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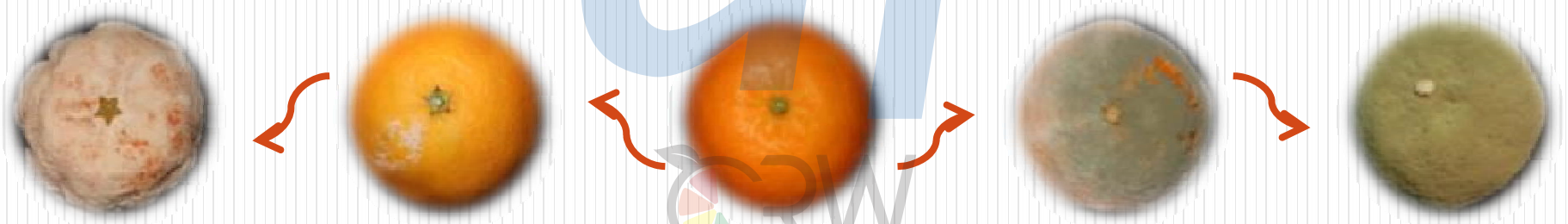
The efficacy of imazalil sulphate dip applications for the control of citrus green mould



Arno Erasmus

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Department of Plant Pathology

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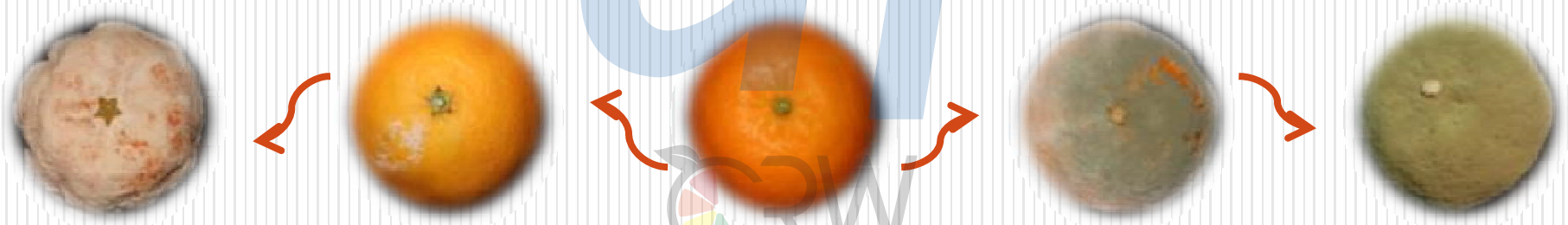
Faculty of Agriculture and Forestry Sciences

Layout

1. Imazalil applied through dip tank
2. Incubation time
3. Effect of brushes on imazalil residue loading



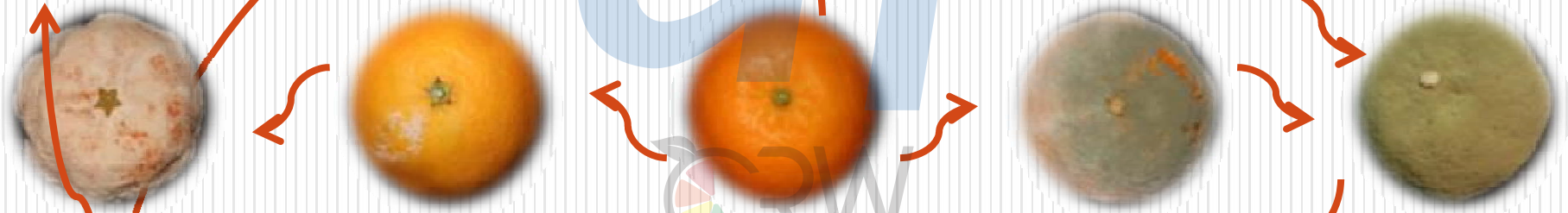
Citrus Green Mould in South Africa

RSA second largest exporter of fresh citrus in the world

Achieved this by delivering excellent quality citrus to market

Losses occur due to decay

Green mould most common post harvest disease on export citrus



Caused by *Penicillium digitatum*

Wound pathogen

Orchard

Harvest

Bin

Packhouse

Fresh wound + Water + Nutrients

= Conidia germination + 4 h

= Infection

At least 24 h from harvest to fungicide treatment

Ideal fungicide

Imazalil (IMZ)

Inhibit sporulation

Curative action

Imazalil

Imazalil (IMZ)

Formulations

Emulsifiable concentrate (EC)

Oily suspension

Sporulation

Sporulation inhibition

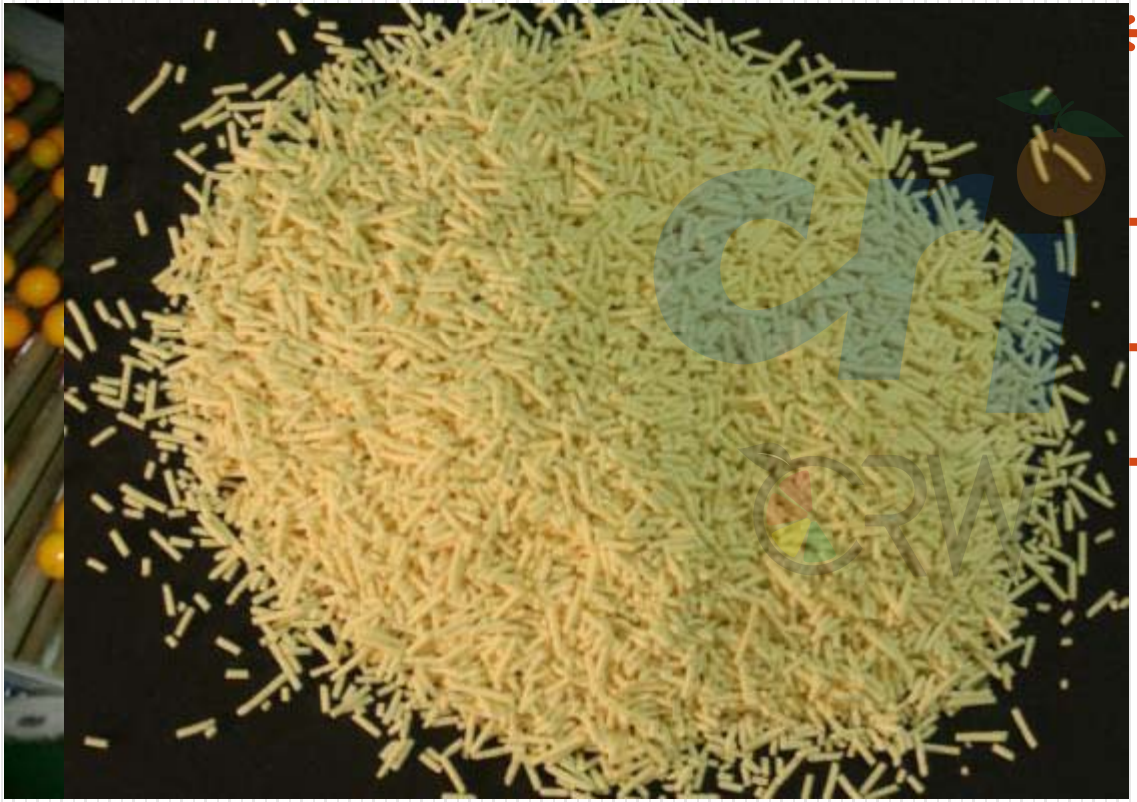
Inhibits demethylation of ergosterol biosynthesis

Process necessary for normal growth and reproduction

Wax application

Imazalil – dip application

Dip application – fungicide dip tank



Soluble granules

IMZ sulphate

Survey (2008):
IMZ application in SA citrus packhouses

78% use dip tank

Exposure time = 47 s
(Range: 16 – 107 s)

pH = 5.4
(Range: 3.3 – 8.0)

Temperature = 33.4°C
(Range: 11.5 – 44.6°C)

Residue = 1.02 $\mu g.g^{-1}$
(Range: 0.24 – 3.85 $\mu g.g^{-1}$)

Majority commercial residue = 1.1 $\mu g.g^{-1}$

Imazalil – residue loading

Clementine
Lemon
Navel
Valencia

Buffered: pH 6 and 8

Sodium bicarbonate ($NaHCO_3$)

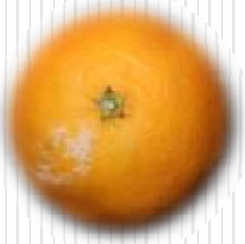
Sodium hydroxide (NaOH)

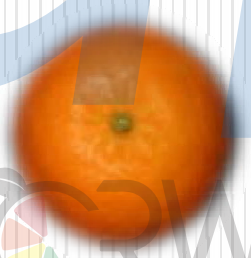
Unbuffered: pH 3

IMZ sulphate

500 $\mu g.mL^{-1}$

IMZ EC (pH 7)





Exposure time: 15 to 540 s

Improve residue loading

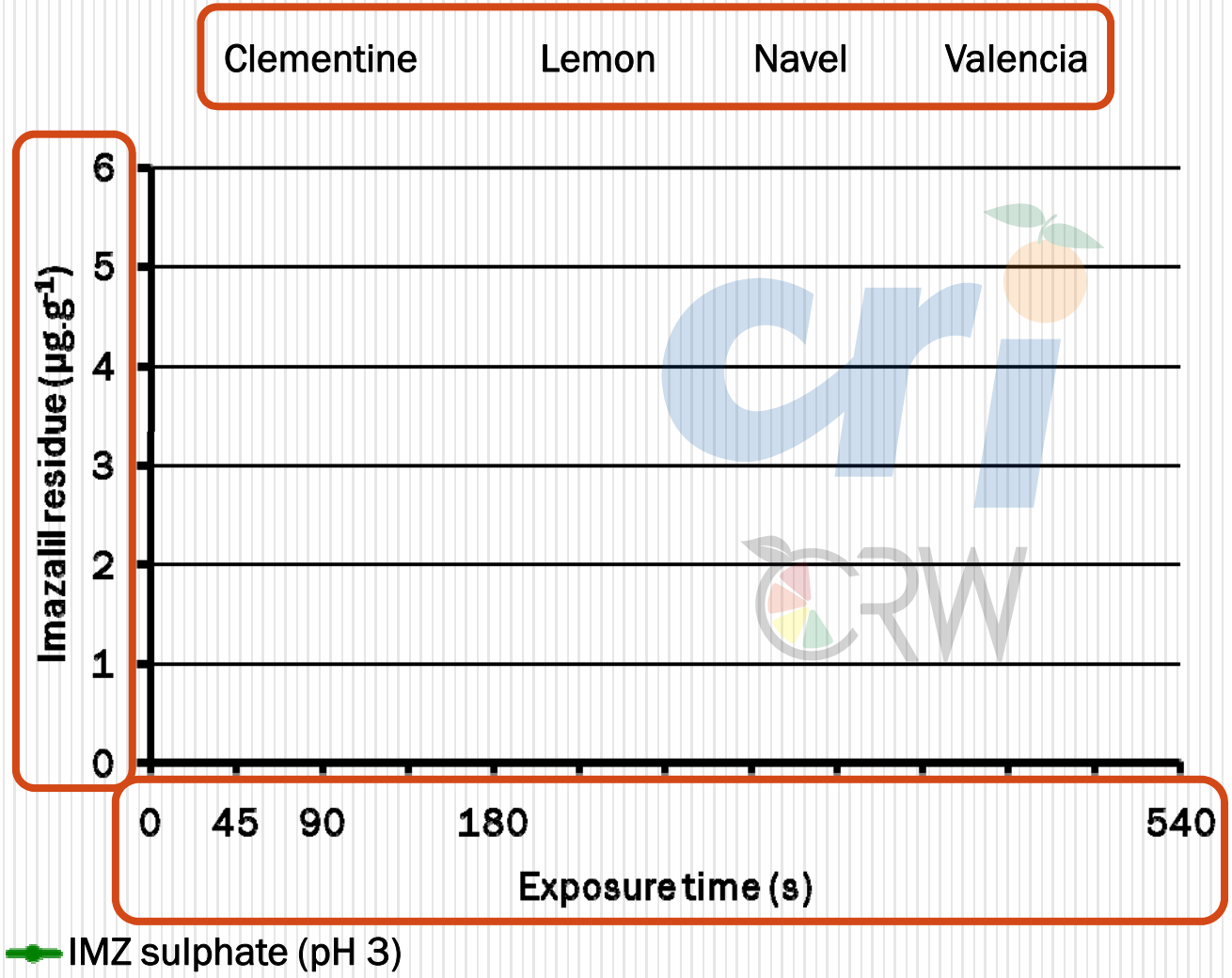
?

Residue = 1.02 $\mu g.g^{-1}$
(Range: 0.24 – 3.85 $\mu g.g^{-1}$)

Majority commercial residue = 1.1 $\mu g.g^{-1}$

IMZ sulphate (pH 3)

Imazalil – residue loading



Imazalil – residue loading

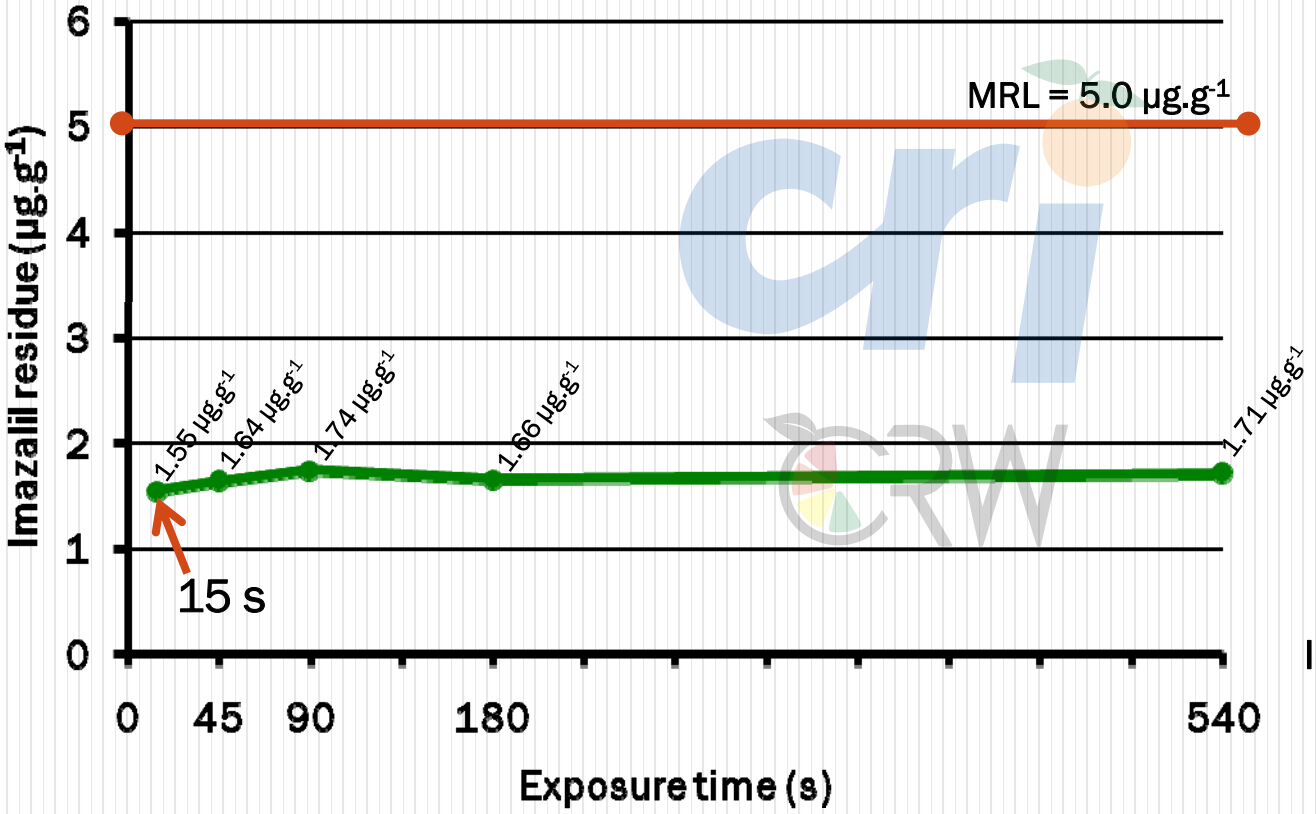
IMZ bisulphate $\leftrightarrow$ H_2O IMZ sulphate + H_3O

pH 7 (35 °C)

(Municipal - CL)

