SYSTEMS OF AERIAL SPRAYING FOR SOYBEAN RUST CONTROL

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ABSTRACT: The soybean rust caused by *Phakopsora pachyrhizi* is considered the main soybean disease and consequently the appropriate selection and the use of spraying equipment are vital for its control. The aim of this study was to evaluate the performance of aerial application equipment for soybean rust control. It was used: Micronair AU 5000 at 10 L ha^{-1} (with oil) and at 20 L ha^{-1} (without oil); Stol ARD atomizer at 10 and 20 L ha^{-1} (both with oil) and Spectrum (electrostatic) at 10 L ha^{-1} (without oil). The adjuvant was cotton oil (1.0 L ha^{-1}) with emulsifier (BR 455) at 0.025 L ha^{-1}. The field trial was set up at the 3rd fungicide application, when f four replications of each treatment. There were no statistical differences among treatments related to fungicide deposits by at a Confidence Interval of 95%. It was observed that the best results were obtained with Micronair (10 L ha^{-1} with oil), Stol (20 L ha^{-1} with oil) and electrostatic system at 10 L ha^{-1} with the lowest relative humidity (64%).

KEYWORDS: application equipments, agricultural aviation, fungicides deposits, *Phakopsora pachyrhizi*

SISTEMAS DE PULVERIZAÇÃO AÉREA PARA CONTROLE CURATIVO DA FERRUGEM DA SOJA

RESUMO: A ferrugem asiática da soja, causada pelo fungo *Phakopsora pachyrhizi,* é considerada a principal doença da soja, e, portanto, a escolha e o uso adequado dos equipamentos de pulverização são essenciais para seu controle. O objetivo deste trabalho foi avaliar o desempenho de diferentes equipamentos de pulverização aérea para o controle curativo da ferrugem da soja, utilizando o fungicida Impact 125 SC (flutriafol) a 0,5 L p c ha^{-1}. Os seguintes tratamentos foram avaliados: atomizador Micronair AU 5000 (10 L ha^{-1} com óleo e 20 L ha^{-1} sem óleo na calda); atomizador Stol ARD (10 e 20 L ha^{-1} ambos com óleo) e o sistema eletrostático Spectrum (10 L ha^{-1} sem óleo a 64 e 71% de umidade relativa). Utilizou-se óleo de algodão (1,0 L ha^{-1}) acrescido de emulsificante BR 455 a 0,025 L ha^{-1}. O ensaio foi realizado na terceira aplicação de fungicidas, quando foram analisadas quatro repetições nas áreas aplicadas e quatro testemunhas não aplicadas para cada tratamento, avaliando-se a severidade da ferrugem, os depósitos de flutriafol nas folhas de soja e o percentual de redução de ferrugem. A análise dos depósitos nas folhas mostrou que não houve diferenças significativas entre os tratamentos. Os melhores controles da ferrugem foram obtidos com os tratamentos Micronair (10 L ha^{-1} com óleo), Stol (20 L ha^{-1} com óleo) e o sistema elestrostático (10 L ha^{-1}) com a menor umidade relativa do ar (64 %).

PALAVRAS-CHAVE: equipamentos de aplicação, aviação agrícola, depósitos de fungicidas, *Phakopsora pachyrhizi.*

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INTRODUCTION

The Asian soybean rust caused by *Phakopsora pachyrhizi* is considered the main disease of the soybean crop and therefore, the choice and proper use of spraying equipment are essential for its control.

For fungicide spraying on soybean crop, the most commonly technologies used are those that produce fine droplets that provide greater coverage of the target, especially when using protective pesticides; however these droplets usually are easily dispersed by wind (CUNHA et al. 2008).

The aerial application is an additional tool to control the soybean rust, providing applications as fast and efficient as the terrestrial ones. The devices most commonly used in aerial applications are rotary atomizers, hydraulic tips and the electrostatic system (ANTUNIASSI, 2009). Still, according to BAYER et al. (2011), the agro-aerial activity is a viable alternative for its high operational efficiency, which allows for fast solutions at short intervals of time even in vast tracts of land; moreover, it is possible to achieve satisfactory results with affordable economic cost, if the adequate technical resources are adopted.

According to WOMAC et al. (1997), criteria such as equipment and application volume are defined as essential when working with aerial spraying. The proper selection of points determines the amount applied per area, uniformity of application, the droplet coverage and potential risk of drifting, and hence the accuracy and security of pesticide application.

