SCIENTIFIC NOTE

EFFECT OF PRESSURE ON THE QUALITY OF PESTICIDE APPLICATION IN ORCHARDS

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ABSTRACT

Only part of the active ingredient used in agrochemical applications in orchards is retained on the trees. The product that is not retained is lost as sedimentation in the soil and as drift, the latter being a major source of environmental pollution. Unfavorable atmospheric conditions affect the uniformity of distribution and increase product loss. This can be mitigated by the utilization of larger drops. The objective of the present work was to evaluate the effect of service pressure on distribution in the trees and product loss by using a conventional hydro pneumatic sprayer. A fluorescent tracer was applied on fruit trees by an airblast sprayer, with two treatments: high pressure (1800 kPa) and low pressure (500 kPa). Samples were collected from the trees, in columns and from the soil. The results indicated that there were no differences between the two treatments in the total quantity of deposits recovered from leaves. There was one third less drift with the low-pressure than with the high-pressure treatment, whereas deposits on the soil were similar with the two treatments, with the low-pressure treatment presenting a higher concentration of deposits in the proximity of the treated row. In conclusion, the use of sprayer systems that operate with low pressure is a valid alternative to reduce environmental pollution because it tends to loss to the area where the treatment is being applied, without affecting deposits on the trees.

Key words: orchards, sprayers, drift, service pressure.

INTRODUCTION

During the application of agrochemicals only part of the active ingredients being used is retained on the trees, depending on the vegetative state, the technique being used and the environmental conditions at the time of application (Baraldi *et al*., 1993; Doruchowski, 1993; Solanelles *et al*., 1996). The unretained product is lost as sedimentation in the soil and as drift, becoming a serious source of environmental contamination.

The Environmental Protection Agency of the USA, as cited by Salyani and Cromwell (1992), estimated that between 10 and 60% of the agrochemicals applied drift to more than 300 m from the treated area. This is even more relevant in regions with intensive cultivation characterized by a higher density of rural population. Vercruysse *et al*. (1999), upon applying a fungicide in low fruit trees, found deposits up to 40 m from the application site that, while 20 times as low as deposits found at 5 m, represented between 2.5 and 4.5% of the volume sprayed. Copes *et al*. (2006) found residues from an application in fruit orchards up to 48 m from the treated row. They emphasized that the rural population within this area and beyond is at risk of contamination.

Huijsmans *et al*. (1994) indicated that air assisted spray systems, while they facilitate transport and penetration of the drops in the interior of the tree canopy, could also increase drift and deposits of chemical product in the soil. They argued that it is necessary to improve application techniques to reduce environmental contamination.

Heijne *et al*. (2004) described a series of methods and technologies to mitigate drift, such as windbreak barriers, areas free from cultivation, spraying the last row only from the side to the outside of the field, spraying tunnels, reflective screens and foliage sensors. In relation to technological aspects, Di Prinzio *et al*. (2004) evaluated a spraying tunnel design and found a reduction of drift on the order of 95% compared to that caused by divergent flow air-blast sprayers. Nevertheless, Cross *et al*. (2003)

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affirmed that while sprayers with tangential flow fans and spraying tunnels present a substantial reduction in drift, they are not widely used owing to the high cost and/or reduced operational flexibility.

The size and characteristics of the tree are also factors that affect the efficiency of the application. In this sense, Travis *et al.* (1987) pointed out that the quantity of deposits found on the tree decrease with height and the depth of the canopy, while Magdalena *et al.* (1996) found, in pear plants trained on trellises at a height of over 4 m, that the quantity of deposits in the upper part of the tree was only 40% of the quantity found in the lower part.

Holownicki *et al.* (2004) affirmed that wind affects the uniformity of spray distribution and increases product loss. The authors indicated that this effect could be mitigated with the use of large drops produced by air-induction nozzles.

The influence of service pressure on drop size is well known. In this regard, Musillami (1980) points out that with a reduction of pressure of six times (from 30 to 5 bar), the size of the drops doubles. A similar behavior was cited by Balsari and Airoldi (1993).

With regard to biological efficiency, Frießleben (2004) conducted a series of studies on various crops, including apples, and at different periods of the year. He did not find significant differences in effects using technologies that produce heavier drops compared to those that produce finer drops.

Magdalena *et al.* (2003) reports that the service pressure used in the Comahue region in the early 1990s was on the order of 30 bar. More recently, as a result of extensive outreach work, it has been reduced to 20 bar. The authors note that the reduction in pressure results in less waste and lower fuel consumption, as well as a better quality of work.

The objective of the present work was to evaluate the effect of service pressure on distribution on the tree and product loss using conventional air-blast sprayers.

MATERIALS AND METHODS

Site

The study was conducted at a pear orchard (*Pyrus communis* L.) cv. Willams, trained on trellises, with 4 m between rows. The plants had an average height of 4.5 m and a thickness of 1.7 m. The required application rate was 1800 L ha^{-1}, calculated according to the TRV method (Cichón and Magdalena, 1992).

