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AERIAL AND GROUND APPLICATION OF FUNGICIDE IN CORN SECOND CROP ON DISEASES CONTROL

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ABSTRACT: The aim was to evaluate the diseases severity on corn second crop. The research was conducted on the agricultural year of 2013 and 2014, evaluating the application quality over the fungicide spraying. The hybrid used was PIONEER 30k75 BT HERCULEX, evaluating the diseases severity previously and after the fungicide spraying, spray deposition on the culture and productivity. The aerial application was carried out with solution volume of 7.5, 13.5, 20 and 30.3 L ha^{-1}, using automatic rotating nozzles, and the ground application with 90, 110, 130 and 150 L ha^{-1}, uniform flat spray tips. As control a non-fungicide treatment was used. The aerial and soil treatment showed diseases control from the corn crop, being the biggest cover of drops acquired at the volumes 30.30 L ha^{-1} for aerial and 150 L ha^{-1} for soil, with no significant change on the productivity of the corn harvest for both forms of spraying: aerial or soil.

KEY WORDS: farming plane, corn productivity, spraying.

INTRODUCTION

The corn second crop (*Zea mays*) is subject to attack by pathogens that can cause considerable losses in productivity (COSTA et al., 2012).

According to BRITO et al. (2011), fungal diseases can reach up to 80% of loss in corn productivity. Among the most important leaf diseases, there are the leaf spot, brown eye spot, southern and tropical rusts. In addition to these, diseases such as leaf anthracnose and Diplodia leaf spot, considered of minor importance, have occurred, in the last decade, at high severity in some producing regions.

Traditionally, the management of corn diseases was carried out by the use of resistant cultivars associated to crop measures. From the severe epidemics that happened in 2000, the use of fungicide in the diseases control, especially the leaf diseases, became almost mandatory for the crop viability, verifying a sharp increase in its use in commercial crops for the production of grain across the country (BARROS, 2011).

For the successful application of the fungicide, in addition to recognizing the nature of the product, it is also necessary to master the appropriate application form to ensure that the product efficiently reaches the target. The application technology aims to deposit the crop protection product at the desired target, in proper amount, economically and with minimal contamination to the environment (VIANA, et al., 2010).

Among the technologies used in large-scale in agriculture for spraying, there are the aerial applications, using agricultural aircraft, and ground sprayers equipped with bars. The ground spraying is the method most commonly found in agricultural regions, but the spraying with aircraft is a reality in the country, mainly due to their increased operational capacity in relation to ground application.

Whereas, the aerial technology leads to questions, especially between producers, in relation the volume used by the aircraft, the capacity of penetration and deposition of agrochemical drops in the plant canopy, since the rates are relatively small when compared to the solution volume (Lha^{-1})

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used by the ground sprayer (OLIVEIRA et al., 2010).

In the past, this could only happen when the crop received large volumes of solution per area. However, the tendency is to reduce the volumes to be applied, avoiding the encumbrance on application costs, losses by drainage and reduction of soil contamination (ANTUNIASSI & BOLLER, 2011).

The choice between aerial or ground technology has to do especially with the operational choices of the farmer and the general characteristics of the property. Both aerial and ground application are efficient and effective tools in the spraying, but their settings must be properly adjusted, the machinery in good condition, so the spraying aim is achieved without causing damage and not exceeding the environmental limits (CUNHA et al., 2011).

Thus, this research aimed to evaluate the quality of aerial and land fungicide application in corn second crop, using parameters related to application technology, control in the diseases severity and its effect on grain yield.

MATERIAL AND METHODS

The experiment was carried out in the São Bento farm, municipality of Goioerê, Northwest in the state of Paraná, with center coordinates of latitude 24°12’57.48” S and longitude 52°56’06.58” E and altitude of 519 meters. The essays were conducted in a commercial crop in 2013 and 2014 in corn second crop. The planting was carried out with Pioneer 30K75 BT Herculex corn hybrid, spaced 0.45 m between rows and 2.5 plants per linear meter. The crop sowing date in the first year of research was between March 17th and 19th, 2013 and between February 21st and 24th, 2014 in the second year.

The basic fertilization was carried out with the NPK 10-28-16 formulated at the dose of 250 kg ha^{-1} according to soil analysis and technical recommendation. In seed treatment, the product (Fipronil 250 g L^{-1}, Thiophanate-Methyl 225g L^{-1}; Pyraclostrobin 25g L^{-1}) was used in a ready mixture at a dosage of 50+45+5g.ia for each 100 kg of seed. The invasive plants control was carried out at ten days after crop emergence with the herbicide (Atrazine 400 g L^{-1}) in the dose 1.400g.i.a ha^{-1}.

The research was conducted in bands in the horizontal direction of the ground, due to the difficulty in carrying out applications with the aircraft and the area was about 800 meters long. The design used was the completely randomized, with Regression analysis for quantitative data and average test for qualitative data.

