Research Inventy: International Journal of Engineering And Science
Vol.10, Issue 11 (November 2020), PP 38-44
Issn (e): 2278-4721, Issn (p):2319-6483, www.researchinventy.com

Deposition and endo- and exodrifts in simulated herbicide spraying in Conilon coffee inter-rows

[1]João Vitor Sossai, [2]Edney Leandro da Vitória, [3]Ismael Lourenço de Jesus Freitas, [4]Tamara Locatelli, [5]Elcio das Graça Lacerda

[1] Docente de Química do Instituto Federal de Educação, Ciência e Tecnologia do Rio Grande do Norte, campus Apodi, RN 233, N° 999, Apodi-RN, Brasil.
[2] Docente do Progama de Pós-graduação em Agricultura Tropical da Universidade Federal do Espírito Santo, Campus São Mateus ,BR101 km60, São Mateus-ES, Brasil.
[3,4]Pós-doutorando do Progama de Pós-graduação em Agricultura Tropical da Universidade Federal do Espírito Santo, Campus São Mateus ,BR101 km60, São Mateus-ES, Brasil.
[5]Docente de Agronomia do Instituto Federal de Educação, Ciência e Tecnologia do Espírito Santo, Campus Santa Teresa, São Roque do Canaã-ES, Brasil.

Abstract:*Application errors can provide toxicity to coffee plants, burdening productive costs and reducing the physiological performance of plants. The objective of this work was to quantify the exodrift and soil deposition in simulated herbicide spraying in Conilon coffee inter-rows using different application technologies. The experiment was conducted in a randomized block design in a 4×4 factorial scheme, with four compositions of spraying equipment (knapsack sprayer with fan nozzle without "Napoleon's hat"; knapsack sprayer with fan nozzle with Napoleon's hat; knapsack sprayer with air induction nozzle, and electrostatic knapsack sprayer) and four collection positions of syrup deposition (weed, soil, lower half of the coffee tree, and upper half of the coffee). To evaluate the deposition of the canopy, two leaves of each plant were collected, one in the lower third and the other immediately above, all of them positioned at the median depth of the plant. It was concluded that by using the knapsack sprayer, 50% of the deposition volume reached the leaves of the coffee tree, about 30% reached the weeds, and 2% was deposited on the soil. Using the knapsack sprayer with Napoleon's hat, the deposition on the leaves was 70, 10, and 2% lower than the knapsack sprayer without Napoleon's hat on the leaves of the coffee tree, weeds, and soil, respectively. The knapsack sprayer with air induction nozzle presented the highest exodrift for the coffee leaves, the electrostatic sprayer presented less exodrift for the coffee leaves, less deposition on the soil, and greater deposition on the target (weeds).*

Keywords:*application technology; electrostatic; herbicides; drift; Canephora coffea.*

Date of Submission: 01-11-2020 Date of Acceptance: 13-11-2020

I. INTRODUCTION

Coffee culture has been of extreme economic and social importance for Brazil since the colonial period, extending to the present day. It is estimated that the total area planted in the country totals 2.2 million hectares, of which 345.19 thousand hectares (15.6%) with crops in formation and 1.86 million hectares (84.4%) with crops in production (CONAB, 2017). Espírito Santo stands out for the production of the species Coffea canephora Pierre. In that state, we find the largest area with this species, 266.47 thousand hectares, followed by Rondônia, with 83.34 thousand hectares, and Bahia, with 49.12 thousand hectares. According to estimates, in 2017, coffee production (Arabica and Conilon) indicated the harvest of 44.77 million bags of 60 kg of processed coffee (CONAB, 2017).

Coffee production can be affected by several factors such as water availability, soil fertility, pests and diseases, and the presence of weeds. The latter has a negative influence due to competition with coffee plants for light, water, and nutrients, significantly contributing to the increase in production costs and loss of productivity (Ronchi & Silva, 2006; Pais et al., 2011; Carvalho et al., 2014).

