

Fresh Produce Supply-Chain Food Safety

*UCGAPs research update on food safety
associated with vegetable crops*

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UCCE Santa Maria Grower Workshop



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Food Safety Management Goes from Farm to Fork



Develop a Better Appreciation of Food Safety Needs Across the Farm to Fork Supply-Chain



Why the Concern for Food Safety of Edible Horticultural Products?

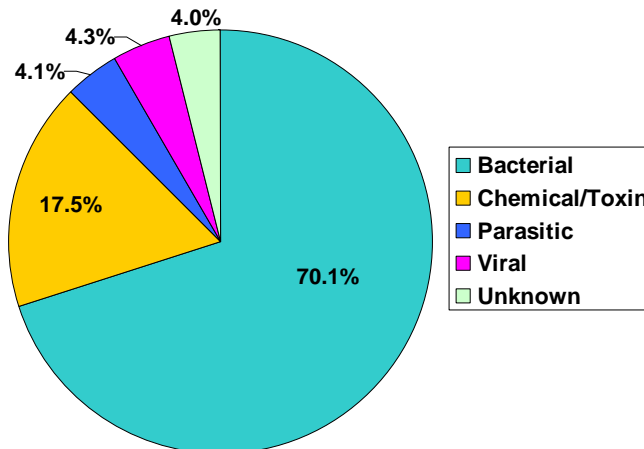
- ❖ Overview of Food-borne Illness in U.S.
- ❖ UCGAPs Brief Research Topics
- ❖ Rapid Response Case Example
- ❖ Systems-Approach: Case Example



U.S. Foodborne Illness

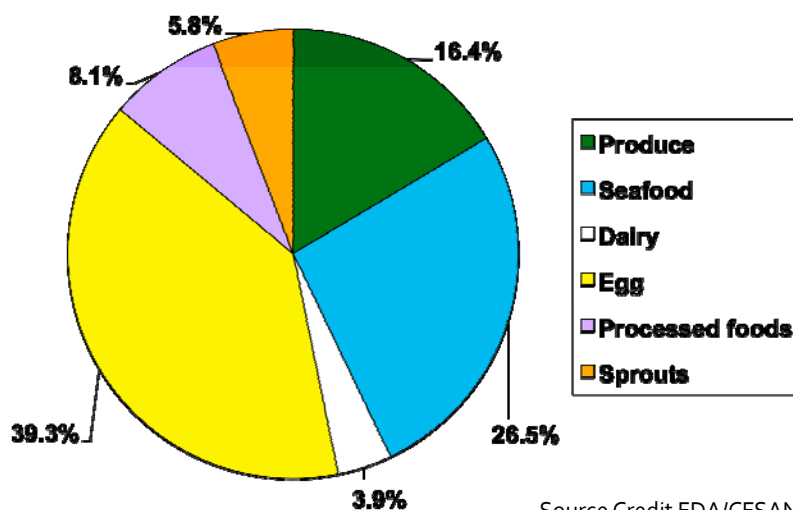
- CDC **ESTIMATES** (Scallan et al., 2011)
 - Major foodborne pathogens (31 organisms)
 - 9.4 million cases/year (6.6 to 13 million)
 - 56,000 hospitalizations (40,000 to 76,000)
 - 1,200 deaths (710 to 2,300)
- Unspecified illness
- 20 to 61 million cases/year
- Combined about 1 in 6 ill every year – most very mild but many severe

Reported **outbreaks** linked to FDA-regulated foods, by agent, 1996-2009 (N=532 outbreaks)

