprayed perpendicular to the tractor displacement. This sprayer produced very fine droplet spectra, according to the manufacturer, and worked at 46, 67, and 92 L ha^{-1} volumes, with the spraying liquids pressurized at 275.8, 310.7 and 413.7 kPa, respectively, and using outflows restrictor of 0.5, 0.6 and 0.7 in diameter. The air assistance generated by the sprayer was 1.75 m^3 s^{-1} with the droplets presenting around 50 µm in volumetric median diameter, being the smallest droplet size comparing to the nozzles used with the conventional sprayer.

All the spraying volumes were applied in the same day with the sprayers at 6.4 km h^{-1}. The volumes 46, 67 and 92 L ha^{-1} were performed under temperature of 26ºC, relative humidity of 64% and wind speed at 5.3 km h^{-1}, on average. The volumes of 200 and 400 L ha^{-1} were sprayed under temperature of 28ºC, relative humidity of 43% and wind speed of 1.5 km h^{-1}. The temperature (<30ºC) and wind speed (<10 km h^{-1}) were favorable for all the sprays, while relative humidity was lower than the recommended (50%) for the volumes with the conventional sprayer.

The spraying liquids were applied at a fixed dose of 800 mL ha^{-1} of the insecticide Curyom 550 EC (55% active ingredient g L^{-1}). This insecticide is composed of profenofos (50% of the active ingredients), which is an organophosphate that acts on the nervous system, and lufenuron (5% of the active ingredients), which is an insect growth regulator that affects chitin synthesis. This insecticide is registered for coffee plantations and affect *L. coffeella* for up to 60 days, as stated on the product label. Because other diseases in the experimental area needed to be controlled, the evaluations were terminated after 21 days after spraying (DAS).

The adjuvant mineral oil (Argenfrut®) was added at 10% of volume for ULV spraying liquids, to increase the droplets diameter in the sprays and reduce its loss by drift (LASMAR et al., 2014). The same adjuvant was included at 1 L ha^{-1} (fixed dosage) in the 400 and 200 L ha^{-1} treatments with the conventional sprayer, this dose was used on the property in previous years. For all 5 treatment volumes, water was mixed to generate the final spraying liquids.

A tracer composed of sulfate of manganese (31% Mn^{2+}) was added to all of the spraying liquids at 20 g L^{-1}. This tracer is commonly used in researches to determine the amount of spraying liquid deposited on leaves after the sprays (DEKEYSER et al., 2014; FERREIRA; LEITE; LASMAR, 2013). Furthermore, sulfate of manganese has good stability when added to the spraying liquids and is retrieved in more than 95% when subjected to acid extraction (ANDRADE; FERREIRA; FENOLIO, 2013; COSTA, 2013).

The sampling of coffee leaves for extracting the tracer was done for all the treatments, including the control without spraying. On each parcel, 2 plants were sampled. The plants had 2 leaves collected from each different sampling points. These latter were composed by the two sides of the plant in front of the inter-row (external) and two between plants (internal), so that the sampling points were equidistant and surrounded the whole plant. These external and internal points were also divided in the heights lower and upper, at 50 and 200 cm from the ground, respectively. The leaves of each sampling point were put into plastic bags and conducted to the laboratory. Each bag (containing two leaves) received 150 mL of 0.2N HCl and remained for 1 hour to extract the manganese tracer deposited on the leaves surfaces. Then, the solutions were filtered and individually analyzed in a spectrophotometer to determine the Mn^{2+} concentration in µg per sample volume. After the extraction, the total surface area in cm^2 of the leaves (adaxial + abaxial) on each bag was analyzed in an LI-3100C Area Meter (LI-COR®).

The quantity of manganese read in spectrophotometer for each sampling point were then multiplied by 150 (previous dilution in mL used) and divided by the total leaf area in cm^2, resulting in the deposit of Mn^{2+} cm^{-2}. Subsequently, the mean values of deposit in the external and internal points on each height found for the control parcels were subtracted from the deposits of each sprayed parcel on its respective point. It was done in order to avoid the influence of manganese pre-existing in the plants and guarantee that the resulting values considered only the tracer derived from the sprays.

A sample of each spraying liquid used in the experiment was collected and analyzed on its manganese concentration. According to this latter and the amount of manganese deposited in the sprayed sampling points, was found the volume of spraying liquid (in µL) deposited per cm^2 of coffee leave area, by using a simple rule of three. Similarly, the volume of insecticide (in nL) deposited per cm^2 of coffee leave area was found by a simple rule of three, considering the volume of the product added to the spraying liquid.

