Introduction to…..
Impact of Preharvest Factors Affecting Quality and Marketability of Horticultural Foods

UC Postharvest Technology of Horticultural Crops
June 15, 2009

T. Suslow & M. Cantwell
Dept. Plant Sciences
Postharvest Program
tvsuslow@ucdavis.edu 1

The quality of horticultural products cannot be improved during postharvest management

Achieving optimal postharvest quality in;
- **visual**
- **sensory**
- **nutritive attributes**

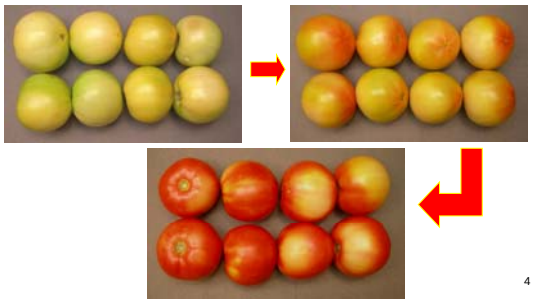
are determined or greatly influenced by preharvest events and management

2

Our topic focus….
Quality factors that cannot typically be avoided, graded, or scored at harvest

3

Sun injury (sunburn)
May be hard to see until fruit ripen



4

Preharvest Factors Affecting Quality
Principles underlying our expectations

- **The interaction between variety, location, and season cannot be underestimated**
- **Fertility management can greatly impact postharvest quality, directly and indirectly**
- **Fertility management impacts postharvest decay susceptibility, directly and indirectly**
- **Crop water status can significantly determine postharvest quality and phytonutrient content**
- **Various canopy and microclimate manipulations affects postharvest quality**

5

QUALITY ATTRIBUTES

- **size and shape**
- **color uniformity and intensity**
- **firmness and texture**
- **cuticle thickness – water loss & decay**
- **postharvest physiological disorders**
- **flavor – sugar : acid ratio and volatiles**
- **nutritive value**
- **curing and storage behavior**
- **bruising susceptibility**
- **chilling injury / internal breakdown incidence**
- **chilling injury / internal breakdown severity**
- **and much more….**

6

Variety Selection

Breeding and selection strategies include;

- Best overall performance in all regions
- Best performer within region or season
- Time to maturity within a region+season

7

Role of cultivar in postharvest quality loss Example: Grape tomatoes and weight loss

Cultivar	Soluble solids, %	Sugars mg/ml	Titratable acidity, %	Vitamin C mg/100ml	Shrivel score*	% weight loss 12d 20C 50%RH
Ahern 299	6.7	32.0	0.60	90.1	3.5	13.2
Amsterdam	6.3	31.5	0.54	89.6	3.2	15.2
Harris LI-34	6.1	25.8	0.61	111.6	4.6	15.6
Hazera 1319	7.3	32.7	0.80	108.2	4.3	18.0
Rotterdam	6.7	33.0	0.62	89.7	2.4	11.8
TC 1260	7.3	32.7	0.67	103.6	3.6	14.9
LSD.05	0.8	2.8	0.09	13.7	0.6	1.5

*Shrivel scored on 1-5 scale, 1=none, 2=slight, 3=moderate, 4=moderately severe, 5=severe

Grape tomatoes in mesh plastic punnets

1 2 3 4 5

Cantwell, 2004

8

Carrot varieties have been selected for mechanical harvest and uniform internal color

9

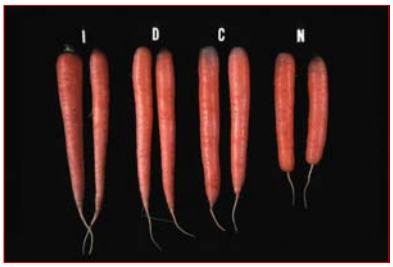
Longitudinal cracking is common with mechanically harvested carrots

Longitudinal cracking is highly dependent on variety

10

CARROT CRACKING

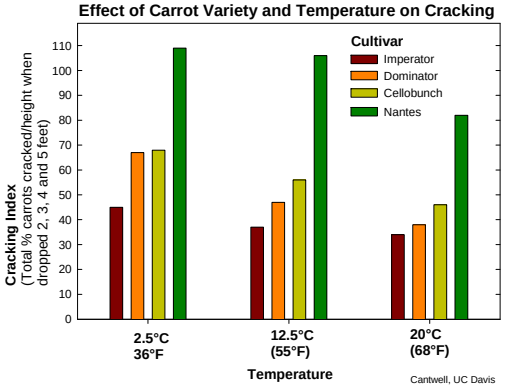
- Variety is very important
- Temperature is a minor factor
- Cracking is increased by high N fertilization



a. Imperator
b. Dominator
c. Cellobunch
d. Nantes

Cantwell, UC Davis

11



Cantwell, UC Davis

12

Impact of Soil Quality and Seed Bed Preparation on Market and Sensory Quality

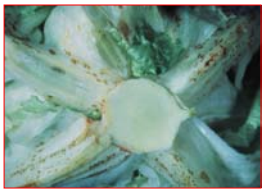
Green Core &
Green Shoulders

Predisposing factors
- Compacted soil
- Sub-surface hardpan
- Poor foliar disease management

