POTENTIAL OF ADJUVANTS TO REDUCE DRIFT IN AGRICULTURAL SPRAYING

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ABSTRACT: The reduction of pesticide spraying drift is still one of the major challenges in Brazilian agriculture. The aim of this study was to evaluate the potential of different adjuvant products, such as surfactants, drift retardants, mineral oil and vegetable oil for reducing drift in agricultural spraying. The experiment consisted of quantifying drift of sprayings of 18 adjuvants dissolved in water under controlled conditions in a wind tunnel. Tests were performed in triplicates with spraying nozzles type Teejet XR8003 VK, pressure of 200kPa and medium drops. Solutions sprayed were marked with Brilliant Blue dye at 0.6% (m v^{-1}). The drift was collected using polyethylene strips transversally fixed along the tunnel at different distances from the nozzle and different heights from the bottom part of the tunnel. Drift deposits were evaluated by spectrophotometry in order to quantify deposits. The adjuvants from chemical groups of mineral oil and drift retardant resulted in lower values of drift in comparison with surfactants and water. The results obtained in laboratory show that the selection of appropriate class and concentration of adjuvants can significantly decrease the risk of drift in agricultural spraying. However, the best results obtained in laboratory should be validated with pesticide under field conditions in the future.

KEYWORDS: Wind tunnel, drift retardant, mineral oil, vegetable oil, surfactant.

POTENCIAL DE ADJUVANTES PARA REDUÇÃO DA DERIVA EM PULVERIZAÇÕES AGRÍCOLAS

RESUMO: A redução da deriva das pulverizações agrícolas continua sendo um dos maiores desafios da agricultura brasileira. O objetivo deste trabalho foi avaliar o potencial de adjuvantes dos grupos surfatantes, redutores de deriva, óleos minerais e óleos vegetais para a redução da deriva em pulverizações agrícolas. O experimento quantificou a deriva de pulverizações realizadas com 18 adjuvantes em diferentes concentrações, em solução aquosa, sob condições controladas em túnel de vento. Os ensaios foram realizados em triplicatas, com pontas de pulverização Teejet XR8003 VK, pressão de 200 kPa e gotas médias. As soluções pulverizadas foram marcadas com corante Azul Brilhante a 0,6% (m v^{-1}). A deriva foi coletada por meio de fios de polietileno posicionados transversalmente ao fluxo de ar, a diferentes distâncias da ponta e alturas do piso do túnel. A solução de lavagem de cada fio foi processada por meio de espectrofotometria para a quantificação dos depósitos. Os adjuvantes dos grupos funcionais óleos minerais e redutores de deriva proporcionaram valores menores de deriva em comparação com os surfatantes e a água. Os resultados de laboratório indicam que a seleção de produtos e de concentrações adequadas pode reduzir significativamente o risco de deriva nas pulverizações agrícolas. Entretanto, os melhores resultados obtidos em laboratório deverão ser validados com os produtos que irão constituir as caldas de pulverização em condições de campo no futuro.

PALAVRAS-CHAVE: túnel de vento, redutores de deriva, óleo mineral, óleo vegetal, surfatantes.

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INTRODUCTION

The high demand for pesticides in agricultural systems, coupled with the possible misuse of these products, makes the spray drift one of the biggest problems of pesticide application technology, and probably one of the bottlenecks for reducing the environmental impacts of Brazilian agriculture. The correct choice of adjuvants can be one of the main practices adopted to minimize the negative impacts of the spray drift, as well as allowing greater safety and efficacy in applications in less favorable operating conditions and environments (OLIVEIRA, 2011).

Adjuvants are products added to the spray solution with specific functions. “Activators” adjuvants are those which directly improve the efficiency of the pesticide increasing the rate of absorption by the plant. Adjuvants with "special purposes" are those added to reduce the negative effects of drift, but do not directly influence the efficiency of the pesticide (HAZEN, 2000; McMULLAN, 2000; PENNER, 2000; TU & RANDALL, 2003). Previous studies performed with different products than those used in Brazil have shown that the addition of adjuvants modify the physical properties of the solution and changed the risk of drift. These trends were confirmed in both experiments in which the drift was measured in wind tunnels and in measurements taken directly in the field (WALKLATE et al., 2000; BUTLER ELLIS, 2002; NUYTTENS et al., 2006). However, not always "drift retardant" adjuvants available to the Brazilian market fulfill the function specified by the manufacturer, and, therefore, independent trials should be conducted to prove its efficacy in reducing drift.

