Resistance of *Botrytis* to fungicides in California strawberries

S.D. Cosseboom[1], G. Schnabel[2], K.L. Ivors[1], and G.J. Holmes[1]

[1]Strawberry Center, California Polytechnic State University; [2]Clemson University, SC

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Outline

- Background of Botrytis resistance to fungicides in strawberry
- How fungicide resistance develops
- Current status of resistance in California strawberries
- Conclusions
  - Disease management options
  - Resistance management strategies

Background

Fungicide Resistance Profiles in *Botrytis cinerea* from Strawberry Fields of Seven Southern U.S. States

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Independent Emergence of Resistance to Seven Chemical Classes of Fungicides in *Botrytis cinerea*

Phenotypic Characterization of Multifungicide Resistance in *Botrytis cinerea* Isolates from Strawberry Fields in Florida

A. Amiri, S. M. Heath, and **N. A. Peres,** University of Florida, Gulf Coast Research and Education Center, Wimauma, FL 33598

Eastern U.S.

- High levels of resistance to important fungicides for Botrytis gray mold control in strawberries
- Resistance increasing from
- Isolates resistant to multiple

Fungicide Resistance Among *Botrytis cinerea* Isolates from California Strawberry Fields

Julien Mercier (present address, Harris Moran Seed Co., 9241 Mace Blvd, Davis, CA 95618), **Mansun Kong,** and **Fred Cook**, Driscoll Strawberry Associates Inc., 151 Silliman Road, Watsonville, CA 95076

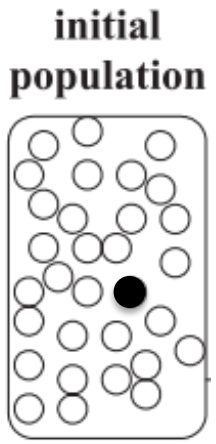
Management of Pre- and Postharvest Gray Mold of Strawberry