pH < 3

At low pH IMZ in stable solution

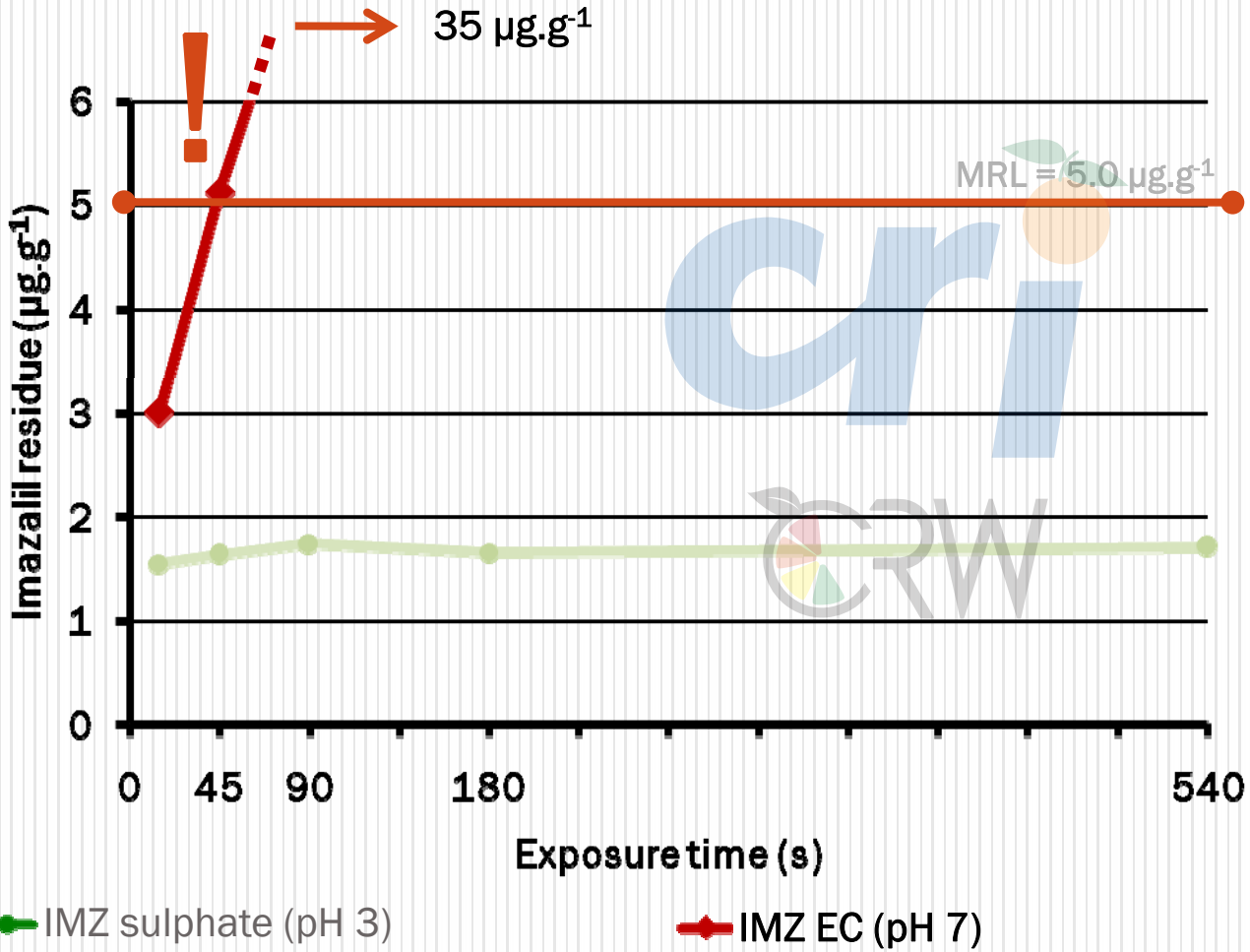


Ion exchange equilibrium

IMZ sulphate solution $\leftrightarrow$ Fruit rind

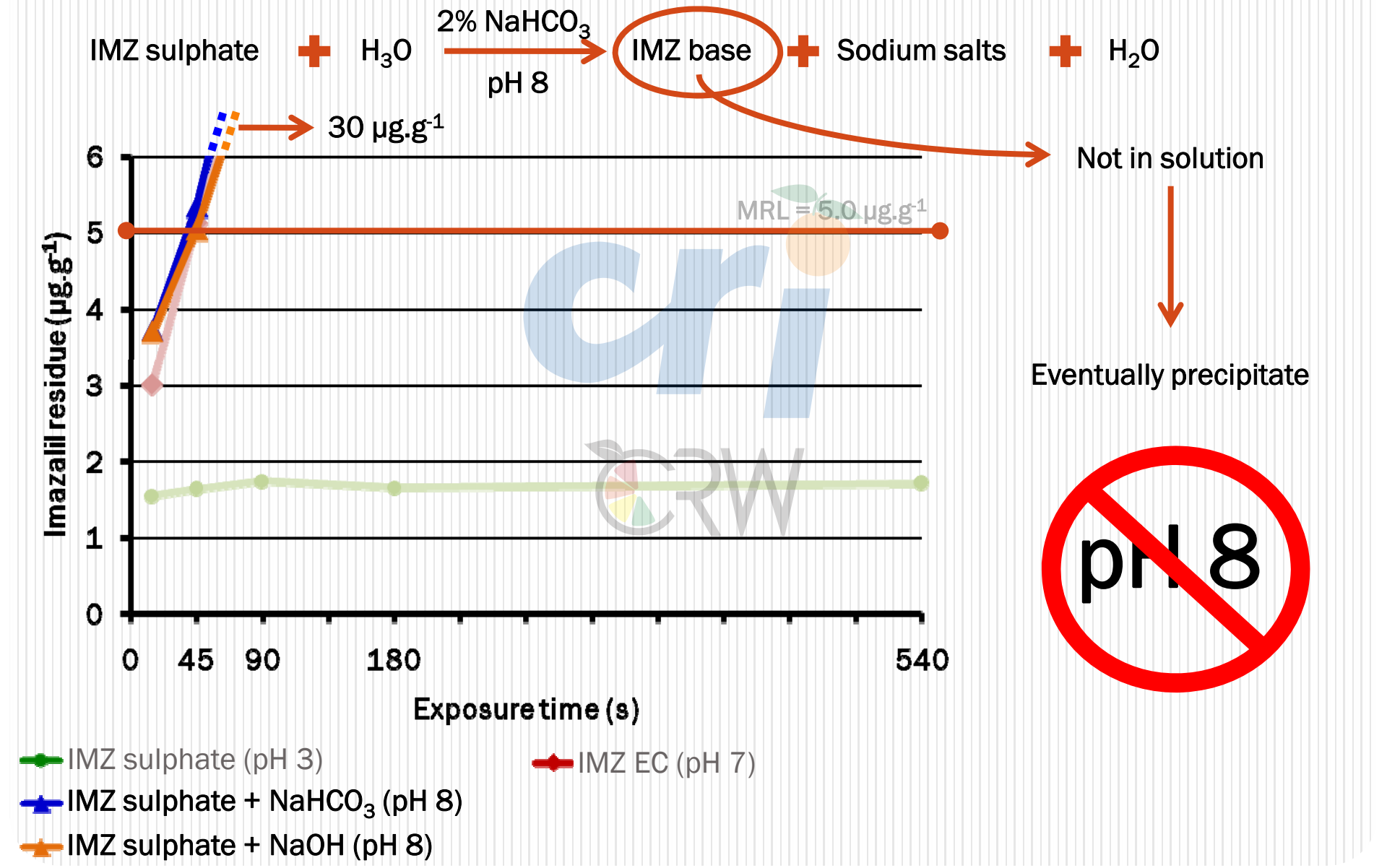
Imazalil – residue loading

IMZ EC = IMZ base molecule emulsified in oily droplets + H_2O = Suspension

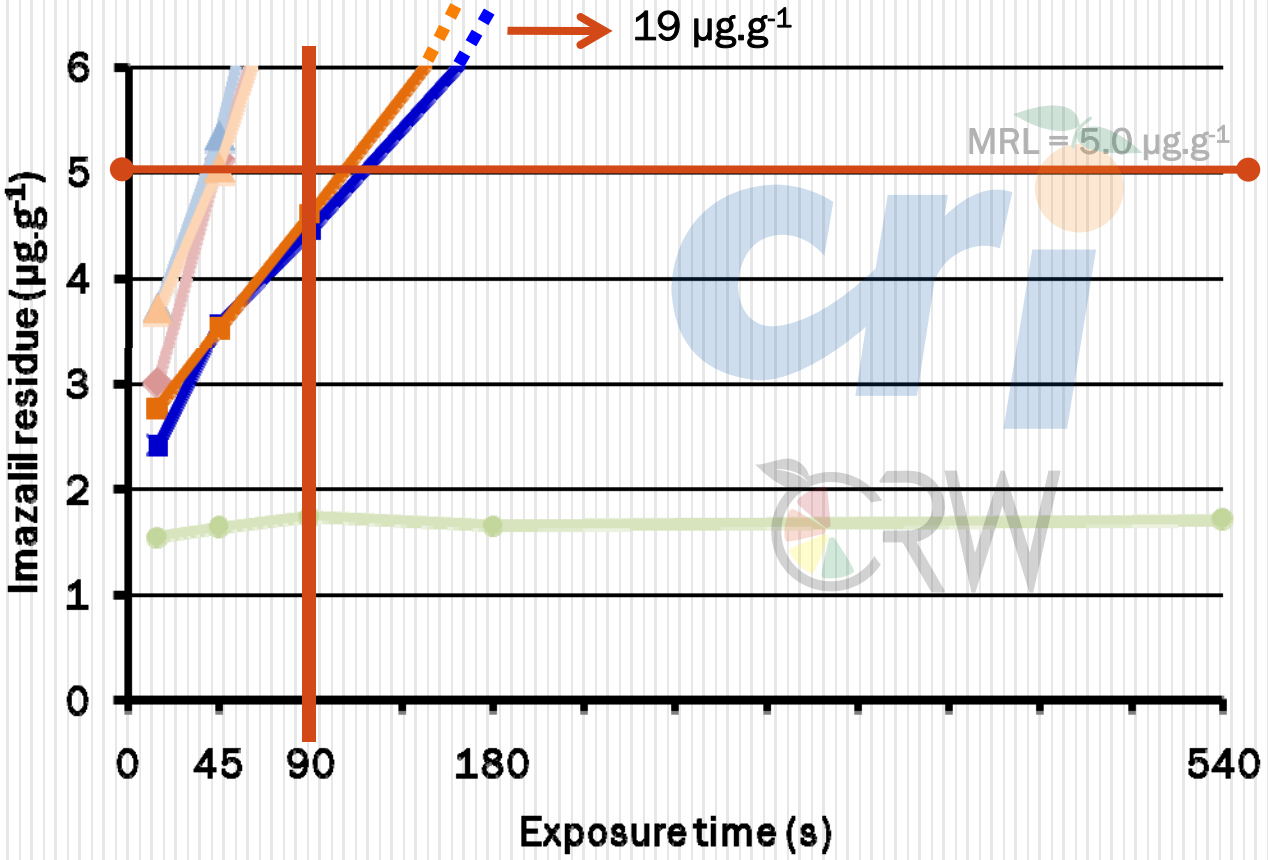


!! After 45 s MRL exceeded !!

Imazalil – residue loading



Imazalil – residue loading



IMZ pKa = 6.5

↓

pH level where:

50% in IMZ sulphate form

50% in IMZ base form

Improved residue loading

IMZ residue - control

1. Inoculated: ▲ IMZ sensitive isolate ◆ IMZ resistant isolate
2. Incubated: 4 hours @ 20°C
3. Treated - IMZ
4. Stored: 12 days @ 3.5°C + 7 days @ 20°C
5. Evaluated: Infection

How much residue is required to curatively control green mould ??

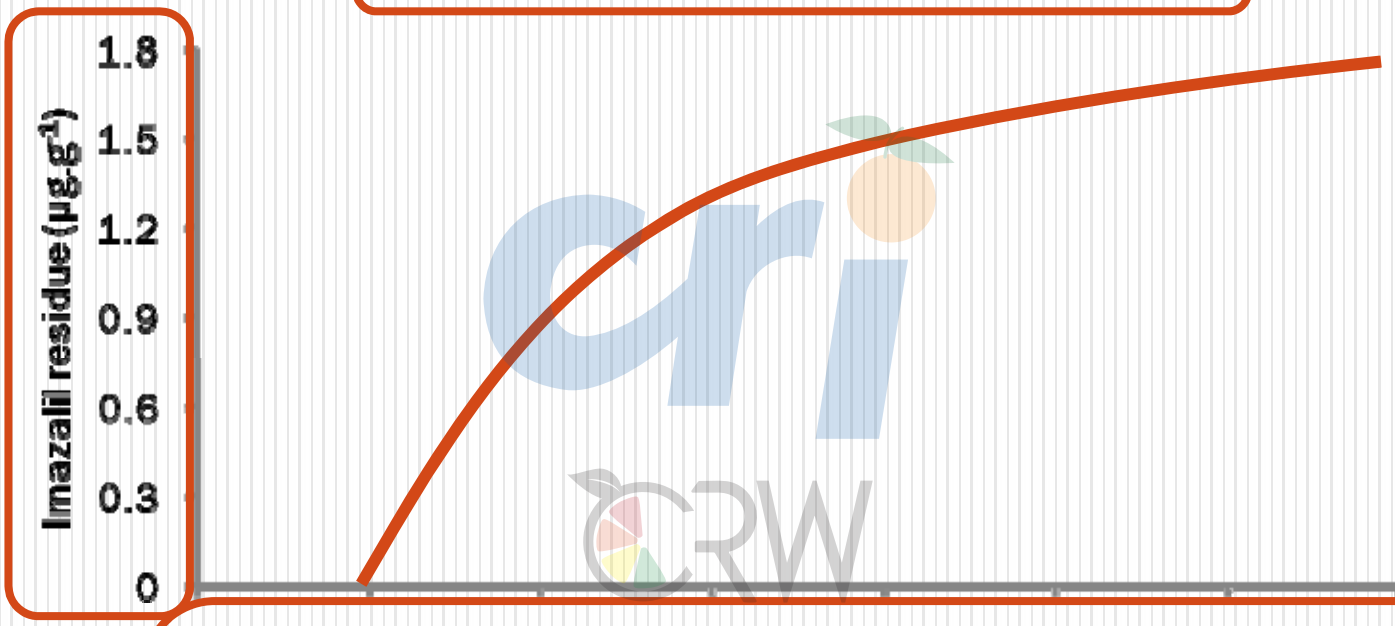
?.?? µg.g^{-1}

Exposure time:	0 s	60 s	5 s	15 s	90 s	15 s	90 s	540 s
Concentration:	0 µg.mL^{-1}		250 µg.mL^{-1}			500 µg.mL^{-1}		

IMZ sulphate (pH 3)

IMZ residue - control

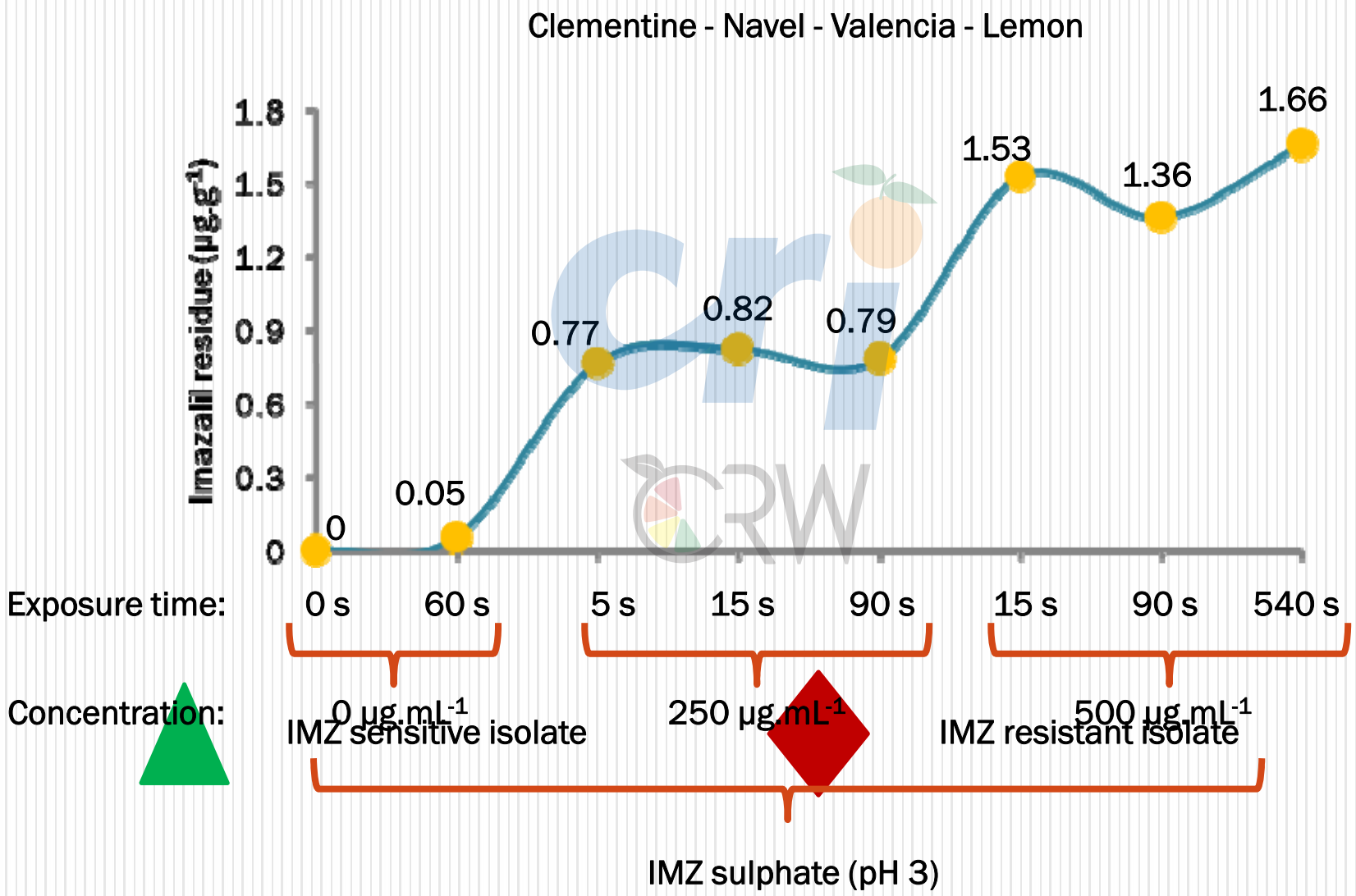
Clementine - Navel - Valencia - Lemon



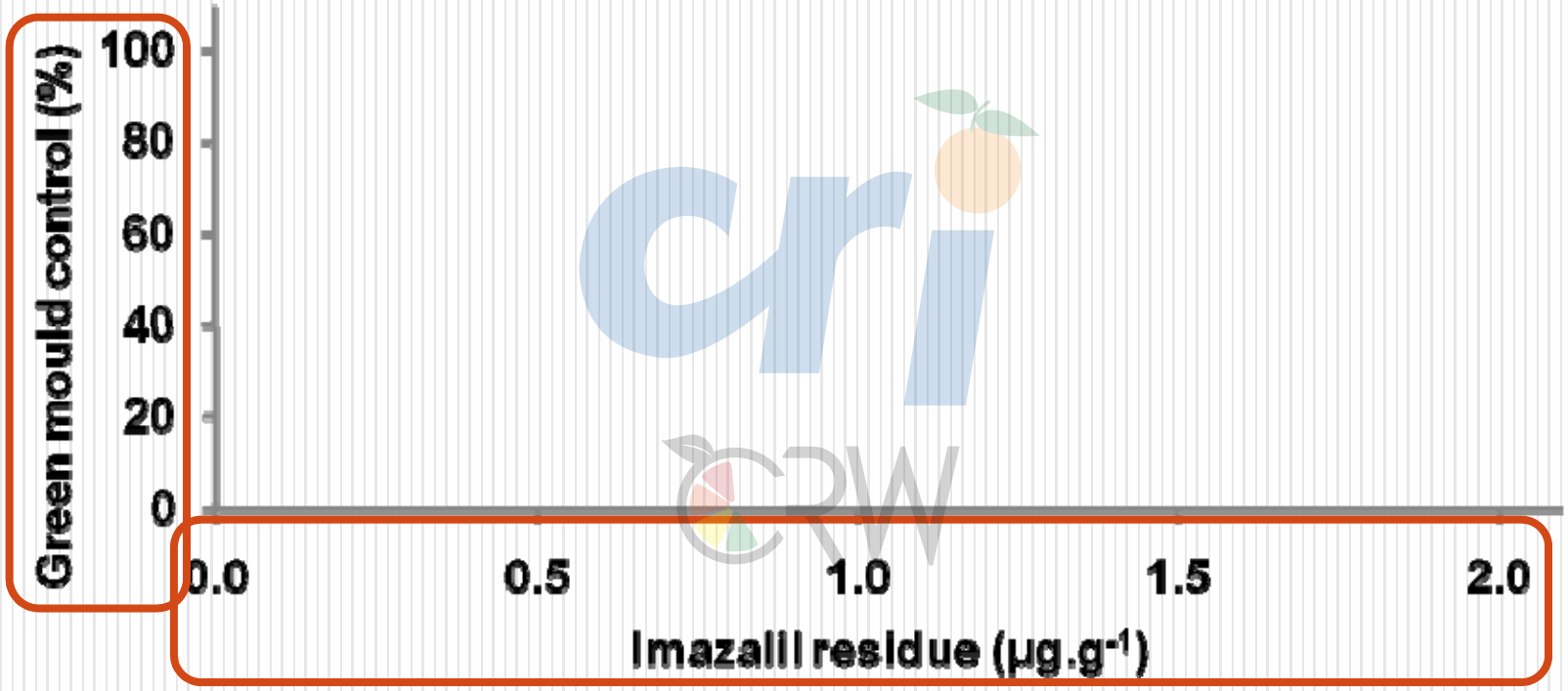
Exposure time:	0 s 60 s	5 s 15 s 90 s	15 s 90 s 540 s
Concentration:	0 µg.mL^{-1}	250 µg.mL^{-1}	500 µg.mL^{-1}

IMZ sulphate (pH 3)