Treatments

High pressure. Pressure 1800 kPa, nozzles 6 ATR (flow: 2.75 L min^{-1}) and 3 ATR (flow: 3.32 L min^{-1}), arrayed from above on the main arc, application flow: 53 L min^{-1}. Working velocity: 4,54 km h^{-1}. Application rate: 1750 L ha^{-1}.

Low pressure. Pressure 500 kPa, nozzles 6 ATR (flow: 1.39 L min^{-1}) and 3 ATR (flow: 1.77 L min^{-1}), arrayed from above on the main arc and 4 D8 (flow: 3.2 L min^{-1}) intercalated in the upper part of the arc located in an additional barral; application flow: 53 L min^{-1}. Working velocity: 4.54 km h^{-1}. Application rate: 1750 L ha^{-1}.

The same sprayer was used in both treatments, operating with a fan with a ratio of 3.5:1 and at 470 v min^{-1} of power takeoff, the air flow supplied on the order of 35 000 m^3 h^{-1}, similar to what is required by the orchard used in this assay. For the low-pressure treatment, the left side of the sprayer was used, supplied by the centrifuge pump of the sprayer; while for the high-pressure treatment, the right side of sprayer was used, supplied by a piston, considering that the air velocity of the sprayer is symmetrical for the two sides.

Climatic conditions

Sampling: 1 m s^{-1}; temperature: 16 ºC; relative humidity: 50%.

Sampling and evaluation

Sodium fluorescein ($C_{20}H_{10}Na_2O_5$) was applied as a tracer, with doses of 80 g ha^{-1} (Sigma-Chemical F6377, Steinheim, Germany). Two pairs of pipe cleaners were used to collect drift, located at heights of 2 and 6 m over four columns 2 m apart and located behind the second row adjacent to the treated row, along a parallel line 9 m from the application.

Losses in the soil were collected in Petri dishes and the sampling station consisted of two boxes located on a tray. Eight stations were defined along a line perpendicular to the treated row, located every 2 m, such that they were alternatively under the row and in the middle of the inter-row space. The sampling area covered a distance 16 m from the treated row.

Two samples of 20 leaves each were collected at three heights: 1.5, 2.5 and 3.5 m, to evaluate the distribution on the tree.

The concentrations of deposits in the rinsing water of the collectors (pipe cleaners, Petri dishes and leaves) were determined with a fluorometer (Kontron SFM 25, Milan, Italy).

The surface area of the leaves was determined with a foliar area optical meter (Li-Cor, LI 3100, St. Louis, Nebraska, USA).

Experimental design

An entirely ramdomized experimental design were performed and three replications of each treatment were conducted. An statistical software was used for the ANOVA, and the Tukey test was used to compare means, with a level of significance of 0.05%.

RESULTS AND DISCUSSION

Deposits on the tree

The use of low pressure results in 20% more deposits on the tree than with high pressure. Nevertheless, the treatments were not statistically different (Table 1).

The low-pressure treatment presented a greater quantity of deposits in the upper part of the tree than the high-pressure treatment (Figure 1). This effect could be related to the number and type of nozzles used in the two treatments. Nevertheless, this behavior tends to solve the lack of uniformity in the distribution on the tree observed by Travis *et al*. (1987) and Magdalena *et al*. (1996) in plants with characteristics similar to those used in this assay.

Drift

The results indicate that there was a lower quantity of product on the columns with the low-pressure treatment, with statistical differences at heights of both 2 m and 6 m, reducing losses from drift by a third (Table 2). Though not of the same magnitude, this reduction concurs with what was reported by Di Prinzio *et al*. (2004). The greatest difference can be appreciated at a height of 6 m, where the high-pressure treatment generated three times as much drift; which could be attributed to the fact that it generated smaller drops, a behavior cited by Musillami (1980) and Balsari and Airoldi (1993), which would be the most affected by the effect of drift. These results concur with what was reported by Holownicki *et al*. (2004), who indicated that generating larger drops constitutes a valid method to mitigate drift, although making reference to the use of air-induction nozzles.

Deposits in the soil

Because the Petri dishes from row 1 and from inter-row 1 were affected by air from the fan during the treatments, they were eliminated from the study.

There were no differences in the average quantity of deposits between the two treatments (Table 3). Likewise, two well-differentiated groups can be appreciated. Row and inter-row 2 presented a higher quantity of deposits than rows and inter-rows 3 and 4; probably because the former could be reached by the remaining product transported by the air from the fan more than by the effect of atmospheric air.

Analyzing the distribution of deposits (Table 3), it can be noted that the low-pressure treatment resulted in a higher quantity of loss than the high-pressure treatment

Table 1. Distribution of sodium fluorescein deposits on the tree.

Height	High pressure	Low pressure	Average
	μg cm^{-2}		
1 m	0.483	0.286	0.384
2 m	0.370	0.542	0.456
3 m	0.224	0.496	0.360
Average	0.359Aa	0.441Aa	0.400

Table 2. Assessment of agrochemical drift according to sodium fluorescein deposits in columns located at 2 and 6 m.