The estimated risk of drift has been performed satisfactorily by tests conducted in wind tunnel (MOREIRA JÚNIOR & ANTUNIASSI, 2010). Although values under real drift conditions can only be obtained in field experiments, experiments of drift in the wind tunnel have a great advantage over the field experiments, since wind tunnels allow the determination of the potential risk of drifts from different application systems, which could not be repeated and compared under field conditions due to climatic variations (DERKSEN et al., 1999; FIETSAM et al., 2004; NUYTTENS et al., 2009). By isolating environmental factors, experiments in the wind tunnel showed that the drift depends on the type of spray nozzle, the pressure used and the proper adjuvant, as these factors directly influence the size of the spray drop (COSTA et al., 2006).

Researches on the effectiveness of adjuvants are increasing due to the emergence of new products (OLIVEIRA, 2011). However, in Brazil, there are still few studies in the wind tunnel to evaluate the effectiveness of adjuvants to reduce drift applications. The aim of this study was to evaluate the potential of adjuvant of the groups of surfactants, drift retardants, mineral oils and vegetable oils to reduce agricultural spray drift.

MATERIAL AND METHODS

The experiment consisted of 18 spray adjuvants in aqueous solution at different concentrations according to the manufacturer’s recommendations, and measurement of drift in the wind tunnel under controlled conditions (Table 1). The adjuvants were chosen based on the acceptability of the product by the market, and were used in concentrations recommended by the manufacturer or representing real situations of use in the field. The adjuvants belong to the groups of surfactants, mineral oils, vegetable oils and drift retardants and represent the major functional groups of adjuvants commonly used in Brazil (Table 1). Distilled water was used in the formulations of the solutions and spraying, and presented surface tension of 72.6mN m^{-1}.

TABLE 1. Functional groups of adjuvants, chemical composition of main component and number of treatments according to the label of products.

Functional groups	Chemical composition of main component[1]	Number of treatments
Drift retardant (RD)	Emulsified synthetic resin (RD1); Vegetable polymer (RD2); Synthetic latex and organosilicon fluid (RD3 and RD4); Phosphatidylcholine and propionic acid compound (RD5); sodium dodecylbenzenesulfonate and Carboximethylcellulose (RD6)	13
Surfactant (S)	Nonylphenoxypoly ethanol (S1); Nonylphenol ethoxylate (S2 and S3); Polyester copolymer (S4 and S5); Alkyl phenyl polyoxyethylene ether (S6); Sodium lauryl ether sulphate (S7)	11
Vegetable oil (OV)	Glycerol esters of fatty acids (OV1); Esters of fatty acids (OV2 and OV3)	03
Mineral oil (OM)	Aliphatic and aromatic hydrocarbons (OM1); Aliphatic hydrocarbons (OM2)	03
Water (control)	Distilled water with surface tension of 72.6mN m^{-1}	01
Total of solutions		31