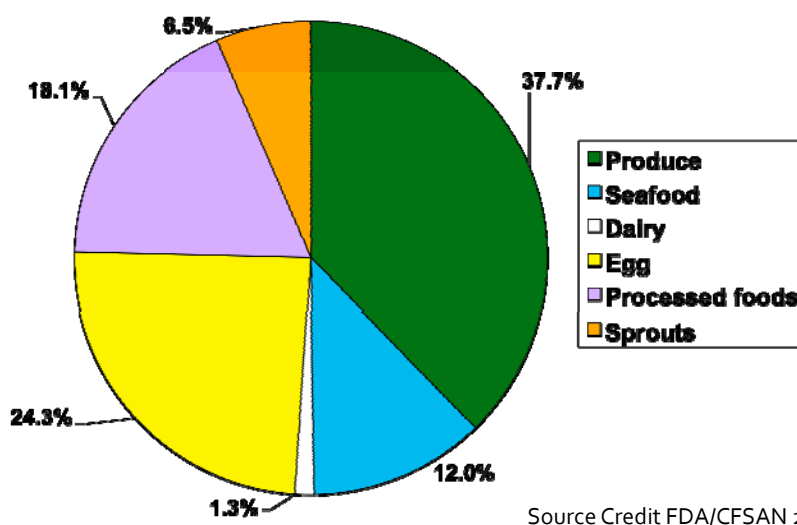


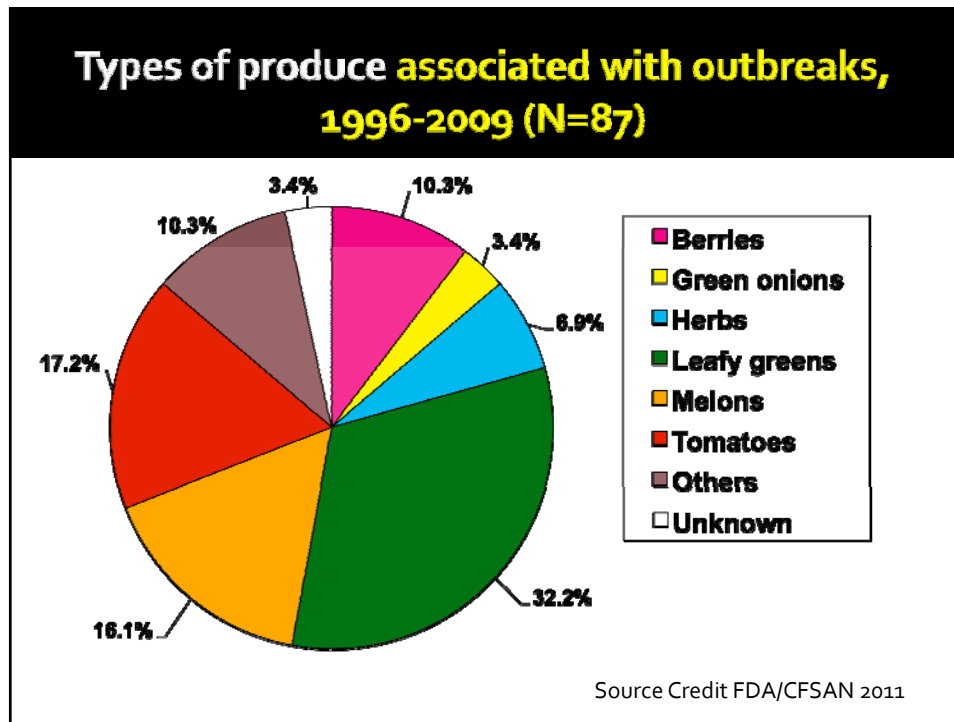
Source Credit FDA/CFSAN 2011

Reported *outbreaks* linked to FDA-regulated foods by vehicle, 1996-2009 (N=532 outbreaks)



Reported *illnesses* linked to FDA-regulated foods, by vehicle, 1996-2009 (N=29,750 illnesses)





78 Produce Outbreaks 1999-2010 Attribution by Commodity

Lettuce/Romaine	19	Basil	3
Spinach	3	Basil or mesclun	2
Cabbage	1	Cilantro	2
Tomatoes	15	Celery	1
Cantaloupe	7	Parsley	1
Melons	3	Green onions	2
Honeydew	2	Mango	2
Squash	1	Table grapes	2
Cucumber	1	Jalapeño/Serrano	1
Raspberries/berries	7	Snow Peas	1
Sprouts	30	Snap Peas	1
		Unknown	2

Source: FDA CFSAN

Where does Fresh-cut produce fit in the picture?

