Management of Soilborne Pathogens of Tomato and Strawberry: Local Solutions and Global Benefits

Compiled by Frank J. Louws

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SUMMARY:

Multiple soilborne pathogens limit production of tomato and strawberries in NC and surrounding states. A multi-state, interdisciplinary and stakeholder driven research and extension program was implemented to mitigate losses associated with the phase-out of methyl bromide (MeBr) as a soil fumigant due to its ozone depleting properties. Three broad levels of IPM research and extension were implemented in parallel including 1) Tactic Substitution that addressed short term needs of growers who sought non-ozone depleting fumigant alternatives; 2) Tactic Diversification that focused on medium term alternatives that included non-fumigant and IPM based tactics (e.g. rotation, vegetable grafting); and 3) Tactic Development that advanced long-term goals to explore microbial ecology and farming systems-based approaches to replace MeBr-dependent production systems (e.g. anaerobic soil disinfestation; biofumigation; compost- cover crop systems). Significant advancements were made in the science and practice of disease management and crop production. Considerable work was accomplished to identify the presence, diversity and dynamics of the soilborne pathogens associated with root and crown rot problems. Advances were accomplished through Phase I trials to evaluate new products or methods of disease management, and Phase II (small scale) or Phase III (large scale) on farm tests. On-farm work was often designed as randomized complete block design experiments with 3-4 replications and many data sets were collected by growers. All growers in the region transitioned away from MeBr and this local effort contributed to the overall decline in measurable stratospheric bromine levels and apparent increase in ozone levels in the upper stratosphere (global benefits).

Root and crown rot problems of strawberry in NC

Pathogen/Disease	Importance	Fumigation	Other Tactics
Black Root Rot	****	****	***
Phytophthora crown rot (*P. cactorum*)	***	***	****
Nematodes (RKN, sting, *Pratylenchus*)	***	****	**
Red Stele (*P. fragariae*)	*	*	***
Southern stem blight (*Sclerotium rolfsii*)	*	**	**
Anthracnose crown rot (*Colletotrichum gloeosporioides*)	**	NA	***
Botrytis crown rot	**	NA	***
Fusarium wilt (*F. o.* f.sp. *fragariae*)	*? NA	**	**
Verticillium wilt	NA	****	*
Macrophomina phaseolina	*	***	*

Blue = non soilborne; Red = occur in CA but not NC (yet!)

Who is the enemy that causes black root rot of strawberry?

- *Isolated and characterized over 1300 fungi using a hierarchical sampling scheme*
  - *Fungal complex varies with crop production site*
  - *Clean plants are difficult to obtain*
- *Rhizoctonia fragariae* : AG-G, AG-A, AG-I
- *Pythium irregulare, Pythium spinosum, Pythium artotrogus, Pythium HS*
- *Fusarium solani* and *Fusarium oxysporum*
- Phytophthora crown rot: *Phytophthora cactorum*
- *Phytophthora bisheria* Abad, Abad and Louws sp. nov.
- *Fusarium oxysporum* f.sp. *Fragariae*
  - *Work by Gloria Abad and Frank Louws*

Estimated Returns per Acre for Strawberries as Impacted by Fumigant

Fumigant	Additional Returns	Net Returns
Chloropicrin	$1,768	$16,687
Telone-C35	$291	$15,210
Metam Sodium (Shank)	$3	$14,992
Methyl Bromide	$0	$14,919
Metam Sodium (drip)	-$2,164	$12,755
Telone II	-$4,167	$10,752
Non-fumigated (check)	-$6,052	$ 8,867

Based on up to 15 trials over 10 years and multiple locations

(Sydorovych et al. HortTechnology)

Regional importance of various soilborne tomato pathogens in North Carolina based on Louws et al. 2010

Pathogen	ECOLOGICAL ZONE: Coastal Plain	Piedmont	Mountains
Verticillium dahliae race 1	----	*	***
Verticillium dahliae race 2	----	*	****
Fus. oxy. f.sp. *lycopersici race 0 or 1*	****	****	****
Fus. oxy. f.sp. *lycopersici race 2*	*	**	****
Ralstonia solanacearum (race 1)	****	***	*
Sclerotium rolfsii	****	**	----
Phytophthora capsici	***	***	***
Meloidogyne incognita	****	**	*

Example of a **Phase I** trial on **Tactic Substitution**: Marketable yield as impacted by fumigants, time of application and time of tomato transplanting. Primary targets: Verticillium wilt and weeds.