The deposition of droplets on rice crop compared to the conventional hydraulic tips, electrostatic system and disk rotary atomizer at different application rates by air was studied by BAYER et al. (2001). The best penetration of droplets into the canopy was achieved with hydraulic tips with application rates of 20 and 30 L ha^{-1} and the disk rotary atomizer at 15 L ha^{-1}. According to the authors, this fact is linked to the production of small droplets and the addition of adjuvant, which allowed for better stability, increasing the chances of reaching the target.

OLIVEIRA et al. (2010) evaluated the spectrum and uniformity of droplets as a function of rotary and hydraulic tips and the volume of pesticides under laboratory conditions and concluded that the rotary tip produces droplets of greater uniformity and lower percentage of droplets susceptible to drifting, and they also found no differences between the volumes applied; however, according to BAYER et al. (2011), in field conditions this may not occur due to physical barriers, where the best performance is achieved with greater volumes.

Advances in technology of pesticide aerial application have been taken towards reducing the volume of water, which can lead to poor distribution and irregular deposition (REIS et al., 2010). In general, it is recommended that applications with very low volume be carried out with methods of controlling water evaporation or even the replacement of water by other means. An example of this technique is the use of oil as an additive in low-volume applications, as it occurs in aerial application.

With the prevalence of soybean cultivation in large areas and the fast expansion and severity of the soybean rust, it is necessary to evaluate spraying systems with high efficiency and operational performance for its control at the most appropriate instant.

The objective of this study was to evaluate the performance of different systems for aerial spraying to the curative control of the soybean rust.

MATERIAL AND METHODS

The study was carried out at Rancho Novo Farm, in the municipality of Pedra Preta, State of Mato Grosso. The experimental area occupied a single plot of 102 ha, planted with the cultivar Pioneer 98C81, where all cultural treatments were carried out uniformly, according to the farm routine. The rust control was conducted in three stages with the following fungicides: myclobutanyl at 0.4 L p c. ha^{-1}; tebuconazole at 0.4 L p c. ha^{-1} and flutriafol at 0.5 L p c. ha^{-1} (installation test).

The test was conducted, therefore, in the third application with the purpose of curative rust control. The severity of the plots was less than 1.0% at the time of test installation, according to evaluations performed using the diagrammatic scale used by EMBRAPA as described by GODOY et al. (2006). The spraying was carried out only in the experimental plots demarcated in the plot, according to the features and technologies described in each treatment (Table 1). For aerial application it was used an Ipanema EMB 202 aircraft equipped with the following spray equipment: sprayers Micronair AU 5000 (screen type), Stol ARD (disk type) atomizers and the electrostatic system (Spectrum). The treatments involving the Spectrum electrostatic system were performed in two application conditions, one at a higher and one at lower relative humidity. Considering the conditions present for the installation of the field tests, the values of 71% and 64% represent the extreme values observed at the time. This change of conditions was requested by the manufacturer of the electrostatic system in order to evaluate the influence of relative humidity on the performance of this type of spraying.

The fungicide used in the test was flutriafol (Impact 125 SC) at 0.5 L p c ha^{-1}, with the use of cotton vegetable oil (1.0 L ha^{-1}) plus BR 455 emulsifier to 0.025 L ha^{-1} for the treatments with Micronair rotary (10 L ha^{-1}) and Stol (10 and 20 L ha^{-1}) atomizers.

TABLE 1.Description of treatments and technologies used.

Treatments	Speed (km h^{-1})	Height/Range of Flight (m)	Atomizer or Tip	Drop Class ASAE S572
Micronair (10 L ha^{-1} with oil)	177	4/18	AU 5000	Fine
Micronair (20 L ha^{-1} with no oil)	177	4/16	AU 5000	Fine
Stol (10 L ha^{-1} with oil)	185	2/20	Stol ARD	Fine
Stol (20 L ha^{-1} with oil)	185	2/15	Stol ARD	Fine
Spectrum (10 L ha^{-1} and 71% RH)	177	4/15	TXVK6	Very Fine
Spectrum (10 L ha^{-1} and 64% RH)	177	4/15	TXVK6	Very Fine

During the applications, the relative humidity ranged between 64 and 71%, temperature was between 26 and 31 ^{o}C and wind speeds were between 4 and 11.7 km h^{-1}. The interval between the application and collection was less than 60 minutes for all treatments.

