Preharvest-Applied Fungicides & Postharvest ClO_2 Gas for Reducing Diplodia Stem-end Rot on Fresh Grapefruit

Mark A. Ritenour
University of Florida
Indian River Research and Education Center
Estes Citrus Inc

UF UNIVERSITY of FLORIDA
The Foundation for The Gator Nation

Control Options

- Preharvest - No reliable replacement yet for Benlate or Topsin
  - **However, copper, Aliette, and phosphorous acid products to reduce Brown rot**
- Postharvest control measures
  - **Good sanitation practices**
  - **Careful handling**
  - **Use of fungicides**
    - Must be effective against latent organisms such as Diplodia and Anthracnose

Diplodia stem-end rot

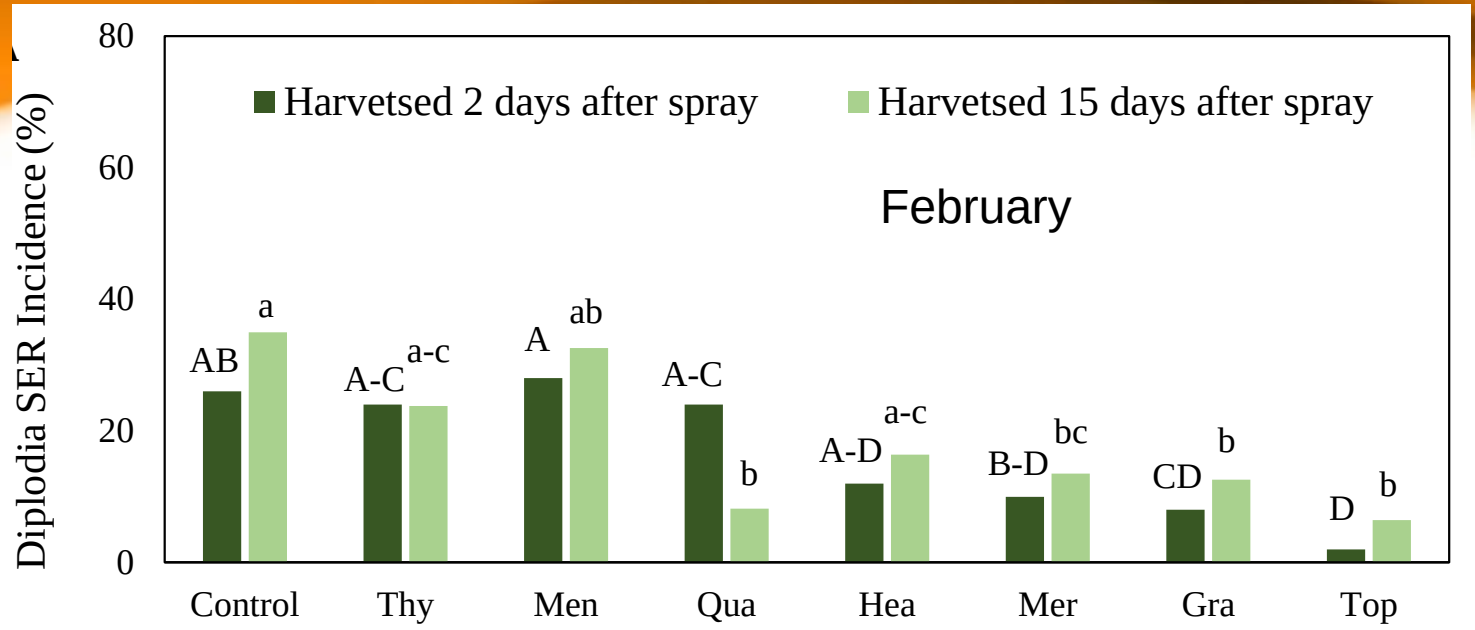
Fruit Decay - on Tree!

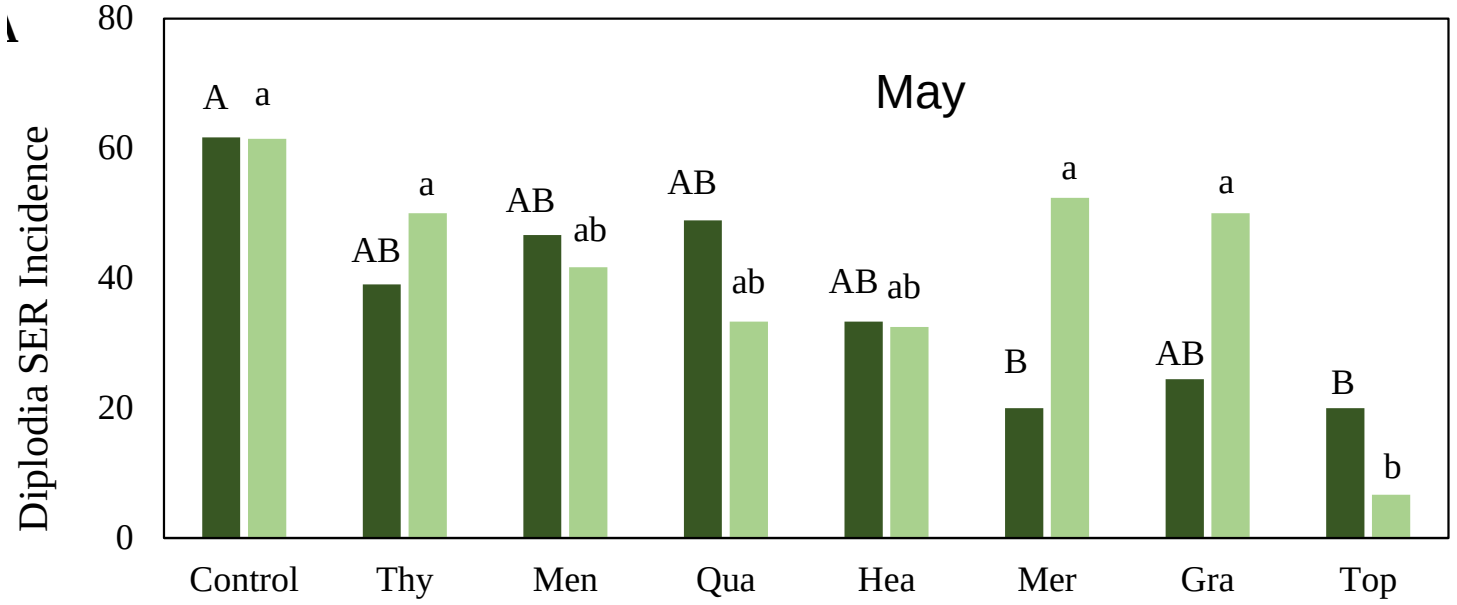
- Diplodia (*Lasiodiplodia theobromae)* causes fruit stem-end rot and was:
  - **Consistently detected in the abscission zone and juice of HLB-infected fruit**
  - **Greater abundance of Diplodia was positively correlated with lower fruit detachment force**
  - **Fruit ethylene production is positively correlated with Diplodia infection levels**
  - **Quadris Top = multiple applications gave intermittent control under HLB conditions**

Zhao et al., 2015, 2016

Materials and Methods (2019-2020 season)