The most common means used for weed control has been the application of herbicides, through spraying (Ferreira et al., 2007). However, many times the expected result is not reached, because for the control to be efficient, it is necessary to improved its use, which is not yet a reality in the field. There is a great concern about the active ingredient to be used, and almost no concern regarding the application technology (Rodrigues et al., 2008).

In fact, there is a lack of information about application technologies due to the frequent occurrence of poisoned coffee plants by herbicides in the crops, even with the use of recommended herbicides (Costa et al., 2007).

Usually, weed control is performed with the use of manual knapsack sprayers in small properties, areas of high declivity, and low technological level. In larger properties with a higher technological level, where mechanization is feasible, tractor applications are carried out with hydraulic boom sprayers to control weeds in the inter-rows of coffee crops (Santiago et al., 2017).

Few studies aim to study herbicide exodrift and deposition on the soil and the possible occurrence of phytotoxicity caused by herbicide drift. Therefore, the objective of this work was to quantify the endo- and exodrift and deposition on weeds in simulated herbicide spraying in Conilon coffee inter-rows using different application technologies.

II. EXPERIMENTAL PROCEDURE

The experiment was conducted in a Conilon coffee crop, located at the Experimental Farm of the Universidade Federal do Espirito Santo (UFES) - Campus São Mateus (latitude 18° 40'22.25" S and longitude 39°51'22.37" W, 36 m altitude). The region, of tropical climate, classified as Aw, according to Köppen (1928) classification, presents hot and humid summers and dry winters.

The experimental units were composed of an area of 10 m2 (4×2.5 m) and were implanted in the inter-rows of a Conilon coffee crop, of approximately one year old. The crop had an average height of 1 m and dense spacing of 2.5×1.0 m, totaling a stand of 4,000 plants ha^{-1}. The weed of Eleusine indica (L.) Gaertn., commonly known as goose grass, was predominant in the inter-rows, where the experimental units were installed.

To conduct the experiment, two knapsack sprayers were used, a Jacto manual knapsack sprayer, model SP 20, with a 20L tank capacity, and an electrostatic Jetbras sprayer, model JE8999, with an 18L tank capacity, 12V and 9Ah rechargeable battery, 35-W electric pump with 70 psi, and pressure regulation by potentiometer, which uses the pneumatic principle for the formation and fractionation of droplets, besides using the indirect charge induction method for electrifying the droplets.

The experiment was carried out in a randomized block design in a 4×4 factorial scheme, with four spray equipment compositions (T1 - knapsack sprayer with fan nozzle without “Napoleon’s hat”; T2 - knapsack sprayer with fan nozzle with Napoleon’s hat; T3 - knapsack sprayer with flat-jet nozzle with air induction; and T4 - electrostatic knapsack sprayer) and four collection positions of syrup deposition (weed, soil, lower half of the coffee tree, and upper half of the coffee tree). The sprayer used in the T1 and T2 treatments was equipped with a Teejet F110 SF02 flat fan spray tip. In turn, in treatment T3, the sprayer had the Teejet A110015 spray tip, with air induction. The working pressures were measured, and the calibration of the sprayers was performed to apply a spray volume of 200 to 250 L ha^{-1}, according to the recommended application of the main herbicides used for coffee crops. For the electrostatic sprayer, the position number 06 of the potentiometer was adopted to obtain the proper pressure of the spray tip used.

The environmental conditions were obtained by the meteorological station located on the UFES campus. At the time of spraying, environmental conditions were monitored, and the air speed remained between 0.7 and 4.4 m s^{-1}, reaching gusts of up to 8 m s^{-1} in the predominant southeastern direction, relative humidity above 60%, and air temperature between 23 to 25 ℃. The wind direction was considered, with all spraying carried out in the same direction to minimize action of wind.

To evaluate the spray mix deposition on the weed leaves, the runoff to the soil, and the deposition due to exodrift on the coffee tree leaves, a tracer composed of a blue food dye was used, internationally cataloged by the “Food, Drug & Cosmetic” as FD&C Blue no.1 (Bright blue), at a dose of 400g ha^{-1}, for later absorbance reading in the spectrophotometer. During spray mix preparation, a sample was taken to determine the actual or standard concentration of the dye (Palladini, 2000).

