Aspects of Applied Biology **122**, *2014*
International Advances in Pesticide Application

Control of Citrus Black Spot and juice quality after spraying fungicide in contrasting water volumes

By G F G CARVALHO, M C FERREIRA and O LASMAR

Department of Phytosanitary, Faculty of Agriculture and Veterinary Sciences, São Paulo State University, Jaboticabal, São Paulo, Brazil
Corresponding Author Email: giorge-carvalho@uol.com.br

Summary

The principal citrus national producer, the State of São Paulo - Brazil had in the 90s, an average spending on phytosanitary treatment of around a third of the cost of production. However, in recent years, this percentage has been higher than these historical values. The Today, very high volume application is used and the spray liquid is applied beyond the point of runoff.

To reduce in-put costs targets may require different characteristics of sprayer setting may be needed to offer efficiency in treatment. In this study a range of water volumes were applied at two contrasting speeds and application methods using a copper based compound at a fixed concentration to quantify and locate spray deposits. A lower and more optimal water volume rate has been identified in this study that does not compromise Thus, we were able to reduce the application rate without compromising the spray coverage of the plants surfaces and is therefore not likely to risk the pesticides subsequent performance.

Key words: Application technology, Brazilian citriculture, *Guignardia citricarpa*, surrounding sprayer

Introduction

The productive sector of the Brazilian citriculture, Brazil, the world's largest producer of oranges and orange juice concentrate, faces intense occurrence of pests and diseases in crops. In an attempt to maintain high productivity, there is intensive use of pesticides in the production areas.

The principal national producer, the State of São Paulo had, in the 90s, an average spending on phytosanitary treatment, around a third of the cost of production (Silva, 1996), spraying was responsible for about half of the operating costs (Maggione, 1998). However, in recent years, this percentage has been higher than the historical values.

The pesticides used in citrus as a general rule are applied by via spraying using similar methods for, which is used to apply since acaricides until the and foliar fertilizers; contrasting . The targets that may require different characteristics of sprayer setting to offer efficiency in treatment. It is assumed, for example, that the uniformity of spray distribution within the tree canopy for acaricides is likely to be for more demanding than foliar nutrients.

The local of occurrence, levels of infestation of pests and handling has greatly interfering in the phytosanitary treatment, whose effectiveness depends on the distribution of the product by tree canopy.

In this case, the Application technology is one of the most important factors for the success of phytosanitary treatment; and is based on the use of scientific knowledge for the correct placing of the pesticide on the target, in sufficient quantity, in an economical manner, with safety to the tractor driver and with minimal contamination of non-target areas (Matuo, 1990).

It is common to see bad coverage after spraying in citrus that is linked to poor and does not have control of pests and diseases because they don't have contact with the pesticide. (Ferreira, 2003). The most part of the spray volume is barred kept to in the outermost layer of the leaves canopy, which often results in a reduced number of drops inside the plant canopy.

To minimize the occurrence of these failures, high volume application is used and the spray liquid is applied beyond the point of runoff. However, in many papers it is verified that using more than fifteen thousand litres of spray liquid per hectare [15 000 L ha^{-1}], exists risks of control failure and consequent resurgence of the pests in a short time (Whitney *et al*., 1978; Peregrine *et al*., 1986; Wiles, 1996).

In addition to the problems associated with the treatment efficiency, there are still economic and environmental consequences related to losses by runoff and drift, it is sometimes observed that even more than 50% of the volume sprayed is lost in this way (Matuo, 1988). It is worth mentioning that these 50% were bought and paid by user and that this volume does not disappear, but is deposited outside the target, causing, in addition to waste a real contamination threat to the local environment and ground water and prejudice, some kind of.

Sprayers which are set to follow accompany the plant outline, with well positioned nozzles, with lower power consumption, with droplet less sensitive to meteorological factors, result in greater safety for the tractor driver and the environment as well as being more suitable to application technology needs of pesticides. Matuo (1988) developed an intermittent sprayer considering the principles of application technology for fruit trees that accompany the plant outline, with nozzles closer to the target in order to decrease the losses by dragging wind and using lower power to transport the droplet. The equipment was produces smaller droplets, offers a and more uniform for providing better utilization of spray liquid sprayed, as well as to promote a better distribution around the canopy. Thus, were able to reduce the application rate without compromising the coverage of the plants.

