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POTENCIAL DE DERIVA NA PULVERIZAÇÃO AÉREA COM PONTA DE JATO PLANO DE IMPACTO*

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RESUMO: O objetivo do presente trabalho foi avaliar o potencial de deriva de pulverizações aéreas com a ponta CP-03 e caldas contendo inseticida e adjuvantes. O experimento utilizou caldas com o inseticida isolado (Engeo Pleno, Syngenta) e misturas deste inseticida com três adjuvantes: um multifuncional baseado em surfactantes (TA35, Inquima) e dois óleos emulsionáveis, um vegetal e um mineral (Natur’oleo, Stoller e Nimbus, Syngenta). Um viscosímetro Brookfield DV-II+ Pro foi utilizado para determinar a viscosidade das caldas. A aplicação aérea foi simulada através de um ventilador com velocidade média de vento de 180 km h^{-1}. A taxa de aplicação foi de 20 L ha^{-1}. Todas as caldas foram pulverizadas com os três ângulos defletores da ponta CP-03 na pressão de 200 kPa e o espectro de gotas foi determinado utilizando o método de análise de gotas/partículas por análise de imagens (Particle/Droplet Image Analyses - PDIA). Os resultados mostraram que quanto maior o ângulo do defletor da ponta CP-03 maior foi o risco de deriva da pulverização. Observou-se que a adição de óleo à calda aumentou o risco de deriva das aplicações de Engeo Pleno. Não foram observadas correlações significativas entre a viscosidade das caldas e as características do espectro.

Palavras–chave: aplicação aérea, tamanho de gotas, inseticida

DRIFT POTENTIAL IN AERIAL SPRAYING WITH DEFLECTOR FLAT FAN NOZZLE

ABSTRACT: The objective of this research was to evaluate the drift potential from aerial applications with a CP-03 nozzle and spray solutions containing insecticides and adjuvants. The experimental design was composed of four spray solutions, one with the insecticide (Engeo Pleno, Syngenta) and another three with a mixture of this insecticide with adjuvants: a multifunctional adjuvant based on surfactants (TA35, Inquima) and two emulsifiable oil adjuvants, vegetables and mineral oils (Natur'oleo, Stoller and Nimbus, Syngenta). A Brookfield DV-II+ Pro viscometer was used to measure the solution viscosity. aerial application was simulated via a fan with an average wind speed of 180 km h^{-1}. The application volume rate was 20 L $ha^{-1,}$ and the spray pressure was 200 kPa. All spray solutions were tested with the three deflection angle settings of the CP-03 nozzle, and the droplet spectra were determined via Particle/Droplet Image Analysis (PDIA). The results showed that larger deflector angles on CP-03 increased the risk of drift. The use of oil-based adjuvants increased the risk of drift, whereas no significant correlations were found between the droplet spectra and the viscosity of the solutions.

Keywords: agricultural aviation, droplet size, insecticide

1 INTRODUCTION

Agricultural aviation is an important tool in the agricultural sector in the search for greater operational capacity and greater productivity with the application of phytosanitary products to control insect pests, weeds and diseases that interfere with crop development. The success in using this tool depends on minimizing the drift that occurs

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during the process and harms the adjacent environment. The droplet formation process is the result of the interaction between the spray tip and the liquid, and the performance of the tip is susceptible to the properties of the liquids and the addition of adjuvants (Ruiter, 2002). Fritz *et al*. (2009) highlighted that, depending on the concentration of adjuvants in the spray solution, there may be interference in the formation of droplets, becoming an important factor with a high potential for modifying the spectrum of these drops, which can increase or reduce their diameter, increasing losses. . Although smaller drops have greater coverage potential and thus greater efficiency in controlling insect pests, diseases and weeds, they are also more prone to drift than larger drops are (Antuniassi *et al*., 2011). Kirk (2003) mentioned that the droplet spectrum is a tool that has been used as the most important variable for analyzing drift reduction in applications. Engeo Pleno® (thiamethoxam) is a second-generation neonicotinoid insecticide that has a toxicological classification III (medium toxicity) and an environmental class III (dangerous for the environment) and is used in various crops, such as citrus and cotton. In this context, the objective of this research was to simulate an aerial application to evaluate the influence on the drift potential of aerial sprays with a CP-03 tip and sprays containing insecticides and adjuvants, with the goal of identifying the use of these techniques with respect to the safety of aerial applications. .