IMZ residue - control



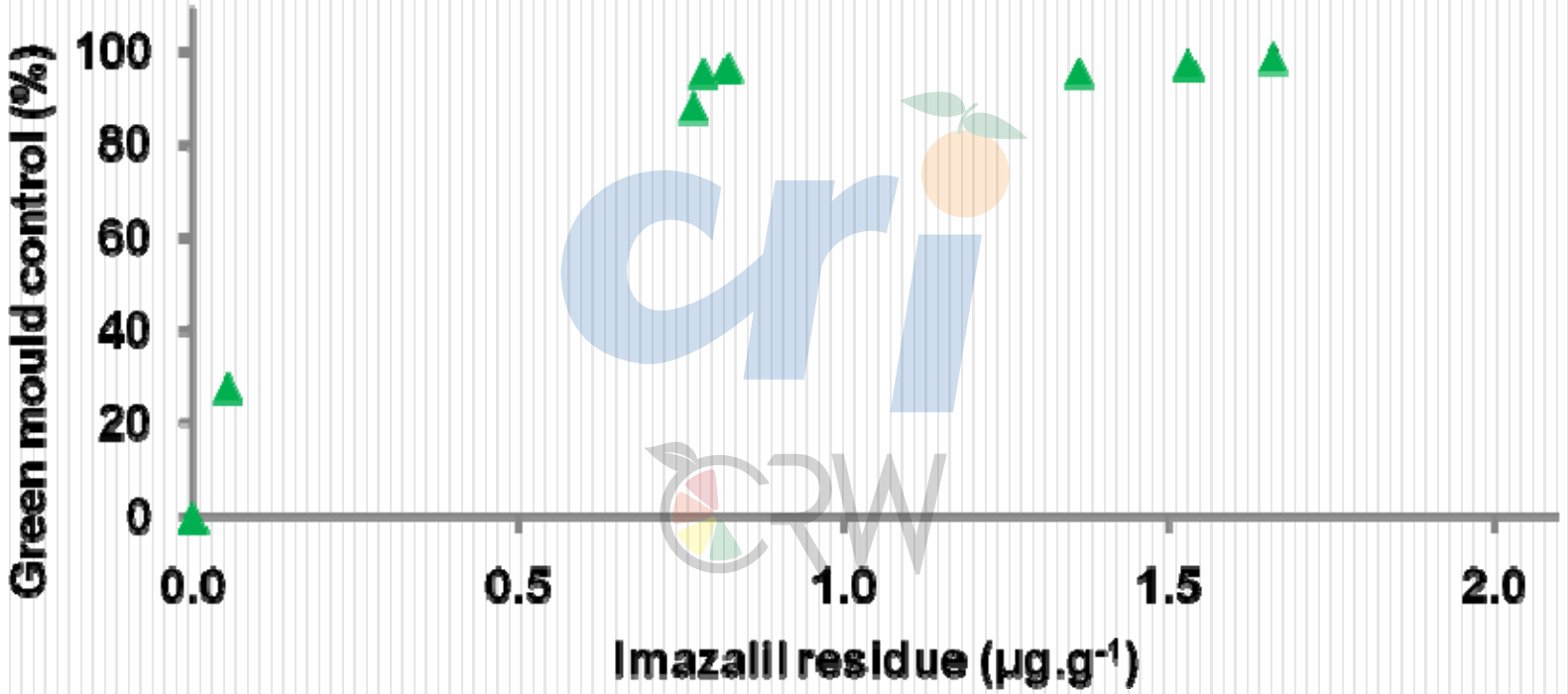
IMZ residue - control



IMZ sensitive isolate

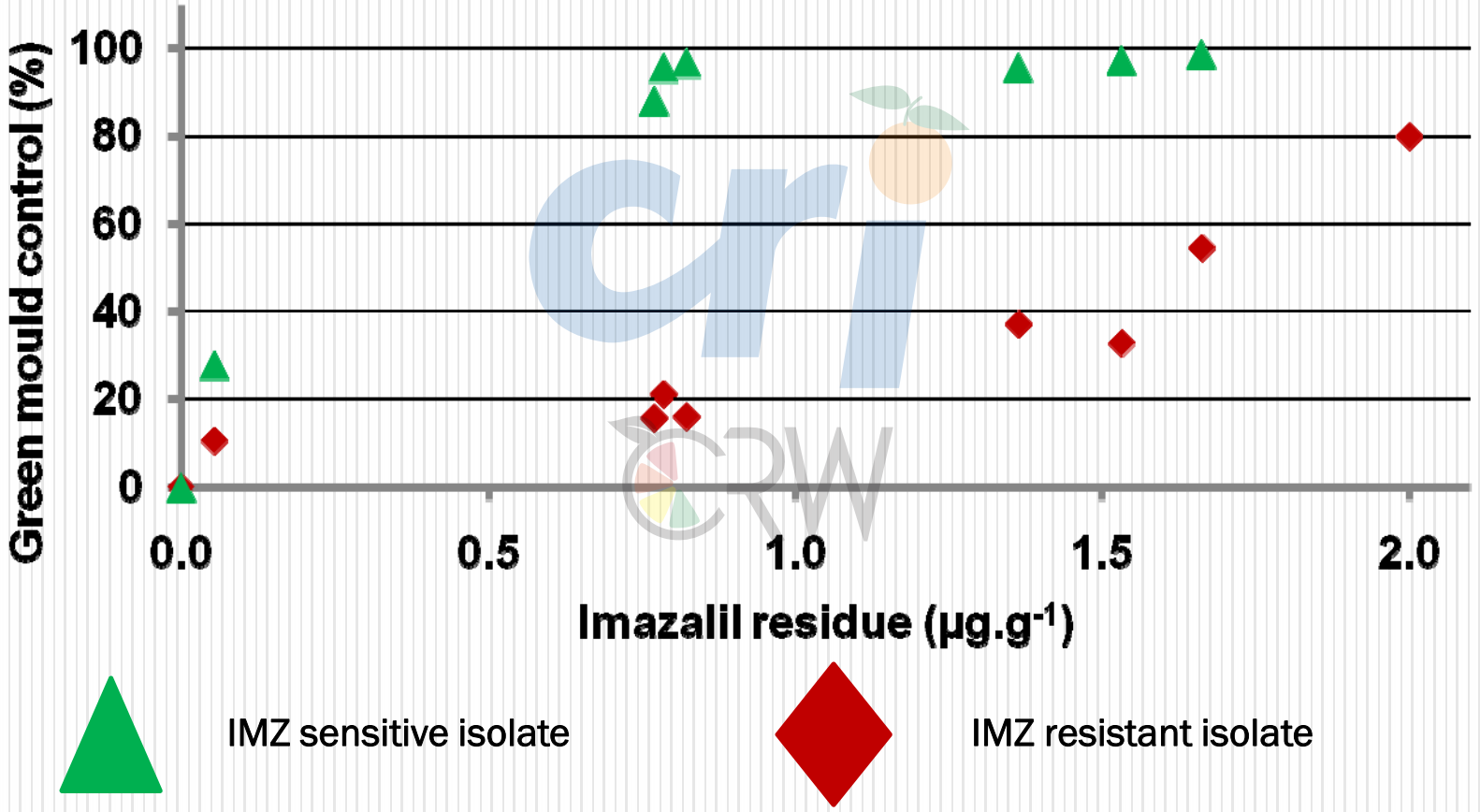
IMZ resistant isolate

IMZ residue - control

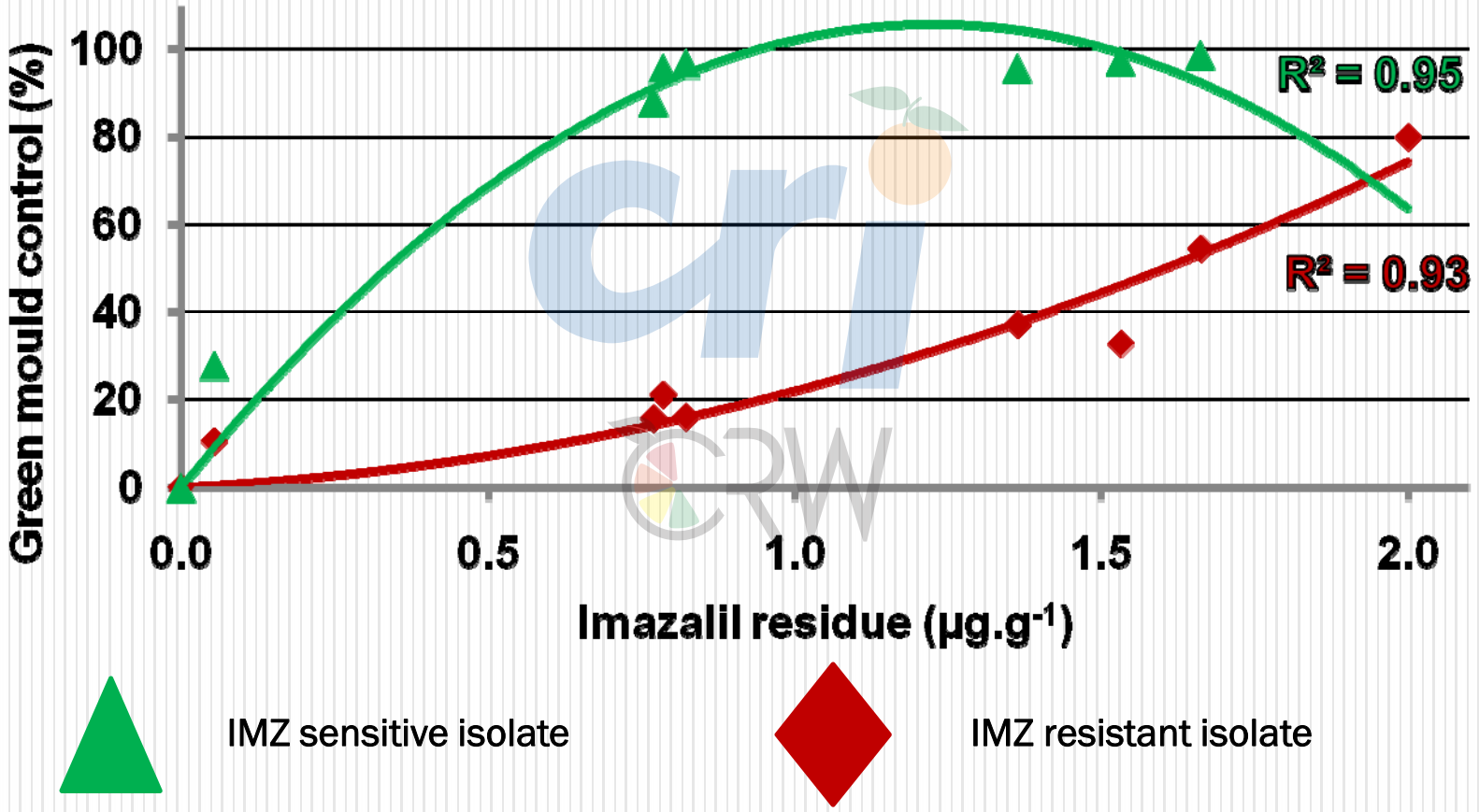


IMZ sensitive isolate

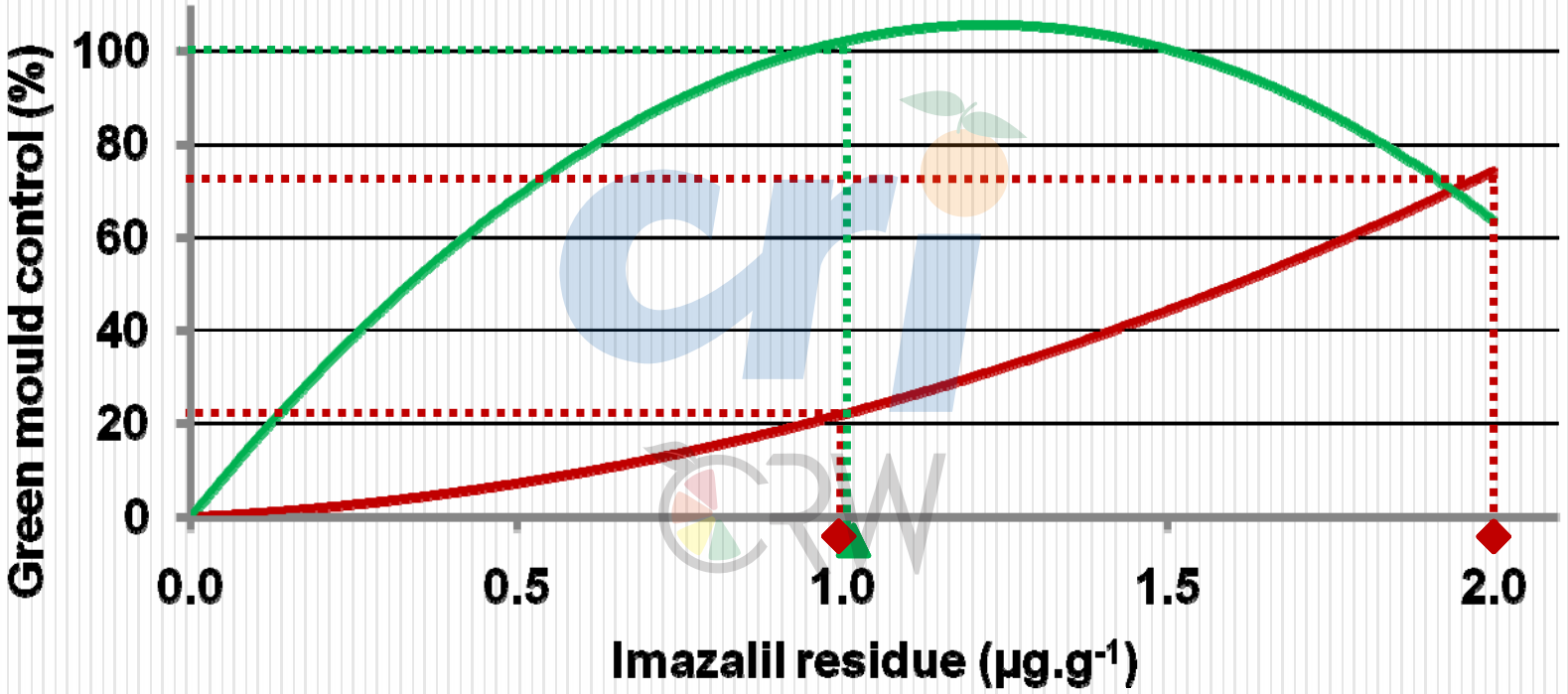
IMZ residue - control



IMZ residue - control



IMZ residue - control



IMZ sensitive isolate

- 1.0 µg.g^{-1} = 100% control

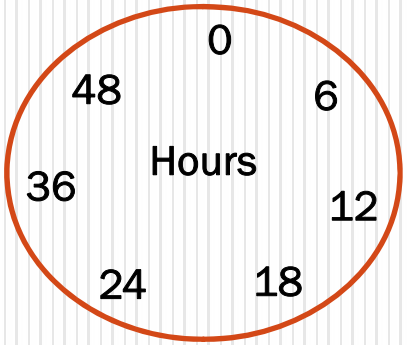
IMZ resistant isolate

- 1.0 µg.g^{-1} = 22% control
- 2.0 µg.g^{-1} = 74% control

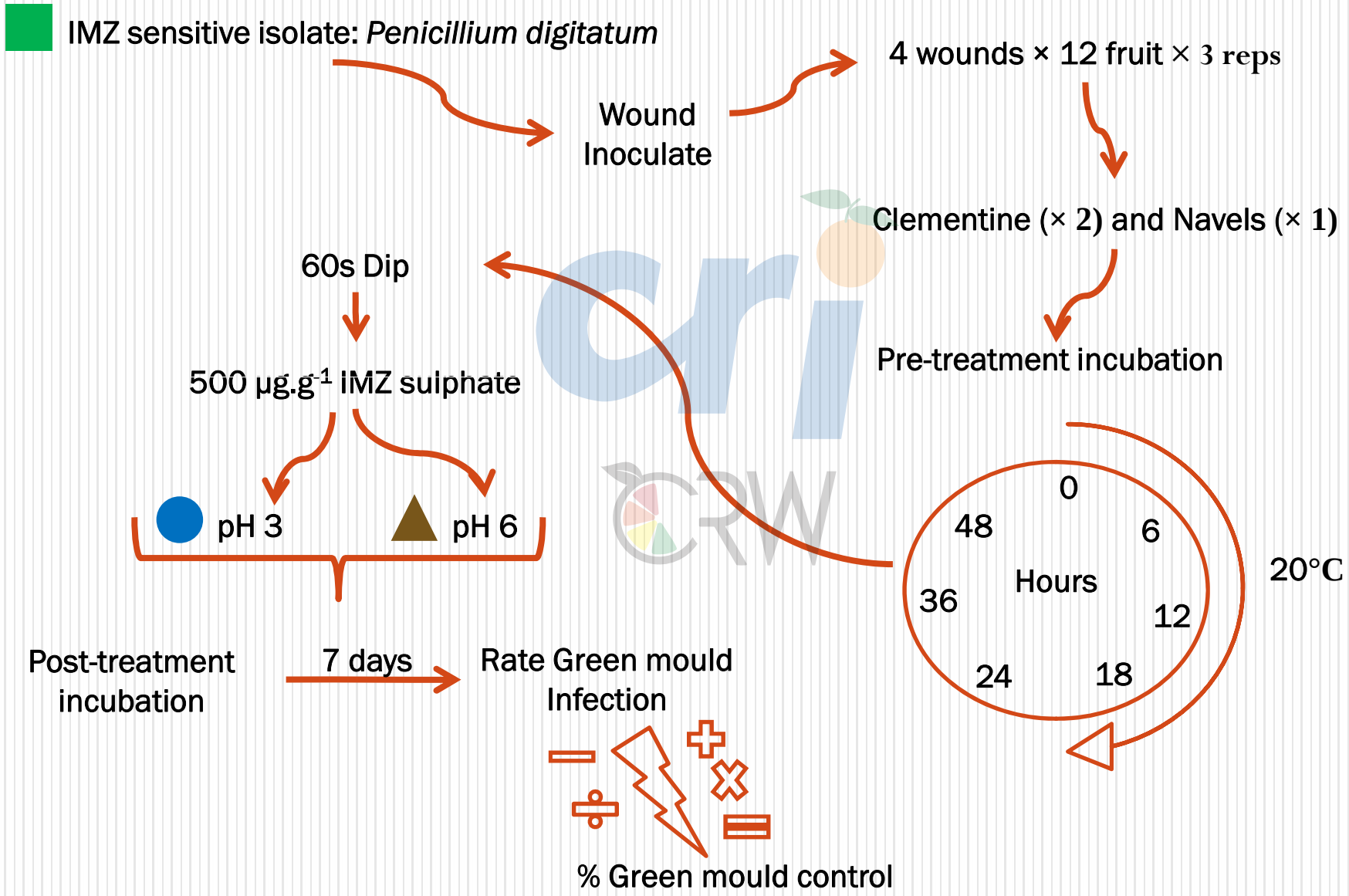
Summary

IMZ kick-back action

How long from harvest to dip tank?

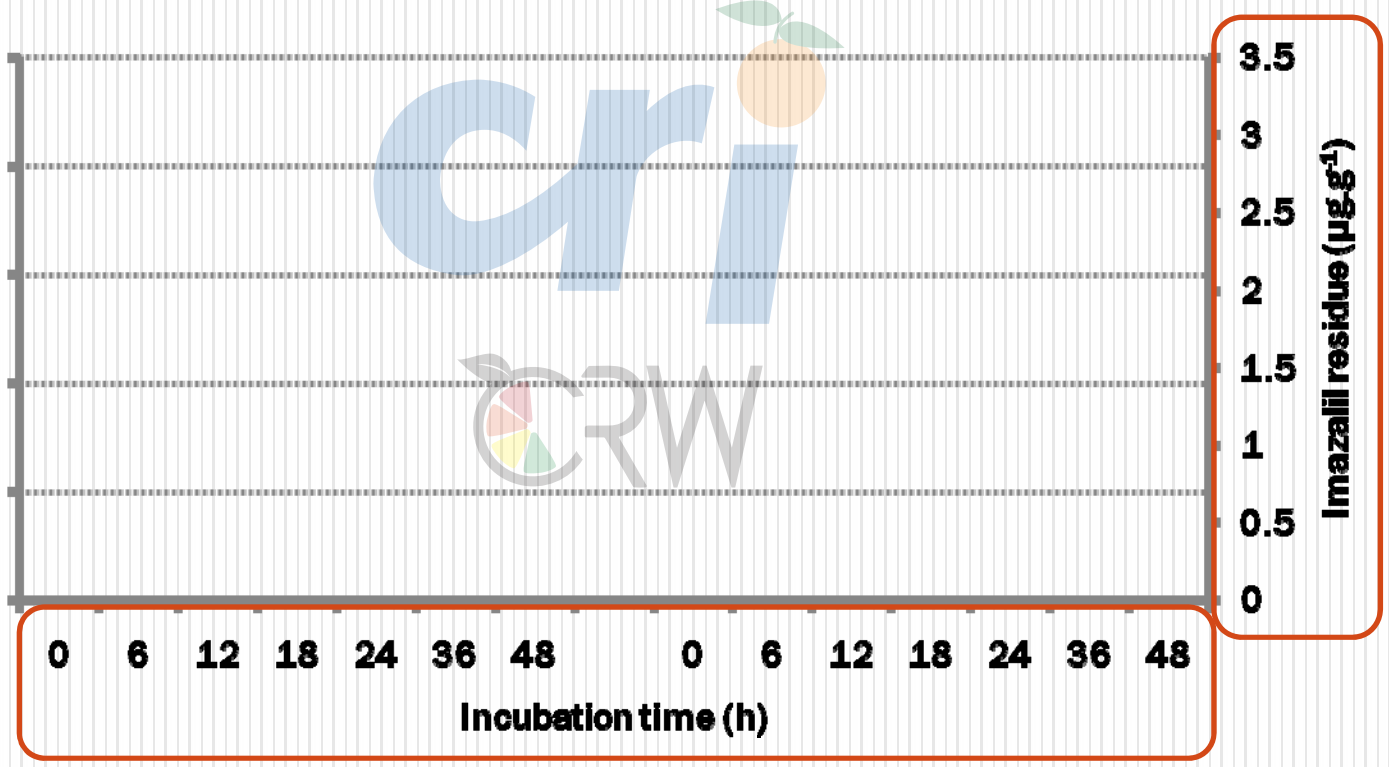


Effect of incubation time on the curative action of IMZ



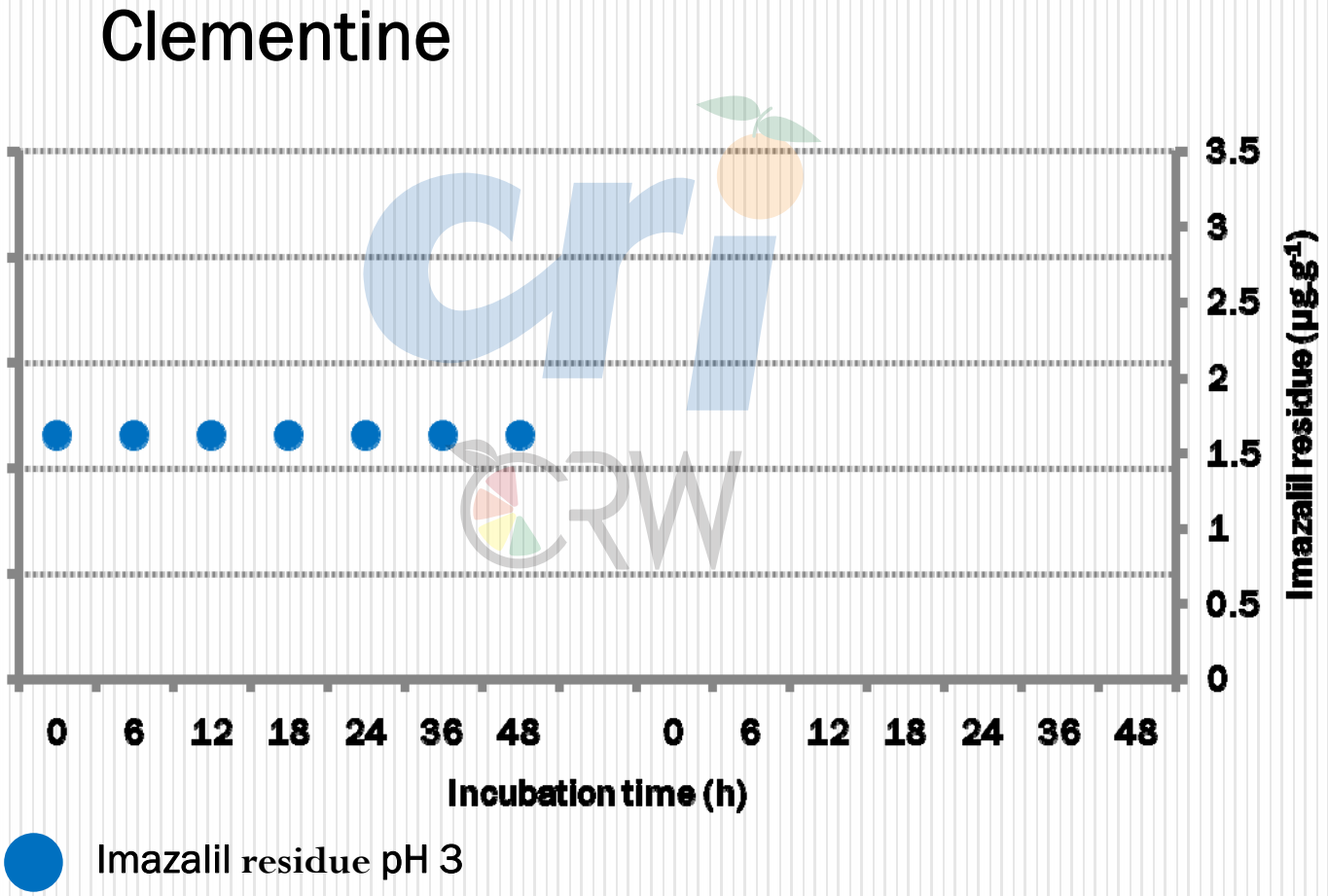
Effect of incubation time on the curative action of IMZ