The objective of this study was to evaluate a new surrounding sprayer developed to perform spraying in trees using a lower application rate.

Materials and Methods

The field experiment was conducted in 2011/12 season. The orchard of mature (15 year old), orange trees were adults spaced at 7 m × 4 m with a height between 3−4 m, variety Valencia, located in the northeastern region of São Paulo State, Brazil. The orchard is planted in the east/west direction. After the application of fungicides for control of fungus that causes Citrus Black

Fig. 1. Models of sprayers used in experiments to evaluate the control of Citrus Black Spot and juice quality. Arbus 2000 (Conventional) on the left and TOPSpray (surrounding sprayer) on the right.

Spot (*Guignardia citricarpa*) orange fruits were collected to be given grades of severity of fungal damage and to do analyses for qualitative/quantitative of juice.

The spray liquid was composed of one copper fungicide at a dose of 175 g of commercial product/100 L water (840 g.kg^{-1} active ingredient copper oxychloride), was added mineral oil at a concentration of 0.25% v/v for the first and third sprayings. Comet was used (25% a.i. pyraclostrobin) at a dose of 15 mL cp/100 L water to the second and fourth sprayings The first spraying happened on 26 October 2011, the second spraying occurred on 26 November 2011, the third spraying between 7 and 8 January 2012, and the last one on 4 February 2012.

The plots contained 35 plants arranged in five rows. One row on each side was used as "windbreak" and the following two, one on each side, were used as a border. The central line was considered to useful portion area and the middle plant as a sample tree. We sampled four quadrants around the canopy, all with heights of 2.5 m and 0.5 m distant of the ground, total of eight samples. Twelve fruits were harvested in each position sampled. The experimental design was randomized blocks with six replications. The average notes of severity were analyzed by Scott Knott test at 5% while the average related to the data of quality/quantity were analyzed by Tukey test at 5% probability. Two of these were separated to form a composite sample for obtaining qualitative parameters of juice. The other 10 per replication were used to assign a scale of notes of disease severity. Overall, the note scales are subjective methods to assess. For the results it were more reliably, the notes were assigned by two employees of UNESP/São Paulo State University, Department of Plant Protection, with over 15 years of experience in this activity.

Table 1. *Averages of the longitudinal and transverse diameters (cm), weight (g), juice content (%), titrable acidity, soluble solids and Ratio for Valencia orange fruit, orchard with 14 years implanted, sprayed with 2 L, 4 L and 6 L of spray liquid.tree^{-1} using a surrounding sprayer (TOPSpray ®), two-speeds compared to the conventional sprayer (Arbus 2000). Taquaral-SP, 2012*

Litres.tree^{-1}	Longitudinal diameters	Transversal diameters	Weight	Juice content	TA[1]	SS[2]	RATIO[3]
2,0	6,87 b	7,23 ab	180,36	44,74 ab	0,96 ab	12,31	12,93
4,0	6,87 b	6,96 b	179,60	43,19 ab	1,02 a	12,60	12,30
6,0	7,19 a	6,94 b	173,81	46,72 a	1,05 a	12,98	12,31
9,6 (Conventional)	6,75 b	7,12 ab	174,43	42,93 ab	0,95 ab	12,29	12,68
0 (Control)	6,85 b	7,32 a	181,02	42,26 b	0.90 b	12,55	13,64
F	4,99**	3,96**	0,26ns	3,14*	4,45**	2,64ns	2,63ns
SEM	0,30	0,33	27,03	4,10	0,11	0,70	1,38
CV%	3,06	3,32	10,57	6,49	8,28	3,88	7,52
TOPSpray at 6,16 km.h^{-1}							
Liters.tree^{-1}	Longitudinal diameters	Transversal diameters	Weight	Juice content	TA[1]	SS[2]	RATIO[3]
2,0	6,93 ab	6,69 b	171,50	43,28	1,15 a	13,00	11,21 c
4,0	7,10 a	6,75 b	174,04	44,29	0,97 b	12,84	13,33 a
*8,0	6,94 ab	6,67 b	167,70	43,42	1,12 a	13,05	11,76 bc
9,6 (Conventional)	6,75 b	7,12 a	174,43	42,93	0,95 b	12,29	12,68 ab
(0) Control	6,85 ab	7,32 a	181,02	42,26	0,90 b	12,55	13,64 a
F	2,92*	12,00**	0,91ns	0,48ns	15,34**	2,56ns	11,20**
SEM	0,31	0,34	20,78	4,30	0,11	0,81	1,25
CV%	3,12	3,45	8,31	6,93	8,00	4,43	6,94

