



***Exploring the Potential
for
Electronic Grading of Fruit with Canker Lesions***

46th Annual Packinghouse Days

Citrus Research and Extension Center
University of Florida

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Progress Report

- Projected funded by the USDA-TASC through Florida Fresh Packers, Assoc.
- Project team
 - Dr. Tim Schubert
 - Dr. Gordon Bonn
 - Dr. Mark Ritenour



Research Objective

- Investigate various sensing techniques for detecting citrus canker and differentiating it from other common confounding diseases.
- Develop On-line detection technologies that can be commercialized for eliminating cankerous fruit from the packing line.



First Year Objectives

- Determine spectral characteristics of citrus canker and confounding diseases.
- Identify candidate sensing technologies which could be implemented for commercial packingline grading systems
- Develop relationship with Equipment manufacturer and acquire prototype one-lane system



Sample Collection and Preparation

- Identified source of Grapefruit which exhibited canker and other typical disease conditions
- Collected samples from field in Spring 2007
- Sorted, washed, sanitized, waxed at Indian River REC on their packingline under supervision of Dr. Ritenour, FMC, and a local packer.
- Transported to UF-Gainesville under advise of FDACS-DPI.

Citrus Samples & Skin Conditions

■ Grapefruits (Ruby Red), 2006/07 Harvest Season

Market Fruit	Field Fruit with Canker	Field Fruit with Other Diseases
Unwashed	Unwashed	Copper Burn Greasy Spot Wind Scar Cake Melanose Specular Melanose Insect damage
Washed + Chlorine	Washed + Chlorine	
Washed + Chlorine + SOPP	Washed + Chlorine + SOPP	
Washed + Chlorine + SOPP + Wax	Washed + Chlorine + SOPP + Wax	



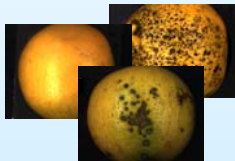
Citrus Data Collection

Four different vision-based systems:

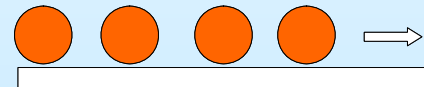
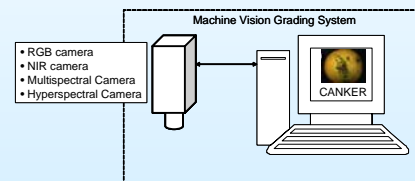
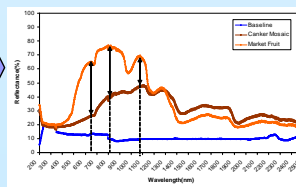
- Reflectance spectra using spectrophotometer ***
- Color images using RGB color camera
- Visible & near-infrared multispectral images
- Hyperspectral reflectance & fluorescence images

Objectives of Spectral Reflectance Studies

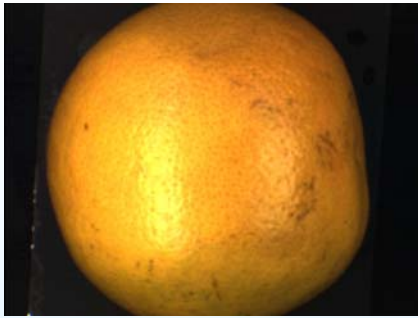
1. To acquire the spectral reflectance of citrus canker and other conditions.
2. To identify the significant wavelengths that have the maximum discriminatory potential.
3. To derive discriminant function that could classify citrus canker from other conditions.