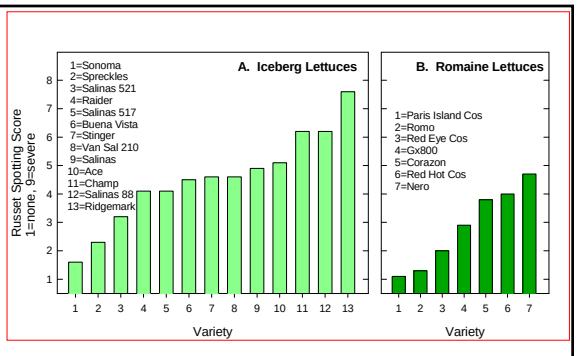
Consequences
- Visual – green core
- Non-visual – bitter, soapy flavor
- High harvest losses

13

Russet Spot Disorder on Iceberg and Romaine Lettuces Is Strongly Influenced by Cultivar



14



Development of Russet Spot Disorder on Iceberg and Romaine Lettuces. Intact heads were stored in 5ppm ethylene at 5°C (1°F) plus 1 week in air.

Cantwell, UC Davis, unpublished

15

When comparing varieties for Russet Spot the key factor to consider is:

a. Soil type
b. Season
c. Maturity
d. All of the above

16

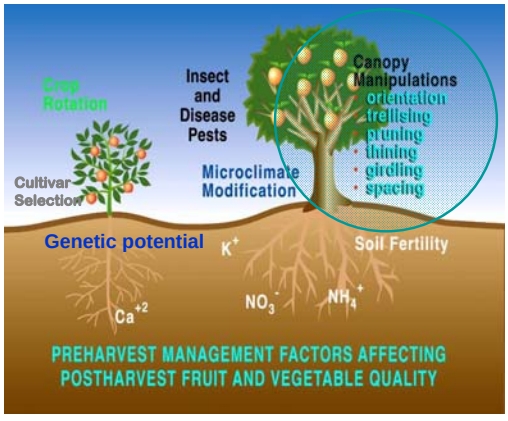
Environmental factors:
Impact on sensory and nutrient content

Examples

- **Soil type, texture, pH**
- **Air temperature**
- **Soil temperature**
- **Light availability**
- **Light quality**
- **Field vs. glasshouse**
- **Air pollution**
- **Altitude**

Genetics + environment generally determine outcome

17



18

Leave removal within canopy reduces RH and lowers *Botrytis* incidence and sporulation

19

What caused this quality defect that showed up on >30% of packed fruit 10 days after harvest ?

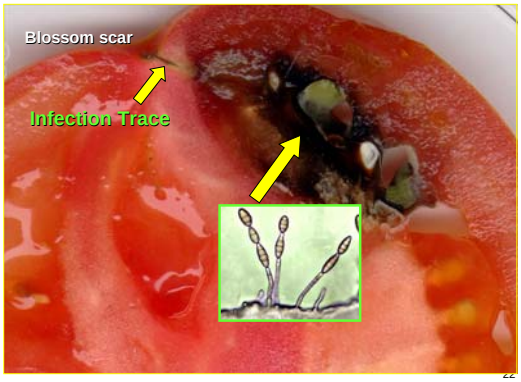
a. Impact bruise
b. Compression bruise
c. Calcium deficiency (Blossom-end Rot)
d. Preharvest flower infection

20

Preharvest infections may form quiescent infections that remain dormant until ripening

High RH and cool temperatures promote floral infections after pollination

21



Problem

High-density plantings have lower color and sugars on fruit in the lower canopy and inner canopy.