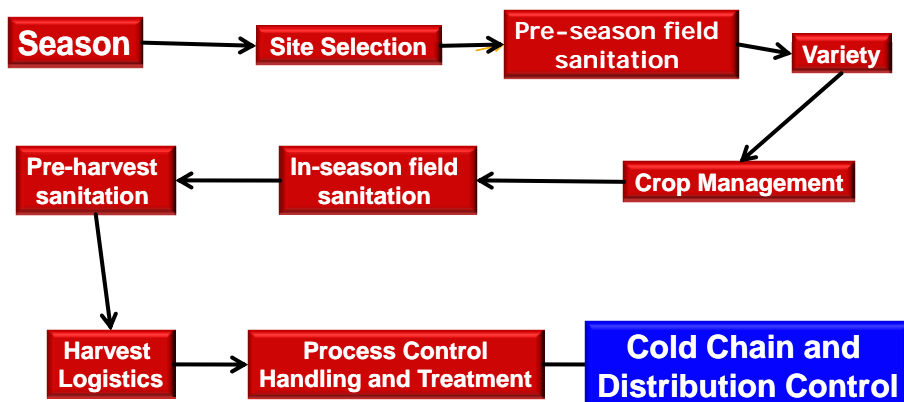


Year	Outbreaks	Illnesses
1999	0	0
2000	0	0
2001	0	0
2002	3	230
2003	3	125
2004	3	532
2005	4	255
2006	4	436
2007	0	0
2008	3	60
2009	0	0
Total	20	1638

* Fresh-cut produce: fresh produce that has been processed by peeling, slicing, chopping, shredding, coring, trimming, or mashing, with or without washing or other treatment, prior to being packaged for consumption.

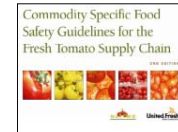
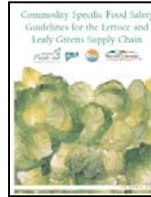
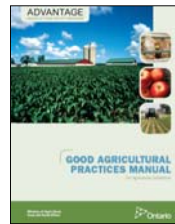
Source Credit FDA/CFSAN 2010

From the Beginning, Variable Risks Along the Supply-Chain were Recognized



Commodity-Specific GAPs and Food Safety Audit Checklists

- Melon
- Tomato
- Stone fruit
- Mushroom
- Lettuce & Leafy Greens
- Culinary Herbs
- Green Onions
- Sprouts
- Almond
- Citrus
- Strawberry
- Watermelon
- Blueberries
- Asparagus



Key Areas for All Scales of Farming and Shipping

- ❖ Water –
 - Preharvest & Postharvest
- ❖ Workers –
 - Hygiene & Training
- ❖ Waste –
 - Manure & Compost
- ❖ Wildlife –
 - Intrusion & Fecal
- ❖ Record-keeping
- ❖ Traceability

Key Grower Concerns

- Setback distances
- Water testing/assuring quality
- Mitigation of animal intrusion
- Impacts of pathogen testing
- On-farm verification requirements

UCGAPs: Research and Extension Program



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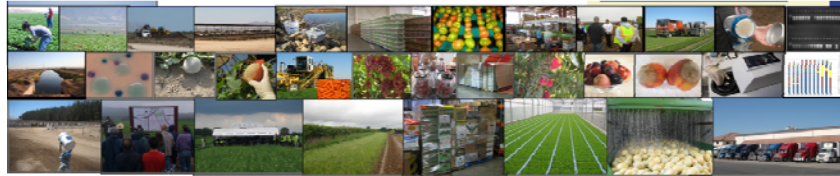


Microbial Food Safety
of Edible Horticultural Crops
<http://ucgaps.ucdavis.edu>

Founding Member of the
National GAPs Program
at Cornell University



UCGAPS: Research and Extension Program



Key Research Commodities & Issues 2007-2011

- ❖ Lettuce, Spinach, Spring Mix, Melons, Tomato, Stone Fruit, Carrots, Table Grapes
- ❖ Preharvest and Postharvest Water
- ❖ Soil survival and Role of N-management
- ❖ Bioaerosols
- ❖ Rapid Response on-farm assessments



Produce Safety Risk Assessemnts

- Survival and epidemiology of *E. coli* in the phyllosphere of diverse leafy green crops.