Imazalil residue:



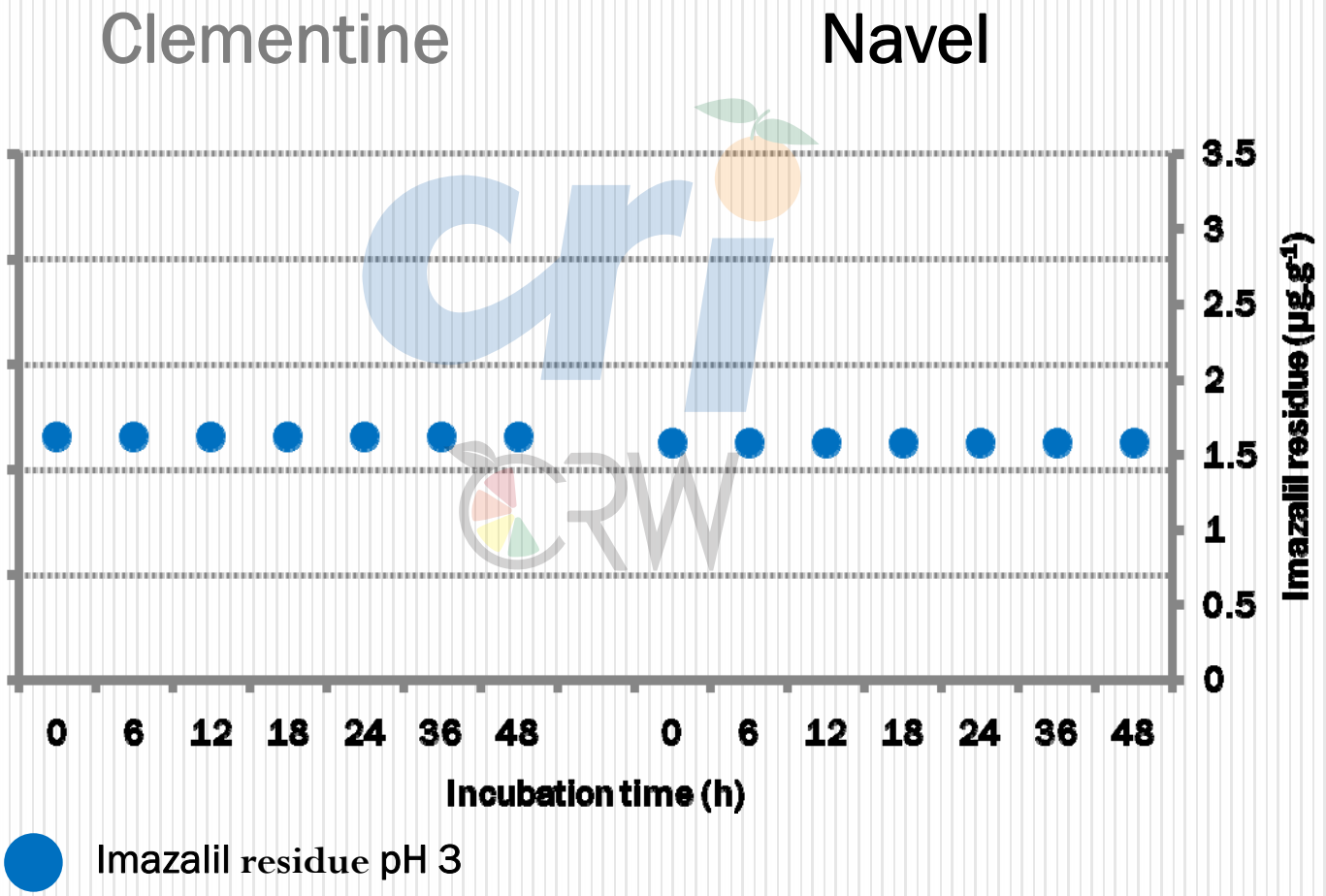
Effect of incubation time on the curative action of IMZ

Imazalil residue:



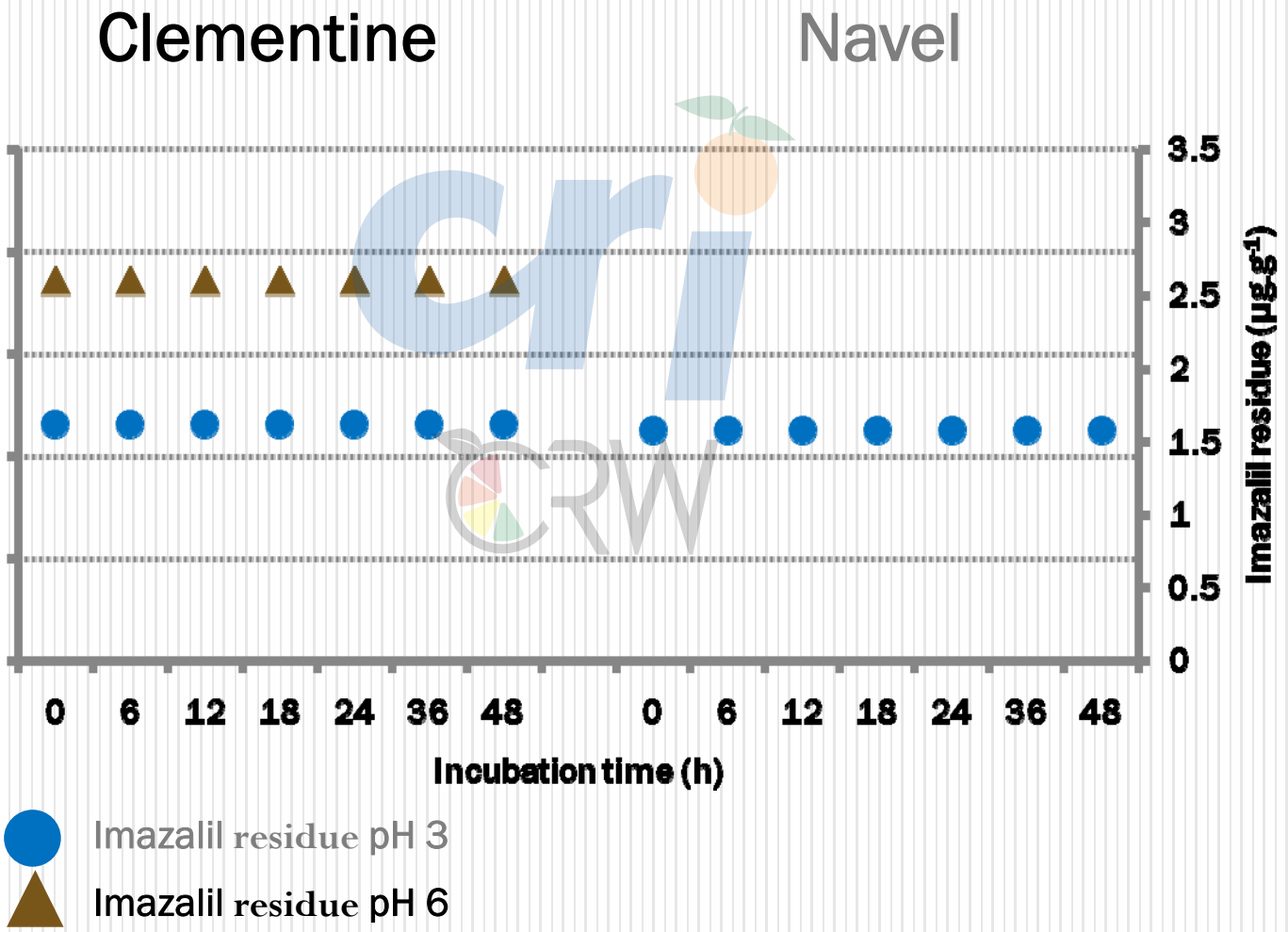
Effect of incubation time on the curative action of IMZ

Imazalil residue:



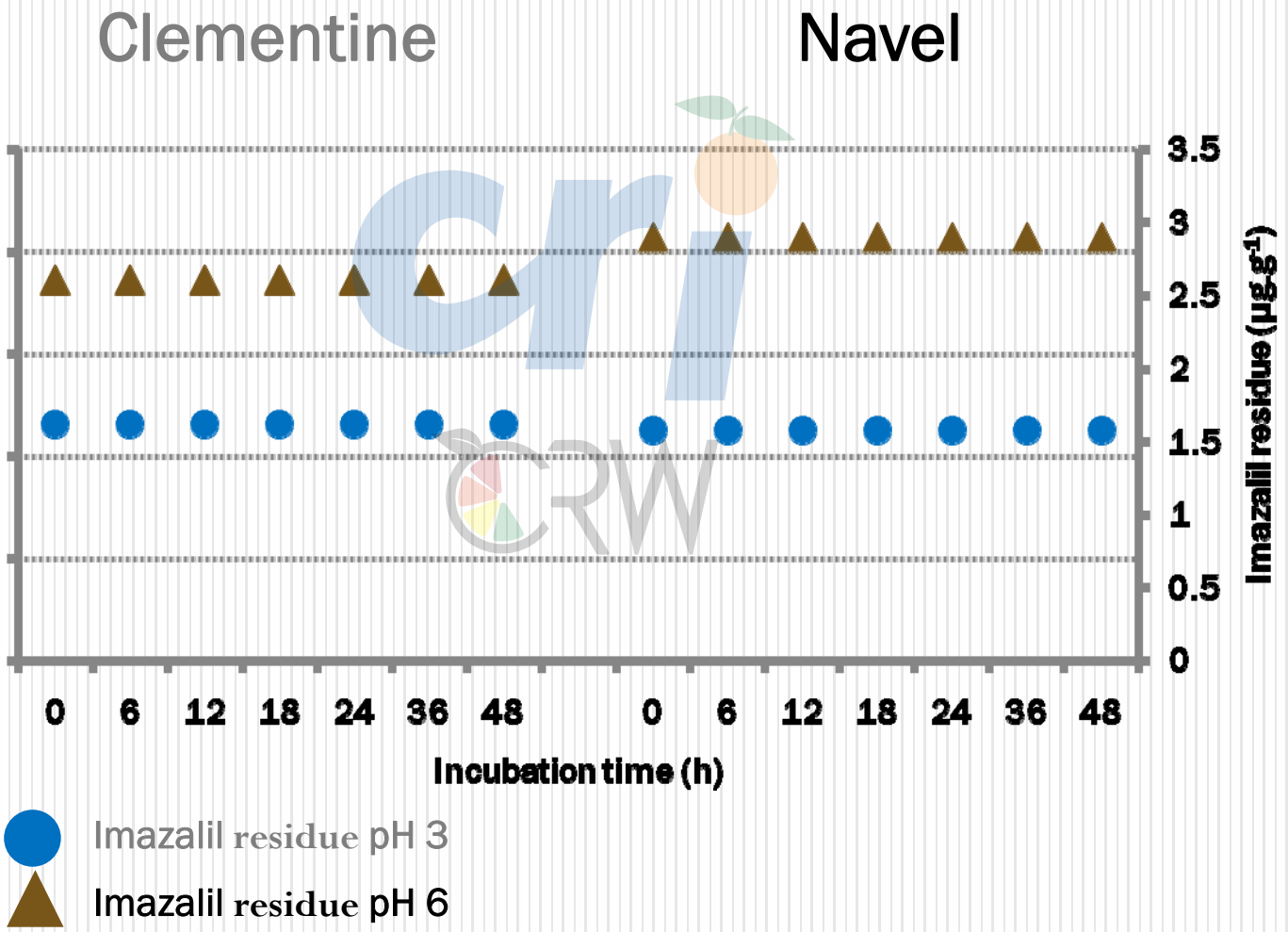
Effect of incubation time on the curative action of IMZ

Imazalil residue:



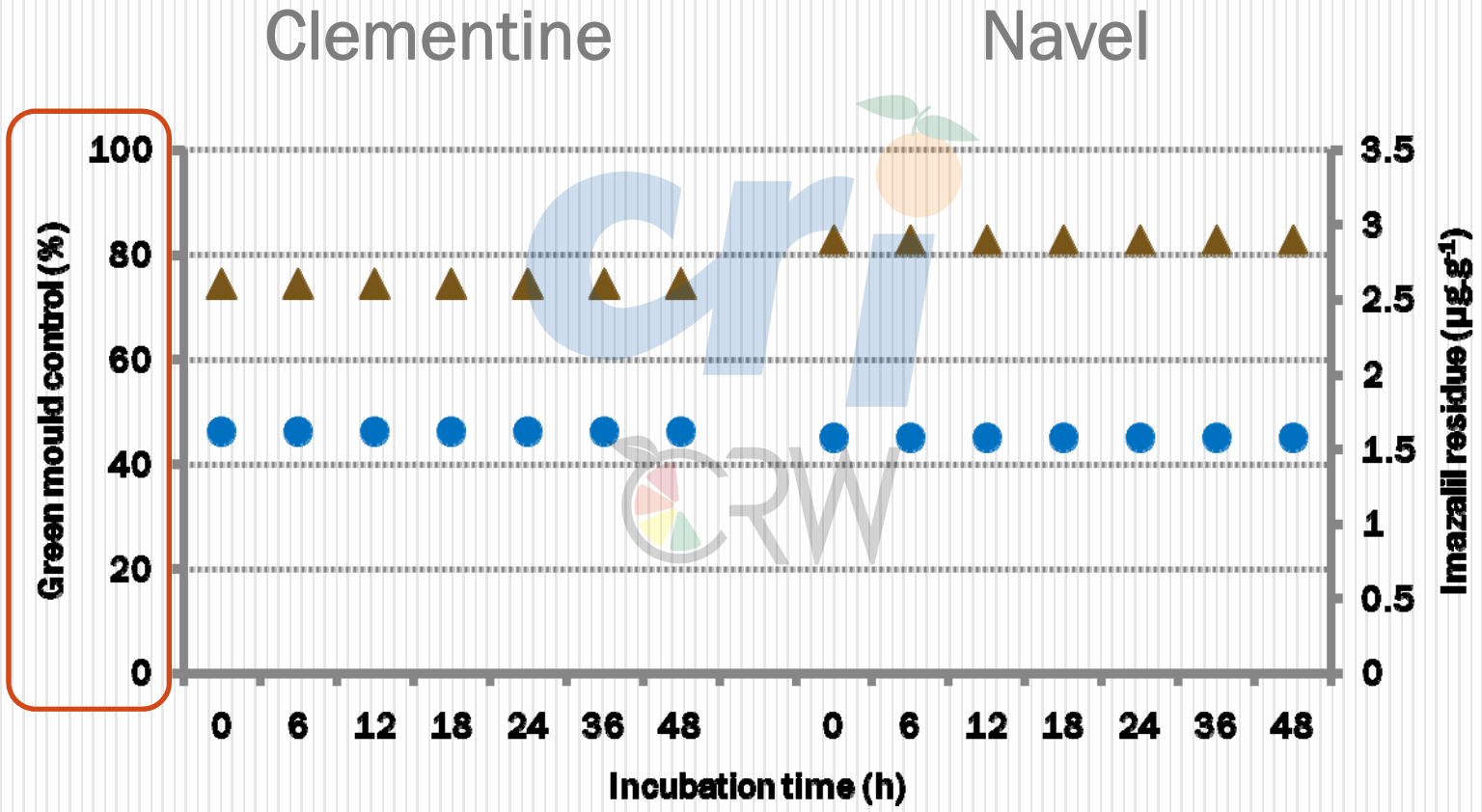
Effect of incubation time on the curative action of IMZ

Imazalil residue:



Effect of incubation time on the curative action of IMZ

Green mould control:

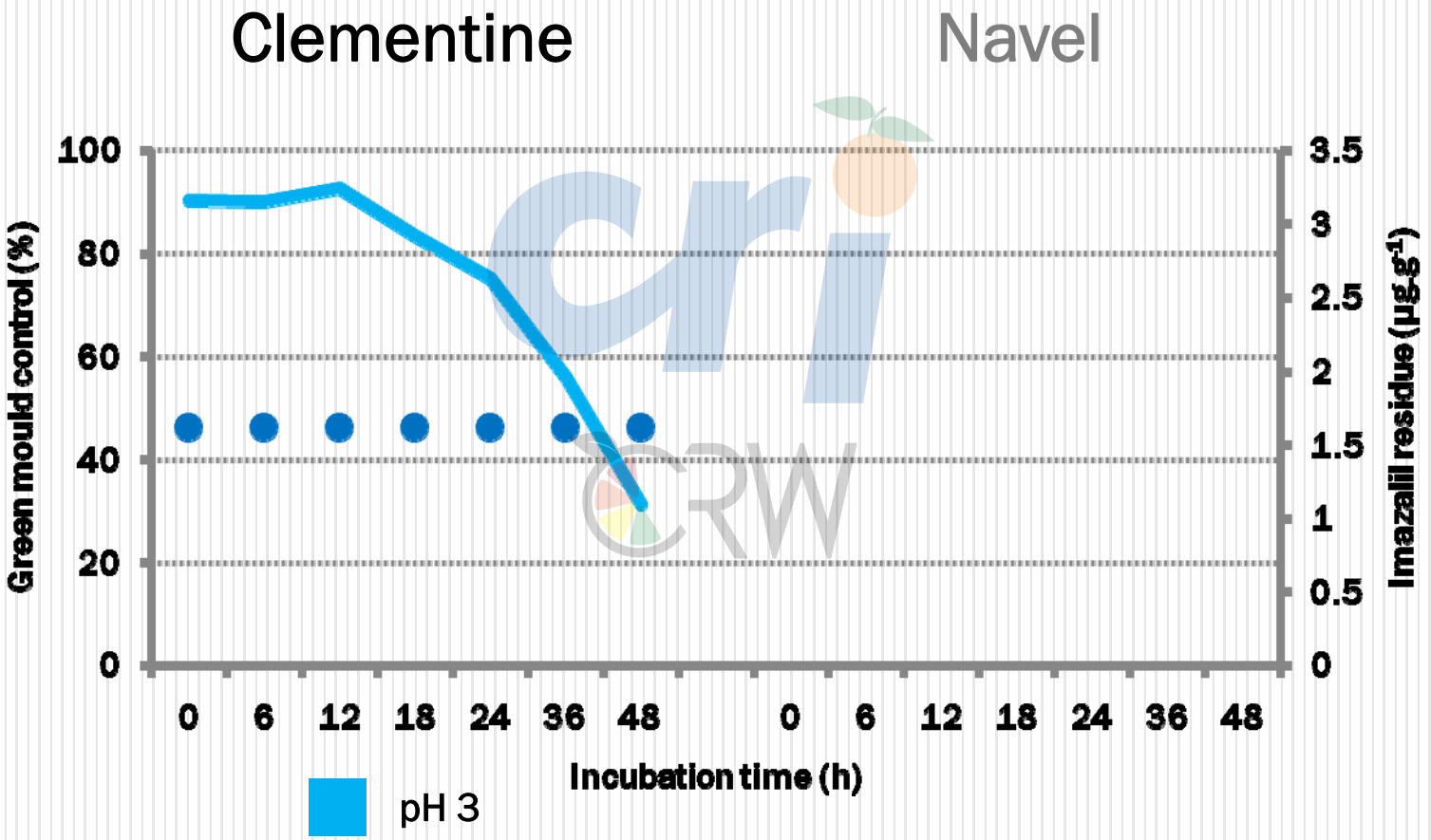


Imazalil residue pH 3

Imazalil residue pH 6

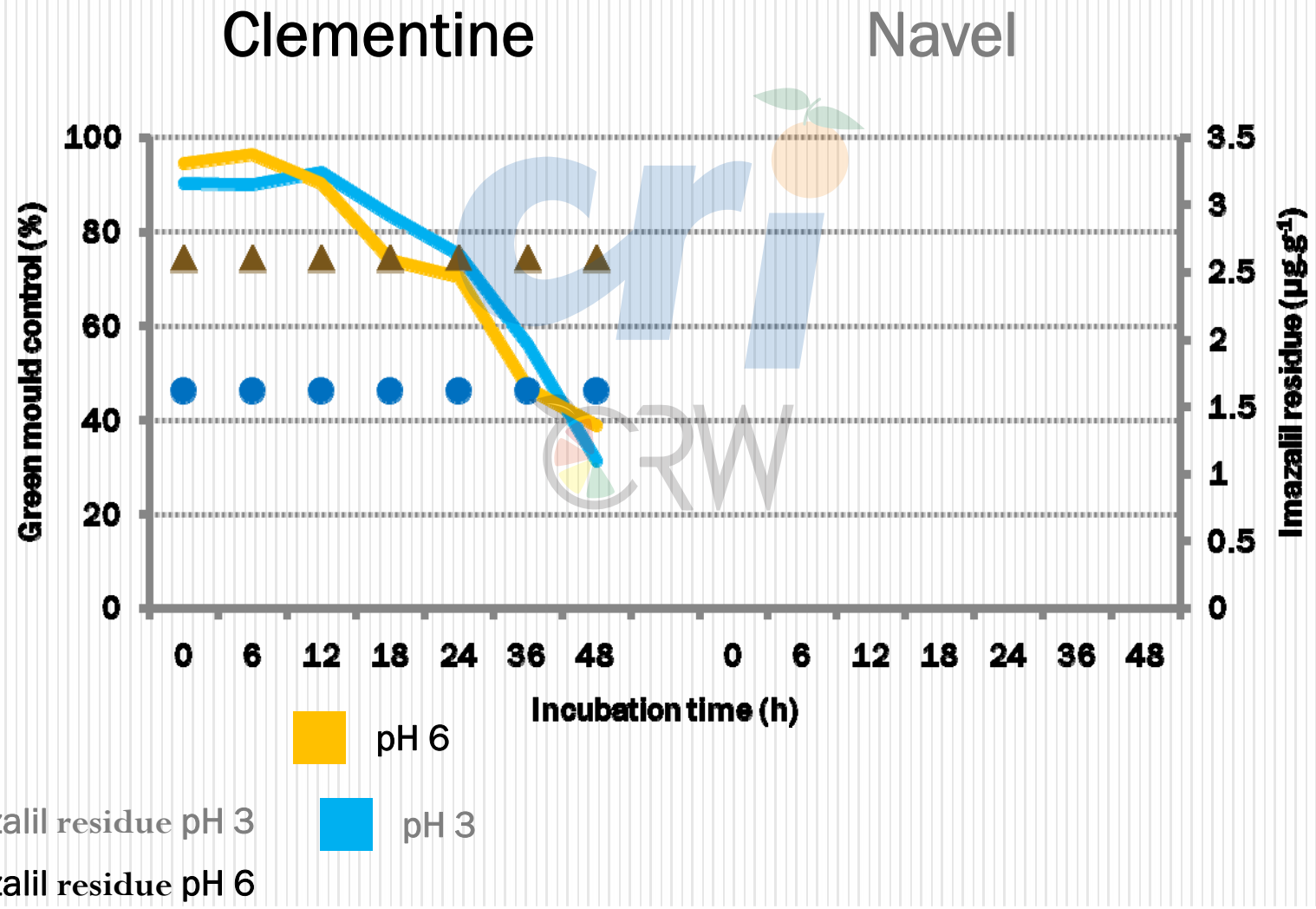
Effect of incubation time on the curative action of IMZ