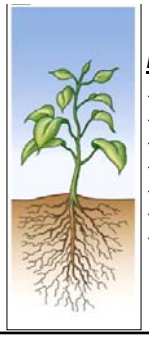
Solution -

Reflective mulch (silver; white)

23

Plant health under the soil surface is the root of many postharvest disorders

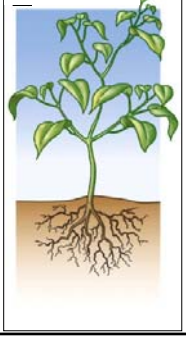
Good Root:Shoot Ratio

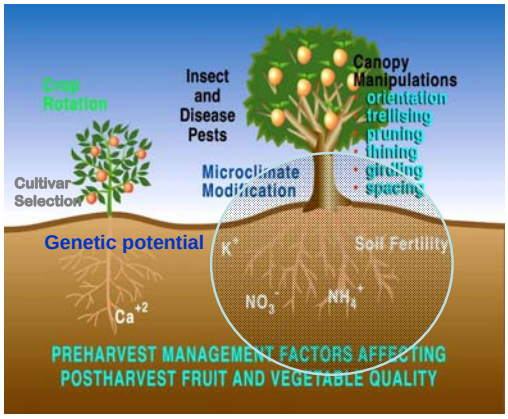


Examples:

- **Calcium disorders**
- **Thin fruit wall**
- **Browning potential**
- **Hollow-heart**
- **Pith decline**
- **Blotchy-ripening**
- **Sunscald**

Poor Root:Shoot Ratio





25

Irrigation and Fertilization

NITROGEN FERTILIZATION

- High N associated with excess vegetative growth
- High N associated with high leaf protein and pigment concentrations (chlorophyll, carotenoids)
- High N associated with reduced postharvest life due to increased susceptibility to decay, mechanical damage and physiological disorders

26

Excess Nitrogen Applications Interfere with Potassium Uptake

Example:

Tomato fruit that develop during K^+ stress conditions can be puffy, soft, low in acidity, irregular shaped, blotchy ripening, and susceptible to ripening-related decays

27

Wall-thickness is important for shipping quality
Prevents high rates of water loss/softening

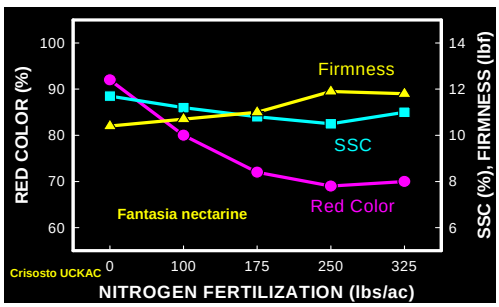
Good wall thickness is inhibited by
- Irregular irrigation
- Excessive N and high temperatures
- Heavy fruit set (less problem with hybrids)

28

To date, fertilization recommendations for fruits and vegetables have been established primarily for productivity goals (yield), and not to optimize good flavor quality, nutritive value and optimum postharvest life potential.

29

Nitrogen level may have little effect on sugar content and firmness but dramatic affects on fruit skin color and cuticle thickness

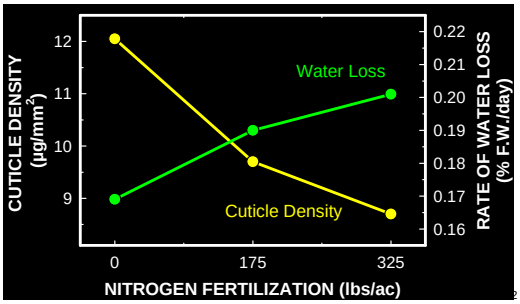


30

C. Crisosto

31

High Nitrogen Reduces Cuticle Density and Increases Water-loss Softening



Effects of nitrogen fertilization on Brown Rot on 'Fantasia' nectarines

	Incidence of brown rot of nectarines inoculated on							
Lb N/Ac	April 4	April 24	May 4	May 21	June 3	June 16	July 1	**Average**
0	6	0	3	19	17	10	5	**9**
100	14	14	0	29	4	49	50	**23**
175	40	27	31	36	29	40	62	**38**
250	56	26	60	30	35	52	59	**45**
325	59	27	31	26	23	38	61	**38**

Fruit were spray inoculated with brown rot spores in the field on the dates indicated.
Fruits were all harvested on July 13, stored 14 days at 1C + 5 days at 20C.

Brown rot *Monolinia fruticola*

Cuticle thickness

Lower N **Higher N**

33

Daane, et al. 1995. Excess nitrogen raises nectarine susceptibility to insects and disease. California Agriculture 49(3): 13-18.