The determination of spray mix deposition on the weeds was done by collecting a complete leaf of the predominant species Eleusine indica (L.) Gaertn from each experimental plot, and then they were packed in plastic bags and properly identified.

The determination of the soil endodrift was performed by positioning a wooden rod containing 14 polyethylene labels of dimensions 0.07×0.03 m spaced 0.02 m in the transverse direction of the inter-row, on the surface of the soil in each experimental unit immediately in the places of greatest weed infestation (Figure 1). After spraying, carried out in two runs – as in this way, the deposition in the displacement commonly performed by the applicators is simulated –, the labels on the rods were collected with the aid of tweezers, packed in identified plastic bags, and stored in a polystyrene box.

Figure 1. Positioning a wooden rod containing 14 polyethylene labels

For the determination of the exodrift, two coffee tree leaves were collected at two heights of the canopy, one from the third or fourth pair of the lower branch and one from the immediately upper branch, in the plant facing the leading row on the left side in the direction of the application, because this was the side with the greatest interference from the prevailing wind, totaling two leaves per experimental unit. These were subsequently packed in identified plastic bags and stored in a polystyrene box.

After spraying, the collected samples were taken to the Laboratório Agronômico de Análise de Solo, Folha e Água (LAGRO) of the Centro Universitário Norte do Espírito Santo of the Universidade Federal do Espírito Santo (CEUNES/UFES). The deposition of the dye in the samples was measured by spectrophotometry.

In the laboratory, 25 mL of distilled water was added to each plastic bag containing the samples; then, the bags were shaken for 30 s to remove the tracer. The liquid resulting from washing each sample was stored in a properly identified test tube. Then, the absorbance readings of these solutions were performed on a Thermo Scientific spectrophotometer, model Genesys 10 UV, set to measure the absorbance at a wavelength of 630 ηm. For this, a 10-mL aliquot was taken from the sample contained in each test tube and placed in a glass cuvette for reading in the pre-calibrated spectrophotometer.

The absorbance values were obtained through the individual reading of each sample in the spectrophotometer and were transformed into concentration (mg.L-1) using the standard curve equation established by 1/100, 1/200, 1/500, 1/1000, 1/2000, 1/5000, and 1/10000 of the spray mix sample collected in the pre-mixing tank, before application. Knowing the initial concentration of the mix (2000 mg.L-1) and the dilution volume of the samples (25 mL), it was possible to determine the dye mass retained on the target and on the other elements.

After removal of the dye, the leaf area of the coffee plant and weed was obtained in square centimeters (cm²) using a Li-Cor leaf area meter model L1-3100. Then, the volume deposited on the leaves was determined using the following equation:

$$C_i \times V_i = C_f \times V_f$$

in which Ci is the initial concentration of the spray mix (2000 mg.L-1); Vi is initial volume to be calculated; Cf is final concentration corresponding to the concentration found in the spectrophotometer reading; and Vf is volume used to wash the leaves. With the deposited volume, the deposition was calculated in microliters of spray mix per square centimeter (μL cm-2) of leaf and polyethylene label surfaces.

The assumption analysis of the normalized unitary deposition data was made. For that, the tests of normality, homoscedasticity, and additivity of the blocks were applied, respectively, by the Kolmogorov-smirnov, Levene, and Durbin-Watson tests. Given the assumptions, the data were subjected to analysis of variance, and the means compared by Tukey's test at 5% probability.

III. RESULTS AND DISCUSSIONS

The analysis of variance (ANOVA) of the deposition data showed a significant interaction between the equipment used and the collection position of spray mix deposition (Table 1).