- Funding Agency: *California Leafy Greens Research Board*



- Establishment of critical operating standards for chlorine dioxide in disinfection of dump tank and flume water for fresh tomatoes.

- Funding Agency: *Center for Produce Safety*



- Survival of *Salmonella enterica* and *Escherichia coli* O157:H7 on cilantro in relation to sequential cutting and re-growth.

- Funding Agency: *Center for Produce Safety*



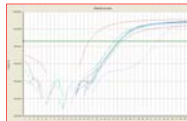
Alejandro Tomás-Callejas

Detection of *Salmonella* and *E. coli* O157:H7 on leafy greens after post-contamination exposure to environmental stress

- Survival from realistic levels of contamination
- Survival on diverse 'mini-greens'/spring mix
- Sampling scheme validations
- Efficiency of commercial test kits
 - Sources of False positives
 - Causes of False negatives



Example of outcome - *Salmonella* out-survives *E. coli*



Funding source: CA Leafy Greens Research Program
USDA SCRI

Gabriela Lopez-Velasco

Survival of *Salmonella enterica* on tomato through foliar pesticide applications



- Evaluation of *Salmonella* survival and growth in commercial fungicides and insecticides solutions under lab and field conditions
- Identification of pesticides that promote or inhibit *Salmonella* growth and/or survival
- Field trials to determine survival rate after open-field exposure on tomato surfaces and following post-harvest processing for fresh tomato market



Funding source: USDA NIFSI

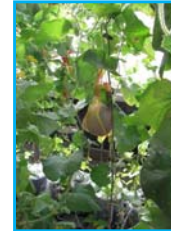
Gabriela Lopez-Velasco

Root uptake and systemic transport of *Salmonella enterica* in melon and other cucurbits

Evaluation of rate of internalization of *Salmonella enterica* after soil contamination

Example of Key Finding;

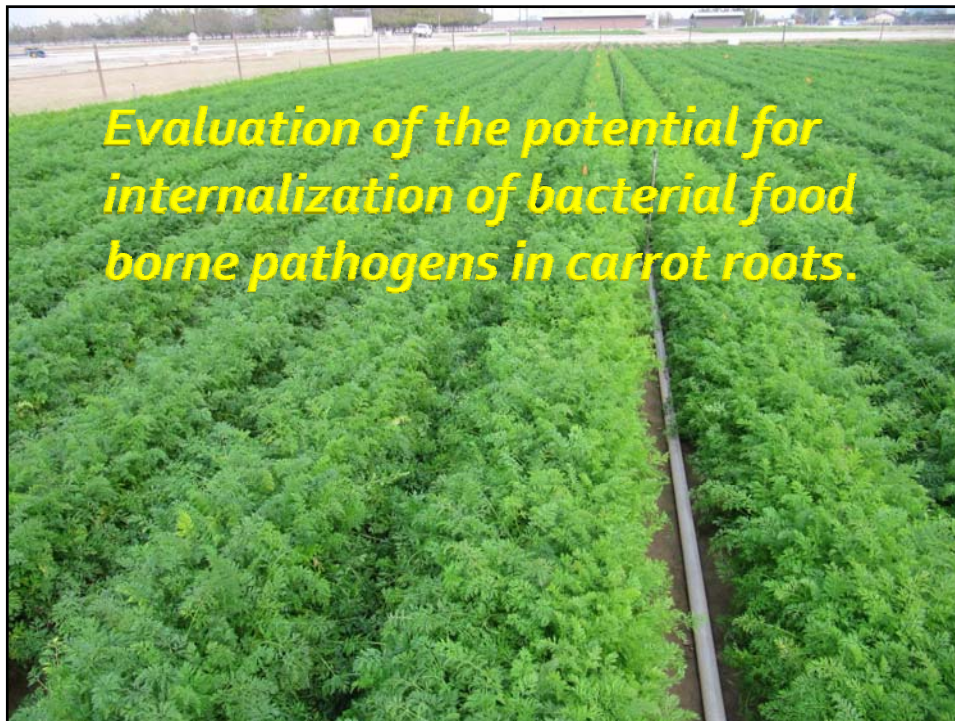
- **No systemic transport in field under furrow or drip**