Four replicates were analyzed for each treatment along with four non-treated controls. The spraying area of each plot was 2.8 ha (100 m x 280 m) with a minimum distance of 350 m between plots to avoid contamination by drift between them. Sampling corresponded to collect leaves in three locations of the plant (upper, middle and lower positions) in each plot, with 15 leaves sampled per position. In total, 1,080 leaves were sampled for laboratory analysis (6 plots applied x 3 sampling positions x 4 repetitions x 15 leaves per position). In each sample point, the leaves were placed in containers with 30 mL of distilled water (five leaves per container) for fungicide extraction. Leaves of one replicate of each treatment were separated after washing and sent to the laboratory for determination of the residue that was not extracted during the washing process, being grouped into two sets: applications with or without oil in the spraying mixture. This procedure was set to adjust an extraction factor for the method (mixtures with and without oil), as well as to determine the retention and absorption characteristics of flutriafol. The distribution of flutriafol was analyzed by quantification of fungicide deposits on the leaves by gas chromatography and mass spectrometry (GC-MS).

The parameters evaluated were rust severity at 15 days after application (DAA), flutriafol deposits on the leaves (top, middle and lower positions) and the percentage of rust reduction, comparing each treatment with its own control. As a way of comparing the capability of each treatment to provide penetration of the mixture into the canopy, we used a direct relationship with the percentage of deposits on the top leaves, according to eq.(1):

$$D(\%) = \frac{D_n}{Ds} 100 \qquad (1)$$

where,

D(%) - deposit, in percentage;
Dn - deposit in the lower or medium position, and
Ds - deposit in the top position.

Data were analyzed using the statistical method “Confidence Interval for Differences between the Averages” with confidence interval of 95% ($CI_{95\%}$) for the comparative analysis of the treatments, as described by VELINI (1995) and used by SOUZA et al. (2002).

RESULTS AND DISCUSSION

In the analysis of total deposits of flutriafol on soybean leaves (Figures 1; 2 and 3), two treatments presented problems, and the data should be considered with caution because they do not provide the necessary reliability. In the case of the treatment with Stol (10 L ha^{-1} with oil), this observation is necessary because of an excessive overlapping error (due to inadequate flying height), which hampered the distribution of the fungicide in the area, thus leading to an uneven deposition. It is noteworthy that the initial planning was that the flights would all be conducted at the height of 4 m above the crop.

However, in the case of treatments with the atomizer Stol, flights were mistakenly made at the height of 2 m, hampering the delivery of the mixture, and leading to track overlapping. This type of problem is described by ANTUNIASSI (2009) as one of the most frequent errors in aerial applications. Interestingly, however, that the treatment Stol 20 L ha^{-1} apparently was not subject to these errors, since their results were consistent. This fact should be credited to a better adjustment of flying height x width of the track (2 m x 15 m) compared to treatment with Stol 10 L ha^{-1}, which ratio was 2 m x 20 m.

In the case of the treatment with Micronair (20 L ha^{-1}), the amount of product detected in the samples was much higher than for the other treatments, with no apparent technical reason. As examples, deposits were observed with 2.7 times more product in the leaves of the middle part (Figure 1B) when compared to the other treatments. These amounts may have been inadequate due to contamination during sample processing.

In general, the data presented regarding the lower leaves of the plants (Figure 1A) showed no significant differences with the $CI_{95\%}$ analysis in deposits among the treatments that used rotary atomizers (excluding the unreliable data treatments of Stol to 10 L ha^{-1} and Micronair to 20 L ha^{-1}). There was a tendency for higher deposits with the use of atomizers, with significant differences at 95% compared to the electrostatic system (at 71% RH). In this regard, SILVA (2009), when evaluating different aerial spraying equipment for rice cultivation, found a higher amount of product in the lower third of the plants when using the rotary atomizer (15 L ha^{-1}), differing significantly from the other treatments. In the middle part of the plant, the situation was the absence of significant differences.