Table 1.Analysis of variance of the spray mix deposition in different collection positions and application equipment

Variation source (VS)	Mean square (MS)	F test
Sprayer (S)	8.769	122.36**
Collection position of deposition (DC)	0.745	10.394**
S×DC	0.209	2.913*
Treatments	2.028	28.299*
Residue	0.071	
CV = 34.3%; KS = 0.886*; F_{Leneve} = 2.603^{ns}; DW = 1.783^{ns}; $F_{pulv/ratio}$ = 12.781*; $F_{position}$ = 12.190*; $F_{interaction}$ = 18.005*		

CV = coefficient of variation; KS = statistics of Kolmogorov-Smirnov tests with Lilliefors correction for normality of residues; FLevene = Levene test for homogeneity of variances; DW = Durbin-Watson test for residue independence; F = F test; ns - normally distributed residues, homogeneous variances, independent residues, and acceptance of the H0 hypothesis (p<0.05); * Residues not normally distributed, non-homogeneous variances, non-independent residues, and rejection of the H0 hypothesis (p>0.05). ** Significant at the 1% probability level (p<0.01); * Significant at the 5% probability level (p<0.05).

The coefficient of variation value (34.3%; Table 1) is due to the fact that, in field applications, it tends to increase because of inherent climatic conditions at the time of application and/or disorderly movements of the applicator.

Table 2. Comparison between the deposition means of the interaction application equipment and collection position

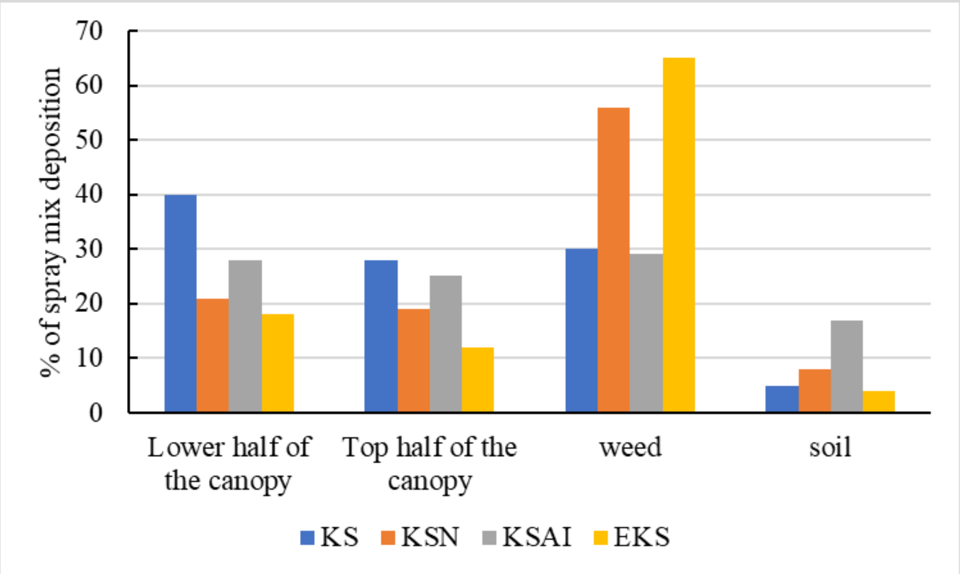
	Position of deposition collection (µL cm^{-2})			
Sprayer	Lower half of the coffee tree	Upper half of the coffee tree	Weed	Soil
KS	1.254 aA	0.829 bA	0.939 bA	0.053 bB
KSN	0.317 cA	0.306 cA	0.844 bA	0.052 bB
KSAI	1.198 bB	1.062 aB	1.213 aA	0.776 aC
EKS	0.154 cB	0.109 cB	0.554 cA	0.023 cC

Means followed by the same lowercase letter in the column and uppercase in the row do not differ at the 5% probability level. KS = knapsack sprayer; KSN = knapsack sprayer with “Napoleon’s hat”; KSAI = knapsack sprayer with air induction nozzle; EKS = electrostatic sprayer.

