Effect of addition of syrup glycerin as adjuvant for spraying in land use

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Abstract

The application of pesticides is a practice that has deficiencies such as low efficiency, environmental contamination and losses on derivatives, runoff and evaporation. Thus, this study aimed to evaluate the behavior of glycerol as an adjuvant in the spray ground, comparing it with vegetable oil and water. The parameters evaluated were volume median diameter (VMD) droplet density (DD) and real potential for drift (RDP). The experiment was a completely randomized design with 15 treatments and 4 replicates in a 5x3 factorial design (5 compositions of spray and 3 volumes of application). The doses of adjuvant used were 2.0 and 2.5% (v/v) glycerin and vegetable oil. We used three spray volumes (100, 150 and 200 L ha^{-1}). The treatments with water + vegetable oil reduced the values of DD and RDP. VMD values were directly proportional to the volume of application. The addition of glycerol increased the DD. Glycerin can be used as an adjuvant, however, studies with lower concentrations should be developed in comparison with plant and mineral oil adjuvant.

Key words: application technology; volume median diameter; density drops; real potential drift

Introduction

The land application of phytossanity products is a very common practice and it is of major importance, considering the wide area occupied by crops in Brazil and the necessity of several applications during the crop cycle, either for the weed control, combat of insects or elimination of diseases.

Technology of application is defined as the use of all the scientific knowledge which provides the correct placement of the product biologically active in the target, in the necessary amount, in an economical way, with the minimum of contamination of other areas (MATUO, 1998).

SANTOS (2007) affirms that the volume of application is one of the fundamental parameters for the success, and its definition is dependent on the type of target to be reached, of the drop size, of the cover needed, among other factors. Besides that, the volume of application influences also in the operational capacity, since the higher the volume used, the larger the number of stops to replenish the sprayer. In average, the volume for the land application is 120 L ha^{-1}, however, the variation is from 100 to 300 L ha^{-1}. The volume of application is divided in classes (Table 1) and type of crop, being specified the volumes from ultra low to high (SHIRATSUCHI and FONTES, 2002).

The volume of application is the main responsible for results that are not completely satisfactory or below the expected in application of agricultural defensives to different crops (AZEVEDO and FREIRE, 2006). The ideal volume is that which generates correct drops and drops which are appropriated to each type of application, provides good deposition over plants, excellent penetration inside the canopy, high efficiency and minimization of losses.

One artifice to reduce losses is the use of adjuvants. According to OZEKI (2006), adjuvants are inert products which are added in the spraying solution in order to raise the biological efficiency of the active ingredients, improving the adherence over the surface of the target and improving the absorption of the active ingredient.

The addition of adjuvants reduced the

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Table 1. Classes of volume of application for two types of crops.

Classes of volumes	Volume (L ha^{-1})	
	Field crop	**Tree crop**
High	> 600	> 1000
Medium	200 – 600	500 – 1000
Low	50 – 200	200 – 500
Very low	5 – 50	50 – 200
Ultra low	< 5	> 50

potential risk of drift and increased the deposition of solution in aerial applications (CUNHA and CARVALHO, 2005). The same authors explain that a higher deposition in the target is only an indicative, and may not be related to the larger absorption.

DEBORTOLI (2008) verified that the application of fungicide combined with the use of mineral oil as adjuvant in the soybean culture had an efficiency superior to the control without the combination of adjuvant either in favorable or in unfavorable (rainfall) conditions after the application. The author also affirms that, depending on the nozzle used in the spraying, the control may be inferior with the use of adjuvant.

One product which is promising as adjuvant is glycerin, which is generated in the productive process of the biodiesel. Nowadays glycerin is used with several aims in various industries, even tough its use as adjuvant is not widely spread there are research works which prove its potential to this aim. Allied to the potential of glycerin as adjuvant, there is the quantity currently produced, which has been considerably growing due to the increase in the production of biodiesel, once glycerin is a proportional fraction of this productive process.

MACIEL et al. (2008) affirmed that glycerin, despite dissolving well in water, in concentrations from 5.0 to 10% (v/v) presents a spraying solution with alkaline pH superior to 9.0, making it unviable to most of the big agricultural defensives, as the herbicide glyphosate among others, with characteristics of weak acids.

Facing this, the present work has as objective to evaluate the behavior of the glycerin as adjuvant in the land application of agrotoxics comparing it to the vegetal oil concerning its influence over the volume medium diameter, drop density and real drift potential.