Green mould control:



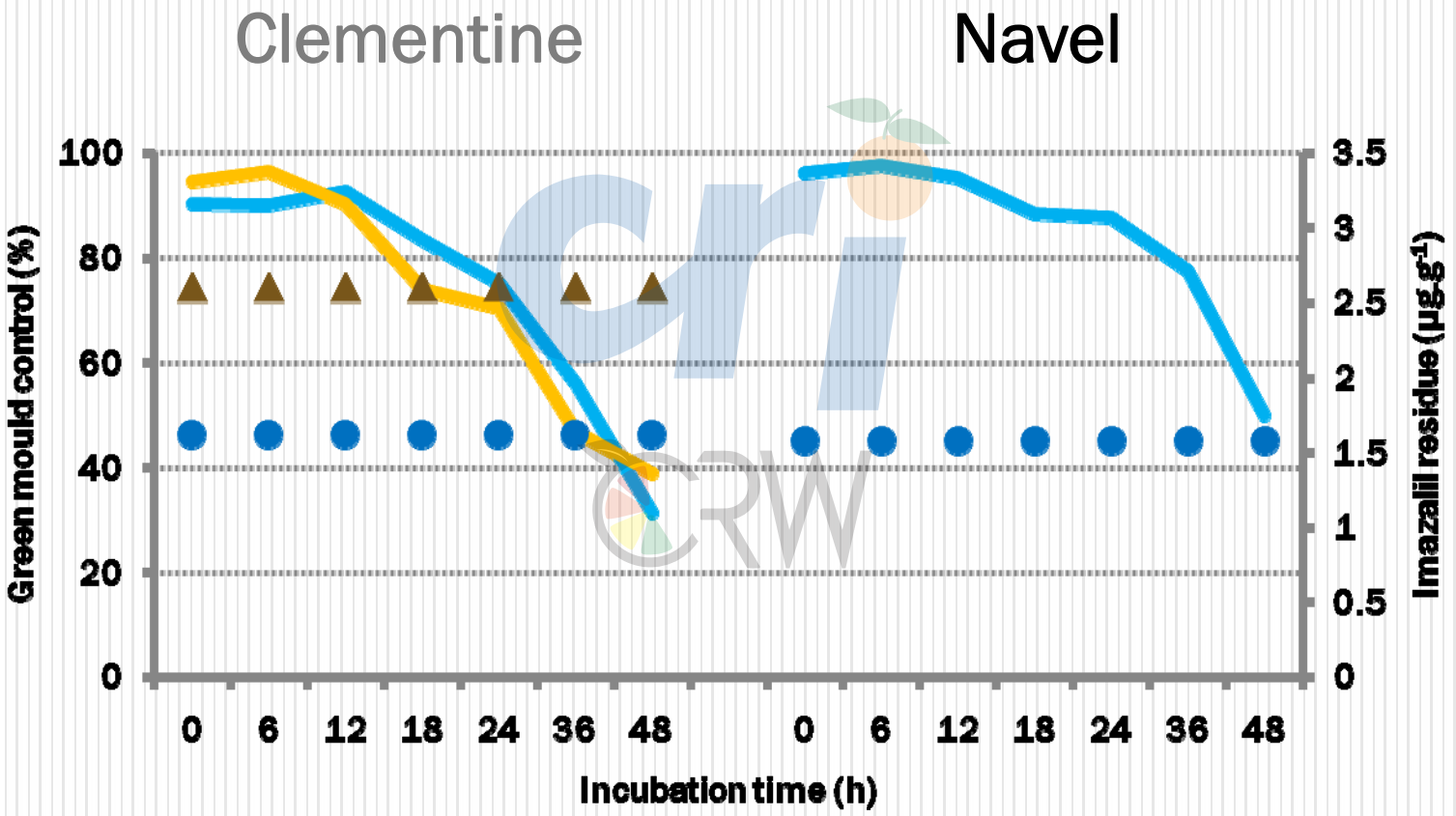
Effect of incubation time on the curative action of IMZ

Green mould control:



Effect of incubation time on the curative action of IMZ

Green mould control:



Imazalil residue pH 3

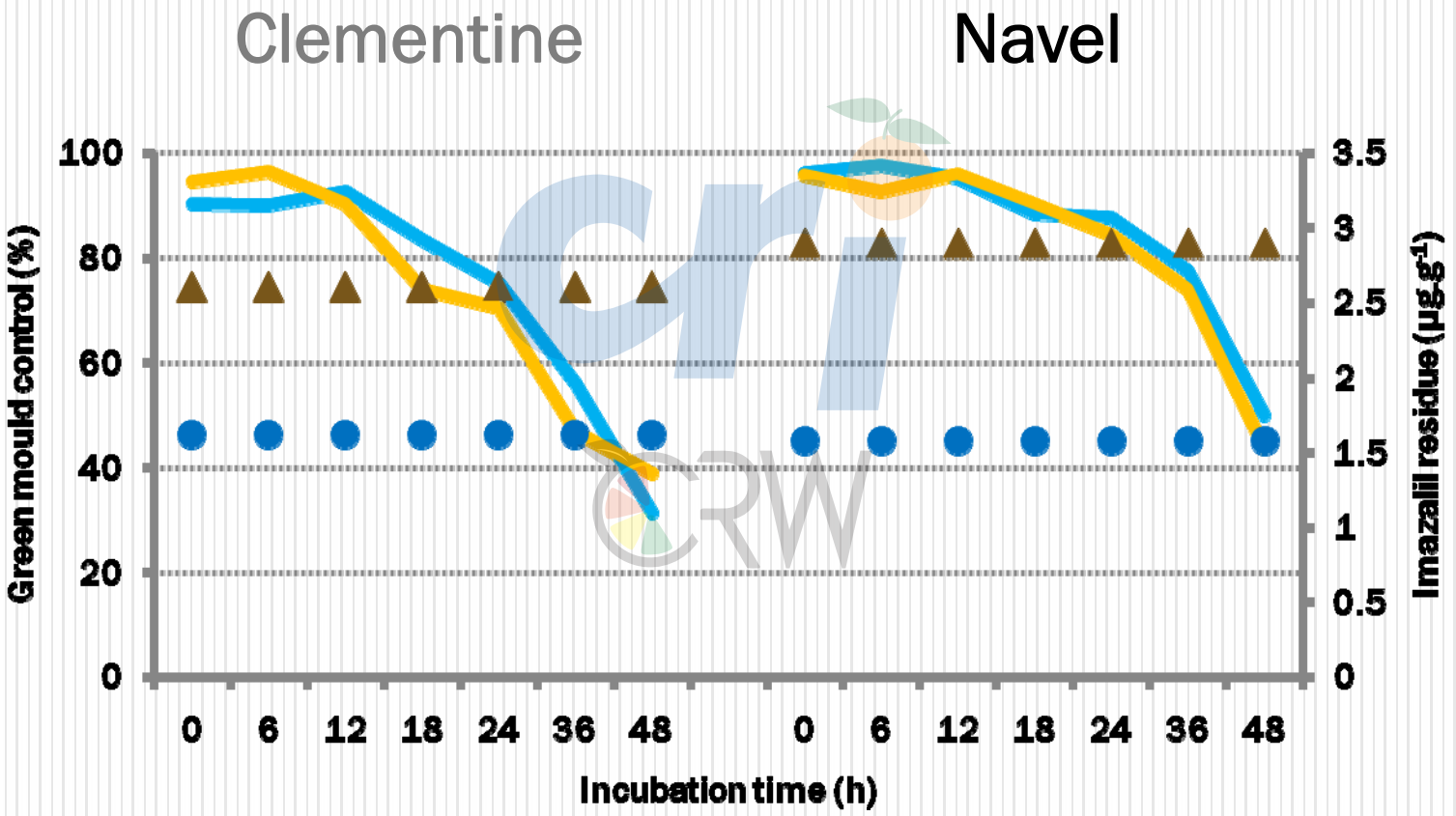
Imazalil residue pH 6

pH 3

pH 6

Effect of incubation time on the curative action of IMZ

Green mould control:



Summary: IMZ kick-back

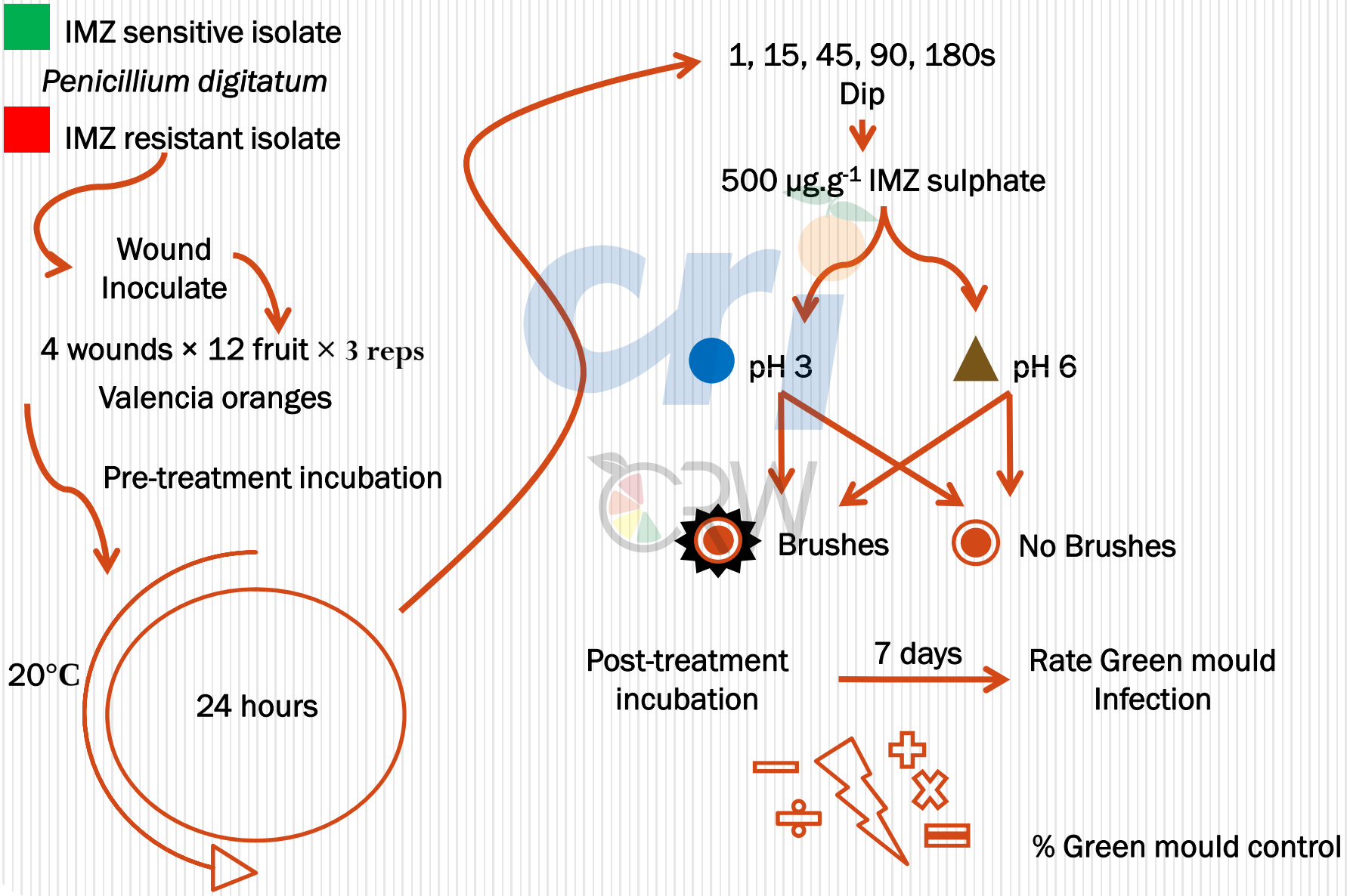
- Ideal: <24 hours from harvest to dip treatment
- Drench: Better than nothing
  - Not as effective as dip tank
    - Poor curative control
- Need >2 ppm for sporulation inhibition

Challenge →  Brushes → Reduce IMZ residue loading

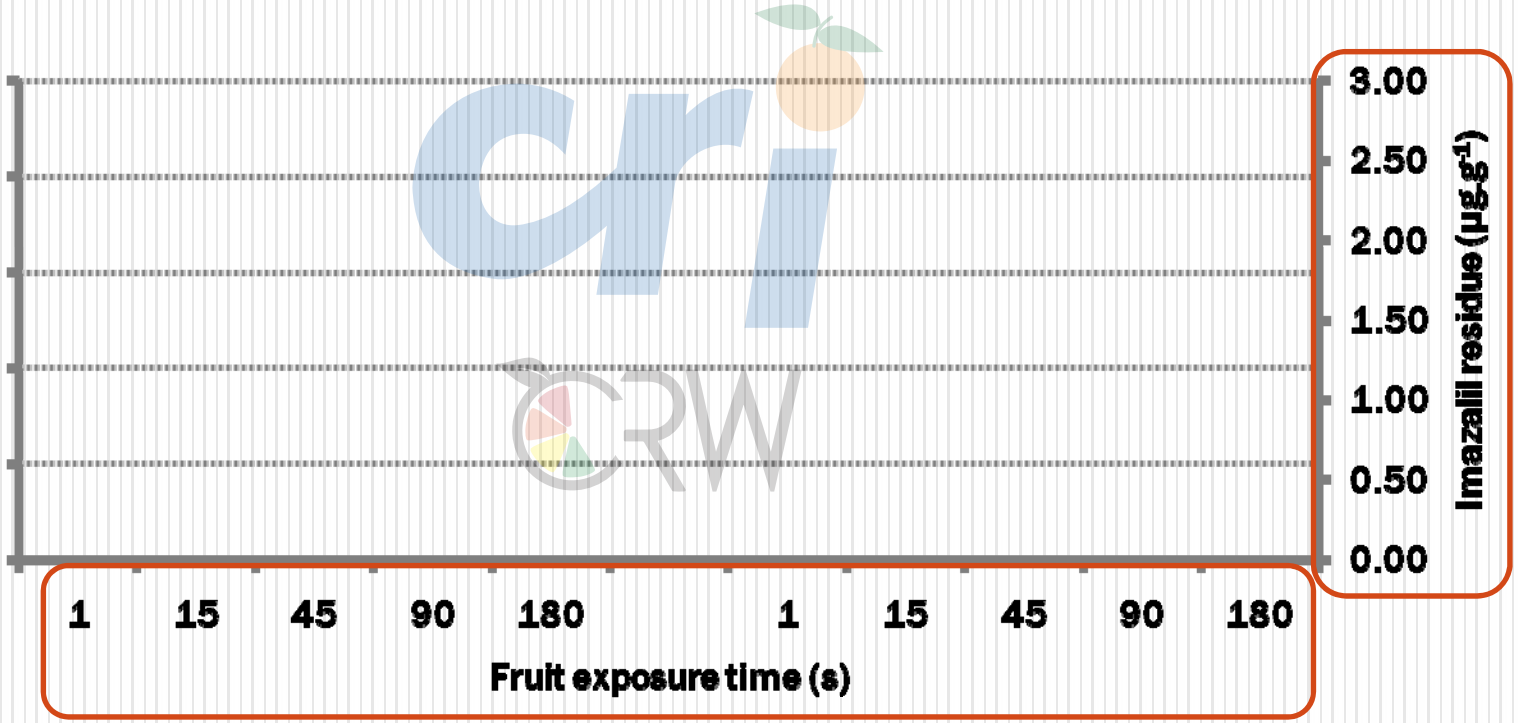
Some packhouse up to 52 brushes

What is the effect of brush-reduced IMZ residue loading on curative control of green mould?