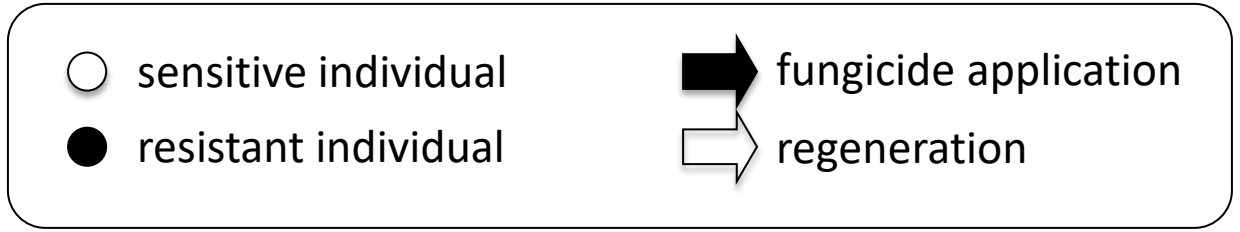
Dr. James E. Adaskaveg

California

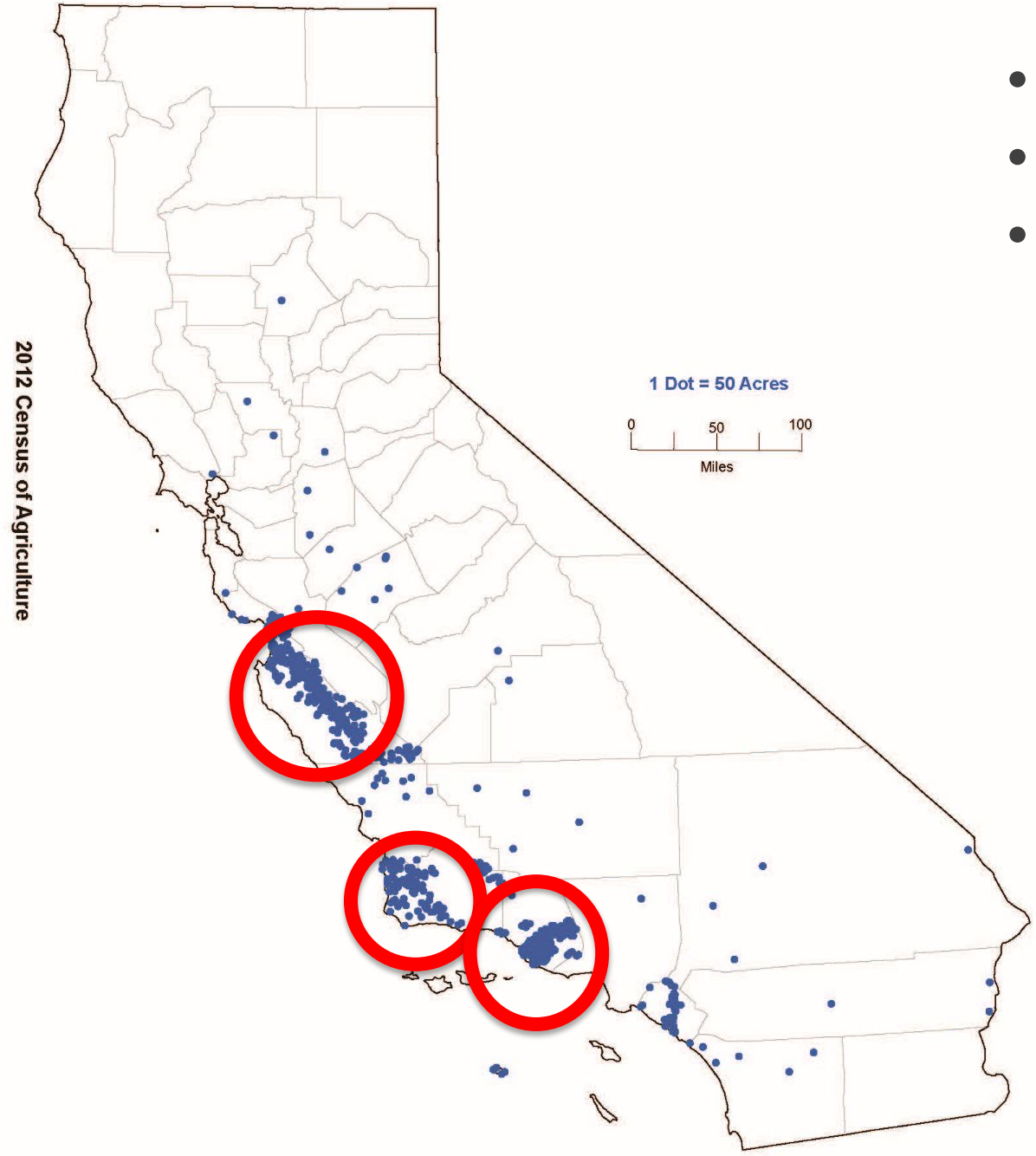
- Resistance reported to frequent
- Resistance increasing in a population within a season

Fungicide resistance





Adapted from: Deisling, H. B., Reimann, S., Pascholati, S. F. 2008. Mechanisms and significance of fungicide resistance. Brazilian Journal of Microbiology. 39:286-295.