Material and methods

The experiment was performed in the Campus of Arenito, in the municipality of Cidade Gaúcha, in the northwest region of the state of Paraná, located in the road PR 482, km 45, with average altitude of 404 m, latitude 23° 22' 30" south and longitude 52° 56' 00" west. The climate of the region is subtropical humid mesotermic, according to the classification of Köppen, hot summers with tendency of concentration of rains, average annual temperature of 22 °C, winters with sparse frost without a defined dry season.

The glycerin used in the experiment is subproduct of the production of biodiesel of soybean produced in the colony Witmarsun, located in the BR 277, km 146, next to the city of Palmeiras – PR. The basic composition of the glycerin is: water, alkalin catalyst, biodiesel, soaps of fatty acids, ethanol and methanol. The vegetal oil used in the experiment was NATUR`L ÓLEO, its composition is 930 mL L^{-1} of esters of fatty acids of vegetal origin and 70 mL L^{-1} of other ingredients (Nonyl phenol ethoxylate). This adjuvant oil is classified as adhesive adjuvant. The water used in the experiment was obtained of an artesian well in the Campus of Arenito.

In the collection of the spraying samples, it was used collectors of water-sensitive paper (OZEKI, 2006). These papers are impregnated with the bromophenol blue dye, which in its non-ionized form presents yellowish color. Water, however, ionizes the substance, and this acquires a strong blue color (CHAIM et al., 1999).

In order to verify the climate conditions in the moment of the experiments it was used a digital hygro-thermo-anemometer Kestrel 3000, in which the values of each variable were instantly verified.

In order to pull and activate the sprayer, it was used a tractor of the brand Massey Ferguson, model MF283, with motor power of 63.00 kW (85 cv) with front wheel assist (Fwa). The sprayer used was of the type tractor mounted, of the brand Montana, model Montana 600, with capacity of the tank of 600 L, with bar with 12 m equipped with nozzles Magno ADGA 02 of the type flat fan spaced 0.5 m from each other. Table 2 presents the technical characteristics of the nozzle (MAGNOJET, 2009).

It was used a computer compatible with PC-IBM, with operational system Windows, for the execution of the computer programs (e-Sprinkle Sadgna, DropCap, Sisvar) and scanner with resolution of 1200 dpi brand Genius Color Page model Vivid3x, to digitalize the image of the water-sensitive collectors.

The computer program e-Sprinkle Sadgna 2005, produced and traded by Ablevision Sistemas Computacionais LTDA, with technology transferred by EMBRAPA Instrumentação Agropecuária, in association with the Universidade Federal de São Carlos (Federal university of São Carlos) and the Instituto Agronômico de Campinas (Agronomical Institute of Campinas), was used to perform the analysis of the parameters of spray (volume medium diameter [VMD], drop density [DD] and real drift potential [RDP]). The computer program DropCap come together with the program e-Sprinkle and it was used to capture the image of the water-sensitive cards.

It was also used other materials as: measuring tape to measure the space between collectors, height of application and height of collectors; breaker to measure the volume in the moment of calibration of the sprayer and dosage of the adjuvants; chronometer to measure the time in the moment of the calibration of the sprayer.

The evaluated product was glycerin, in the doses of 2.0 and 2.5% (v/v). Glycerin was compared with vegetal oil NATUR´L ÓLEO, which is used commercially as adjuvant and also with a control treatment composed of only water (water 100%). The proportions of glycerin and vegetal oil added to the spraying solution were equal.

For the drop deposition, it was placed three water-sensitive paper collectors distributed across the line of application along the spraying bar. These collectors were spaced from each other by 4.2 m.

The collector line (water-sensitive paper) was evaluated 10 m after the beginning of the spraying, in order to guarantee the stabilization of the pressure of the sprayer and the velocity of dislocation of the tractor (Figure 1a). The collectors were identified, from the left to the right, with the acronyms C1, C2, C3 (Figure 1b).

The sprayer was calibrated to apply volumes of application of 100, 150 and 200 L ha^{-1}, and regulated to apply at a height of 0.50 m from the collectors, according to RAMOS et al. (2004). In the moment of the performance of the experiments the pressure of the sprayer was 27,58 kPa (40 lbf pol^{-2}), which is inside the technical limits of the nozzle. The collectors of water-sensitive paper were fixed with their side sensitive to water facing up at a height of 0.15 m from the soil trough metal supports (Figure 1c).