- Materials were hand-sprayed on individual grapefruit within the tree canopy at 2 locations (groves)
- Fruit were harvested 2 and 14 days after fungicide treatments and subjected to 6-day degreening conditions (5 ppm ethylene, 85^{o}F, and 90% RH)
- The fruit were then incubated at 75^{o}F with 90-95% RH for up to 15 days and evaluated for Diplodia SER and other decays every 3 days





Treatments:

Control = Water

Thy = Thymeguard (Thyme oil)

Men = Mentor EC (Propiconazole)

Qua = Quadris Top (now Amistar Top) (Azoxystrobin + Difenconazole)

Hea = Headline (Pyraclostrobin)

Mer = Mertect 340F (Thiabendazole)*

Gra = Graduate A+ (Azoxystrobin + Fludioxonil)*

Top = Topsin (thiophanate-methyl)*

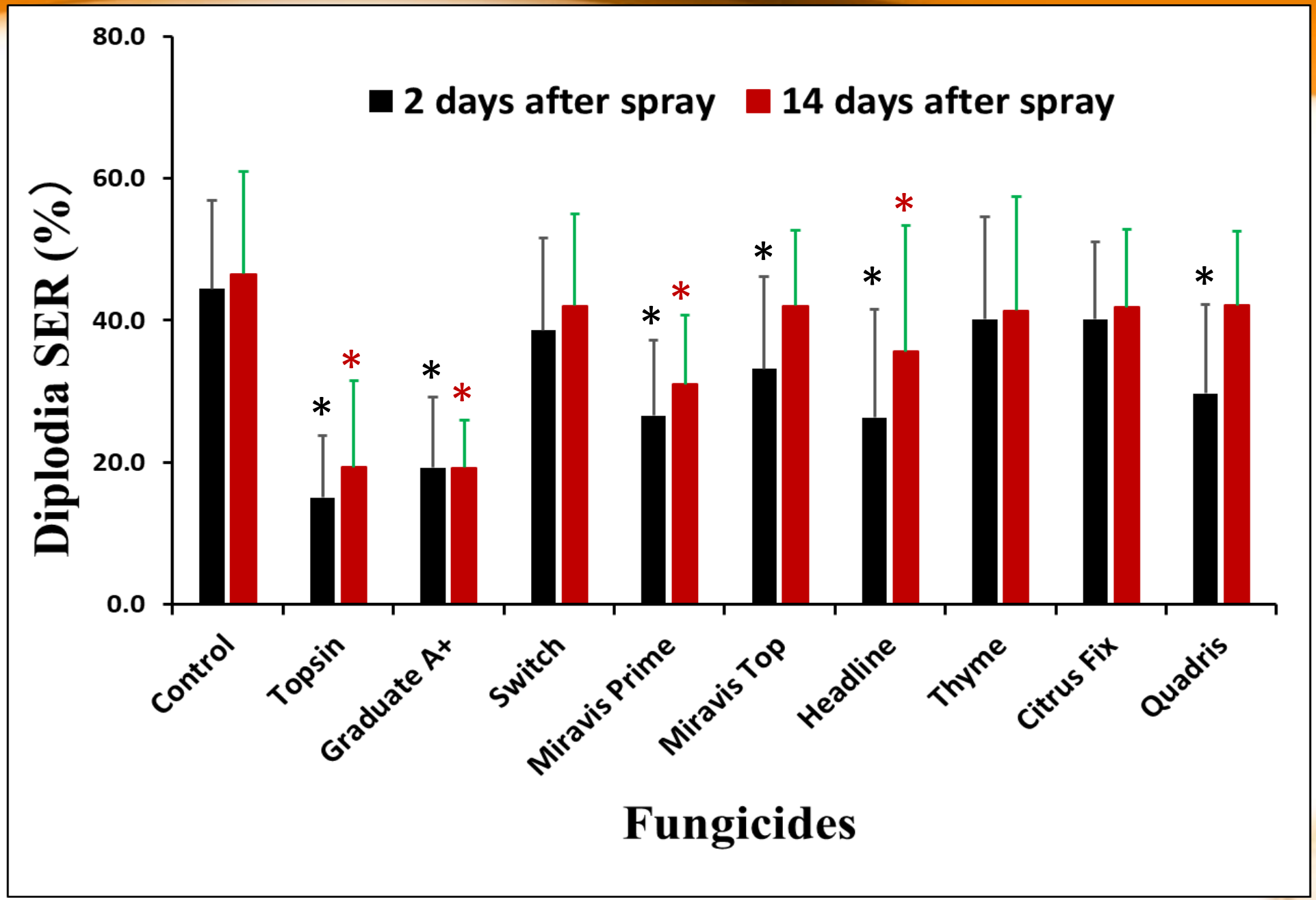
*Not labeled preharvest for Florida grapefruit

Dr. Jiaqi Yan
Dr. Jiuxu (John) Zhang
Cuifeng Hu

2020-21 Preharvest Trials (4 red grapefruit fields)

- CONTROL - WATER
- Topsin 4.5 FL*
  - **thiophanate-methyl (45%)**
- Graduate A+ *
  - **fludioxonil (20.6%) + azoxystrobin (20.6%)**
- Switch 62.5 WG
  - **fludioxonil (25%) + cyprodinil (37.5%)**
- Miravis Prime*
  - **fludioxonil (21.4%) + pydiflumetofen (12.8%)**
- Miravis Top
  - **difenconazole (11.5%) + pydiflumetofen (6.9%)**
- Headline
  - **pyraclostrobin (23.6%)**
- Thyme Guard (Thyme)
  - **thyme (23%)**
- Citrus Fix (2,4-d) *
  - **2, 4-D (45%)**
- Quadris Top (now Amistar Top)
  - **azoxystrobin (18.2%) + difenoconazole (11.4%)**