2 MATERIALS AND METHODS

The experiment was carried out at the Spraying Machinery Laboratory of the Agricultural Machinery and Tire Testing Center (NEMPA), in the Department of Rural Engineering of the Faculty of Agricultural Sciences (FCA/UNESP), Botucatu Campus – SP. Under laboratory conditions with a completely randomized design, a 3 × 4 factorial scheme (3 deflector angles × 4 tails), with 12 treatments and five replications, totaling 60 samples, was used. Sprays were prepared with an insecticide alone and mixed with three adjuvants. The products used in the sprays are described in Table 1. The sprays were diluted to an application rate of 20 L ha $^{-1}$ and sprayed at three deflection angles (30°, 55° and 90°) of the type spray tip. A CP-03 flat impact jet (CP Products, USA) was used at a pressure of 200 kPa. The viscosity of the solutions was measured via a Brookfield viscometer, model LVDV-III+. The volumetric median diameter (MDV) and percentage of drops smaller than 100 µm (V100) were obtained via the particle/droplet image analysis (PDIA) method described by Fritz, Hoffmann and Bagley (2010), which uses the VisiSize system portable together with ViseSize 6.0 software (Oxford Lasers, UK). For the aerial application simulation, a high-capacity fan (of the "sirocco" type) was used, and the wind speed was monitored in real time and maintained on average at 180 km h $^{-1}$ (180 ± 0.2 determined by the 95% CI of five determinations throughout the test).

Table 1. Description of the products used to prepare the spray mixtures.

Business Name	**Class**	**Main component**	**Manufacturers**	**Dose (L pc ha $^{-1}$)**
Engeo Pleno ®	Insecticide	thiamethoxam	Syngenta	0.15
Nimbus®	Adjuvant	mineral oil	Syngenta	0.5
Natur'l oil ®	Adjuvant	vegetable oil	Stoller	1.0
TA $^{35®}$	Adjuvant	sodium lauryl ether sulfate	Inquima	0.05

The CP-03 tip was attached to the output of this wind-generating equipment and connected to a stationary spray system. To form a continuous air current between the spray tip and the droplet reading equipment, a cone-shaped structure was built around the spray tip to the droplet reading equipment, with an initial diameter of 0.31 m and a final diameter of 0.50 m. The droplet analyzer was positioned centrally with the equipment chamber in front of the spray tip. The droplet spectrum results were subjected to analysis of variance with the Tukey test at 5% probability. After comparing the treatments for all the variables evaluated, Pearson correlations ($P<0.05$) were calculated to verify the associations between the viscosity of the syrup and the characteristics of the droplet spectrum. The viscosity means were compared via the confidence interval at the 95% probability level.

3 Results AND DISCUSSION

In Graph 1, the average viscosity values for all the grouts evaluated are presented. The presence of adjuvants in the mixtures increased the viscosity compared with the mixture with the insecticide alone, with the highest values being observed for the mixtures with oil, with significant differences between the adjuvants.

Graph 1. Grease viscosity values (averages ± 95% CI)

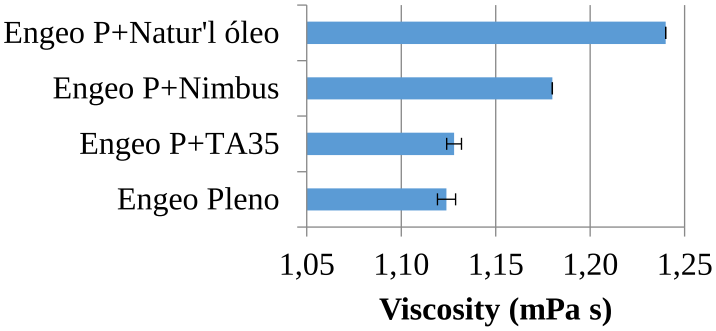

Table 2 presents the values referring to the droplet spectrum, observing in the DMV values that the greater the deflection angle is, the smaller the droplet size. This result is expected because the greater the angle is, the stronger the impact between the syrup and the tip shield, generating greater fragmentation of the sprayed mixture. The presence of adjuvants promoted a reduction in the DMV, with the exception of the 90° $^{\text{angle}}$. When comparing only treatments with adjuvants, TA-35 provided the highest DMV value, with significant differences at all angles of 30 and 55°, whereas the DMV value for Nimbus was lower than that for Natur'l oil, with a significant difference at an angle of $^{30°}$.

Table 2. Breakdown of deflection angles for each grout (CL) in relation to the volumetric median diameter (DMV).

