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Effect of Electrostatic Spraying on Simulated Fungicide Deposition in Papaya Fruits

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Abstract:
Background: Brazil is the world's second largest producer of papaya, behind Mexico and India, respectively. Among the main consumers of Brazilian fruit are the United States, England, Germany and Portugal. The species Carica papaya is the most cultivated in the world. However, papaya is constantly infested and attacked by diseases and pests.
Materials and Methods: The experiment was carried out in experimental area of papaya, cultivated with the species Carica papaya of the formosa group, belonging to the Experimental Farm of CEUNES / UFES in São Mateus – ES, Brazil.. The experiment was conducted in a 4 x 2 x 2 factorial scheme, with two distances (10, 20, 30 and 40 cm), two faces (exposed face and the back of the fruit near the stem) two spray systems (Electrostatic system connected and off) and four replicates, totaling 64 experimental units. The deposition of the syrup on the exposed face and the back of the fruit near the stem were evaluated
Results: In the evaluation of the efficiency of deposition of the application, considering the side of the fruit, it was verified that the back of the fruit next to the stem, side not exposed to the spray receives a deposition at least 10 times smaller than the exposed side. The higher deposition value presented on the exposed side indicates application inefficiency, in addition it is observed that the deposition decreases with the application distance. The range with the highest application efficiency for the deposition of syrup is 10 to 20 cm of the fruit. There is low deposition of syrup on the unexposed side of the fruit. In the climatic conditions presented in this experiment, the application with electrostatic sprayer is not efficient.
Key Word:Carica Papaya, Application distance, Spray

I. Introduction

Brazil is the world's second largest producer of papaya, behind Mexico and India, respectively. Among the main consumers of Brazilian fruit are the United States, England, Germany and Portugal. The species Carica papaya is the most cultivated worldwide[1]. According to the Confederation of Agriculture and Livestock of Brazil (CNA), Brazilian production is 1.5 million tons, in an area of 32 thousand hectares, which generates productivity close to 50 tons per hectare. In addition to Espirito Santo, Bahia, the largest national supplier, and Rio Grande do Norte stand out in the activity[2].Papaya is constantly infested and attacked by diseases and pests, the most economically important being the Papaya Mosaic, Meleira Virus, Tipping or Damping-off, Powdery Mildew, Smallpox or Pinta Preta, Anthracnose, Mealybugs, Fruit Fly, among others. When papaya is affected by any of these agents, it is necessary to care, due to the damage they can cause, such as a drop in production and quality of the harvested fruits and, consequently, losses[3, 4].

The search for reducing the environmental impacts caused by agriculture, as well as a strong demand for alternatives that allow its sustainability, has been increasingly accentuated. The method of application of pesticides most used today is extremely wasteful, therefore not suitable for the new proposed paradigm[5].

Difficulties are observed in the application of pesticides in the papaya crop, due to its architecture, height and fruit insertion, and it is necessary to seek and improve new technologies already used in other crops, in order to minimize environmental impacts[6]. Among these technologies, the application of pesticides with electrostatic sprays has been highlighted, due to its efficiency of application and deposition.

When spraying in the field, it is expected that the distribution of the application solution will allow the greatest possible uniformity in the plant, however, this is not always possible[7]. Spraying with a reduced droplet diameter provides a better dispersion of the same on the leaf surface, obtaining a greater density of droplets on the target and reducing the volume of spray that will be applied per unit of area. When referring to electrostatic spraying, the smaller the diameter of the droplets, the easier to be loaded, however, drops with reduced size, in the condition of low relative humidity and high temperatures, can cause evaporation[8]. Small droplets are subject to a high risk of drift, as they are more likely to deviate from the application range compared to application with larger droplets[9].

Several studies have demonstrated the advantages of electrostatic spraying. According to Hislop (1988), a 50% reduction in the use of pesticides is possible, maintaining their biological effectiveness in phytosanitary treatments, corroborating the data[10], working in orchards, found an increase in deposition with the electrostatic system of up to 50%, compared to conventional spraying systems. Evaluating the electrostatic application in peppers[11] achieved similar results, using application volumes six times smaller than those used in conventional treatments. [12]found that, depending on the size of the plant, electrostatic spraying can provide an increase in deposition by up to 2.51 times compared to conventional spraying in apple trees.

However, despite the great potential of this sprayer, there are studies carried out with electrostatic spraying that did not improve the application of pesticides, such as those carried out by[13] in the rice crop, which found lower penetration of droplets inside the crop and lower droplet densities, compared to other spraying systems. [14]Evaluated the electrostatic spraying on citrus and found that the electrostatic spraying did not provide an increase in the deposition of the application solution. Therefore, the objective was to evaluate the spraying electrostatic spray, with costal electrostatic sprayer, regarding the efficiency in the deposition of the application solution on papaya fruits.

