

# Evaluating Public Health Impacts and Cost-Effectiveness of Implementing Good Agricultural Practices (GAPs) in the Tomato Farm Environment

Amy R. Sapkota, PhD, MPH  
University of Maryland School of Public Health

Co-Investigators: Sam Joseph; Shirley Micallef;  
Rachel Rosenberg Goldstein; Andrew Estrin;  
Marc Boyer; Cristina McLaughlin



# Background



- Multi-state outbreaks of salmonellosis associated with the consumption of raw tomatoes and other produce have increased in recent years
  - Estimated number of human illnesses: 3,000-80,000
  - 2008: *Salmonella* Saintpaul outbreak alone caused ~1,500 human illnesses
- There is a critical public health need to:
  - Understand how and where tomatoes are contaminated in the farm-to-fork continuum
  - Develop and implement innovative, cost-effective solutions that can prevent/reduce contamination events and minimize the burden of disease

# GAPs: A Possible Solution?



1998: CFSAN Guide To Minimize Microbial Food Safety Hazards For Fresh Fruits And Vegetables

2004: CFSAN and North American Tomato Trade Work Group action plan to prevent bacterial contamination of fresh produce

## Good Agricultural Practices (GAPs)

- GAPs assessment survey was developed by CFSAN and administered at tomato farms in 2007, **but no environmental samples were analyzed simultaneously**
  - Does the implementation of GAPs prevent or reduce bacterial contamination on tomato farms?
  - Are GAPs cost-effective to growers?



# Univ. of MD/CFSAN Study



## Purpose:

- To conduct a 2-year on-farm study on Mid-Atlantic tomato farms

## Goals:

- To understand the impacts of GAPs implementation on levels of on-farm bacterial contamination
- To determine costs to tomato growers of implementing GAPs and to evaluate whether costs present a barrier to implementation