Funding source: *Center for Produce Safety*
CA Melon Research Board

Gabriela Lopez-Velasco

Evaluation of the potential for internalization of bacterial food borne pathogens in carrot roots.



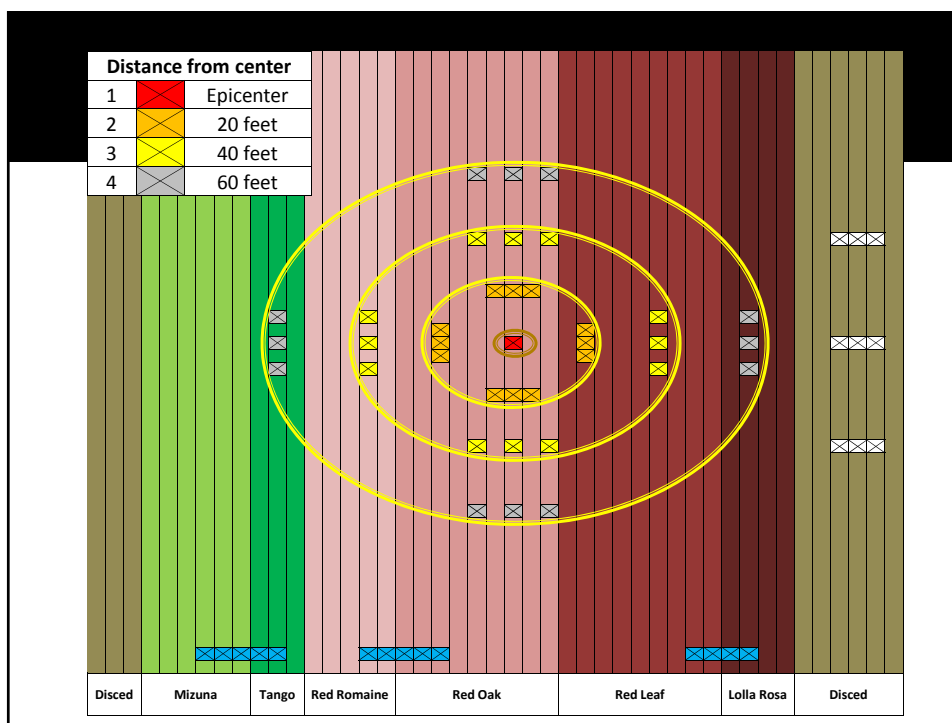
OBJECTIVE

To evaluate the potential for the internalization of bacterial food borne pathogens in carrot roots from contaminated irrigation water