Each plot of the treatment was represented by different volumes tested for the aerial and ground application. The experiment consisted of nine treatments, four replications. In the aerial application, four volumes of spray were tested (7.5, 13.5, 20, and 30.3 L ha^{-1}) and for the ground application, four other solutions (90; 110; 130 and 150L ha^{-1}). The ninth treatment was the control without fungicide. Four flights of the aircraft formed each plot in the aerial treatment. Individually the plots showed distinct size (m²) because the plots wide bands alter with the change of the volume applied by the plane (Figure 1). In the ground equipment, the size of each plot was only 21.600 m^2 (27x800), represented by a single pass of the equipment. Unlike the aircrafts, the ground sprayers do not change the band size with the change of the volume.

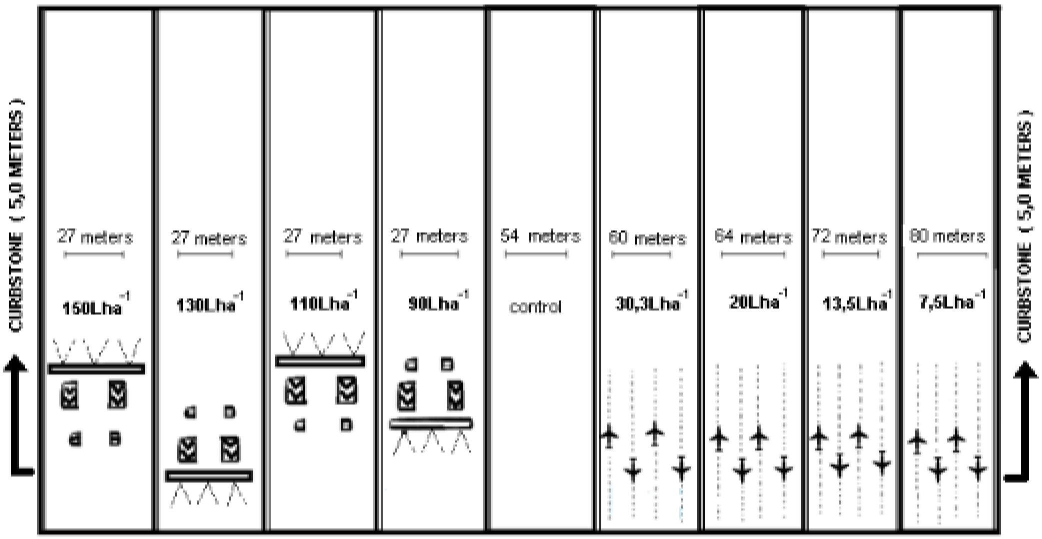

FIGURE 1. Sketch of the experimental area in two years of treatment (2013 and 2014).

The systemic fungicide of ready mixture containing strobilurin (200 g L^{-1}) and triazole (80 g L^{-1}) at a dose of 60 + 24g.i.a.ha^{-1} was used. Along with the fungicide, vegetable oil was added at a dose of 1.0 L ha^{-1} for aerial spraying and in the ground application, the adhesive spreader in 0.5L dose was used for each 100 liters of spray.

In the ground application was used a self-propelled, Stara brand, Gladiator model, equipped with 21 m bars, electronic flow controller, spacing of 0.5 m between nozzles (AVI11002 jet), free span height 1.55 m and with spraying speed of 8 Km h^{-1}. The aircraft, Ipanema 202A model, configured with eight rotary atomizers, Micronair brand, working speed of 160 Km h^{-1} (100 miles h^{-1}) and flight height above the plant canopy of 3.5 m.

The temperature conditions, relative humidity and wind speed were monitored at the application time, with favorable conditions for the fungicide application: relative humidity 81%, temperature 21°C and wind speed between 2 and 4.6 km h^{-1} in the first year. In the second year of research, the relative humidity was 76%, temperature of 22 °C and wind speed between 4 and 6 km h^{-1}.

The fungicide application happened between the V10 and VT stages (pre-silking) of the crop. For the study of drop deposition, volume median diameter (µm), drops density (cm2), drops coverage (%) and application volume (L ha^{-1}) were analyzed, fixing water sensitive paper in the lower, middle and high third in the adaxial leaf side of each plant. After the application, they were collected and deposited in thermal packaging, and later their images were captured by the scanner at resolution of 600 DPI, to be evaluated by the Gotas® Software.

In the first year of experiment (2013), at 21 days that preceded the fungicide application, the disease evaluation severity began with an interval of five days between each survey up to the application moment, totaling four evaluations. The crop was in the V6 to V8 stage (six to eight developed leaves), which were randomly marked six plants per plot (with yellow color spray paint) totaling 24 plants analyzed for the aerial application and 24 plants for ground application and six plants in the control. In the second year of the experiment (2014), besides the diseases evaluation at 21 days prior to the spraying, diseases evaluation were also carried out after the application with the fungicide, starting at five days after the application and ending at 21 days.

The diseases evaluations were carried out by three Agronomists, in which they went alone to the analysis, using a diagrammatic scale proposed by CHESTER (1950).

When the crop was in the maturity stage, the corn productivity was quantified. Within each plot, it was randomly marked with signaling flags, four areas (repetitions) with 2.25 m² of size. All the corncobs in these repetitions were collected (average of 10 plants/repetition), threshed and its humidity adjusted to 13% for the weight determination of 100 grains and productivity.

The obtained results were submitted to analysis of variance and the averages were compared using regression analysis in the two years of research.

