

*California Orange Industry*

**Navel and Valencia Exports  
to Korea (NAVEK)**

*Plans for 2011/12 Growing Season & Beyond*

---

J. E. Adaskaveg

University of California, Riverside

D. Felts, H. Forster, L. Hou, and Y. Luo

University of California, Riverside

# Septoria spot of citrus caused by *Septoria citri*

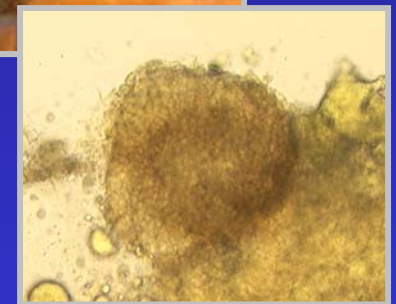
- A disease of leaves, fruit, and twigs of oranges, lemons, and grapefruit.
- Occurs in many citrus-growing countries



Early symptoms:  
Small, irregular, pitted,  
shallow lesions



Advanced symptoms:  
Dark lesions that extend  
into the albedo.



Pycnidia  
producing  
filiform conidia

# Economic importance of Septoria spot

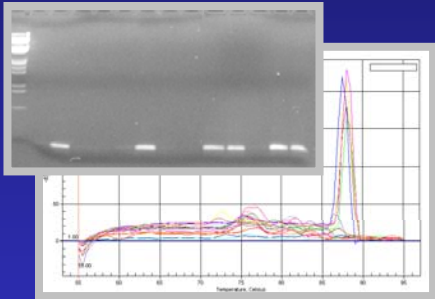
- Septoria spot has generally been considered to be a minor problem
- In 2004, Korean National Plant Protection and Quarantine Service (NPQS), detected and rejected orange fruit that was infected with Septoria spot from California.
- *S. citri* is a quarantine pest in Korea because it has not been reported on the Unshu orange grown in the Cheju province.
- Korean market a major export market valued at \$112 million was *jeopardized* for the CA citrus industry.
- Korean market maintained through compliance with quarantine measures following GAPs and fruit certification of NAVEK - currently voluntary (mandatory for 6 / 7 years of program).



# Navel and Valencia Exports to Korea (NAVEK)

- The NAVEK program was established through negotiations between USDA APHIS and Korean NPQS to comply with quarantine laws and help the California orange industry maintain trade with Korea
- NAVEK is part of a “Work Plan” to certify fruit as disease free
- Goals include:
  - *Develop information of forecasting and managing the disease*
  - *Design rapid detection methods*
  - *Certify “disease-free” orange fruit destined for Korea*
  - *Divert disease-positive fruit to other markets*