[1]TA = Titrable Acidity; [2]SS = Soluble Solids; [3]Ratio = relationship SS/TA.

* Unilateral application with surrounding spray with 4,97 km.h^{-1}. Means followed by the same letter do not differ statistically among themselves. We used the Tukey test at 5% probability.

Results & Discussion

It is recommended that the fruit is mature for evaluation of fungus control (*G. citricarpa*). This mature condition can be evaluated at the field by quantities of soluble solids (SS) on period preceding the harvest. The measurements shown in Table 1 were obtained one day after harvesting and it is seen that the quantity of SS to Valencia oranges matches the mature state of the fruit.

Low volume application, sprayed at lower velocity with the surrounding sprayer did not differ from conventional sprayer and the control. However, the speed increase for both equipments resulted in a decrease in a relationship between soluble solids/titrable acidity.

However, the use of 4 L.tree (surrounding sprayer) had better control in six sample points, a total of eight. Not only that, the use of 4 L.tree that promoted a better uniformity in control around the canopy, as well as conventional spray (Table 2).

It is worth mentioning that the bilateral applications made with surrounding sprayer had not the support of spraying upwards offered by a creeping bar parallel to the ground. Both spray applied bilaterally (Table 2).

For to be possible to spray with a speed of 6 km.h^{-1}, it was necessary to suspend the bilateral spraying with 6 liquid.tree^{-1} (setting for high flow rate), replaced by a unilateral bar creeping (Table 3). This allowed it to be implemented 8 L spray liquid.tree^{-1} and still apply less spray liquid than conventional sprayer. Of the eight sampled points, this calibration was the one with the best control.

The application of 8 L spray liquid.tree^{-1} comes next, with satisfactory control in half of the sampled points. Even with the increase in speed, the application of 4 L spray liquid.tree^{-1} was maintained more uniform control of Citrus Black Spot.

Table 2. *Average notes of severity of the disease given to Valencia orange fruit, 14 years of implantation and treated with fungicide for the control of Citrus Black Spot, sprayed with 2 L, 4 L and 6 L of spray liquid.tree^{-1} using a surrounding sprayer (TOPSpray ®) at 2,74 km.h^{-1} compared to the conventional sprayer (Arbus 2000). Taquaral-SP, 2012*

Positions Sampled*				
Upper				
Liters.tree^{-1}	1	3	5	7
2,0	1,68 bA	1,62 bA	1,02 bB	1,25 bB
4,0	0,87 cB	1,41 bA	0,56 cB	0,89 bB
6,0	1,22 cA	1,31 bA	0,50 cB	0,89 bB
9,6 (Conventional)	1,93 bA	1,43 bA	0,54 cC	1,18 bB
0 (Control)	3,39 aA	2,70 aB	2,47 aB	2,29 aB
Bottom				
	2	4	6	8
2,0	1,06 bB	1,16 bB	0,93 bB	1,64 bA
4,0	0,62 bB	1,27 bA	0,72 bB	1,12 cA
6,0	0,93 bB	1,33 bA	0,79 bB	1,14 cA
9,6 (Conventional)	1,00 bB	1,68 bA	0,81 bC	1,64 bA
0 (Control)	3,06 aA	3,27 aA	2,16 aB	2,41 aB

Means followed by the same lowercase letter in the column and uppercase in the line (positions 1−8) did not differ statistically among themselves. Was applied Scott-Knott test at 5% of probability.