FRUIT DISORDERS CAUSED BY MINERAL DEFICIENCIES OR EXCESSES

Boron deficiency	***malformation of stone fruits*** ***corking of apples, apricots, pears*** ***lumpy rind of citrus*** ***marking face in olives*** ***cracking of apricots***
Calcium deficiency	***bitter pit of apples*** ***blossom end rot of tomatoes, peppers and watermelons*** ***cork spot in apples and pears*** ***black-end in pears*** ***brown discoloration of apple tissue*** ***red blotch of lemon***

(from Kader, 1996)

34

FRUIT DISORDERS CAUSED BY MINERAL DEFICIENCIES OR EXCESSES

Copper deficiency	***poor kernel development in walnuts*** ***gumming of citrus***
Iron deficiency	***pale skin and flesh color of stone fruits***
Zinc deficiency	***poor color of cherries*** ***extended, pointed styler ends of peaches and cherries***
Excess Na or Cl	***reduced fruit size*** ***higher soluble solids content***

(from Kader, 1996)

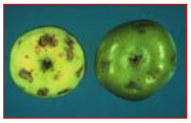
35

Physiological Role of Calcium

Calcium is an important mineral determining quality and decay resistance.

Examples of impacts of low Ca concentration

- **Internal breakdown**
- **Accelerated senescence**
- **Increased rate of softening of fruit**
- **Increased decay potential, especially at wounds**
- **More susceptible to physiological disorders**



Bitter pit in apples

Blossom end rot in tomato & pepper

36

Calcium Deficiency Disorders Generally Have an Underlying Cause

...not related to calcium availability in soil

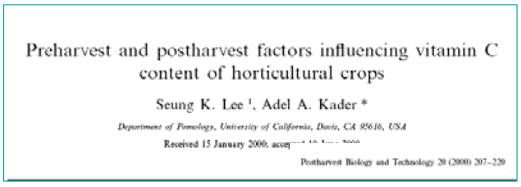
37

The issue is temporary deficiencies of calcium due to inadequate water movement to critical locations of the plant at critical periods

-- too rapid growth
-- high temperature
-- water stress
-- low transpiration

38

Preharvest Management and Human Nutrition



Preharvest and postharvest factors influencing vitamin C content of horticultural crops

Seung K. Lee [1], Adel A. Kader *

Department of Pomology, University of California, Davis, CA 95616, USA

Received 15 January 2006; accepted

Postharvest Biology and Technology 20 (2000) 207–220

Key preharvest factors

- **Nitrogen applications**
- **Irrigation and climatic interactions**

39

Nitrates and Food Safety:
Another concern about excessive N:

- Nitrates (relatively non-toxic) in water and food are a threat to health because of formation of Nitrites (5-10% conversion).
- Nitrites react with hemoglobin and impair oxygen-carrying capacity of blood.
- Nitrites react with amines to form carcinogenic N-nitroso compounds
- EU recommends limit of nitrates in vegetables of 2000 mg/kg FW

P. Santamaria. 2006. Review. Nitrate in vegetables: toxicity, content, intake and EC regulation. J. Sci. Food Agric. 86: 10-17.
Boink, A. and G. Speijers. 2001. Health effects of nitrates and nitrites, a review. Acta Hort. 563: 29-36.

40

Classification of vegetables by nitrate content (mg/kg FW)

Very Low (<200)		Low (200-500)	Moderate (500-1000)	High (1000-2500)	Very High (>2500)
Artichoke	Onion	Broccoli	Cabbage	Celeriac	Celery
Asparagus	Pea	Carrot	Dill	Chinese cabbage	Chervil
Broad bean	Pepper	Cauliflower	Radicchio	Endive	Cress
Eggplant	Potato	Chicory	Rapini	Escarola	Lamb's lettuce
Garlic	Summer squash	Pumpkin	Savoy cabbage	Fennel	Radish
Green bean	Tomato		Turnip	Kohlrabi	Red beetroot
Melon	Watermelon			Leaf chicory	Rocket
Mushroom				Leek	Spinach
				Parsley	Swiss chard

P. Santamaria. 2006. Review. Nitrate in vegetables: toxicity, content, intake and EC regulation. J. Sci. Food Agric. 86: 10-17.

41

Effect of N level in nutrient solution Nitrate content of rocket (arugula, roquette)

Parameter	2 mM nitrate In solution	0.25 mM nitrate in solution	Statistical significance
Nitrate content (mg/kg) Fresh weight	4196	1488	<0.05

Applied during the 5 days before harvest

Santamaria et al., 1998. J. Plant Nutrition 21: 1791

42

Fertility Management and Phytonutrients

The effects of mineral nutrition on plant phytonutrients *minimally* depends on

1) the nutrient
2) the nutrient form
3) the phytonutrient
4) inherent levels determined by genetics
5) irrigation practices
6) may be elevated or reduced by stress factors

43

Summary

Maximum postharvest quality for any crop can be achieved only by understanding and managing the various roles that preharvest factors play in postharvest quality.

We are just beginning to characterize the impacts of preharvest factors on phytonutrient content and sensory volatiles

44

Take Home Lesson:

Remember the P5 Mantra

Preharvest Planning Prevents Postharvest Problems

45

Thank you for your attention