

EVALUATION OF PROTECTIVE AND CURATIVE CONTROL OF *PENICILLIUM* *DIGITATUM* FOLLOWING IMAZALIL APPLICATION IN WAX

BY: Ncumisa Njombolwana¹, Arno Erasmus¹

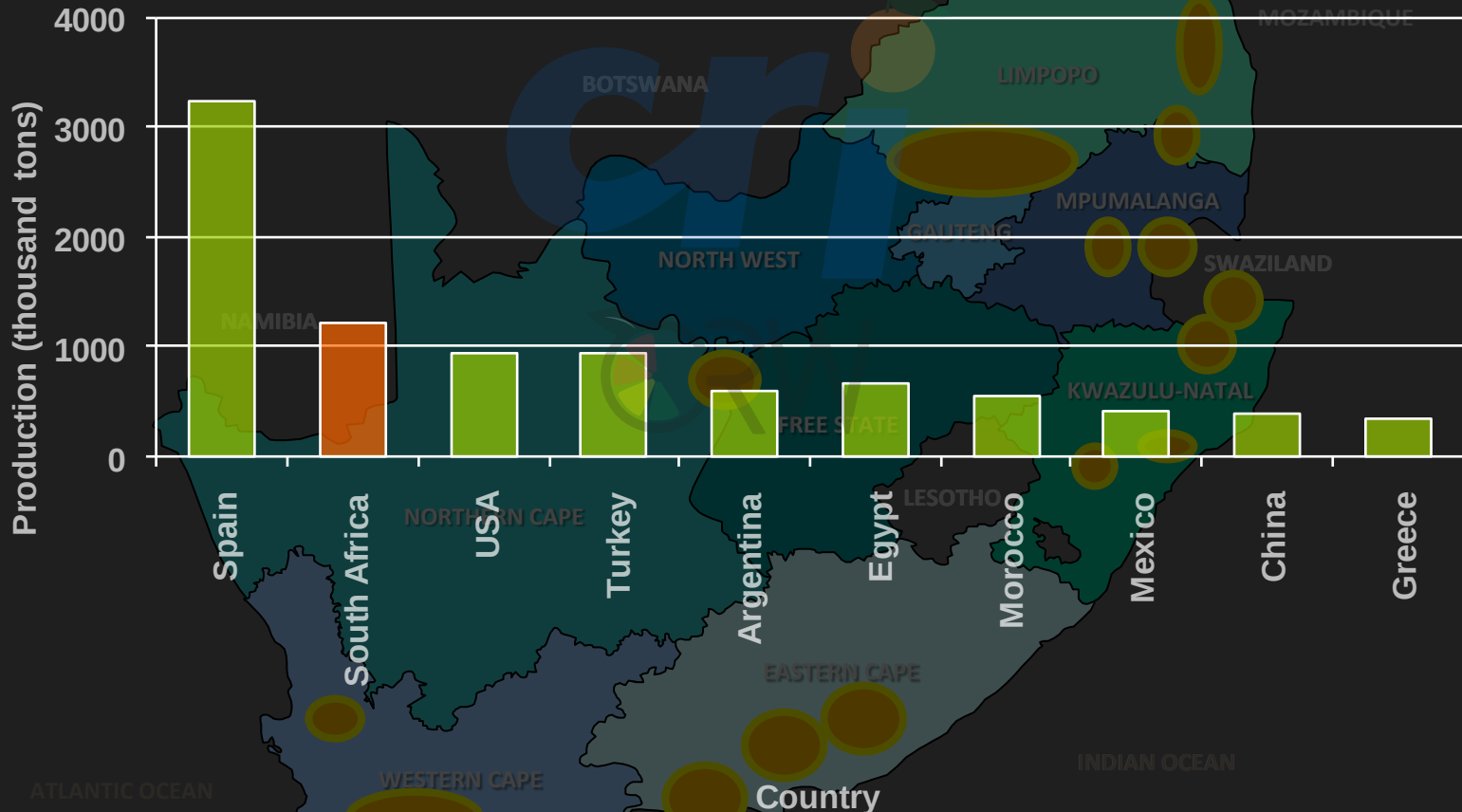
Wilma du Plooy³

Paul Fourie^{1,2}

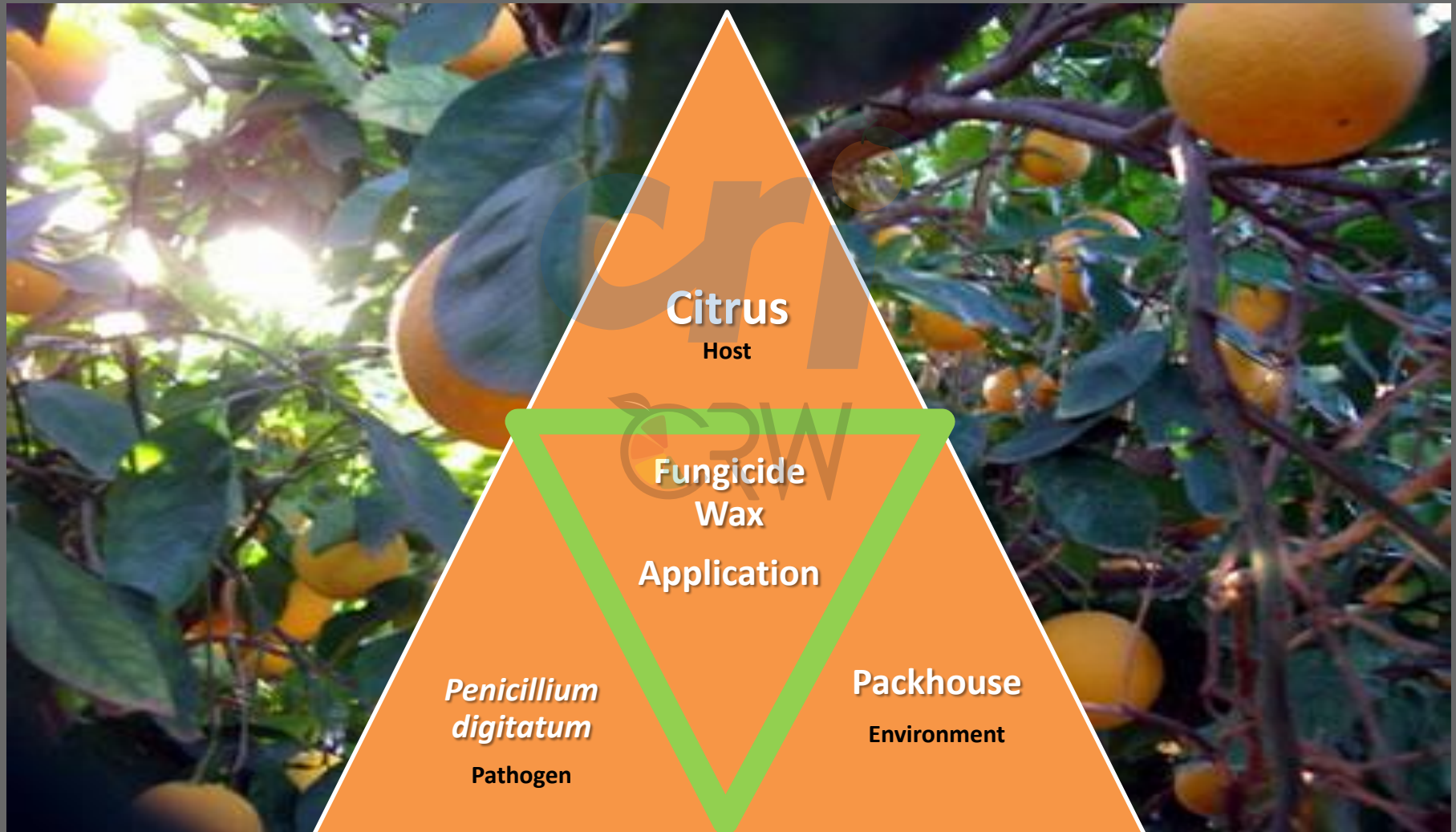
University of Stellenbosch¹
Citrus Research International² and
John Bean Technology³

Citrus in SA

World Fresh Citrus Exports (2005/06)



Citrus and green mould



Green mould

Wound pathogen (*Penicillium digitatum*)



Fungicide - Imazalil

- Mode of action: demethylation inhibitor
- Curative and protective action against green mould
- Sporulation inhibition
- Two formulations:
 - Sulphate salt (fungicide dip tanks)
 - Emulsifiable concentrate (in wax)



Why Wax?

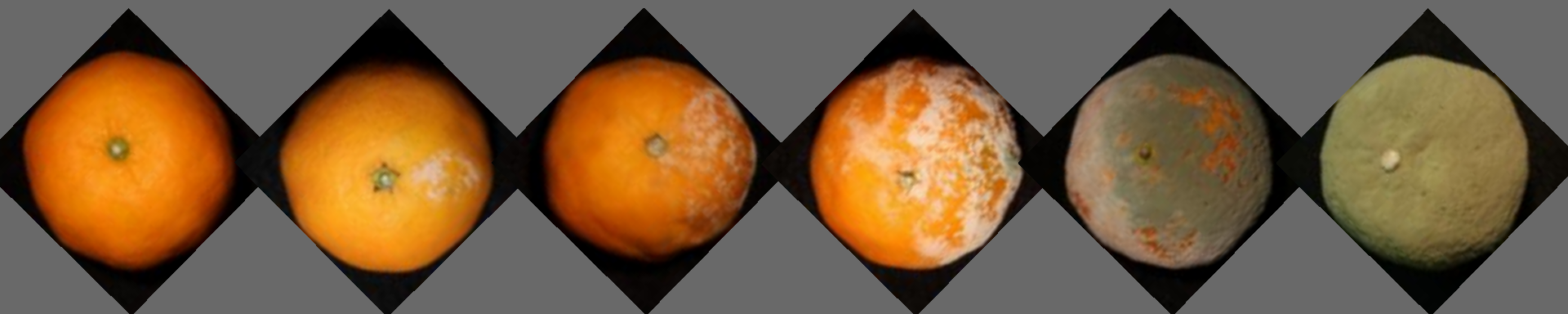
- Improve appearance
- Reduce weight loss
- Preserve fruit quality
- Carrier for fungicides
 - NB: Little knowledge on contribution of IMZ+wax to IMZ residue loading and control of green mould



Objectives

To evaluate the effect of imazalil applied through wax on the control of green mould

- Imazalil (IMZ) residue loading through wax application
- Curative and protective green mould control
- Single and double application of IMZ in wax



Packline

- [video](#)

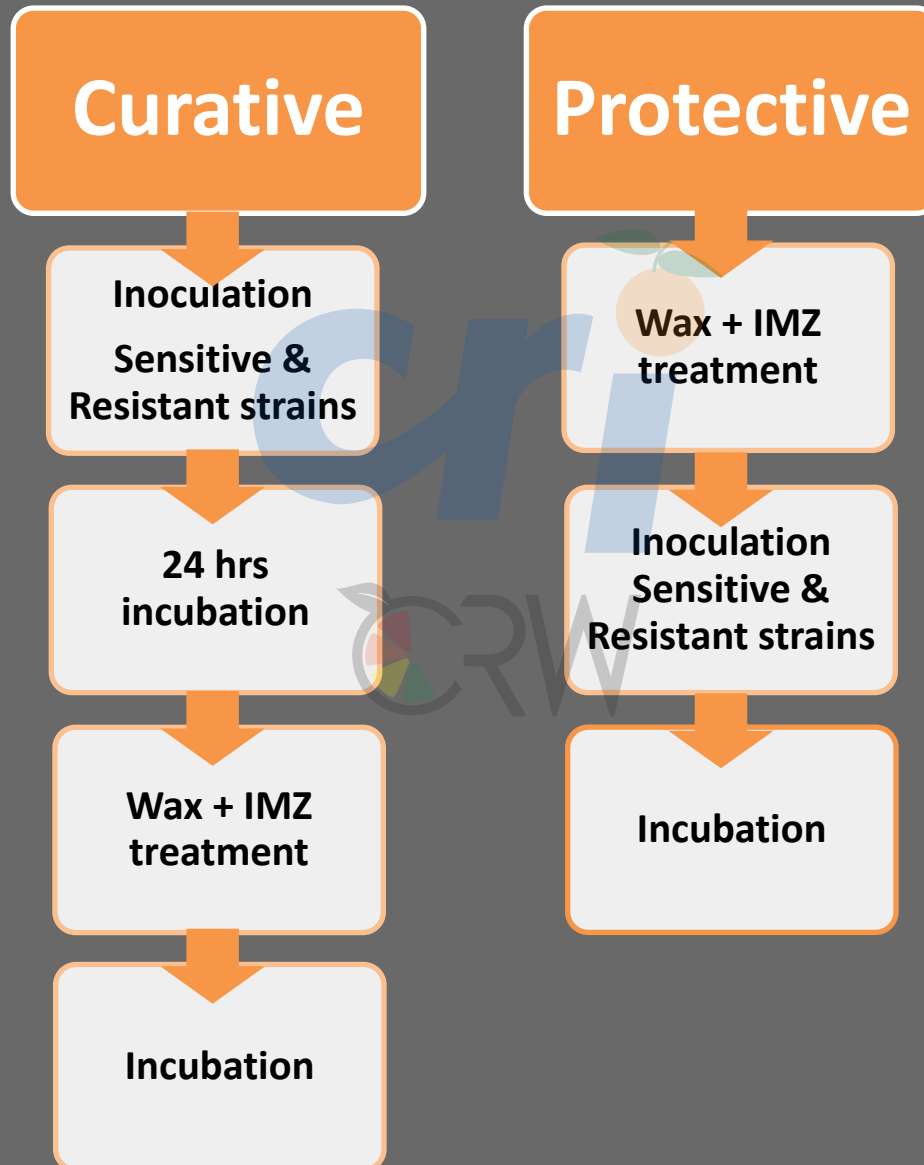


Experiment 1: Curative vs. protective action of imazalil in wax

A. Imazalil treatment	Curative (inoculated 24 h prior to treatment) Protective (treated prior to inoculation)
B. Penicillium isolates	Imazalil sensitive or resistant
C. Fruit exposure time on wax applicator	10s (0.6 L/ton) 20s (1.2 L/ ton) 30 s (1.8 L/ton)
D. Fruit incubation	Ambient (20°C, 10 days) vs. Cold storage (-0.5°C, 30 d + 7 d, 20°C)