# Univ. of MD/CFSAN Study (cont)

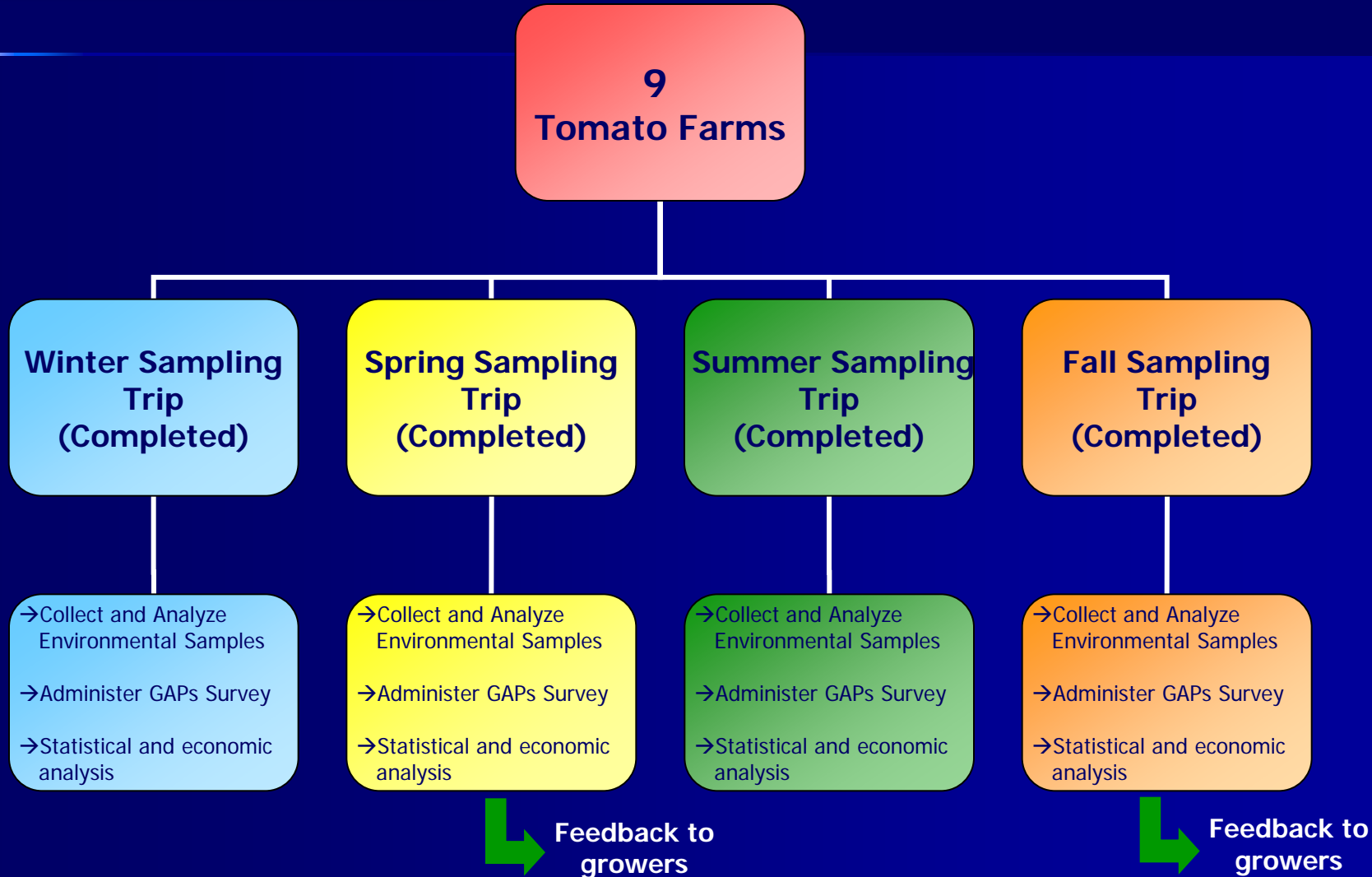


## Specific Aims:

1. To modify the CFSAN GAPs assessment survey to include questions about the costs of GAPs implementation, and to administer the new survey at tomato farms in the Mid-Atlantic region
2. To determine the prevalence of *Salmonella* and *Enterococcus* spp. in environmental samples collected from the same tomato farms
3. To evaluate associations between specific GAPs, the costs of the GAPs, and the prevalence of *Salmonella* and *Enterococcus* spp. in environmental samples

# Univ. of MD/CFSAN Study (cont)

## Overall Approach:



# Sampling Trips



# Collection of GAPs/Cost Data

- "Tomato Farm Sampling Questionnaire":
  - General farm information
  - Meteorological conditions
  - Tomato field characteristics
  - Water sources
  - Worker hygiene
  - GAPs implementation
  - GAPs costs
- Administered during each sampling trip

**Tomato Farm Sampling Questionnaire**  
**JIFSAN - UMD/CFSAN Tomato Farm Study 2009**

**1. General Information**

1.1 Sample collection date (mm/dd/yyyy) \_\_\_\_\_

1.2 What is the name of the packing company? (please specify) \_\_\_\_\_

1.3 What is the name of the specific tomato farm? (please specify) \_\_\_\_\_

1.4 What is the field name or number? \_\_\_\_\_ (On each farm, we will assign each field that we sample a unique field code. This same field will be sampled on all subsequent sampling trips.)

1.5 Are there any animals or birds in or around the tomato field that is sampled at the time of sampling?  
a) Yes  
b) No  
If YES describe \_\_\_\_\_

1.6 Is there any evidence of animals or birds in the tomato field that is sampled (feces, tracks, etc)?  
a) Yes  
b) No  
If YES describe \_\_\_\_\_

1.7 Are there fences around the field that is sampled?  
a) Yes - completely fenced  
b) No  
c) Partially fenced  
d) Other describe \_\_\_\_\_

