

CHOICE OF TRACERS FOR THE EVALUATION OF SPRAY DEPOSITS

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ABSTRACT

The objective of the present study was to establish a methodology using tracer substances for the evaluation of the distribution and amount of spray deposits, with the possibility to adjust the surface tension of the spraying solution. The following products were tested: 0.15% Brilliant Blue, 0.15% Saturn Yellow in 0.015% Vixilperse lignosulfonate and 0.005% sodium fluorescein, and mixtures of Brilliant Blue plus Saturn Yellow and Brilliant Blue plus sodium fluorescein at the same concentrations. This permitted the development of a qualitative method based on visual evaluation of the distribution of the pigment under ultraviolet light and of a quantitative method based on the determination of the amount of the dye deposited in the same solution. Moreover spray deposition could be evaluated at different surface tensions of the spraying solution, in order to simulate the effect of agrochemical formulations.

KEY WORDS: spray deposition, surface tension, tracer, citrus plants.

SELEÇÃO DE TRAÇADORES PARA AVALIAÇÃO DOS DEPÓSITOS EM PULVERIZAÇÕES

RESUMO

O presente trabalho teve como objetivo definir uma metodologia com substâncias traçadoras, para avaliar a distribuição e a quantidade de produto depositada em pulverizações, com a possibilidade de ajustar a tensão superficial da solução. Foram testados os produtos Azul Brilhante a 0,15%, Saturn Yellow a 0,15% suspenso em lignosulfonato Vixilperse a 0,015% e a Fluoresceína Sódica a 0,005%, e as misturas de Azul Brilhante mais Saturn Yellow e Azul Brilhante mais Fluoresceína, nas mesmas concentrações. Isto permitiu o desenvolvimento de uma metodologia qualitativa pela avaliação visual da distribuição do pigmento sobre luz ultravioleta e quantitativa com a determinação da quantidade depositada do corante numa mesma solução, em diferentes tensões superficiais da calda de pulverização, simulando o efeito das formulações de agroquímicos.

PALAVRAS – CHAVE: deposição em pulverização, tensão superficial, traçador, citros.

INTRODUCTION

The distribution and amount of product deposited on the target is one factor determining the success of phytosanitary culture control.

Basically two methodologies are used for the evaluation of spraying efficacy: the first system quantifies deposition without visualizing the distribution using metals and nutrients, dyes or the active ingredient (Matuo, 1988). The other method is based on the visualization of distribution without determining the deposited amount using fluorescent pigments under ultraviolet light (Edwards et al., 1961; Sharp, 1974). Salyani & Whitney (1988) consider the latter method to be simple, fast and suitable for the determination of large differences in coverage, but highly subjective for more detailed studies.

In an attempt to improve spraying evaluation, image analysis, which recognizes a tracer applied to and deposited on the target, has emerged as a method for the determination of the amount of and total area covered by the spray (Evans et al., 1994).

However, these methods do not consider variations in the surface tension of the solution to be applied which, according to Lefebvre (1993), is an important property in drop size and distribution of drops on surfaces when spraying. The objective of the present study was to establish a methodology for the qualitative and quantitative evaluation of spray deposition using tracer substances, with the possibility to adjust the surface tension of the solution in order to evaluate the effect of different formulations of agrochemicals.

MATERIAL AND METHODS

The study was carried out at the Laboratory of Weed Science, Faculty of Agronomical Sciences, UNESP - Campus de Botucatu-SP.

The concentrations of the tracer products were as follows: 0.15% Brilliant Blue food dye (FD&C No. 1); 0.15% Saturn Yellow (Ax-17) suspended in 0.015% sugar-free and oxidized sodium lignosulfonate called Vixilperse, and 0.005% sodium fluorescein. The mixtures were Brilliant Blue and Saturn Yellow dissolved in Vixilperse and Brilliant Blue and fluorescein at the same concentrations.

