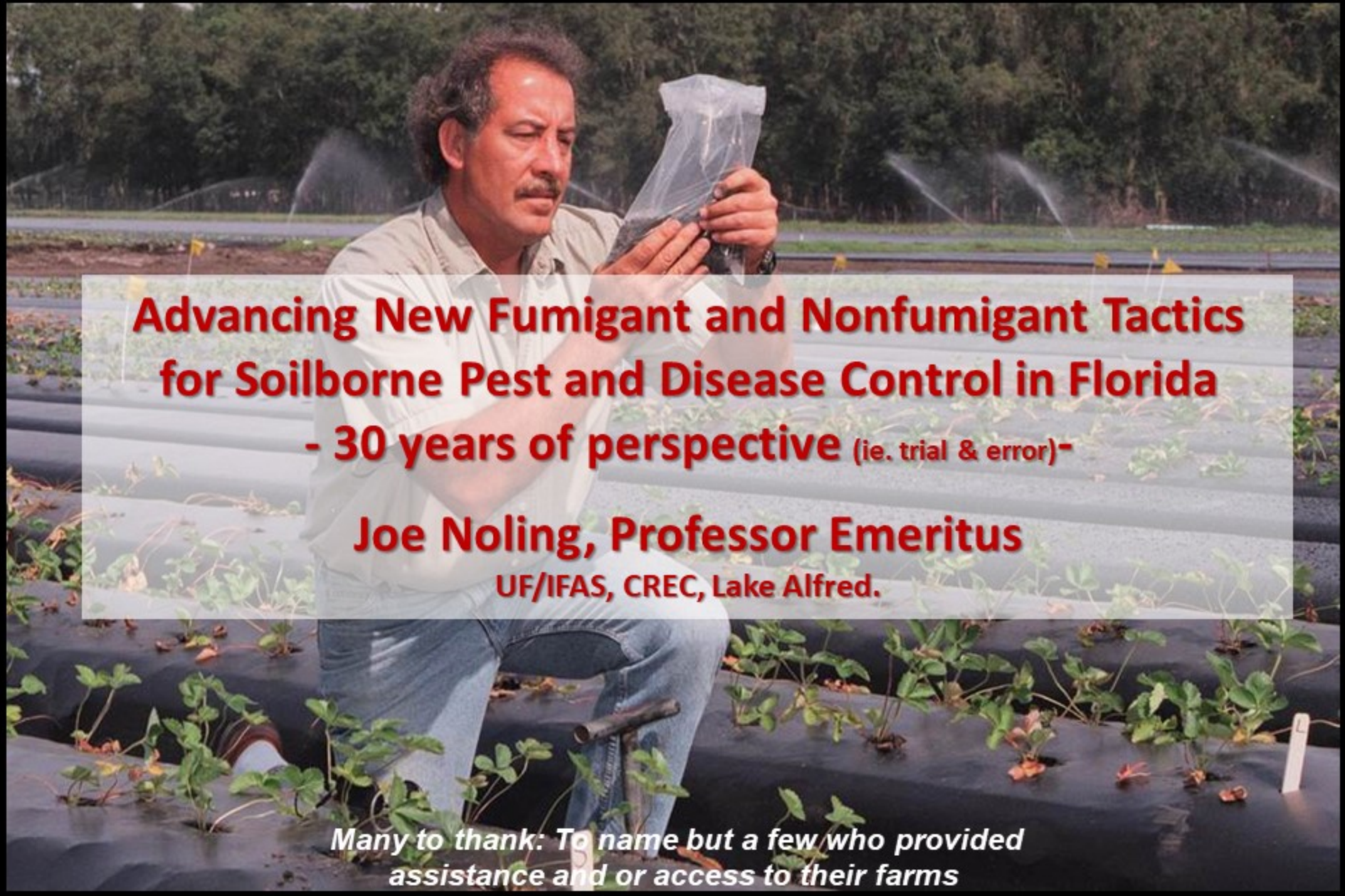


Advancing New Fumigant and Nonfumigant Tactics for Soilborne Pest and Disease Control in Florida - 30 years of perspective (ie. trial & error)-

Joe Noling, Professor Emeritus

UF/IFAS, CREC, Lake Alfred.

Many to thank: To name but a few who provided assistance and or access to their farms

Dr. Jim Gilreath, Dan Botts (FFVA), Reggie Brown(FTC), Kenneth Parker (FSGA)
Grower Cooperators: Jay Shivler, Wes Roan, John Stickles, Mike Lott, Marvin Brown
Ag Chem : Jerry Nance, Robert Kipp and crew, Mike Herrington, John Mirusso

The Path Taken

A 33 year Research / Extension Timeline & Development of IPM Alternatives

Under the Radar Period
Nematode Management and Crop Loss Prediction in Florida Tomato '1985-1992'

← Grower Demo Trialing-Technology Transfer-Transition Strategies →

Problem Definition Phase *'No Stand Alones'* Target Pest Specificity '1994-1996'

The Scientific, Economic, and Political Reality of the Phase-out of Methyl Bromide

Study of: Methyl bromide alternatives, and Outcomes and Impacts of EPA reassessments of Soil Fumigants.

Achieving consistency with methyl bromide Alternative Fumigants

Joe Arrives | MBr Detected Stratosphere | CUE's Begin | 100%

1985 1987 1989 1991 1993 1995 1997 1999 2001 2003 2005 2007 2009 2011 2013 2015 2017 2019

1991 Nematode Management Crop Loss Prediction in Florida Tomato Production

1986 Prescriptive Approaches To Mbr + PIC

1987 Future of Drip Delivery Nematicides

1996 Drip Fumigation

1997 Relative Lethal Dose

1999 Plant Resistance Soil Amendments Biorationals Double Cropping

2001 Effect of Irrigation Volume on Wetting Patterns in Florida Vegetable Soils

2003 Weed Hosts Sampling Strategies

2007 Potential Impacts of Buffer zones

2008 VIF Films Measuring Gas [CxT] w/ MiniRae PID-VOC

2011 - Achieving Consistency w/ Alternatives - Influence of Compaction Layer

2014 NDVI

2015 Targeting Fumigant Placement

2016 Vertical Management Zones

2018 Noling Goes Rouge

1988-1991 Melon SLN Section 18's Use of Methyl Bromide/chloropicrin on Melon Group

1988

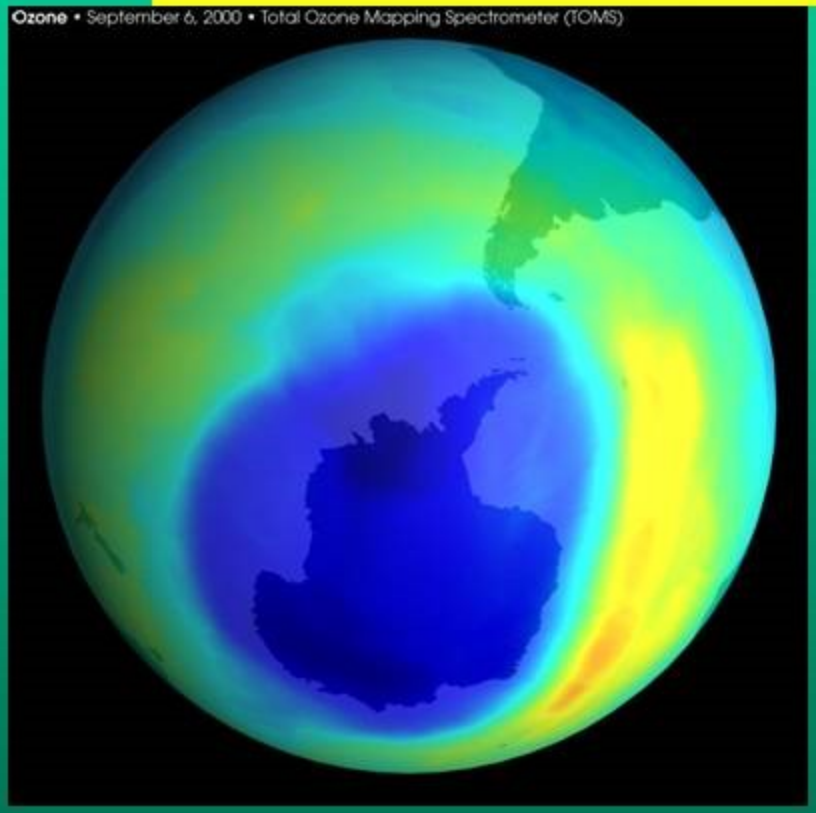
I did the efficacy trials and Field demo's, and submitted the Field research and grower surveys

so..... When the melon growers were awarded the exemption by the state I think they thought they won the lotto, even thought they had to give me an appreciation award at their annual meeting.