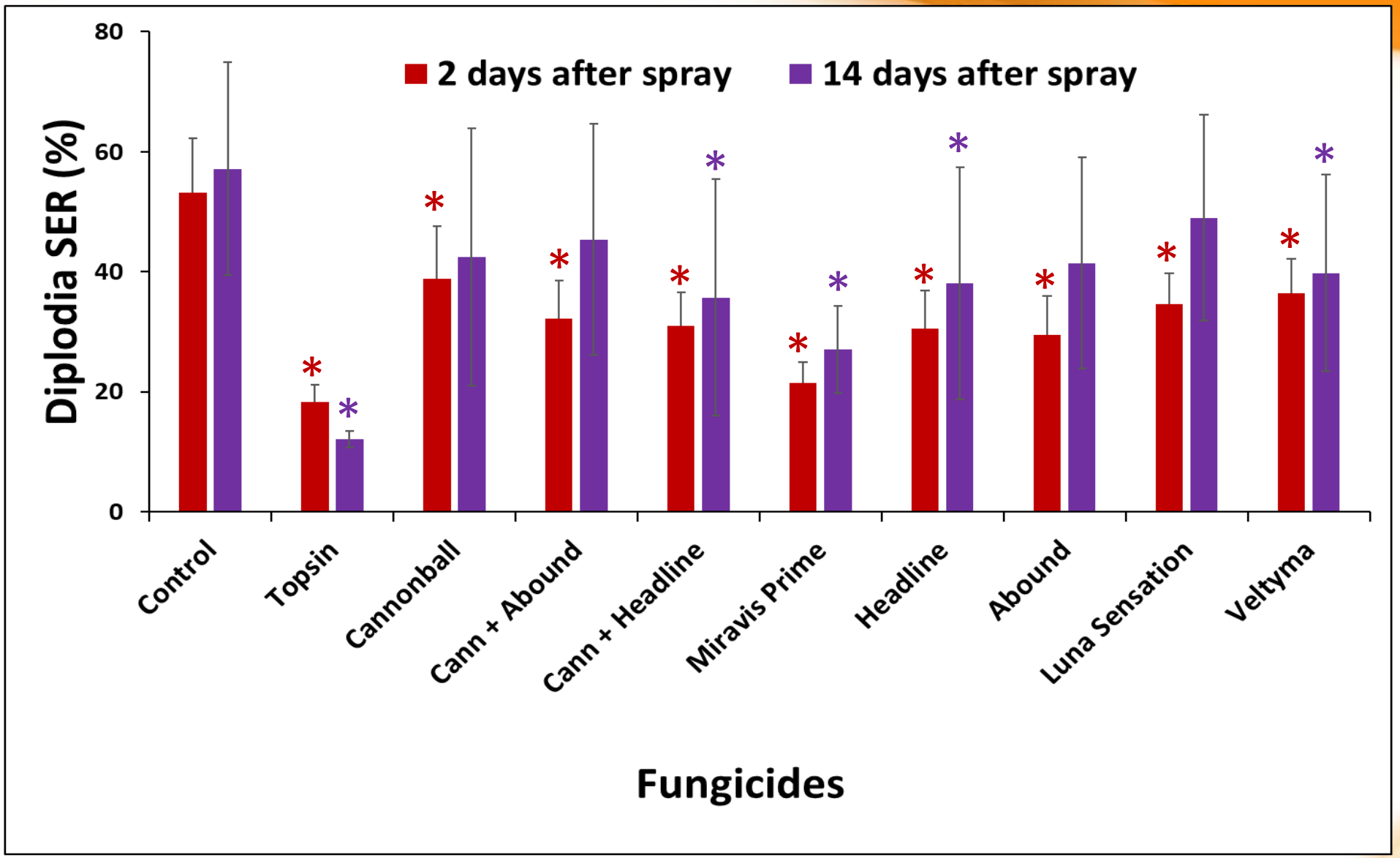
***not labeled preharvest for FL grapefruit**


80.0
60.0
40.0
20.0
0.0
Diplodia SER (%)
2 days after spray
14 days after spray
Control
Topsin
Graduate A+
Switch
Miravis Prime
Miravis Top
Headline
Thyme
Citrus Fix
Quadris
Fungicides

2021-22 Preharvest Trials (3 red grapefruit fields)

- CONTROL - WATER
- Topsin 4.5 FL*
  - **thiophanate-methyl (45%)**
- Cannonball *
  - **fludioxonil (50%)**
- Miravis Prime*
  - **fludioxonil (21.4%) + pydiflumetofen (12.8%)**
- Abound
  - **Azoxystrobin (22.9%)**
- Headline
  - **pyraclostrobin (23.6%)**
- Cannonball* + Abound
- Cannonball* + Headline
- Luna Sensation
  - **Fluopyram (21.4%) + trifloxystrobin (21.4%)**
- Veltyma
  - **Pyraclostrobin (17.56%) + mefentrifluconazole (17.56%)**

***not labeled preharvest for FL grapefruit**


2 days after spray
14 days after spray
Diplodia SER (%)
80
60
40
20
0
Control
Topsin
Cannonball
Cann + Abound
Cann + Headline
Miravis Prime
Headline
Abound
Luna Sensation
Veltyma
Fungicides

Summary

- **Topsin** 4.5FL demonstrated the best Diplodia SER control
  - **but it is NOT registered**
- **Graduate A+** controlled Diplodia SER
  - **But it is NOT registered, and component fungicide concentrations are much higher than what would be allowed preharvest**
- Strobilurin-based fungicides (such as **Abound** and **Headline**) moderately reduced Diplodia SER when decay pressure
- **Miravis Prime** (not yet registered for grapefruit) consistently showed significant and moderate Diplodia SER control and appears to be a good candidate for grapefruit registration for Diplodia SER control

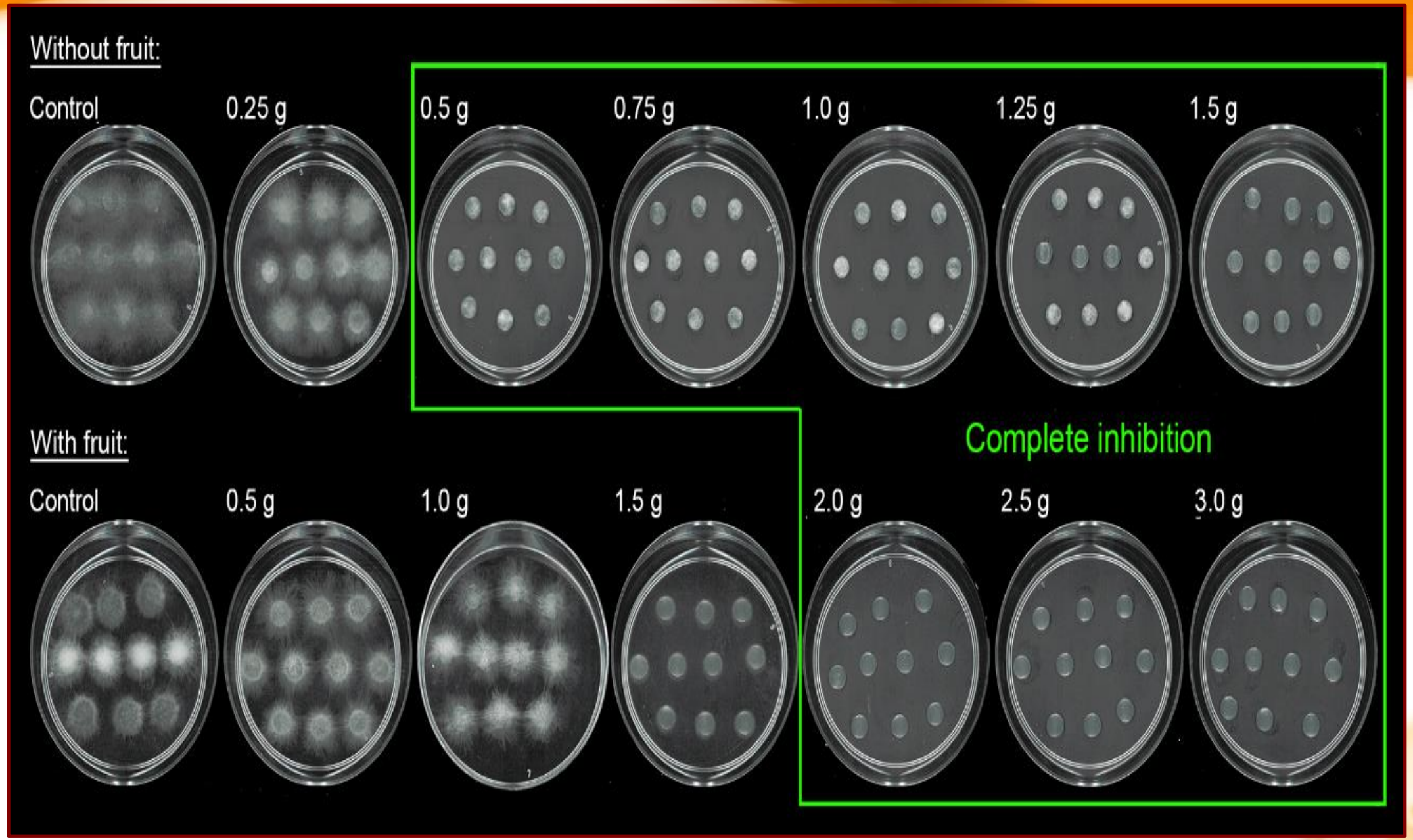
ClO_2 Gas for Reducing Postharvest Diplodia Stem-end Rot on Grapefruit