Example of Rapid Response: RR15



Bird Impacted Spring Mix:2011



Molecular Detection- Results

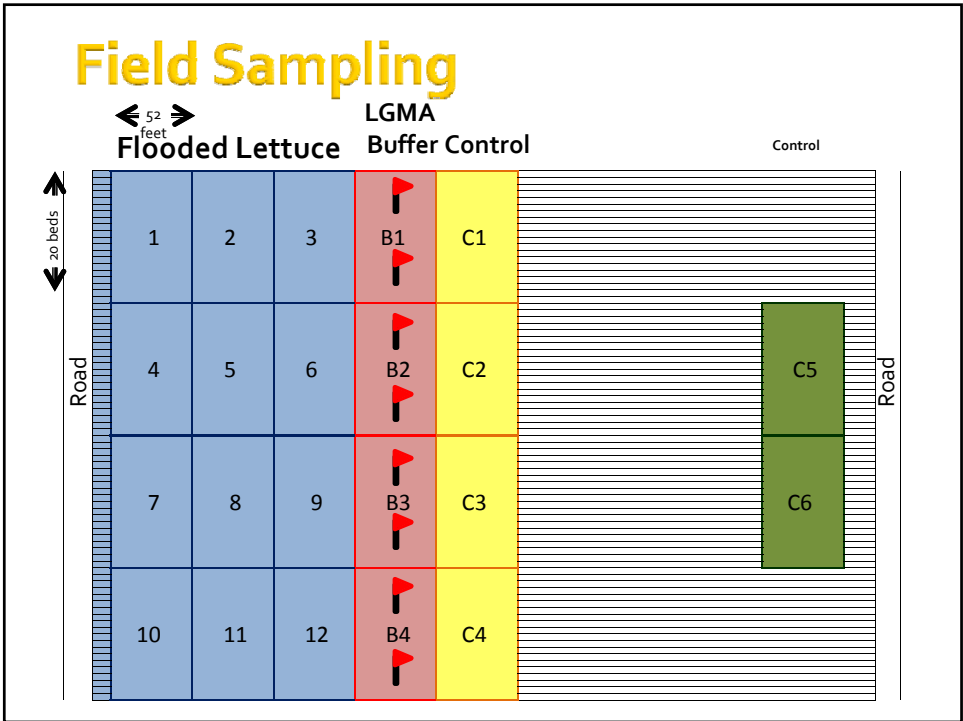
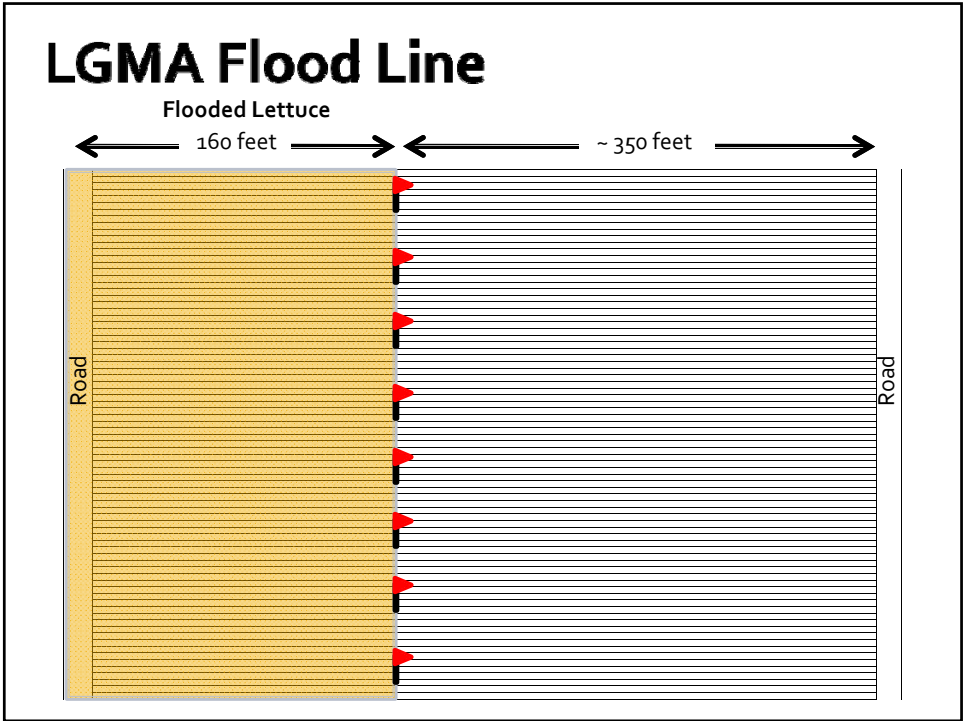
	Distance from center	Salmonella (Normal processing)	Salmonella (Temp Abuse)
	Epicenter	0/4	0/4
	20 feet	0/4	0/4
	40 feet	0/4	0/4
	60 feet	0/4	0/4
	Control	0/4	0/4
	Soil	0/4	N/A
	Rinse Water (Temp Abuse)	N/A	0/4