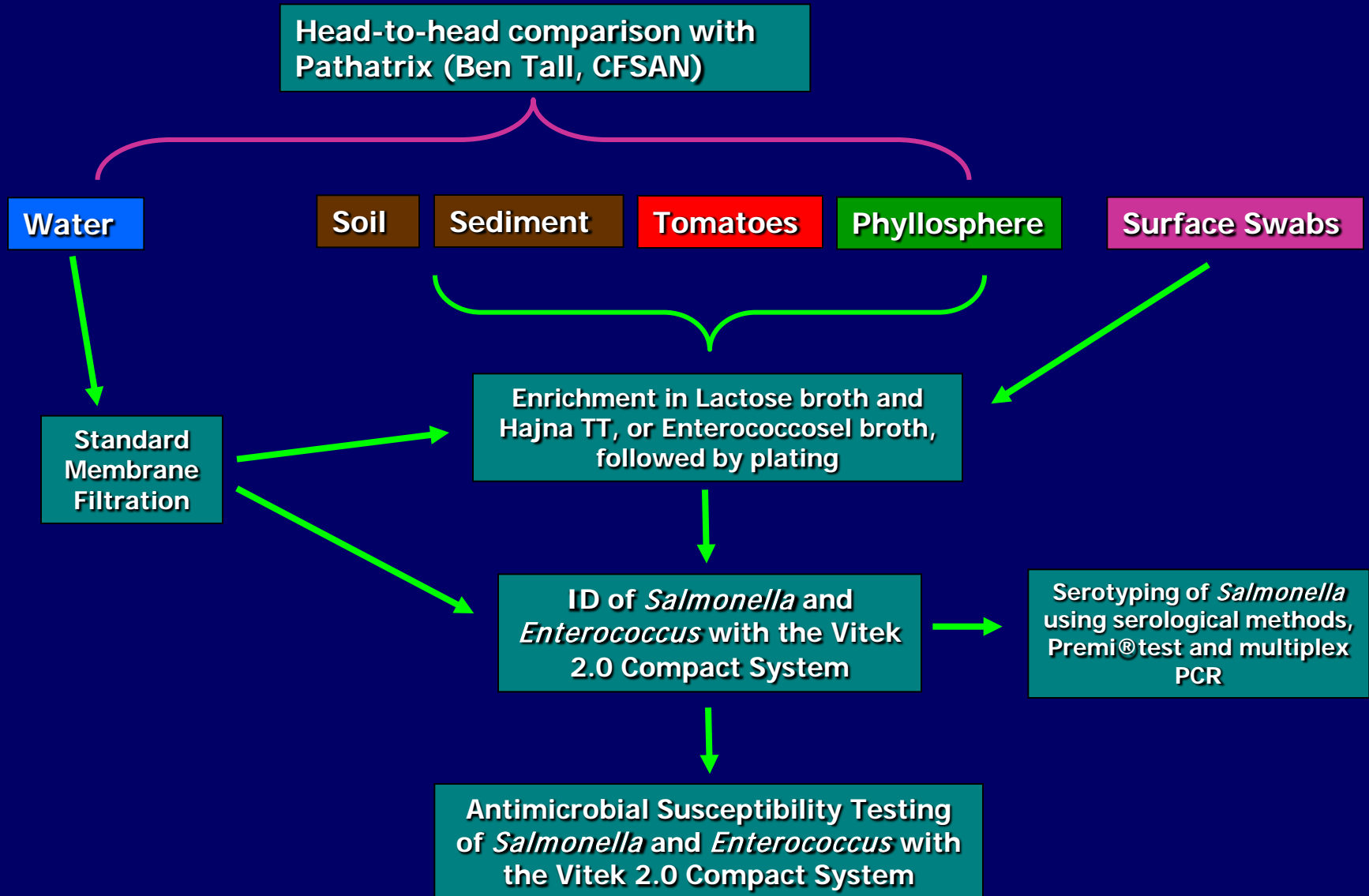
1.8 Are there ditches, ponds, streams, or other water where birds, reptiles, amphibians, etc can inhabit directly adjacent to the tomato field that is sampled?  
a) Yes  
b) No  
If YES describe \_\_\_\_\_

1.9 Are there forested, wooded or marsh areas adjacent to the field that is sampled?  
a) Yes  
b) No  
If YES describe \_\_\_\_\_

1.10 Are there any chicken farms or other large scale animal production facilities in close proximity to the farm?  
a) Yes  
b) No  
If YES describe \_\_\_\_\_



# Environmental Sample Analysis



# GAPs Analysis

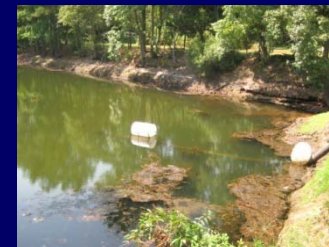


- A scoring system based on the GAPs questionnaire was developed
  - A point is given for each practice that is NOT consistent with GAP's
  - A score of 0 implies a high level of consistency with GAP's and a score of 24 implies a low level of consistency with GAP's
- These scores will be used in a logistic regression analysis that analyzes the association between GAPs implementation and on-farm bacterial contamination

# Results: *Salmonella* Contamination on Participating Tomato Farms

Sample Type	Number of Farms where <i>Salmonella</i> was detected			
	Feb	May	July	Oct
Ground water	0/3	0/3	0/5	0/4
Pond water	0/7	1/7	1/7	1/7
Filter back wash	-	-	1/1	-
Pond sediment	0/7	0/7	0/7	1/7
Soil	2/9	0/9	0/9	0/9
Control soil	1/9	0/9	0/9	0/9
Irrigation ditch soil	1/5	0/5	0/6	0/4
Irrigation ditch water	-	-	1/4	0/2
Phyllosphere	-	0/2	0/6	0/2
Tomatoes	-	-	0/4	0/4
Harvest trays	-	-	0/1	0/3
Port-a-potty swabs	-	0/2	0/1	0/1