II. Material And Methods

The experiment was carried out at the Experimental Farm of the North University Center of Espirito Santo, at the Federal University of Espirito Santo, Brazil, latitude 18º40' 25"S, longitude 40º 51' 23" W. The climate of the region is hot and humid, type Aw, with dry season in autumn-winter and rainy season in spring-summer, according to the Köppen classification.. The papaya plants were 17 months old. The soils in the region are predominantly Dystrophic Yellow Argisols, with a medium sandy texture.

The experiment was carried out in a 4 x 2 x 2 factorial scheme, with four distances (0.10, 0.20, 0.30 and 0.40 m), two faces (exposed side and non-exposed side of the fruit) two spraying systems (electrostatic system on and off) and four replications, totaling 64 experimental units (Figure 1).

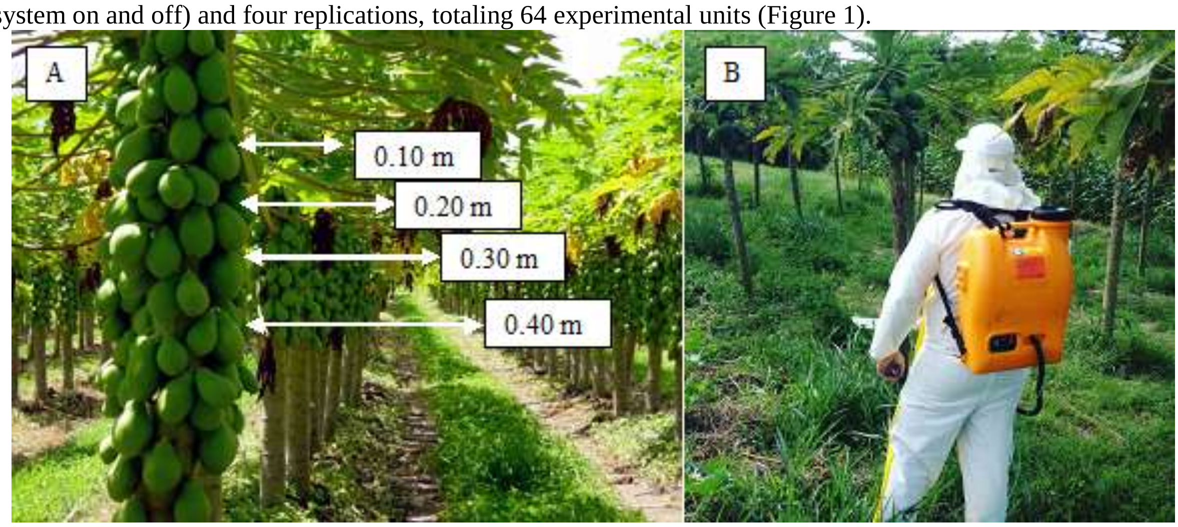

Figure 1. (A) application distances, (B) electrostatic backpack sprayer.

An electrostatic sprayer, *JetBras* brand, with a tank capacity of 18 L was used. This sprayer uses the hydraulic principle for the formation and fractionation of drops, in addition to using the indirect charge induction method for the electrification of drops. For the preparation of the syrup, good quality water and the Blue Brilliant dye were used in the dilution of 3g L^{-1}.

In the field, the equipment flow was adjusted to 0.56 $Lmin^{-1}$ and calibration was carried out to apply a spray volume of 400 $L.ha^{-1}$. In all sprayings, the sprayer motor was set at maximum acceleration, spraying was carried out, considering two methods: 1- Electrostatic system on and 2- Electrostatic system off.Before spraying, the fruits were labeled with polyvinyl chloride (PVC) labels measuring 0.07 m in length and 0.07 cm in height, with an area of 35 cm^2, on the exposed face and on the back of the fruit near the stalk. A sample of the solution was also removed for later calibration of the standard solution in the laboratory. At the time of spraying, environmental conditions were monitored and the air speed was 0.9 m/s, relative humidity of 88% and air temperature between 23.0 and 18.9°C. The sprays were carried out on random fruits, in the direction of the wind, applying to the exposed front of the fruit, the exposed face of the fruit was adopted as the display surface and the back part close to the stem.

The collected labels were placed in plastic bags in a styrofoam box, washed in 25 mL of distilled water and the absorbances determined in the spectrophotometer. Then, the deposition of the dye per unit of area was determined in the LAGRO (Laboratory of Agronomic Analysis) according to the methodology proposed by[15], using the Blue Brilliant dye in the dilution of 3g L^{-1} as a tracer (Figure 2). The data were submitted to analysis of variance by the F test ($p<0.05$) and the means were compared by the Tukey test ($p<0.05$), with the aid of the Assistet statistical software.

Figure 2. Tracer dye deposition analysis from sample preparation to spectrophotometer analysis

III. Result

Table 1 presents the analysis of variance of the syrup deposition data on papaya fruits.