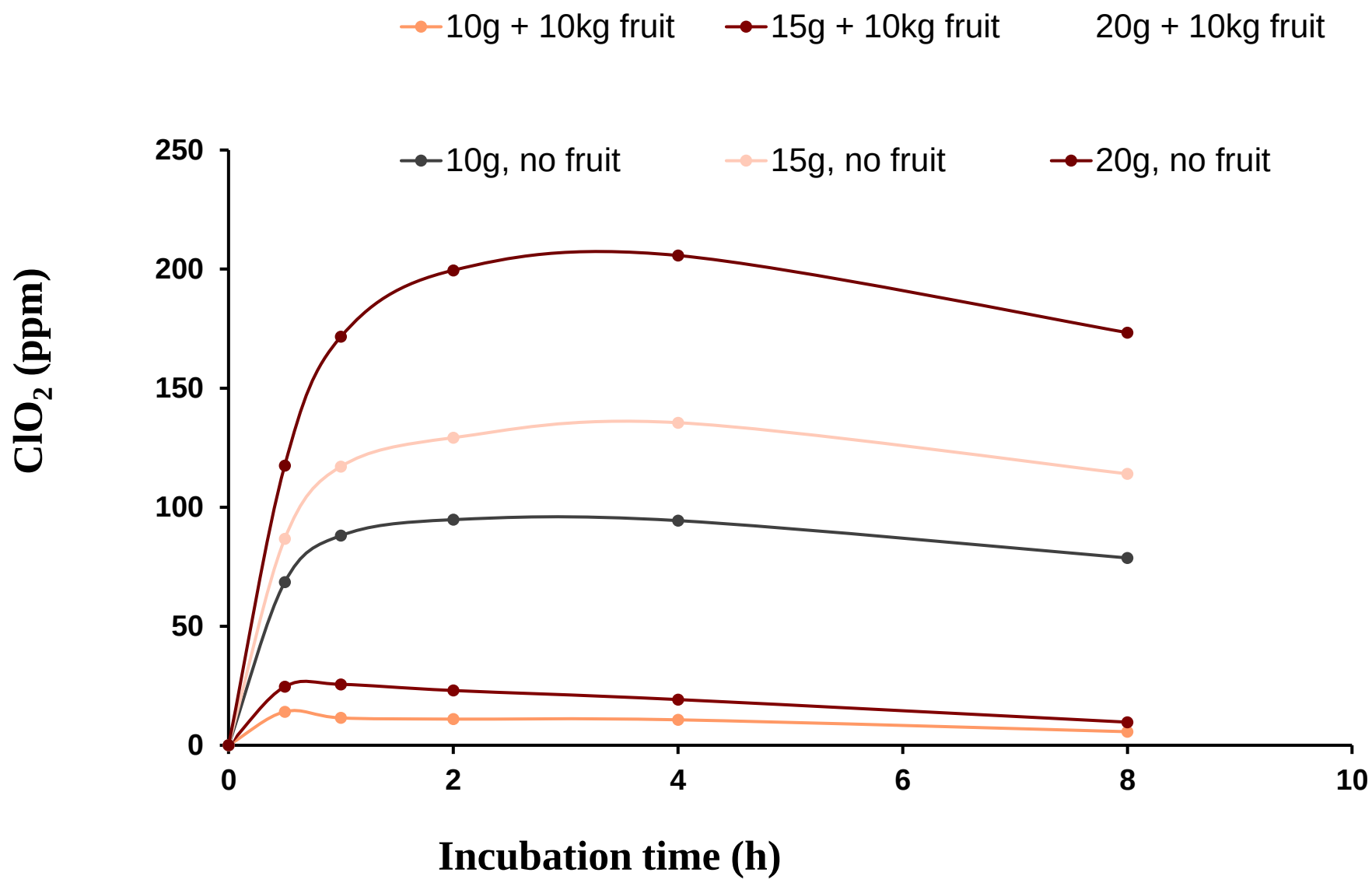
Chlorine Dioxide (ClO_2) Gas

- Strong oxidizing agent, with about 2.5 times higher activity than chlorine
- Broad biocidal effectiveness
- Previously tested in water solutions as a sanitizer
- Previous work in our lab (Zhong et. al. 2021) showed that gaseous ClO_2 treatments (ICA TriNova, LLC.) reduced Diplodia SER on mandarins
- The objective of the current studies were to evaluate the potential of ClO_2 gas to control postharvest Diplodia SER on grapefruit