Effect of brushes time on the curative action of IMZ

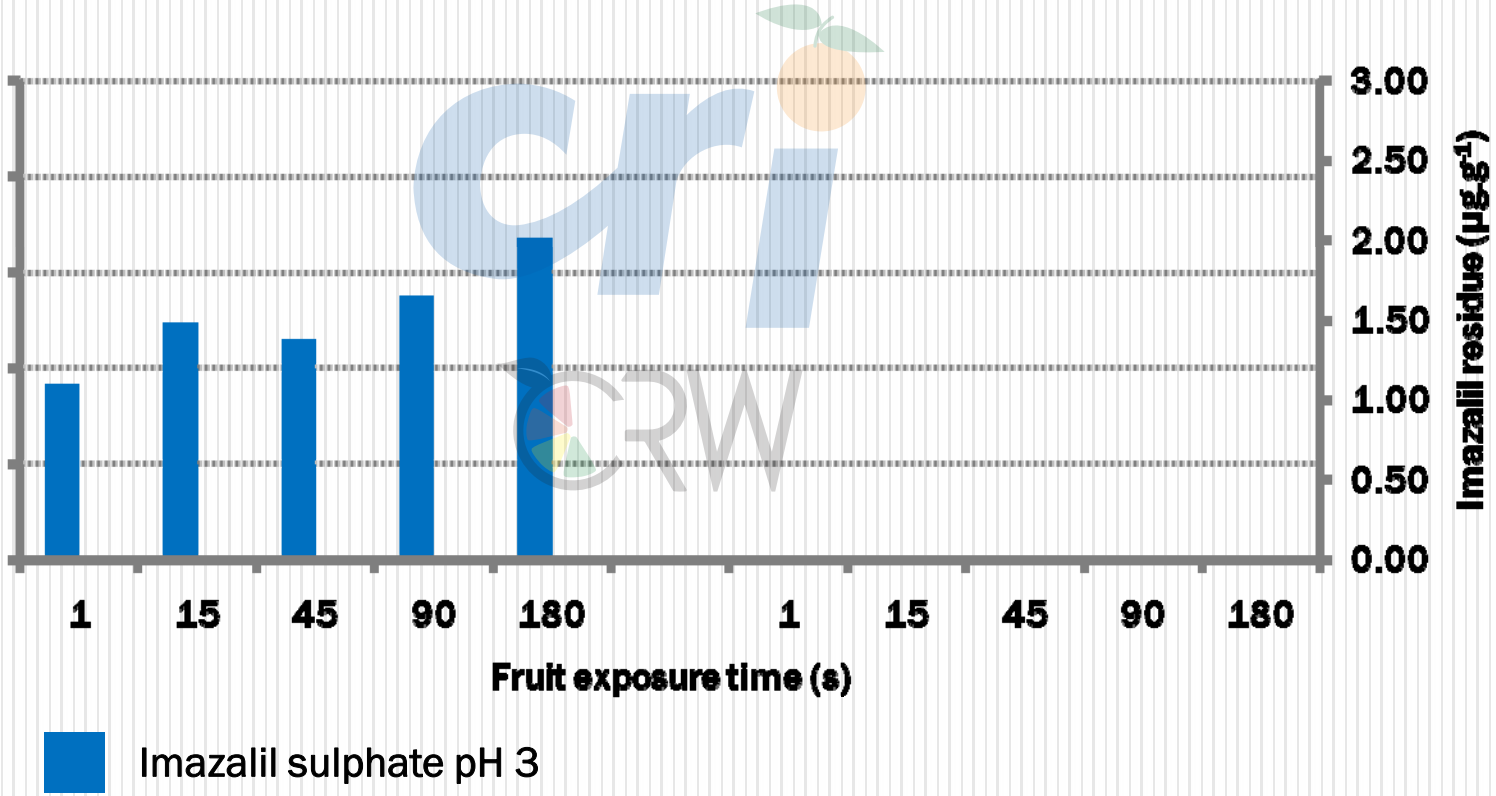


Effect of brushes: IMZ residue loading

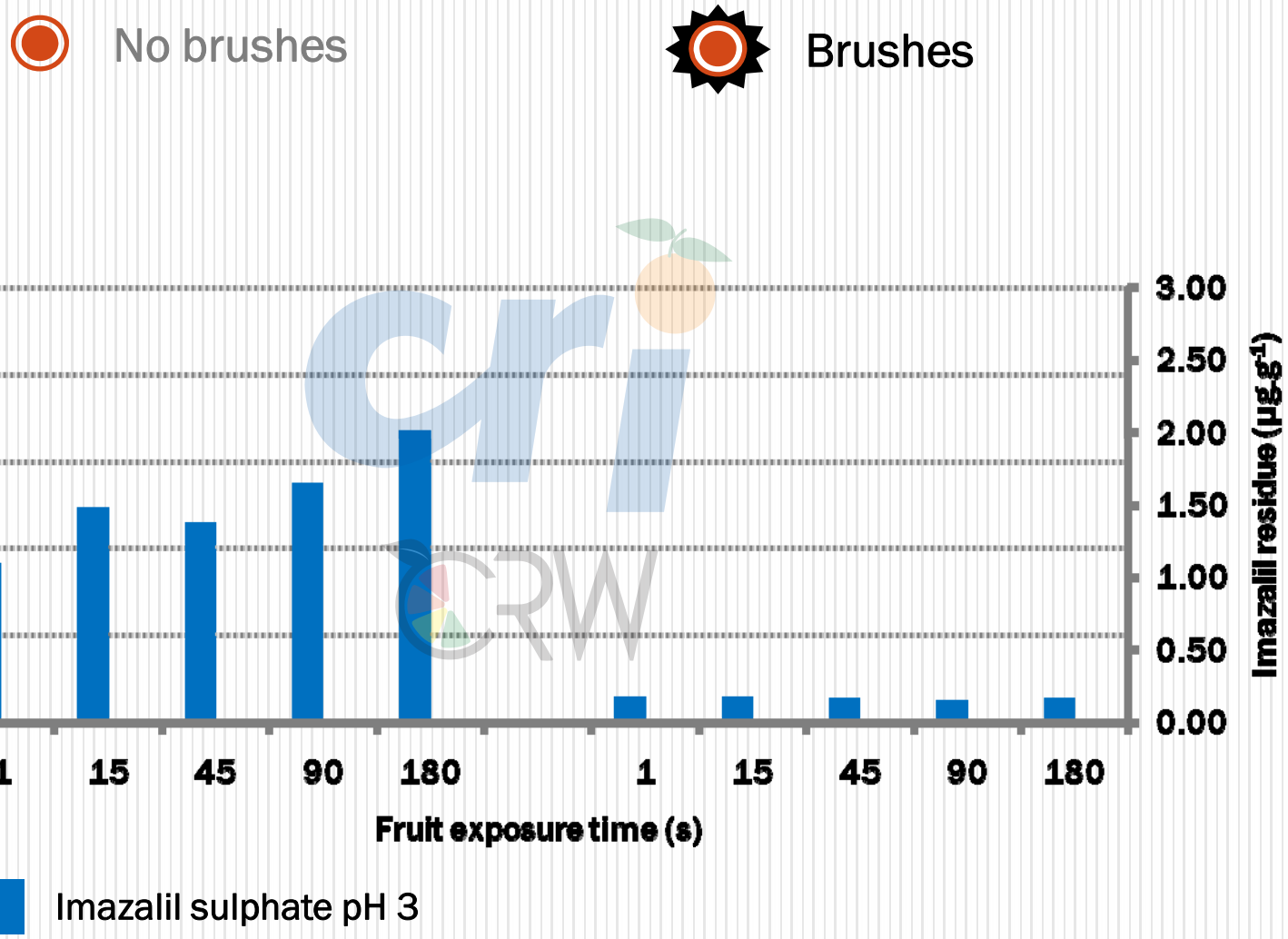


Effect of brushes: IMZ residue loading

No brushes



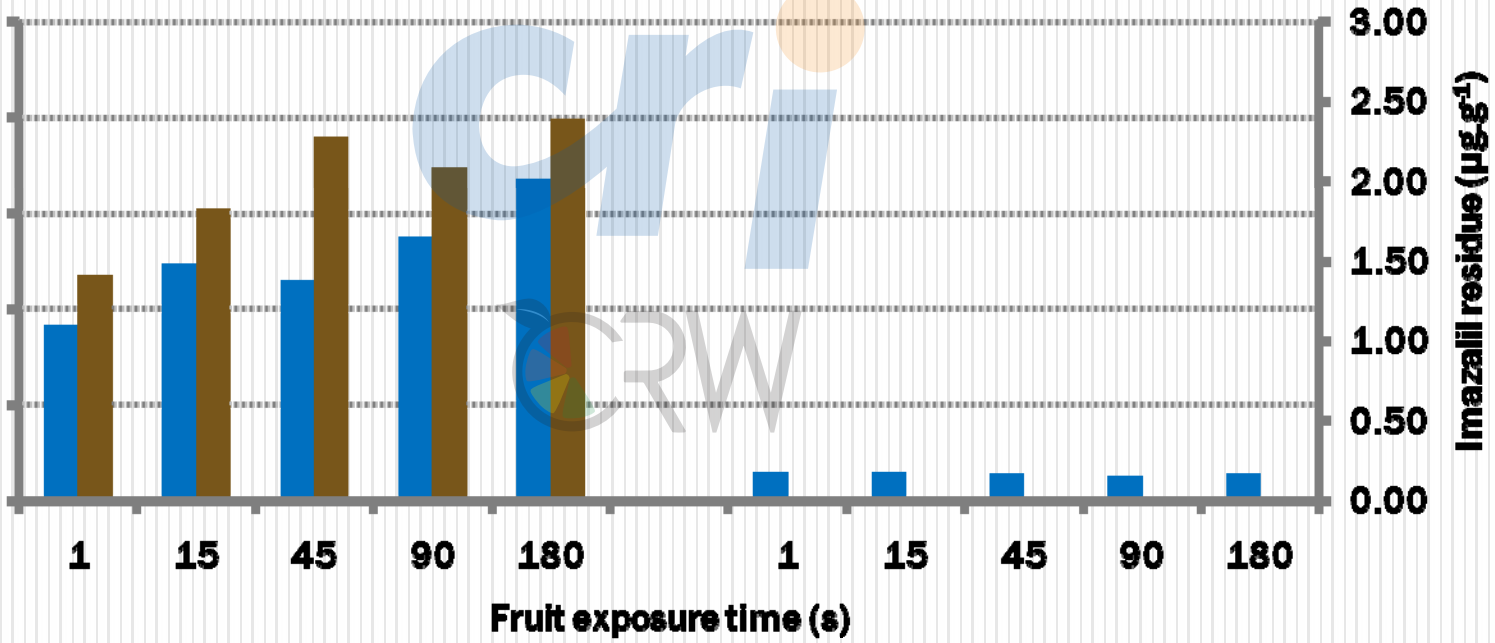
Effect of brushes: IMZ residue loading



Effect of brushes: IMZ residue loading

No brushes

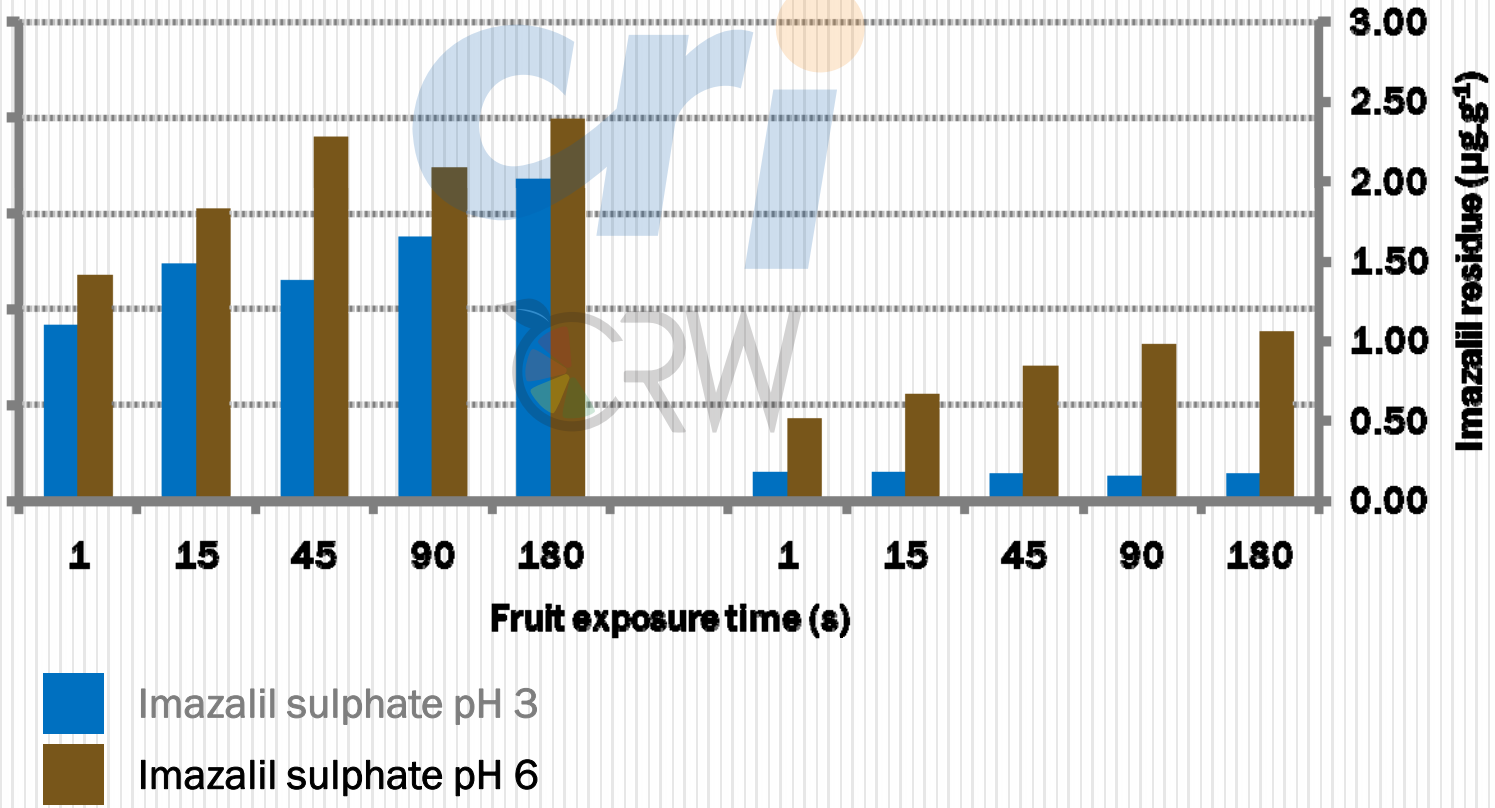
Brushes



Effect of brushes: IMZ residue loading

No brushes

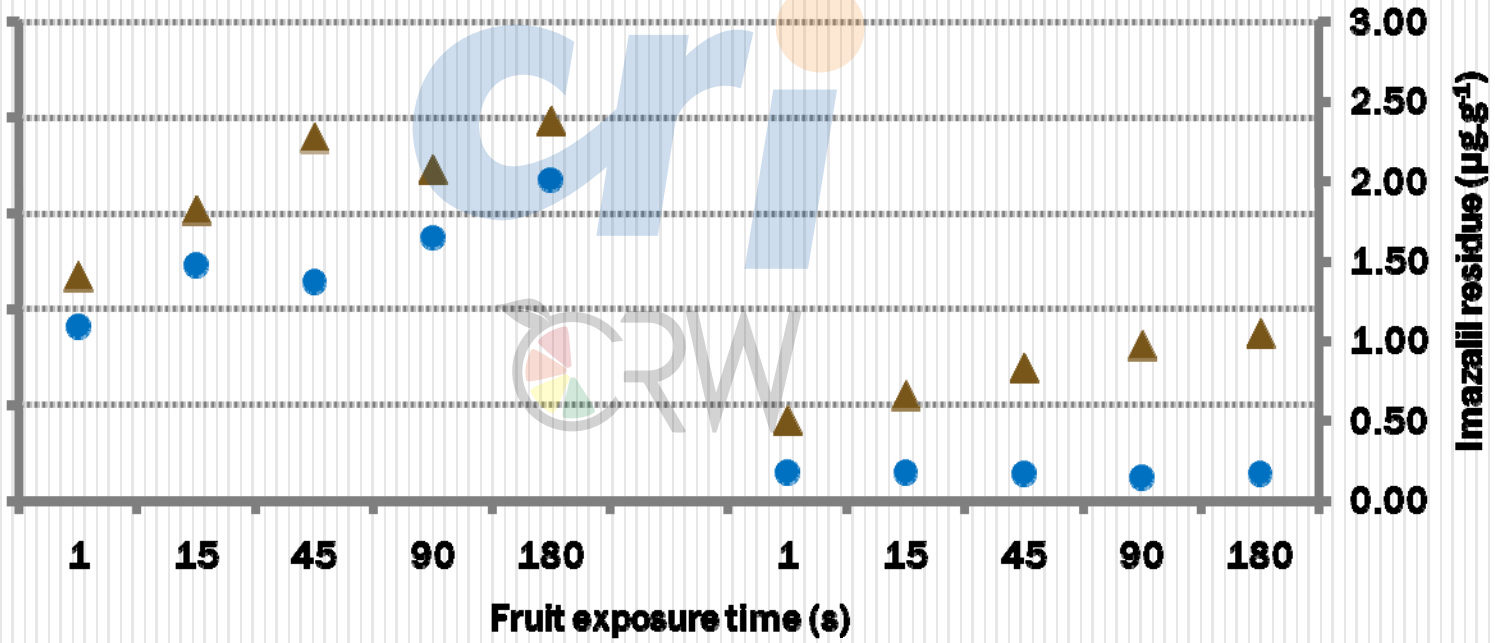
Brushes



Effect of brushes: IMZ residue loading

No brushes

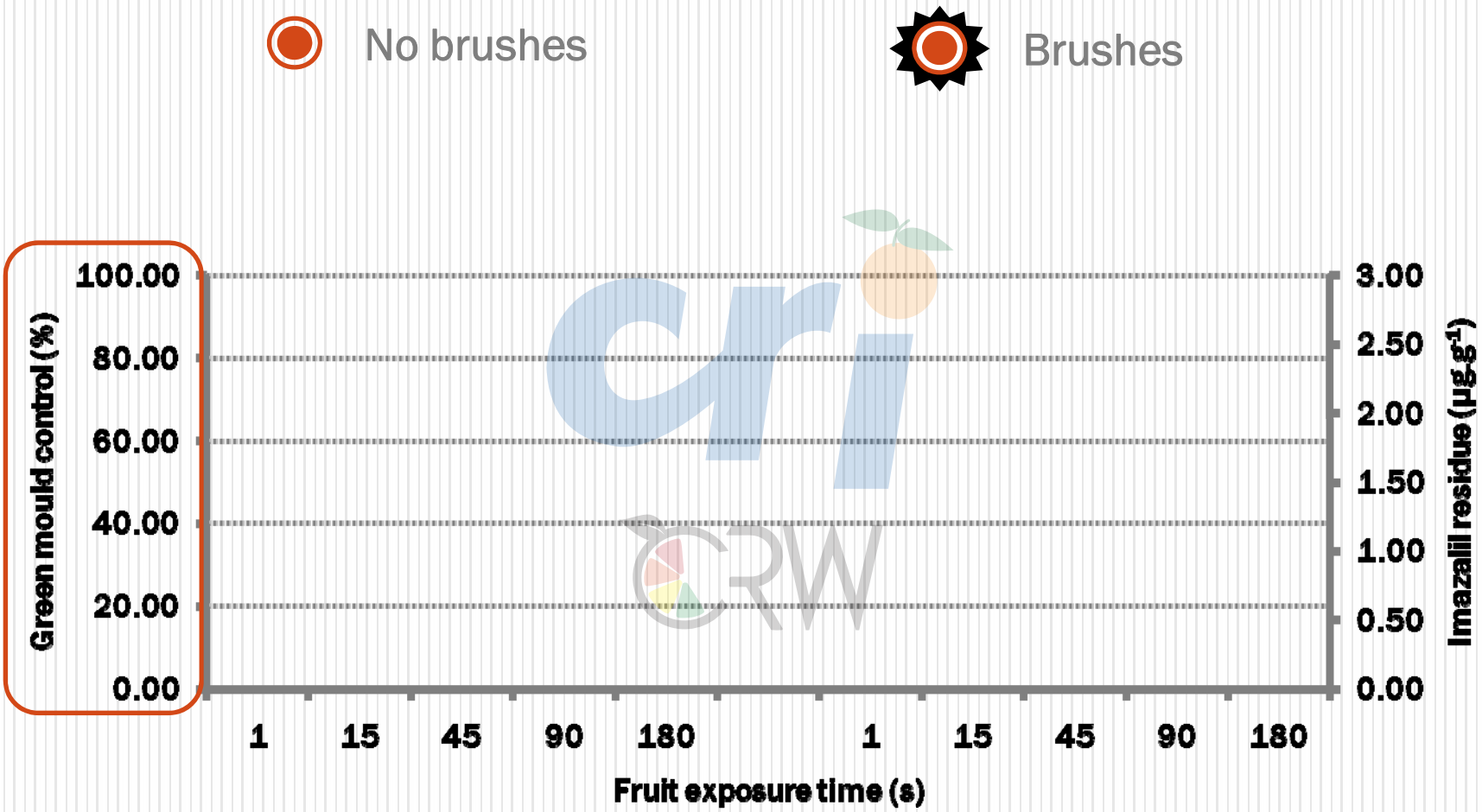
Brushes



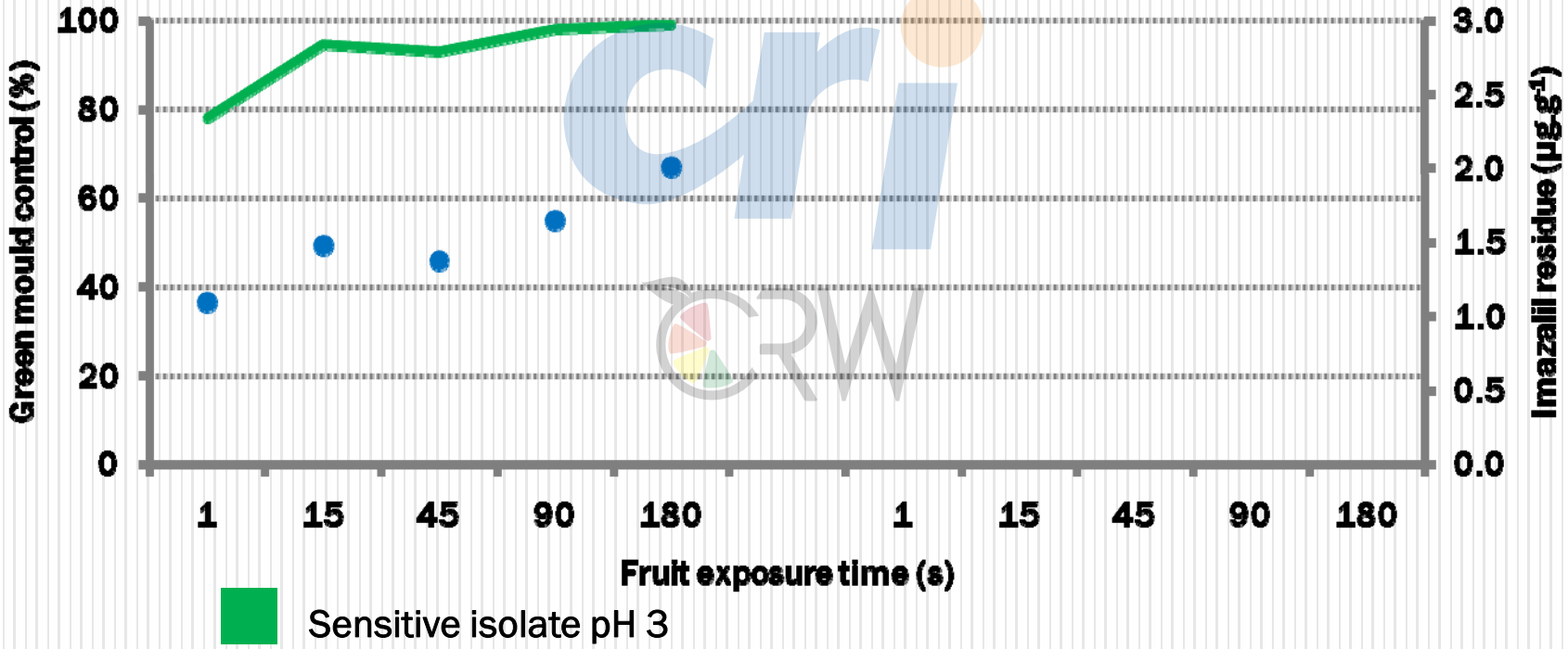
Imazalil sulphate pH 3

Imazalil sulphate pH 6

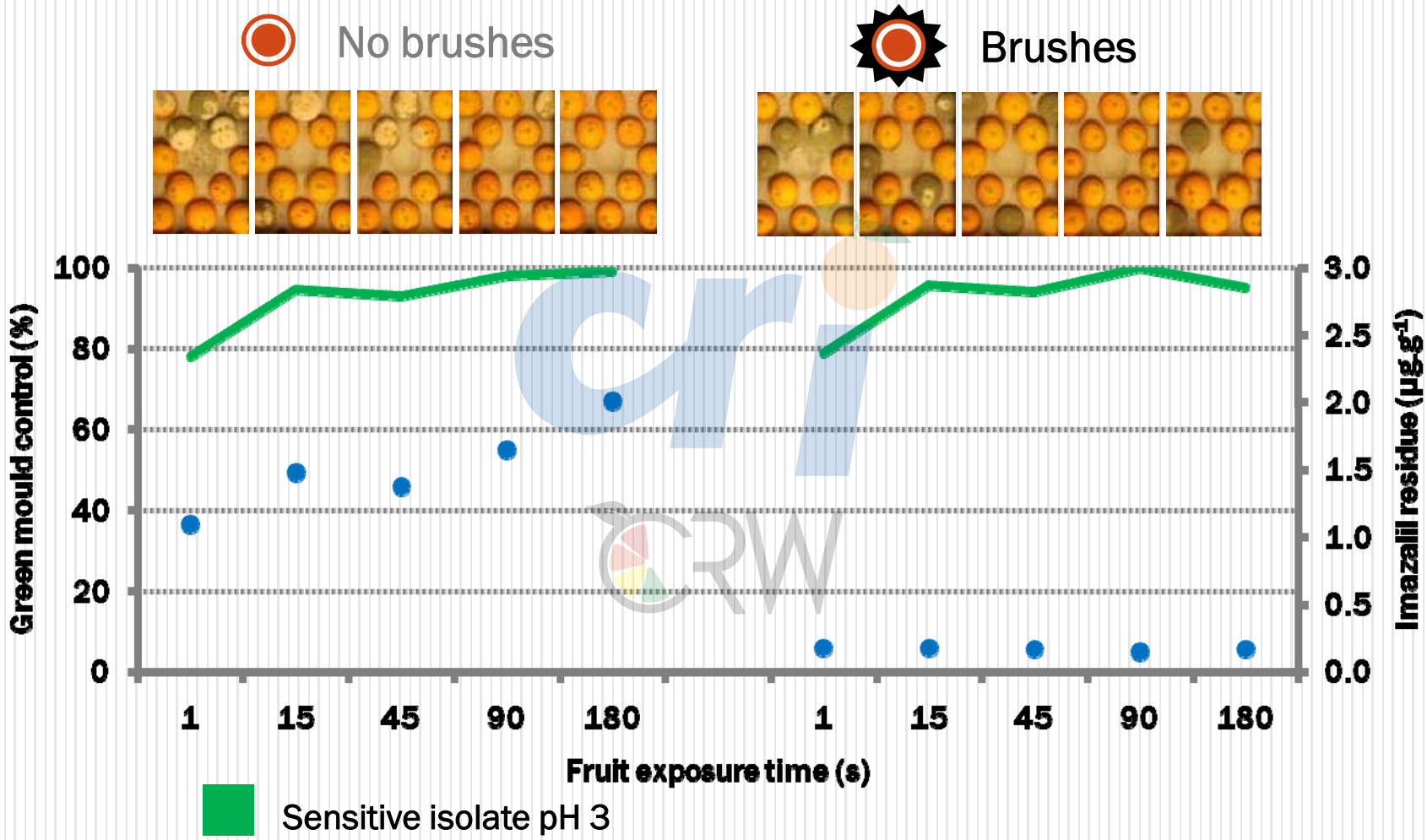
Effect of brushes: IMZ green mould control