Table 1. Analysis of variance of spray deposition data on papaya fruits as a function of application distance, operating condition and fruit side.

source of variation	medium square	Test F
application distance (D)	7,800	11,324
operating condition (C)	0,604	$0,877^{ns}$
fruit side (L)	59,903	86,960**
D x C	0,132	$0,198^{ns}$
D x L	4,111	5,964**
C x L	0,357	$0,519^{ns}$
D x C x L	0,110	$0,161^{ns}$
Trataments	6,488	9,419**
Error	0,689	
CV = 69,57%		

**significant at 1% probability level; ^{ns}not significant at the 1% probability level

Table 2 presents the results of the comparisons of the deposition averages of the papaya fruit.

Table 2. Average spray deposition on the papaya fruit side

Side of fruit	Deposition (μL cm^{-2})
exposed side	2,16 a
unexposed side	0,23 b

Means followed by the same letter do not differ from each other at 1% probability by the F test.

Figure 3 shows the behavior of sprayed syrup deposition on the fruit, regardless of the exposed face.

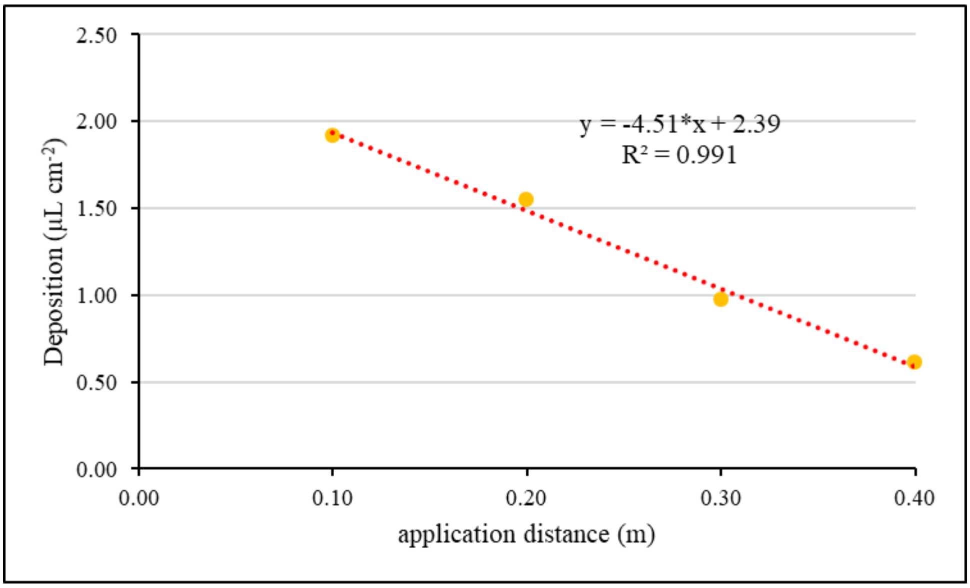

Figure 3. Spray deposition on papaya fruits as a function of application distance.

Table 3 shows the sprayed solution deposition as a function of the application distance and exposed face of the papaya fruit.

Tabela 3. Spray deposition (µL cm^{-2}) on the papaya fruit side as a function of application distance

application distance (m)	Fruit side in relation to spraying	
	exposed side	unexposed side
0,10	3,44 a	0,53 b
0,20	2,75 a	0,22 b
0,30	1,78 a	0,11 b
0,40	0,67 a	0,04 a

Means followed by the same letter on the line do not differ at the 5% level of significance by Tukey's test.

IV. Discussion

The analysis of variance (ANOVA) of the deposition data shows that there was a significant difference in relation to the deposition of syrup on the fruit side alone and in the interaction with the distance (Table 1).

These ANOVA results were noted in part by [7, 10], the first studying deposition on coffee leaves and the second on artificial targets, both in the laboratory. In these works, the efficiency of electrostatic spraying on when compared with the same off was evidenced. The fact that similar results were not observed in this work is due to the influence of weather conditions at the time of application, mainly due to the wind which, although it was within the range suggested by ISO at the time of application, varied considerably in direction. Another factor that must be taken into account is that the application rate favored very fine droplets, susceptible to drift.

In the evaluation of the deposition efficiency of the application, considering the fruit side, it was found that the side not exposed to spraying receives a deposition at least 10 times lower than the exposed side (Table 2).

Figure 3 presents the deposition results as a function of the application distance. It is possible to observe that the greater the distance, the lower the spray deposition.

The highest deposition value presented on the exposed side indicates application inefficiency, in addition, it is observed that deposition decreases with application distance at a rate of 5.4, that is, for every 0.10 of application distance, deposition decreases 5.4 times. Climatic factors at the time of application, the size of droplets produced and the interaction with the application distance (Table 3) are explanations for this difference.

Analyzing the interaction between application distance and fruit side, the same decreasing trend of deposition is observed, that is, greater deposition in the part of the fruit exposed to spraying. This was possibly due to the fact that the electrified drops tend to settle at the closest possible point. Similar results were found by [13,16].

V. Conclusion

According to the results obtained, it is concluded that the best application range for spray deposition is 10 to 20 cm from the fruit. There is no good spray deposition on the unexposed side of the fruit. Application with electrostatic spray is not efficient in the climatic conditions presented in this experiment.

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