- 40 ranches
- 888 isolates collected
- 2 sampling times

U.S. Department of Agriculture, National Agricultural Statistics Service

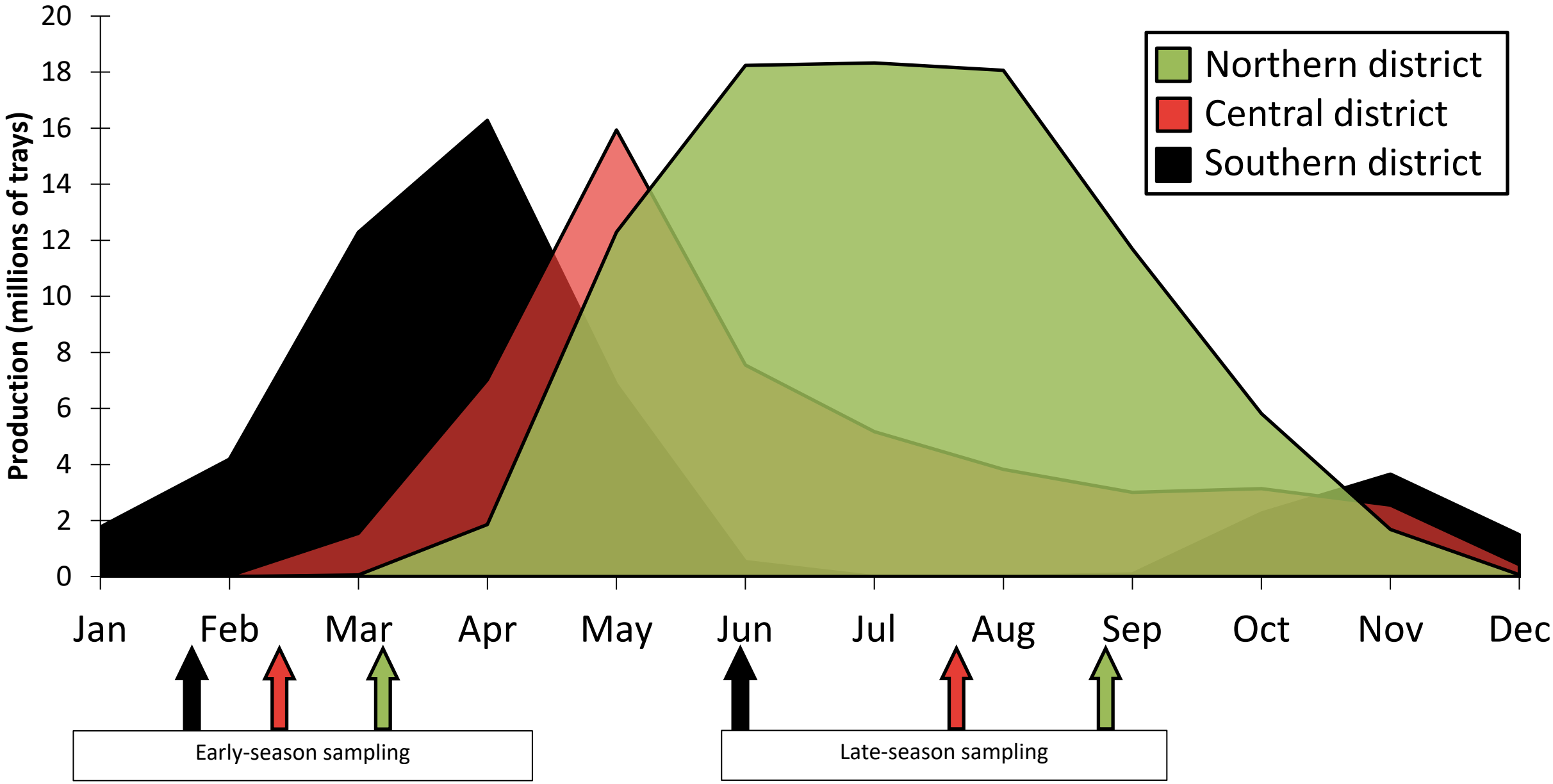
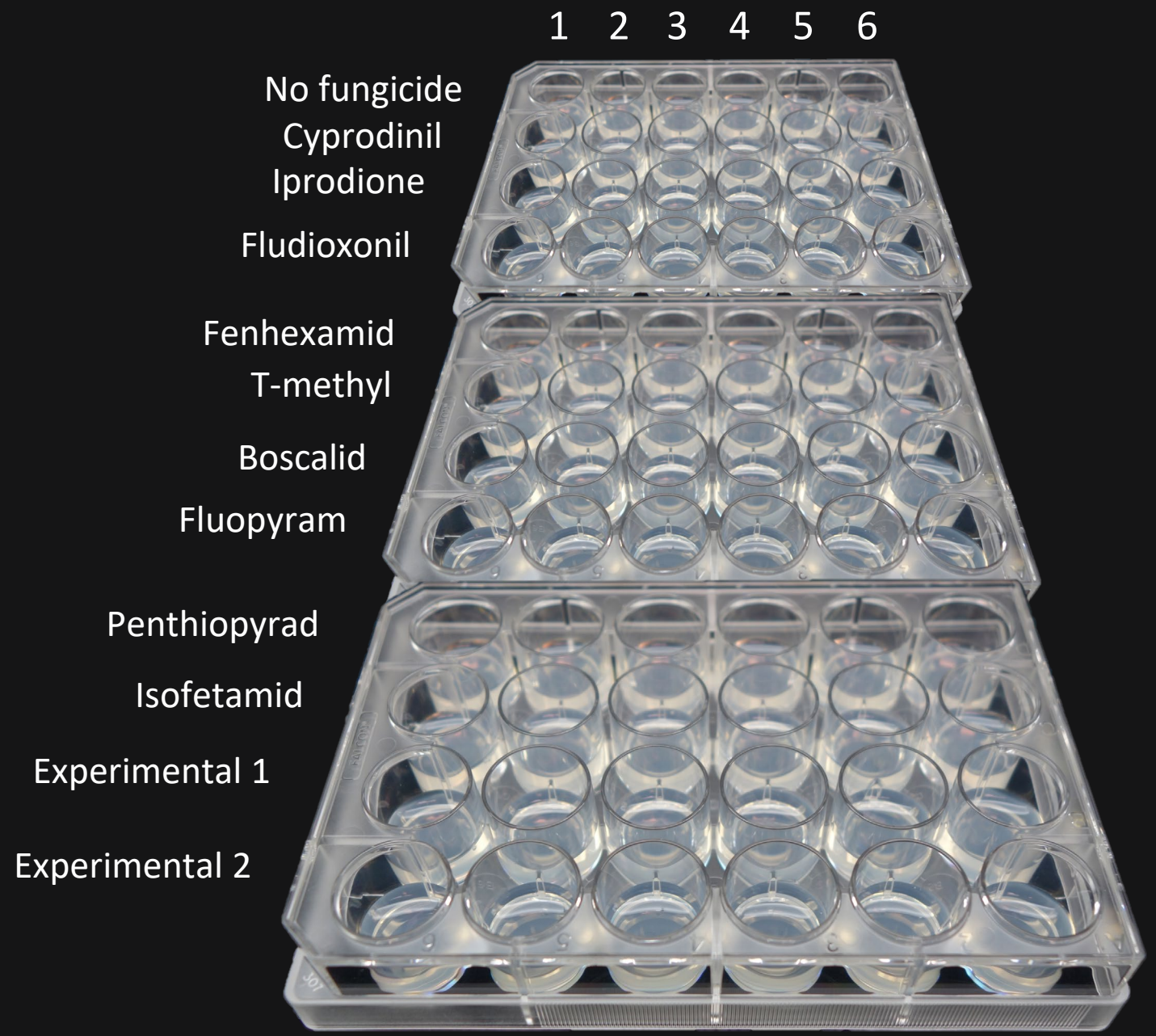