Methyl Bromide Timeline to Transition – There's No turning back....
No Legislated miracl

1992

ATMOSPHERIC ASSESSMEN



- ***Hole not disappeared***
- ***ODP = 0.4 - 0.7***
- ***Outgassing from Bed 40 – 90 %***
- ***Anthropogenic sources 10 - 40%***

Based on the most recent ODP estimate of 0.4, Methyl bromide is still considered a very important ozone depleting substance, and whether natural or manmade, will ultimately be completely phased out of production and of Critical Exempted Use as mandated by the U.S. Clean Air Act of 1990 and globally by consensus decision by the Parties of the Montreal Protocol.

Lots of Different Soilborne Pests to Consider

"Any one of them a potentially limiting factor"

Disease

Bacterial Wilt
Southern Blight
Fusarium Wilt
Verticillium Wilt
Pythium sp.
Rhizoctonia sp.
Fusarium Crown & Root Rot

Nematode

Root-knot
Sting
Reniform
Others

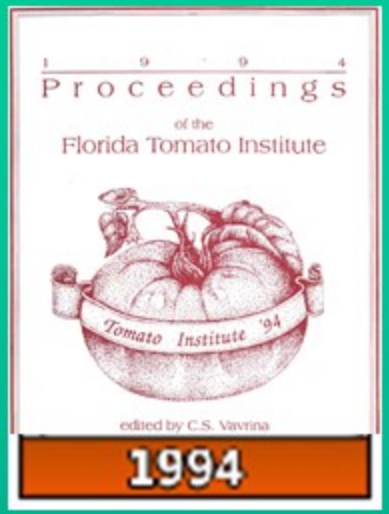
Arthropod

Wireworm
Mole Crickets
Cutworms
Others

Weeds

Nutsedges
Nightshades
Many Others

Team efforts…



Alternatives to Methyl Bromide for Nematode Control

J.W. Noling
IFAS
Citrus Research & Education Center, Lake Alfred, FL

D.W. Dixon and S.J. Locasio
IFAS
Department of Entomology & Nematology and Horticultural Sciences Department, Gainesville, FL

J.P. Gilreath
IFAS
Gulf Coast Research & Education Center, Bradenton, FL

R.J McGovern
IFAS
Southwest Research & Education Center, Immokolee, FL

and

S.M. Olson
IFAS
North Florida Research & Education Center, Bradenton, FL

GNV

GCFREC

SWFREC

NFREC

ontrol for nine chemical treatments at each of four state locations during spring 1994.

Treatment	Broadcast Rate[1]	Bradenton GCREC	Quincy NFREC	Gainesville Hort. Farm	Gainesville Green Acres	Average Rating
MBC[2] (98/2)	400 lbs	.028	.500	.222	.459	.302
MBC (67/33)	350 lbs	.014	.238	.259	.406	.229
Telone C17	35 gals	.056	.167	.265	.714	.301
Chloropicrin	350 lbs	.042	.786	.962	.956	.687
Vapam (Drip)	100 gals	.972	1.191	.846	.557	.892
Vapam (Spray)	100 gals	1.5	1.548	.710	1.025	1.196
Basamid	400 lbs	.667	1.476	.716	.833	.923
Enzone	200 Gals	1.153	—	.951	1.094	1.066
Check	—	1.000	1.000	1.000	1.000	1.000

Very clear differences

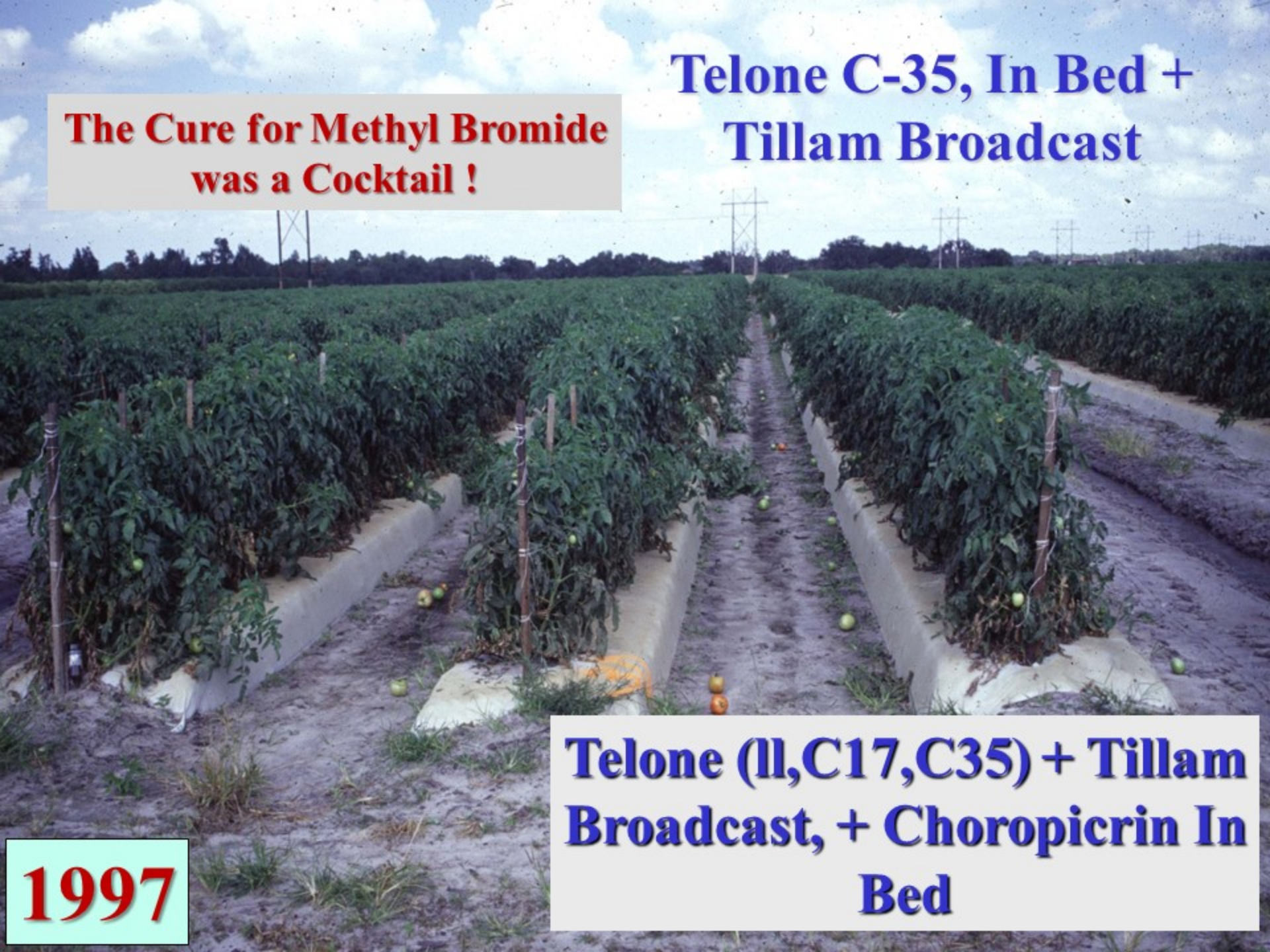
- ***Nematicidal Efficacy***
- ***Target Pest Specificity***