RESULTS AND DISCUSSION

The results obtained of the quality variables in the ground application in the first year of experiment are shown in Figure 2. In study criteria, the upper, middle and lower third covers of corn culture were analyzed, however, in 2013; the middle third evaluation was compromised because of the considerable loss of the sensitive paper in the field operation, obtaining only the results of the upper and lower thirds.

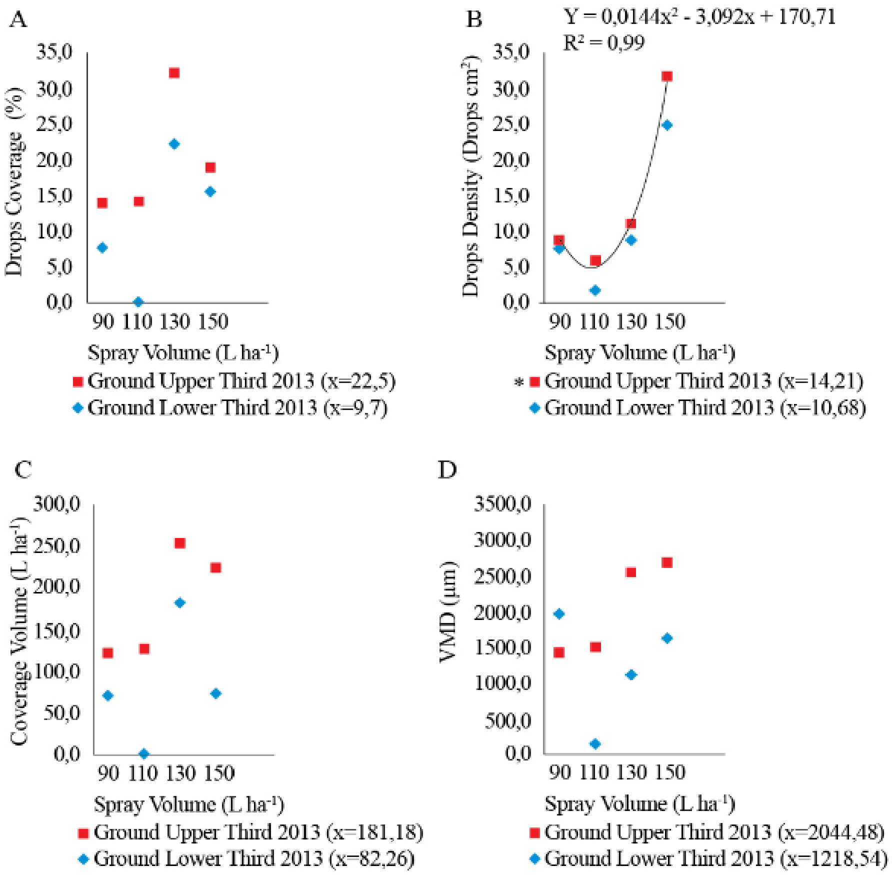

FIGURE 2. A. Drops Coverage (%) B. Drops density (drops cm²) C. Coverage volume (L ha¹) D. VMD (µm), after ground spraying in the upper and lower third of the corn in 2013. Turkey test *Significant (P<0.05).

There was significant difference (P <0.05) in the drops density variable (drops number cm^{-2}) in the upper third of the crop, when compared to the lower third, showing the largest number of drops in the application rate of 150 L ha^{-1}. Greater drops coverage (%) and volume coverage (L ha^{-1}) were also found in the upper thirds of the crop in application volume of 130 L ha^{-1}.

These results were expected, since the upper third is closer to the drop release point. The umbrella effect, formed by the upper leaves, should be considered because it may interfere with the fungicide spray distribution to the lower third. These results are in agreement with CUNHA et al. (2010) that carried out fungicide application in corn and found similar results.

VMD values above 1000 µm were found in ground application for the 2013 year, not showing significant difference between the thirds of the crop at the 5% level. These values are far above the averages found in similar studies cited by the literature about the fungicide spraying.

Possibly, the explanation of the high VMD values is the occurrence of drops with extremely large size, produced by tips with air induction used in ground application, causing dripping on the surface of the sensitive paper, hampering the analysis of the drop spectrum, making impossible an analysis with credibility by the software used. This same factor may have influenced the analysis on the drops density, especially in smaller application rates (Figure 2B), showing drops below the minimum density (45 drops cm $^{-2}$) for a good effectiveness of systemic fungicides.

In relation to the aerial spraying, any variable analyzed showed a significant difference in relation to the thirds of the corn culture (Figure 3).The aerial treatment shows lower values of drops coverage, drops density, coverage volume and VMD when compared to the ground application results.

BAYER et al. (2011) studying the drops spectrum in the aerial spraying of rice, noted that smaller drops were produced by automatic rotating nozzles, when compared to the electrostatic system and hydraulic tip.