There was no significant difference in the spray mix deposition in relation to the collection positions, except for the soil, which received less product, with 0.053 and 0.052 µL cm^{-2} when using the manual knapsack sprayer with fan nozzle, with and without the Napoleon’s hat accessory, respectively (Table 2). Spraying with a flat jet nozzle with air induction provided less spray mix deposition on the coffee plant leaves, differing significantly from the amount deposited on the weed and soil, in which the deposition on the weeds was greater, with 1.213 µL cm^{-2} and on the soil was lower with 0.776 µL cm^{-2}. For the electrostatic sprayer, there was a significant difference between the collection positions, which allowed a greater deposition on the weed (0.554 µL cm-2) and lower deposition on the soil (0.023 µL cm^{-2}).

When using the backpack sprayer with a fan nozzle without the Napoleon’s hat accessory (Figure 2), it was observed that 67.8% of the spray mix was deposited on the leaves, 40.8% on the lower half, 27% on the upper half of the coffee plant, 30.5% on the weed, and 2% on the soil. With the same sprayer and nozzle, however, now using the Napoleon’s hat accessory, there was a reduction in the exodrift, with 41% deposition on the leaves, 20.9% on the lower half, and 20.1% on the upper half of the coffee plant, 55.6% on the weed, and 3.4% on the soil.

Figure 2. Representative histograms of algorithm estimates expressing the spray mix deposition percentage applied by the different application technology settings.



KSAI = knapsack sprayer with air induction nozzle; KS = knapsack sprayer; KSN = knapsack sprayer with Napoleon's hat; EKS = electrostatic sprayer.

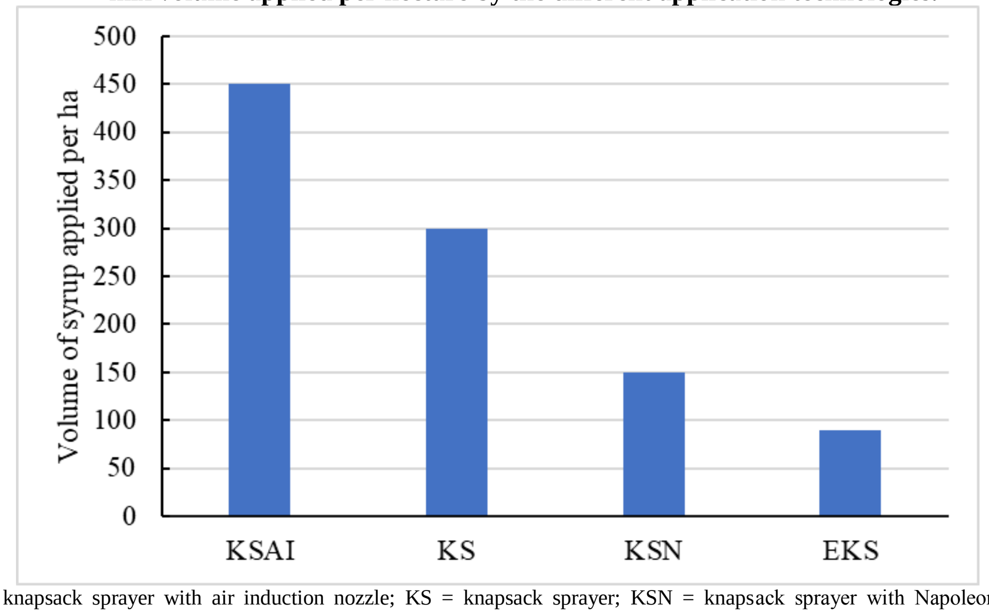
This reduction in exodrift shows that the Napoleon's hat accessory succeeded in directing the jet towards the weeds, contributing to reduce drifts, as demonstrated by Costa et al. (2014), who evaluated the effect of glyphosate, paraquat, and glufosinate-ammonium applied in directed jets in the initial development of Jatropha curcas and observed phytointoxication of up to 72% when using the backpack sprayer without Napoleon's hat.