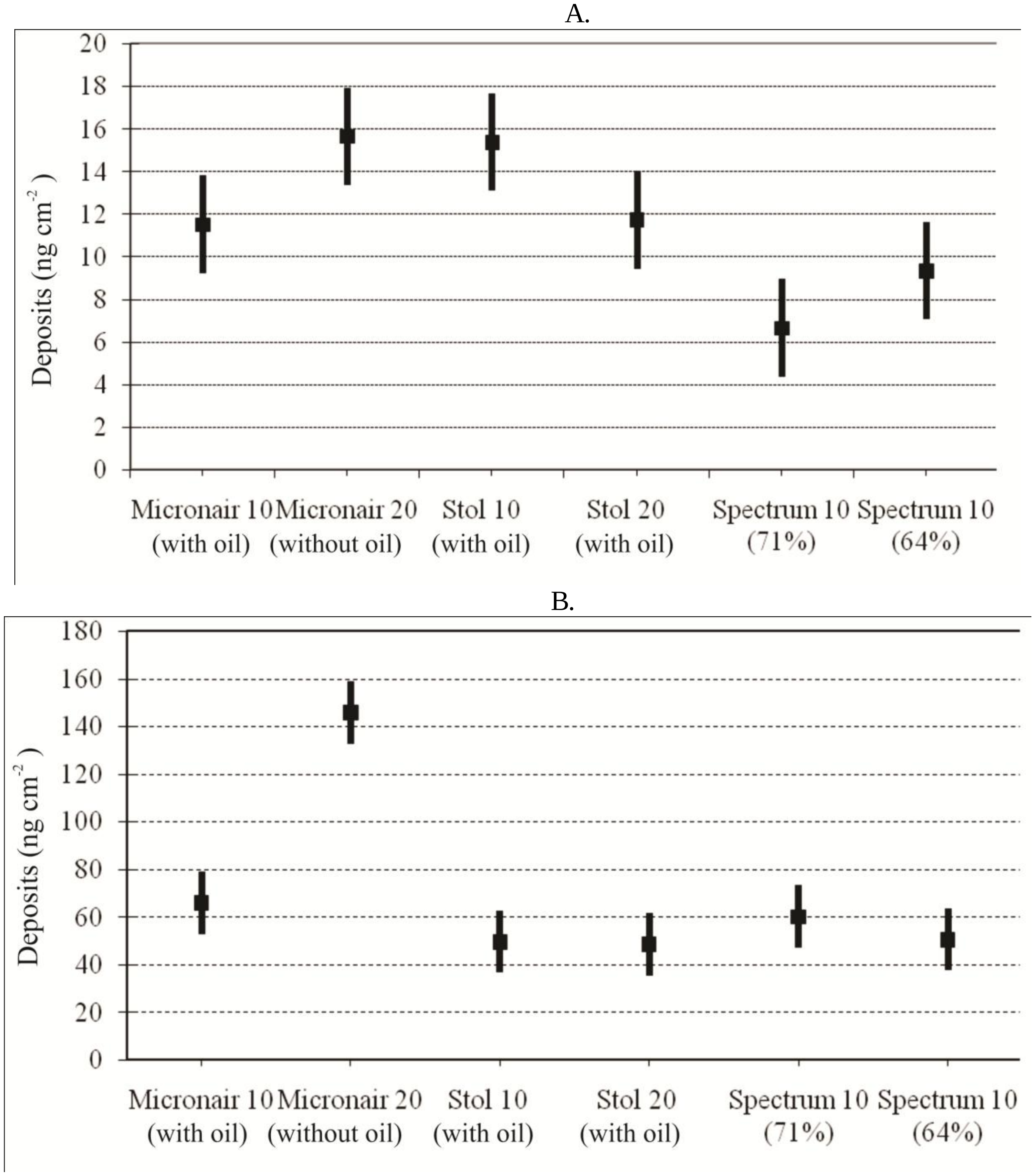


FIGURE 1. Fungicide deposits on the medium and top part of the canopy. The points represent mean values and the vertical lines indicate the confidence interval at 95%.

At the top of the canopy (Figure 2), only the electrostatic treatment with 71% RH showed significantly lower deposition values. It is observed that treatments with a volume of 20 L ha^{-1} tended to show higher deposits at the top leaves compared with treatment with 10 L ha^{-1}. Similar results were found by OZEKI (2006) showing that, in applications with higher volumes, the resulting droplets from the spraying tend to settle on the top of the plant, with lower depositions in the innermost part of the canopy.

