Tree row volume based sprays for control of citrus diseases and pests

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Update on optimizing citrus canker management

Outline
✓ Spray volume in São Paulo state
✓ Research results using TRV-based sprays
✓ SPIF
Spray volume in SP

1970s and 1980s

- Gun sprayers
  - 20 – 40 L/tree (5,000 to 10,000 L/ha) 535 to 1,070 gal/acre
  - 60 L/tree (15,000 L/ha) 1,600 gal/acre
  - trees/2,000L (20,000 L/ha) 2,140 gal/acre

(Ramos, H.H., personal communication)

Spray volume in SP

1990s

- 40L/tree (10,000 L/ha) 1,070 gal/acre
Spray volume in SP

2000s

References of spray quality
Spray volume in SP

2000s

8 to 10 thousand L/ha
~850 to 1,070 gal/acre

2 to 3 thousand L/ha
~200 to 320 gal/acre

Spray volume in SP

✓ Measuring the spray volume
  ✓ L/ha   gal/acre
  ✓ L/tree  gal/tree
  ✓ trees/spray tank
Spray volume in SP

- Measuring chemical rates
  - active ingredient/tank
  - a.i./100 L water
  - a.i./ha

- Sources of variation
  - Tree spacing
  - Tree age
  - Tree height
  - Nozzles
  - Work speed
  - Etc.

Tree row volume based sprays

Tree volume/ha

\[ TRV (m^3/ha) = 10,000/\text{row spacing} \times \text{tree depth} \times \text{tree height} \]

Spray volume and a.i. rate/m³
Tree row volume based sprays

- **Apple** (Manktelow and Praat, 1997; Sutton and Unrath, 1984, 1988)
- **Stone fruit** (Rüegg et al., 1999)
- **Grape** (Gil and Escola, 2009; Pergher and Petris, 2008; Siegfrieda et al., 2007)
- **Protected tomato plantings** (Sanchez-Hermosilla et al., 2013)

**Concept:** based on the runoff point

- **Spray volume ABOVE runoff**
  - ~ 100 mL/m$^3$ 3.40 fl oz – exterior of the tree canopy
  - ~ 40 mL/m$^3$ 1.40 fl oz – interior of the tree canopy

**(Ramos, H.H., unpublished data)**
**Tree row volume based sprays**

**Spray volume**

- **Tree spacing**:
  - 7 x 3 m
  - 23 x 10 ft

- 476 trees/ha
- 193 trees/acre

<table>
<thead>
<tr>
<th>2.5m (8.2 ft)</th>
<th>4.5m (14.8 ft)</th>
</tr>
</thead>
</table>

| Non TRV-based volume: | 1.5 L/tree 0.4 gal/tree |
| TRV-based volume:     | 1.5 L/tree 0.4 gal/tree |

- **Non TRV-based volume**:
  - 9,520 m³/ha (20 m³/tree)
  - 3,850 m³/acre
  - 75 mL/m³ 2.50 fl oz/m³
  - 1.5 L/tree 0.4 gal/tree
  - 715 L/ha 77 gal/acre

- **TRV-based volume**:
  - 28,560 m³/ha (60 m³/tree)
  - 11,540 m³/acre
  - 75 mL/m³ 2.50 fl oz/m³
  - 4.5 L/tree 1.2 gal/tree
  - 2,140 L/ha 230 gal/acre

**Pesticide rate**

- **Young grove**
  - Non TRV-based rates
  - Fungicide (a.i.)

- **Mature grove**
  - TRV-based rates
Research results
Scapin et al., 2015. Crop Protection.

**Citrus canker**
- 6-year-old ‘Valencia’ sweet orange
- air blast sprayer
- 23,300 m³/ha (49 m³/tree) 9,430 m³/ac

- Optimal volume: 40 to 70 mL/m³
- 1.4 to 2.40 fl oz/m³
- 20 mL/m³ 0.7 fl oz/m³ reduced copper sprays effectiveness (unpublished data)

<table>
<thead>
<tr>
<th>Coverage (%)</th>
<th>Internal</th>
<th>External</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spray volume (mL/m³)</td>
<td>Internal Coverage (%)</td>
<td>External Coverage (%)</td>
</tr>
<tr>
<td>150</td>
<td>70.6 As</td>
<td>92.6 As</td>
</tr>
<tr>
<td>100</td>
<td>67.7 Bab</td>
<td>96.7 As</td>
</tr>
<tr>
<td>70</td>
<td>53.8 Bab</td>
<td>96.0 As</td>
</tr>
<tr>
<td>40</td>
<td>27.3 Bab</td>
<td>96.0 As</td>
</tr>
</tbody>
</table>

Research results
Silva Junior et al., 2016. Crop Protection.