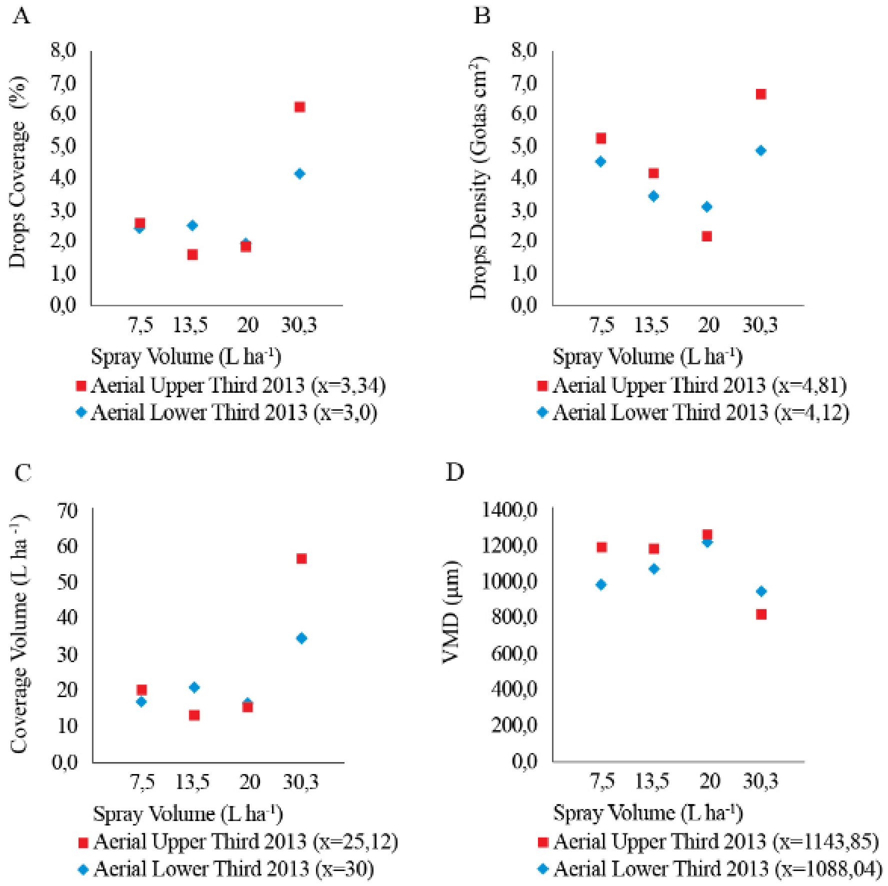

FIGURE 3. A. Drops Coverage (%) B. Drops density (drops cm²) C. Coverage Volume (L ha¹) D. VMD (µm), after Aerial spraying on the upper and lower third of the corn crop in 2013. Tukey test *significant ($P<0.05$).

The spray volume used in the ground application is superior to the aerial application, which helps to explain the higher values to the ground technology. However, the productivity (Figure 10 and 11) in aerial spraying did not show major differences when compared to the ground spraying.

In figures 4 and 5, there is the diseases severity in corn in plots for fungicide application in the first year of the research. There was no significant difference in disease severity between plots and their respective breaks of disease evaluation in the ground and aerial spraying, respectively.

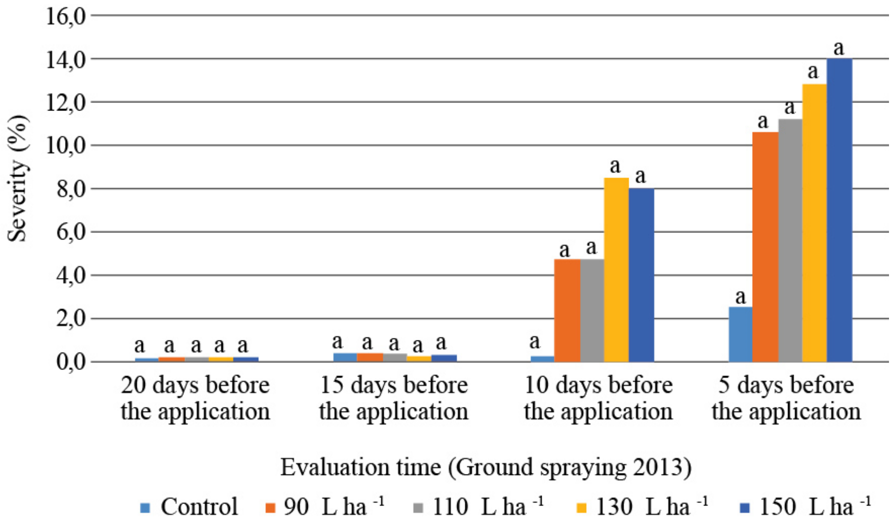

FIGURE 4. Severity of foliar diseases (%) evaluated in the corn crop, within the plots destined for ground spraying before the fungicide application in 2013. Averages followed by equal or lower case letters in the column do not significantly differ from each other (P<0.05) Tukey test.

This result was expected because a crop that so far has not undergone any treatment to control foliar diseases naturally present uniformity in disease severity between plots. However, there was an increase in the diseases severity with the evolution of the vegetative stage of the crop.