The variables spraying liquid and insecticide deposit were compared among the spraying volumes. The insecticide deposit was also compared among the sampling points as a factorial 5 (application volumes) x 4 (sampling points: upper external, upper internal, lower external and lower internal). Data of the two variables were transformed by the expression ln(x+5) to stabilize the variance of the residue and then subjected to analysis of variance. The means of each treatment were compared by Tukey's test ($p<0.05$).

To evaluate the dynamics of the *L. coffeella* population, leaf samples were collected before spraying and at 7, 14, and 21 DAS. For each sample, 25 leaves were collected from two central plants in the parcel. Leaves were collected only in the third or fourth leaf pair from the tops of the branches located in the middle third of the plant at a convenient height for harvest inside every parcel (MORAES, 1998). After 24 hours, the number of live and dead larvae was evaluated by using a stereoscopic microscope (40x) and stylus to open the mines.

Data of the variables live and dead larvae were transformed by the expression ln(x+5) to stabilize the variance of the residue and then subjected to analysis of variance. The means of the five application volumes and the control were compared by Tukey's test ($p<0.05$) for each DAS, separately.

The variable spray efficiency was calculated by considering the population of live larvae using the formulae of Henderson and Tilton (1955) and presented in a graphic to verify the differences among the volumes sprayed.

3 RESULTS AND DISCUSSION

The quantity of spraying liquid deposited on the coffee leaves was significantly affected by increasing the spraying volume (Table 1). The volumes of 200 and 400 L ha^{-1}, with the conventional sprayer, provided the same spraying liquid deposits.

The meteorological conditions during the conventional sprays were very similar with wind speedy around 1.5 km h^{-1}. Possible losses by drift and mainly by runoff would be positively correlated to the increase in the application volume, leading to similarity of 200 and 400 L ha^{-1}, according to Silva, Cunha and Nomelini (2014). These authors as well as Ferreira, Leite and Lasmar (2013) employed different types of sprayer in coffee plantations and found the same spraying liquid deposit comparing high and reduced volumes, by only changing the model and outflow of the nozzles.

Increases in the ULVs from 46 to 67 and 92 L ha^{-1}, with the ULV sprayer, did not provide significant differences in the spraying liquid deposit on the leaves as the same pattern found for the conventional sprayer (Table 1). The meteorological conditions during these sprays were similar with wind speed around 5.3 km h^{-1} could have driven the sprays to losses by drift. Even under recommended meteorological condition such as temperature below 30^{o}C, relative humidity above 55% and air speedy below 10 km h^{-1} (FERREIRA, 2006), the higher losses by drift are possibly related to the increase of the applied volume.

There was significant interaction between the factors spray volume and the sampling points in the coffee plants for the insecticide volume deposited on the leaves (Table 1).

Considering the sampling points in the coffee plant, the volume of 200 L ha^{-1} provided the highest insecticide deposit in the external and internal points in both the upper and lower heights (Table 1). Nevertheless, this volume was not significantly different from the 400 and 92 L ha^{-1} for all the sampling points evaluated. Conversely, the 67 L ha^{-1} had significant lower insecticide deposits on external upper and internal lower points, while the 46 L ha^{-1} provided the lowest insecticide deposit on external lower point of coffee plants, compared to the 200 L ha^{-1} (Table 1).

On the average, the volume of insecticide deposited on coffee leaves was significantly higher for the 200 L ha^{-1} in comparison to the other volumes (Table 1). The ULVs of 46, 67 and 92 L ha^{-1} and the highest volume of 400 L ha^{-1}, by the conventional sprayer, were similar.

Thus, sprays deposited with a conventional sprayer at 400 L ha^{-1} do not represent an appropriate application of technology by using higher spraying liquid volumes, which waste insecticide and rise the operational costs (DECARO JUNIOR et al., 2014; MIRANDA et al., 2012). Similar results were found in other crops where the use of high spray volumes showed lower efficiency (CHUECA; GRAFTON-CARDWELL; MOLTÓ, 2009; KHOT et al., 2012).

The insecticide deposit homogeneity was smaller for the ULV sprayer at 67 L.ha^{-1} in comparison to the other volumes, where significant differences occurred between the heights in the external points and between the external and internal points (Table 1). Comparatively, a better homogeneity was found for the 92, 200 and 400 L ha^{-1} in which no differences occurred between the heights while significant differences were found between the external and internal points, with small values for this latter.

Differently from that observed in this experiment, Miranda et al. (2012) observed higher spraying liquid deposited on lower heights of coffee plants by employing conventional sprayers with hydraulic nozzles.