Production (millions of trays)
0
2
4
6
8
10
12
14
16
18
20
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Northern district
Central district
Southern district
Early-season sampling
Late-season sampling

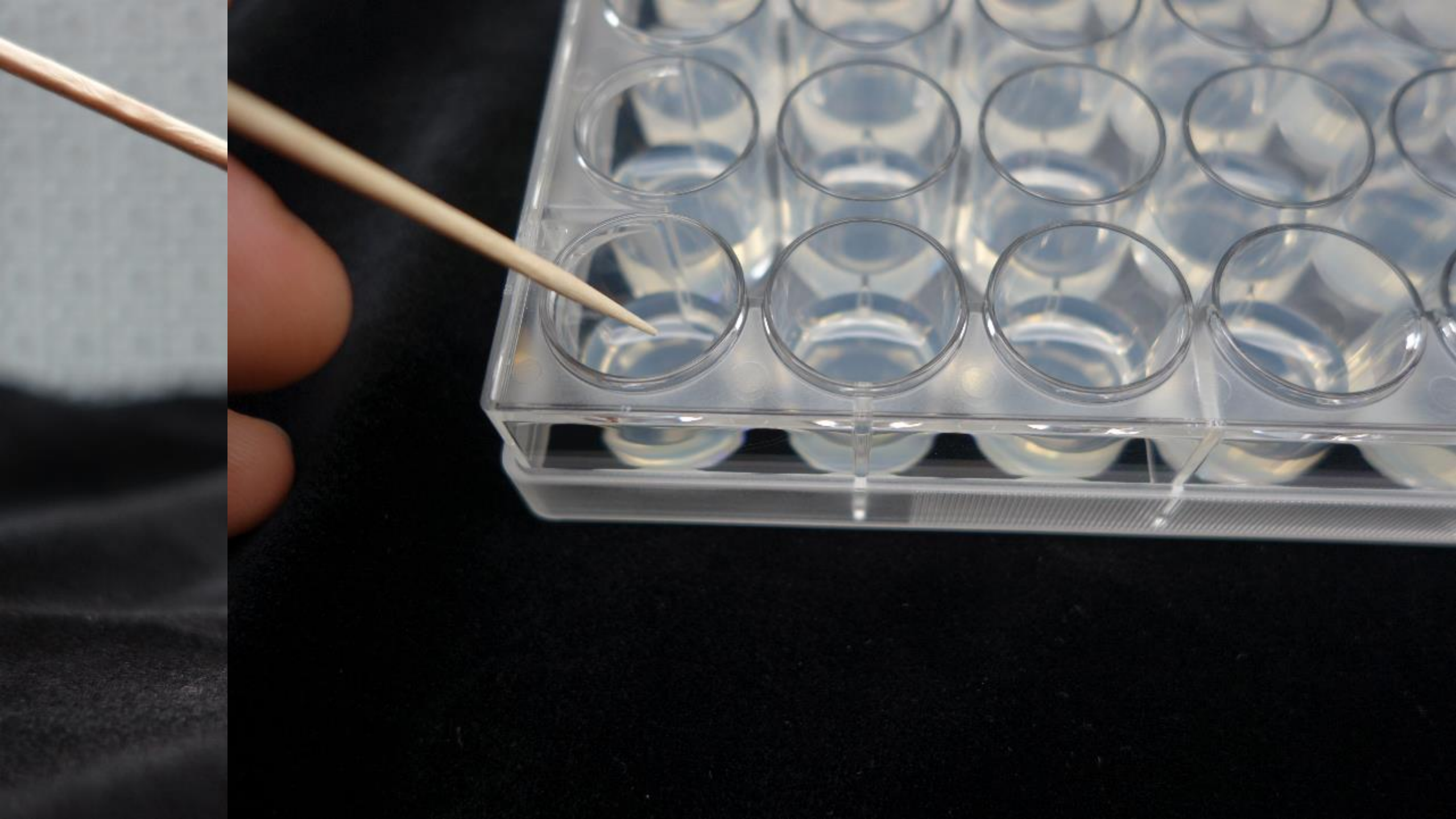
Table. Fungicides labeled for Botrytis gray mold of strawberry in California