After each application, a time of one minute was waited so that the drops deposited over the collectors would dry and then they were packed individually, with aluminum foil and placed in an airtight box so it would not absorb humidity from the environment.

Later, the collectors were digitalized individually by the scanner with aid of the computer program DropCap, and the parameters drop density (drop cm^{-2}), volume medium diameter (μm) and real drift potential (%) were evaluated by the computer

Table 2. Technical characteristics of the nozzle ADGA 02.

Color	Description	Preassure (lbf pol^{-2})	Flow (L min^{-1})	Velocity (km h^{-1})*						
				4	5	6	7	8	9	10
				Flow (L ha^{-1})						
Yellow	BD-02	30	0.66	198	158	132	113	99	88	79
	AD-02 ADGA-02	45	0.82	246	197	164	141	123	109	98
	Malha 50	60	0.95	285	228	190	163	143	127	114

** The values of the flow in (L ha^{-1}) are referent to spacing of 0.5 m between nozzles.*

program e-Sprikle.

The experiment was composed by 15 (fifteen) treatments, which are presented in Table 3, disposed in factorial scheme 5 x 3 (5 compositions of spray and 3 volumes of application), in completely randomized design with four replications. The analysis of variance was performed by the F test and the decomposition by the Scott-knott test in level of 5% of significance, trough the statistic computer program SISVAR 4.6.

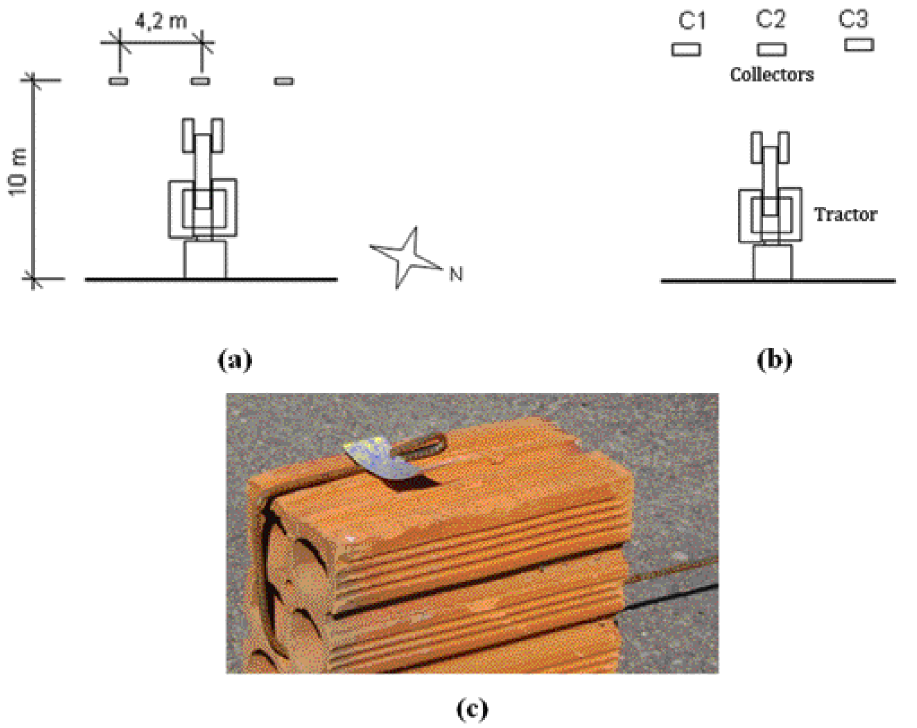

Figure 1. Positioning of the mechanized joint and water-sensitive paper (a), identification of the collectors of the water-sensitive paper (b) and metallic supports (c).

Table 3. Treatments used in the experiment.

Treatments	Composition	Volumes of application (L ha^{-1})
T1	Water 100%	
T2	Water + Vegetal oil 2.0%	
T3	Water + Vegetal oil 2.5%	100
T4	Water + Glycerin 2.0%	
T5	Water + Glycerin 2.5%	
T6	Water 100%	
T7	Water + Vegetal oil 2.0%	
T8	Water + Vegetal oil 2.5%	150
T9	Water + Glycerin 2.0%	
T10	Water + Glycerin 2.5%	
T11	Water 100%	
T12	Water + Vegetal oil 2.0%	
T13	Water + Vegetal oil 2.5%	200
T14	Water + Glycerin 2.0%	
T15	Water + Glycerin 2.5%	

The percentage of the composition of glycerin and vegetal oil are considered in function of the volume of spray per volume of product (v/v).