TABLE 1 - Means of spraying liquid and estimated insecticide volume deposited per cm^2 of collected coffee leaves area as a function of spray volume and sampling points. Altinópolis – São Paulo State, Brazil, 2012.

Volumes (L ha^{-1})	Spraying liquid (µL)	Insecticide volume (nL)	External (nL)		Internal (nL)	
			Upper	Lower	Upper	Lower
46	1.80 b[1]	2.58 b	3.40 abA	2.27 bB	2.51 aB	2.16 abB
67	1.92 b	2.63 b	2.92 bB	4.15 aA	1.81 aC	1.64 bC
92	1.99 b	2.76 b	3.62 abA	3.81 aA	1.78 aB	1.83 abB
200	2.54 a	3.36 a	3.88 aA	4.57 aA	2.31 aB	2.69 aB
400	2.47 a	2.82 b	3.36 abA	3.71 aA	1.98 aB	2.23 abB
F volumes (p)	0.000	0.000	0.038	0.000	0.080	0.011
F blocks (p)	0.764	0.437	0.437	0.437	0.437	0.437
CV (%)	26.28	31.17	31.17	31.17	31.17	31.17
LSD (5%)[2]	0.27	0.43	0.86	0.86	0.86	0.86
Standard error	0.07	0.11	0.22	0.22	0.22	0.22
LSD (5%)[3]	-	-	0.81	0.81	0.81	0.81

[1] Means transformed by ln(x+5) followed by the same lowercase letters in the column and capital letters in the line do not significantly differ according to Tukey's test ($p<0.05$). [2] Lowest significant difference for application volumes in the columns. [3] Lowest significant difference for the sampling points in the lines.

These authors also found higher homogeneity of deposit for the sprayer with pneumatic nozzles, as well as found by Magno Júnior et al. (2011), working with electrostatic nozzles. Both researches suggest the possibility of reducing the application volumes after more works involving the efficiency of the spray for crop protection problems.

The number of dead larvae of *L. coffeella* was similar among all the spray volumes, with no difference compared to the untreated control (Table 2). Prior to the sprays, no difference was observed among the parcels, as expected.

Significant differences were found in the variable live larvae of *L. coffeella* as a function of the sprays. The untreated control had higher number of live larvae compared to all the ULVs and the volumes by the conventional sprayer at 7 and 21 DAS, as exception for the 14 DAS (Table 2), when only the volume of 200 L ha^{-1} was significant.

The highest spray efficiency, according to Henderson and Tilton (1955) calculus, was observed with the volume of 200 L ha^{-1} at 21 DAS. Nevertheless, the application of 400 L ha^{-1} resulted in the lowest variation in efficiency observed during this study. The ULVs produced good efficiency values, particularly 92 L ha^{-1} (Figure 1). In general, at 21 DAS, all of the volumes displayed a satisfactory efficiency of spray values, i.e., values greater than 80%.

The highest spray efficiency values were associated with a decrease in the live larval population. Thus, there was a decrease in the number of live larvae in the parcels between the previous evaluation and at 7 DAS, followed by continuous increases during the next evaluations. At 7 DAS, all of the spray treatments had similar effects, although the 3 largest volumes of 92, 200 and 400 L ha^{-1} were most effective. At 14 DAS, the 400 and 67 L ha^{-1} treatments were the most effective, followed by 92 and 46 L ha^{-1}. At 21 DAS, the 46, 92, 200 and 400 L ha^{-1} treatments were the most effective and produced similar results (Figure 1). In general, although all of the treatments exhibited high spray efficiency values, the 92 and 400 L ha^{-1} treatments produced high efficiency values with the smallest variations.

The ULV of 46 L ha^{-1}, with the smallest insecticide deposited in the external lower point, and the 67 L ha^{-1}, with the worst homogeneity of deposit, provided poor sprays on the plants. Due to the characteristics of the sprayer and the pneumatic nozzles employed, these low spray volumes may not produce enough number of droplets with energy to reach the target, thereby resulting in worse larval control than for the conventional sprayer (NUYTTENS et al., 2007).

TABLE 2 - Effect of application volumes and days of evaluation on the number of dead and live *L. coffeella* larvae in coffee plants. Altinópolis, São Paulo State, Brazil, 2012.