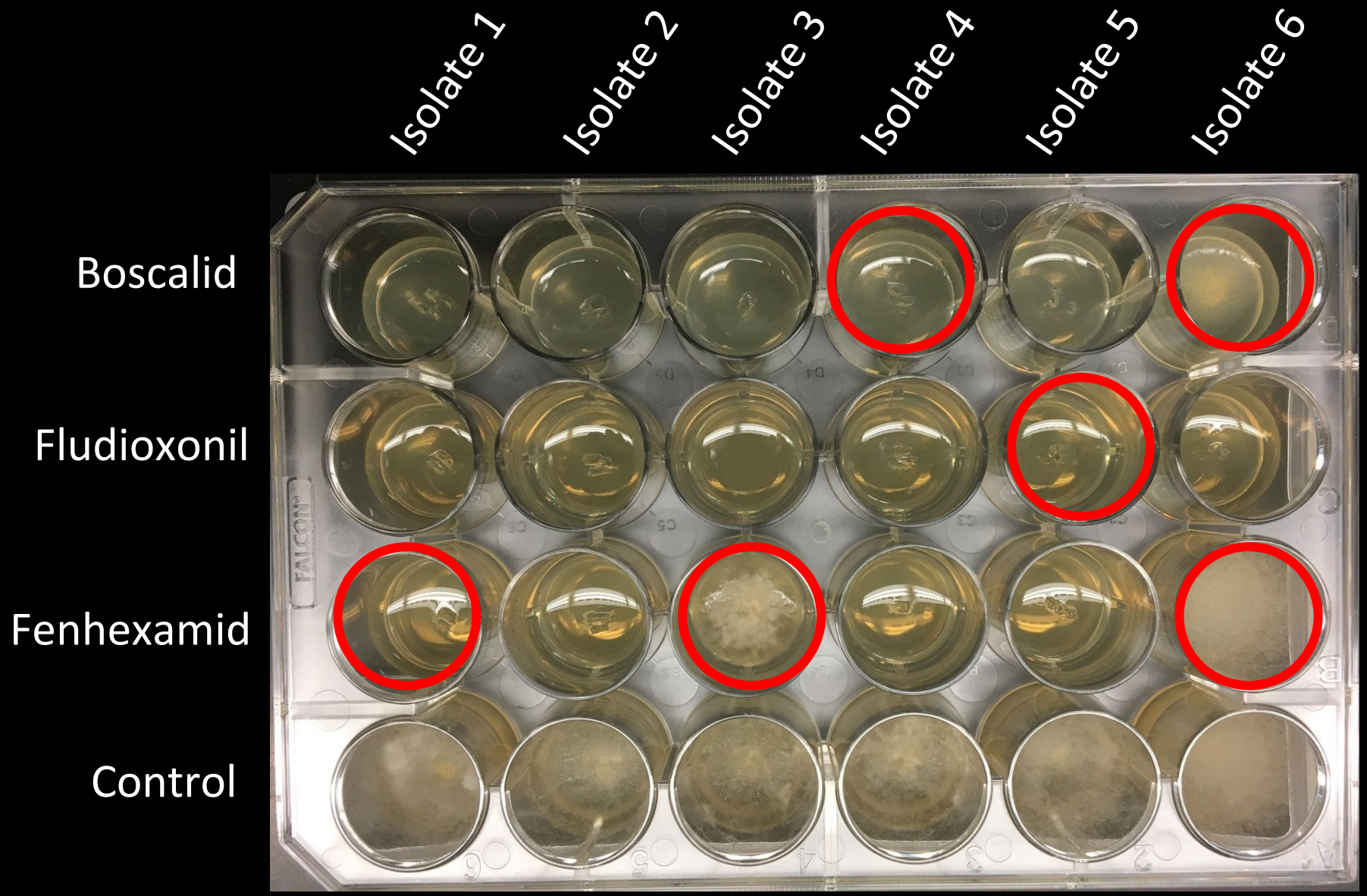
Example trade name	Active ingredient(s)		FRAC code(s)	
Topsin	Thiophanate-methyl		1	
Rovral	Iprodione		2	
Fontelis	Penthiopyrad		7	
Kenja 400	Isofetamid		7	
Luna Sensation	Fluopyram	Trifloxystrobin	7	11
Luna Tranquility	Fluopyram	Pyrimethanil	7	9
Pristine	Boscalid	Pyraclostrobin	7	11
Merivon	Fluxapyroxad	Pyraclostrobin	7	11
Scala	Pyrimethanil		9	
Switch	Cyprodinil	Fludioxonil	9	12
Elevate	Fenhexamid		17	
PH-D	Polyoxin-D		19	