Resuts and disctussion

In the Table 4, it is presented the average values of the climate conditions during the performance of the experiments obtained from the automatic meteorological station of the INMET (2009).

In Table 5 it is presented the average values of the climate conditions obtained with the digital hygro-thermo-anemometer during the performance of the experiments in the field. It can be verified that some values of velocity of wind (T5, T10, T15) are below the recommended by ANTUNIASSI (2005) and OZEKI (2006).

With exception of the treatment Water (W), all the treatments presented increase in the values of VMD with increase of the spray solution volume (Figure 2).

It can be verified statistic differences for volume of application and composition of spray solution. Trough the average values of VMD, it can be verified that they are proportional to the volume of spray solution (Vs), i.e., the higher the volume of application, the higher the average volume of VMD, so the highest value obtained was for the volume of application of 200 L ha^{-1} (858.8 μm). For the composition of spray solution, highest average value of VMD were obtained for the spray solution WO2.0 (848.1 μm) and WO2.5 (819.2 μm) (Table 6).

For the composition of spray solution WG2.5 and W02.0, the values of VMD in the volumes of application of 150 and 200 L ha^{-1} were superior to the volume of application of 100 L ha^{-1}. For W02.5, VMD was directly proportional to the spraying solution volumes.

When analyzing the volumes of VMD for the composition of spray solution inside the volumes of application (analysis of line), it can be verified that highest values of VMD were obtained for the solutions WO2.0 and WO2.5 (997.8 μm and 1055.8 μm respectively), associated to the volume of application of 200 L ha^{-1}.

When analyzing the values of VMD for volume of application inside the composition of spray solution (analysis in the column), it can be seen that the volumes of application of 150 and 200 L ha^{-1} provide higher values of VMD for the solutions WG2.5 and WO2.0, however, only the volume of application of 200 L ha^{-1} provided higher value of

Table 4. Average climate conditions during the experiments.

Day/hour	Temperature (°C)	Relative humidity (%)	Velocity of the wind (m s^{-1})	Direction (°)[1]
04/08-10:30/11:30*	14.56	72.17	1.23	116.00
04/08-14:00/15:30**	22.87	52.67	2.00	86.00
07/08-0:00/11:15***	21.23	80.00	0.57	129.00

*Data of the station of automatic surface, Cidade Gaúcha – PR, coordinates: 23°21'33"S, 52°55'53"W. * referent to the treatments T1, T4, T6, T9, T11 and T14. ** referent to the treatments T5, T10, T15. *** referent to the treatments T2, T3, T7, T8, T12, and T13. 1The direction of the wind is the measure in degrees from the geographic North to the right.*

Table 5. Climate conditions observed during the experiments.

Treatment	Relative Humidity (%)	Vel. Wind (m s^{-1})	Temperature (°C)	Treatment	Relative Humidity (%)	Vel. Wind (m s^{-1})	Temperature (°C)
T1**	51.00	1.11	21.00	T9**	50.00	1.05	25.50
T2*	77.00	0.97	25.80	T10***	52.00	0.61	28.20
T3*	77.00	0.97	25.80	T11**	51.00	0.97	24.00
T4**	50.00	0.94	25.00	T12*	77.00	0.97	25.80
T5***	51.00	0.55	27.00	T13*	77.00	0.97	25.80
T6**	51.00	0.97	23.00	T14**	50.00	0.97	26.00
T7*	77.00	0.97	25.80	T15***	52.00	0.58	28.00
T8*	77.00	0.97	25.80				

** Experiments performed in August 07 2009 from 10:00am to 11:15am. ** Experiments performed in August 04 2009 from 10:30am to 11:30am. *** Experiments performed in August 04 2009 from 02:00pm to 03:30pm. Data obtained with a digital hygro-thermo-anemometer.*