The surface tension of the products and mixtures was measured by weighing the droplets produced during a period of 20 to 40 seconds with a 4-decimal precision scale using a 25-ml burette, according to the methods of Mendonça et al. (1996) and Costa (1997).

Visual evaluation of the fluorescent tracer under ultraviolet light was used for the qualitative determination of spray distribution, with the leaf deposit classified on a scale as described by Palladini (1990) and Raetano (1996): grade 0 - no deposition; grade 1 - surface containing traces of the deposit; grade 2 - low deposition throughout the leaf; grade 3 - mild deposition on 1/3 of the leaf; grade 4 - mild deposition throughout the leaf; grade 5 - medium deposition on half the leaf; grade 6 - medium deposition throughout the leaf; grade 7 - deposition on 2/3 of the leaf, and grade 8 - high deposition throughout the leaf.

Fluorescence and absorbance of the products were determined with a Biotek model FL600FA fluorescence and absorbance reader. A fluorescence filter with 485 nm excitation and 530 nm emission wavelengths was used for fluorescein and the Saturn Yellow tracer, and an optical density filter of 630 nm for the Brilliant Blue dye.

Degradation or absorption of the tracers by the plants was determined for the individual products and the mixtures using different wavelength to avoid reading interference

between products.

Stability and the time available between the application and field collection of the samples were determined by comparing the fluorescence and optical density units of the single products and mixtures obtained in the absence and presence of sunlight during different periods of exposure.

Readings of the deposits were obtained in the citrus leaf washing solution or directly in water. For the former, 5 sets of 20 leaves were used for each product or mixture. The leaves were placed individually in 40-ml plastic flasks containing approximately one third of water, in such a way that the petiole and part of the leaf were soaked in water to prevent dehydration. Twenty microliters of the solution were placed on each leaf in the form of small droplets with a 50- μ l chromatography microsyringe. The first reading was obtained for one of the sets of each solution without drying. To resolve doubts between product degradation and absorption by the leaves, the other sets of leaves were placed in the dark at a temperature of 24°C and 62% relative humidity until the droplets were dry. A second reading was obtained for one additional set of each dried solution in the dark.

The remaining sets were exposed to sunlight for 2, 4 and 8 h during the period from 10:00 to 18:00 h, so that all treatments received sunlight during the same 8-h period. In the treatment involving 2h exposure, the samples were exposed to sunlight for 15 min and then left in the dark for 45 min during each hour. For the 4h treatment, samples were alternately exposed to sunlight for 1 h and left in the dark for 1 h, while for the 8-h treatment they remained exposed to sunlight throughout the period.

To remove the deposits, the leaves were placed individually in 12 x 25 cm polyethylene bags containing 10 ml distilled water and 1% of the surfactant Iharaguem-S, a solution which has been previously shown not to interfere with the readings.

RESULTS AND DISCUSSION

The use of Vixilperse lignosulfonate at the 10% proportion in relation to the remaining components of the mixture was found to be efficient to maintain the Saturn Yellow pigment in suspension. It also permitted the adherence of the suspension to the leaves and reflexion of the pigment deposits under ultraviolet light.

The solutions of 0.005% sodium fluorescein, 0.15% Saturn Yellow dissolved in 0.015% Vixilperse, 0.15% Brilliant Blue, and the mixtures of 0.005% fluorescein + 0.15% Brilliant Blue and 0.15% Saturn Yellow + 0.15% Brilliant Blue (Figure 1) showed the same surface tension as that of water. This demonstrated that these products can be used as tracers since the surface tension of the solution is not altered in the absence of surfactants.