Summary of the general effectiveness of various soil fumigants for nematode, soilborne disease, and weed control

FUMIGANT	NEMATODE	DISEASE	WEED
1)Methyl bromide[1]	Excellent	Excellent	Good to excellent
2) Chloropicrin	None to Poor	Excellent	None-Poor
3) MetamSodium	Poor to Good	Poor to Good	Good-Excellent[3]
4) Telone II	Good to Excellent	None to Poor	Poor
5) DMDS[2] +PIC	Good -Excellent	Good-Excellent	Good - Excellent
6) C35 or PicClor60	Good to Excellent	Good to excellent	Poor-Good
7) Metam Potassium (KPAM)	Poor to Good	Poor to Good	Good-Excellent[3]
8) Allyl isothio-cyanate (Dominus)	Poor to Good	Poor to Good	Poor to Good
9) Ethane Dinitrile (EDN) *Not Currently Registered*	*Still in Asse*		*sment*
10)Sulfuryl Fluoride *Not Currently Registered*	*Still in Assessment*	*Still in Assessment*	*Still in Assessment*

Beginning 1994

[1] *Federal CUE Exemption has expired for all Florida crops, continued use only from existing non CUE stocks;* [2] *Includes coformulations with other fumigants i.e., Chloropicrin and Telone II ;* [3] *Minicoulter applications. For all above, consistency determined by chemical, cultural, physical and environmental condition.*


The Cure for Methyl Bromide was a Cocktail !
Telone C-35, In Bed + Tillam Broadcast
Telone (II,C17,C35) + Tillam Broadcast, + Choropicrin In Bed
1997

CONSISTENCY IMPROVED

1999

Telone C-17 or C-35 Broadcast treatments w/ Yetter System

Particularly with additional Choropicrin (100-150 lb) at the time of Bedding

Methyl Bromide Alternatives Technology:

2001

Drip Fumigation

- Ease of Fumigant Application
- Minimizes PPE Requirements & Costly Certifications. Most workers out of field
- Minimizes Buffer Zones (25ft)
- Double Cropping Pest Management

CHEMIGATION "BED WETTING" RESEARCH

Drs Jim Gilreath, Joe Eger, Alex Csinos, Joe Noling, Johan Deseager

Principal Objective:

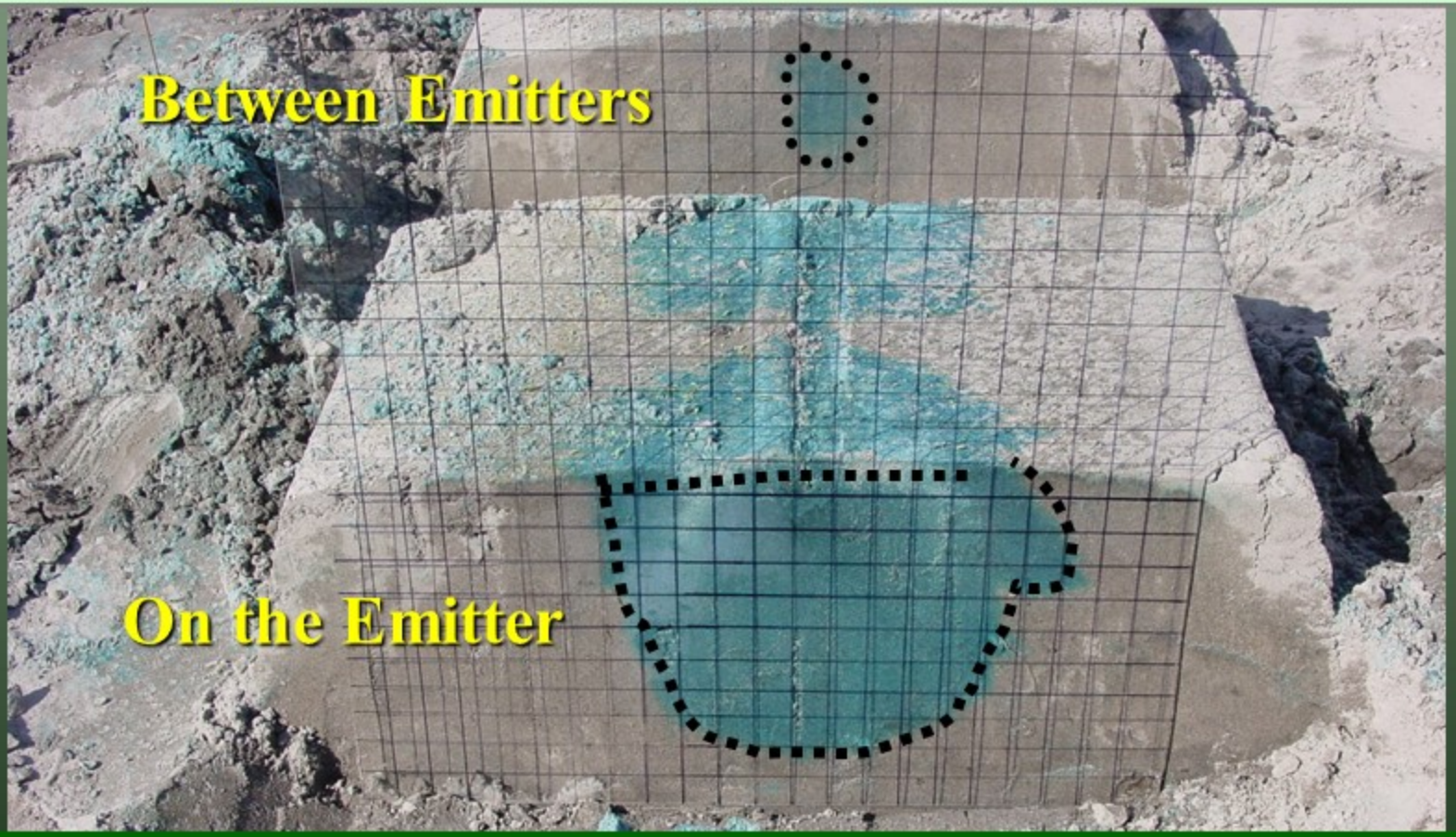
Characterize movement and resultant spatial distribution of a chemigated, water soluble dye in soil

2001

Variables Examined:

Injection Period, Tube Numbers, Flow Rates, Emitter Spacings, Soil Compaction, Pulsing , Adjuvants, others…

GRID EVALUATION METHOD FOR MEASURING WIDTH, DEPTH, AND AREA OF DRIP WATER MOVEMENT



Mapped grid coordinates were then entered into the computer to analyze size of treated or dye stained areas relative to Bed Size, Run Time, Water Volume, Tape Number, and other treatment regimes.

The IMPORTANCE of INJECTION TIME (water volume) ON WATER DISTRIBUTION ACROSS THE BED ON THE EMITTER

The more water you add the more radial expansion occurs!