Treatment		Rate	Time of Application	Marketable Yield (ton/A)
1	No Fumigation	--------	Fall	26.5 a
5	Methyl Bromide:Pic (67:33)	400 lbs/A	Fall	34.3 bc
7	Telone C35	35 gal/A	Fall	36.4 bcd
10	InLine	26 gal/A	Fall bedding; Spring injection	38.9 d
6	No Fumigation	--------	Spring	34.4 bc
9	Telone C35	35 gal/A	Spring	38.6 d
11	Methyl Bromide:Pic (67:33)	400 lbs/A	Spring	38.9 d

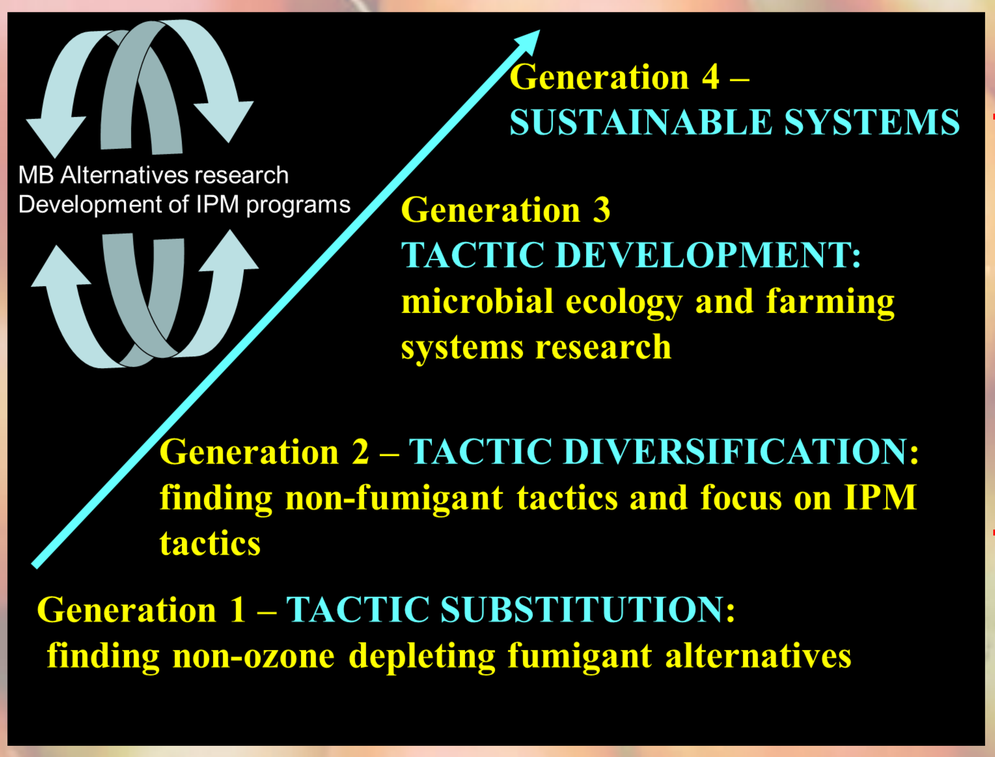
Tomatoes: Economic Analysis of Alternatives

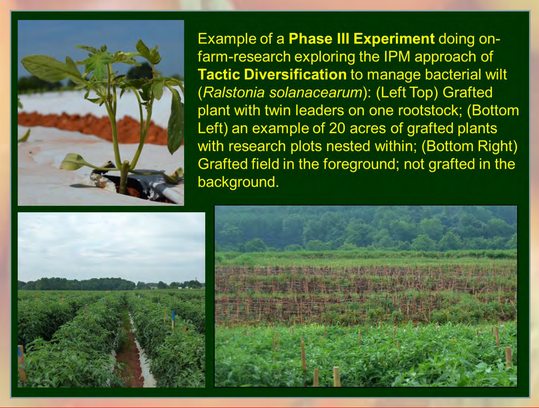
(Sydorovych et al. HortTechnology: 2008)

Selected alternative soil treatments	Net returns relative to MeBr ($/acre)
Chloropicrin (high rate)	+906.68
Telone-C35	+848.02
Metam sodium (drip applied)	+136.65
MeBr	0.00
Metam sodium (broadcast + till)	-72.20
Non-fumigated	-2,133.01

Over 9 years of trials

Net return of MeBr = $8,758/A = $21,641/ha; 1 EUR/ha ~ $3.6/A





Example of a **Phase III Experiment** doing on-farm-research exploring the IPM approach of **Tactic Diversification** to manage bacterial wilt (*Ralstonia solanacearum*): (Left Top) Grafted plant with twin leaders on one rootstock; (Bottom Left) an example of 20 acres of grafted plants with research plots nested within; (Bottom Right) Grafted field in the foreground; not grafted in the background.