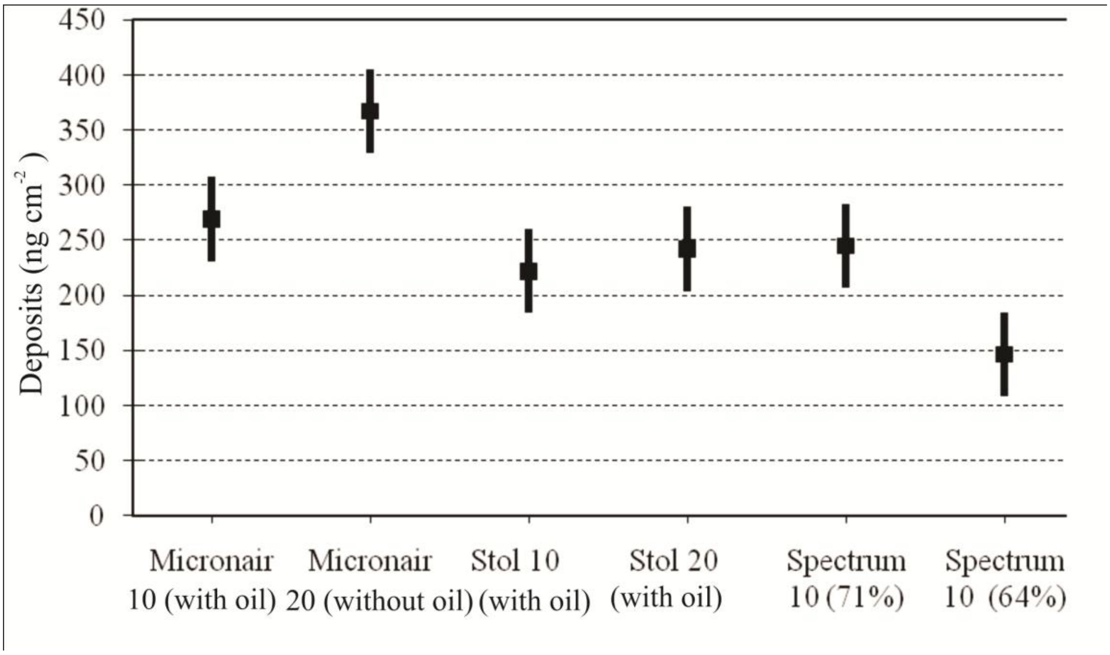
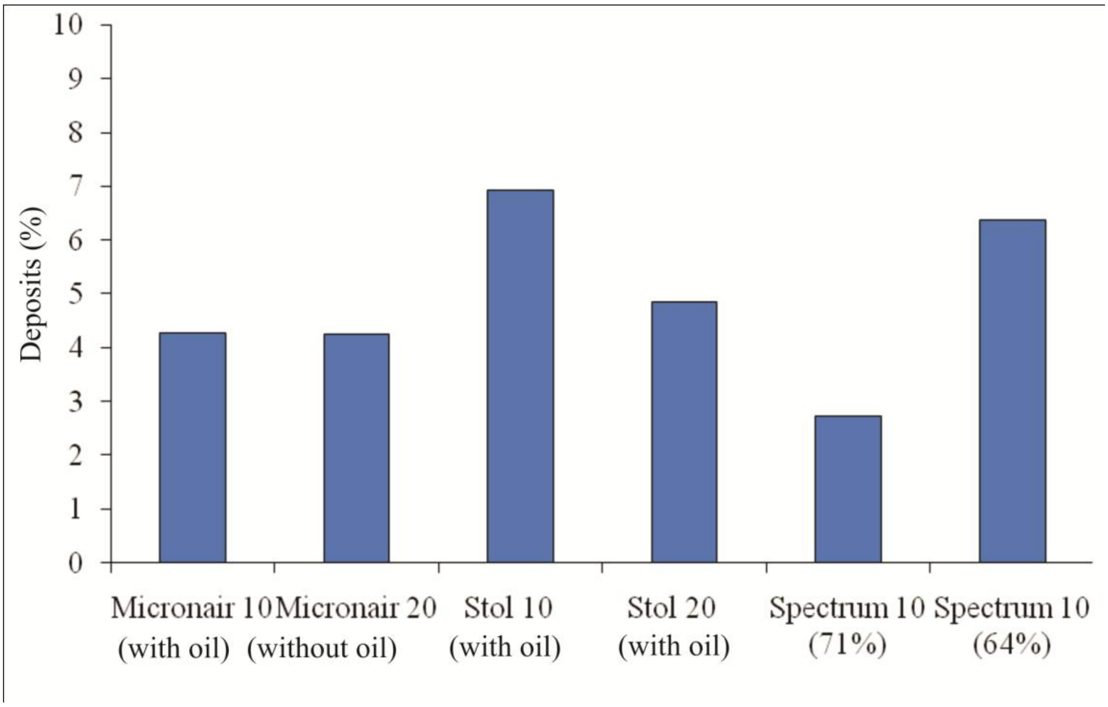


FIGURE 2. Fungicide deposits on the top part of the canopy. The points represent mean values and the vertical lines indicate the confidence interval at 95%.