[1] Composition mention does not mean recommendation or consent of the authors

The drift tests were performed in a wind tunnel designed, developed and validated by MOREIRA JÚNIOR & ANTUNIASSI (2010). The tunnel has an open circuit and closed test section with a total length of 4.8m, having a square test section of 0.56m x 0.56m and useful area of $0.31m^2$ and 2.5m of useful length. It was made of wood and produced a uniform laminar air flow of 2.0m s^{-1} by a fan with a motor of 180W of power. After the formulations, the solutions were placed in a stainless steel tank with capacity of 15L for storage and pressurization of solutions for a cylinder of compressed gas (CO2), a nozzle with anti-drip valve and a new spray tip TeeJet XR8003 VK, installed in a way it generates a perpendicular jet to the length of the tunnel, subjected to a pressure of 200kPa, with an average drop formation. All solutions were labeled with a Brilliant Blue dye in a concentration of 0.6% (m v^{-1}). To collect the deposits of particles of sprayed solutions it was used polyethylene strips with 2.0mm of diameter and 0.56m of useful length (width of the wind tunnel), positioned horizontally and perpendicularly to the length of the tunnel through holes in its wall and secured by clamps placed on the outside. The strips were placed 1.0, 1.5, 2.0 and 2.5m away from to the spray tip, referring to the length of the tunnel. For all distances the wires were fixed at 0.10 and 0.20m high, with respect to the floor of the tunnel. The environmental conditions were monitored and the tests were conducted only at temperatures lower than 30°C and relative humidity higher than 50%. Further details of the methodology for the collection and analysis of the solutions derived from the wind tunnel are described in MOREIRA JÚNIOR & ANTUNIASSI (2010). The study evaluated 31 different solutions grouped into four functional groups of adjuvants. Some adjuvants were sprayed more than once with different concentrations according to the practice of the field or the manufacturer's recommendation. Data were analyzed for normality and the presence of "outliers", and submitted to ANOVA. Treatments were compared using the confidence interval (95%) and the Tukey’s test at 5% of probability, considering three replicates and completely randomized design (CRD).

RESULTS AND DISCUSSION

The estimated drift of spray solutions containing different concentrations and adjuvants are presented in Figure 1. These values indicate the average of the sum of drift collected at all distances within the wind tunnel. The addition of most of the adjuvants yielded changes in drift, and 78% of adjuvants reduced the drift in relation to the water spray drift (Figure 1).

The "RD3" drift retardant added to the solution at high concentrations (0.30 and 0.60%) reduced drift, respectively, in 30% and 25% less than the water drift. However, when applied at low concentration (0.165%), it increased the drift of the applied product, which represents an increase of 22% in regard of the water and 57% in regard of itself, when applied at high concentrations of 0.60% (Figure 1). These variations were expected, since the physical and chemical properties of the adjuvant determine their functions and depend on the relative proportion of each component in the mixture, including water (STOCK & BRIGGS, 2000, ANTUNIASSI et al., 2010).