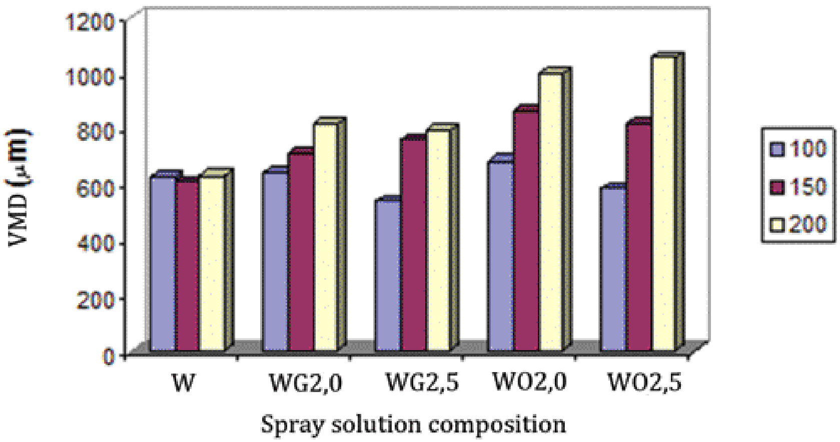

Figure 2. Average values of volumetric mean diameter (μm).

Table 6. Average value of the medium volume for the composition and volume of spray solution.

Volume of spray solution (L ha^{-1})	Volume Medium Diameter - VMD (μm)					
	W	WG2,0	WG2.5	WO2.0	WO2.5	Means (Vs)
100	627.6 Aa	641.1 Aa	538.5 Ba	684.9 Ba	585.6 Ca	615.5 C
150	610.8 Aa	711.8 Aa	757.2 Aa	861.5 Aa	816.1 Ba	751.5 B
200	631.0 Ab	816.9 Ab	792.5 Ab	997.8 Aa	1055.8 Aa	858.8 A
Averages (Cs)	623.2 b	723.3 b	696.1 b	848.1 a	819.2 a	
Coefficient of variation (CV): 29.32%						

Vs = volume of applied spray solution (L ha^{-1}); Cs = composition of spray (v/v); W = water (100%); WG2.0 = Water (98.0%) + Glycerin (2.0%); WG2.5 = Water (97.5%) + Glycerin (2.5%); WO2.0 = Water (98%) + Vegetal oil (2.0%); WO2.5 = Water (97.5%) + Vegetal Oil (2.5%).Averages followed by the same letter, lowercase in the line and uppercase in the column, do not differ statistically from each other, by Scott-Knott test and F test, respectively, at 5% of probability.

VMD for the solution WO2.5. It can be verified also that for the volume of application of 200 L ha^{-1}, the treatments in which it was used the adjuvant vegetal oil the values of VMD were statistically higher that the other treatments.

For the volumes of solution (100, 150, 200 L ha^{-1}), there was no significant difference in the values of VMD with the increase of the concentration of adjuvant glycerin. The same behavior is observed for the adjuvant vegetal oil.

Trough Figure 2, it can be observed that for the treatment WO2.5 the value of the VMD increased proportionally with the increase of the volume of application, i.e., the higher the volume of application, the higher the VMD.

Trough the valued of VMD (Table 6), according to OZEKI (2006) the drops resulting from the operation of spraying may be classified as very thick, with exception of the treatments WG2.5 and WO2.5 associated to the volume of spray solution of 100 L ha^{-1}, which can be classified as thick. To VELLOSO et al. (1984), diameters close to 100 μm are appropriated to the distribution of fungicides and insecticides, while drops from 200 to 300 μm are appropriated to the application with herbicides. Considering this indication, the values obtained in Table 6 are not recommended for them.

MÁRQUEZ (1997) affirms that drops bigger than 800 μm tend to drain from the leaf surface, situation which occurs in the treatments WG2.0, WO2.0, WO2.5 applied with the volume of 200 L ha^{-1} and for the treatments WO2.0 and WO2.5 applied with volume of 150 L ha^{-1}.

In Table 7 and Figure 3 it is presented the values of drop density for the treatments composition of spray solution and volume of spray solution.

In Figure 3 it can be observed that the solution Water 100% (W) increase the values of

DD with the volumes of the spraying solution. In treatments WG2.0 and WG2.5, the volume of praying solution of 150 L ha^{-1} presented superior values of DD. Treatments WO2.0 and WO2.5 present reduced values of DD independent on the volume of application.

In Table 7, it can be verified that there was statistical difference between treatments volume of spray solution and composition of spray solution. For the volumes of application, the higher average values of drop density were obtained for the volumes of 150 and 200 ha^{-1}, (164.3 drops cm^{-2}) and (161.6 drops cm^{-2}), respectively.