When using the backpack sprayer with a flat jet nozzle with air induction, there was a deposition of 53.2% of spray mix on the leaves, 28.2% on the lower half, and 25% on the upper half of the coffee plant, 28.6% on the weed, and 18.3% on the soil. Even with the highest mix volume applied (425 L ha^{-1}) (Figure 3), this equipment provided the lowest deposition on the target. The greatest runoff to the soil corroborates the results found by Silva et al. (2014), who tested two types of nozzles (hollow cone spray and hollow cone spray with air induction) for spraying coffee tree with a hydropneumatic sprayer, driven by a tractor, and verified greater runoff to the soil when using the air induction nozzle. The authors attributed this result to the larger droplet size produced by this nozzle.

Spraying with the electrostatic sprayer provided a deposition of 31.3% of spray mix on the leaves, 18.3% on the lower half, and 13% on the upper half of the coffee plant, 66% on the weed, and 3% on the soil. With a lower volume of spray mix applied (84 L ha^{-1}) (Figure 2), the electrostatic sprayer had the best result in terms of application to the target. Gitirana Neto et al. (2016), confirmed that the electrostatic technology is viable at low application rates, since when comparing different volumes, they found no significant difference between treatments. This result allows us to infer the possibility of gains from saving water and phytosanitary products.

Herbicide absorption is higher in new leaves than in older leaves. In older leaves, the increase in cuticle thickness increases the resistance to penetration. In addition, the younger leaves have greater metabolic activity, consuming nutrients more quickly in the synthesis processes, thus reducing their internal ionic state. On the other hand, lipoid substances can be absorbed more easily by old leaves, due to the greater amount of wax and cutin in them (Taiz et al., 2017). However, the concern with reducing the herbicide exodrift to coffee leaves is of fundamental importance for greater application efficiency and risk reduction of phytotoxicity in the coffee crop.

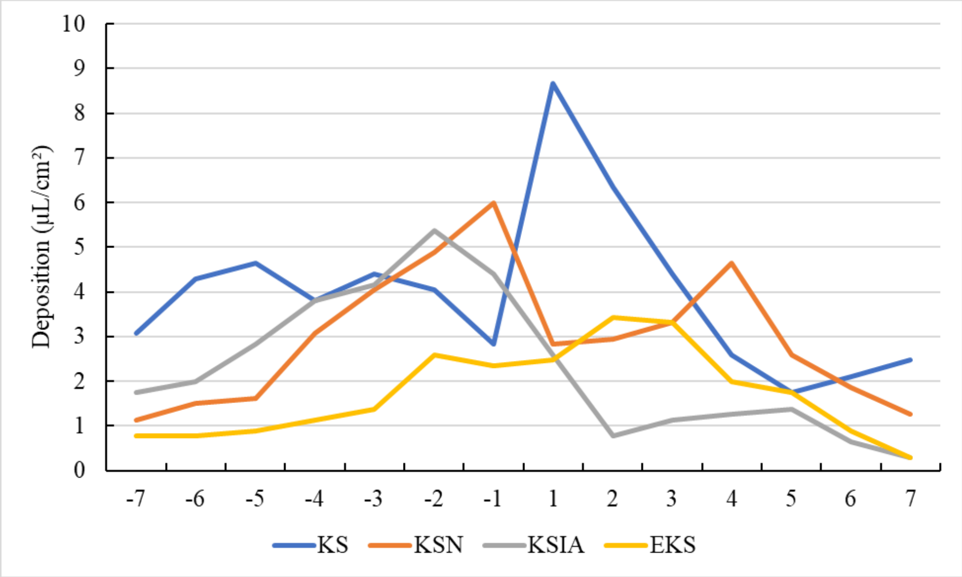
Figure 3. Representative histograms of the algorithm estimates expressing the total estimation of spray mix volume applied per hectare by the different application technologies.



KSAI = knapsack sprayer with air induction nozzle; KS = knapsack sprayer; KSN = knapsack sprayer with Napoleon's hat; EKS = electrostatic sprayer.