# Major accomplishments of NAVEK



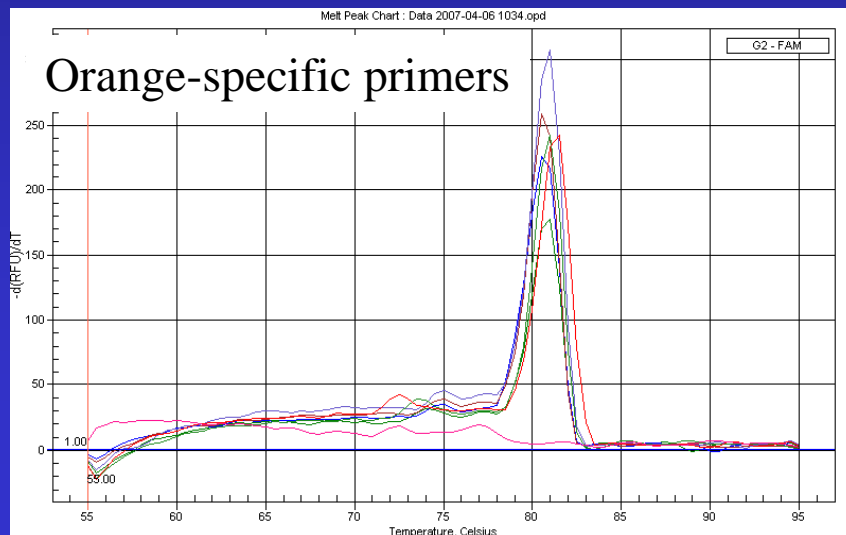
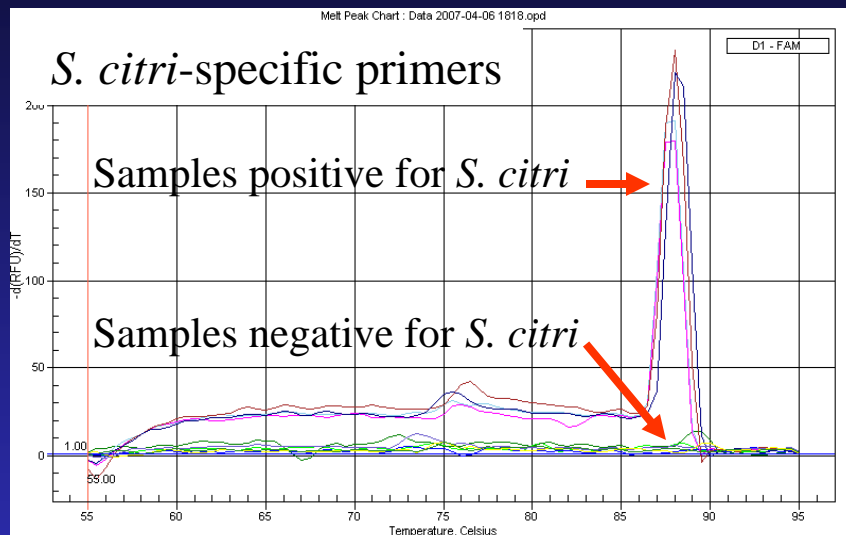
- Provided **color guides and sampling strategies** based on growers and packers evaluating and submitting fruit to lab.
- Developed molecular-based **detection method** for Septoria spot to be used in a fruit certification program.
- Implemented **on-line submission forms** and confidential reporting system
- Developed a **disease forecasting** system and optimal timing of fungicide treatments
- Identified and evaluated **pre- and postharvest fungicide treatments** for management of the disease and for **inhibition of sporulation**

**Numerical Risk Model for forecasting Septoria Spot**

Hrs with T< -1 C	Precipitation (mm)				
	31-60	61-90	91-120	121-150	151-180
<10	0	1	2	3	4
10-20	1	2	3	4	4
21-30	2	3	4	4	4
>30	3	4	4	4	4

**Abound**  
**Quadris Top**  
**Bravo**

# Further modification of method: Use of an internal standard for verification of DNA quality



For verification of DNA quality a primer pair that specifically amplifies orange DNA is used. (primers made available by M. Roose, UC Riverside).

Over the last 7 seasons, 3000 to 4000 orange samples were processed annually using this method resulting in low detection levels by Korean import officials and allowing the California export market to Korea to remain open.

---

# Studies on the epidemiology of *Septoria citri*

---

**Goal:** Model the disease and predict infection periods of the pathogen to ultimately develop a disease risk assessment for different growing locations

**Objectives:** *Determine* -

- Frequency of disease
- Temporal occurrence of disease
- Geographical distribution of disease
- Associate environmental events with the occurrence of disease

# Symptoms of Septoria spot on orange fruit

---

- Symptoms of Septoria spot are almost always associated with cold-temperature damage (ice marks) and occur on mature fruit.
- In high-disease years, 10-20% of cold-injured fruit may be diseased.