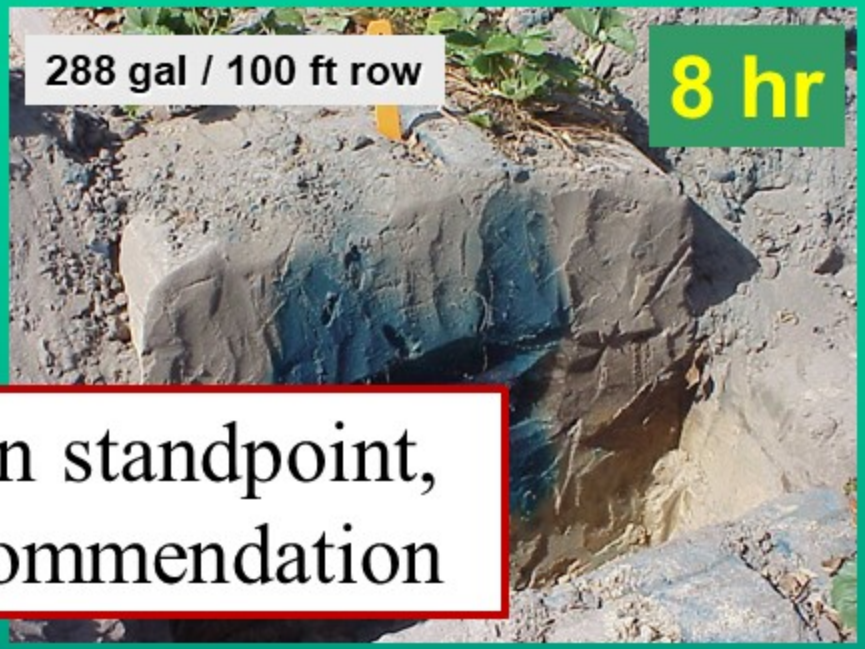
28/32”bed, 0.45 gpm/100ft, 10psi T-tape 12”emitter spacing on new plastic

Important Outcome: ***Much of previous chemigation research evaluated suboptimal irrigation regimes***

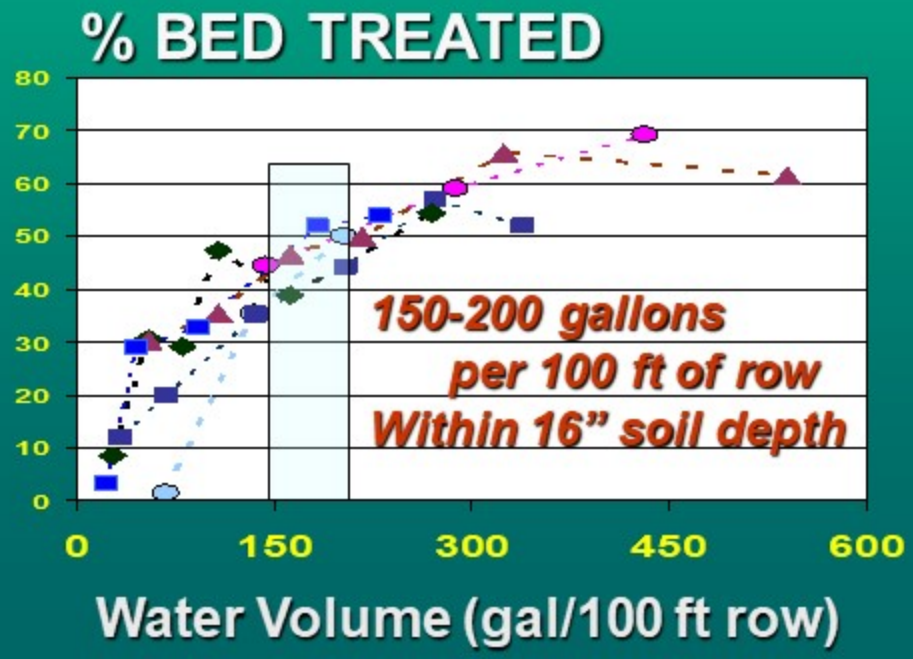
From an extension standpoint,
This was a significant finding