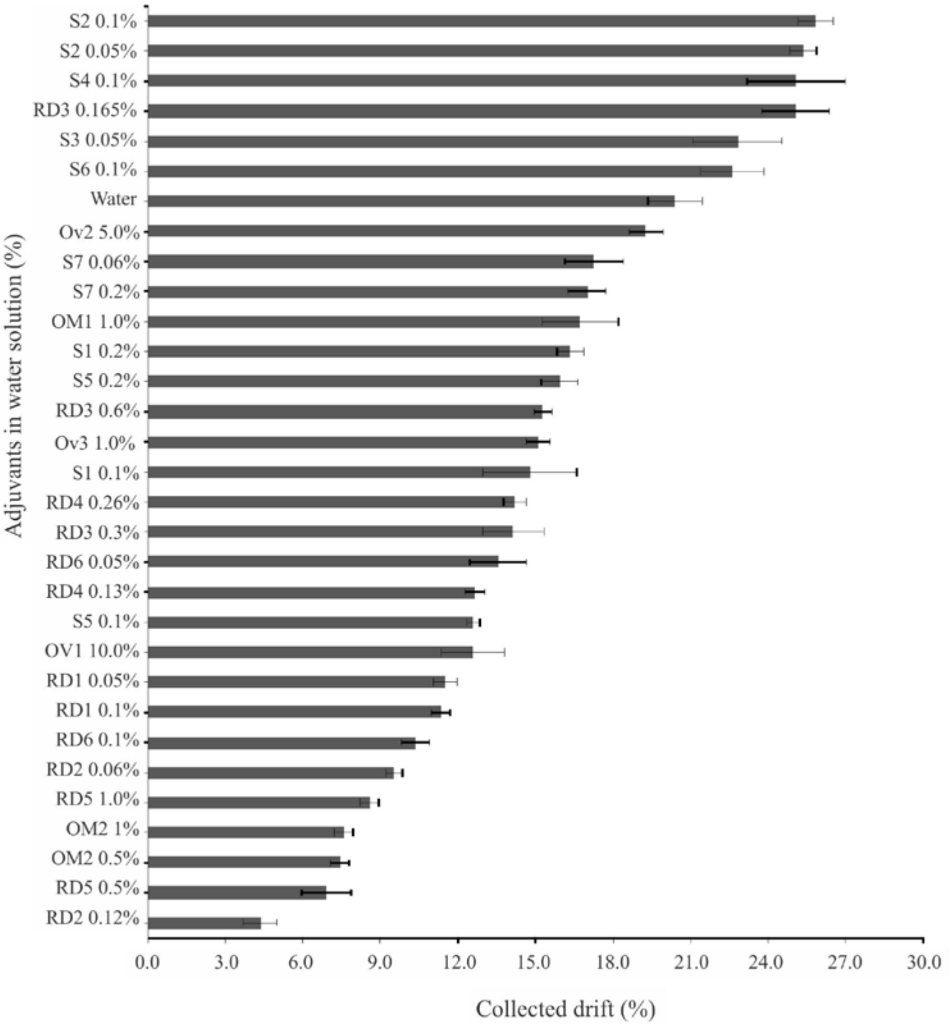

FIGURE 1. Collected drift (means ± $CI_{95\%}$) of spray containing different concentration of adjuvants dissolved in water. Surfactants are represented by “S”, mineral oil by “OM”, vegetable oil by “OV” and drift retardants by “RD”.

Also in relation to drift retardants, some variations were observed in the behavior of products depending on their concentrations, although all of them have reduced the drift in relation to water, except "RD3" at 0,165%. The "RD6" drift retardant caused the reduction in the values of drift increasing its concentration, thus, with regard to water, "RD6" at 0.05% reduced drift by 24%, and at 0.10% decreased it by 49% (Figure 1). On the other hand, "RD2" at 0.6% reduced the drift by 54% with regard to water, whereas at 0.12% it was reduced by 78%. Within the limits of minimum and maximum concentration, this should be the behavior of an adjuvant for it to be functionally characterized as a drift retardant and present operational feasibility and economic use (HAZEN, 2000; McMULLAN, 2000; PENNER, 2000; TU & RANDALL, 2003). In general, drift retardant adjuvants have been developed to modify the spectrum of drops, but many other adjuvants, used to improve the dynamics of the drop on the target, also influence the droplet size and drift (BUTLER ELLIS & TUCK, 1999). There is a consensus in several studies that drift retardant adjuvants derived from synthetic polymers soluble in water are generally effective for increasing the drop size and reduce the quantity of drops formed, which are susceptible to drift (KIRK, 2003).

During the tests, the particles of all solutions were deposited in higher concentrations near the spray nozzle at the beginning of the wind tunnel, and increasingly smaller concentrations along the wind tunnel (Figure 2). This gradient drift is consistent with the estimates of CUNHA et al. (2004), who calculated the terminal velocity and the theoretical horizontal distance traveled by drops of known diameter. It should be noted that mineral oils had significantly lower values of deposits, regardless of the distance traveled inside the wind tunnel. The surfactants and water showed the highest values of drift. The surfactants showed less drift than water to a distance of 1m, but there was no difference between the two drift groups from this point. The use of mineral oil, followed by drift retardant, resulted in significantly less drift than the drift resulting from use of surfactants or water. Vegetable oils presented intermediate drift values, with a lower value than surfactants and water, and higher than drift retardants and mineral oil. Figure 2, below, shows these significant changes.