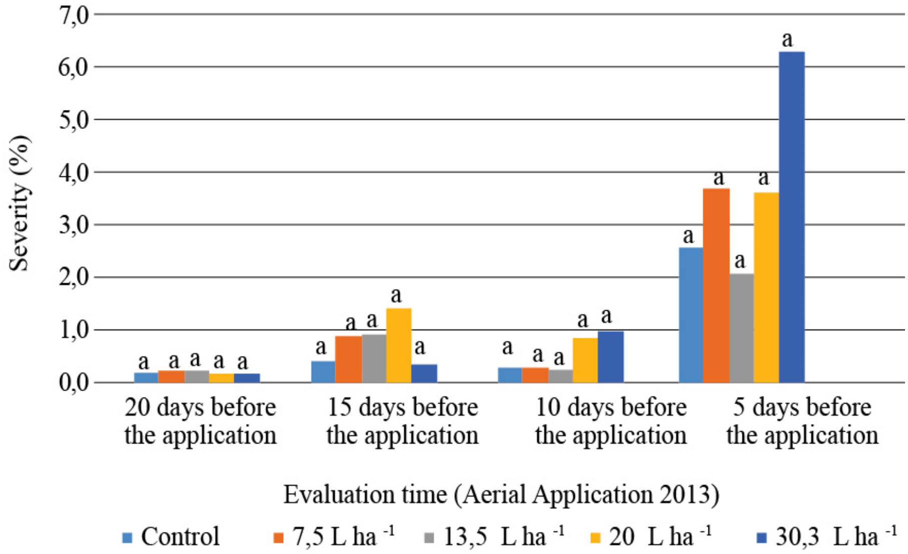

FIGURE 5. Foliar diseases severity (%) evaluated in the corn crop, within the plots for aerial spraying before the fungicide application in 2013. Averages followed by equal or lower case letters in the column do not significantly differ from each other (P<0.05) Tukey test.

In the second year of the experiment, the volume median diameter component (VMD) evaluated in the ground application, showed statistical significance (P <0.05) between the thirds of the corn cultures (Figure 6). Larger drops were found in the upper third of the crop, differing significantly from the other thirds. The middle and lower third received smaller drops, having its minimum point represented by the concavity of the chart in the VMD value of 842 µm (Figure 6D).

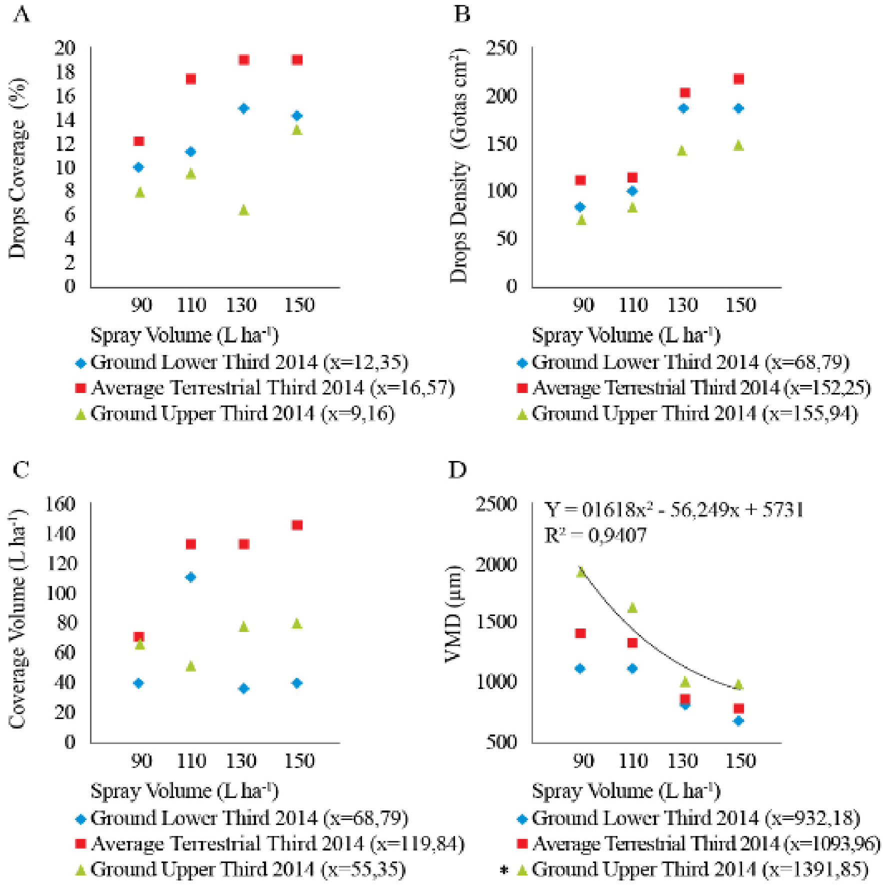

FIGURE 6. A. Drops Coverage (%) B. Drops density (drops cm^2) C. Coverage volume (L ha^1) D. VMD (µm), after ground spraying on the upper, middle and lower third of the corn crop in 2014. Tukey test *significant ($P<0.05$).

Therefore, it was observed that in one spraying the smaller drops penetrated better the crop canopy, and the larger drops were better deposited in areas positioned horizontally, facilitating the deposition on the outside of the plants and hampering the penetration into the crops.