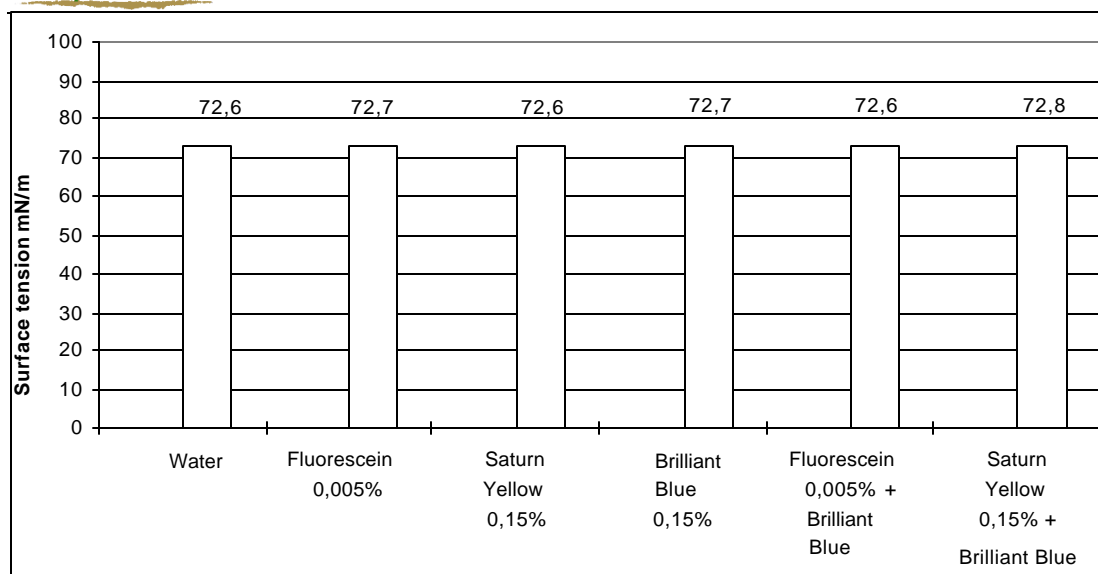


Figure 1. Surface tension of the different products and mixtures used as tracers for the evaluation of spray deposition.

To determine the stability and time between application and field collection of the product to be used a tracer, natural exposure to 21.3 mJ/m² sun radiation was used to assess the degradation of the tracers under sunlight. Higher fluorescence units of the pigments alone and as a mixture with Brilliant Blue were observed when the readings were obtained directly in water (Table 1) than in the solution directly after washing the leaves. The fluorescein plus Brilliant Blue mixture (Table 1) showed fluorescence readings similar to those obtained with fluorescein alone both for the deposits measured directly in water and after 8-h exposure to sunlight. However, a reduction of approximately one third in fluorescence units was observed for leaf deposits without drying compared to deposits measured directly in water. Leaves dried in the dark which were or were not exposed to light for 2 and 4 h showed similar values, considering the confidence interval.

To obtain the fluorescence readings were subtracted the fluorescence units of the water and leaves alone of the values showed in the present study.

Table 1. Fluorescence units and confidence interval of deposits containing fluorescein and Saturn Yellow alone and as a mixture with Brilliant Blue obtained directly in water, for leaves without drying, for leaves dried in the dark and for leaves exposed to sunlight for 2, 4 and 8 h.

Condition	Fluorescence units \pm confidence interval			
	Fluorescein	Fluorescein + Brilliant Blue	Saturn Yellow	Saturn Yellow + Brilliant Blue
Directly in water	4884.0 \pm 56.2	4805.9 \pm 61.7	5317.9 \pm 86.1	5390.9 \pm 65.3
Leaf without drying	3642.4 \pm 95.4	3272.8 \pm 138.8	5004.1 \pm 189.8	5179.3 \pm 78.7
Leaf dried in the dark	3095.1 \pm 64.7	3093.4 \pm 72.8	5017.4 \pm 153.4	5024.8 \pm 182.9
Leaf exposed to 2 h sunlight	2710.8 \pm 111.9	2968.6 \pm 116.9	4824.7 \pm 127.8	5034.6 \pm 126.5
Leaf exposed to 4 h sunlight	2936.4 \pm 61.9	3133.5 \pm 65.7	5068.9 \pm 109.8	5143.3 \pm 82.1
Leaf exposed to 8 h sunlight	2560.9 \pm 108.7	2528.7 \pm 87.0	5125.8 \pm 120.5	5171.0 \pm 118.2