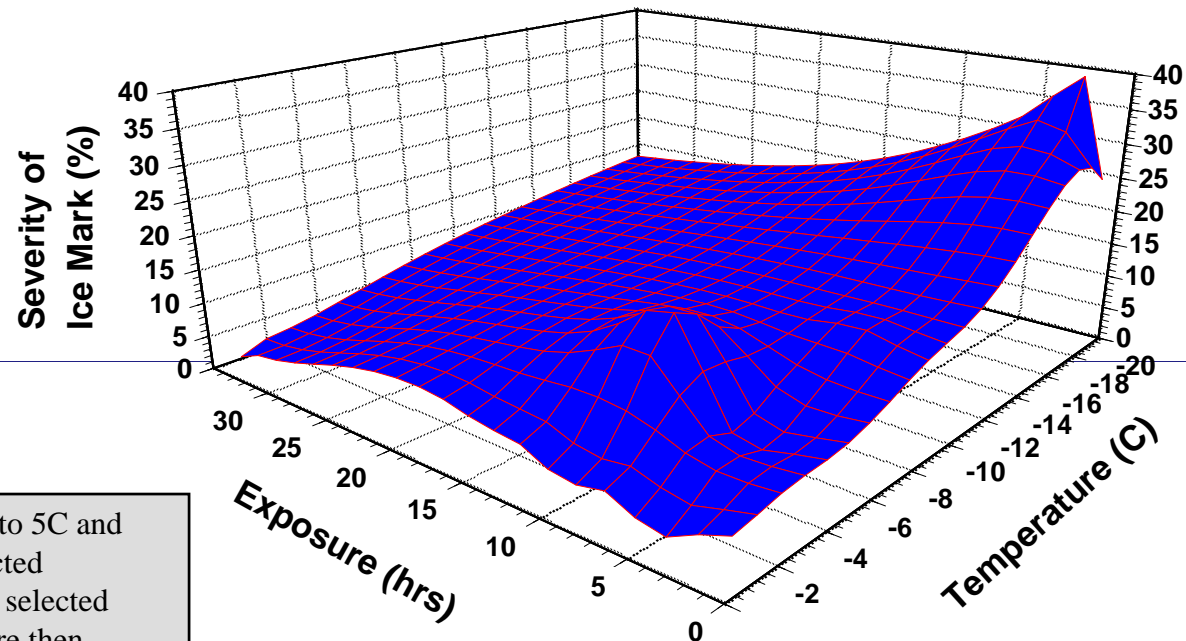
Orange fruit with cold-injury



Orange fruit with symptoms of cold-injury and Septoria spot

# Modeling of the role of low-temperature conditions in disease development

## Relationship between low temperature exposure durations and severity of ice mark on navel oranges



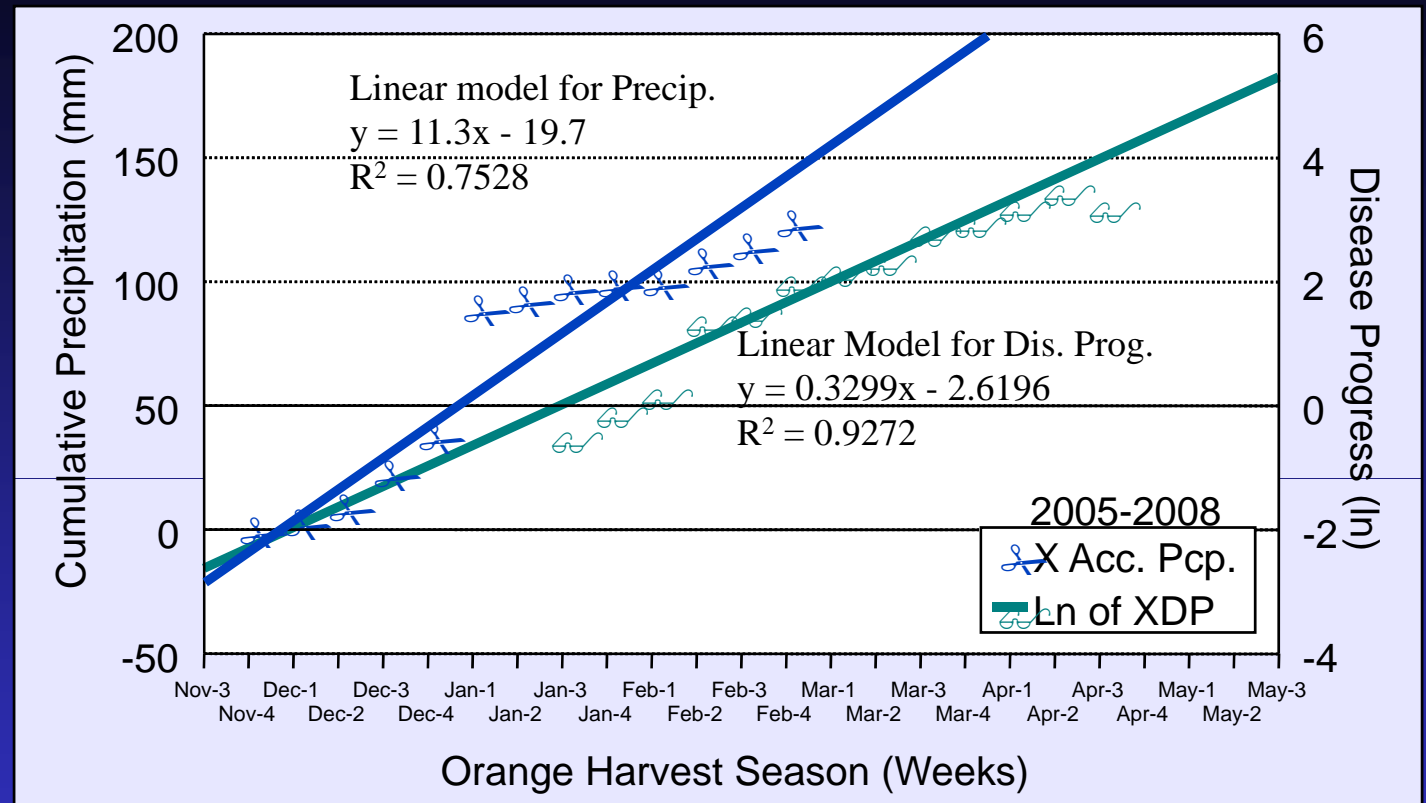
Fruit were pre-cooled to 5C and then incubated at selected temperatures <-1C for selected time periods. Fruit were then incubated at 20C.

