Reduced volume spray application in South African citrus orchards: effects on deposition quantity, quality and uniformity

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Introduction

Spray application forms the backbone of pre-harvest pest and disease management strategies in South African citrus production. Due to zero tolerance status of Citrus black spot (caused by *Phyllosticta citricarpa*) (McAlpine) for export to the European Union, growers tend to use high application fungicide volumes ranging from 8000 to 12000 l ha^{-1}. These high volumes realise good disease control whilst growers are hesitant to risk compromising disease control by applying at reduced volumes. Moreover, high spray volumes act as a "safety buffer" for poor sprayer maintenance, calibration and application techniques.

However, high spray volumes are costly in terms of off-target losses (run-off and drift) and environmental pollution, amount and cost of water, fuel and plant protection product (PPP), the strain on equipment, and it is more labour intensive and therefore ultimately less efficient than reduced volume applications. Uptake of more efficient spray application strategies is generally slow due to a number of factors: poor understanding of the process of spray application; fear of loss of disease control (especially with quarantine pathogens and pests) with use of 'different' or 'new' control strategies; legal aspects constraining change due to outdated legislation in South Africa; PPP labels mostly registered as dilute, high volume applications; and the use of obsolete equipment. Thus growers need *confidence* through *evidence* to be *convinced* to change their ways.

The deposition assessment protocol (van Zyl *et al*.,2014) involving fluorometry, photomacrography and digital image analysis is a superb tool to evaluate deposition quantity, quality and uniformity, and is used to help researchers and spray technicians visualise and quantify deposition following spray application; additionally, it can be used to better advise growers. This protocol was used to evaluate novel sprayersat reduced spray volumes in relation to conventional high volume sprayers in various citrus orchard spray trials.

Material and Methods

Orchard spray trials were conducted with two novel sprayers, a Martignani Whirlwind KWH M612 (high profile mist blower; air speed ≈80 ms^{-1}; air volume ≈20000 m^3 h^{-1}; www.martignani.com)and a CIMA T55 Super(high profile venturi atomiser; air speed ≈170 m s^{-1}; air volume ≈14000 m^3 h^{-1};www.cima.it) at 1000 to 4000 l ha^{-1}. To serve as control treatments, various conventional sprayers were evaluated at spray volumes ranging from 8000 to 11000 l ha^{-1}. A yellow fluorescent pigment (40% EC; SARDI Yellow Fluorescent Pigment, Loxton, Australia) (1ml l^{-1}), were added to the spray mixture. Pigment concentration was maintained as a dilute application (1×) for all treatments, but in certain trials was also amended (2×; 4×) at reduced volume applications to realise the same dosage of pigment as that of a high volume 'dilute' spray at 8000 l ha^{-1}. Forward spray speed and PTO speed (540 rpm)were kept constant throughout trials with only pressure [conventional sprayer (10 bar) and reduced volume sprayer(1.5 to 1.8 bar)]and when applicable, nozzle selection, used to manipulate spray volume. Sprayers were set-up carefully to ensure that the spray plume was adequately intercepted by the spray target from the top to bottom of the canopy [depending on trial site, tree size of 4-5 × 2.8-3.5 m (H×W); 5-7x2-3.5m row spacing].After application, 12 leaves were randomly sampled from the inner and outer canopy at the top, middle and bottom tree positions. According to the methods described for the deposition assessment protocol (van Zyl *et al*., 2014), high quality digital images were taken of sampled material illuminated by UV-A ≈ 365 nm light source (www.labino.com) in a dark room and the following deposition parameters determined by means of digital image analyses: deposition quantity, measured as percent of total leaf area covered by pigment particles (percentage fluorescent particle coverage; %FPC);

deposition uniformity, measured as the coefficient of variation (CV%) of deposition quantity between leaves at various positions in the tree; and deposition quality, measured as the interquartile coefficient of dispersion (%ICD) of deposition quantity measured in each 100 × 100 pixel square of each leaf image (3888×2592 pixels). A previously developed FPC benchmark model (van Zyl *et al*., 2014), was used to evaluate the effectiveness of deposition in relation to theoretical disease control. The FPC_{50} (2.07 %FPC) and FPC_{75} (4.14 %FPC) benchmarks respectively indicated 50% and 75% theoretical control of a fungal disease Alternaria Brown Spot on mandarin leaves.

Results and discussion

As was found in previous trials, high spray volumes (> 8000 l ha^{-1}) at 1×pigment concentrations with conventional sprayers realised the highest deposition quantity and lowest variation in deposition uniformity. Higher spray volumes did not improve deposition quantity and uniformity, indicating high losses due to run-off and drift.

Reduced volume applications (1000 to 4000 l ha^{-1}) with the Martignani and Cima sprayers at 1×pigment concentrations realised significantly lower deposition quantities and in some cases varying deposition uniformity. However, by increasing the pigment concentration (2×, 4×) at these reduced spray volumes relative to a similar dose as 8000 l ha^{-1}, deposition quantity and qualitylevels were better than those of conventional high volume 1× sprays . Similar levels of deposition quality were observed at dilute application concentrations with spray volumes ranging from 4000 to 8000 l ha^{-1}; better than 1× sprays at 1000 and 2000 l ha^{-1}. However, sprays at 2000 l ha^{-1}at 2× and 4× realised improved deposition quality, indicative of a more optimal calibration.

Reduced volume sprays were therefore much more efficient with much less off-target losses. Canopy density was highlighted as an important factor as dense citrus canopies impeded deposition uniformity and canopy penetration. Deposition quality on hard-to-reach targets (such as top and inner canopy leaves) also varied with spray machine, volume and concentration, with quality improving at increased concentrations at lower volumes.

These results support the change toward reduced volume application for PPPs in South African citrus production. However, bio-efficacy trials are needed to demonstrate comparable disease and pest control following reduced volume application strategies. Furthermore, PPP labels in South Africa commonly prescribe dilute, high volume application rates (l or g product hl^{-1}), with off-label recommendations at higher concentrations being illegal due to outdated legislation. Harmonisation to more effective dose rate expression (Leaf-Wall-Area or Tree-Row-Volume) together with accurate canopy geometry and density characterisation is also needed in South Africa to facilitate change to more efficient spray application methods.

Acknowledgements

The authors acknowledge Citrus Research International and THRIP for funding, as well as farmers for providing trial sites and spray applicator companies for providing sprayers, inputs and participation.

References

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