Again the VMD values verified in the ground spraying in the second year of the research were high, reinforcing the claim that tips with air induction produce drops of greater size and weight (CHECHETTO & ANTUNIASSI, 2012).However they are within the average of reality practiced in most of the crops in the state of Parana, according to data recorded by SILVEIRA et al. (2006).

In Figure 7, there is the results obtained in aerial treatment in 2014, the values for volume coverage and VMD in the upper third were higher than the other thirds of the corn, with significant difference ($P<0.05$).The coverage volume showed averages of 93.11; 72.8 and 59.78; L ha^{-1} at the upper, middle, and lower thirds, respectively, with its minimum point of 14.04 L ha^{-1} using an application rate of 21.32 L ha^{-1} (Figure 7.C).

BUENO et al. (2011) point out that this result follows a normal trend in the volume distribution between the thirds. Higher volumes are concentrated in the upper third with a reduction for the middle and lower thirds, which limited by the umbrella effect they are influenced by the first leaves of the crop canopy.

Regarding the VMD, lower values were also found in the crop lower third for aerial treatment in the second year of research, statistically differing from the other thirds, with its highest point of 543 µm, using a 22 L ha^{-1} application rate (Figure 7.D). REIS et al. (2010), evaluating the application quality of spray in aerial application, noted similar characteristics, where smaller VMD values were found in the lower thirds of the crop.

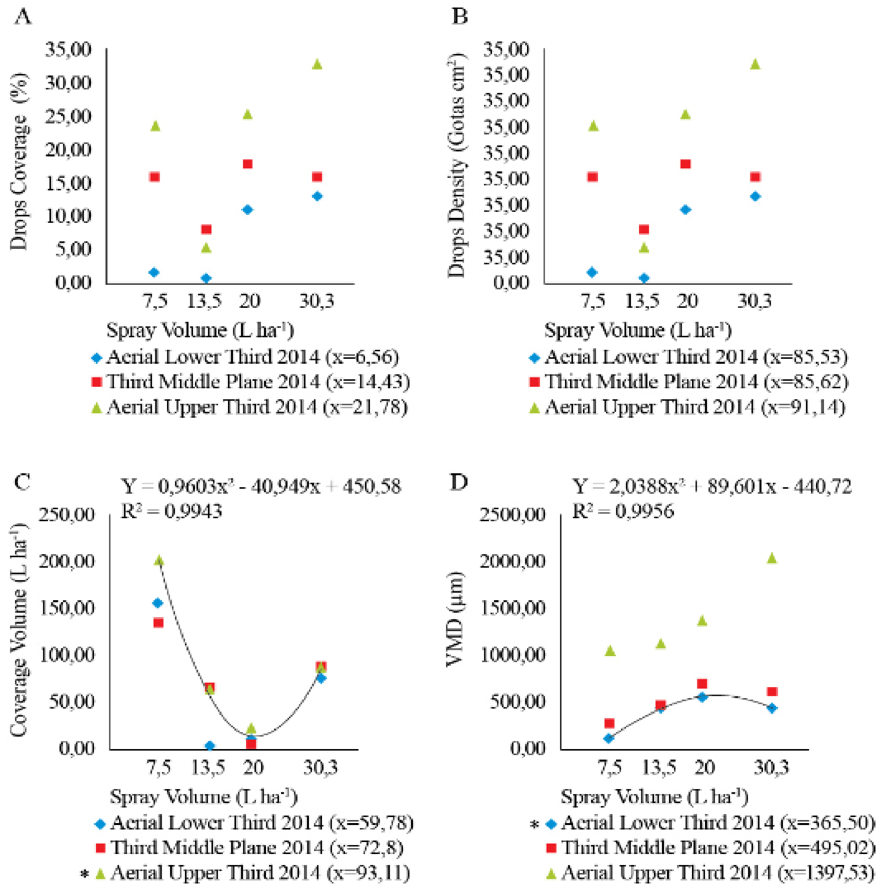

FIGURE 7. A. Drops Coverage (%) B. Drops density (drops cm²) C. Coverage Volume (L ha¹) D. VMD (µm), after aerial spraying on the upper, middle and lower third of the corn crop in 2014. Tukey test *significant (P<0.05).

Analyzing the drops characteristics captured by sensitive papers in the aerial treatment in 2014, there was a malformation in the drops deposit, showing a scattered form, not producing on its formation, spray drop spectrum but stains drops, especially in the upper third of the corn. Thus, there are high values of VMD (above 1000 µm), differing from normal-size drops produced by rotating atomizers used in aircraft that are usually between 60 to 180 µm.

According to FAROOQ et al. (2011), when a spray drop is thrown into the air, especially at high speed, as happens in aerial application, variables such as wind, relative humidity and displacement speed of the equipment affect its dynamics to the target, enabling to mask the drops spectrum, making difficult the reading by the software used, significantly changing the VMD values.

Figures 8 and 9 shows the evaluations in disease severity before and after application of the fungicide in plots intended for ground and aerial application in the second year of research. There was no significant difference (P <0.05) in the diseases severity prior to fungicide application. Result similar to the first year of experiment, however, after the application, there was the disease control in the treated plots, on the two technologies studied (ground and air), differing statistically from the control, but in the different volumes used, they showed no significant difference in disease control, confirming the efficiency of all volumes in the research.