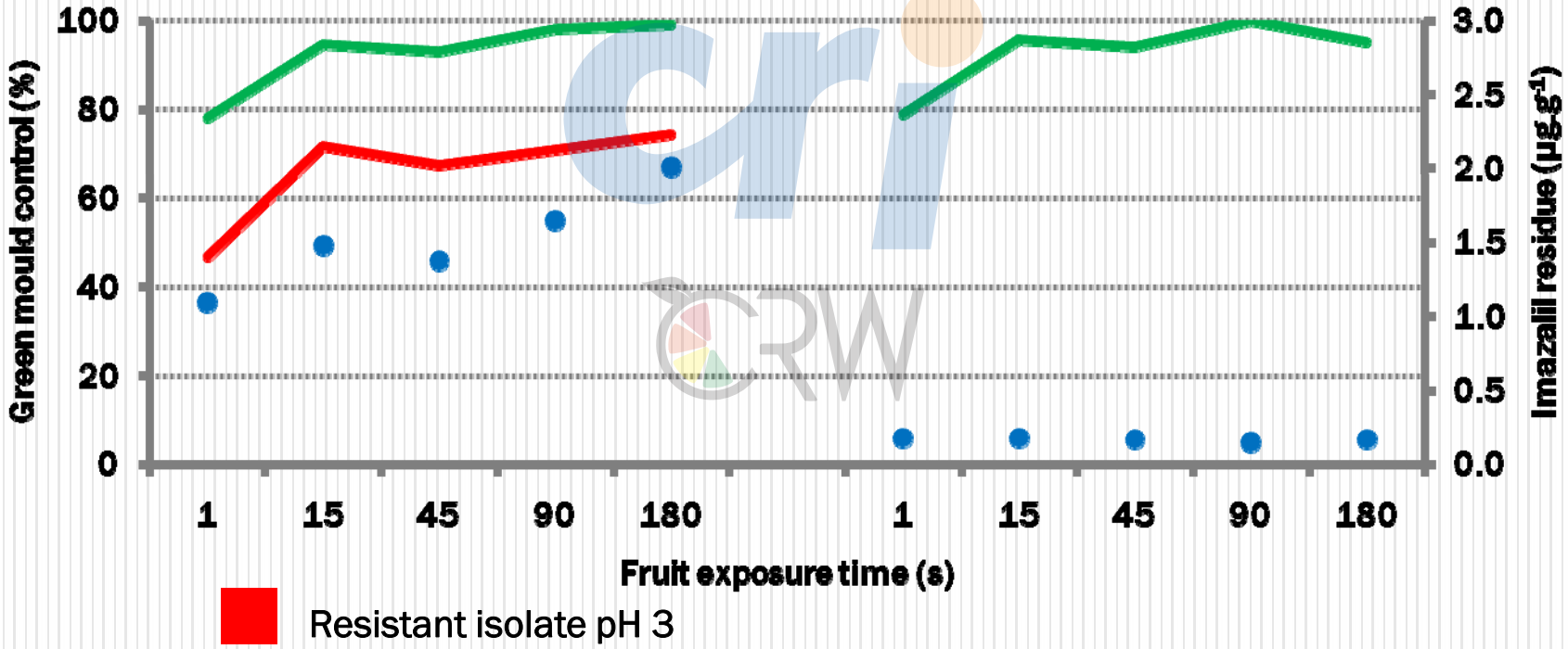
Effect of brushes: IMZ green mould control



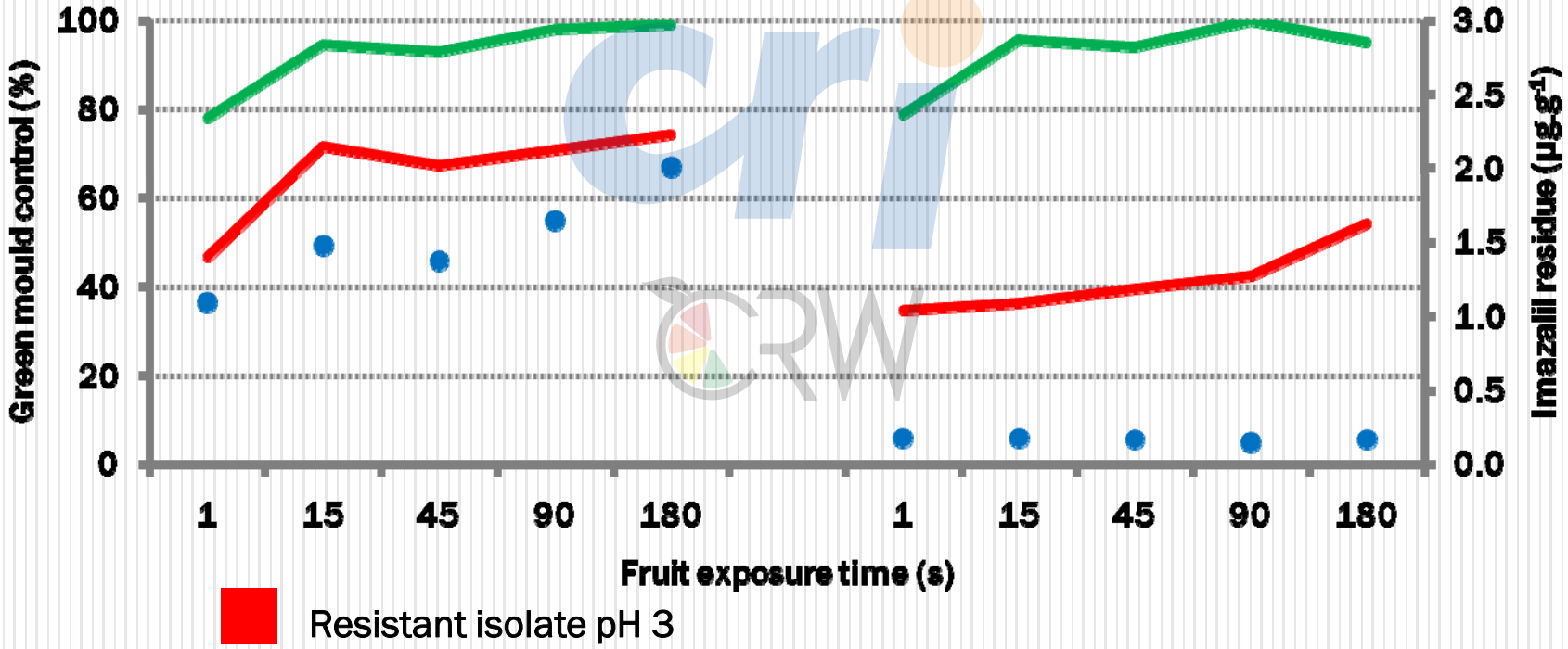
Effect of brushes: IMZ green mould control



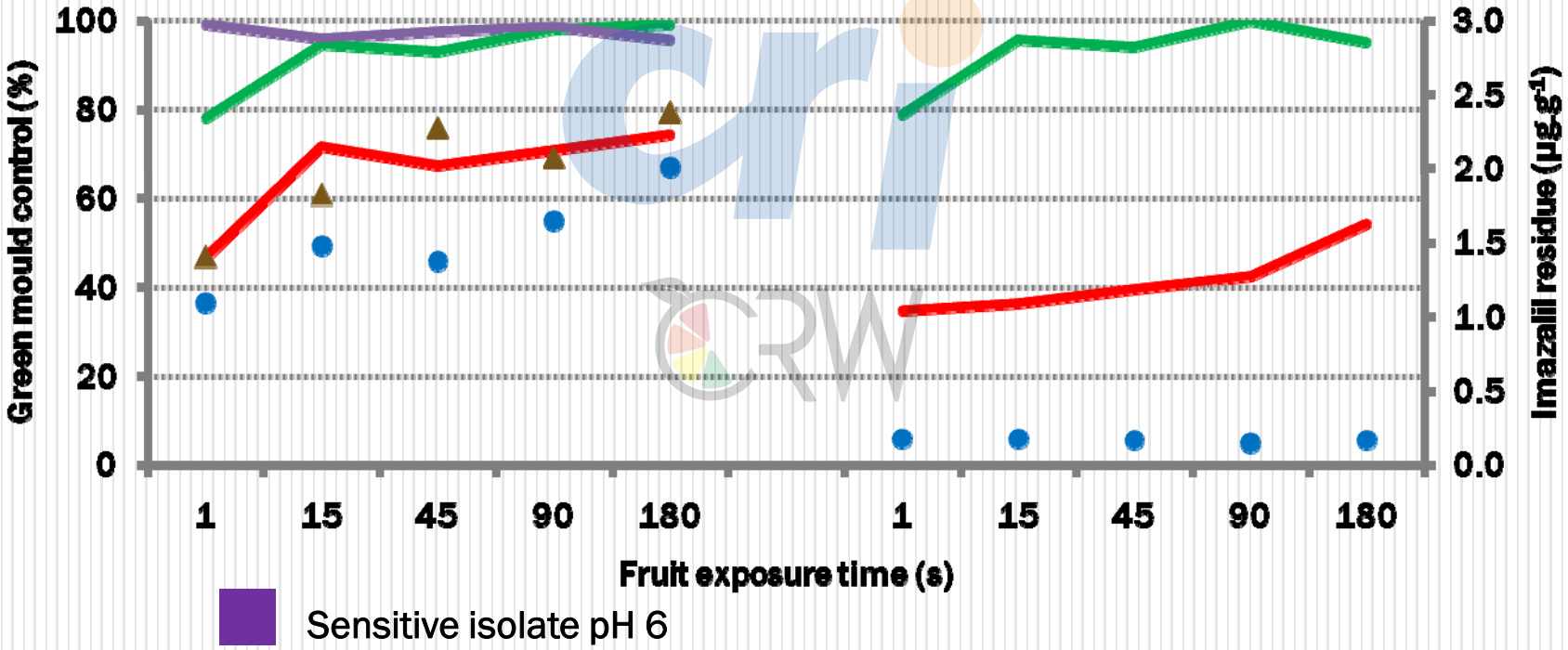
Effect of brushes: IMZ green mould control



Effect of brushes: IMZ green mould control

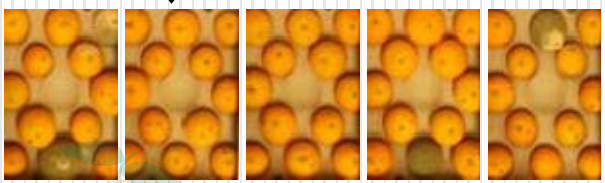


Effect of brushes: IMZ green mould control

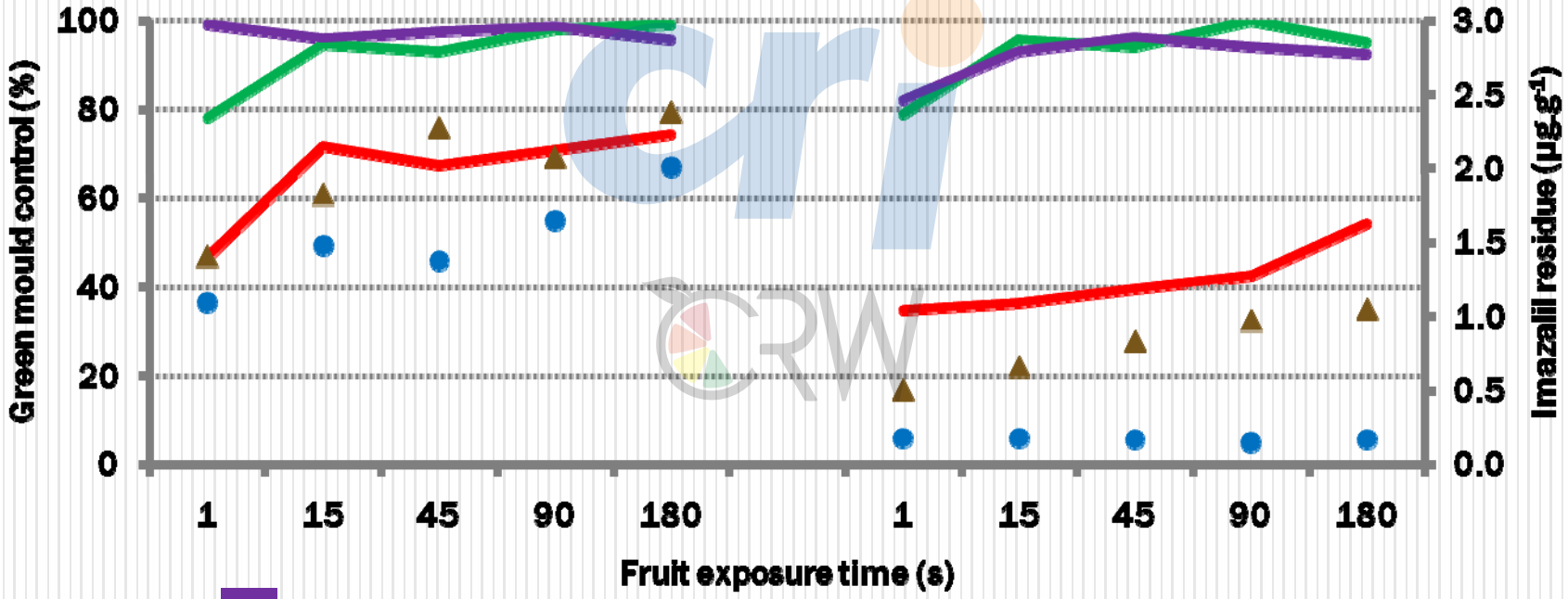


Effect of brushes: IMZ green mould control

No brushes



Brushes



Sensitive isolate pH 6

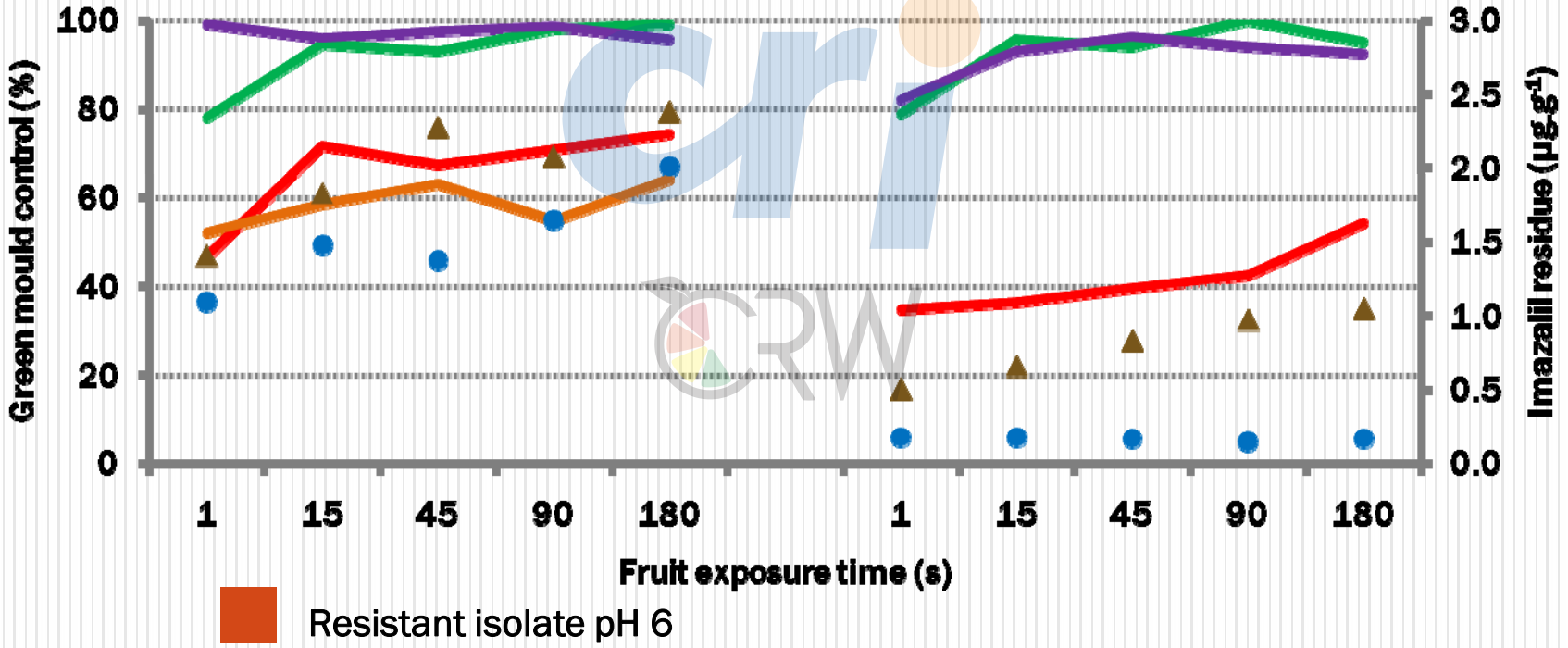
Imazalil sulphate pH 6

Imazalil sulphate pH 3

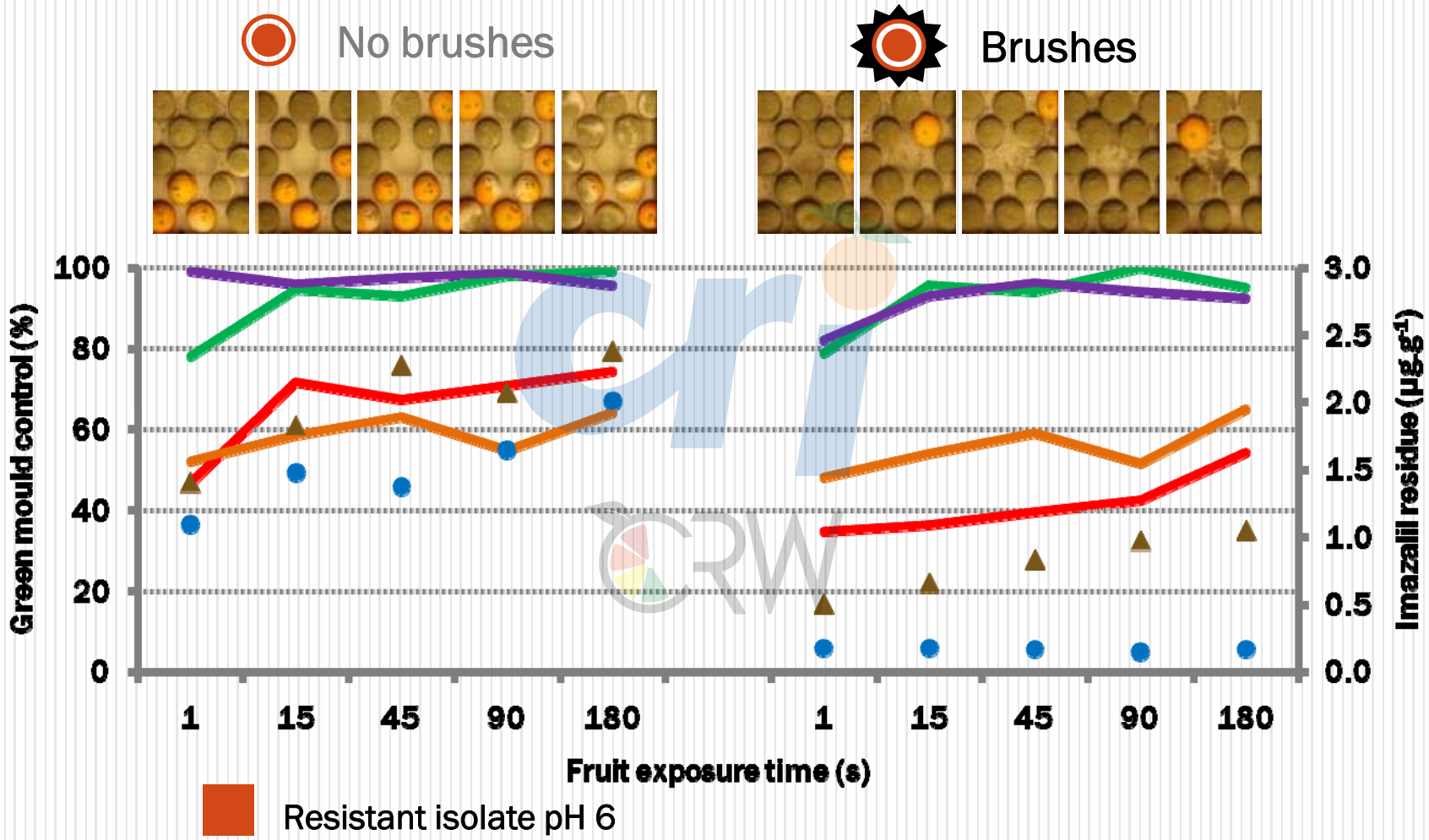
Sensitive isolate pH 3

Resistant isolate pH 3

Effect of brushes: IMZ green mould control



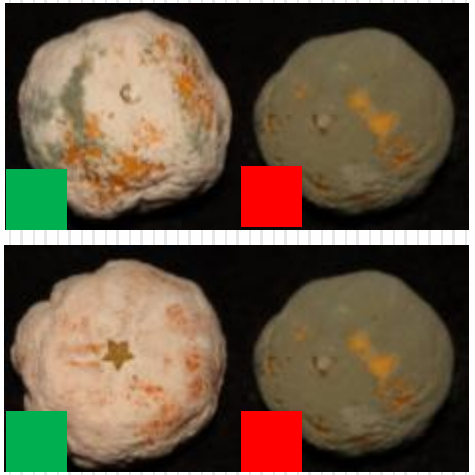
Effect of brushes: IMZ green mould control