Treatment: 2 hr Chemical Injection Period

INTEGRATING IRRIGATION & PEST MANAGEMENT

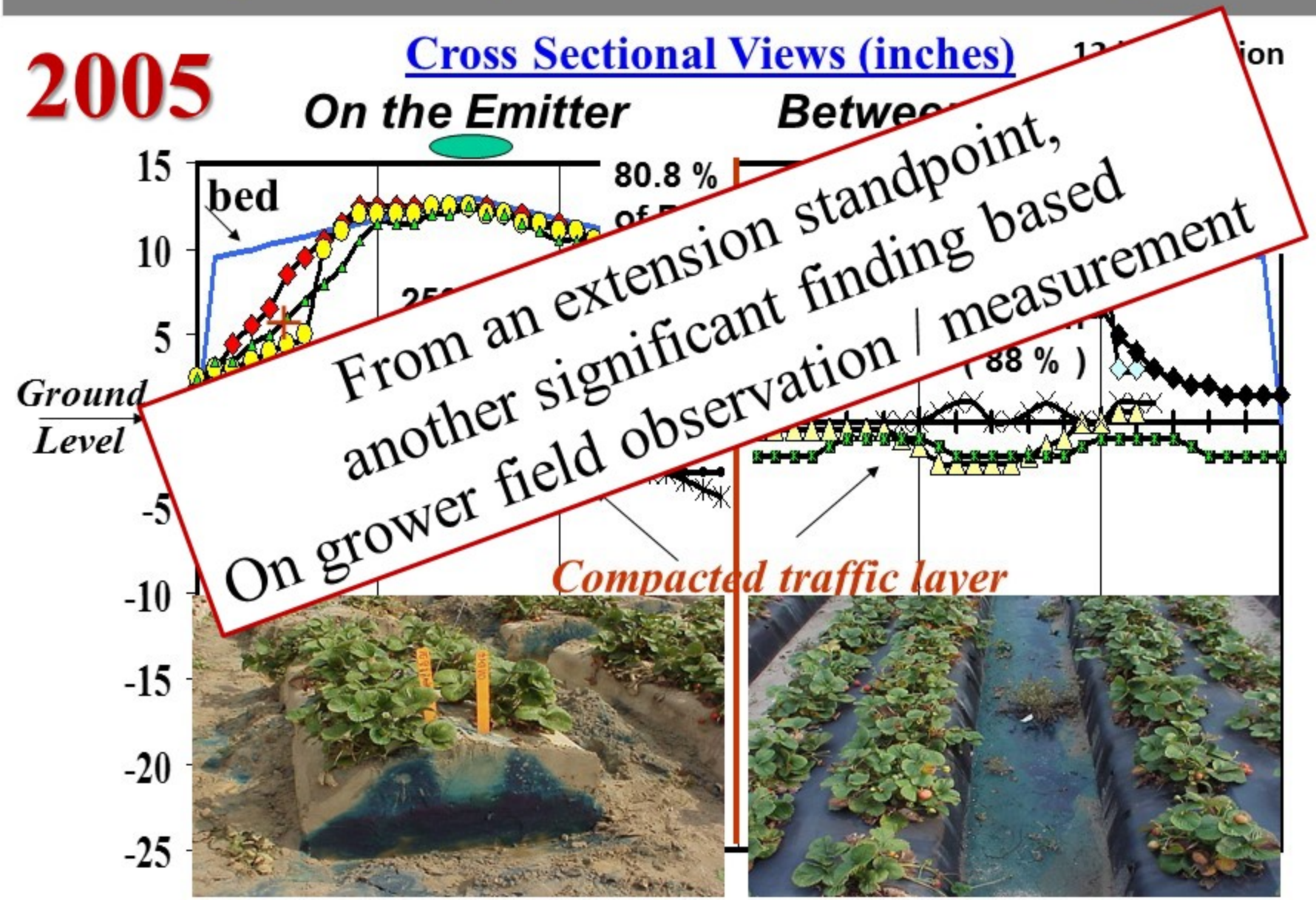


From an extension standpoint,
This was the recommendation



Soil Compaction Layer as Barrier to Water Infiltration

2005



The dye hit the compacted traffic layer and then flooded into middles

UNIVERSITY OF FLORIDA
EXTENSION
Institute of Food and Agricultural Sciences

2003

Role of Weed Hosts in Population Enhancement of Sting and Root-Knot Nematode

J.W. NOLING
J.P. GILREATH
University of Florida, IFAS

Project Supported by
USDA / FFVREF
Many Thanks-Dr.Janete Brito

We Demonstrated the Importance of Weeds for Nematode Management

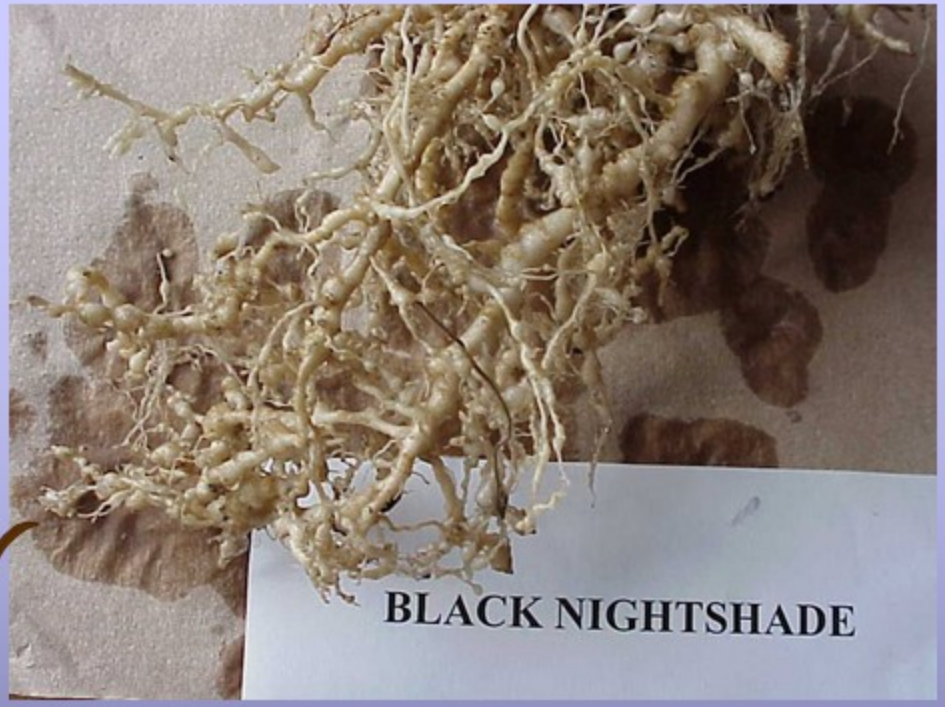


Figure 1. Heavy galling of weed roots by root knot nematode, Melodigyne spp.

-WEED MANAGEMENT-ROW MIDDLES-

- **PERIODIC HERBICIDE**

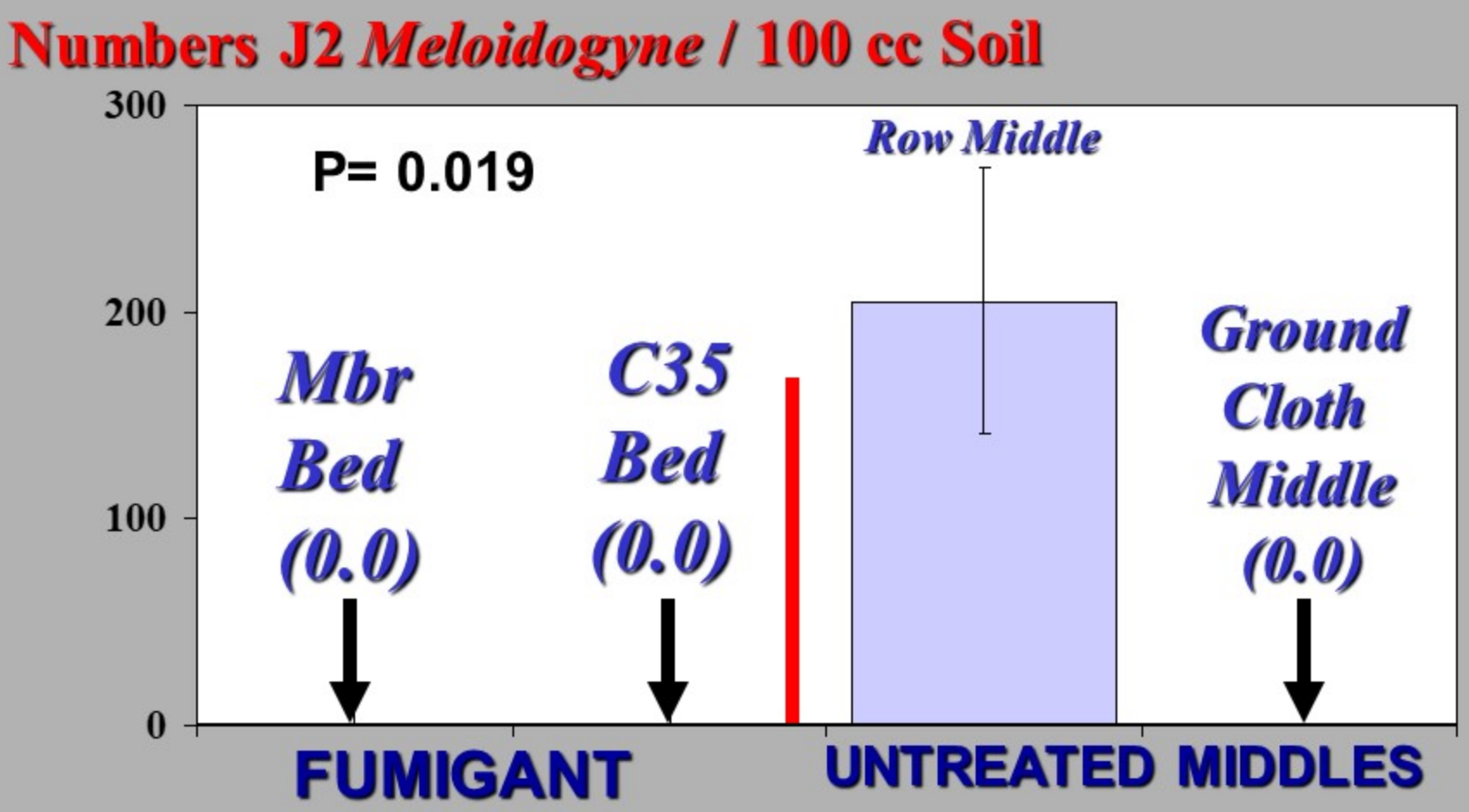
- **GROUND CLOTH**

- ***ROTOVATION***

early season

final harvest

Weed / Middles Management
Ground Cloth Trial – Spring 2003
Final Harvest 1st crop Tomato



Shivler, Spring 2003

SYSTEMS APPROACH (IPM)

Nematodes cannot be effectively managed without simultaneous consideration of weed management

And thereby increase pest incidence and severity !

Weeds as Hosts of Disease

Black Nightshade (*Solanum nigrum*)

Phytophthora capsici
Phytophthora infestans
Phytophthora nicotiana
Phythium sp.
Rhizoctonia solani
Fusarium oxysporum
Verticillium dahliae
Verticillium albo atrum
Sclerotia rolfsii

Colletotricum gleosporoides
Botrytis cinerea

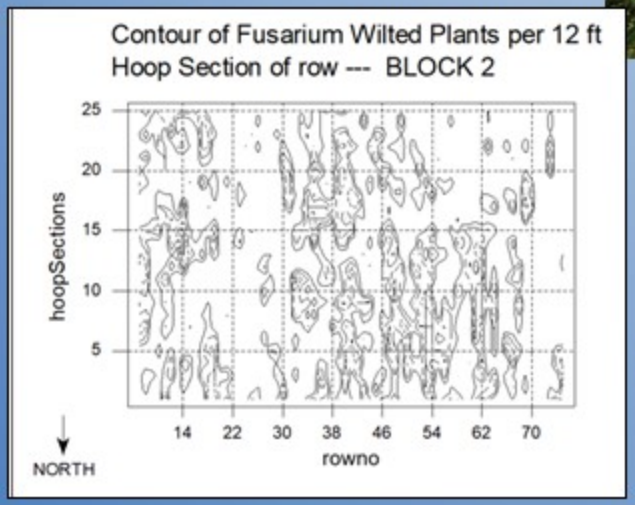
Erwinia carotovora
Psuedomonas solanacearum
Xanthomonas campestris