Table 3. *Average notes of severity of the disease given to Valencia orange fruit, 14 years of implantation and treated with fungicide for the control of Citrus Black Spot, sprayed with 2 L, 4 L and 8 L* of spray liquid.tree^{-1} using a surrounding sprayer (TOPSpray ®) at 6,16 km.h^{-1} compared to the conventional sprayer (Arbus 2000). Taquaral-SP, 2012*

Positions Sampled*				
Upper				
Liters.tree^{-1}	1	3	5	7
2,0	1,37 cB	1,62 bB	0,95 bC	1,43 bB
4,0	1,33 cA	1,02 cB	0,85 bB	1,14 bB
8,0*	1,41 cA	0,97 cB	0,50 bC	0,56 cC
9,6 (Conventional)	1,93 bA	1,43 bA	0,54 bC	1,18 bB
0 (Control)	3,39 aA	2,70 aB	2,47 aB	2,29 aB
Bottom				
	2	4	6	8
2,0	1,45 bB	1,52 bB	0,54 cC	2,04 aA
4,0	1,08 cB	1,60 bA	0,93 bB	0,81 cB
8,0*	0,83 cB	0,93 cB	0,37 cC	0,60 cC
9,6 (Conventional)	1,00 cB	1,68 bA	0,81 bC	1,64 bA
0 (Control)	3,06 aA	3,27 aA	2,16 aB	2,41 aB

*Unilateral application and parallel creeping bar with surrounding sprayer at 4,97 km.h^{-1}.
Means followed by the same lowercase letter in the column and uppercase in the line (positions 1–8) did not differ statistically among themselves. The Scott-Knott test was applied at 5% of probability.

The titratable acidity was higher after spraying fungicides occurring decreased in a relationship between SS/TA (Ratio).

The application with 4 L spray liquid.tree^{-1} promoted acceptable control of Citrus black spot on fruit intended for the processing industry. It was also the calibration which better distributed the spray liquid around the canopy.

Acknowledgements

We are grateful to the São Paulo Research Foundation (FAPESP) for the PhD scholarship (process 2009/15660-0) for the first author and Research Aid (process 2010/01842-7) approved.

References

Ferreira M C. 2003. Caracterização da cobertura de pulverização necessária para o controle do ácaro *Brevipalpus phoenicis (G., 1939) em citros*. Tese (Doutor em Agronomia) - Faculdade de Ciências Agrárias e Veterinárias, Universidade Estadual Paulista. Jaboticabal. 64 pp.

Maggione C S. 1998. Planejamento e custo citrícola. *Citricultura Atual* **1**(5):6.

Matuo T. 1988. *Desenvolvimento de um pulverizador intermitente operado fotoeletricamente para tratamento de pomares de citros*. Tese (Livre docente) – Faculdade de Ciências Agrárias e Veterinárias, Universidade Estadual Paulista. Jaboticabal. 167 pp.

Matuo T. 1990. *Técnicas de aplicação de defensivos agrícolas*. Jaboticabal: FUNEP. 140 pp.

Peregrine D J, Doughton N E, Southcombe E S E. 1986. The influence of application volume on the efficacy of clofentezine used early season for control of *Panonychus ulmi* (Koch) on apples. *British Crop Protection Conference Pests and Diseases*, pp. 307–314.
Silva M M. 1996. Defensivo bem dosado é economia na certa. In *AGRIANUAL 97. Citros: laranja*, pp. 203–204. São Paulo: FNP Consultoria $ Comércio.
Whitney J D, Brooks R F, Bullock R C. 1978. Pesticide application methods for citrus in Florida. *International Society of Citriculture* **5**:163–167.
Wiles T. 1996. Projeto e uso de equipamentos de pulverização agrícola na América Latina. (Parte II Brasil). In *Simpósio Internacional de Tecnologia de Aplicação de Produtos Fitossanitários* **1**:16–29. Jaboticabal: Anais.