For the spray solution composition, the highest average value of drop density were obtained for WG2.0 (178.7 drops cm^{-2}) and WG2.5 (182.5 drops cm^{-2}). For the treatments W, WG2.5 and WO2.5 the values of density of drops for the volumes of 150 and 200 L ha^{-1} were statistically superior to the volume of 100 L ha^{-1}. It can be verified also that for the treatment WG2.0 the volume of application of 150 L ha^{-1} provides higher drop density in relation to the volumes of application of 100 and 200 L ha^{-1}.

For the volume of application of 100 L ha^{-1} higher value of drop density was obtained in the treatments with addition of glycerin (WG2.0 and WG2.5). For the volume of application of 150 and 200 L ha^{-1}, lower values of drop density were obtained for the treatments WO2.0 and WO2.5.

In Table 7, it can be observed that for the volumes of spray solution (100, 150, 200 L ha^{-1}), there was no significant difference in the values of DD, with an increase in the concentration of adjuvant glycerin. The same behavior is observed for the adjuvant vegetal oil. The same DD value presented in Table 7 are above the recommended by RAMOS

Table 7. Average values of drop densities for the composition and volume of spray solution.

Vol. Solution (L ha^{-1})	Drop Density - DD (drop cm^{-2})					Averages (Vs)
	W	**WG2.0**	**WG2.5**	**WO2.0**	**WO2.5**	
100	125.8 Bb	173.2 Ba	162.9 Ba	124.1 Ab	108.2 Bb	138.8 B
150	177.2 Aa	194.0 Aa	196.0 Aa	124.8 Ab	129.7 Ab	164.3 A
200	189.1 Aa	168.8 Ba	188.7 Aa	131.3 Ab	129.9 Ab	161.6 A
Averages (Cs)	164.1 b	178.7 a	182.5 a	126.7 c	122.6 c	
Coefficient of Variation (CV): 16,11%						

Vs = volume of applied spray solution (L ha^{-1}); Cs = composition of spray (v/v); W = water (100%); WG2.0 = Water (98.0%) + Glycerin (2.0%); WG2.5 = Water (97.5%) + Glycerin (2.5%); WO2.0 = Water (98%) + Vegetal oil (2.0%); WO2.5 = Water (97.5%) + Vegetal Oil (2.5%).Averages followed by the same letter, lowercase in the line and uppercase in the column, do not differ statistically from each other, by Scott-Knott test and F test, respectively, at 5% of probability

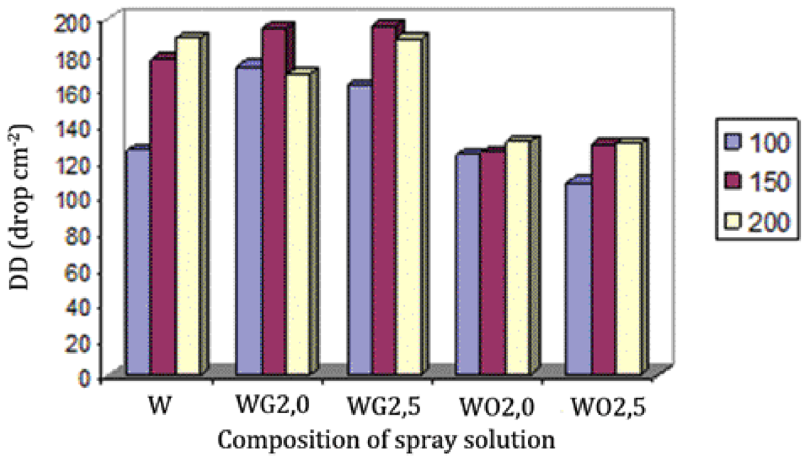

Figure 3. Average value of drop density (drops cm^{-2}).

et al. (2004) for the application of insecticides, herbicides and fungicides.

In Table 8 and Figure 4 it is presented the values of real drift potential (%) for the treatments volume of spray solution and composition of spray solution. According to GRANATO (2008), lower values of real drift potential are more advantageous, since they indicate that the probability of occurrence of drift is lower. Trough Figure 4, it can be observed that with exception of the treatment WO2.0, all the others reduced the RDP with the increase of the volume of spray solution.

Trough Table 8, it can be verified that there was significant differences between the treatments volume of spray solution and composition of spray solution. It can be seen that among the volumes of application, the best result was obtained for 200 L ha^{-1} (1.3%) and for the spray solutions the best results were obtained for the spray solutions WO2.0 (0.5%) and WO2.5 (0.6%).