Empirical risk scales were developed following severity data.

Low Temp. Risk	Accumulated exposure at <math>\leq -1\text{ C}</math>
4	>30 h
3	21-30 h
2	10-20 h
1	<10 h

# Modeling of the role of precipitation in disease development

Precipitation accumulation and Septoria spot disease progress after the first seasonal freeze event



Empirical risk scales were developed following regression and correlation data analysis.

Risk	Accum. Precipitation (mm)
5	151-180
4	121-150
3	91-120
2	61-90
1	≤60

## Current Trade Requirements - Key Points of Plant Quarantine Agreement as of July 2010 Work Plan

---

- ***Septoria spot remains a quarantine pest in Korea***
- **Koreans will evaluate fruit for sporulation of the fungus on **imported** fruit in Korea**
  - ***No incubation of fruit by NPQS***
  - ***No molecular (PCR) testing by NPQS***
- Continued molecular detection allowed for fruit certification in the NAVEK lab
- Inspection upon arrival based on visual observation of fruiting structures and spores of the pathogen using standard 2% sampling procedure
- Guidelines for 'Good Agricultural Practices' to minimize the occurrence of Septoria spot need to be followed as a voluntary program.

*These advances have resulted in a highly efficient & successful program with minimal burden, while maintaining agreements with Korea*

---

# Summary of NAVEK program

## 2010-11 season

---

# Risk Assessment Model for Forecasting Septoria Spot of Citrus

<i>Numerical Risk Model for forecasting Septoria Spot</i>					
	Precipitation (mm)				
Hrs with T < -1 C	31-60	61-90	91-120	121-150	151-180
<10	0	1	2	3	4
10-20	1	2	3	4	4
21-30	2	3	4	4	4
>30	3	4	4	4	4

## Summary of Risk Assessment Model for Septoria Spot of Oranges in California - 2010-11 Season

- Model based on accumulation of low temperature (rind injury) and precipitation (fungal growth) is being used for recommendations of copper/zinc/lime applications.
- Moderate accumulation of low temperatures (+32 hr < -1 C) & record precipitation (7-14 in) = *Record high levels of disease*

