Influence of Spray Mixture Volume and Flight Height on Herbicide Deposition in Aerial Applications on Pastures[1]

Influência do Volume de Calda e da Altura de Voo na Deposição de Herbicida em Aplicações Aéreas em Pastagens

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ABSTRACT - The objective of the present study was to analyze the influence of spray mixture volume and flight height on herbicide deposition in aerial applications on pastures. The experimental plots were arranged in a pasture area in the district of Porto Esperidião (Mato Grosso, Brazil). In all of the treatments, the applications contained the herbicides aminopyralid and fluroxypyr (Dominum) at the dose of 2.5 L c.p. ha^{-1}, including the adjuvant mineral oil (Joint Oil) at the dose of 1.0 L and a tracer to determine the deposition by high-performance liquid chromatography (HPLC) (rhodamine at a concentration of 0.6%). The experiment consisted of nine treatments that comprised the combinations of three spray volumes (20, 30 and 50 L ha^{-1}) and three flight heights (10, 30 and 40 m). The results showed that, on average, there was a tendency for larger deposits for the smallest flight heights, with a significant difference between the heights of 10 and 40 m. There was no significant difference among the deposits obtained with the different spray mixture volumes.

Keywords: application technology, agricultural aviation, pulverization.

RESUMO - O objetivo do presente estudo foi analisar a influência do volume de calda e da altura de voo na deposição em aplicações aéreas de herbicidas em áreas de pastagens. Para a montagem das parcelas experimentais, foi escolhida uma área com pastagens no município de Porto Esperidião-MT. Em todos os tratamentos, as aplicações foram realizadas utilizando os herbicidas aminopiralide e fluroxipir (Dominum) na dose de 2,5 L p.c. ha^{-1}, incluindo o adjuvante óleo mineral (Joint Oil) na dose de 1,0 L ha^{-1} e um traçante para determinação da deposição por cromatografia HPLC (rodamina, na concentração de 0,6%). O ensaio considerou nove tratamentos que consistiram nas combinações de três volumes de calda (20, 30 e 50 L ha^{-1}) e três alturas de voo (10, 30 e 40 m). Os resultados mostraram que, em média, houve tendência de maiores depósitos para as menores alturas de voo, com diferença significativa entre 10 e 40 m de altura. Não houve diferença significativa entre os depósitos obtidos com os diferentes volumes de calda.

Palavras-chave: tecnologia de aplicação, aviação agrícola, pulverização.

INTRODUCTION

When aerial spraying is used, it is crucial to choose the correct flight height and spray volume for an efficient operation, reducing the risk of drift and environmental impact. Porcile et al. (1995) reported that agricultural activities alter the native vegetation cover; therefore, many species increase their population, becoming weeds that interfere in the implementation and development of some crops.

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The potential for environmental contamination by pesticides has always raised concerns over their misuse. The increasing demand for production processes with less environmental impact has created the need to assess the behavior and destination of pesticides used in agroecosystems (Luchini, Andrea, 2000; Luchini, 2004). The dynamics of herbicides in the environment and their residual effects are conditioned on the physicochemical properties of the products used, the weather conditions at the time of application, and other factors. (Monquero et al. 2010).

Although farmers are increasingly required to use pesticides correctly and carefully, lack of knowledge of application technology can still be observed in the field. The applications are not always performed with the appropriate technique or equipment (Cunha et al., 2004). In general, it is estimated that about 50% of the pesticides are wasted due to inadequate application (Friedrich, 2004).

According to Antuniassi (2010), the correct time for performing the applications is a factor of paramount importance. One of the advantages of aerial application is the greatest operational efficiency. For Araújo & Gontow (1993), aerial application technology is advantageous because it avoids crop damage and offers speed of dispersal, optimal use of weather conditions and possibility of application when convenient. Antuniassi (2006) describes spray volume as one of the most important aspects for highly-efficient application, because it influences the percentage of target coverage.

Research on deposition patterns show variability along the spray swath, reducing the effectiveness of treatments (Gupta, Duke, 1996; Pergher et al. 1997). According to Carvalho et al. (2011), heights used in aerial applications range from 3 to 4 m. However, on pastures, the application is often performed over obstacles, which requires the use of greater heights for herbicide application. This author states that weather conditions at the time of application should be carefully considered, because droplets could take longer to achieve the targets. The aim of this study was to analyze the influence of spray volume and flight height on spray deposition in aerial herbicide applications on pastures.