Tobacco Etch Virus
Tobacco Mosaic Virus

French etal., 2002; Alfieri etal, 1994; Farr etal, 1989

A Memorable Moment Observing 1st Hand a Classic Interaction and importance of Weeds

The first crop of tomato after 40 years of Citrus



- **The Perfect Storm: Root Knot & Fusarium**
- **Fumigation failure due to dry soil conditions**
- **3 under citrus canopy weed species hosting RKN**

Brazilian pusley, crabgrass, Spanish needles

The importance of weeds and pest interactions

SHANK FUMIGATION
DRIP FUMIGATION
CROP TERMINATION
RESEARCH

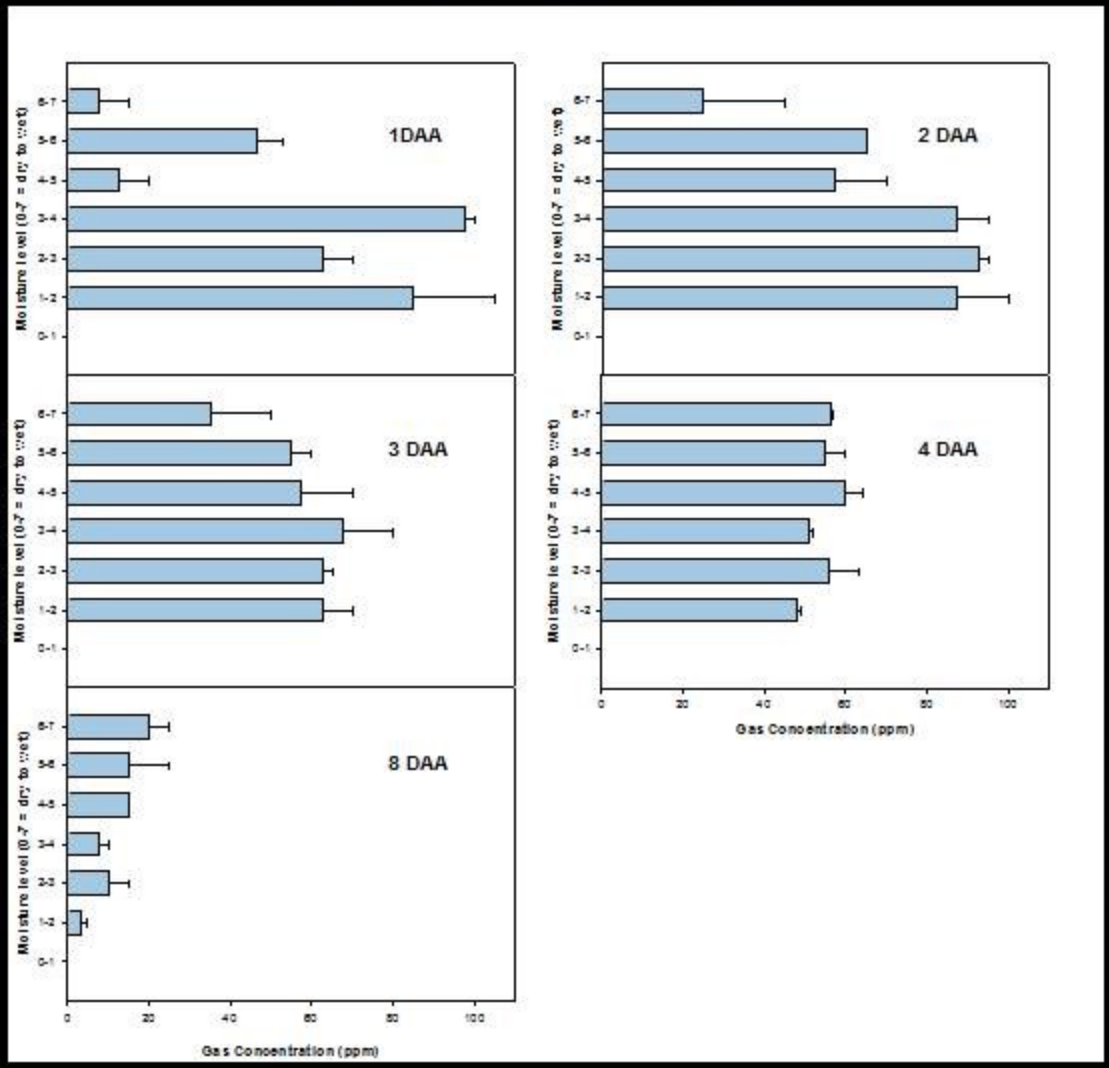
2008

MINIRAE 2000

Gas Phase Monitoring of Soil and Cross-Bed Movement of Fumigants in Soil

Measuring Concentration and Persistence of Fumigant gases

A Wonderful Research & Demonstration Tool



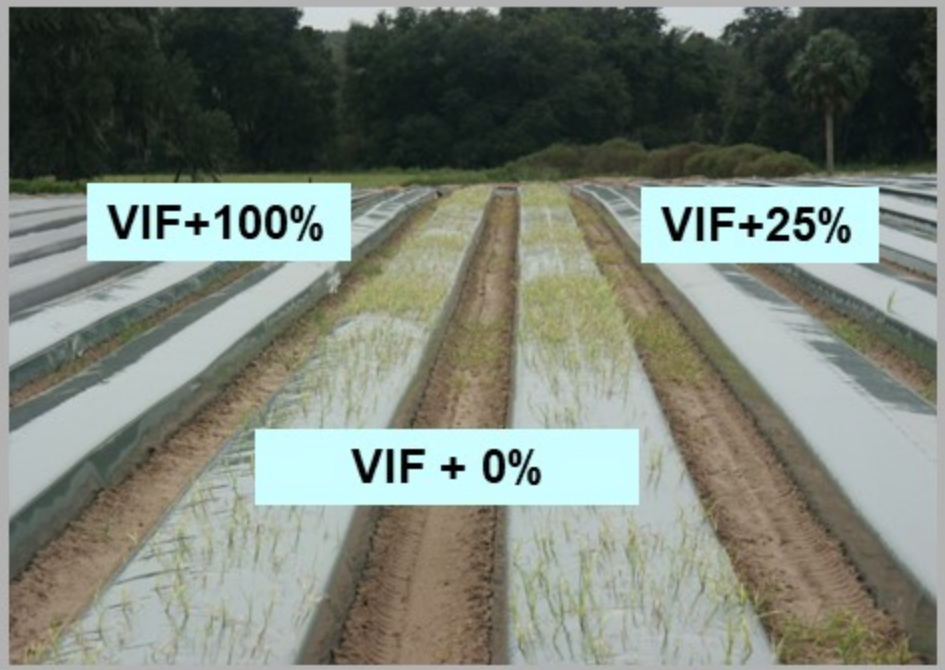
INTEGRATING HIGH BARRIER MULCH TECHNOLOGY