**Citrus Black Spot**
- 11-year-old ‘Valencia’ sweet orange grove
- air blast sprayer
- 24,180 m³/ha (44 m³/tree) 9,790 m³/ac

- Optimal volume 75 mL/m³ (2.5 fl oz/m³)
- 50 mL/m³ (1.7 fl oz/m³) (?)

<table>
<thead>
<tr>
<th>Internal Coverage (%)</th>
<th>Spray volume (mL/m³)</th>
<th>Fungicide rates</th>
</tr>
</thead>
<tbody>
<tr>
<td>45 a</td>
<td>44 a</td>
<td>34 ab</td>
</tr>
<tr>
<td>45 b</td>
<td>44 a</td>
<td>24 b</td>
</tr>
<tr>
<td>45 b</td>
<td>44 a</td>
<td>34 ab</td>
</tr>
<tr>
<td>45 b</td>
<td>44 a</td>
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<tr>
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</tr>
</tbody>
</table>

Average of 3 seasons

* 75C and 50C = a.i. corrected to 100 mL/m³
Research results

G. Silva Junior et al., unpublished data.

Postbloom fruit drop

- 21-year-old ‘Pera’ sweet orange grove
- Air blast sprayer
- 446 tree/ha
- 22,746 m³/ha (51 m³/tree) **9,190 m³/ac**

**Treatments**

- 50 mL/m³ = 1,130 L/ha = **125 gal/ac**
- 40 mL/m³ = 900 L/ha = **100 gal/ac**
- 30 mL/m³ = 680 L/ha = **75 gal/ac**
- 20 mL/m³ = 450 L/ha = **50 gal/ac**

\[
\text{Symptomatic flower (\%)}
\]

<table>
<thead>
<tr>
<th>Spray volume (mL/m³)</th>
<th>b</th>
<th>b</th>
<th>b</th>
<th>20</th>
<th>a</th>
</tr>
</thead>
</table>

Optimal volume:
20 to 40 mL/m³

(0.7 to 1.4 fl oz/m³)

Research results

Psyllid

- 4-year-old ‘Pera’ sweet orange grove
- Air blast sprayer
- 10,087 m³/ha (25 m³/tree) **4,085 m³/ac**
- Insecticide: dimetoate

\[
\text{Psyllids were confined after spraying}
\]

**Treatments**

- 80 mL/m³ = 1,034 L/ha = **110 gal/ac**
- 40 mL/m³ = 517 L/ha = **55 gal/ac**
- 30 mL/m³ = 387 L/ha = **41 gal/ac**
- 25 mL/m³ = 323 L/ha = **34 gal/ac**

*30C and 25C = a.i. corrected to 40 mL/m³

\[
\text{External coverage (%)}
\]

<table>
<thead>
<tr>
<th>Spray volume (mL/m³)</th>
<th>80</th>
<th>60</th>
<th>40</th>
<th>25</th>
</tr>
</thead>
</table>

Optimal volume:
25 to 40 mL/m³ (0.85 to 1.40 oz/m³)

*30C and 25C = a.i. corrected to 40 mL/m³
**Research results**

M. S. Scapin et al., unpublished data.

### Leprosis
- 13-year-old ‘Pera’ sweet orange grove
- air blast sprayer
- 476 tree/ha
- 25,143 m³/ha (62 m³/tree) **10,150 m³/ac**

**Treatments**
- 100 mL/m³ = 2,514 L/ha = **270 gal/ac**
- 200 mL/m³ = 5,029 L/ha = **540 gal/ac**
- 242 mL/m³ = 7,184 L/ha = **770 gal/ac**

*100C = a.i. corrected to 100 mL/m³*

**Optimal volume: no more than 100 mL/m³ (3.4 fl oz/m³)**

### Tree row volume based sprays

**Summary**

- **Spray volumes (mL/m³ fl oz/m³)**
  - Psyllid: 20 (0.7)
  - Black spot: 40 (1.4)
  - Citrus canker: 70 (2.4)
  - Leprosis: 100 (3.4)

- **Max. speed (km/h mph)**
  - Psyllid: 7.0 (4.3)
  - PFD: 7.0 (4.3)
  - Citrus canker: 5.5 (3.4)
  - Black spot: 4.5 (2.8)
  - Leprosis: 3.0 (1.9)

- **Drop size:** 100 to 200 µm
- **Pressure:** 100 to 200 psi
Tree row volume based sprays

Advantages

- Water
- Chemicals
- Environmental impact
- Costs
- Operational efficiency

SPIF

SISTEMA DE PULVERIZAÇÃO INTEGRADO DO FUNDECITRUS

FUNDECITRUS INTEGRATED SPRAY SYSTEM
- Register area
- Set up spray volume
- Select chemical
- Select rates
- Reports

- Tree canopy volume
- Report history
- Volumes and rates
- Select nozzles
- Pressure
Spray settings summary

SPIF

Sprayer Settings
Number of nozzles

SPIF

Calibrar pulverizador

Volume de calda utilizado (L/h)
150.00

Diâmetro orifícios (mm)
1,00

Tipo de pulverizador
Bilateral

Número total de bicos abertos
60

Veio a frente / ponta a 100 por (cm³/min)
1,1

Dose do produto: 2,438 kg ou l/2000L.