Materials and Methods

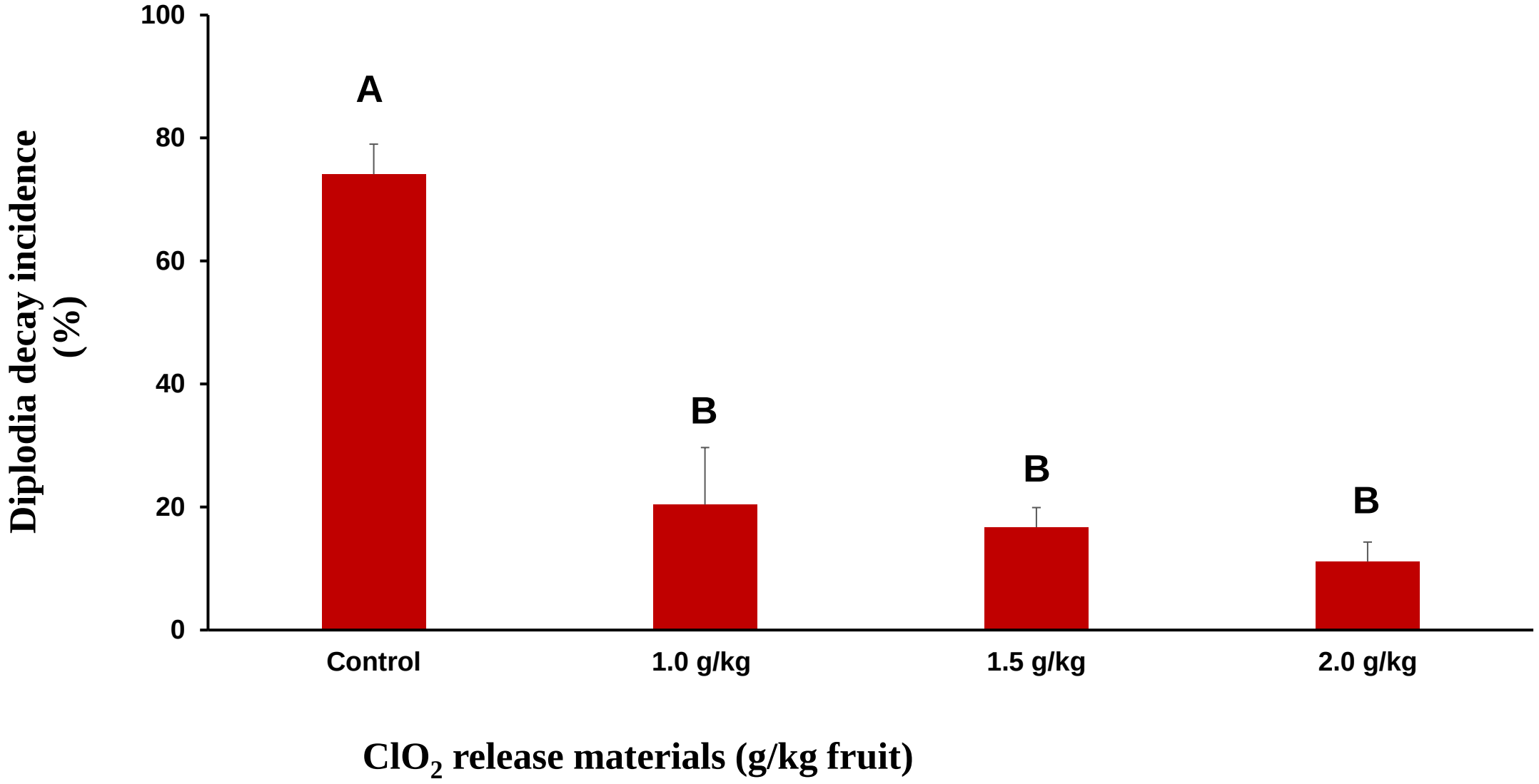
- **In vitro** antifungal activity tests:
  - **Place fungal PDA plugs and "fast" ClO_2-releasing materials at various rates in sealed plastic containers**
  - **Incubate for 24 h**
  - **Measure mycelial growth by incubating fungal plugs for an additional 24 h after treatment**


Without fruit:
Control
0.25 g
0.5 g
0.75 g
1.0 g
1.25 g
1.5 g
With fruit:
Control
0.5 g
1.0 g
1.5 g
Complete inhibition
2.0 g
2.5 g
3.0 g


10g + 10kg fruit
15g + 10kg fruit
20g + 10kg fruit
10g, no fruit
15g, no fruit
20g, no fruit
ClO2 (ppm)
250
200
150
100
50
0
0
2
4
6
8
10
Incubation time (h)