In the qualitative analysis of the spray mix deposition, a difference in its distribution was observed in both treatments (Figure 4), which represents the average mix deposition per unit area (μL cm-2) of all blocks. This analysis shows the behavior of the spray profile and the mix deposition on the soil corresponding to each treatment.

Figure 4. Volumetric distribution profile of spray mix on the ground.



KS = knapsack sprayer; KSN = knapsack sprayer with Napoleon's hat; KSAI = knapsack sprayer with air induction nozzle; EKS = electrostatic sprayer.

Due to the characteristics of the air-induction nozzle and the non-uniformity of weeds between the rows of the experimental units, greater deposits of spray mix on the soil were observed. However, it is well known that the treatments KS (knapsack sprayer) and KSN (knapsack sprayer with Napoleon's hat) showed the most uneven deposition profiles when compared with the others.

IV. CONCLUSION

The knapsack sprayer with fan nozzle without the Napoleon's hat accessory presents the greatest exodrift for coffee leaves; however, it has the lowest deposition on the soil.

The knapsack sprayer with fan nozzle with Napoleon's hat increases mix deposition on weeds and reduces exodrift; however, it does not alter the runoff to the soil.

The knapsack sprayer with a flat jet nozzle with air induction showed the lowest values in terms of spray mix deposition on the target (weed); however, the runoff to the soil was greater.

The electrostatic sprayer provided less exodrift for the coffee leaves, greater deposition of spray mix on the weeds, and low deposition on the soil.

Conflict of interest

There is no conflict to disclose.

ACKNOWLEDGEMENT

The authors are grateful to the "Espírito Santo Research Support Foundation"- FAPES

REFERENCES

[1]. Abdulla, I.Q., 2014. Synthesis and antimicrobial activity of Ibuprofen derivatives. Natural Science 6, 47–53.Agairupdate (2000) El sistema de pulverización electrostática trae carga a la aviación agrícola. AgAirUpdate Latinoamerica, Perry, v.3, 3:14-15.

[2]. Arantes R et al. (2006) Uniformidade de distribuição volumétrica de pontas de pulverização de jato plano duplo com indução de ar. Pesquisa Agropecuária Tropical, 36 (1):61-66

[3]. Barbosa BFF (2011) Controle de Ipomoea nil utilizando ponta centrífuga de pulverização em diferentes volumes de aplicação com e sem adjuvante. Rev. Bras. Herb., 10 (3): 277-290.

[4]. Bauer, FC.; Raetano, CG & Pereira, F. de AR (2006) Padrões de distribuição volumétrica de pontas de pulverização de jato plano 11002, com e sem indução de ar, sob diferentes espaçamentos e alturas. Engenharia Agrícola, Jaboticabal, 26(2):546-551.

[5]. Blanco FMG & Velini, ED (2005) Persistência do herbicida sulfentrazone em solo cultivado com soja e seu efeito em culturas sucedâneas. Planta Daninha, Viçosa, 23(4):693-700.

[6]. Carvalho FP et al. (2014) Sensibilidade de plantas de café micorrizadas à herbicidas. Revista Brasileira de Herbicidas, Londrina, 13(2):134-142.

[7]. Chechetto RG et al. (2013) Influência de pontas de pulverização e adjuvantes no potencial de redução de deriva em túnel de vento. Semina: Ciências Agrárias, Londrina, 34(1):37-46.

[8]. Conab (Companhia Nacional de Abastecimento) (2017) Acompanhamento da safra brasileira V. 4 - Safra 2017 - n.3 Terceiro levantamento. Disponível em: <http://www.conab.gov.br/OlalaCMS/uploads/arquivos/17_09_21_17_00_05_cafe_setembro_2017.pdf>. Acesso em 05/10/2017 às 16:22.