Dead larvae	Before spray	Days after spray (DAS)			Mean
		7	14	21	DAS
46 L ha^{-1}	2.07 a[1]	1.70 a	2.48 a	2.28 a	2.15 a
67 L ha^{-1}	2.00 a	1.70 a	2.27 a	2.29 a	2.08 a
92 L ha^{-1}	2.06 a	1.78 a	2.61 a	2.26 a	2.22 a
200 L ha^{-1}	2.06 a	1.91 a	2.44 a	2.17 a	2.17 a
400 L ha^{-1}	2.10 a	1.82 a	2.05 a	2.19 a	2.02 a
Control	2.41 a	1.82 a	2.60 a	2.24 a	2.22 a
CV (%)	13.16	13.16	13.16	13.16	14.45
F volumes (p)	0.403	0.900	0.062	0.990	0.567
LSD (5%)	0.60	0.60	0.60	0.60	0.37
Standard error	0.14	0.14	0.14	0.14	0.09
Live larvae	Before spray	Days after spray (DAS)			Mean
		7	14	21	DAS
46 L ha^{-1}	2.10 a	2.02 b	1.98 ab	1.90 b	1.97 b
67 L ha^{-1}	2.10 a	1.94 b	1.78 ab	2.03 b	1.92 b
92 L ha^{-1}	2.28 a	1.77 b	1.91 ab	2.11 b	1.93 b
200 L ha^{-1}	2.17 a	1.77 b	2.11 ab	1.70 b	1.86 b
400 L ha^{-1}	2.02 a	1.77 b	1.65 b	1.87 b	1.76 b
Control	1.92 a	2.62 a	2.26 a	2.72 a	2.54 a
CV (%)	14.06	14.06	14.06	14.06	14.11
F volumes (p)	0.592	0.000	0.046	0.000	0.000
LSD (5%)	0.59	0.59	0.59	0.59	0.34
Standard error	0.14	0.14	0.14	0.14	0.08

[1] Values of transformed means [$\ln(x+5)$] followed by the lowercase letter within columns do not differ significantly according to Tukey's test ($p<0.05$).

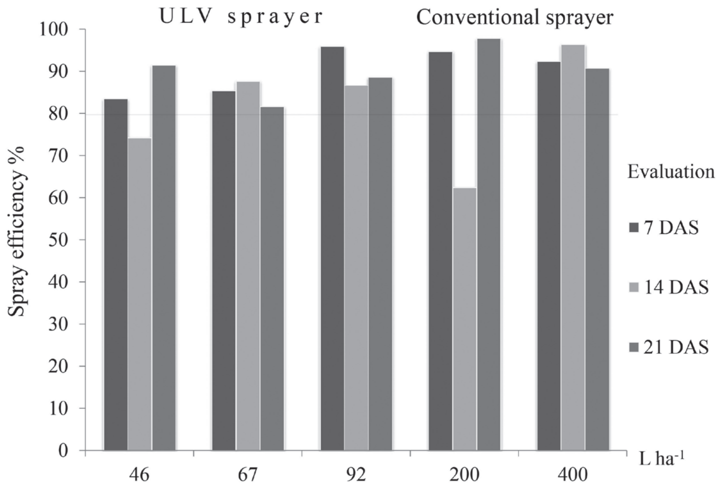

FIGURE 1 - Efficiency in the control of L. coffeella larvae as a function of different application volumes in the days after spraying (DAS). Altinópolis, São Paulo State, Brazil, 2012. Calculus of Henderson and Tilton (1955) based on live larvae of L. coffeella.

Conventional sprayers commonly working at high volumes generate wastes of water, fuel by the tractor and working hours as a result of low operational field capacity. The less spraying liquid is applied, less stoppages is needed for replenishment the sprayer. Despite the lower cost per hectare during the spray, a larger coffee area can be treated per time unit.

The reduced spray volume of 92 L ha-1, with the ULV sprayer, did not affect the efficacy of the plant protection product. Beneath this spray volume, the ULV sprayer is not suitable for the control of L. coffeella in coffee plants with the same dimensions of the assessed in this experiment.

By spraying a product at a ULV in high concentrations, the same control may be obtained compared with spraying lower concentrations of product at a higher volume. Therefore, by correctly adjusting and calibrating a sprayer and employing a plant protection product admixture containing water and adjuvant, an effective and efficient spray can be produced (FERNANDES; FERREIRA; OLIVEIRA, 2010; WISE et al., 2010). However, there is a limit to how much the application volume can be reduced, which depends on the application technology utilized (MAAS, 1971).

4 CONCLUSION

The application volume currently used with conventional sprayers to deposit insecticide and control *L. coffeella* in coffee plants, with the same dimensions of the present work, may be reduced from 400 to 200 L ha^{-1} maintaining the spray efficiency while decreasing application costs.

Similarly, the use of a ULV sprayer with pneumatic nozzles may be adopted on coffee plantations for spraying the volume 92 L ha^{-1} to control *L. coffeella*, thereby increasing spray efficiency and work autonomy while reducing costs.

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