MATERIAL AND METHODS

The experiment was conducted in a commercial area of livestock breeding on farm Fazenda Morro Branco, located in municipality of Porto Espiridião, Mato Grosso, Brazil. The study area is located in the geographic coordinates 16º07'49" S and 58º45'42" W, with an average altitude of 170 m.

In all treatments, applications were made with a herbicide mixture with a mineral oil and a tracer in order to determine spray deposition by high-performance liquid chromatography (HPLC). The tracer used was rhodamine at a concentration of 0.6%. The herbicide resulted from a mixture containing aminopyralid+fluroxypyr (Dominum) in a water-in-oil (W/O) emulsion formulation, applied at a rate of 2.5 L of commercial product per hectare. The adjuvant used was a mineral oil hydrocarbon (Joint Oil), with a concentration of 761 grams per liter, applied at a rate of 1.0 liters per hectare.

Table 1 shows the treatments and describes the technologies used for applying each one of them.

The experiment was arranged with nine treatments which consisted of combinations of three spray volumes (20, 30 and 50 L ha^{-1}) and three flight heights (10, 30 and 40 m). The spray volumes were sorted in the plots, and the flight heights, in the subplots. Each plot consisted of an area of approximately 3.7 ha (320 x 115 m) with nine data collection points, with a total of 81 sampling points. Statistical analysis was based on the comparison of the treatments using the statistical method "Confidence Interval for Differences between Means" with confidence level of 95% ($CI_{95\%}$).

A WMR928NX weather station (Figure 1) was installed and outfitted with remote sensors for monitoring and collecting the average, minimum and maximum temperatures, minimum and maximum relative air humidity, and wind speed and direction at the time of application. The plots were positioned in the field with a shorter distance between 541 m plots and a greater distance between

Table 1 - Description of treatments (spray volumes and flight heights) used in the aerial applications

Treatment	Volume (L ha^{-1})	Flight height (m)	Tip/Pressure (psi)	VMD (µm)	Droplet size
20 L ha^{-1} 10 m	20	10	CP-A256-4025/55	334	Medium
20 L ha^{-1} 30 m	20	30	CP-A256-4025/55	334	Medium
20 L ha^{-1} 40 m	20	40	CP-A256-4025/55	334	Medium
30 L ha^{-1} 10 m	30	10	CP-A256-4012/30	284	Medium
30 L ha^{-1} 30 m	30	30	CP-A256-4012/30	284	Medium
30 L ha^{-1} 40 m	30	40	CP-A256-4012/30	284	Medium
50 L ha^{-1} 10 m	50	10	CP-A256-4020/50	312	Medium
50 L ha^{-1} 30 m	50	30	CP-A256-4020/50	312	Medium
50 L ha^{-1} 40 m	50	40	CP-A256-4020/50	312	Medium

Figure 1 - Weather Station used in the experiment, with details of sensors and screen.

831 m plots (in the direction of the prevailing wind to avoid drift between treatments). Control points (controls) were installed in the opposite direction of the prevailing wind. The applications were made in varied weather conditions, with temperature ranging between 22.5 and 33.4 °C, relative humidity between 29 and 81% and wind speed between 5.8 and 11.1 km h^{-1}.

During spray mixture preparation, 0.6 grams per 100 liters of a tracer (rhodamine) was added to the mixing tank of the aircraft for each spray volume prepared. Deposition was analyzed by quantifying the spray deposits on nine 10 x 20 cm glass slides inserted horizontally into PVC collectors fixed onto wooden stakes measuring approximately 1.5 m in height within each plot applied, totaling 81 slides. After each application, the samples were placed in plastic pots, and then in black bags to avoid direct sunlight; after that, they were stored in temperature-controlled environments. In the laboratory, the product was collected from the samples by washing the glass slides with distilled water. After the slides were washed, the rhodamine tracer present in each sample was quantitated by high performance liquid chromatography (HPLC) to determine the amount of spray deposited on the application targets for the different aerial technologies employed. Figure 2 shows the steps followed during the experiment.

The applications were performed using an Air Tractor AT-802 agricultural aircraft (Figure 3), outfitted with bars containing 54 direct-flow (40°) flat fan spray nozzles (Figure 3A), manufactured by CP® Products Company, Inc., with tips adjusted to deliver medium droplets in the three spray volumes used in the experiments. The aircraft had a SATLOC AirStar DGPS system with lightbar guidance so that the pilot could fly over parallel strips spaced at 25 m and cover the applied area in all treatments.