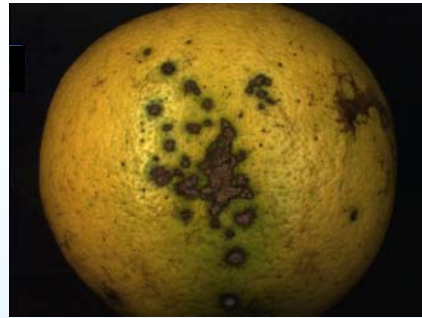
Main GOAL



Fruit samples



Market fruit



Fruit with canker



Fruit with greasy spot



Fruit with copper burn



Fruit with wind scar

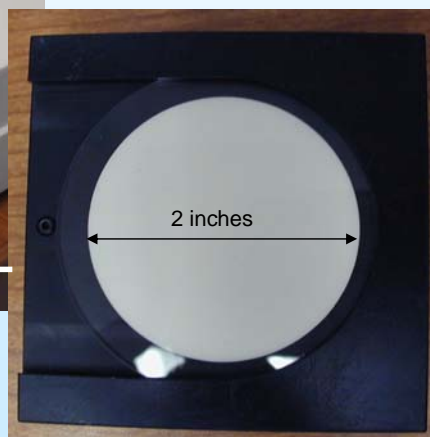


Fruit with cake melanose

CARY Spectrophotometer

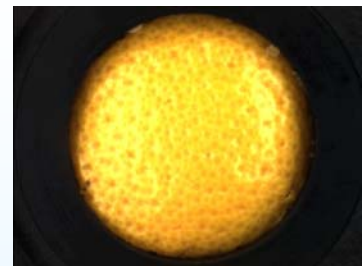
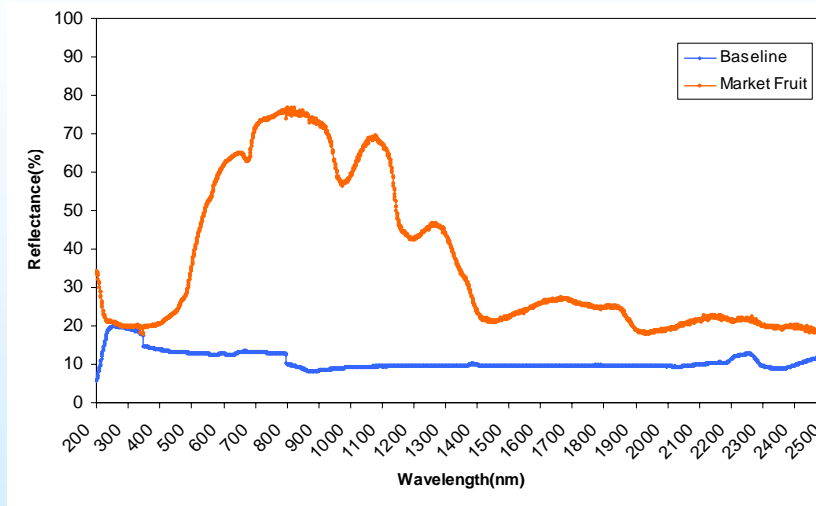


Spectrophotometer
- Measures spectral reflectance from 200nm
to 2500nm



Sample holder

Sample reflectance result from spectrophotometer

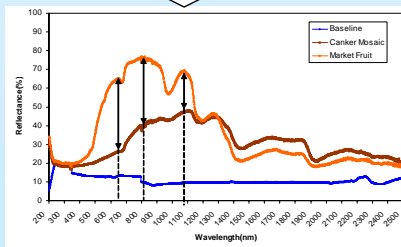
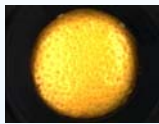