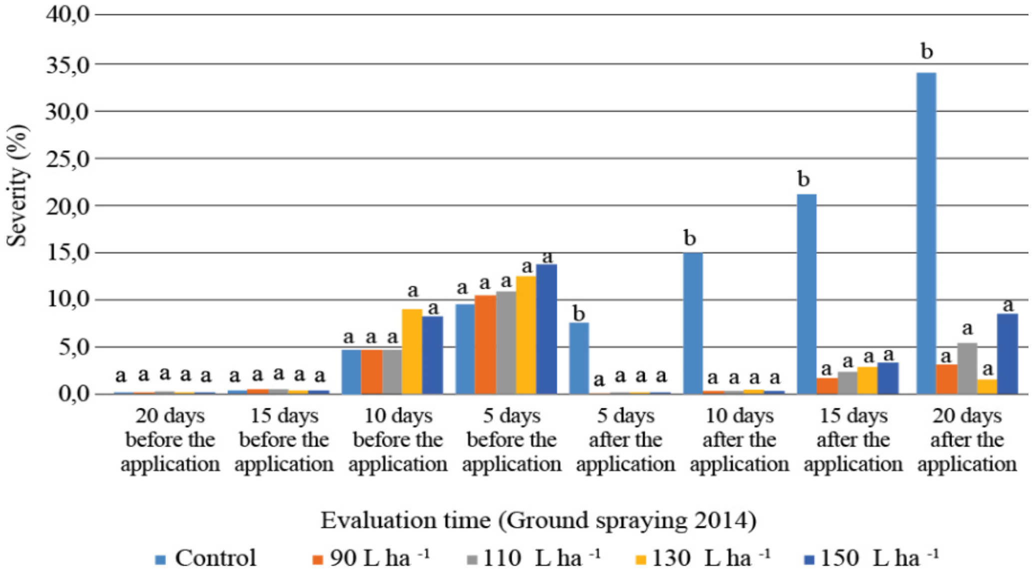

FIGURE 8. Foliar diseases severity (%) evaluated in the corn crop before and after the fungicide application with ground spraying. Averages followed by equal or lower case letters in the column do not significantly differ from each other (P<0.05). Tukey Test.

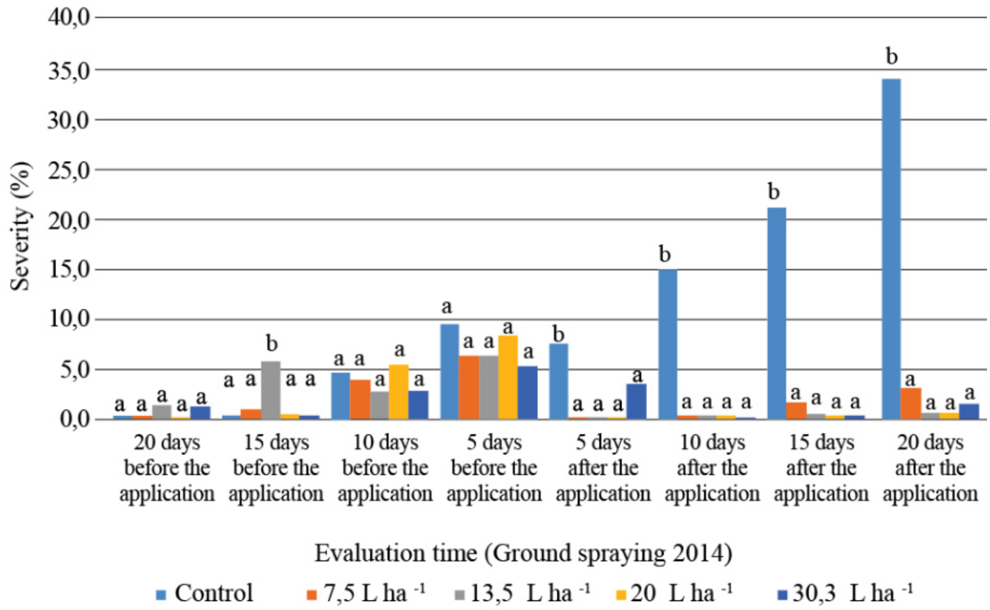

FIGURE 9. Foliar diseases severity (%) evaluated in the corn crop before and after the fungicide application with aerial spraying. Averages followed by equal or lower case letters in the column do not significantly differ from each other (P<0.05). Tukey test.

To OLIVEIRA et al. (2011) the reduction of disease severity after the fungicide application in relation to the control explains the product efficiency in the control of leaf spots present in corn, confirming the minimum coverage acquisition required for success in the diseases control. Systemic fungicides are effective in conditions of lesser coverage when compared to the contact action, but should take into account that even so-called systemic, usually they only have translaminar movement in various crops, reinforcing the importance of the application technology.

In figures 10 and 11 there are the averages of productivity measured in corn in the two years of research in ground and aerial spraying, respectively. In the two year of experiment, the average productivity showed significant differences (P <0.05) between the plots that have undergone treatment when compared to the control, indicating the fungicide efficiency on the two technologies used. However, in the different flow rates used, there was no statistical difference in productivity for ground and aerial spraying.