As a way of comparing the capacity of each treatment to provide penetration of the drops into the canopy in the lower and middle parts of plants, it was used a direct relationship with the percentage of deposits on the top leaves (Figure 3). The deposits at the bottom and middle of the plant for all treatments were proportionally similar. This fact indicates that the treatments did not differ much regarding the ability of the drops to penetrate the canopy. There is a tendency towards a better penetration with the electrostatic treatment at 64% RH, compared to 71% RH, due to higher percentages in both the bottom and middle parts of the plant.

A.



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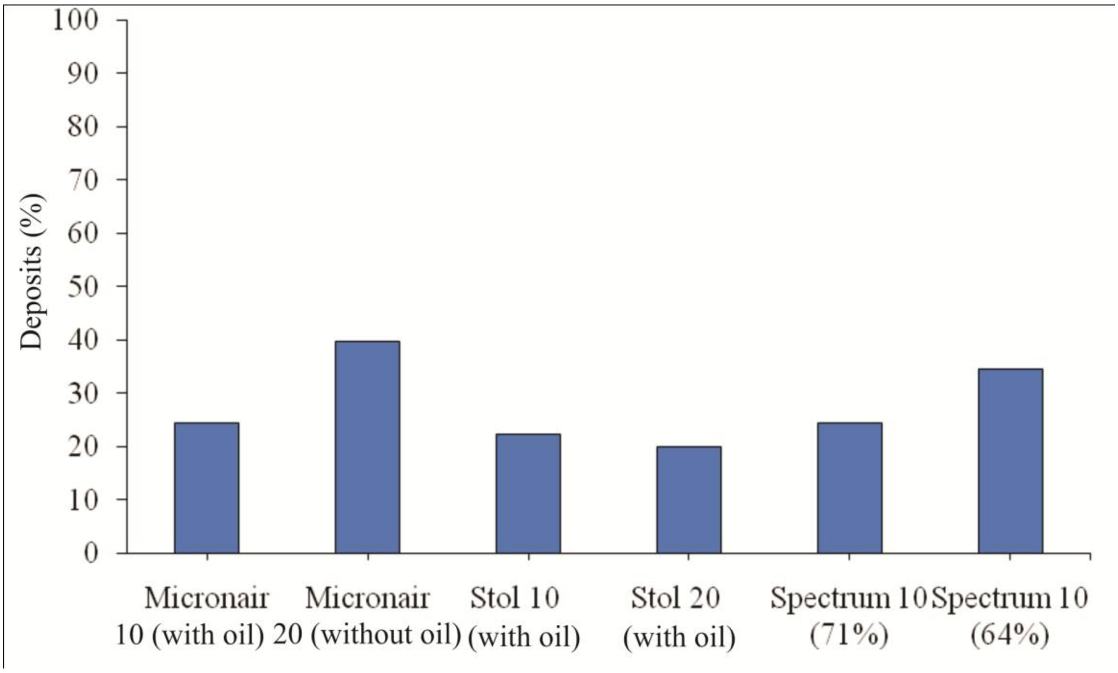

FIGURE 3. Comparative analysis of flutriafol deposits on the lower (A) and middle (B) parts of the canopy in relation to average deposit observed on top leaves (considering the deposit on the top leaves of each treatment as 100%).

Comparative analysis between the plots of treatments and their controls for calculated values of rust reduction potential are shown in Figure 5. The best results were obtained with Micronair (10 L ha^{-1} with oil), Stol (20 L ha^{-1} with oil) and the electrostatic system at 64% RH, with no significant statistical difference among them. The treatments with Micronair (20 L ha^{-1} without oil) and electrostatic at 71% RH with Stol (10 L ha^{-1}) showed the least favorable outcome. The results showed the best performance with the electrostatic system in a condition of drier climate, with a significant difference between applications at 64 and 71% RH.