It can be verified that for the treatment WG2.0 the lowest real drift potential was obtained for volume of application of 200 L ha^{-1} (1.2%). It can also be verified that for the treatments W and WG2.5 lower values of real drift potential were provided by the volumes of application of 150 and 200 L ha^{-1}.

In Table 7, it can also be verified that for the three volumes of application used in the work (100, 150 and 200 L ha^{-1}), the lower values of real drift potential were obtained in the treatments in which there was addition of vegetal oil (WO2.0 and WO2.5).

Nevertheless, the treatments in which there was addition of glycerin provided values of real drift potential better than the treatments in which there was no addition of adjuvant except for the

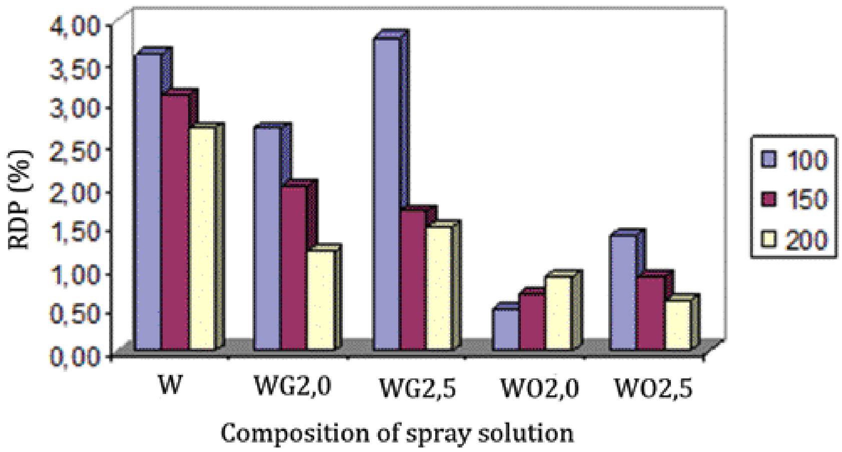

Figure 4. Average values of real drift potential (%).

Table 8. Average values of the real potential of drift for decomposition and volume of spray solution.

Volume of solution (L ha^{-1})	Real Drift Potential - RDP (%) W	WG2.0	WG2.5	WO2.0	WO2.5	Averages (Vs)
100	3.6 Aa	2.7 Ab	3.8 Aa	0.5 Ac	1.4 Ac	2.5 A
150	3.1 Ba	2.0 Ab	1.7 Bb	0.7 Ac	0.9 Ac	1.6 B
200	2.7 Ba	1.2 Bb	1.5 Bb	0.9 Ac	0.6 Ac	1.3 C
Averages (Cs)	3.1 a	2.0 b	2.3 b	0.7 c	0.9 c	
Coeficient of variation (CV): 48.93%						

Vs = Volume of applied spray solution (L ha^{-1}); Cs = composition of spray (v/v); W = water (100%); WG2.0 = Water (98.0%) + Glycerin (2.0%); WG2.5 = Water (97.5%) + Glycerin (2.5%); WO2.0 = Water (98%) + Vegetal oil (2.0%); WO2.5 = Water (97.5%) + Vegetal Oil (2.5%).Averages followed by the same letter, lowercase in the line and uppercase in the column, do not differ statistically from each other, by Scott-Knott test and F test, respectively, at 5% of probability composition of spray solution WG2.5 associated to the volume of application of 100 L ha^{-1}, where the result did not differ statistically with the result of the treatment in which there was no addition of adjuvant for the same volume of application. These results corroborate GRANATO (2008), who observed reduction in the real drift potential with the addition of adjuvant vegetal oil in air spraying.

For the concentration of adjuvant of 2.5%, the RDP was lower for the treatment with adjuvant vegetal oil, similar result was obtained by ANTONIEL (2010), who also observed reduction in the RDP for the same concentrations.

Conclusions

The addition of glycerin provided increase in drop density.

The composition of spray solution water 100% (W) presented behavior inversely proportional of drop diameter (DD) and directly proportional of real drift potential (RDP) with the volume of spray solution.

In treatments with glycerin and vegetal oil, the volumetric mean diameter (VMD) presented direct relation with the volume of spray solution, independent on the concentration used.

The composition water + vegetal oil, independent on the concentration, reduced the valued of DD and RDP independent on the volume of spray solution applied.

Glycerin can be used as adjuvant in the studied concentrations.

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