Market fruit peel



Baseline material

Flowchart for spectral reflectance acquisition and analysis



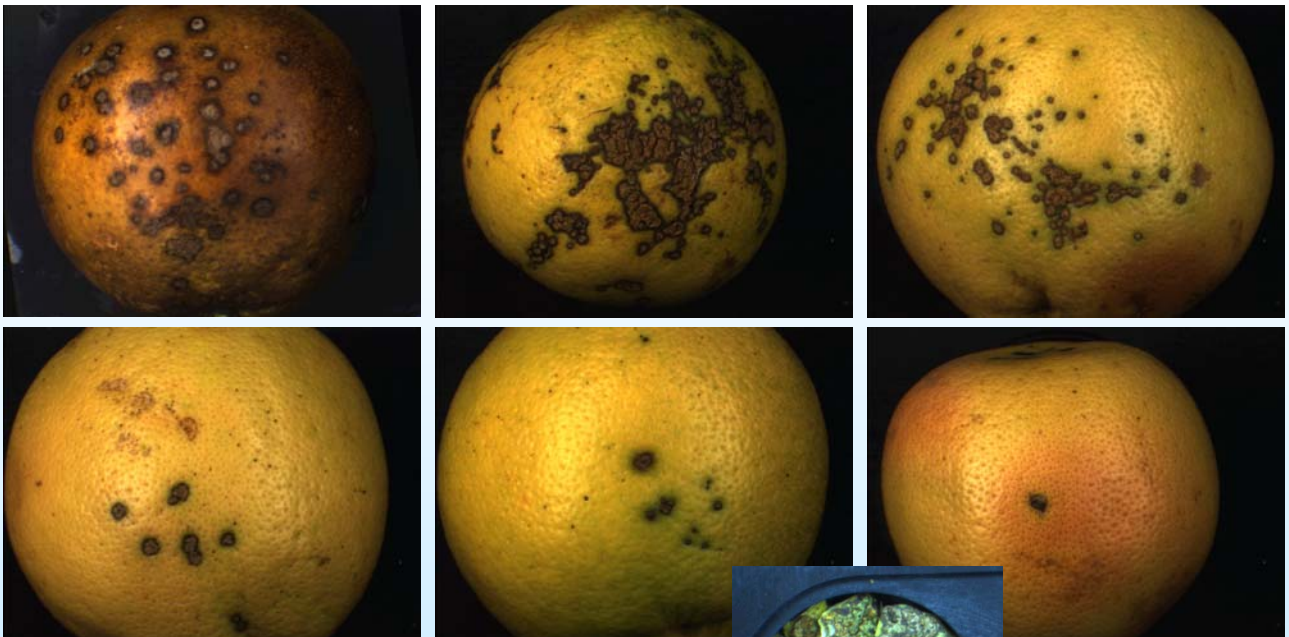
1. Color image acquisition of whole fruit

2. Preparation of peel sample in holder

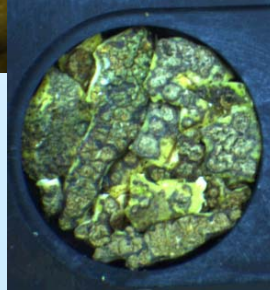
3. Sample with spectrophotometer

4. Statistical analysis to identify wavelengths with high discriminant potential

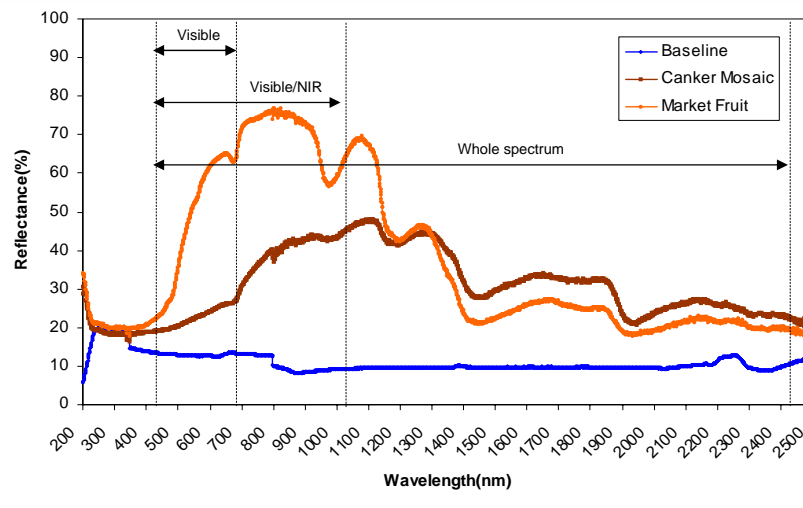
Different faces of canker



- different distribution of canker infection
- spectrophotometer averages the area of the sample holder
- canker "mosaic" was prepared →