- Imazalil (EC) @ 3000 $\mu\text{g ml}^{-1}$ wax
- Untreated controls

Curative and protective treatments



Evaluation

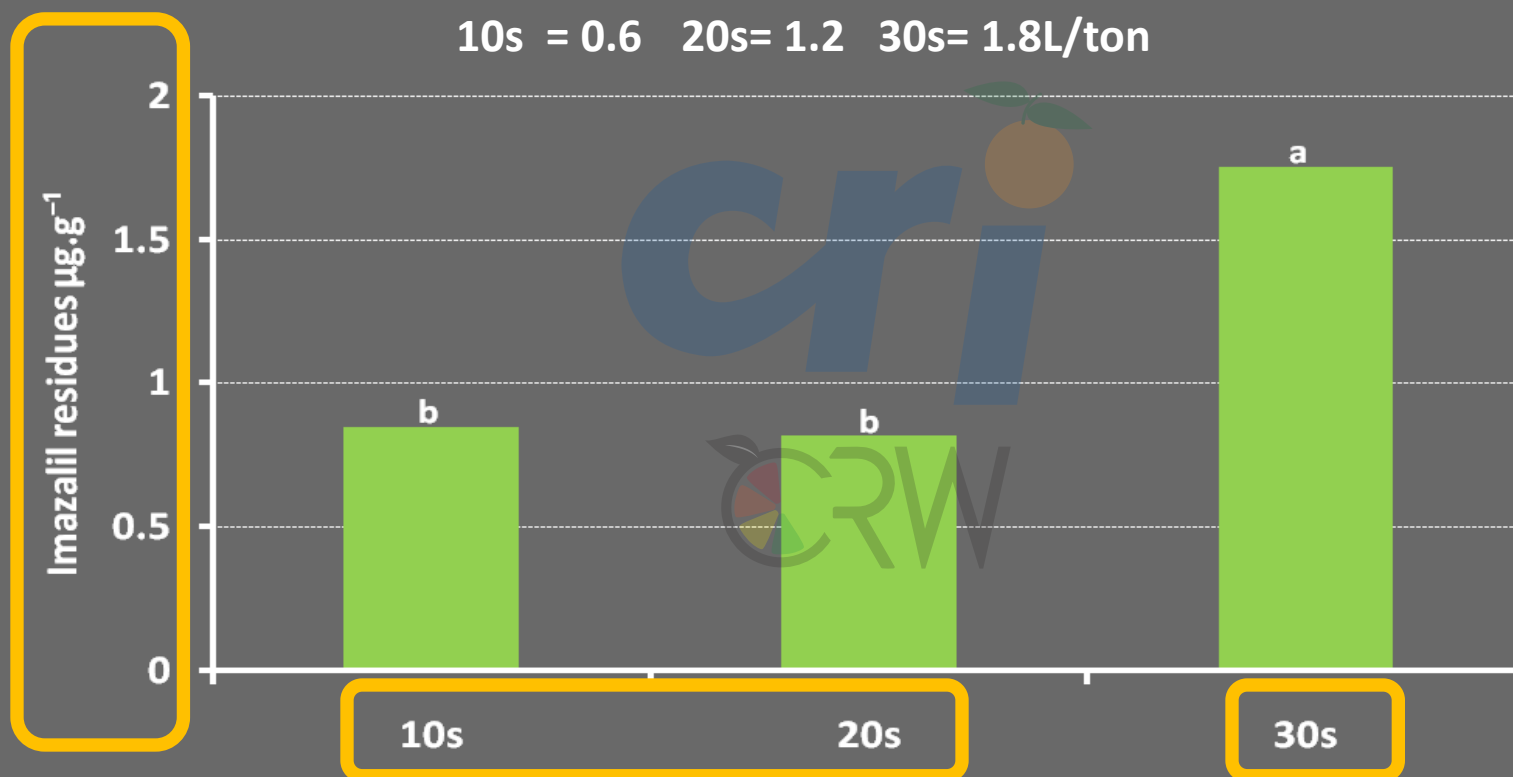
- **Infection**
 - Wounds rated using a UV-light
 - 4 wounds per fruit
 - After 4 and 7 days
- **Sporulation**
 - After 10-12 days



Results: Exposure trial - IMZ residue loading

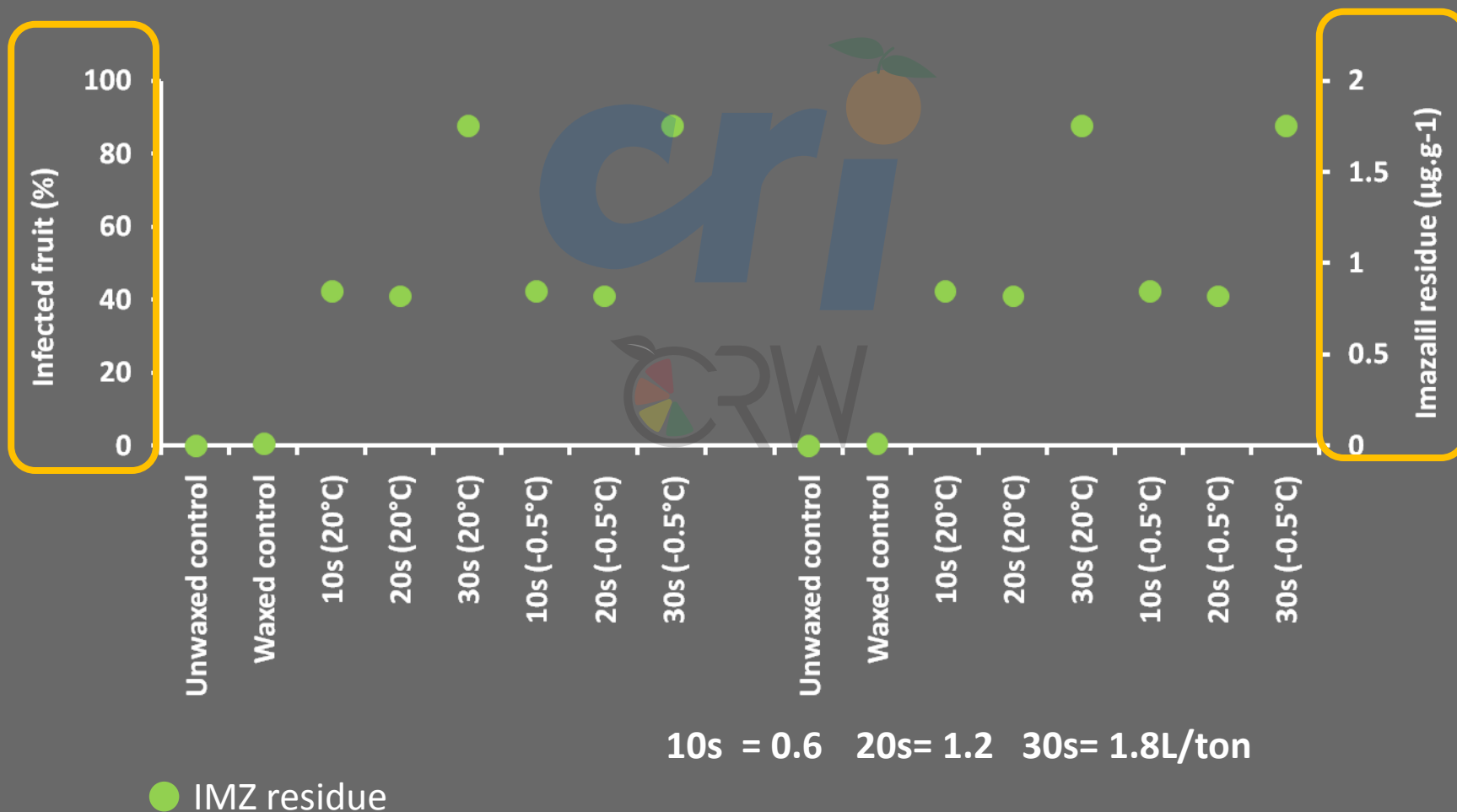
Valencia: 4 × Repeats, 3 × Replicates, 12 × fruit per treatment

10s = 0.6 20s = 1.2 30s = 1.8L/ton



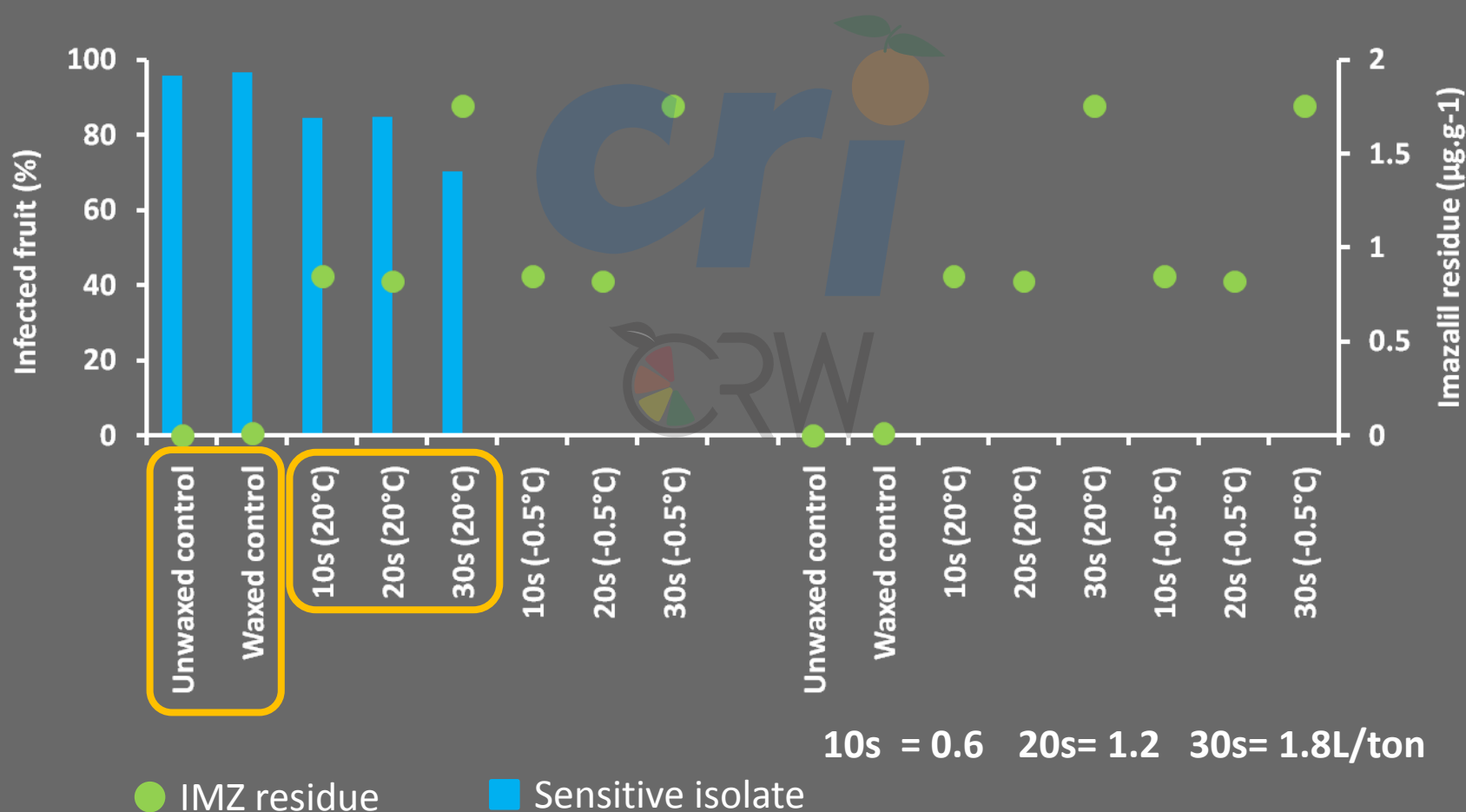
Fruit exposure time under wax application