RESULTS AND DISCUSSION

Data on flight height of 10 m for 20 L ha^{-1} were discarded because of a methodological error, i.e., excessive spray deposits (the deposited amount was much higher than the one actually applied).

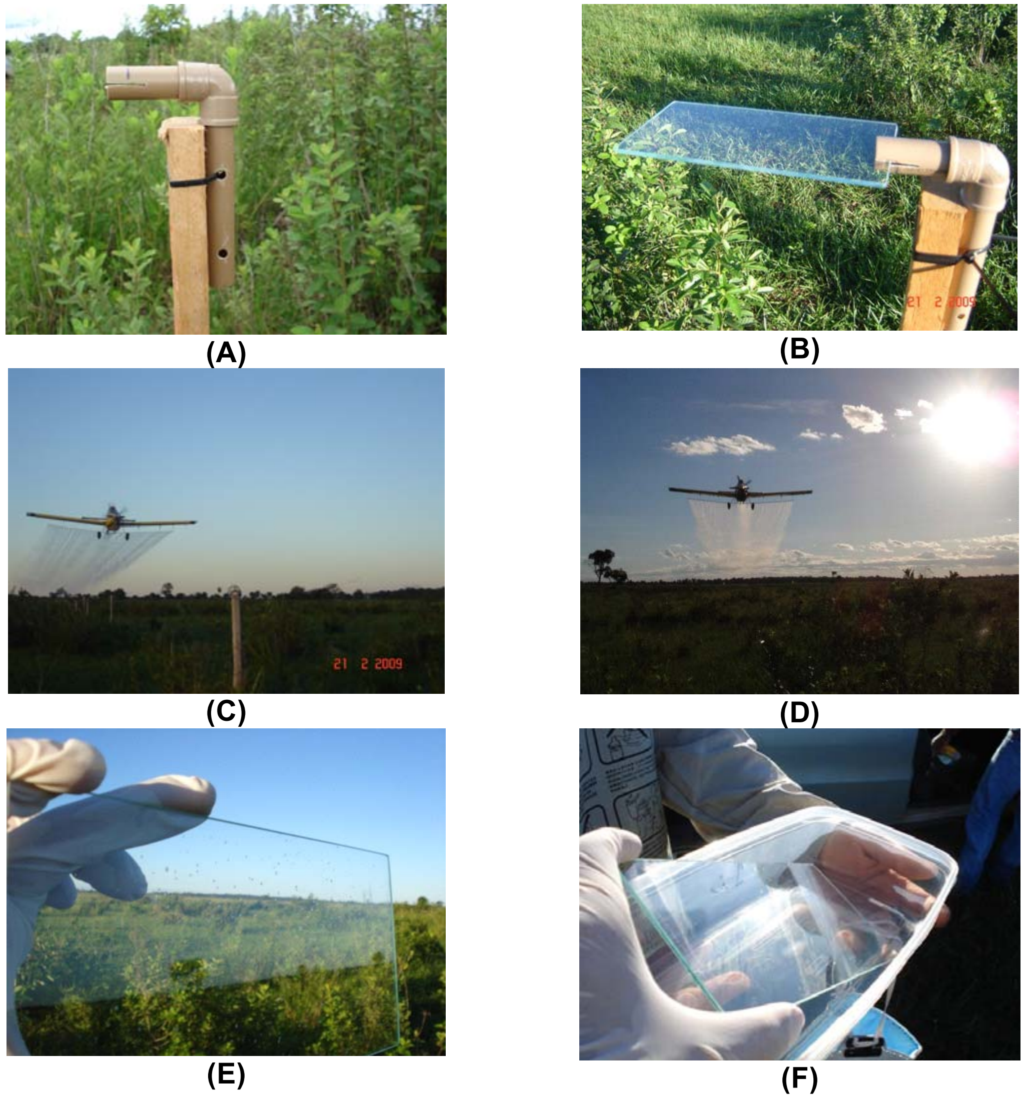

Figure 2 - Stages of the experiment: fixing the collectors onto the stakes (A), inserting the "target" glass slides into the collectors (B); spraying the plots at different flight heights (C) and (D); removing the slides after the applications (E) and storing the slides in plastic pots (F).

Figure 3 - Air Tractor AT-802 (A) outfitted with bars containing 54 direct-flow (40°) hydraulic nozzles (B).