On-Farm-Research: Incidence of Bacterial Wilt

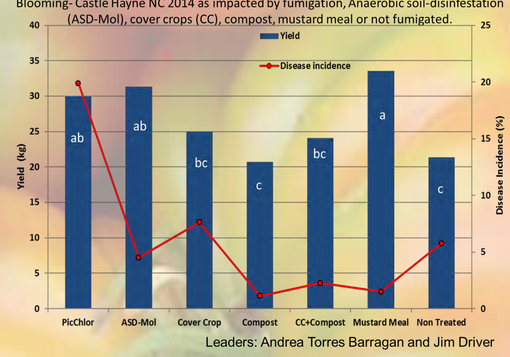
Main Effect		Fumigated Field Estimate(%)
Grafting:	Nongrafted	29.1a
	Grafted	1.1b
Rootstock:	Nongrafted	29.1a
	'801'	0.9b
	'802'	0.2b
Training System:	Single-Leader(Nongrafted)	29.1a
	Single-Leader (Grafted)	2.6b
	Double-Leader (Grafted)	0.1c
Spacing: 18, 24, 30 in.	45.7cm(Nongrafted)	29.1a
	45.7cm(Grafted)	0.9b
	60.9cm(Grafted)	0.02b
	76.2cm(Grafted)	3.2b

[Y] Means followed by the same letter within a main effect are not significantly different by the Tukey method at P=.05 level of significance.

[Z] Least-Squares Estimate for percent wilt derived from the number of diseased plants per 10-plant plot.

Diversity of Tomato Vegetable Production Systems:

Example **of Phase I** trial to evaluate **Tactic Development (Systems):** Average strawberry yield (marketable berries) and average disease incidence (black root rot) at Peak Blooming- Castle Hayne NC 2014 as impacted by fumigation, Anaerobic soil-disinfestation (ASD-Mol), cover crops (CC), compost, mustard meal or not fumigated.



Leaders: Andrea Torres Barragan and Jim Driver

Mustard Meal Use:

Compost

Cover crops

EXAMPLES OF IPM STRATEGIES EXPLORED

Host Resistance:
- Bacterial wilt resistance/grafting
- Grafting of tomatoes
- Phytophthora resistance in peppers

Complementary Pesticides:
- Seed treatment technologies (nematodes)
- Drip applied fungicides; herbicides; insecticides

Cultural/Husbandry Practices:
- Crop rotation and cover cropping
- Soil Amendments
- Disease Free Plants (Strawberries)
- Anaerobic Soil Disinfestation
- Biofumigation
- Biocontrol and Plant Growth Promoting agents

Phase I: research station trials; new products or methods of application; farming systems research

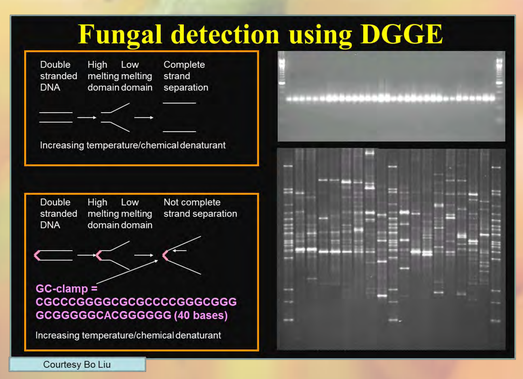
Phase II: on farm research trials; on farm demonstrations (field scale implementation)

Phase III: large scale on-farm research or demonstration trials

Who is Our Clientele?

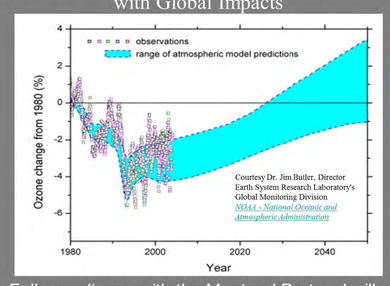
- Our clientele's challenges tend to be very different than the clientele in other major methyl bromide dependent production systems.
- We typically do not work with large farming enterprises that have an extensive infrastructure.
- Rather, we work with many growers who tend to have limited acreages that are essential to farm viability.

Fungal detection using DGGE



Courtesy Bo Liu

Benefit of The Montreal Protocol - Local Research with Global Impacts



Full compliance with the Montreal Protocol will see concentrations of stratospheric ozone return to baseline levels towards the middle of this century.

Collaborators in research and extension: A Participatory model to build infrastructure

- Plant Pathology
- Horticulture
- Mycology
- Nematology
- Entomology
- Weed Science
- Economics
- Engineering
- Crop Physiology
- Grower Stakeholders

Funding:
- USDA Competitive Grants
- IR-4 MB Alternatives Project
- NC Strawberry Growers Association
- NC Tomato Growers Association
- NC Vegetable Growers
- Industry Support
- USDA-ARS – Area Wide Program

Industry participants:
Chemical suppliers and distributors
MANY STRAWBERRY and VEGETABLE GROWERS

All growers in our region have transitioned away from Methyl Bromide and use alternative fumigants or alternative farming systems. Advances in understanding pathogen diversity, dynamics and management enhances efficacy of managing soilborne pathogens.