Results: Green mould infection



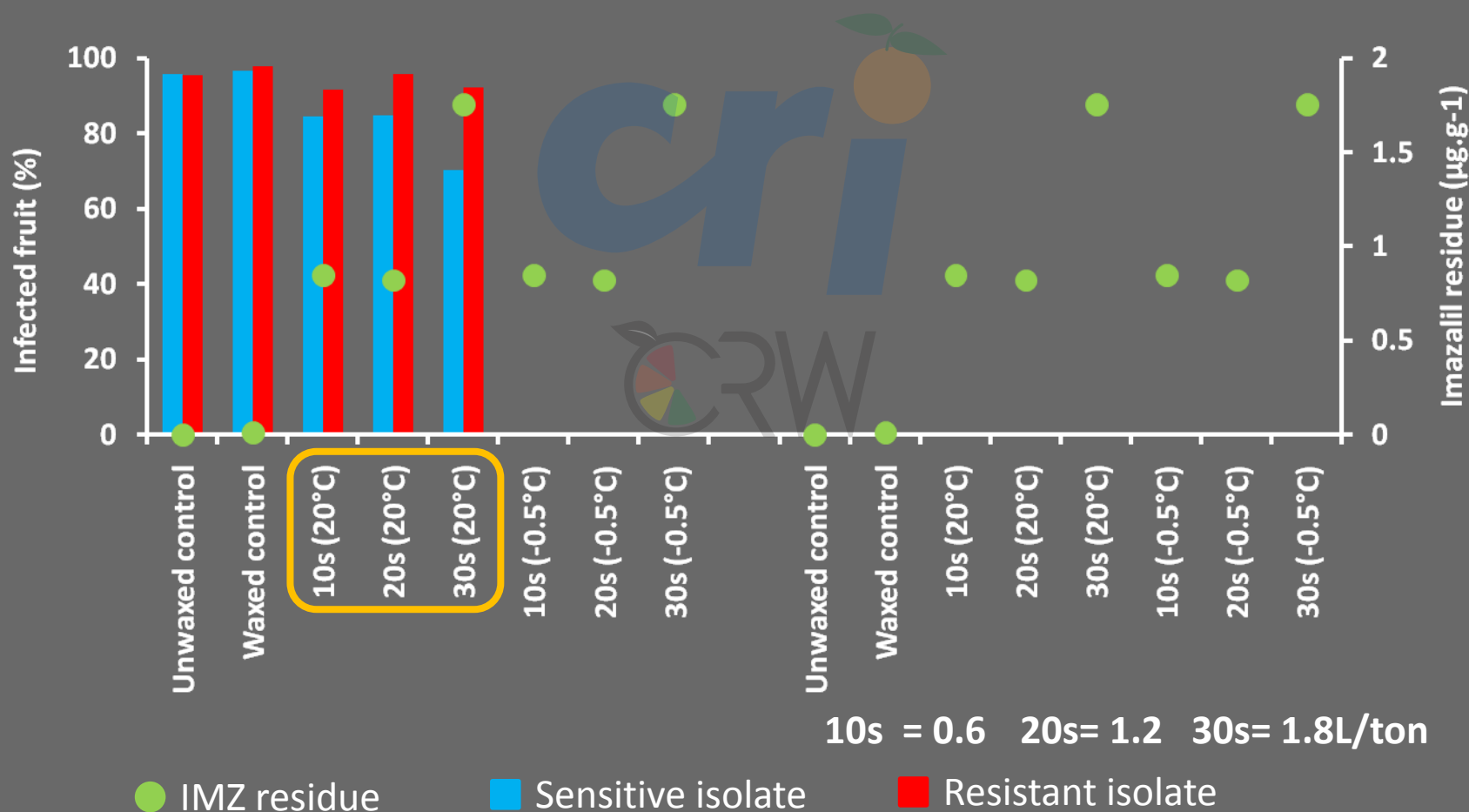
Results: Green mould infection

Curative



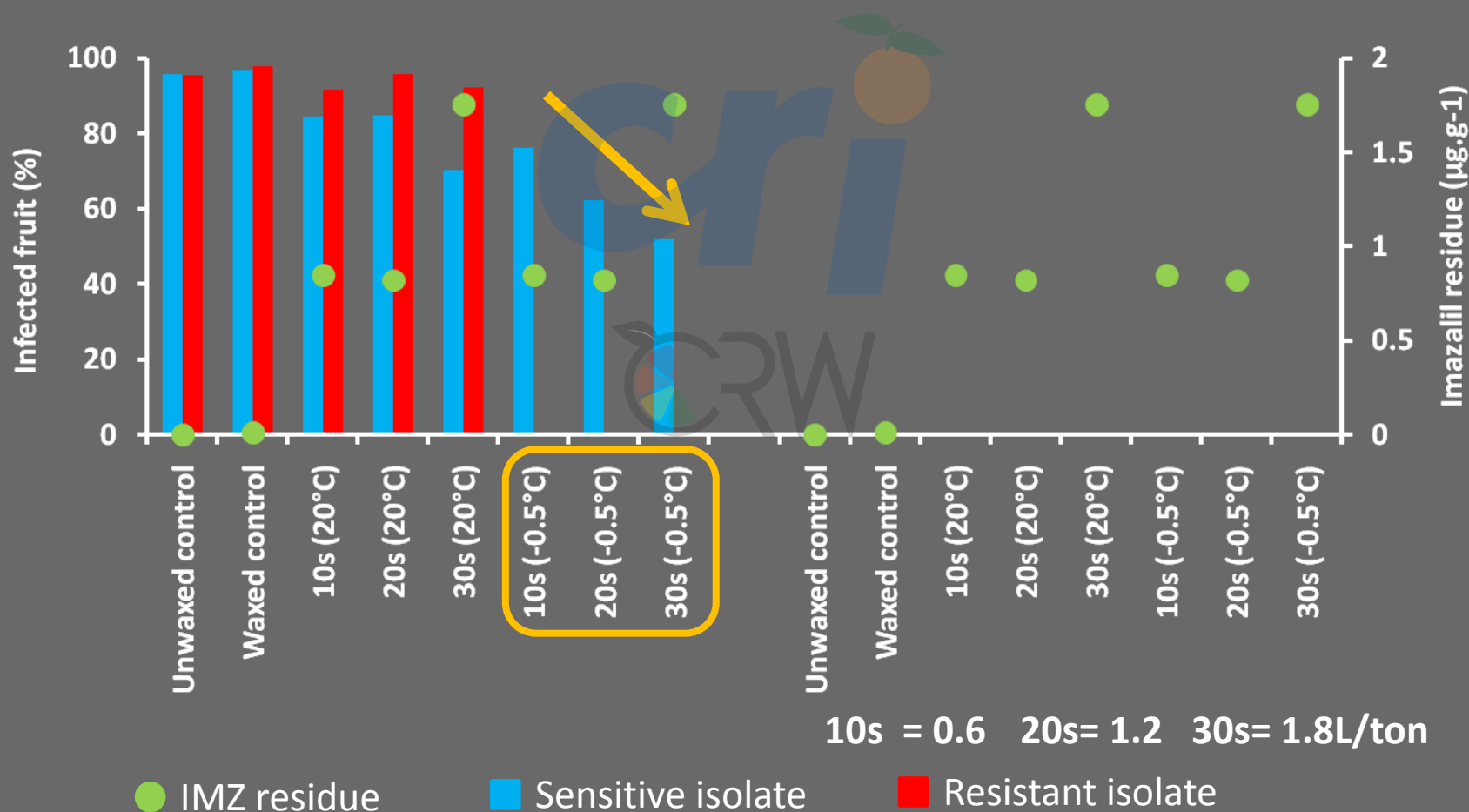
Results: Green mould infection

Curative



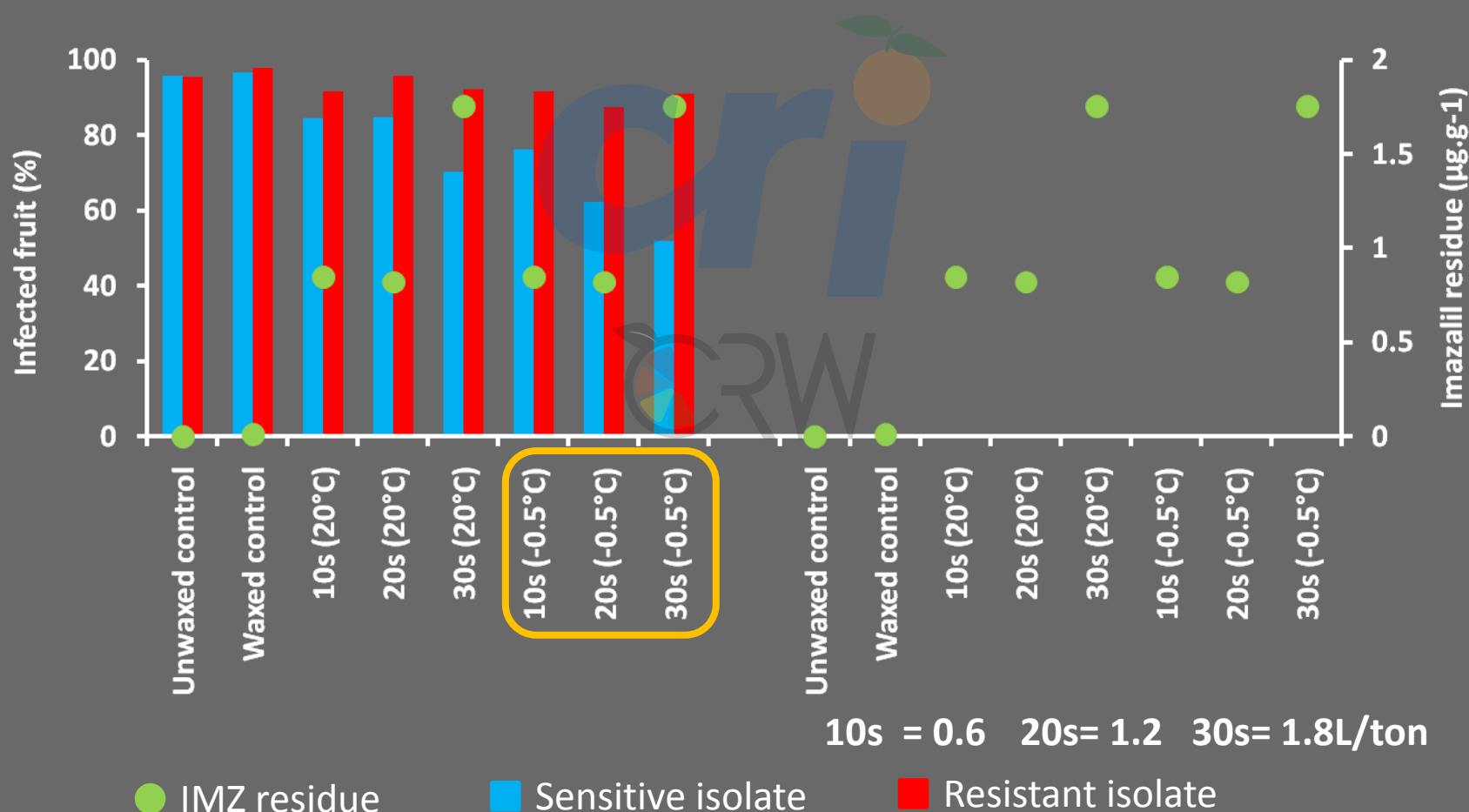
Results: Green mould infection

Curative

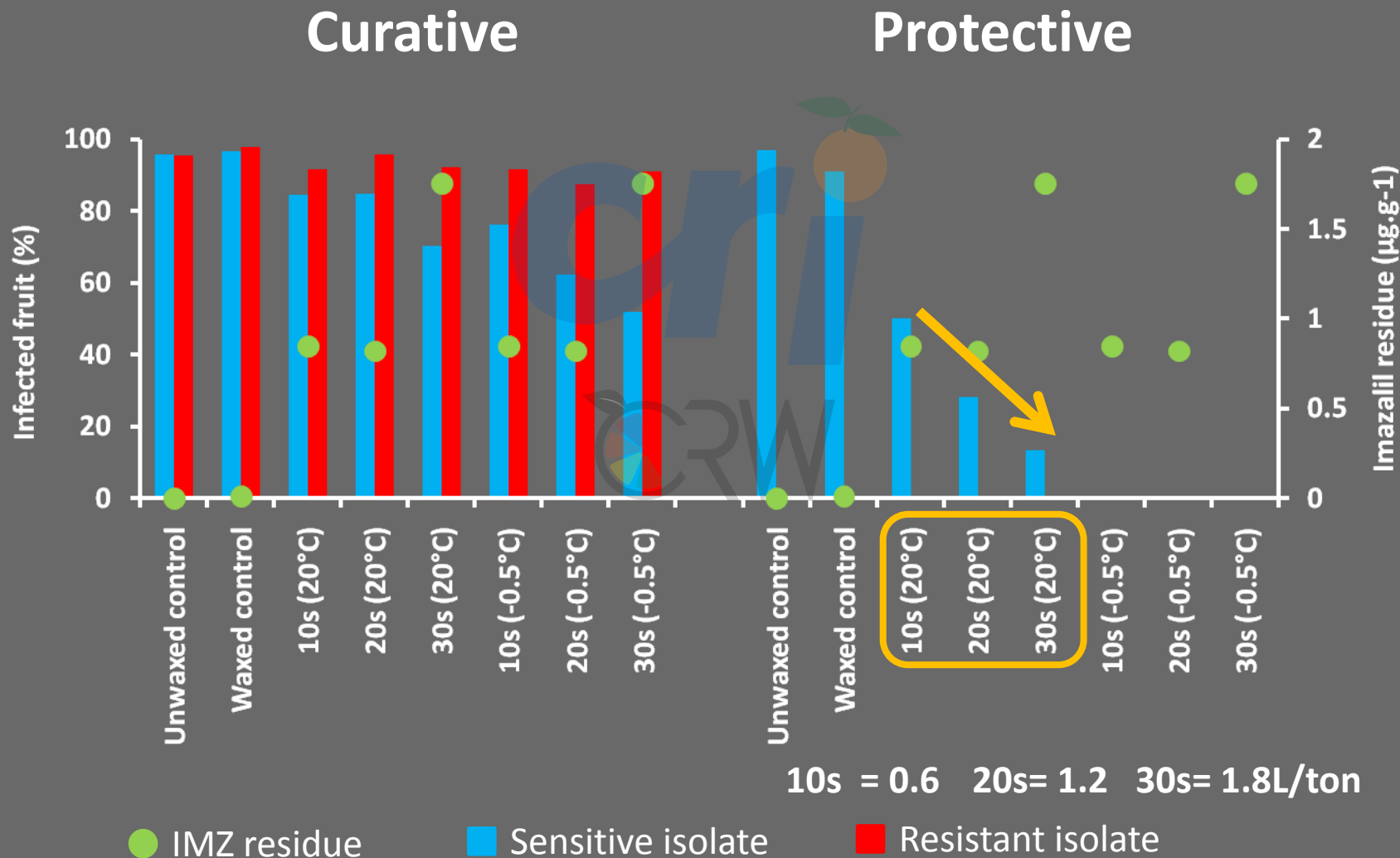


Results: Green mould infection

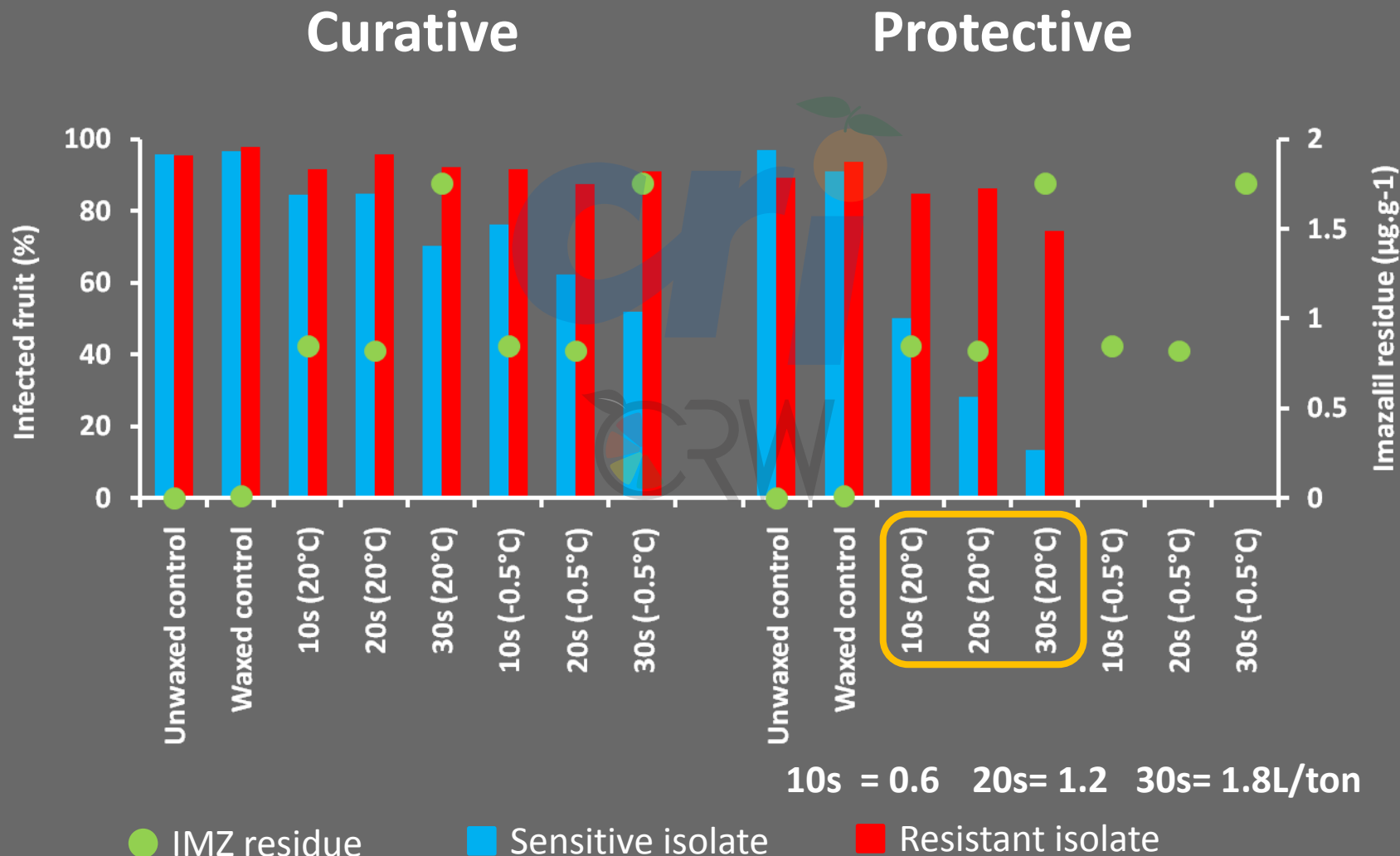
Curative



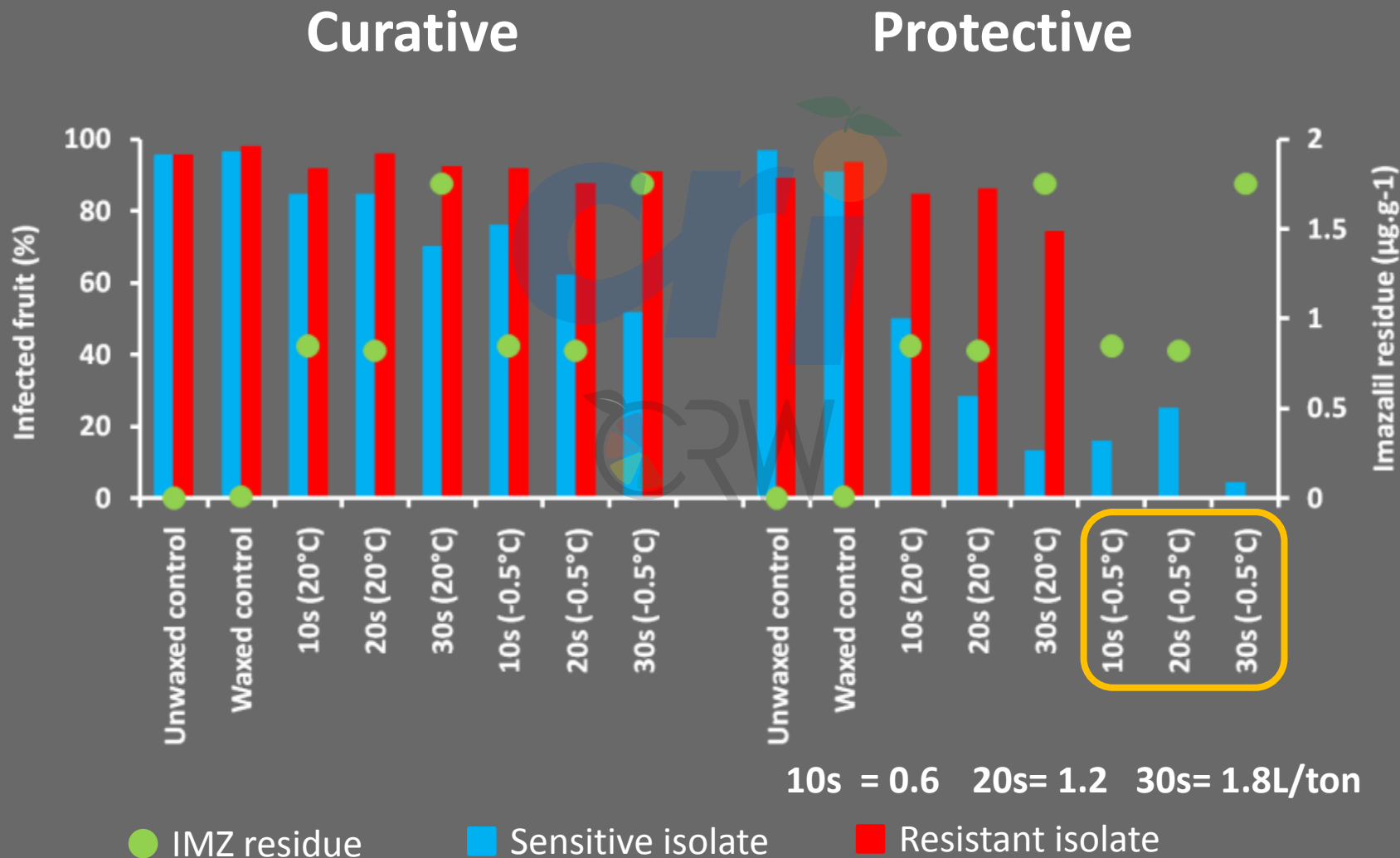
Results: Green mould infection



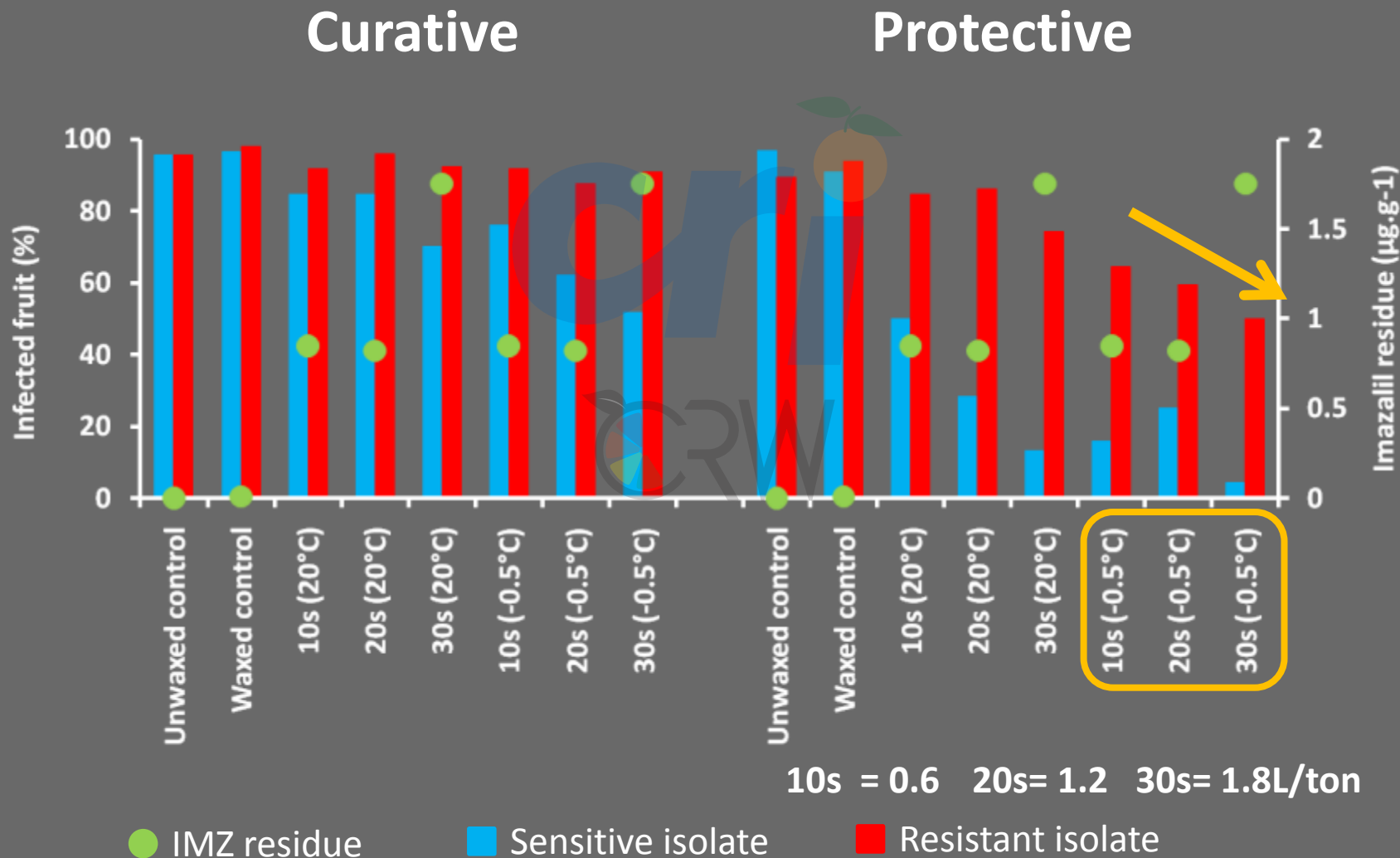