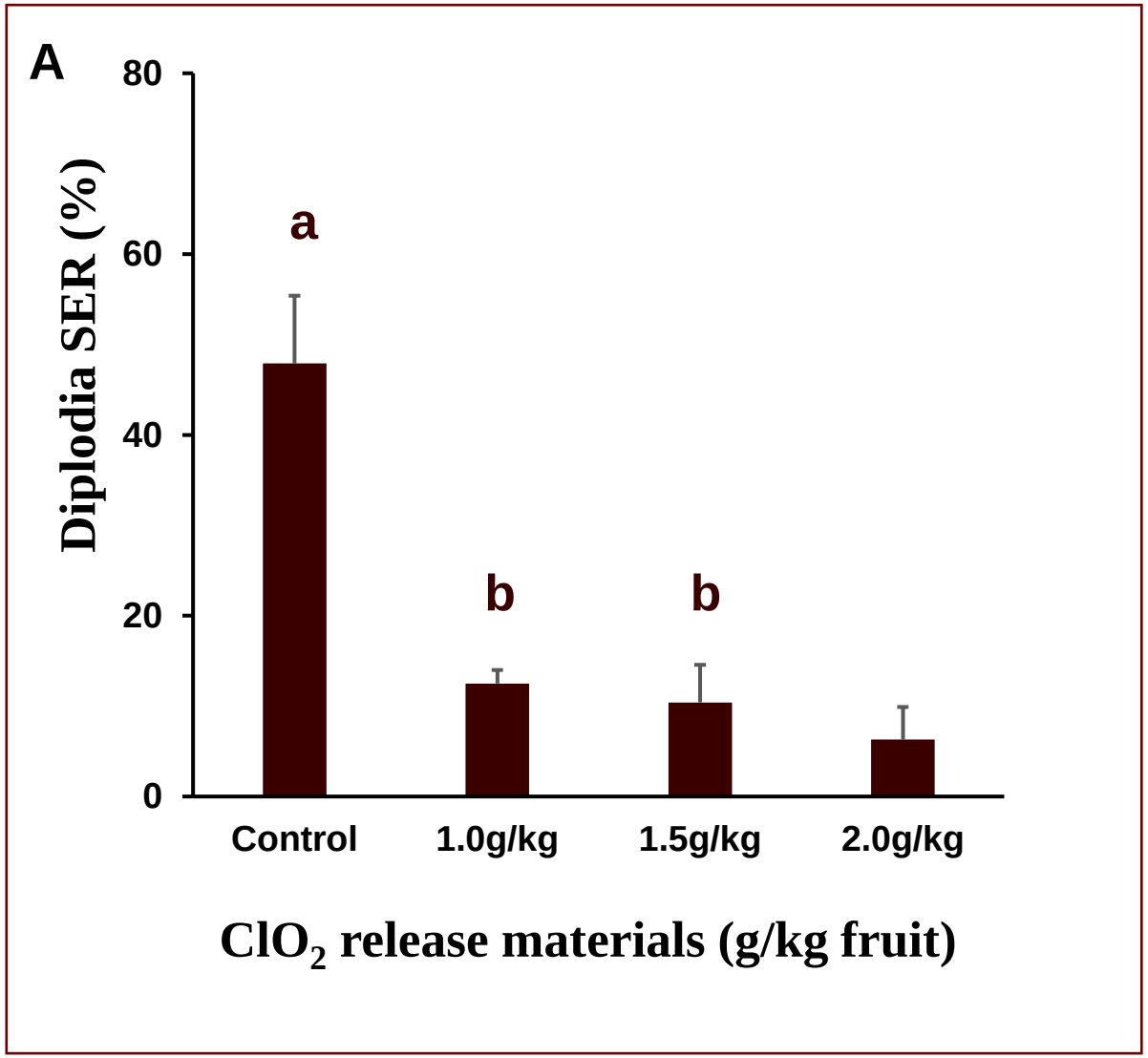
Materials and Methods

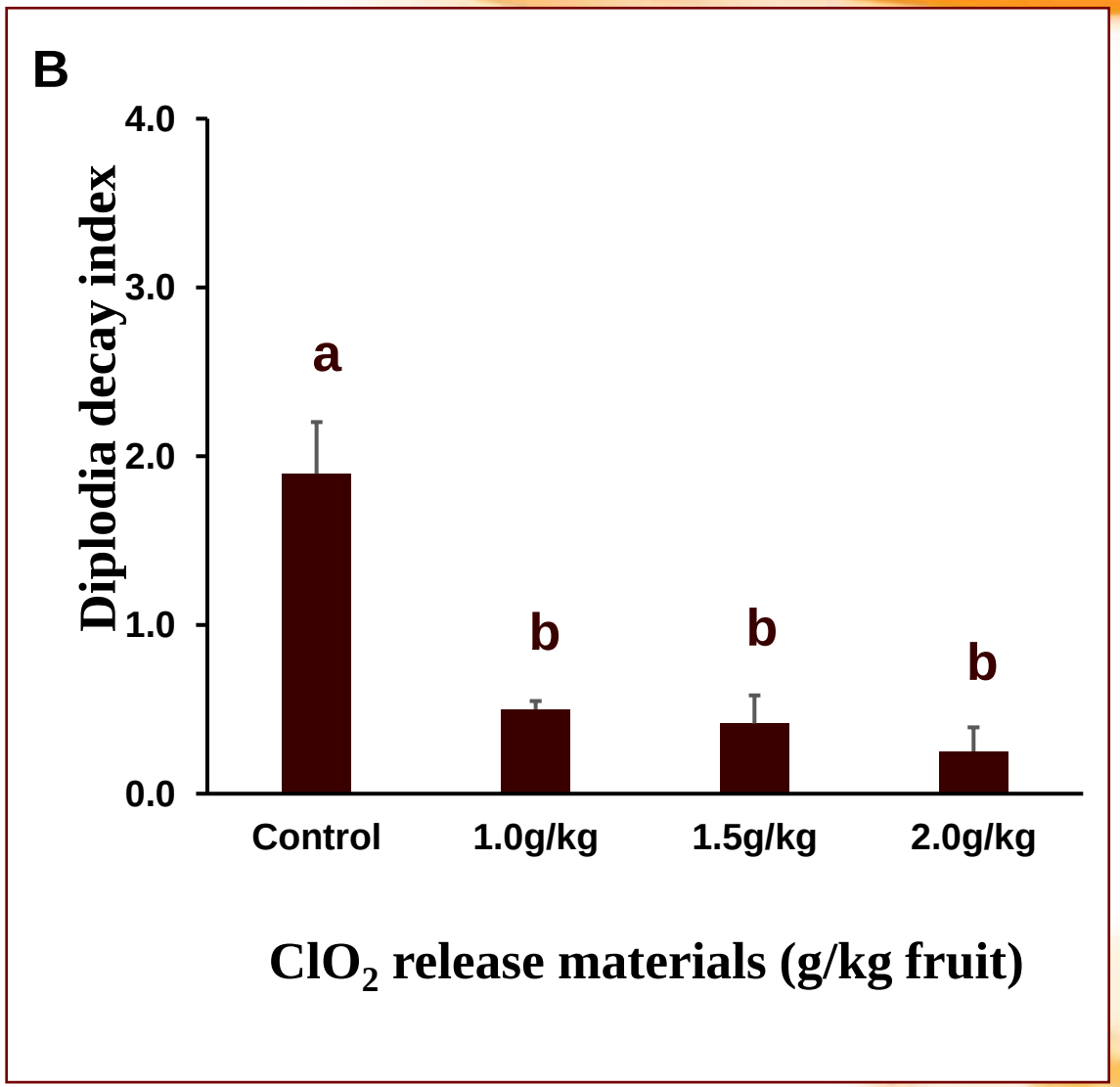
- **Inoculated grapefruit** (4 h prior):
  - **Treated with fast ClO_2 gas release materials at three concentrations for 8 h in sealed plastic containers**
  - **ClO_2 concentrations were monitored using a PortaSens II ClO_2 gas detector**
  - **Decay was evaluated 3 and 6 days after fruit were incubated at 75ºF with 90-95% RH**

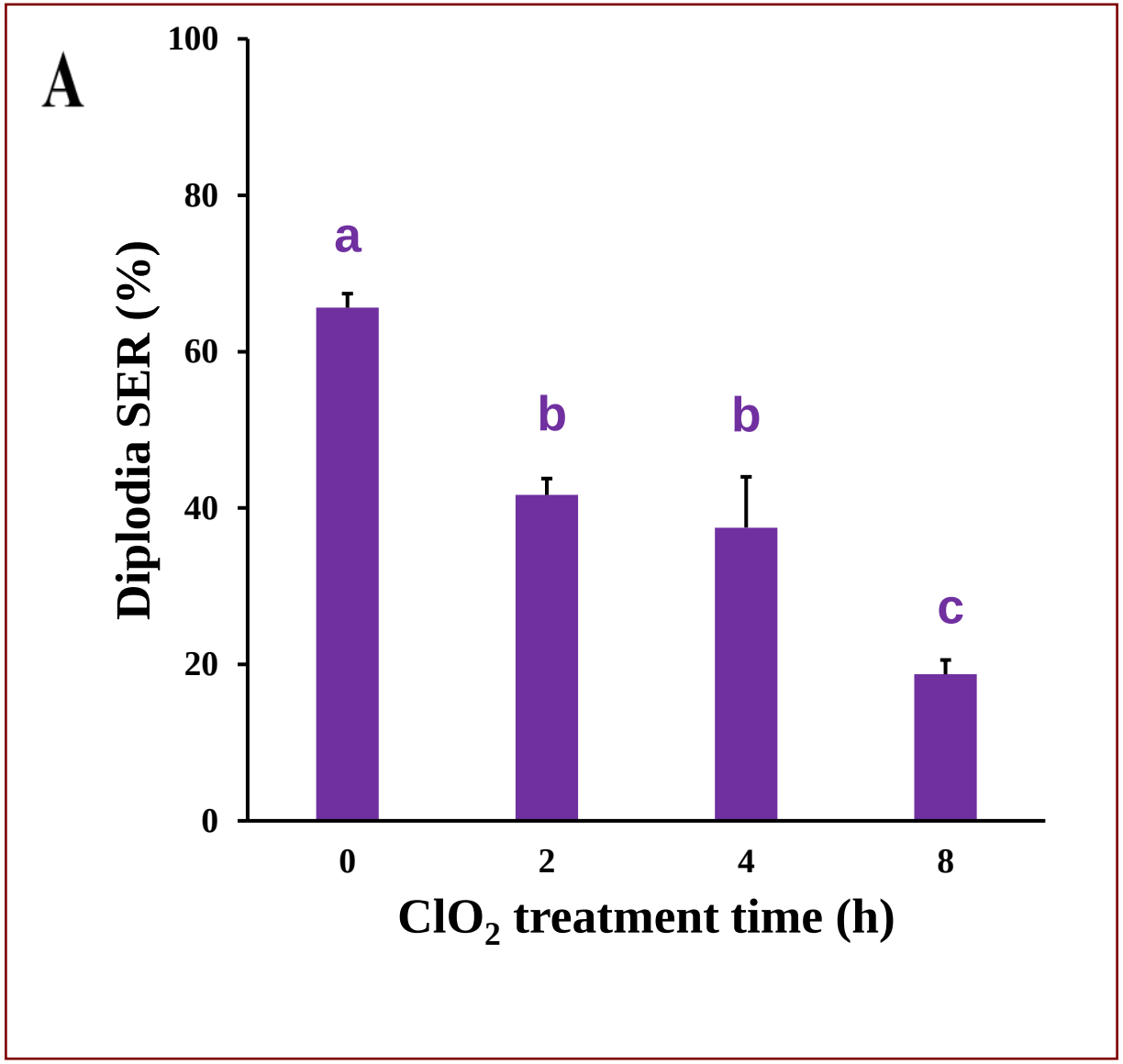

Diplodia decay incidence (%)
100
80
60
40
20
0
A
B
B
B
Control
1.0 g/kg
1.5 g/kg
2.0 g/kg
ClO2 release materials (g/kg fruit)