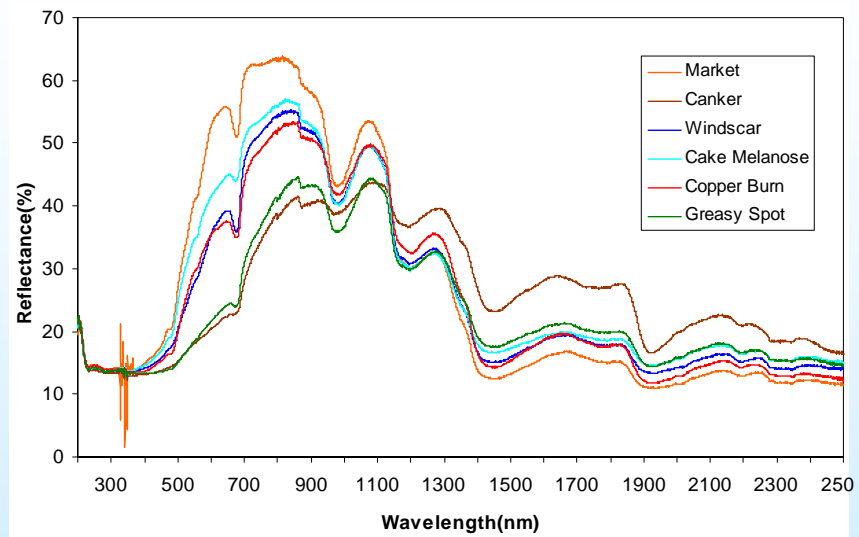
Statistical analysis of reflectance data



3 Spectral Ranges

1. Visible (400-750)
2. Visible/NIR (400-1100)
3. Whole spectrum(400-2500)

Spectral reflectance of the different conditions



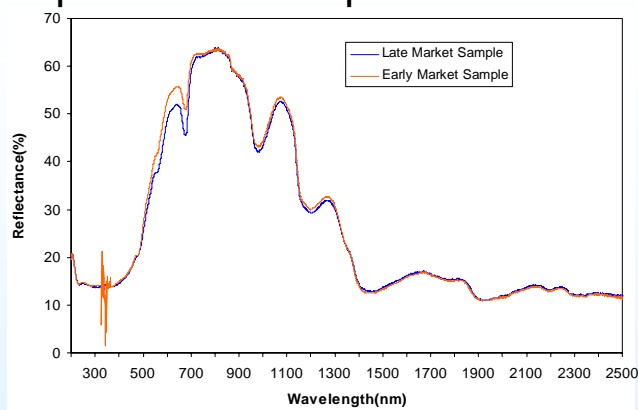
- Different spectral characteristics
- Potential for separation



Interpreting Initial Results

- These results are encouraging although caution must be used.
 - Disease sample sizes were large
 - Spectrophotometer results are not always implementable under different light sources
 - Good results required 7 to 10 bands
- Results provide a starting point for on-line system development, more detailed experiments in multi-spectral and hyper-spectral detection.

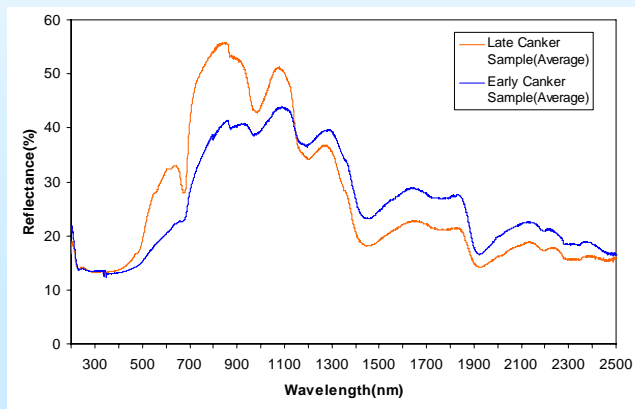
Comparison of samples taken on different dates