Results: Green mould infection



Results: Green mould infection



Results: Green mould infection

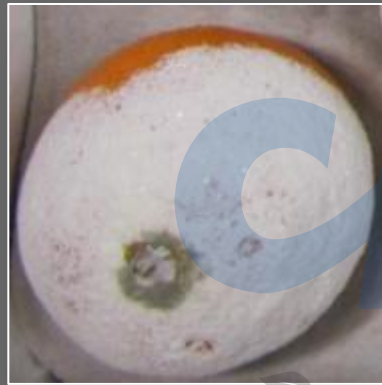


Sporulation inhibition

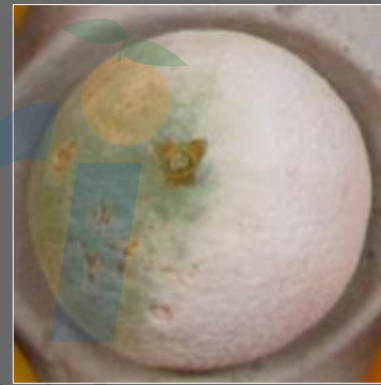
- Sporulation index : 1 - 6



1



2



3

Inhibition



4



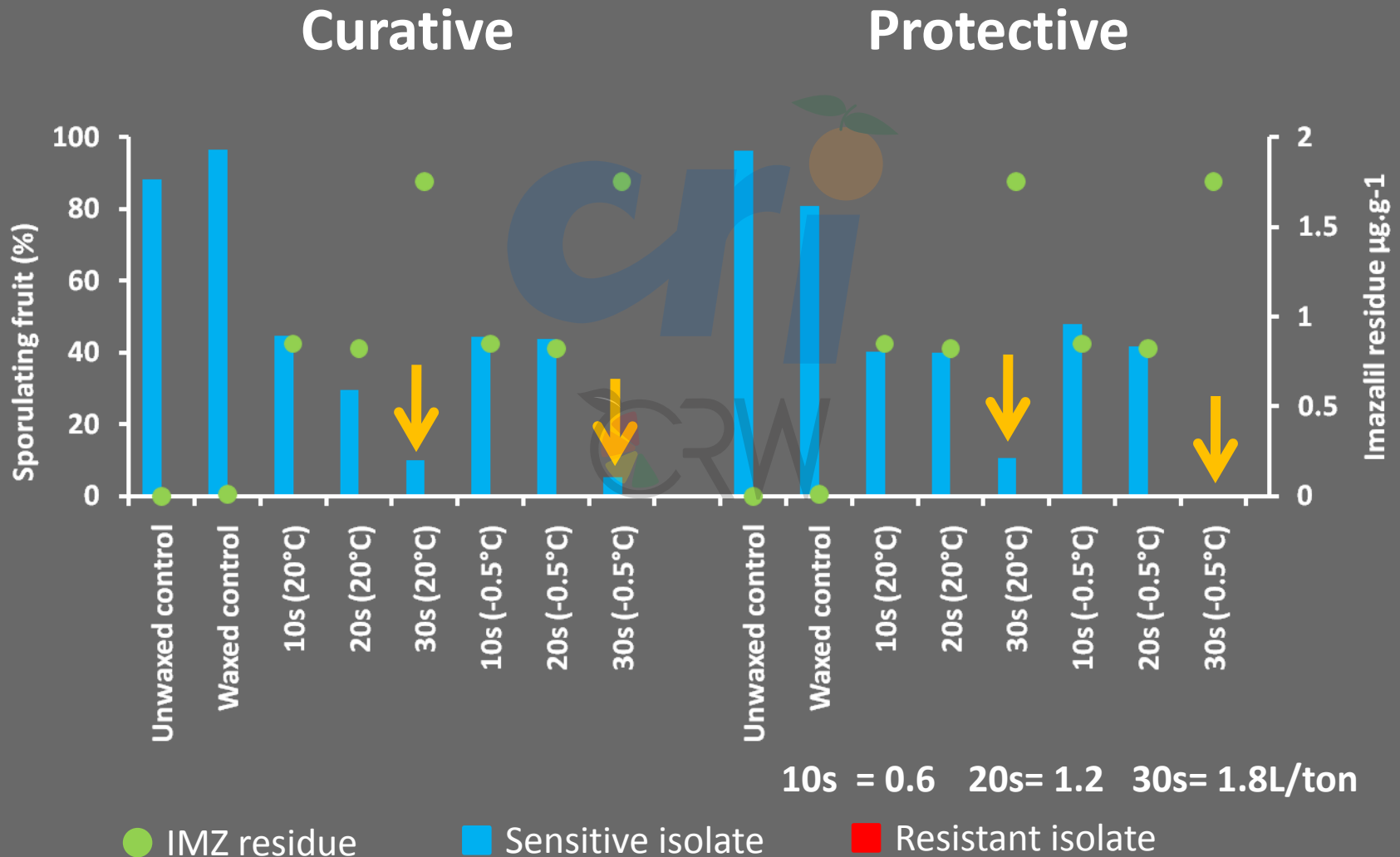
5



6

Sporulation

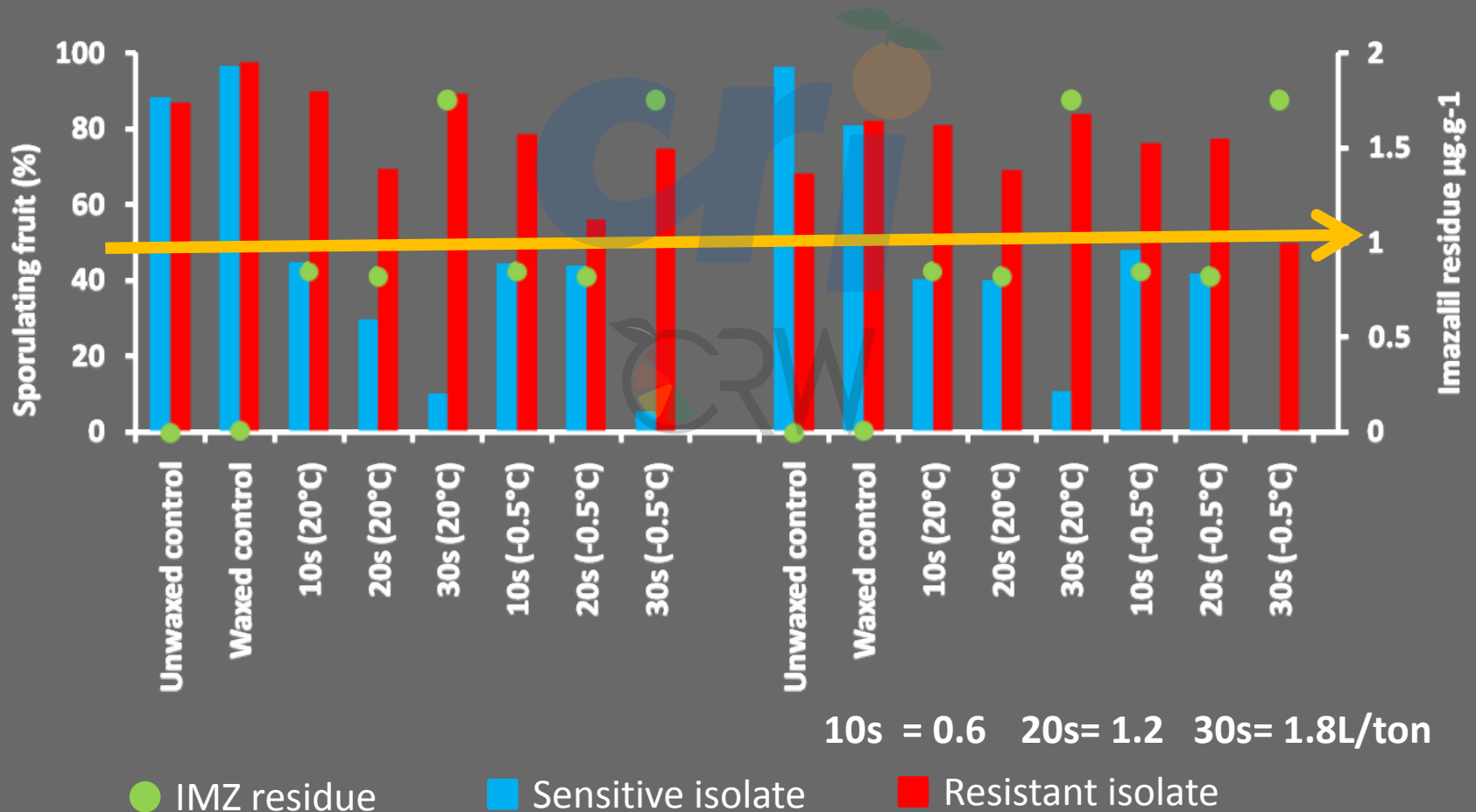
Results-Sporulation



Results-Sporulation

Curative

Protective



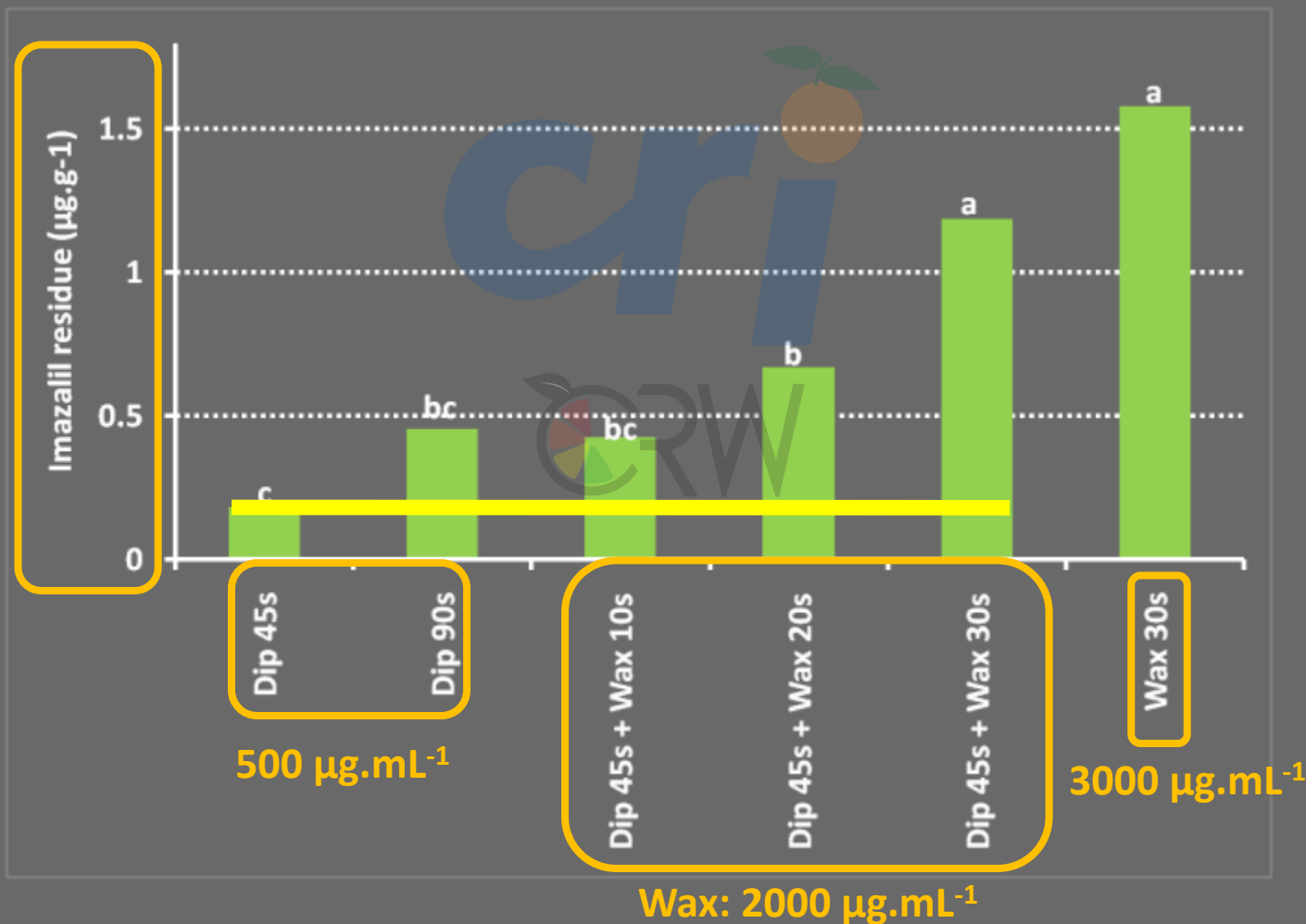
Experiment 2: Double vs. single application of imazalil in wax

A. Imazalil application	-Curative (inoculated 24 h prior to treatment) - Protective (treated prior to inoculation)
B. Penicillium isolates	-Imazalil sensitive or resistant
C. Dip only treatments	-Imazalil sulphate @ 500 $\mu\text{g.ml}^{-1}$ - 45 and 90s
D. Double application	- Dip : 45s in IMZ sulphate @ 500 $\mu\text{g.ml}^{-1}$ - Wax : 10, 20 or 30 s (imazalil EC @ 2000 $\mu\text{g.ml}^{-1}$)
E. Wax only treatment	- 30 s (Imazalil EC @ 3000 $\mu\text{g.ml}^{-1}$)
F. Untreated controls	