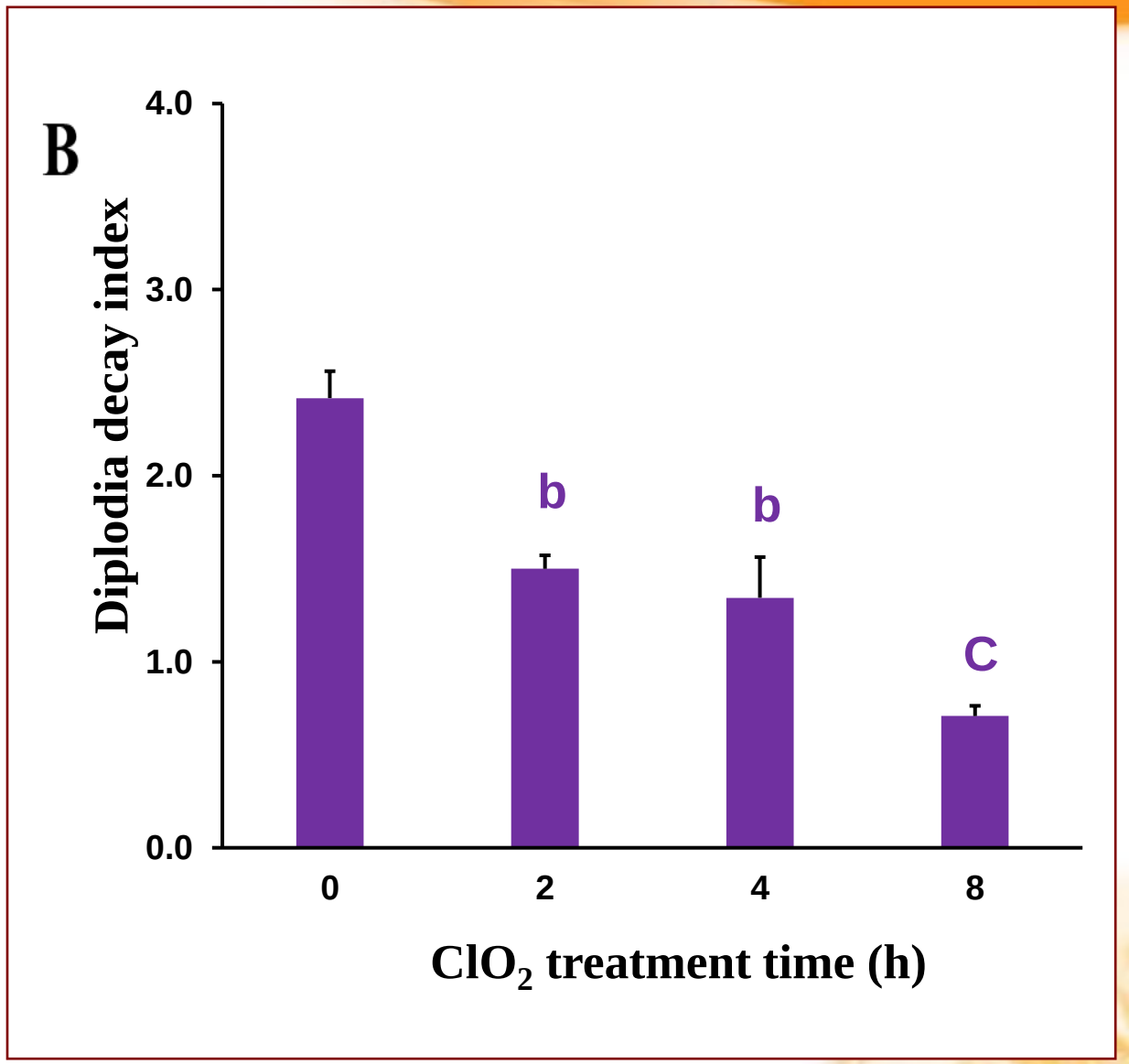
Materials and Methods

- **Naturally infected grapefruit**:
  - **Placed in a sealed plastic container**
  - **"Fast" ClO_2 gas release materials applied:**
    - at three concentrations at 75ºF for 8 h, or
    - At one concentration (1g/kg fruit) for 2, 4, or 8 h
  - **After degreening (5 ppm eth) for 3 days, the fruit were incubated at 75ºF with 90-95% RH for up to 3 weeks and decay evaluated weekly**


A
Diplodia SER (%)
80
60
40
20
0
a
b
b
Control
1.0g/kg
1.5g/kg
2.0g/kg
ClO2 release materials (g/kg fruit)


B
Diplodia decay index
4.0
3.0
2.0
1.0
0.0
a
b
b
b
Control
1.0g/kg
1.5g/kg
2.0g/kg
ClO2 release materials (g/kg fruit)


A
100
80
60
40
20
0
Diplodia SER (%)
a
b
b
c
0
2
4
8
ClO2 treatment time (h)


B
4.0
3.0
2.0
1.0
0.0
Diplodia decay index
b
b
C
0
2
4
8
ClO2 treatment time (h)

Summary

- Grapefruit treated with 1.0g/kg fruit of a ClO_2 releasing product for 8 h significantly reduced Diplodia SER of inoculated and naturally infected fruit without causing fruit peel damage and or altering other quality attributes (e.g., weight loss, firmness, acids, soluble solids)
- This ClO_2 gas treatment shows potential to be included as a component of Florida's fresh citrus decay control strategy
- However, this system requires further testing under more commercial conditions

Pesticie

Maximum Residue Limits

Maximum Residue Limits (MRLs)

- Industry vigilance is required when MRLs for export markets are lower than U.S. MRLs
  - **Countries change MRLs periodically**
  - **Limited knowledge of how fast residues of various compounds decline under different production/postharvest conditions**

http://irrec.ifas.ufl.edu/postharvest/

Or simply search for

"UF Postharvest"

UF/IFAS Postharvest Programs & Information

- **General Postharvest Information**
- **Citrus Packinghouse Newsletter**
  2010-2019, Index, Archives
- **Topical Index**
  Preharvest, Maturity & Quality, Diseases & Decay Control, Cold Storage, Sanitation & Food Safety, Marketing