Timing of 2nd Application (1st application Oct. 15-Dec. 3 Oct 15 to				
County	Date	Hrs <-1	Pp (mm)	RISK
Fresno	4-Dec	10.3	62.8	2
Tulare	4-Dec	14.0	53.9	1
Kern	4-Dec	16.3	19.3	0
Fresno	11-Dec	10.3	72.9	2
Tulare	11-Dec	14.0	67.3	2
Kern	11-Dec	16.3	21.9	1
Fresno	18-Dec	10.3	121.5	3
Tulare	18-Dec	14.0	121.6	3
Kern	18-Dec	16.3	65.9	2

## NAVEK Certification Program for *Septoria* *Spot of Citrus* – 2010-2011 Accomplishments :

---

- Total samples evaluated: 3059
- Navel positives: 313/2783 (11.2%) –
  - Tulare Co. - 256/2106 (12.2%)
  - Fresno Co. – 41/295 (13.9%)
  - Kern Co. - 13/331 (3.9%)
  - Madera Co. – 3/51 (5.9%)
- Valencia positives: 23/276 (8.3%)
- **Zero Detections in Korea!**

---

*Note: In the 2009/10 season, only two detections were found in Korea with 1.3% (56) detections out of 4312 samples evaluated.*

---

# Going Forward with the NAVEK program

## 2011-12 season

---

## *Septoria Spot of Citrus – current trade agreement*

---

*As of the July 2010 Korean export agreement, industry efforts are voluntary based on ‘Good Agricultural Practices’:*

- Growers should prevent *S. citri* infections.
- This includes application of preharvest fungicides. **Risk assessments** will continue to be made based on environmental conditions and **Disease Forecasts are** made available to the industry.
- Packers and growers should continue to **scout and sample** for the disease.
- Submitting fruit samples to the **NAVEK detection lab** should still be done to effectively avoid costly fruit rejections in Korea.

# *Septoria Spot of Citrus – Current Suggested Actions*

---

- Good Agricultural Practices (**GAPs**) have been developed from the previous ‘Guidelines’ in managing Septoria spot and are “voluntary”.
- GAPs and Color Symptom Guides for disease identification are posted on the CCQC website ([www.calcitrusquality.org](http://www.calcitrusquality.org)).
- Fruit sample testing will be available for growers and regulators (USDA-APHIS) (**NAVEK** program).
  - *Electronic forms will be available (KOR numbers no longer required - just lot identification)*
  - Molecular testing (PCR) of fruit only on the “export side” i.e., in California before shipping

# Management of the Disease

---

- Removal of dead branches and twigs that harbor the pathogen.
  - Irrigation systems that minimize wetting of foliage.
  - Fungicide applications are protective treatments:  
Copper-zinc-lime treatments or registered alternatives should be applied prior to winter rains. These treatments are ineffective if applied after precipitation and have been part of management guidelines for the disease in California for the past 65 years.
- 

- The first field-application of the fungicide treatment of zinc-copper-lime treatment or registered alternative is **highly recommended** for all oranges planned for exportation to Korea.

The treatment **should be applied between October 15 and November 30** for all California oranges (Navels and Valencias) shipped to Korea.

## First Application 2011-12 Season

### Zinc-Copper-Lime Applications

Fixed coppers (e.g., copper hydroxide and copper oxide)

Application Volume		Metallic Zinc/100 gal	Metallic Copper/100 gal	Hydrated Lime/100 gal
400	gal/A	0.63-1 lb	0.41-0.75 lb	0.5-1.0 lb
600	gal/A	0.42-0.67 lb	0.28-0.5 lb	0.33-0.67lb
800	gal/A	0.31-0.5 lb	0.21-0.38 lb	0.25-0.5 lb
Total*	lb/A	2.5-4	1.65-3	2-4 lbs

\* - If the disease was observed or a positive NAVEK report was issued for Septoria spot in a grower lot last season, use a higher rate of each spray component (e.g., 4 lb metallic zinc, 3 lb metallic copper, and 4 lbs of lime per acre) within the range provided.

# Management of the Disease

## The Second and Third Fungicide Treatments -

Timing of the second and third fungicide treatments will be based on the accumulation of temperatures below  $-1^{\circ}\text{C}$  and subsequent accumulation of precipitation.