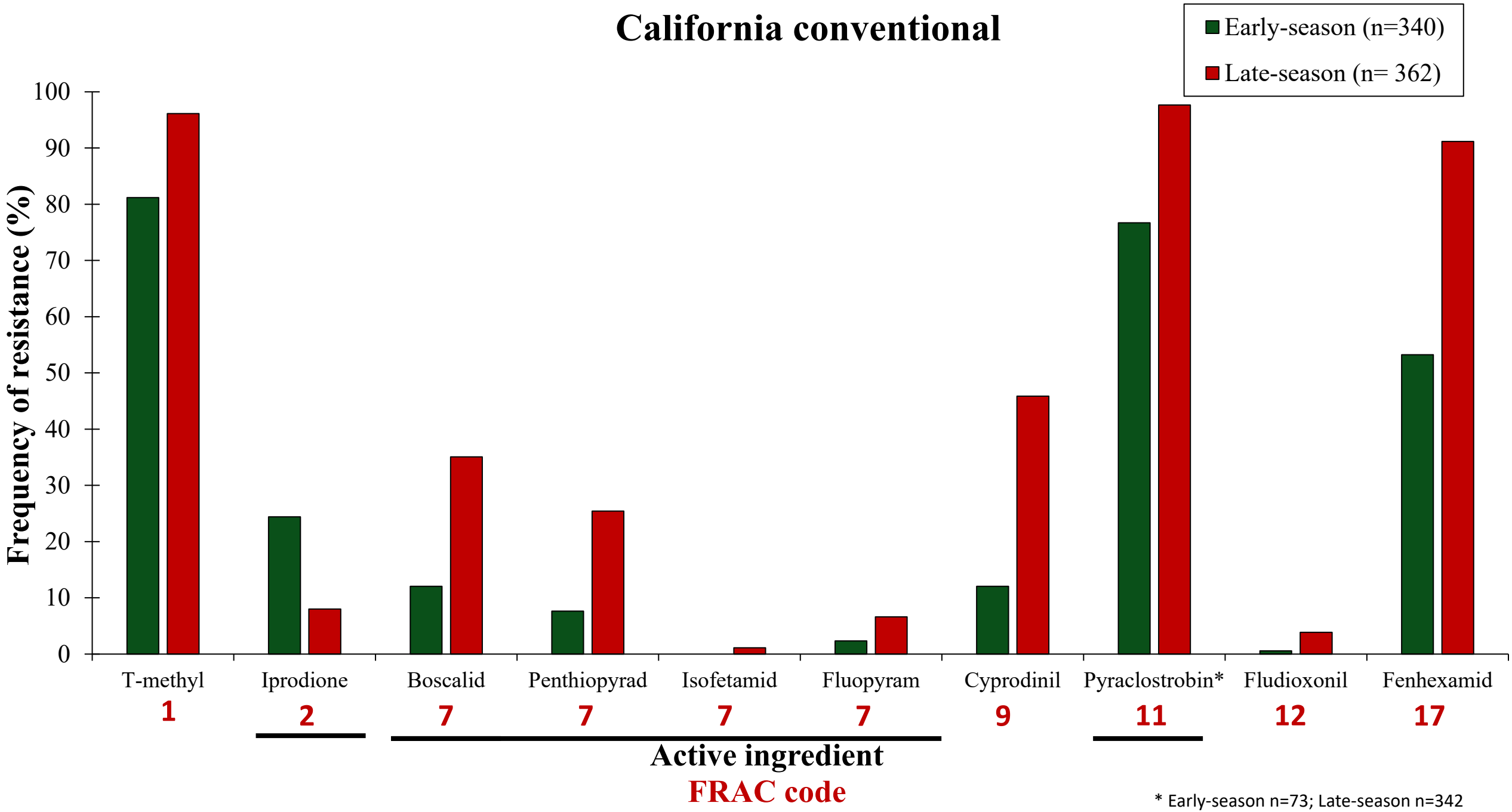
active ingredient was not tested in this study