[9]. Costa AGF et al. (2007) Efeito da intensidade do vento, da pressão e de pontas de pulverização na deriva de aplicações de

herbicidas em pré-emergência. Planta Daninha, Viçosa, 25(1):203-210.
[10]. Costa, NV et al. (2008) Efeito de pontas de pulverização na deposição e na dessecação em plantas de Brachiaria brizantha. Planta Daninha, Viçosa-MG, 26(4):923- 933.
[11]. Costa, NV et al. (2014) Efeito de herbicidas aplicados em jato dirigido no desenvolvimento inicial de plantas de pinhão-manso. Revista Brasileira de Herbicidas, 13(1):8-14.
[12]. Cross JV et al. (2001) Spray deposits and losses in diferente sized apple trees from an axial fan orchard sprayer: 2. Effects of spray quality. Crop Protec., 20(2):333-343.
[13]. Faggion F & Antuniassi UR (2004) Ar na aplicação. Cultivar Máquinas, Pelotas, Ano IV, 26:12-15.
[14]. Ferreira MC et al. (2007) Fatores qualitativos da ponta de energia hidráulica ADGA 110015 para pulverização agrícola. Eng. Agríc., Jaboticabal, 27(2):471-478.
[15]. Figueredo SS et al. (2007) Influência de doses reduzidas do glyphosate no tomateiro (Lycopersicon esculentum Mill.). Planta Daninha, 25(3):849-857.
[16]. França JAL (2016) Caracterização de gotas e risco potencial de deriva de aplicações de produtos fitossanitários. Dissertação de Mestrado. Universidade Federal de Uberlândia, Uberlândia. 65p.
[17]. Köppen W & Geiger R (1928) Klimate der Erde. Gotha: Verlag Justus Perthes. Wall-map 150cmx200cm.
[18]. Maciel CDG et al. (2008) Possibilidade de aplicação de misturas de herbicidas de ação total com jato dirigido em mamoneira de porte anão. Planta Daninha, 26(2):457-464.
[19]. Malavolta E (2006) Manual de nutrição mineral de plantas. São Paulo: Agronômica Ceres, 2006. 638 p.
[20]. Matthews GA (1989) Electrostatic spraying of pesticides: a review. Crop protection, 8:3-15.
[21]. Matthews GA (2000) Pesticide application methods. Malden: Blackwell. 432p.
[22]. Palladini LA (2000) Metodologia para avaliação da deposição em pulverizações. Tese de Doutorado. Universidade Estadual Paulista, Botucatu, SP. 111p.
[23]. Pais PSM et al. (2011) Compactação causada pelo manejo de plantas invasoras em Latossolo Vermelho-Amarelo cultivado com cafeeiros. Revista Brasileira de Ciência do Solo, Viçosa, 35(6):1949-1957.
[24]. Rigoli RP et al. (2008) Resposta de plantas de beterraba (Beta vulgaris) e de cenoura (Daucus carota) à deriva simulada de glyphosate. Planta Daninha, 26(2):451-456.
[25]. Rodrigues GJ et al. (2008) Características do fluxo de ar de um pulverizador hidropneumático para aplicação de agroquímicos em plantas arbustivas. Engenharia na Agricultura, Viçosa, MG, 16(2):199-207.
[26]. Ronchi CP & Silva AA (2006) Effects of weed species competition on the growth of young coffee plants. Planta Daninha, 24(2):415-423.
[27]. Teixera MM (1997) Influencia del volumen de caldo y de la uniformidad de distribución transversal sobre la eficacia de la pulverización hidráulica. Tese de Doutorado. Escuela Técnica Superior de Ingenieros Agrônomos, Universidad Politécnica de Madrid, Madrid. 310p.
[28]. Tuffi Satos LD et al. (2007) Crescimento do eucalipto sob efeito da deriva de glyphosate. Planta Daninha, 25(1):133-137.
[29]. Viana RG et al. (2007) Características técnicas de pontas de pulverização LA-1JC e SR-1. Planta Daninha, 25(1):211-218.

João Vitor Sossai, et. al. "Deposition and endo- and exodrifts in simulated herbicide spraying in Conilon coffee inter-rows." *International Journal of Engineering and Science*, vol. 10, no. 11, 2020, pp. 38-44.