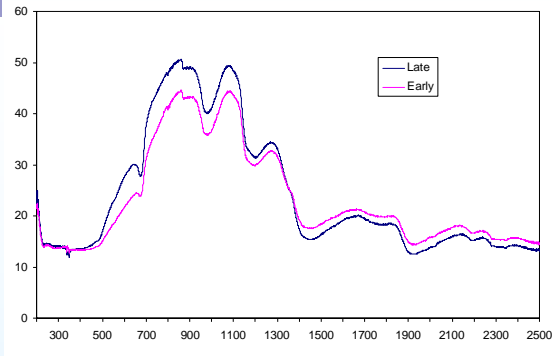
Sampling Dates

Early : March 12, 2007

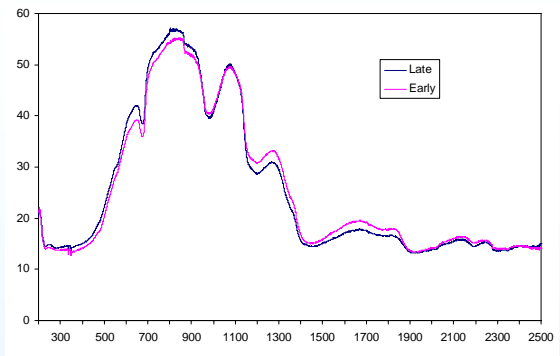
Late : April 16, 2007



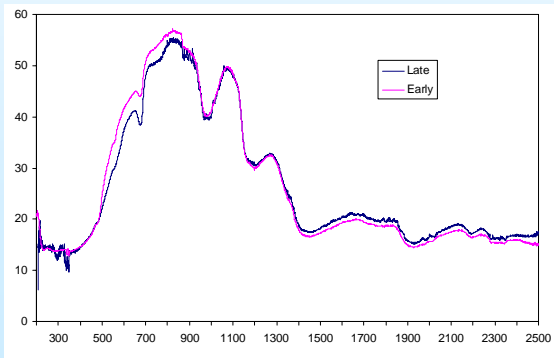
- No difference was observed with market fruit and other conditions
- There was a shift of the reflectance curve of the canker samples



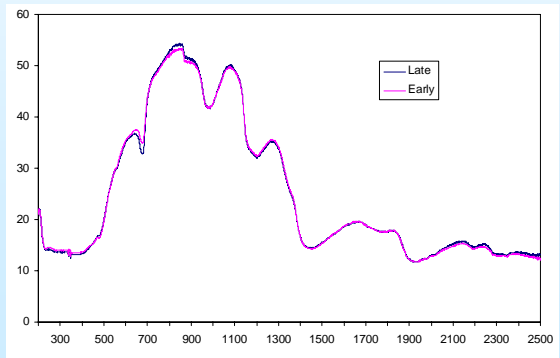
Greasy Spot



Wind Scar



Cake Melanose



Copper Burn



Industry Contact

- We have visited numerous Florida packinghouse's and have sought close working relationships and advise.
- We have made contact with a prominent grading equipment manufacturer and have discussed the potential for collaboration.
- We have purchased a one-lane grading system prototype, where we will integrate our sensing/grading technology on their system to test design, detection and control concepts.



Year Two Objectives

- Further develop On-line sensing technologies
- Integrate sensing technologies with one-lane grading system.
- Monitor canker spectral characteristics over the entire growing season on grapefruit to see if there is a seasonal difference.
- Explore spectral characteristics of other citrus varieties: navel, and tangerine are likely candidates.



Conclusions

- Spectral reflectance of citrus canker and other disease conditions were acquired, and key wavelengths have been identified in the visible and the NIR bands.
- A discriminant function was able to separate canker from other conditions with overall accuracies of 93% for all conditions, and 100 % for canker.
- Results have shown a shift in the reflectance curves between “early” samples with canker and “late” samples with canker. Further spectral reflectance test and analysis will be conducted to study influence of time of season on canker spectral response.