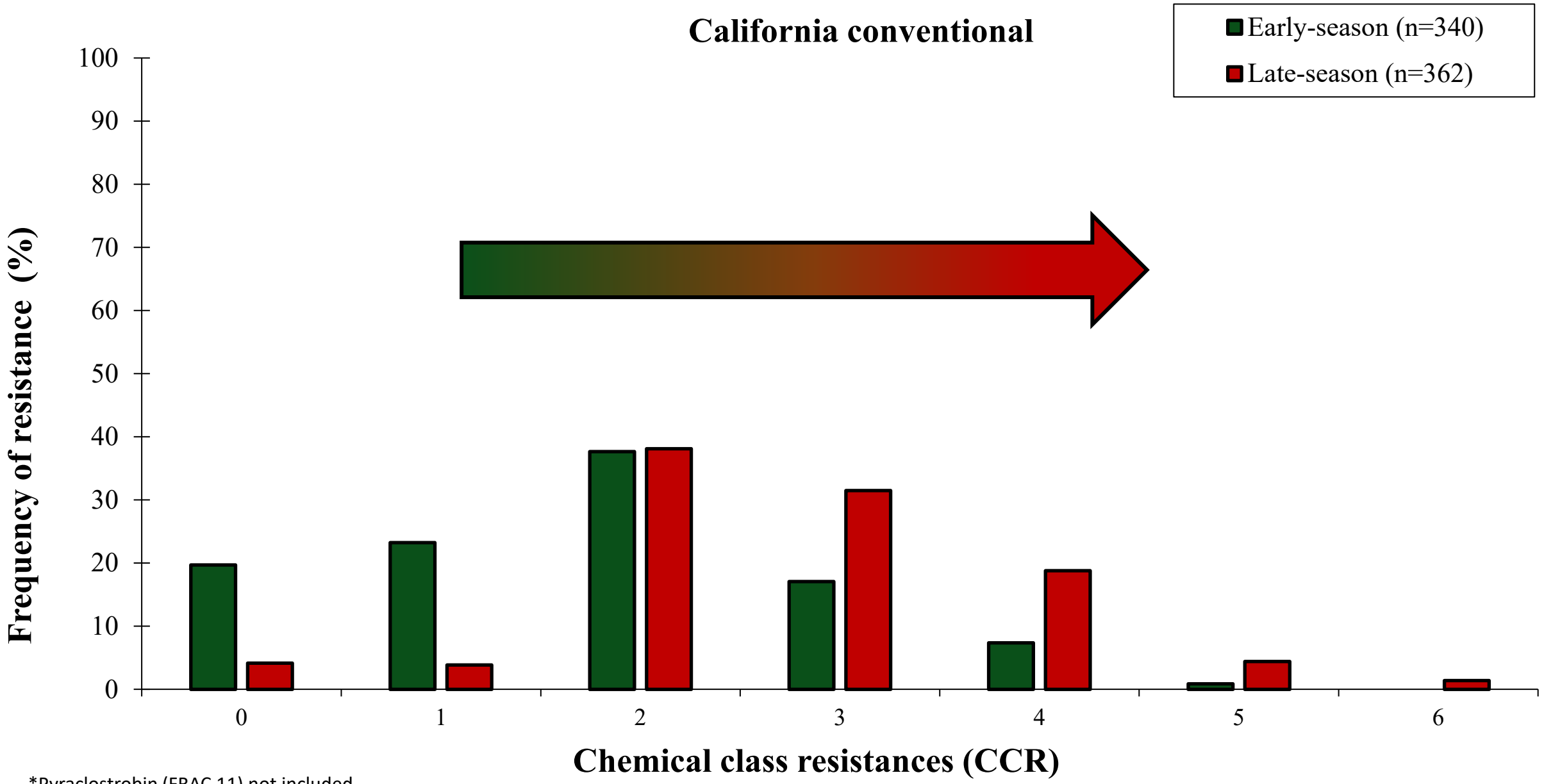


Fernandez-Ortuno, D., Grabke, A., Bryson, P.K., Amiri, A., Peres, N. A., and Schnabel, G. 2014. Fungicide resistance profiles in Botrytis cinerea from strawberry fields of seven southern U.S. states. Plant Dis. 98:825-833.