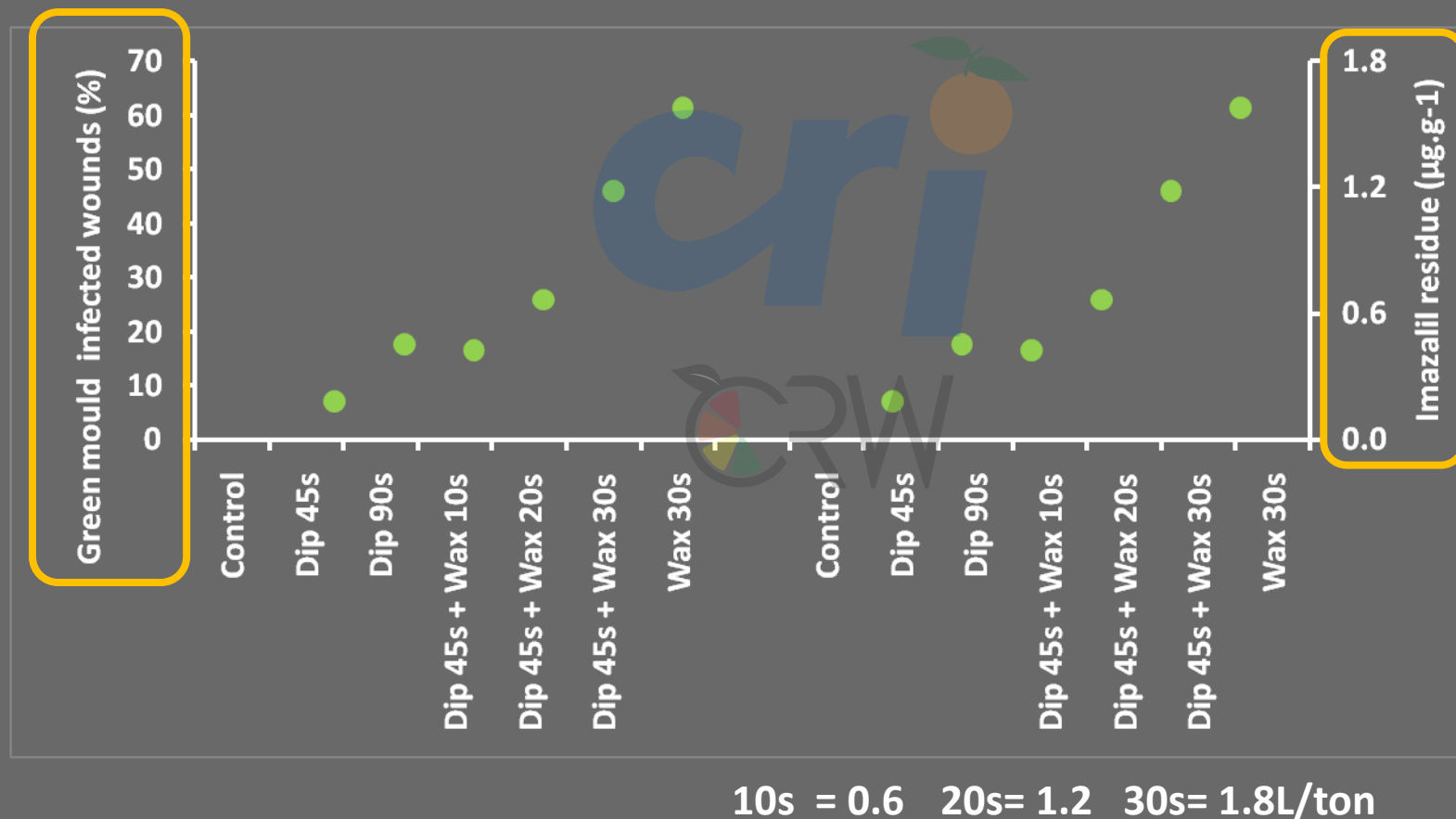
Results – Imazalil residue loading

Valencia: × 2 Repeats × 3 Replicates × 12 fruit per treatment

10s = 0.6 20s = 1.2 30s = 1.8L/ton



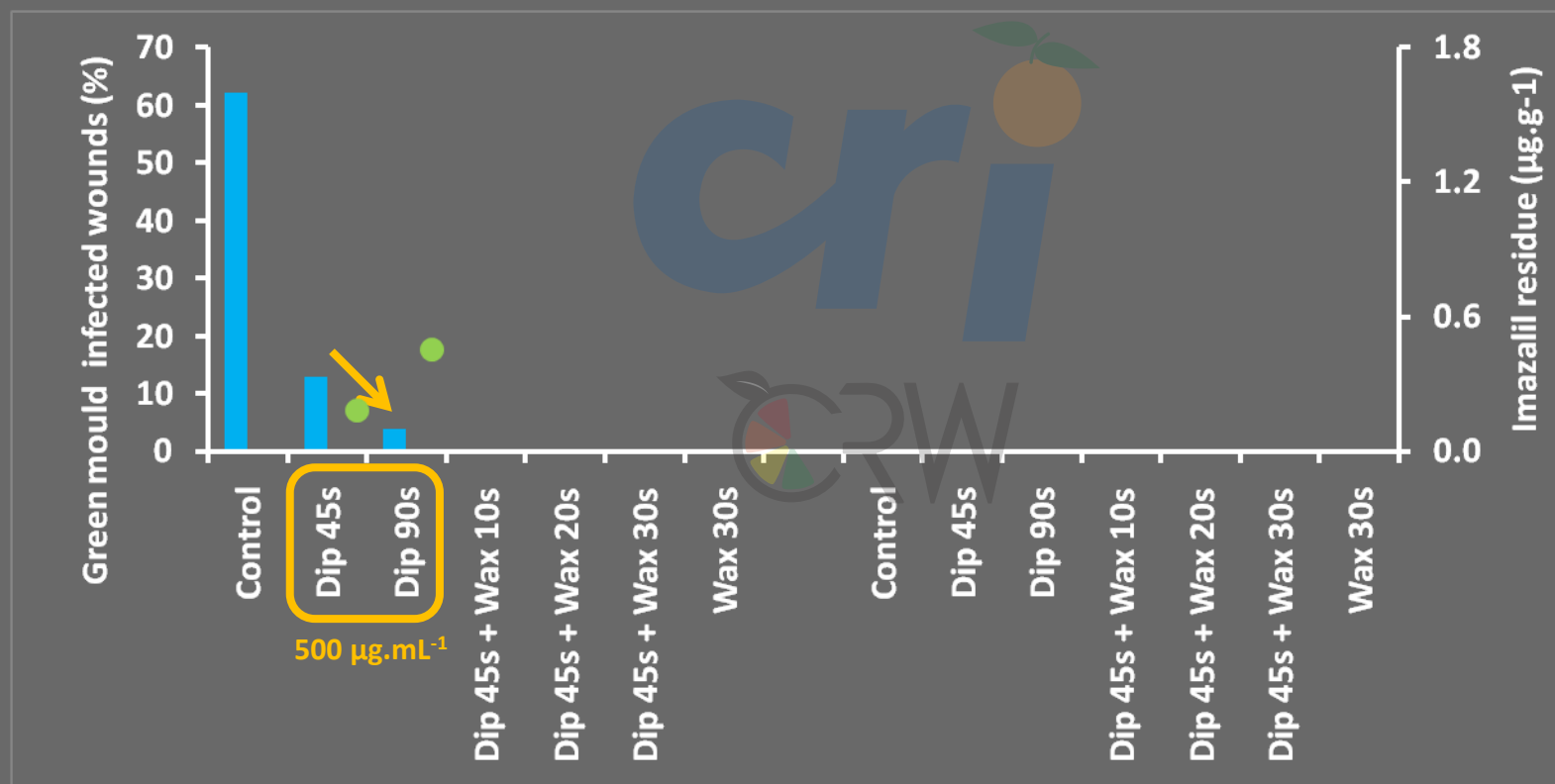
Results – Green mould infection



● IMZ residue

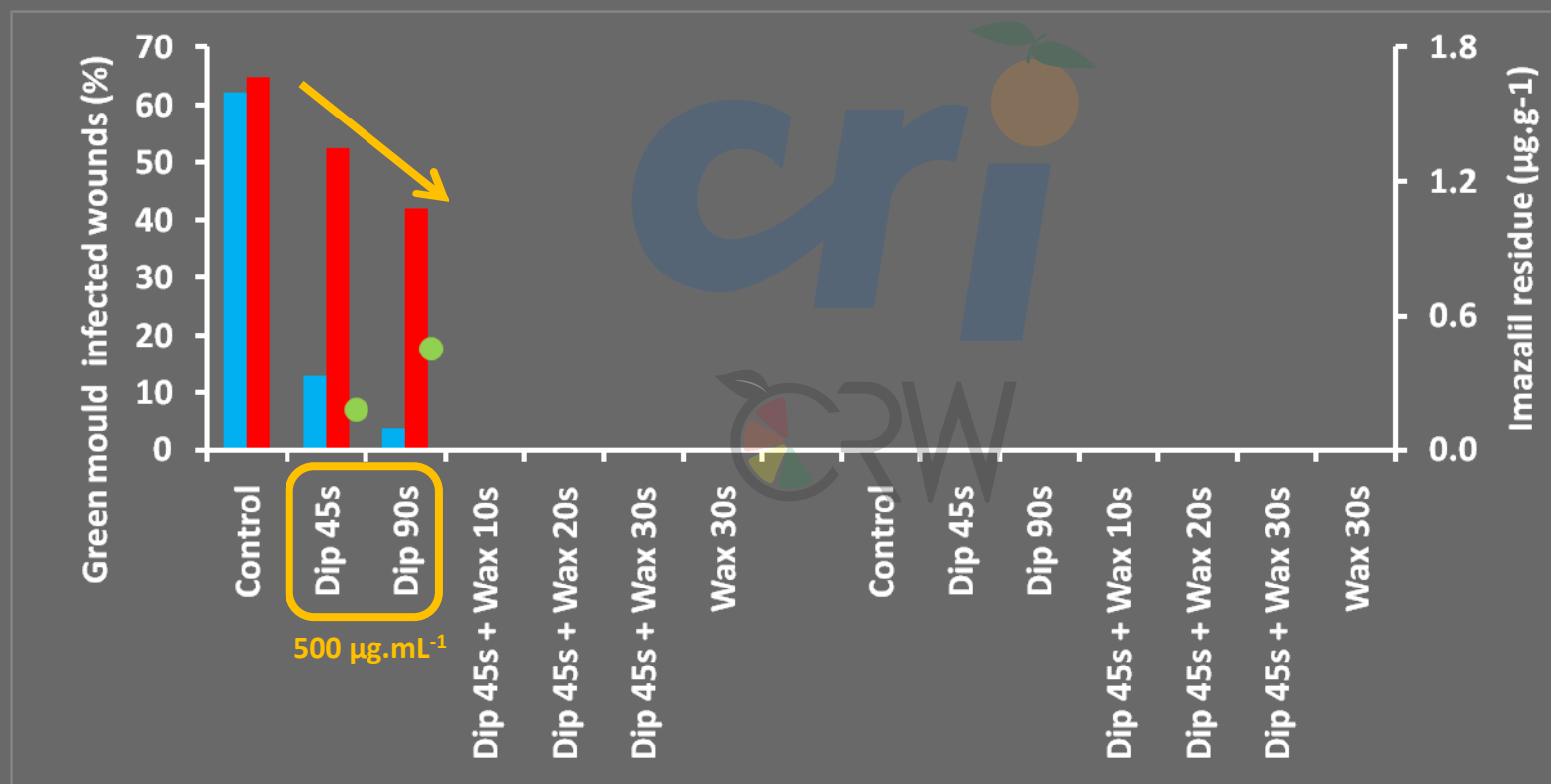
Results – Green mould infection

Curative



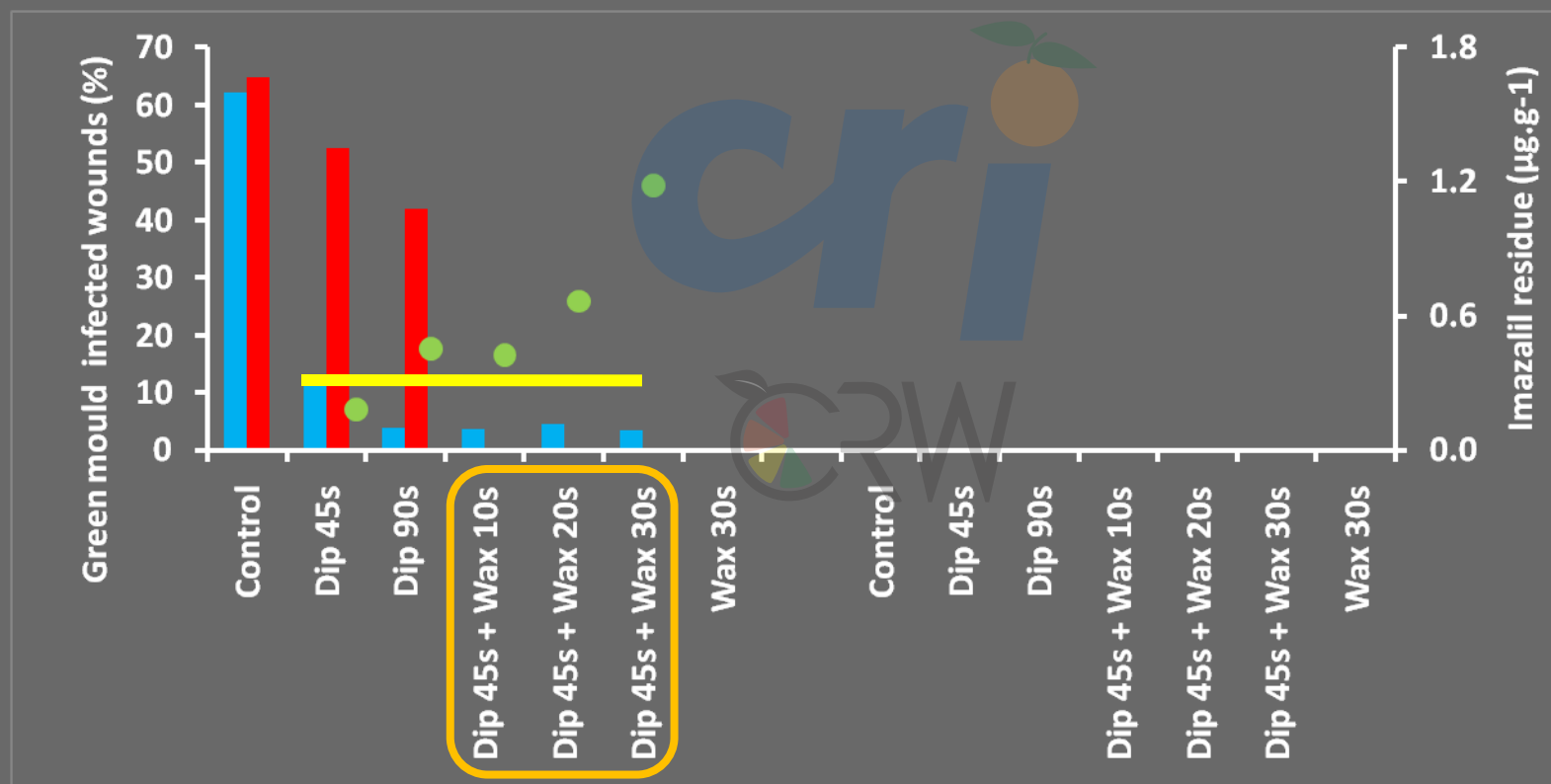
Results – Green mould infection

Curative



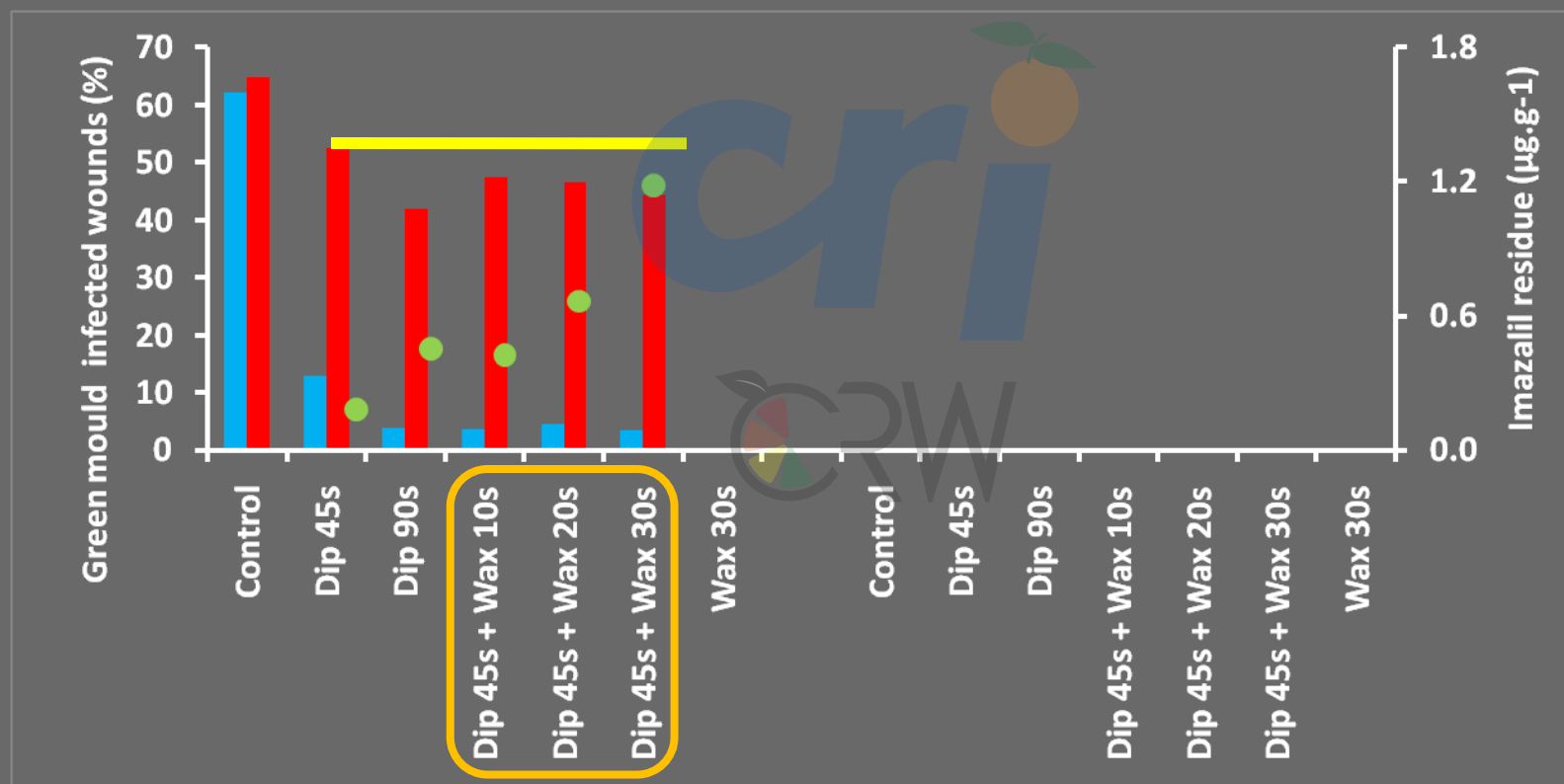
Results – Green mould infection

Curative



Results – Green mould infection

Curative



10s = 0.6 20s = 1.2 30s = 1.8L/ton

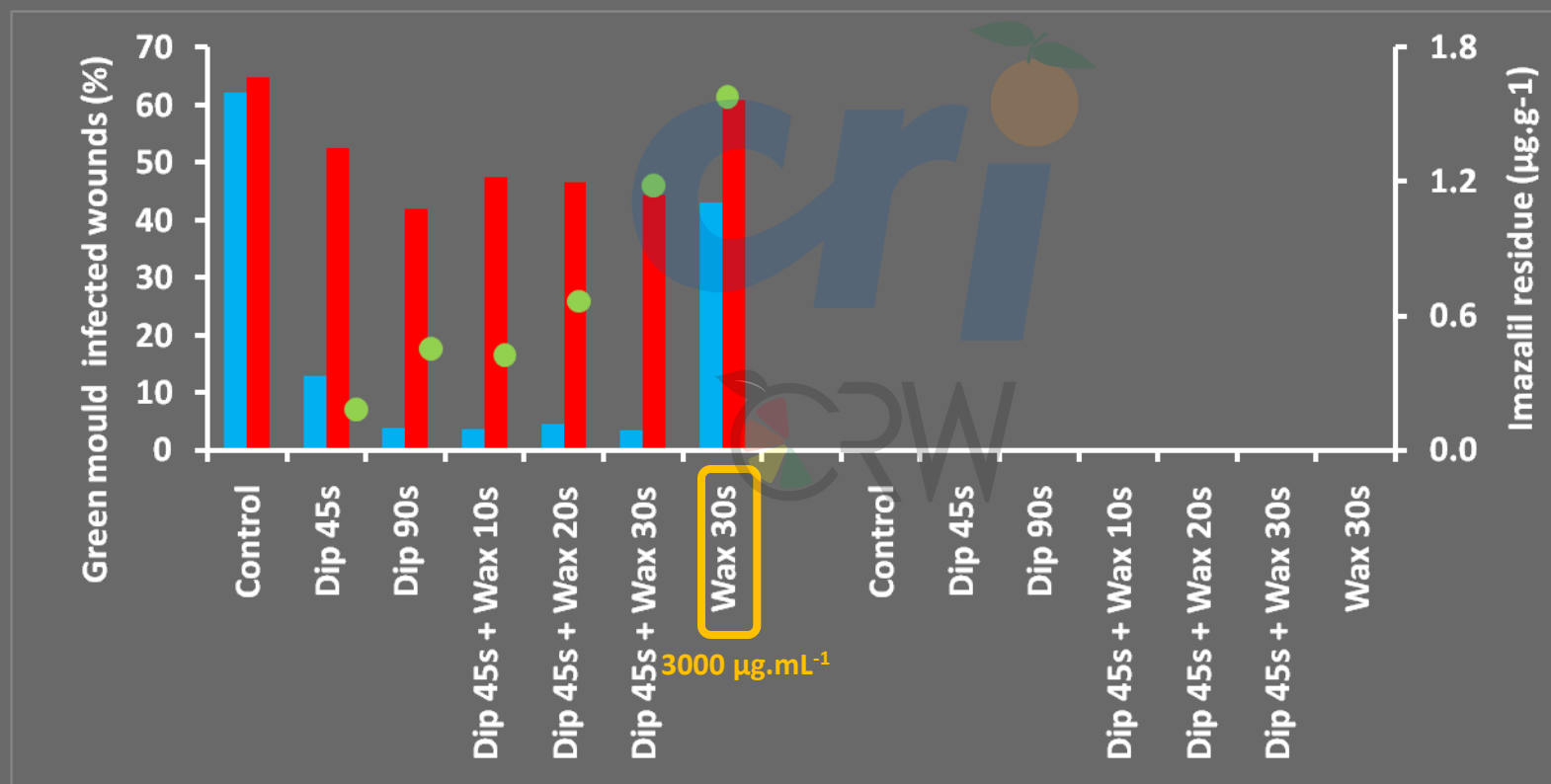
● IMZ residue

■ Sensitive isolate

■ Resistant isolate

Results – Green mould infection

Curative



10s = 0.6 20s = 1.2 30s = 1.8L/ton

● IMZ residue

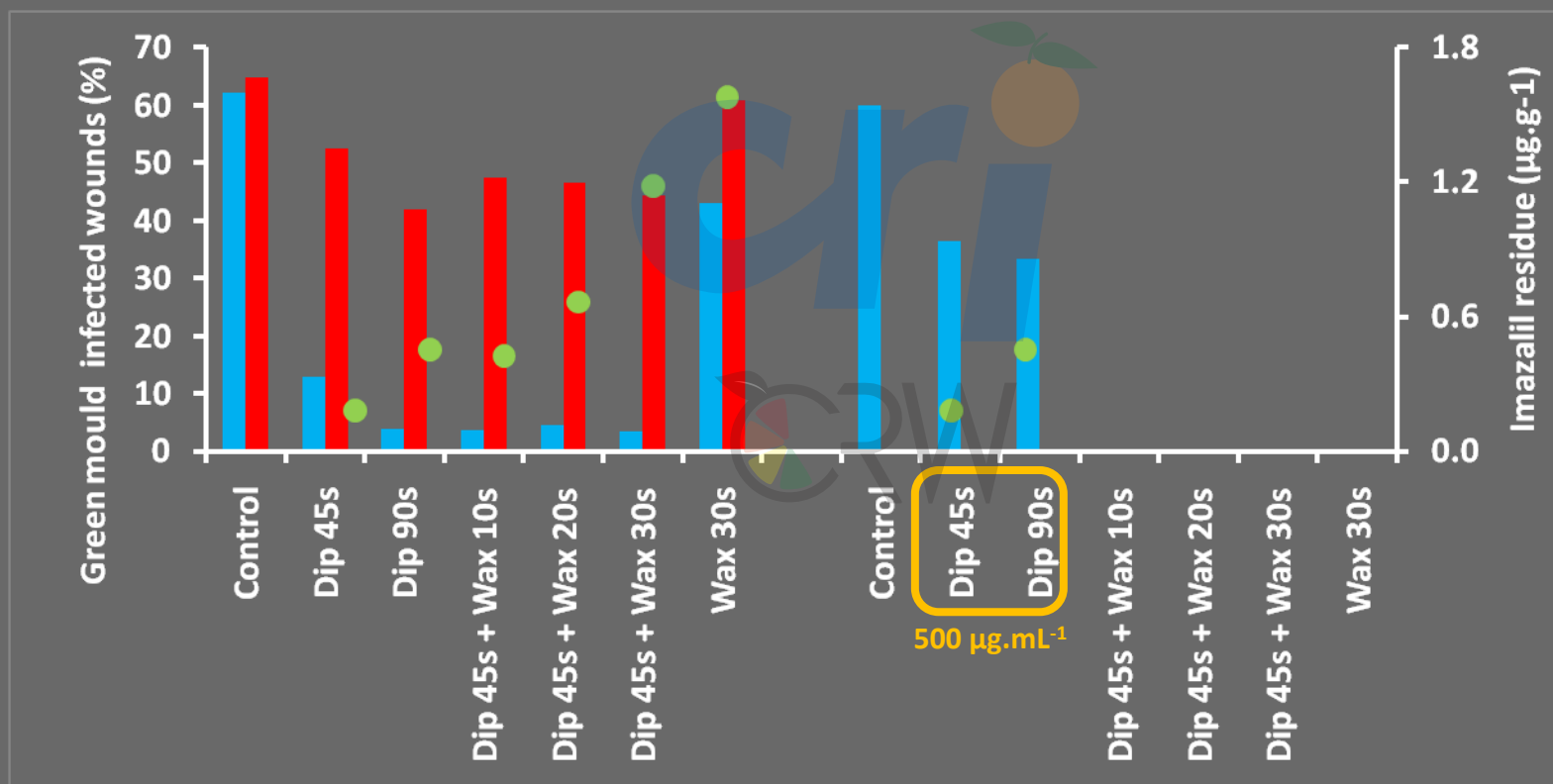
■ Sensitive isolate

■ Resistant isolate

Results – Green mould infection

Curative

Protective



10s = 0.6 20s = 1.2 30s = 1.8L/ton

● IMZ residue