Figure 4 shows the results for the comparison of deposits (ng cm^{-2}) across the different treatments by the confidence interval ($CI_{95\%}$). In all the treatments, a significant reduction of deposits was observed as flight height increased, regardless of spray volume. Treatments with a volume of 50 L ha^{-1} combined with heights of 10 and 30 m showed higher amount of deposits, with a significant difference for treatments with volumes of 20 and 30 L ha^{-1} at 40 m, respectively. The treatment with 30 L ha^{-1} at 10 m showed no significant difference compared to the others. In reference terms, Derksen & Sanderson (1996) evaluated the influence of spray volume on foliar deposition by pesticides and found that, when large volumes are used, there is better coverage and lower variation in deposition along the canopy.

An analysis of deposit averages for flight heights and spray volumes (Figure 5) showed that there is tendency to lower deposit rates as flight altitude increases (Figure 5A). In this case, the difference between 10 m and 40 m is significant for the analysis of CI95%. When spray volumes are compared directly (Figure 5B), although the deposit average for the highest spray volume was numerically higher, the comparison with the other spray volumes showed no significant difference by the analysis of CI95%. These results are in agreement with the findings of Carvalho et al. (2011). They also show that higher flights pose a greater risk of drift, again in agreement with the findings of Carvalho et al. (2011).

Figure 6 shows the response surface of the deposits according to the combination of

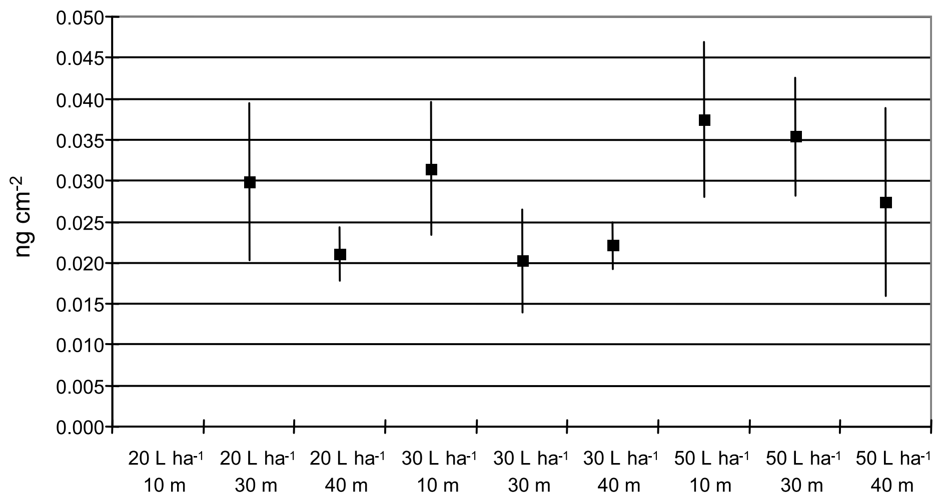

Figure 4 - Spray deposits (ng m^{-2} for different treatments (volume x height). To compare the results, the dots represent the mean values and the vertical lines indicate the confidence interval ($CI_{95\%}$).

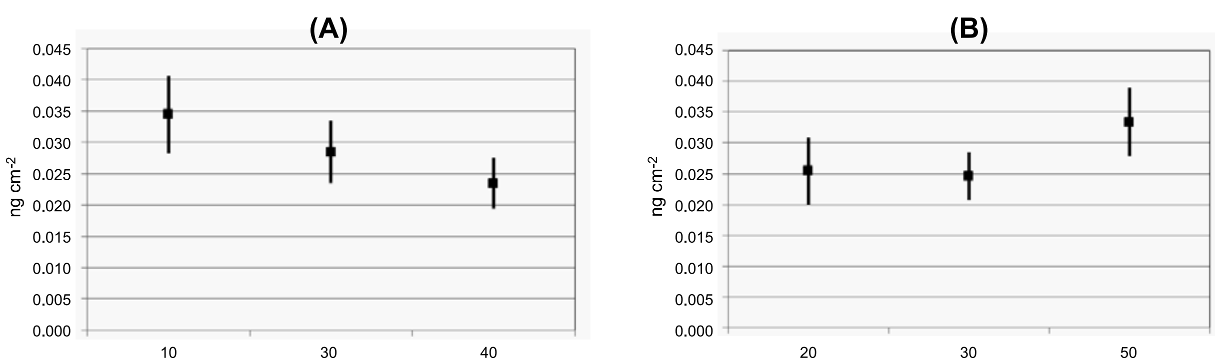

Figure 5 - Mean spray deposit values (ng cm^{-2}) when flight heights (A and spray volumes (B are compared. To compare the results, the dots represent the mean values and the vertical lines indicate the confidence interval ($CI_{95\%}$).