Categories 1 to 4 represent increasing risk for disease. Advisories will be made at category 1 (green) or 2 (yellow) based on actual or highly probable, forecasted weather conditions. The following is the risk assessment table that will be followed:

**Numerical Risk Model for forecasting Septoria Spot**

Hrs with $T < -1^{\circ}\text{C}$	Precipitation (mm)				
	31-60	61-90	91-120	121-150	151-180
<10	0	1	2	3	4
10-20	1	2	3	4	4
21-30	2	3	4	4	4
>30	3	4	4	4	4

# Sampling Guidelines for an Effective Detection Program

---

**A. Grower lots from Madera, Fresno, Tulare, and Kern Co. should be evaluated in the field by scouting. Submitted samples of fruit should have symptoms.**

Follow the guidelines for Categories I, II, III, and IV (see color photo guide). Mechanical injuries described in Category V are acceptable for early season fruit (Oct.-Nov.).

# *Septoria Spot of Citrus* – Alternative treatments becoming available

---

- **Multi-site fungicides for preharvest use:**
  - Micro-encapsulated coppers (e.g., Kocide 3000, GWN4620)
  - Chlorinated hydrocarbons (e.g., chlorothalonil)
- **Single-site fungicides used alone or in pre-mixtures:**
  - Qol Fungicides (e.g., Azoxystrobin) –
    1. Abound - *preharvest*
    2. Graduate A+ - *postharvest*
  - Other new active ingredients such as difenoconazole alone or in combination (e.g., Qol and DMI fungicides - Quadris Top). - *preharvest*

# Septoria Spot of Citrus – Evaluate copper and non-copper alternatives

## Field trial -A 2009/10

No.	Trt*	Form.	Rate (400 gal/A)	Late Fall 11/20/2009	Winter 1/21/2010	Spring Eval. (%)**	LSD
1	Check	---	---	@	@	37.5	a
2	Bravo Weather Stik	720SC	4 pts	@	@	4.8	b
3	Bravo Weather Stik	720SC	3.2 pts	@	@	5.7	b
	Quadris	2F	16 fl oz	@	@		
4	Kocide 3000	30% MCE	1.65 lb MCE	@	@	7.7	b
	Zinc Oxide	35% MZE	2.5 lb	@	@		
	Lime	99%	4 lb	@	@		
5	Kentan	40DF	1.65 lb MCE	@	@	9.6	b
	Zinc Oxide	35% MZE	2.5 lb	@	@		
	Lime	99%	4 lbs	@	@		
6	GWN 4620	---	4 qts	@	@	8.6	b
	Zinc Oxide	35% MZE	2.5 lb	@	@		

\* - All treatments received: ProGibb 40WDG - 24 g ai/A (mixed with each treatment) on 11/20/09.

\*\* - Fruit were evaluated for Septoria spot in mid-March for the incidence of disease based on 26 fruit for each of four single-tree replications. Disease symptoms were validated using the NAVEK PCR detection system.

# Septoria Spot of Citrus – Management

## Pre- and postharvest fungicide treatments

Field trials on the evaluation of preharvest treatments

Trt	Form.	Rate (400 gal/A)	Late Fall 11-18-10	Winter 2-3-11	Spring Inc. (%)	LSD
Check	---	---	---	---	28.1	A
Bravo Weather Stick	720SC	6 pints	@	@	0	B
Inspire	EC	7 fl oz	@	@		
Bravo Weather Stick	720SC	3.2 pints	@	@	1	B
Quadris	2F	16 fl oz	@	@		
Kocide 3000	30% MCE	1.65 lb MCE	@	@	1	B
Zinc Oxide	35% MZE	2.5 lb	@	@		
Lime	99%	4 lb	@	@		
Bravo Weather Stick	720SC	6 pints	@	@	1	B
Zinc Oxide	35% MZE	2.5 lb	@	@		
Lime	99%	4 lb	@	@		
Quadris Top	SC	14 fl oz	@	@	1	B

Highly effective treatments were identified for managing Septoria spot:

- New copper formulations
- New fungicides (Bravo, Quadris Top) with anti-sporulation properties.
- Mixtures, rotations

Additionally, a single application January or early February with Inspire, Quadris Top, or Bravo-Inspire reduced the disease to very low levels.