Pesticide Residues & Maximum Limits

UF/IFAS Publications

- **Maximum Residue Limits (MRLs) for FL Citrus**
  For U.S. & Selected Export Markets
  Updated Feb. 7, 2022.
  Condensed list of recent changes in Korean MRLs
- UF Pesticide Information Office
  Chemically Speaking Newsletter

Pesticide MRL Web Resources

- **BCGlobal (Global MRL Database)** - Bryant Christie, supported by the USDA Foreign Agricultural Service (FAS).
- **U.S.A. Code of federal regulations** - Go to Title 40, Part 180 found **here** for the official list of U.S. MRLs.
  - See **Subpart D—Exemptions From Tolerances**
  -Substances Generally Regarded as Safe (GRAS)
  -GRAS Overview Website
- **European Union** - EU-MRL Pesticide Database--European Commission Directorate General for Health and Consumers. Quick jump to: **Grapefruit**, **Orange**
  -USDA EU Early Alert Notifications

Downloads

Adobe Reader

Resources

Pesticides--EPA

Chemical Name	Brand or Trade Names (Examples only, not exhaustive)	U.S. Citrus	CODEX Citrus	Canada Citrus	EU (G & O only)	Great Britain (G & O only)	Japan (G & O only)	Korea (G & O only)	Taiwan (G & O only)
2,4-D (2,4-Dichlorophenoxyacetic acid)	Citrus Fix, Hivol	3	1	2	1	1	2 (3 proposed)	0.15	2
Abamectin	Agri-Mek, Clinch, Zephyr, ABBA, Epi-mek, Reaper; Minecto Pro	0.02	0.02	0.02	0.04	0.04	0.1	0.01 (G); 0.05 (O)	0.01
Acequinocyl	Kanemite	0.35		0.35	0.2 (G); 0.4 (O) (0.6 proposed)	0.2 (G); 0.4 (O)	2	0.01 (G); 0.7 (O)	0.2
Beta-cyfluthrin	Baythroid XL	0.2	0.3	0.1	0.02 (E)	0.02	2 (1 proposed)	0.2	0.3
Bifenthrin	Brigade, Capture, Telstar, Fanfare	0.05	0.05	0.1	0.05 (E)	0.05	2	0.01 (G), 0.5 (O)	0.5
Bromacil	Bromo, Hyvar	0.1		0.1	0.01	0.01	0.1	0.01	0.5
Buprofezin	Applaud, Centaur	4	1	0.1 (G, L, P), 4 (O, T)	0.01	0.01	3 (G), 2 (O)	0.01 (G), 2.5 (O)	0.5
Carbaryl	Sevin	10	15	10	0.01	0.01	5	0.01 (G), 7 (O)	1
Carfentrazone-ethyl	Aim	0.1		0.1	0.02	0.01	0.1	0.01	0.1
Clothianidin	Belay	0.07	0.07	0.1	0.06 (E)	0.06	2	0.01 (G); 0.3 (O)	1
Cyfluthrin	Baythroid	0.2	0.3	0.1	0.02	0.02	2	0.2	0.3
Diflubenzuron	Micromite	3	0.5	0.1	0.01	0.01	3	0.01 (G); 2 (O)	1
Dimethoate	Dimethoate, Cygon	2	5	1.5	0.01	0.01	2	0.01	2
Diuron	Diuron, Direx, Karmex	0.05, 0.5 (L)		1	0.01	0.01	0.8 (G), 0.05 (O)	0.01	0.05 (G), 0.2 (O)
Fenbutatin Oxide	Vendex	20	5	2	0.01	0.01	5	0.01	2
Ferbam	Ferbam	4	10 (T), 2 (O)	0.1	0.01	0.01	2	0.01	2
Fosetyl-aluminum	Aliette	9	50 (T), 20 (O)	9	75	75	150	0.01 (G), 4 (O)	10
Glyphosate	Roundup, Durango, Touchdown, & others	0.5		0.1	0.1 (G) 0.5 (O)	0.1 (G) 0.5 (O)	0.5	0.05	0.1
Imazalil	DECCOZIL EC-289, Freshgard 700, Fungaflor 500EC	10	5 (G, T, P), 8 (O), 15 (L)	5	4	4	5	15	5
Malathion	Malathion, Atrapa, Fyfanon	8	7	0.1	2 (E)	2	7	0.01 (G), 4 (O)	2

Chemical Name	Brand or Trade Names (Examples only, not exhaustive)	U.S. Citrus	CODEX Citrus	Canada Citrus	EU (G & O only)	Great Britain (G & O only)	Japan (G & O only)	Korea (G & O only)	Taiwan (G & O only)
Metalaxyl-M, Mefenoxam	Ridomil Gold, Subdue, UltraFlourish	1	5	5	0.7 (E)	0.7	0.7	0.01	0.5
Metaldehyde	OR-Cal Slug & Snail Bait	0.26		0.1	0.05	0.05	0.7	0.01	
Norflurazon	Solicam	0.2		0.1	0.01	0.01	0.2	0.01	0.2
Oryzalin	Oryzalin, Surflan	0.05		0.1	0.01	0.01	0.08	0.01	
Oxamyl	Vydate	3		0.1	0.01	0.01	5	0.01	0.5 (G), 1 (O)
Paraquat Dichloride	Paraquat, Gramoxone, Boa	0.05	0.02	0.1	0.02	0.02	0.05	0.01	0.2
Piperonyl Butoxide	Evergreen EC	8 (O)	5 (O)	8 (O)			5 (O)	0.01 (O)	5 (O)
Propargite	Comite, Omite	5 (G, L), 10 (O)	3	5	0.01 (G), 4 (O) (E)	0.01 (G), 4 (O)	3 (5 proposed)	0.01	5
Pyrethrins	Pyrellin (+ Rotenone), Evergreen (+ Piperonyl Butoxide)	1 (O)	0.05 (O)	1 (O)	1 (O)	1 (O)	1 (O)	0.01 (O)	0.05 (O)
Pyridaben	Nexter	0.9		0.9	0.3	0.3	1	0.01	2
Pyriproxyfen	Distance, Esteem, Knack	0.5	0.5	0.5	0.6	0.6	2	0.01	0.3 (G), 0.5 (O)
Sethoxydim	Poast Plus	0.5		0.1	0.1 (0.01 proposed)	0.1	0.5	0.01	
Simazine	Simazine, Princep, Sim-Trol	0.25 (G, O, L)		0.1	0.01	0.01	0.2	0.01	
SOPP (2 Phenylphenol, O-phenylphenol, OPP)	DECCOSOL 125, FreshGard 5	10	10	10	10	10	10	0.01	10
Spinetoram	Delegate	0.3	0.07 (O), 0.15 (T)	0.3	0.2 (0.02 G; 0.07 O proposed)	0.2	0.7	0.01 (G), 0.05 (O)	0.2
Trifluralin	Trifluralin, Treflan, Trilin	0.05		0.1	0.01	0.01	0.05	0.01	0.05
zeta-cypermethrin	Mustang	0.35	0.5 (G, P), 0.3 (O, T, L)	1	2 (E)	2	2	0.3	2

Thank You!

- For more information,
  visit the UF Postharvest Website

  http://irrec.ifas.ufl.edu/postharvest/