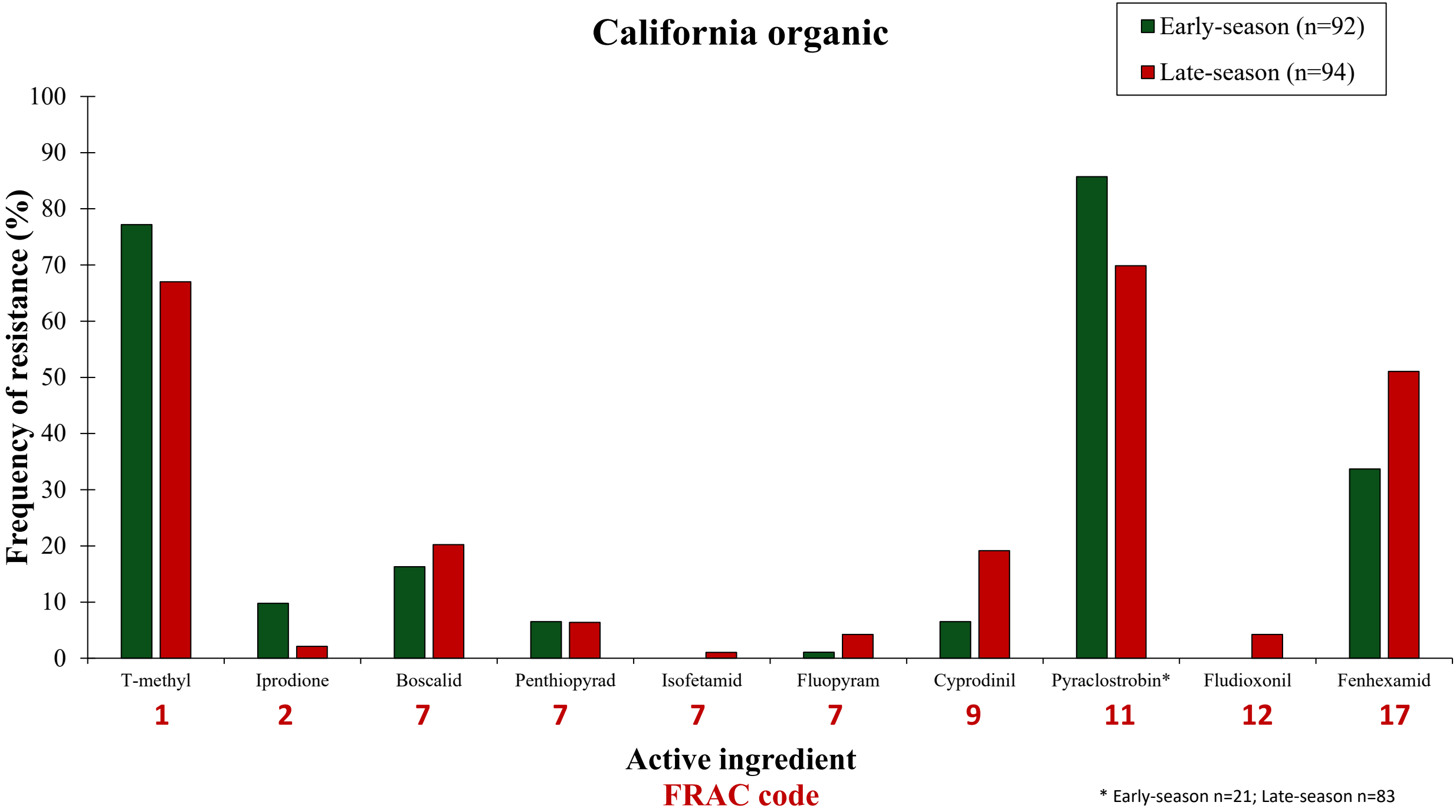



Isolate 1
Isolate 2
Isolate 3
Isolate 4
Isolate 5
Isolate 6
Boscalid
Fludioxonil
Fenhexamid
Control
FALCON


California conventional
Early-season (n=340)
Late-season (n= 362)
Frequency of resistance (%)
100
90
80
70
60
50
40
30
20
10
0
T-methyl
Iprodione
Boscalid
Penthiopyrad
Isofetamid
Fluopyram
Cyprodinil
Pyraclostrobin*
Fludioxonil
Fenhexamid
1
2
7
7
7
7
9
11
12
17
Active ingredient
FRAC code
* Early-season n=73; Late-season n=342



*Pyraclostrobin (FRAC 11) not included


California organic
Early-season (n=92)
Late-season (n=94)
Frequency of resistance (%)
100
90
80
70
60
50
40
30
20
10
0
T-methyl
Iprodione
Boscalid
Penthiopyrad
Isofetamid
Fluopyram
Cyprodinil
Pyraclostrobin*
Fludioxonil
Fenhexamid
1
2
7
7
7
7
9
11
12
17
Active ingredient
FRAC code
* Early-season n=21; Late-season n=83

Strawberry nursery

Summary of results

- High levels of resistance to thiophanate-methyl, pyraclostrobin and fenhexamid
- Within-season shift of frequencies of resistance to all fungicides
- Within-season shift towards isolates resistant to more modes of action
- Fungicide resistant isolates may be disseminated with strawberry transplant stock

Disease control a

- Rotate between mo
  - Tank mix single-sit
- Decrease selectio
  - Spray less often
    - Weather-based
  - Use multisite fungi
  - Use a recently cali
- Reduce inoculum
  - Remove senescent foliage and overripe fruit from the field
- Make the environment less favorable for gray mold
  - Keep the plants dry
- Fungicides can only prevent gray mold, they do not heal the strawberry

Resistance to Increasing Chemical Classes of Fungicides by Virtue of "Selection by Association" in *Botrytis cinerea*

Meng-Jun Hu, Kerik D. Cox, and Guido Schnabel

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Meta-Analysis of a Web-Based Disease Forecast System for Control of Anthracnose and Botrytis Fruit Rots of Strawberry in Southeastern United States

Comparison of Sanitation and Fungicides for Management of Botrytis Fruit Rot of Strawberry

Effects of Plant Spacing and Cultivar on Incidence of Botrytis Fruit Rot in Annual Strawberry

D. E. Legard, C. L. Xiao, J. C. Mertely, and **C. K. Chandler,** University of Florida, Gulf Coast Research and Education Center, 13138 Lewis Gallagher Road, Dover 33527

Comparison of Epidemics of Botrytis Fruit Rot and Powdery Mildew of Strawberry in Large Plastic Tunnel and Field Production Systems

C. L. Xiao, C. K. Chandler, J. F. Price, J. R. Duval, J. C. Mertely, and **D. E. Legard,** University of Florida, Gulf Coast Research and Education Center, Dover 33527

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- Driscoll's & Naturipe

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