# *Septoria Spot of Citrus –* Alternative Treatments for Management

---

- Preharvest registrations of multi-site materials –
  - **Full registration** for chlorothalonil (Bravo) for all citrus (oranges, lemons, etc.) has been planned with the approved IR-4 residue project in 2009 (status – ongoing)
  - MRLs exist for chlorothalonil in Korea and Japan
  - Korean MRLs for Abound (azoxystrobin) and Quadris Top (a mixture with difenoconazole).
- Postharvest registrations of single-site materials –
  - CODEX MRLs have been obtained in 2009 for the newly registered postharvest fungicides (azoxystrobin, fludioxonil, and pyrimethanil).
  - Food Additive Tolerance (FAT) for fludioxonil approved in Japan for this season, whereas azoxystrobin is pending in 2012.

# MRL Guidelines

---

Current United States, Codex, and pending/current Korean tolerances of fungicides on orange:

Crop	Fungicide	US	Codex	Korea
Orange	Azoxystrobin	10	15	5
	Fludioxonil	10	7	5
	Imazalil	10	5	5
	Difenoconazole	1	---	1
	Thiabendazole	10	7	10

# Postharvest Management Guidelines

---

**Fruit treatments** - All fruit destined for Korea should have the following treatments:

**Wash with chlorinated water** (100-200 ppm, pH 7-8)

**Treat with postharvest fungicides:**

- **Aqueous application:** TBZ and/or azoxystrobin (prior to a fruit coating and/or in a fruit coating or wax)
- **Fruit coatings:** may include fungicides
- **TBZ rates:** Aqueous (200 – 400 ppm) or fruit coating (3500 – 5000 ppm).

# Postharvest Management Guidelines

---

## **Grading - All fruit destined for Korea should be graded.**

- Fruit in Categories I-II may be evaluated at the NAVEK lab or by an inspector with the County Ag Commissioner.
- Lots containing ice-marked fruit as shown in Category IV F-J should not be shipped to Korea and should be diverted to other markets.

## **Fruit Storage –**

- Fruit should be stored at 3-5 C
- Fruit should not be stored more than one week following packing.  
*Note: Freezing fruit (storage temperatures of 0 to -1C) will result in increased susceptibility for Septoria spot.*
- Packed fruit destined for Korea Export should be stored separate from domestic or other export shipments to avoid mixing of the load.

# USDA-FAS TASC Funding Completed

---

- Technical Assistance for Specialty Crops or TASC funding obtained in 6 of the last 7 years at approximately \$90,000/yr
- TASC eligibility exhausted
- In 2011/12 funding of NAVEK will be re-charged to packinghouse similar to other export programs

# NAVEK Expenses and Estimated Sample costs

Minimal Annual Program Costs				No. of	Program	Cost per
				Samples	Costs	Sample
Category	Cost			3000	\$60,000	\$20
Salary and Benefits				3500	\$70,000	\$20
	SRA/Specialist	\$45,000		4000	\$80,000	\$20
	Benefits	\$20,000				
	Subtotal	\$65,000				
		x 9 months	\$50,000			
	Lab Assistant	\$5,000				
	Subtotal	\$55,000				
Supplies	\$3,000					
Equipment	\$2,000					
	Total	\$60,000				

CRB Budget		
Salary and Benefits		
SRA/Specialist		\$30,000
Benefits		\$10,000
Lab Assistant		\$5,000
Supplies		\$4,000
Total		\$49,000

# Summary

---

- NAVEK represents an independent certification program separate from the industry & follows Korean Agreement
- NAVEK is centrally located and has been in operation for 7 years – “Industry is familiar with program”
- No detections in Korea last year -
  - Certification program could be concluded in two more seasons of zero detections (USDA-APHIS)
  - Justified by sufficient awareness of GAPs & ability to effectively manage disease
- Research ongoing with the development of new fungicides for disease control and suppressing sporulation
- **NAVEK funded through orange industry sample charges**