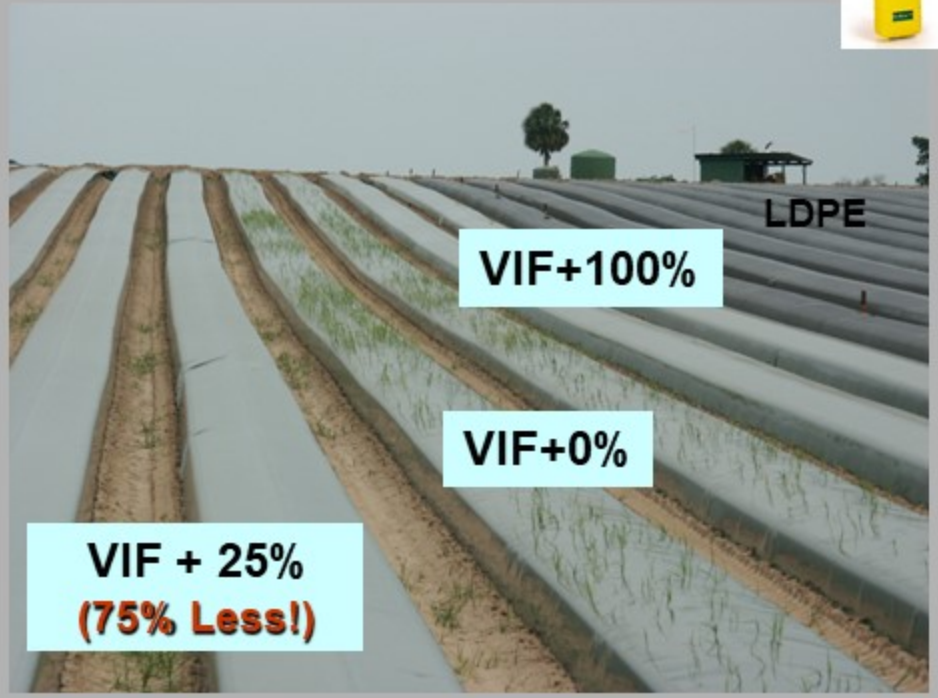
OVER 50 STUDIES SHOW:

- That they Work
- Rates can be reduced

But they can

- Prolong Dissipation





TREATMENT INCONSISTENCY

2011
More Modern Times

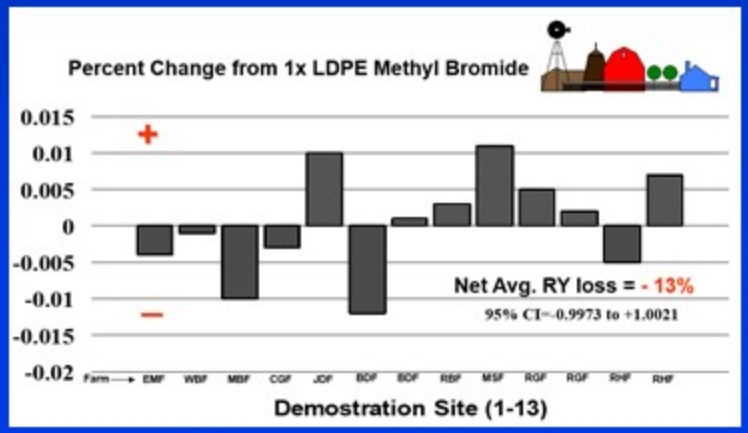
General Performance Summary

EXCELLENT

WHY???

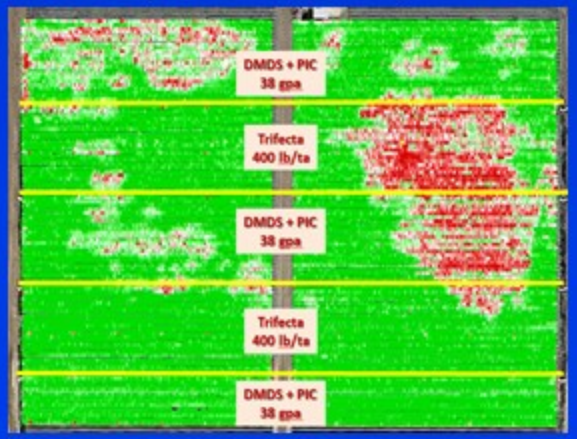
INCOMPLETE

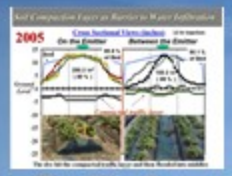
POOR



(between fields)

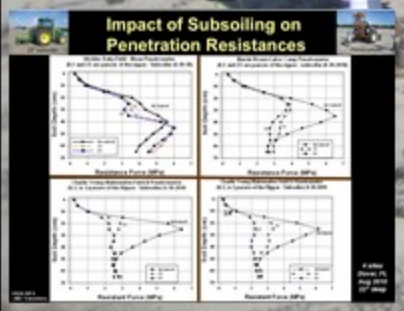
(Within field)





Traffic Pans
Were part of it!

We also brought in the Penetrometer People to measure Resistances



We had done our own surveys
the ole fashion way prior ☺

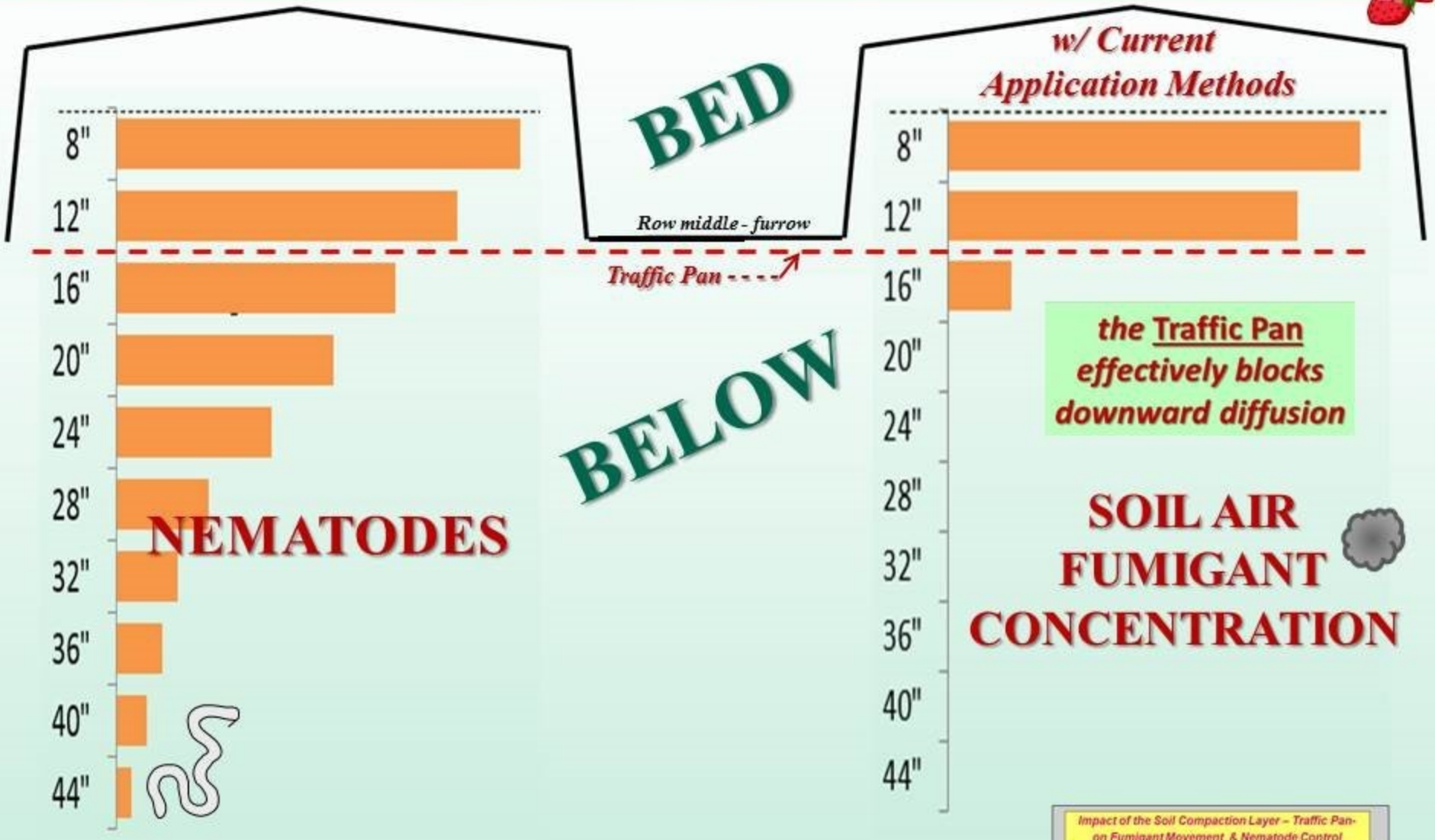
New tools to expedite study of…

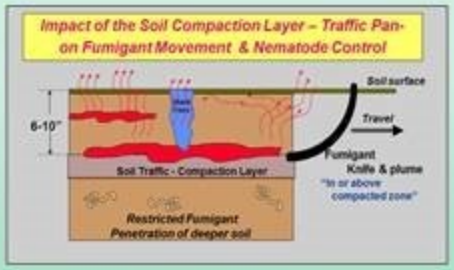
- Identify origins of bed recolonizing populations of plant pathogenic nematodes

- Seasonal depth distribution of nematodes and of their upward mobility

- Study fumigant treatment impact & inconsistency by measuring soil air concentrations within the column

What has the Probinator told us about nematodes & fumigant gases?