Comparing the rotary atomizers, the problem related to flying height was noticed in the application of the treatment Stol (10 L ha^{-1}), showing a significant unfavorable result in reducing the rust levels. In the case of treatment Stol (20 L ha^{-1}), as discussed earlier, the best adaptation of the working track with respect to flying height was responsible for maintaining an adequate performance, generating results similar to the best treatments. Emphasis should be given to the comparison between Micronair (20 L ha^{-1} without oil) with Micronair (10 L ha^{-1} with oil) and Stol (20 L ha^{-1} with oil) applications. Despite the higher volume, Micronair (20 L ha^{-1} without oil) showed a smaller rust reduction potential than Micronair (10 L ha^{-1} with oil), and even smaller than Stol (20 L ha^{-1} with oil).

In this case, it was presented evidence that for the conditions for application of the treatments, oil application presented with better performance regarding disease control. Importantly, even with the mistake of an application with an inadequate flying height, the Stol (20 L ha^{-1} with oil) treatment showed the best results in relation to the control, demonstrating that the use of larger volumes and smaller flight tracks can help to minimize the effects of operational errors. Similar results were found by SILVA (2009), when comparing the equipment in relation to application rates for middle and lower thirds of the plant, confirming that, on average, higher rates promote more deposits. In the case of the application with Stol with smaller volume (10 L ha^{-1}), there was no advantage of using a higher volume, leading the treatment to show its problem with the error. In all cases, it is important to notice that flutriafol is a product that provides a certain degree of systemic action, which helps this application technology to offer greater flexibility against potential application errors or deficiencies.

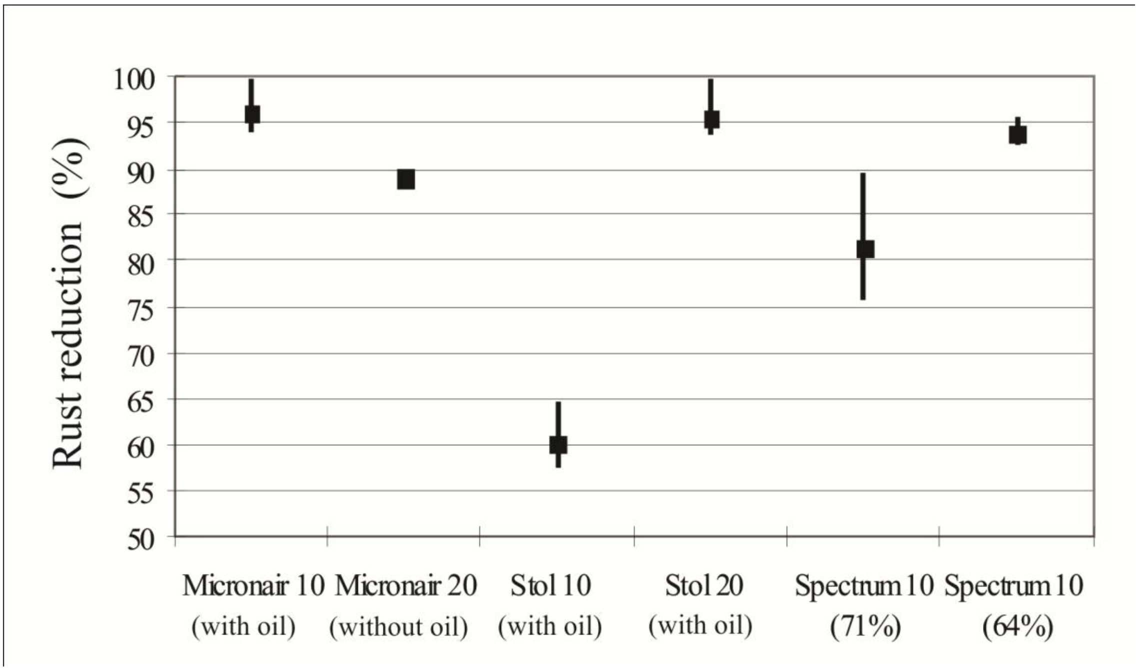

FIGURE 4. Rust control, comparing each treatment with its control. Vertical bars represent the confidence interval at 95%.

CONCLUSIONS

There were no significant differences between the deposits of flutriafol among the different treatments, and all of them provided adequate rust control.

The best rust control was obtained with the treatments Micronair (10 L ha^{-1} with oil), Stol (20 L ha^{-1}) and the electrostatic system with 10 L ha^{-1} applied with the lower relative humidity at 64%.

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ERRATUM

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