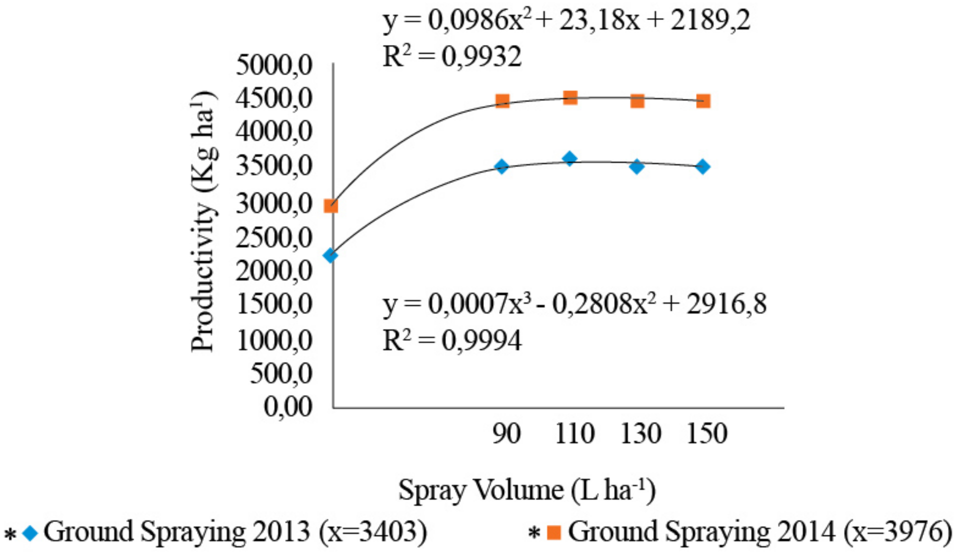

FIGURE 10. Corn productivity (kg ha¹), after the application of fungicide with ground spraying in two years of testing. Regression Analysis *Significant (0.05).

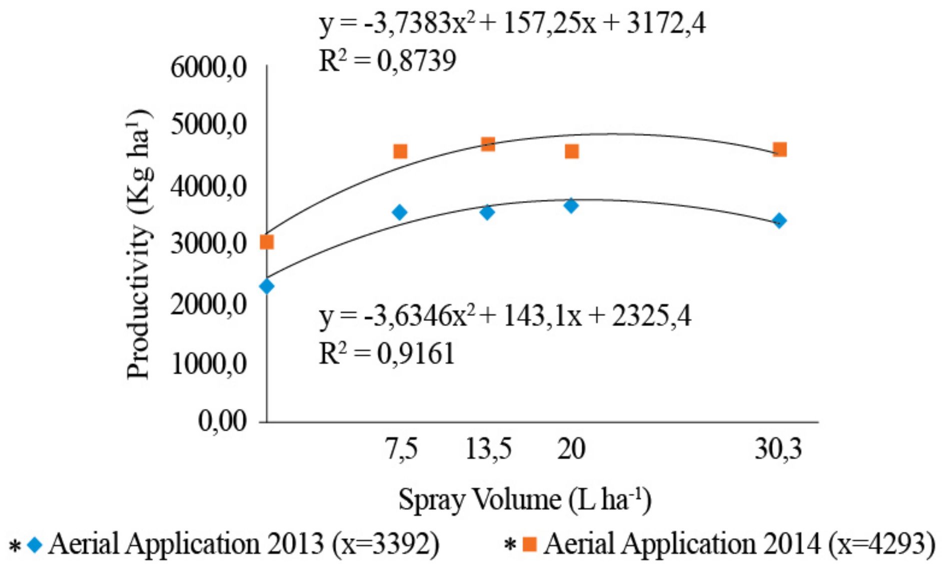

FIGURE 11. Corn productivity (kg ha¹), after the application of fungicide with ground spraying in two years of testing. Regression Analysis *Significant ($P<0.05$).

In the two spraying technologies used, there is a greater crop yield in the second year of the experiment. Possibly, this fact happened because of the damage done to the crop due to the high rainfall in the maturation period in 2013, compromising the grain quality and consequently productivity. However, the productivity showed no statistical difference when compared to the four volumes tested for ground and aerial technology, in the two consecutive years of research.

The area treated with fungicide showed a higher productivity of 1,103 and 1,092 kg ha^{-1}, in the plots with ground and aerial spraying, respectively. Increase of 32% in corn productivity when compared to the one without fungicide in the first year of evaluation (2013). In the second year of the experiment, again the plots that have undergone spraying, confirmed their superiority in productivity when compared to the control without fungicide. Increase of 27% and 32% in corn productivity on the plots intended for fungal treatment with the ground and aerial technology, respectively, demonstrating the fungicide viability in the diseases control.

CONCLUSIONS

The aerial and ground spraying showed control in disease severity in corn of second harvest.

The upper third of the corn showed the highest average of VMD, coverage volume, coverage percentage and drops density, for aerial and ground application. Followed by the middle and lower third.

There was no significant difference in the corn productivity when compared to the different volumes used for aerial and ground application, however all treatments differed statistically from the control, with greater yield. Thus, the use of lower application rates for aerial and ground technology is suggested.

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