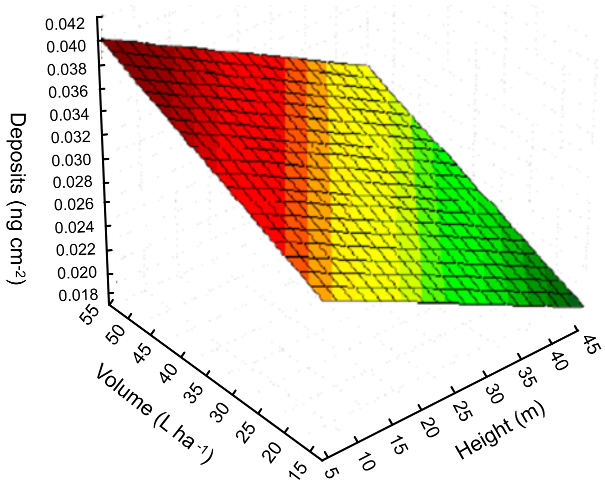

Figure 6 - Response surface of deposits according to the combinations of spray volume (20, 30 and 50 L ha^{-1}) and flight heights (10, 30, and 40 m).

spray volumes (20, 30 and 50 L ha^{-1}) and flight heights (10, 30, and 40 m). There is a clear trend of reduction in deposits as flight height increases and spray application volume decreases.

In general, there was a trend of increased deposits as flight height was reduced, regardless of the amount applied. The lowest spray deposits were obtained at 40 m, regardless of the spray volume used, and treatments with flight height of 10 m showed higher amounts of deposits than the other treatments, regardless of the spray volume applied.

LITERATURE CITED

ANTUNIASSI, U. R. Tecnologia de aplicação de defensivos na cultura da soja. **B. Pesq. Soja Fundação Mato Grosso**, v. 11, p. 199-216, 2010.

ANTUNIASSI, U. R. Tecnologia de aplicação de defensivos. **R. Plantio Direto**, v. 15, n. 1, p. 17-22, 2006.

ARAÚJO, E. C.; GONTOW, M. **Estudo do mercado da aviação agrícola**. Botucatu: Agrotec/Embraer, 1993. (não paginado)

CARVALHO, W. P. A. et al. Tecnologia de aplicação por via aérea. In. ANTUNIASSI, U. R.; BOLLER, W. (Org.) **Tecnologia de aplicação para culturas anuais.** Passo Fundo: Aldeia Norte, Botucatu: Fepaf, 2011. p. 158-177.

CUNHA, J. P. A. R. et al.Espectro de gotas de bicos de pulverização hidráulica de jato plano e jato cônico vazio. **Pesq. Agropec. Bras.**, v. 39, n. 10, p. 977-985, 2004.

DERKSEN, R. C.; SANDERSON, J. P. Volume, speed and distribution technique effects on poinsettia foliar deposit. **Trans. ASAE**, v. 39, n. 1, p. 5-9, 1996.

FRIEDRICH, T. Quality in pesticide application technology. In: RAETANO, C.G.; ANTUNIASSI, U. R. **Qualidade em tecnologia de aplicação**. Botucatu: Fepaf, 2004. p. 93-109.

GUPTA, C. P.; DUC, T. X. Deposition studies of a hand-held air assisted electrostatic sprayer. **Trans. ASAE**, v. 39, n. 5, p. 1633-1639, 1996.

LUCHINI, L. C. Dinâmica ambiental dos agrotóxicos. In: RAETANO, C. G.; ANTUNIASSI, U. R. **Qualidade em tecnologia de aplicação**. Botucatu: Fepaf, 2004. p. 36-39.

LUCHINI, L. C.; ANDRÉA, M. M. Comportamento ambiental de agroquímicos. **Hortic. Bras.**, v. 18, p. 33-35, 2000. (Suplemento).

MONQUERO, P. A. et al. Lixiviação e persistência dos herbicidas sulfentrazone e imazapic. **Planta Daninha**, v. 28, n. 1, p. 185-195, 2010.

PERGHER, G.; GUBIANI, R.; TONETTO, G. Foliar deposition and pesticide losses from three airassisted sprayers in a hedgerow vineyard. **Crop Protec.**, v. 16, n. 1, p. 25-33, 1997.

PORCILE, J. F. Importância de lãs malezas em produccion florestal. In: CONGRESSO LATINOAMERICANO DE MALEZAS, 12., 1995, Montevideo. **Resumos...** Montevideo: INIA, 1995. p. 137.