With respect to the optical density (absorbance) of the Brilliant Blue solution (Table 2), higher values were observed for the deposits measured directly in water compared to the washed leaf solutions. A gradual and different reduction in optical density occurred under the other conditions and during light exposure, considering the confidence intervals. In the case of Brilliant Blue + fluorescein decreased with increasing exposure time of the leaves. Behavior was similar to that observed with the dye alone. With respect to the Brilliant Blue + Saturn Yellow mixture, similar optical densities were observed for all conditions of deposition of the solution and exposure to sunlight. This indicated the absence of degradation of the substances under sunlight or absorption by the leaves when this mixture was used.

The presented results showed that the mixture of 0.15% Brilliant Blue and 0.15% Saturn Yellow dissolved in 0.015% Vixilperse, was stable under sunlight and was not absorbed by the leaves up to 8 h (Tables 2 and 3). This results in sufficient time to collect samples in the field. The surface tension remained as for water (Figure 1). Therefore this solution satisfies the objectives of the study and can be employed as a qualitative and quantitative method for the evaluation of spray deposits. The mixture has the advantage that the surface tension of the tracer solution can be altered by adding surfactants. Mixing with additives can be done until reaching the concentration levels of the phytosanitary product.

After obtaining these results showing that the optical density and fluorescence units of this mixture are stable both in water and in leaf deposits under the different conditions used, we carried out an additional test using only this mixture at the same concentrations to verify repeatability of the results. In the initial test, all solutions were kept in the dark until the time of drying of the solution for subsequent light exposure. In the second test, besides the previous treatments, an additional set of 20 leaves was used to evaluate the possibility of product degradation during the period between deposition and drying under sunlight; natural sun radiation of 25.1 mJ/m² (Table 3).

Table 2. Optical density (absorbance) and confidence interval of deposits containing Brilliant Blue alone and as a mixture with fluorescein and Saturn Yellow obtained directly in water, for leaves without drying, for leaves dried in the dark and for leaves exposed to sunlight for 2, 4 and 8 h.

Condition	Optical density \pm confidence interval		
	Brilliant Blue	Brilliant Blue + Fluorescein	Brilliant Blue + Saturn Yellow
Directly in water	0.406 \pm 0.001	0.397 \pm 0.002	0.382 \pm 0.004
Leaf without drying	0.396 \pm 0.002	0.393 \pm 0.002	0.378 \pm 0.003
Leaf dried in the dark	0.393 \pm 0.003	0.383 \pm 0.002	0.380 \pm 0.004
Leaf exposed to 2-h sunlight	0.376 \pm 0.002	0.386 \pm 0.002	0.380 \pm 0.009
Leaf exposed to 4-h sunlight	0.372 \pm 0.003	0.376 \pm 0.007	0.381 \pm 0.005
Leaf exposed to 8-h sunlight	0.350 \pm 0.004	0.361 \pm 0.004	0.380 \pm 0.006

Table 3. Fluorescence units and optical density (absorbance) confidence interval of deposits containing the Brilliant Blue and Saturn Yellow mixture obtained directly in water, for leaves without drying, for leaves dried in the dark, for leaves dried under sunlight and for leaves exposed to sunlight for 2, 4 and 8 h.