Volume de calda
1500
L/h
66
m³/h

Dose do produto comercial
2,438
kg ou l/2000L
1,03
kg ou l/h
860,00
mg ou g/l

Dose do ingrediente ativo
1.01
kg/ha
60,05
g/100L
460,00
mg/m²
Sprayer Settings
Type of nozzles

Sprayer Settings summary
Who can access?

✓ Anyone

Where to access?

✓ Web, desktop and App versions
✓ Download: spif.fundecitrus.com.br
✓ Registration: spif@fundecitrus.com.br
Update on optimizing citrus canker management

Outline

- Copper sprays
  - Volume
  - Rate
  - Formulation
  - Spray period
- Integrated management
  - Copper
  - Windbreaks
  - Leafminer control

Citrus canker in São Paulo state

- Detected in 1957
- Control: exclusion and eradication
- Several methodologies in near 60 years
- No eradication, but suppression of the disease (<0.20% blocks up to 2009)
- HLB and legal challenges by the growers diverted attention and efforts
- Rules became less stringent in the last years
- 2017: management in SP
Citrus canker incidence in São Paulo

Blocks with canker (%)

- **Observed**
- **Estimated**

Incidence of blocks with citrus canker (%)

- **9.1%**

**Irreversible scenario**

Grower’s reactions
Copper spray volume

- By using 40 mL/m³ we reduced spray volume from 350 to 87 gal/ac without affecting canker control (75%)

- Optimal volume: 40 to 70 mL/m³ **1.4 to 2.40 oz/m³**

- 20 mL/m³ **0.7 oz/m³** reduces effectiveness of copper sprays (unpublished data)
Copper formulation and rate

<table>
<thead>
<tr>
<th>Commercial name</th>
<th>Formulation type</th>
<th>Copper source and concentration (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper Crop</td>
<td>solution</td>
<td>copper nitrate (35.4)</td>
</tr>
<tr>
<td>Magna-Bon CS 2005</td>
<td>solution</td>
<td>copper sulfate pentahydrate (19.8)</td>
</tr>
<tr>
<td>Diffra</td>
<td>suspension conc</td>
<td>copper oxochloride (58.8)</td>
</tr>
<tr>
<td>Supra</td>
<td>suspension conc</td>
<td>copper hydroxide (53.8)</td>
</tr>
<tr>
<td>Kocide WDG</td>
<td>water disp gran</td>
<td>copper hydroxide (53.8)</td>
</tr>
<tr>
<td>Cuprogarb 350</td>
<td>wettable powder</td>
<td>copper oxochloride (58.8)</td>
</tr>
<tr>
<td>Redshield 750</td>
<td>wettable powder</td>
<td>cuprous oxide (86.0)</td>
</tr>
</tbody>
</table>

- Spray interval: 21 days
- Formulation: fixed copper provides better control
- Formulation: there was no difference among the fixed formulations at the same met Cu rate
- Rate: 40 to 50 mg met Cu/m$^3$ up to 1 kg met Cu/ha

**Soluble copper**

**Fixed copper**

- Year 1
- Year 2

Formulation and rate (kg met Cu/ha) *lb/ac*
Period of protection

Lesions associated with fruit drop

- Large (≥ 5 mm) vs. Small (< 5 mm)

Harvested fruit

- Large lesions on harvested fruits: 45.5%
- Small lesions on both dropped and harvested fruit: 54.5%

Dropped fruit

- Large lesions on dropped fruits: 91.3%
- Small lesions on both dropped and harvested fruit: 18.7%

‘Valencia’ orange

Based on Graham et al., 2010, 2011

The earlier that the orange fruit develop citrus canker symptoms the greater...

- the size
- the number
- the proximity to the peduncle
- the severity of lesions

The fruit drop

Fruit is susceptible up to 45 mm diameter (~120 days after bloom)

Incidence of dropped fruit (%)

- October (45/30) vs. November (75/40) vs. December (105/45)

DAB: days after bloom
FD: fruit diameter (mm)

(a)
Integrated management

Importance of Cu, winbreaks and leafminer control

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