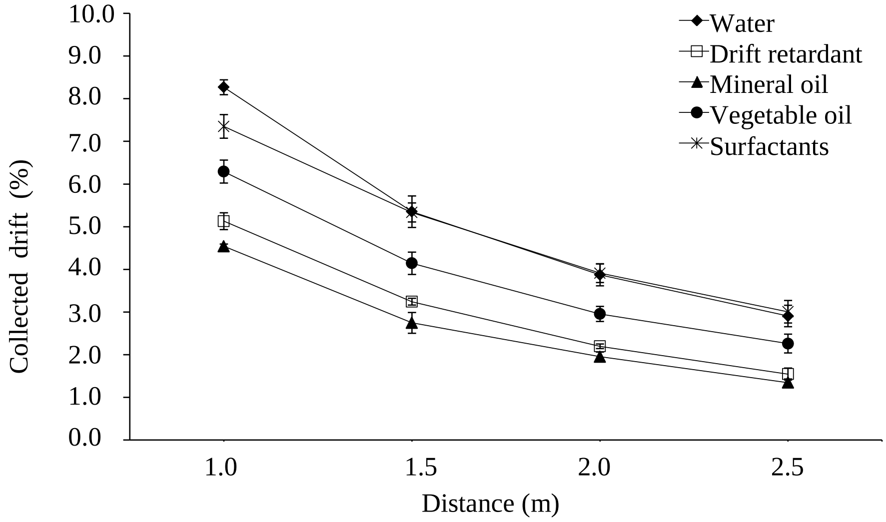

FIGURE 2. Drift (averages ± $CI_{5\%}$) of spraying of different chemical groups of adjuvants in terms of distances to collection inside the wind tunnel. The points represent average values and the vertical lines indicate the confidence interval at 95%.

Figure 3 shows the drift average values in accordance with the functional groups. It is possible to note that the use of surfactants resulted in higher values of drift, although there was no significant differences in the use of vegetable oils. The results corroborate with BUTLER ELLIS & TUCK (1999), who concluded that the addition of surfactants to the solution increases the risk of drift and also observed that while the addition of the emulsion to the solution increased the drop spectrum by 8%, the surfactants reduced the drop spectrum in 12%.

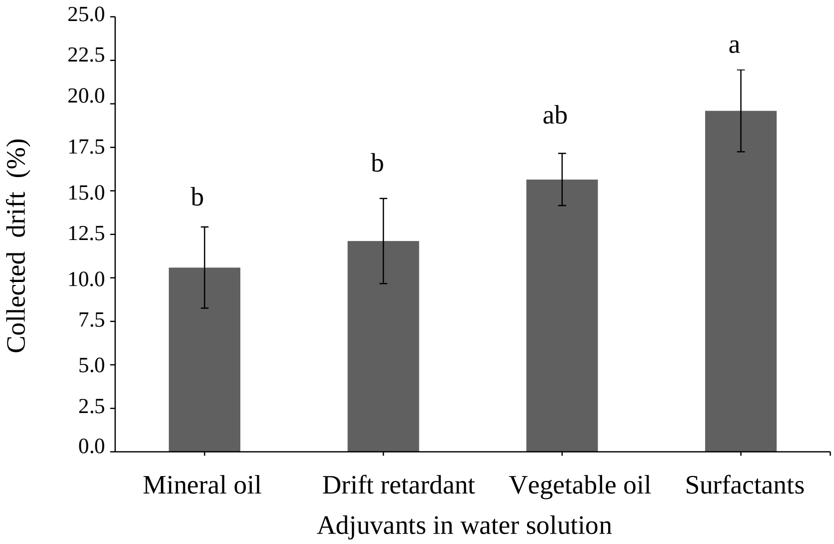

FIGURE 3. Collected drift (averages ± $CI_{5\%}$) found by sprayings with different functional groups. The same letters do not present significant differences according to the Tukey's Test at 5% of possibility ($P<0.05$).

Mineral oils, drift retardants and vegetable oils showed the lowest drift values, without significant differences between them. Although in this study mineral and vegetable oils have not shown significant differences between themselves, mineral oils tend to present greater efficiency in reducing drift. According to ANTUNIASSI et al. (2010), the greater efficiency of these differences can be associated with the components of their formulation, since the label shows the active ingredients, for example, the mineral oils, but omits the remaining formula components ("inert ingredients"). Each group has particular characteristics, i.e., some increase and others reduce drift, indicating that its use depends on the purpose, desired characteristic in mixtures, and especially the conditions of applications and risk of drift.

CONCLUSION

Adjuvants the group of mineral oils and drift retardants provide lower drift values in comparison with the surfactants and water.

The correct selection of the class of adjuvants and concentrations can significantly reduce the potential risk of drift in agricultural sprayings.

The best results obtained in the laboratory should be validated with the products that will compose the spraying solution under field conditions in the future.

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