Summary: Brushes

Brushes reduce IMZ residue loaded on fruit after dip treatment

Unbuffered (pH 3)	>80%	0.15 – 0.18 ppm
Buffered (pH 6)	>50%	0.51 – 1.05 ppm



Sensitive isolate

Resistant isolate

Critical management points:

Imazalil application

- Minimise time from harvest to treatment (<24 h)
- Imazalil dip tank
  - pH 3 : 45 to 90 seconds exposure time
  - pH 6 : 15 to 45 s exposure time
    - Better residue loading

  - Temperature..?
  - Manage concentration between 400-500 ppm IMZ

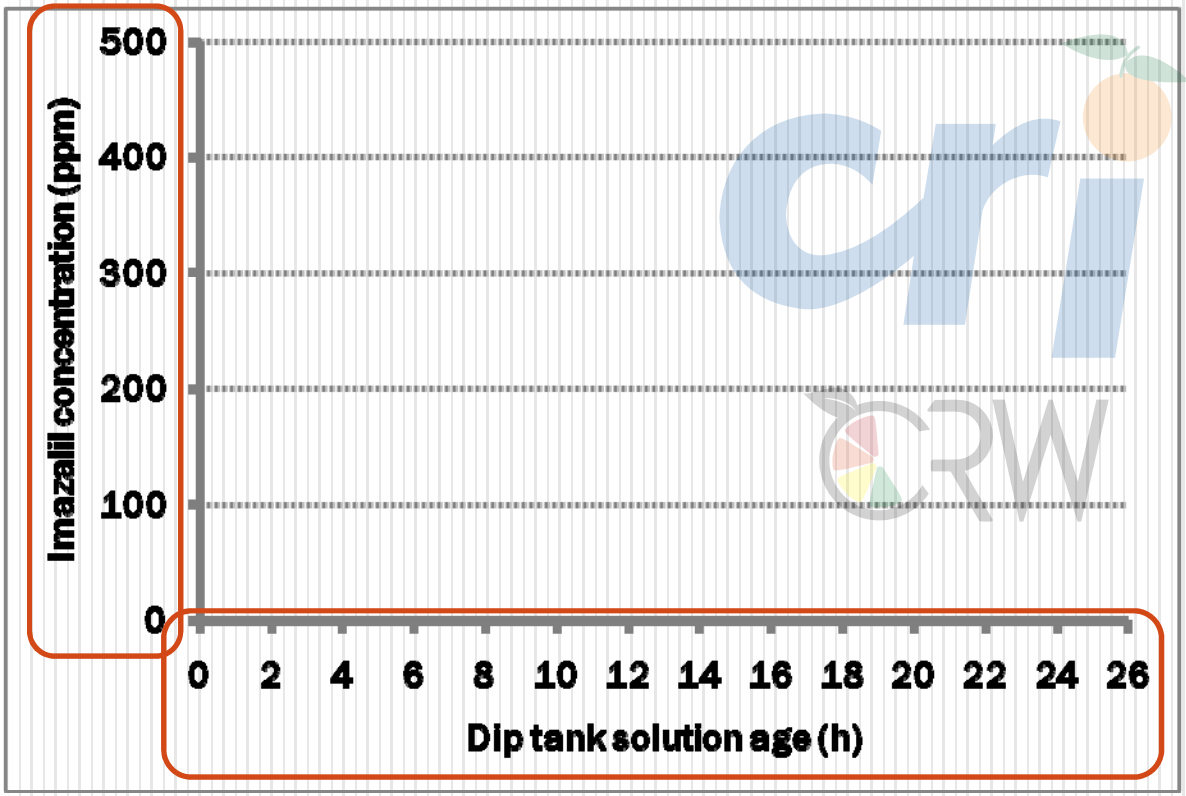
IMZ concentration management

Fungicide dip tank:

- Capacity: 1000 L @ 35°C
- Exposure time: 45 s
- Concentration: 500 µg.mL^{-1} IMZ
- 10 or 20 ton of fruit per hour

IMZ sulphate (pH 3)

IMZ residue per fruit: 1.64 µg.g^{-1}



IMZ concentration management

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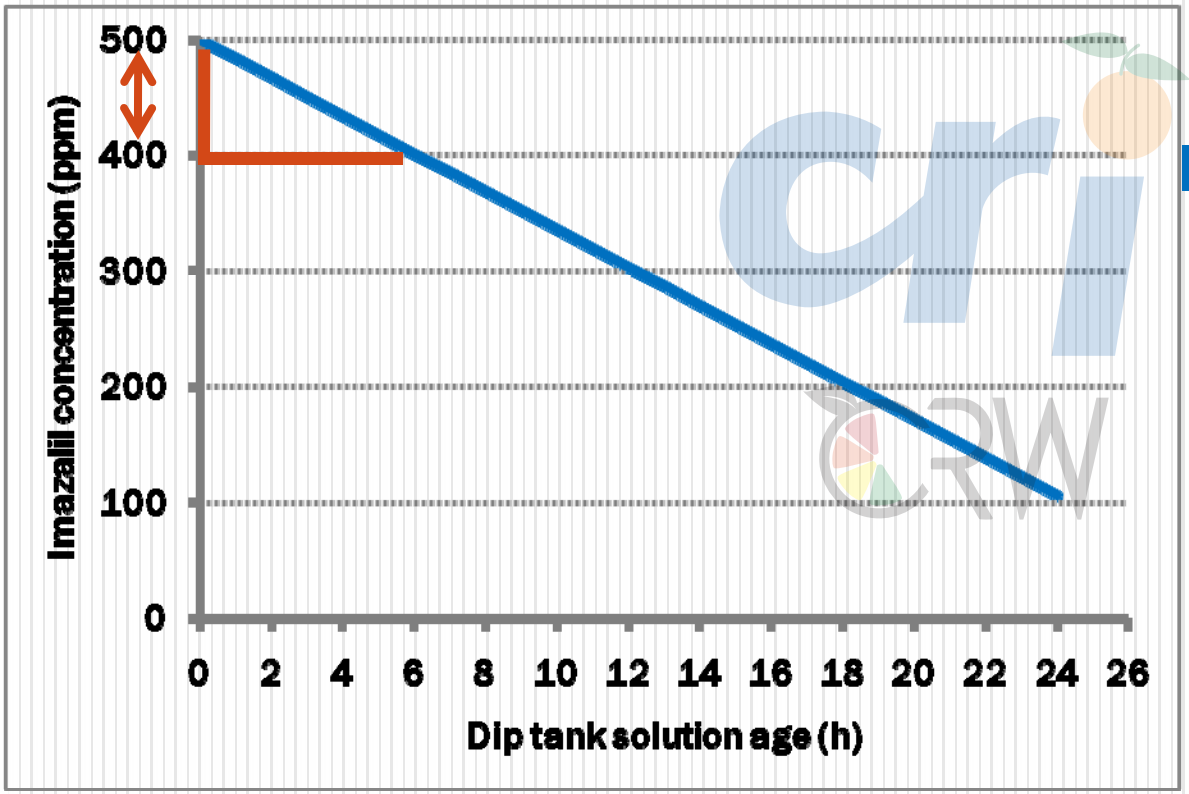


10 ton takes out 16.4 g IMZ per hour

Amend concentration every 6 hours

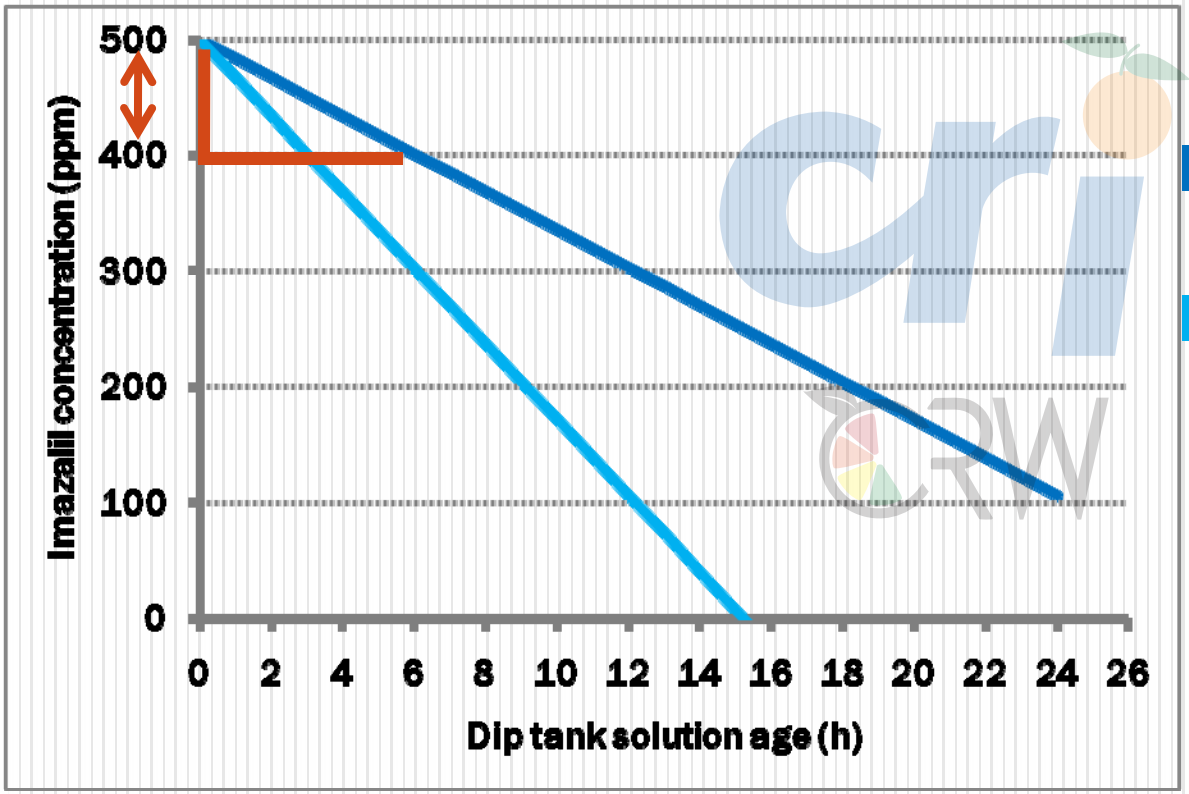
IMZ concentration management

Fungicide dip tank:

- Capacity: 1000 L @ 35°C
- Exposure time: 45 s
- Concentration: 500 µg.mL^{-1} IMZ
- 10 or 20 ton of fruit per hour

IMZ sulphate (pH 3)

IMZ residue per fruit: 1.64 µg.g^{-1}



10 ton takes out 16.4 g IMZ per hour

Amend concentration every 6 hours

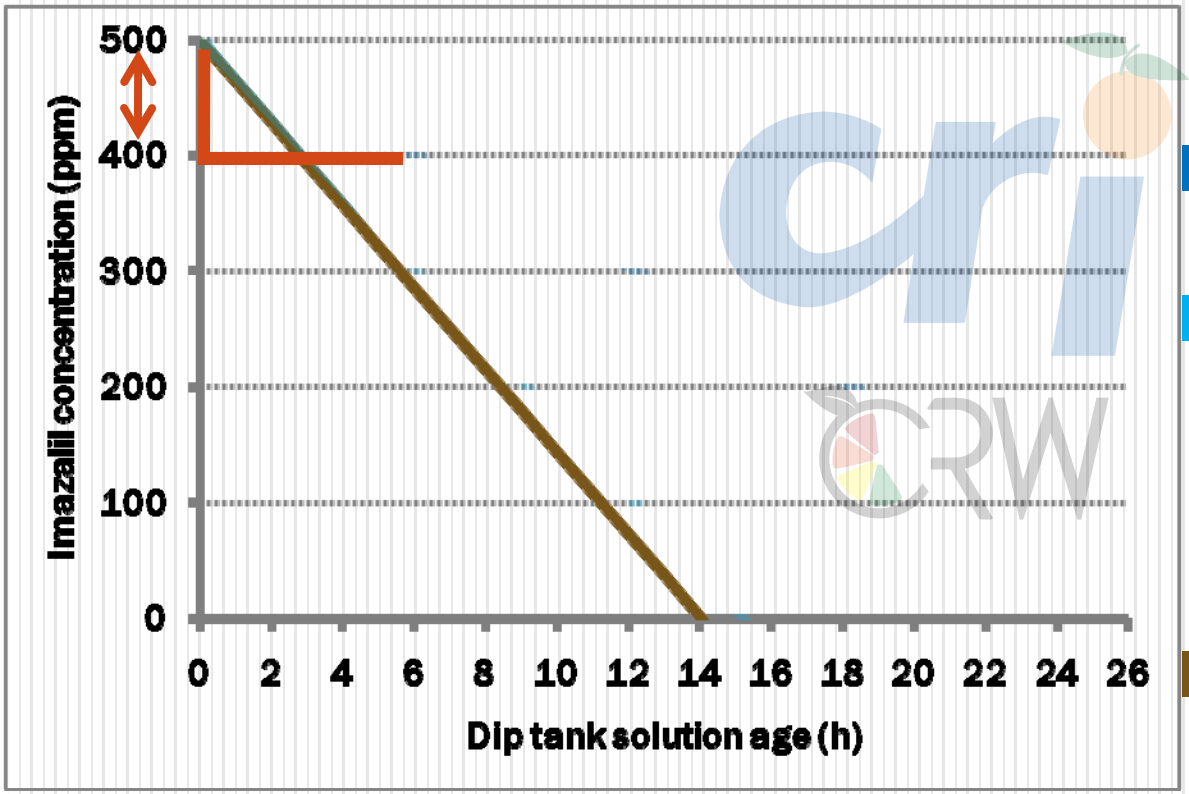
20 ton takes out 32.8 g IMZ per hour

Amend concentration every 3 hours

IMZ concentration management

Fungicide dip tank:

- Capacity: 1000 L @ 35°C
- Exposure time: 45 s
- Concentration: 500 µg.mL^{-1} IMZ
- 10 or 20 ton of fruit per hour



IMZ sulphate (pH 3)

IMZ residue per fruit: 1.64 µg.g^{-1}

10 ton takes out 16.4 g IMZ per hour

Amend concentration every 6 hours

20 ton takes out 32.8 g IMZ per hour

Amend concentration every 3 hours

IMZ sulphate (pH 6)

IMZ residue per fruit: 3.56 µg.g^{-1}

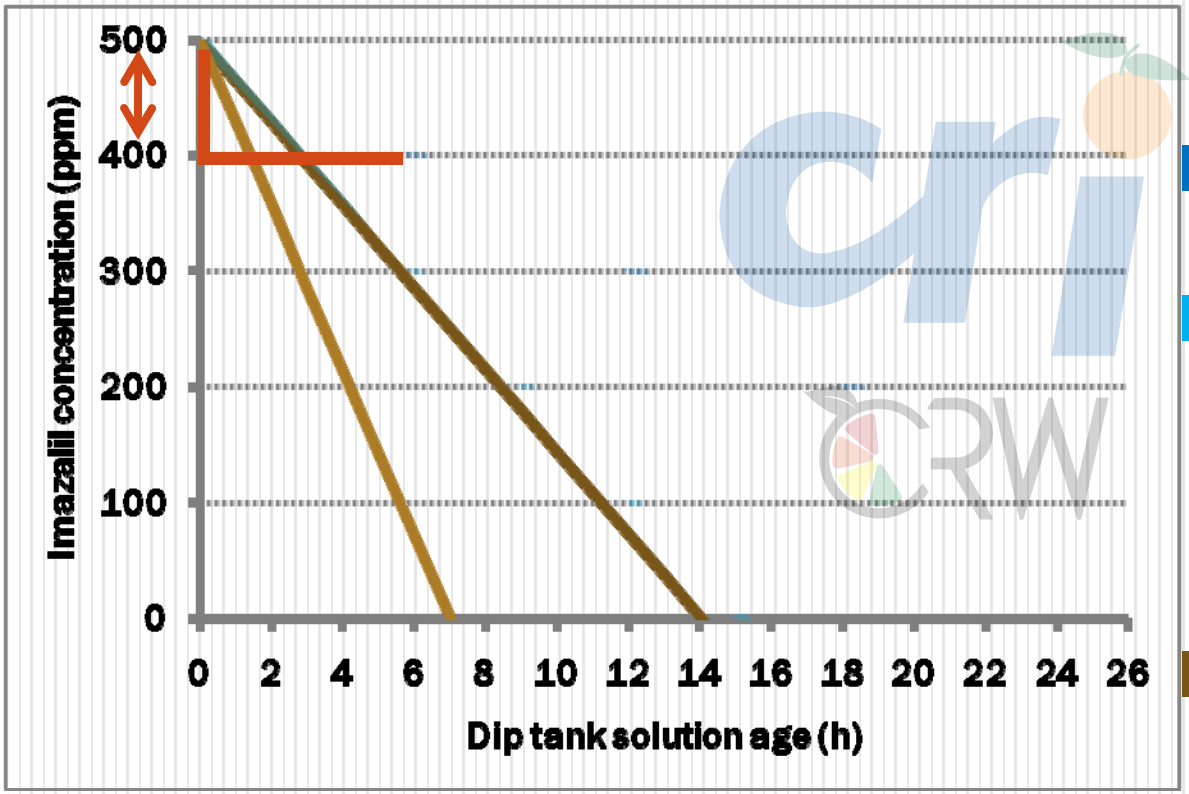
10 ton takes out 35.6 g IMZ per hour

Amend concentration every 3 hours

IMZ concentration management

Fungicide dip tank:

- Capacity: 1000 L @ 35°C
- Exposure time: 45 s
- Concentration: 500 µg.mL^{-1} IMZ
- 10 or 20 ton of fruit per hour



IMZ sulphate (pH 3)

IMZ residue per fruit: 1.64 µg.g^{-1}

10 ton takes out 16.4 g IMZ per hour

Amend concentration every 6 hours

20 ton takes out 32.8 g IMZ per hour

Amend concentration every 3 hours

IMZ sulphate (pH 6)

IMZ residue per fruit: 3.56 µg.g^{-1}

10 ton takes out 35.6 g IMZ per hour

Amend concentration every 3 hours

20 ton takes out 71.2 g IMZ per hour

Amend concentration every 1.5 hours

Complicating factors..?

- Brushes reduce IMZ residue to < 1 ppm
  - Poorer control of Resistant isolate
  - Loss of sporulation inhibition
- How do we load 2-3 ppm...?
  - IMZ in dip tank+ IMZ in wax application

THANK YOU

Hearshaw and Kinnes Analytical Laboratory (Pty) Ltd.

International Chemicals