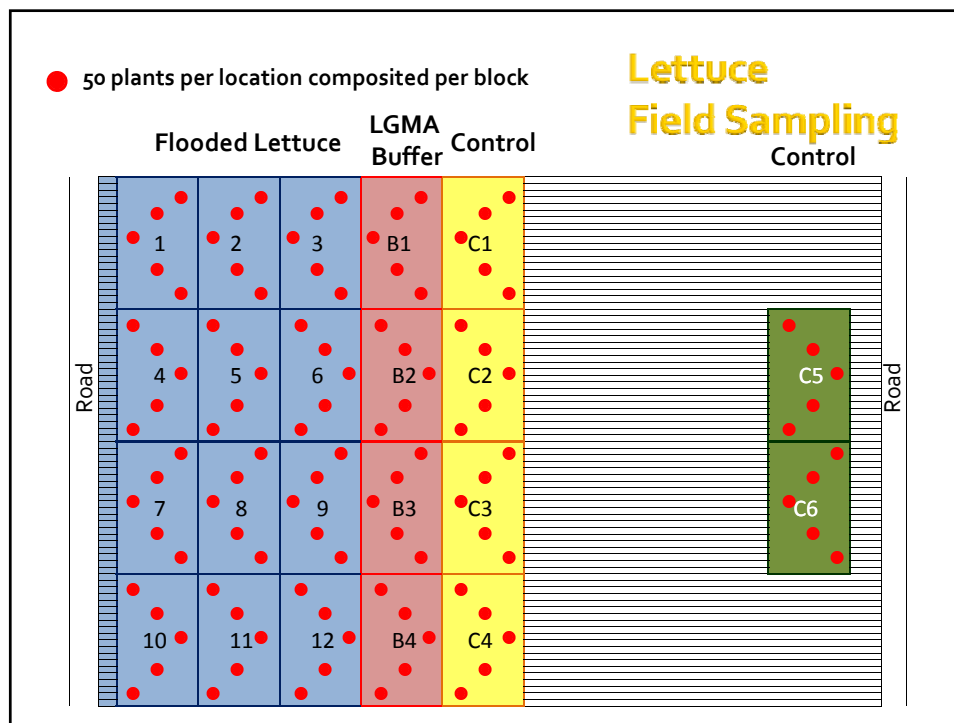
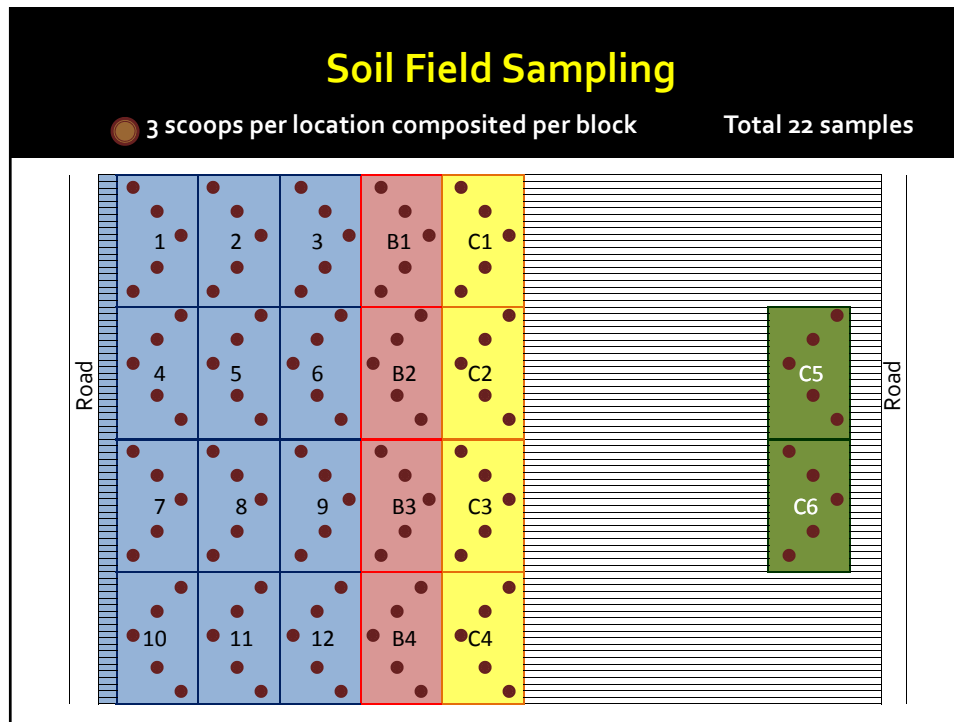