Height	High pressure	Low pressure
	μg	
2 m	0.097A	0.054B
6 m	0.254A	0.072B
Average	0.176A	0.063B

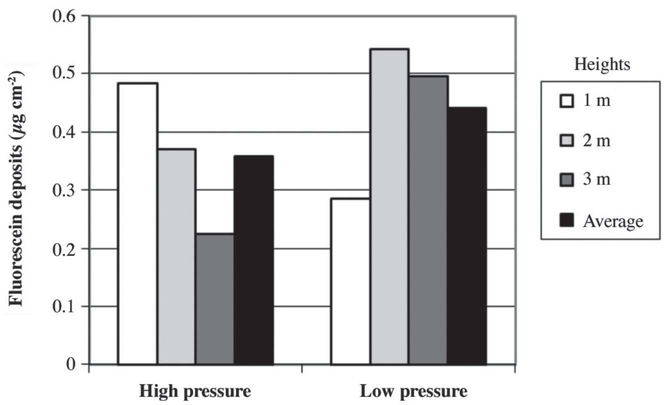

Figure 1. Distribution of sodium fluorescein deposits in the tree.

Table 3. Assessment of agrochemical loss in the soil according to sodium fluorescein deposits in Petri dishes.

Position	Treatments		
	High pressure	Low pressure	Average
	μg cm^{-2}		
Row 2	0.0388	0.0468	0.0428A
Inter-row 2	0.0226	0.0341	0.0284A
Row 3	0.0050	0.0013	0.0032B
Inter-row 3	0.0059	0.0011	0.0035B
Row 4	0.0026	0.0006	0.0016B
Inter-row 4	0.0025	0.0005	0.0015B
Average	0.0129Aa	0.0141Aa	

in row and inter-row 2, with the reverse in the other rows and inter-rows. This behavior could be because the low-pressure treatment generates larger drops, which are deposited in the proximity of the treated area, while the drops generated by the high-pressure treatment are more affected by drag from the air current of the fan. This particularity of the low-pressure treatment is very relevant in relation to the objective of reducing contamination of the soil in treated, counteracting the situation proposed by Vercruysse *et al.* (1999) and Copes *et al.* (2006).

In summary, although the low-pressure treatment had four additional incalated high-flow nozzles in the upper part of the sprayer arc, which contributes to a better distribution at the risk of increasing loses over the trees. This treatment presented a favorable behavior in relation to decreasing drift, which corresponds to what was affirmed by Holownicki *et al.* (2004). Taking into account what was reported by Magdalena *et al.* (2003) and by Frießleben (2004), the low-pressure treatment could be considered more efficient given that aspects related to control and lower energy requirement are added to the possibility of using a larger number of nozzles and orient the to favor a better distribution on the tree, without significantly contributing to product loss through drift.

Nevertheless, more studies would be appropriate to evaluate the influence of drop size and of differential deposits on the upper and lower leaf surfaces, which is expected because of the behavior of larger drops, on efficiency in controlling pests and diseases in fruit trees.

CONCLUSIONS

The use of spray systems that operate with low pressure is a valid alternative to reduce environmental contamination, given that they tend to limit losses to the area where the treatment is conducted, without affecting the quantity of deposits on the tree.

RESUMEN

Efecto de la presión sobre la calidad de aplicación de agroquímicos en huertos frutales. Durante la aplicación de agroquímicos se retiene sobre los árboles sólo una parte del ingrediente activo utilizado. El producto no retenido se pierde como sedimentación en el suelo y como deriva, constituyéndose esta última en la mayor causa potencial de contaminación ambiental. Las condiciones atmosféricas desfavorables afectan la uniformidad de la distribución e incrementan las pérdidas de producto; éstas pueden ser mitigadas con la utilización de gotas de mayor tamaño. El objetivo del presente trabajo fue evaluar el efecto de la presión de servicio sobre la distribución en el árbol y las pérdidas de producto utilizando un pulverizador hidroneumático convencional. Se aplicó fluoresceína sobre frutales conducidos en espalderas con un pulverizador hidroneumático, en dos tratamientos: alta presión (1800 kPa) y baja presión (500 kPa) y se recolectaron muestras en los árboles, en columnas, y en el suelo. No hubo diferencias en la cantidad total de depósitos recuperados sobre las hojas de los árboles entre ambos tratamientos. La deriva fue tres veces menor en el tratamiento de baja presión, mientras que los depósitos en el suelo fueron similares entre tratamientos presentando el tratamiento de baja presión una mayor concentración de los depósitos en la proximidad de la fila tratada. La utilización de sistemas de pulverización que operen con baja presión se constituye en una alternativa válida para reducir la contaminación del ambiente, ya que tiende a delimitar el alcance de las pérdidas al área donde se realiza el tratamiento, sin afectar la cantidad de depósitos sobre el árbol.

Palabras clave: fruticultura, pulverizaciones, deriva, presión de servicio.

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