	DMV (µm)		
CL	**Angle 30°**	**Angle 55°**	**90° angle**
Full Engeo	283.3 aA *	208.3 bA	157.9 cA
Engeo Pleno+TA35	272.0 bB	209.7 bA	163.6cA
Engeo Pleno+Natur'l oil	244.2 BC	195.2 bB	162.2cA
Engeo Pleno+Nimbus	234.1 AD	192.7 bB	157.7cA

*Averages followed by the same letter, lowercase in the row and uppercase in the column, do not differ from each other according to the Tukey test ($p < 0.05$). DMS for columns = 7.7; DMS for lines = 7.0

In Table 3, the V100 values are presented. The V100 values increased with increasing bulkhead angle, with significant differences between the angles for all the grouts. Compared with the other treatments, the addition of mineral oil to the syrup increased the V100 to an angle of 30°. TA-35 provided lower V100 values than mineral oil (Nimbus) did at angles of 55 and $^{90^\circ}$. All adjuvants reduced the V100 value at an angle of $^{90^\circ}$, with TA-35 being the adjuvant that provided the lowest V100 values for this angle.

Table 3. Breakdown of deflection angles for each spray (CL) in relation to the percentage of drops smaller than 100 µm (V100).

	V100 (%)		
CL	**Angle 30°**	**Angle 55°**	**90° angle**
Full Engeo	11.2 cB *	15.4 bBC	23.5 BC
Engeo Pleno+TA35	10.5 cB	14.6 BC	20.5 BC
Engeo Pleno+Natur'l oil	12.0 cB	17.0 bAB	22.4 aAB
Engeo Pleno+Nimbus	13.9cA	18.0 bA	21, 4 BC

*Averages followed by the same letter, lowercase in the line and uppercase in the column, do not differ from each other according to the Tukey test ($p < 0.05$), DMS for columns = 1.6; DMS for lines = 1.4

To better understand the interference of the grouts in the formation of the droplet spectrum, the correlation coefficient between the average viscosity values and the DMV and V100 was determined (Table 4). The DMV presented an inverse correlation coefficient (with a negative sign) with viscosity, which, despite being strong, was not significant. In the case of V100, the correlation coefficient was direct (positive), moderate and not significant. Despite the lack of significance, the signs of the correlation coefficients indicate that as the viscosity of the grout increases, the risk of application drift tends to increase, with lower DMV values and higher V100 values. According to Reichard and Zhu (1996), adjuvants that increase viscosity are added to grouts to increase the DMV and, consequently, reduce drift, a reference that contradicts the results obtained in this work.

Table 4. Correlation between the DMV, V100 and grout viscosity

	Viscosity
DMV	-0.77ns
V100	0.58ns

ns. : not significant at the 5% probability level ($P < 0.05$)

When the interference of different adjuvants in the spectrum of drops was analyzed, Mota and Antuniassi (2013) and Madureira, Raetano and Cavalieri (2015) also reported results *that were different from those reported in this study; in terrestrial applications, an increase in the DMV was obtained in applications with oils compared with that of surfactant-based adjuvants. Furthermore, Sanderson et al.* (1997), through simulation of aerial application with a D8-46 spray tip, reported that mixtures composed of surfactants had lower DMVs than mixtures composed of oil-based adjuvants.

The inverse relationship between the DMV and direct relationship between V100 and viscosity at the CP-03 tip can be explained by the interaction between the impact processes of the liquid with the screen and the shearing of the drops by the wind. Liquids with higher viscosity have a lower flow speed at the exit of the screen, generating a greater difference in speed between the drops and the wind. For this reason, greater droplet shear occurs, resulting in a lower DMV and higher V100.

It is, therefore, a phenomenon that differentiates the condition of droplet formation in relation to all the works described previously, where there is no shearing action by the wind, only the action of viscosity occurring as the liquid passes through the tip orifice. . In this sense, Fritz and Hoffmann (2015) described an effect similar to that obtained in this work when testing spray tips and grouts at different pressures in aerial applications. The authors describe, in the same way as observed in this work, that the difference in the speed of the drops in relation to the air flow was a predominant factor in the process of generating the drop spectrum.

4 CONCLUSIONS

Under conditions of aerial application of the insecticide Engeo Pleno, the greater the angle of the CP-03 tip deflector is, the greater the risk of spray drift. The 30° deflection angle was positioned as the best technique with the potential to reduce drift, as it presented the lowest V100 values and highest DMV values for all grouts evaluated. Taking the DMV and V100 values as a basis, the addition of oil to the syrup increased the potential risk of drift in Engeo Pleno applications.

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