LGMA Best Practices 'Metrics' after a Flooding Event

	Enough? Too much?	Practical? Critical?
Time Interval Before Planting Can Commence Following the Receding of Floodwaters	<ul style="list-style-type: none">60 days prior to planting provided that the soil has sufficient time to dry out.Appropriate soil testing can be used to shorten this period to 30 days prior to planting. manner that accurately represents the production field and indicates soil levels of micro	

What tests? Test for what?





Plant Harvesting

- Field sampling divided in 22 blocks, 20 beds wide and 52 feet long (16 meters)
- 50 plants per location composited per block (**total of 1100 plants**) and divided in 3 subsamples of 150g each
- Inside and outside leaves harvested and processed separately (total of 132 samples combined)
 - Inside leaves composited per block (5-6 leaves per plant, total **~6600 leaves**)
 - Outside leaves composited per block (2 leaves per plant, total **~2200 leaves**)

Averages Among all Block Outcomes

Coliforms log CFU/g							<i>E. coli</i> log CFU/g							Detection Limit
	Flooded			Buffer		Control		Flooded			Buffer		Control	
Plant Inside	7.96	7.83	8.29	7.88	6.30	5.83	Plant Inside	2.26	5.56	3.44	1.26	1.26	1.26	1.26
Plant Outside	5.32	5.44	5.50	8.38	6.13	3.71	Plant Outside	1.43	2.82	1.37	1.26	1.59	1.26	1.26
Soil Bed	2.17	2.32	3.22	2.30	2.44	2.09	Soil Bed	1.43	1.43	1.43	1.43	1.43	1.43	1.43
Soil Furrow	6.37					2.79	Soil Furrow	1.43					1.43	1.43

log CFU/g	
Coliforms	<i>E. coli</i>
8	5
7	4
6	3
5	2
4	1
3	
2	
1	

Summary of 2011 RR-16 Key Learning's

- Defining flood impacted area visually alone not reliable
- T-Coliform counts in soil may help but not *E. coli*
- Appears to have good distinction in *E. coli* on plants
- Younger tissues appear better place to sample
- Flooding of this location did not result in readily detectable pathogen presence

***Salmonella* and *E.coli* O157:H7 Can Survive and Even Grow
In Some Foliar Materials from a Contaminated Water Source**



Peroxide + PerAcetic Acids

- ⦿ Recognized efficacy
- ⦿ Water treatment for spray tanks and lines
 - Reported to be effective in drip lines
- ⦿ 1/100 to 1/1000 use rates
- ⦿ No disinfection by-products
- ⦿ Post-cleaning disinfectant of bins, totes, belts

Example of hard-surface PAA cleaner



Example of Peroxide only formulation



Portable Peroxide Sprayers for Surface Disinfection

- ⦿ Hydrogen peroxide
- ⦿ Broad germicidal claims
- ⦿ Principle is sound
- ⦿ Cleaning first is critical
- ⦿ UCGAPs has not evaluated



Summary



- Fresh fruits and vegetables have be associated with significant foodborne illness
 - Illness to Total Servings per Year ratio is staggeringly small
- Pathogens associated with diverse fruits and vegetables are a reality
- Prevention of contamination throughout the supply chain is preferred over attempts at postharvest disinfection
- Better Cold Chain Control is essential to minimize risks

Current Suslow Lab: Who really gets the work done



Acknowledgements

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