Blue – BAM method  
Green – Pathatrix



# Results: Persistence of *Salmonella* on Participating Tomato Farms?

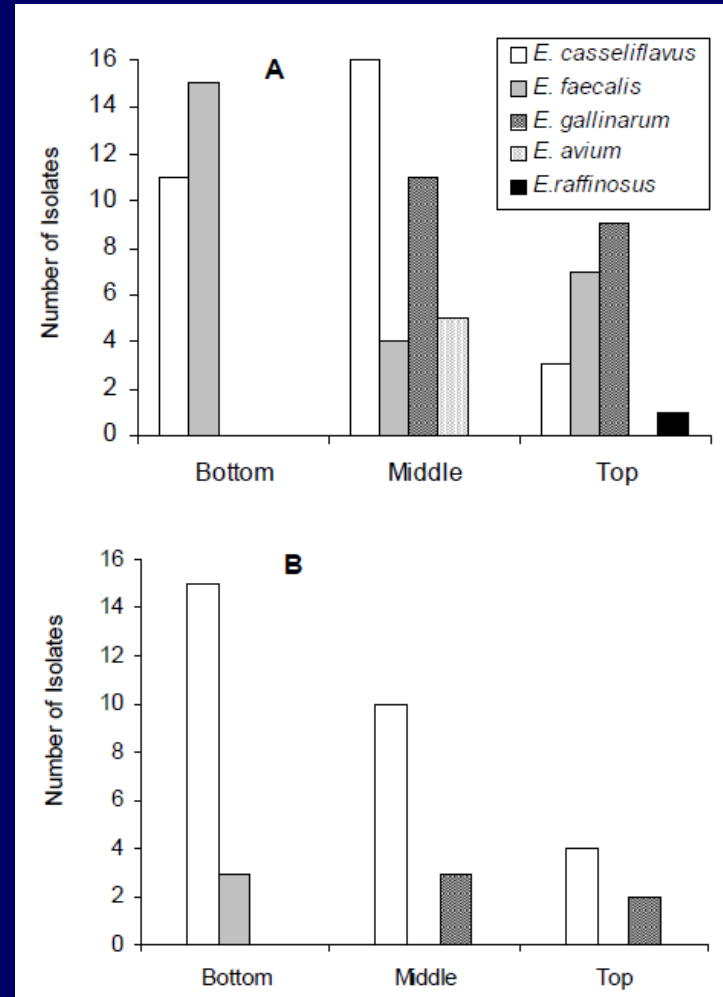
Farm Code	<i>Salmonella</i> Positive Farms			
	February	May	July	October
TF 9	Soil			
TF 25	Soil Control Soil Ditch Soil		Pond Water Filter Back Wash	Pond Sediment
TF 32			Ditch Water	
TF37		Pond Water		Pond Water