Condition	Fluorescence units	Optical density
Directly in water	4968.8 \pm 101.7	0.356 \pm 0.004
Leaf without drying	4980.0 \pm 116.5	0.358 \pm 0.003
Leaf dried in the dark	5015.4 \pm 183.2	0.354 \pm 0.004
Leaf dried under sunlight	4854.0 \pm 113.6	0.355 \pm 0.004
Leaf exposed to 2-h sunlight	4736.1 \pm 159.7	0.350 \pm 0.005
Leaf exposed to 4-h sunlight	4769.7 \pm 97.4	0.352 \pm 0.005
Leaf exposed to 8-h sunlight	4697.9 \pm 137.8	0.350 \pm 0.005

The present results agree with the requirements defined by Cooke & Hislop (1993) that the ideal tracer for the evaluation of spray distribution is a substance that can be visualized in the dry state and can be recovered quantitatively from the natural or artificial surface. Our data are also in accordance with the results obtained by Sharp (1974) who observed that the degradation of the Saturn Yellow pigment was less than 5% after exposure to solar radiation equivalent to 6 h of sun in full English summer.

CONCLUSIONS

The mixture of 0.15% Brilliant Blue and Saturn Yellow dissolved in 0.015% Vixilperse did not show degradation under sunlight, was not absorbed by the plant. The mixture did not alter the surface tension of water, therefore it can be adjusted to the desired working tension levels provided by the concentrations of the phytosanitary products.

This mixture of tracers can be used:

- as a qualitative method for the visual assessment of by means of the distribution of the Saturn Yellow pigment on the target under ultraviolet light, and

- as a quantitative method due to the determination of the amount of Brilliant Blue dye deposited on the target,
- at different surface tensions of the spraying solution, simulating the effect of agrochemical formulations.

REFERENCES

- COOKE, B.K., HISLOP, E.C. Spray tracing techniques. In: MATTHEWS, G.A., HISLOP, E.C. (Eds.) *Application technology for crop protection*. Wallingford: CAB, 1993, p. 85-100.
- COSTA, E.A.D. *Efeitos de surfatantes sobre a tensão superficial de soluções de rodeo*. Botucatu, 1997. 73p. Master's thesis - Faculdade de Ciências Agrônômicas, Universidade Estadual Paulista.
- EDWARDS, G.J., THOMPSON, W.L., KING, J.R., JUTRAS, P.J. Optical determination of spray coverage. *Trans. ASAE (Am. Soc. Agric. Eng.)*, v.4, p.206-7, 1961.
- EVANS, M.D., LAW, S.E., COOPER, S.C. Fluorescent spray deposit measurement via light intensified machine vision. *Applied Engineering in Agriculture*, v.10, n.3, p.441-447, 1994.
- LEFEBVRE, A.H. Droplet production. In: MATTHEWS, G.A., HISLOP, E.C. (Eds.) *Application technology for crop protection*. Wallingford: CAB, 1993, p. 85-100.
- MATUO, T. *Desenvolvimento de um pulverizador intermitente operado fotoeletricamente para tratamento de pomares de citros*. Jaboticabal, 1988. 167p. Thesis (Livro Docência) - Faculdade de Ciências Agrárias e Veterinárias, Universidade Estadual Paulista.
- MENDONÇA, C.G., MENDONÇA, C.G., VELINI, E.D., MARTINS, D. *Avaliação dos efeitos de distintos espalhantes adesivos sobre a tensão superficial e o contato de soluções de glyphosate com folhas de *Cyperus rotundus* L*. Botucatu, 1996. 41p.
- PALLADINI, L.A. *Efeito de condições operacionais de um turboatomizador na cobertura de folhas de citros*. Jaboticabal, 1990. 93p. Master's thesis - Faculdade de Ciências Agrárias e Veterinárias, Universidade Paulista.
- RAETANO, C.G. *Condições operacionais de tuboatomizadores na distribuição e deposição da pulverização em citros*. Piracicaba, 1996. 93p. Doctoral thesis - Escola Superior de Agricultura "Luiz de Queiroz", Universidade de São Paulo.
- SALYANI, M., WHITNEY, J.D. Evaluation of methodologies for field studies of spray deposition. *Trans. ASAE (Am. Soc. Agric. Eng.)*, v.31, p.390-5, 1988.
- SHARP, R.B. Spray deposit measurement by fluorescence. *Pestic. Sci.*, v.5, p.197-209, 1974.