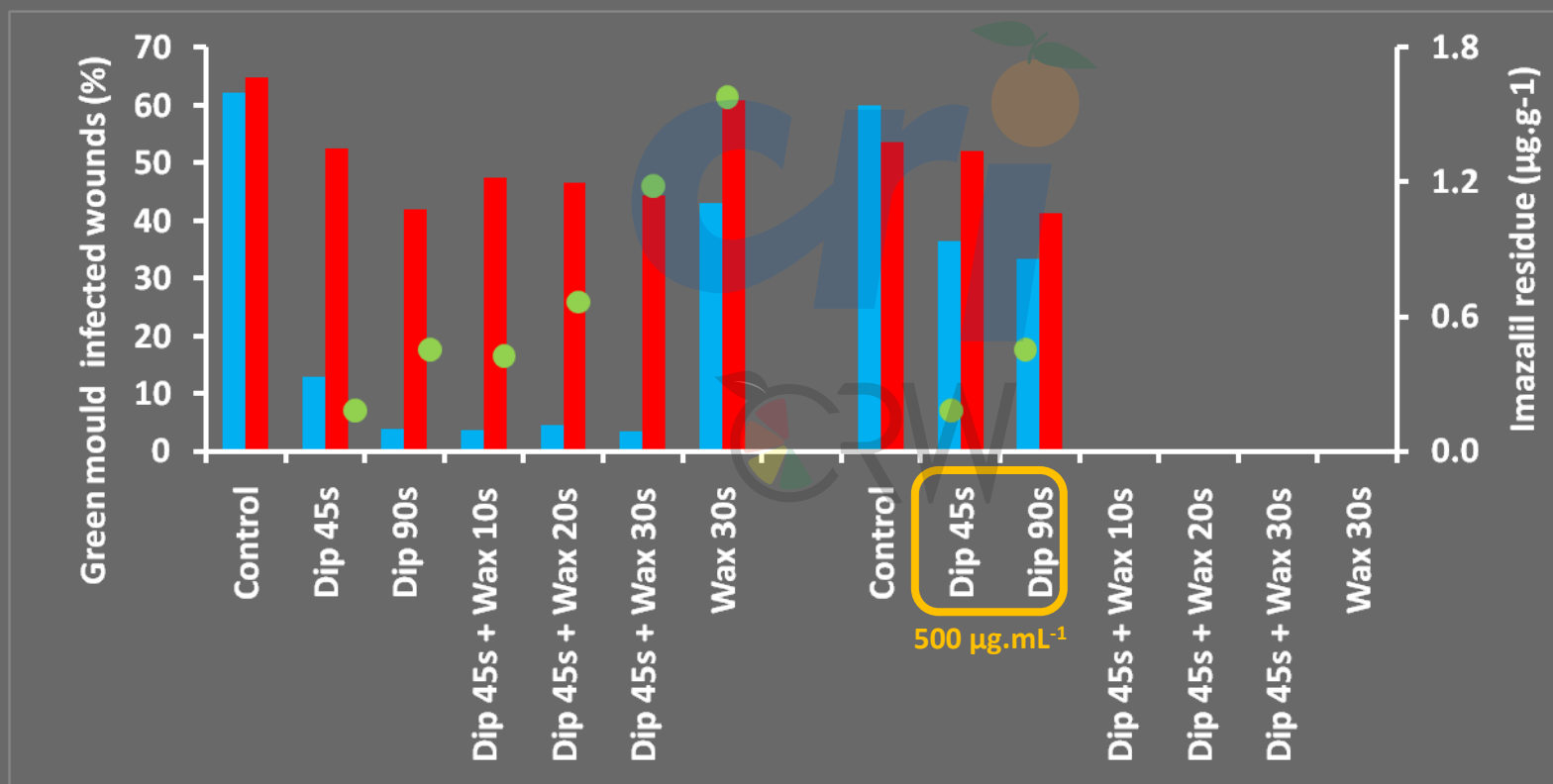
■ Sensitive isolate

■ Resistant isolate

Results – Green mould infection

Curative

Protective



10s = 0.6 20s= 1.2 30s= 1.8L/ton

● IMZ residue

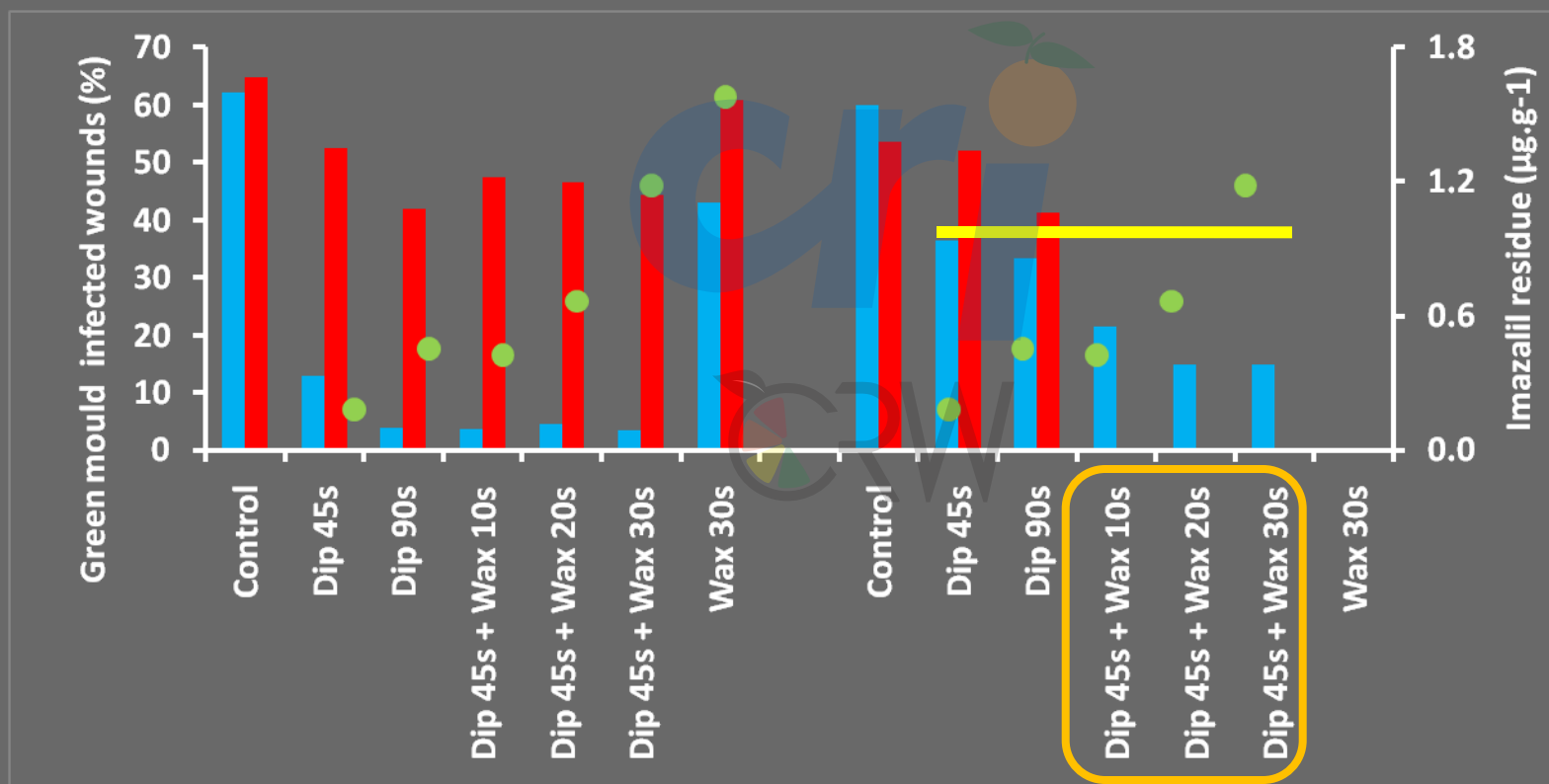
■ Sensitive isolate

■ Resistant isolate

Results – Green mould infection

Curative

Protective



Wax: 2000 µg.mL⁻¹

10s = 0.6 20s = 1.2 30s = 1.8L/ton

● IMZ residue

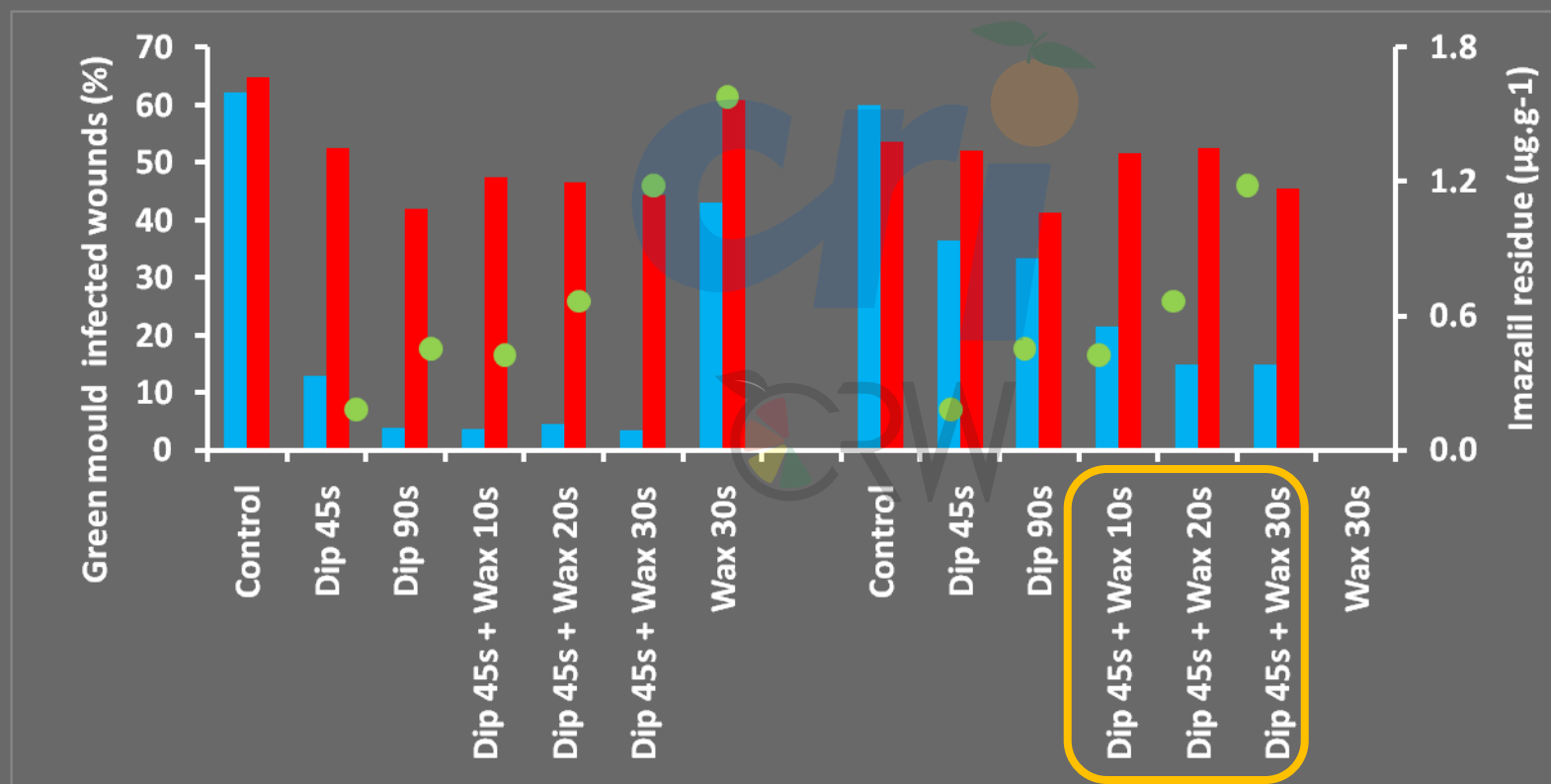
■ Sensitive isolate

■ Resistant isolate

Results – Green mould infection

Curative

Protective



Wax: 2000 µg.mL⁻¹

10s = 0.6 20s = 1.2 30s = 1.8L/ton

● IMZ residue

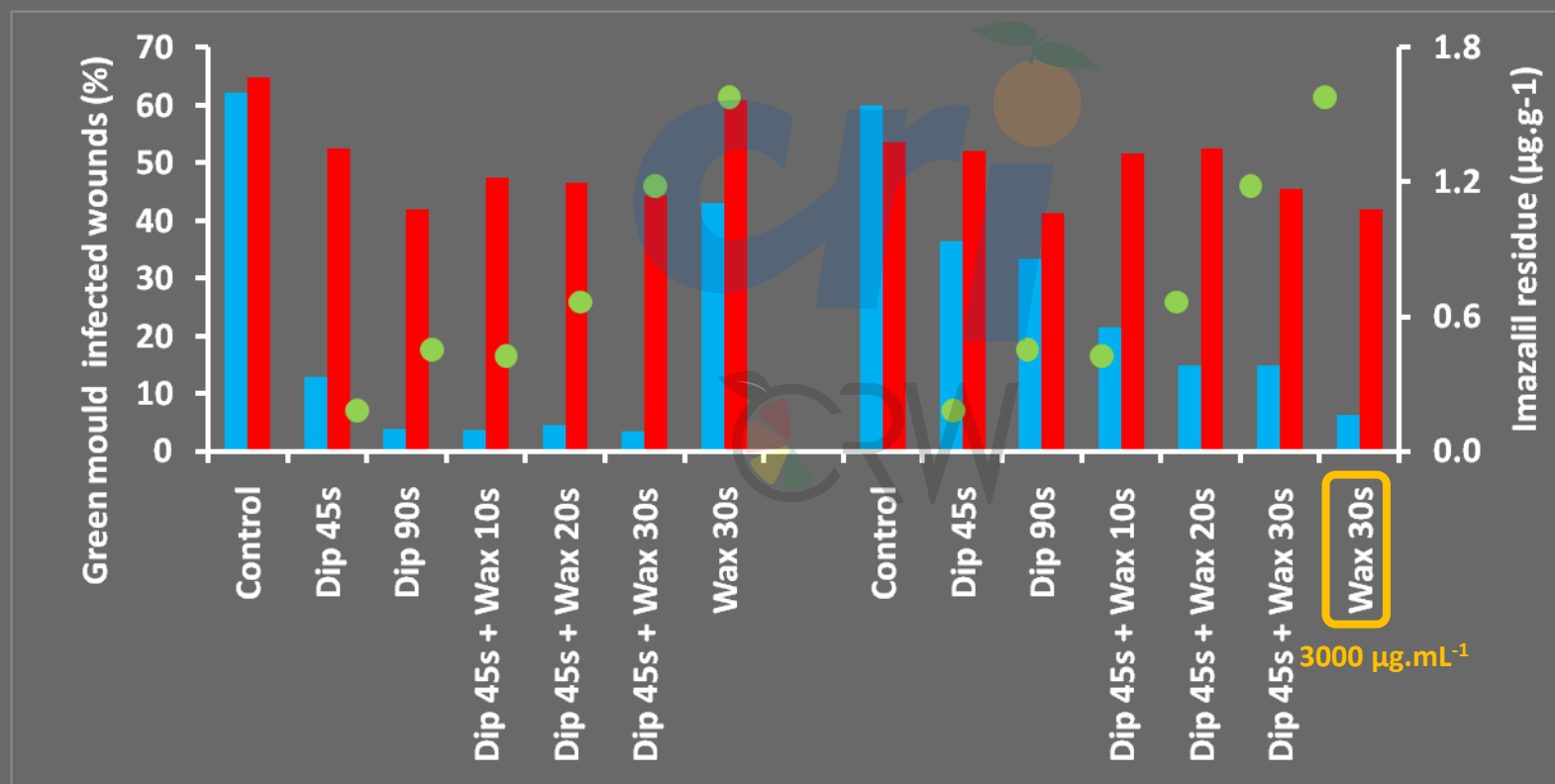
■ Sensitive isolate

■ Resistant isolate

Results – Green mould infection

Curative

Protective



10s = 0.6 20s = 1.2 30s = 1.8L/ton

● IMZ residue

■ Sensitive isolate

■ Resistant isolate

Sporulation





Conclusion

Imazalil applied through wax:

- **Better protective than curative control**
 - opposite to aqueous dip application
- **Synergistic effect between imazalil and cold storage**
- **Longer exposure time on wax applicator = better residue + control + sporulation inhibition**
 - **Poor control of resistant isolate**

Conclusion

Double application of imazalil (dip + wax):

- IMZ residue loading =
 $\text{Wax only} > (\text{Wax} + \text{Dip}) > \text{Dip only}$
- Sensitive isolate:
 - Curative control = $(\text{Wax} + \text{Dip}) > \text{Dip only} > \text{Wax only}$
 - Protective control = $\text{Wax only} > (\text{Wax} + \text{Dip}) > \text{Dip only}$
- Resistant isolate:
 - Loss of control

Recommendation

From this study:

- Double application (dip + wax) will give good curative and protective control of sensitive isolate
- Single application (dip only) = longer exposure time is needed for adequate control
- POOR control of imazalil resistant isolate
 - Imazalil resistance management is important
 - Adequate residue loading
 - Use alternative fungicides / fungicide mixtures
 - SANITATION !!!
 - “Get tested, know your status”

ACKNOWLEDGEMENTS



THANK YOU