Blue – BAM method  
Green – Pathatrix

# Results: *Enterococcus* Contamination on Participating Tomato Farms

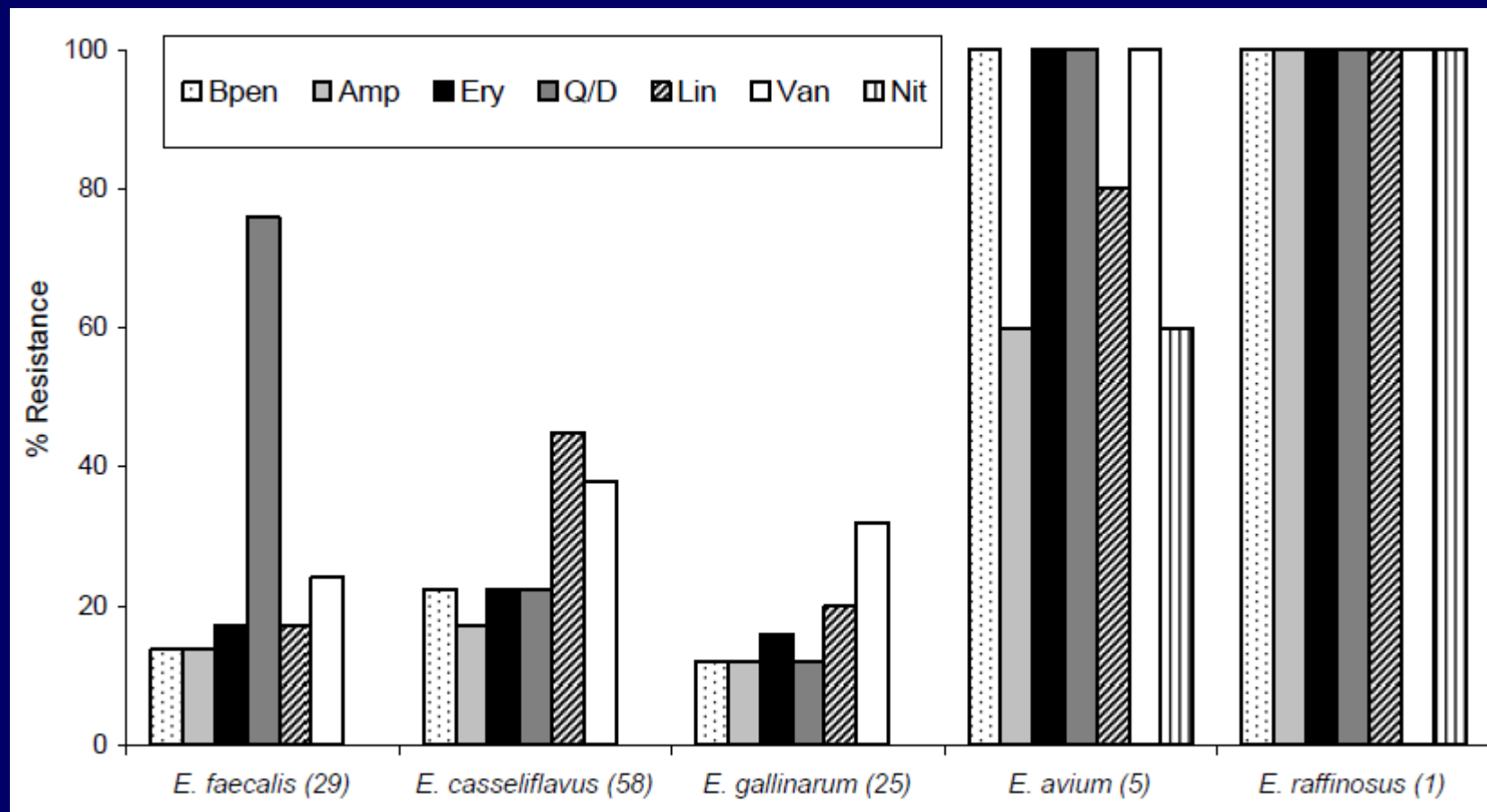
Sample Type	Number of Farms where <i>Enterococcus</i> was detected			
	February	May	July	October
Ground water	0/3	0/3	0/5	0/4
Pond water	1/7	5/7	3/7	6/7
Filter back wash	-	-	1/1	-
Pond sediment	5/7	5/7	5/7	5/7
Soil	9/9	7/9	9/9	9/9
Control soil	7/9	5/9	9/9	9/9
Irrigation ditch soil	5/5	3/5	6/6	4/4
Irrigation ditch water	-	-	2/4	2/2
Phyllosphere	-	0/2	5/6	2/2
Tomatoes	-	-	4/4	4/4
Harvest trays	-	-	1/1	3/3
Porta-potty swabs	-	2/2	1/1	1/1

# Results: *Enterococcus* spp. Distribution on Tomato Plants



**FIGURE 1.** *Enterococcus* spp. distribution on the bottom, middle and top portions of tomato plants on (A) large- and (B) small-scale farms.

# Results: Antimicrobial Susceptibility of *Enterococcus* spp. Recovered from Tomatoes



**FIGURE 3.** Resistance to individual antibiotics for all strains isolated is shown by species. The number of isolates per species is in parentheses.

# Preliminary Results: GAPs and Cost Data

- GAPs and cost data are being cleaned and analyzed
- Some variability in GAPs implemented on participating farms
- To be completed:
  - Logistic regression on GAPs, cost and microbiological data
  - Geographical analysis of participating farms



# Additional Work to be Done

- Confirm serotyping on *Salmonella* isolates
- Completion of manuscripts
- Additional feedback to (and from) growers
- Development of additional hypotheses to be tested

# Acknowledgements



- JIFSAN
- Steve Rideout (Virginia Tech)
- Tomato packers and growers
- The Virginia Institute of Marine Science (VIMS)
- Ben Tall, OARSA, CFSAN
- UMD Students
  - Ashish George
  - Zenas Chang
  - Norman Wang
- CFSAN
  - Samir Assar
  - Jack Guzewich
  - Thomas Hill
  - Mike Mahovic