SPATIAL DISTRIBUTION

VISUALLIZING NEED FOR NEW FUMIGANT STRATEGIES

Prepared by J.W. Noling

General Summary of Plant Growth and Yield Effects

Table 1. Influence of chisel plowing soil to a depth of 14- inches prior to soil fumigant application and bed formation on the average numbers of small (<8"), medium (>8<12"), and large (>12" canopy diameter) plants per 48 ft or strawberry plant row. Relative yield is calculated as increasing contribution in yield, relative to large plants within the respective treated areas. Dover FL ; Fall 2008-Spring 2009.

Treatment / rate	Tillage Treatment	No. Plants per 48 linear feet of row				Relative Yield
		Small	Medium	Large	Dead	
Alexander Farm						
Telone C35 35 gpTa + LDPE	Chisel plow	0.27 a	7.92 b	69.34 a	1.47 a	0.9268 a
Telone C35 35 gal/Ta + LDPE	No Chisel plow	0.58 a	10.95 a	66.7[illegible]	[illegible]	0.9134 a
Sapp Farm						
Pic Clor 60 240 lb/ta +LDPE	Chisel plow	[illegible]	[illegible]	[illegible]	17.21 a	0.6347 a
Pic Clor 60 240 lb/ta +LDPE	[illegible]	[illegible]	[illegible].96 a	44.58 a	18.71 a	0.5992 a
Chanc[illegible]						
Te[illegible] 35 gp[illegible]	[illegible]isel plow	0.18 a	3.25 a	93.13 a	0.45 a	0.9766 a
Telo[illegible] 35 gpTa + LDPE	No Chisel plow	0.08 a	2.40 a	93.80 a	0.72 a	0.9791 a
Brown Farm						
Telone Inline 35gpta 2 tapes /bed + LDPE	Chisel plow	1.72 a	15.58 a	53.64 a	1.06 a	0.8537 a
Telone Inline 35 gpta 2tapes /bed + LDPE	No Chisel plow	1.89 a	15.00 a	53.86 a	1.25 a	0.8533 a

CHISEL PLOWING PRIOR DID NOT IMPROVE FUMIGANT PERFORMANCE

UNDED STUDIES 2008-10

OINTS

significant differences in
berry plant size
ive strawberry yield was
moisture condition and
fumigant use. Moisture can play significant role
influencing fumigant efficacy and crop response.

- The use of chisel plowing strawberry field soil to reduce soil bulk density and penetration resistance to a soil depth of 12 to 14 inches appeared to be insufficient to elicit an improvement in strawberry plant size distribution and relative strawberry yield.

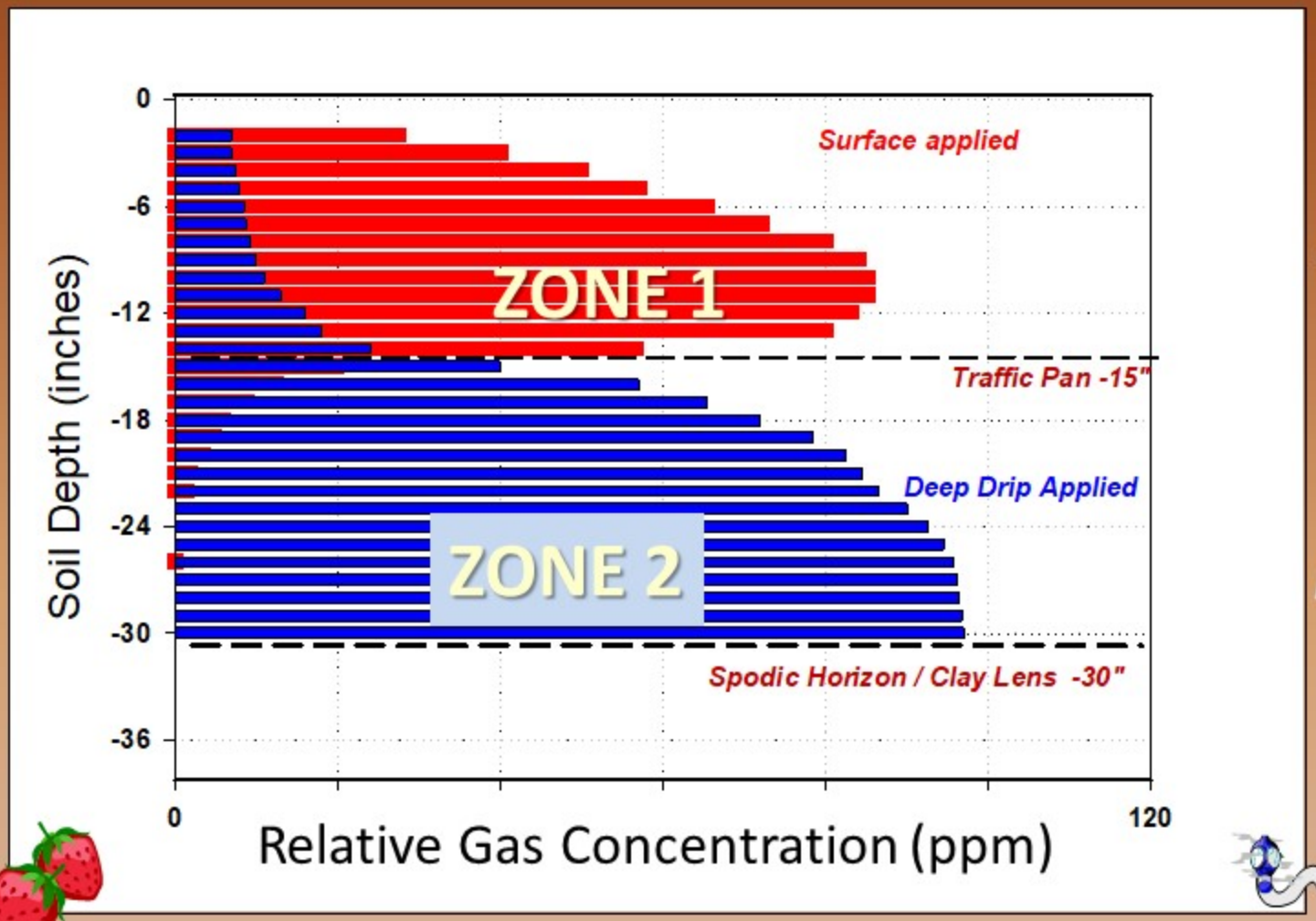
The Conclusion

It won't go there on it's Own !

You want it there, Your going to have to put it there!

The Probinator has allowed us to question the need for:

Structuring Soil Pest & Disease Control As a Composite of Vertical Management Zones



ZONE 1

Surface Drip or Bed Shank

+

ZONE 2

Deep Drip or Deep Shank

Vertical Management Zones

Noling Contribution

Vapor Pressure
1,420 mm Hg

Methyl Bromide

Vapor Pressure
23 mm Hg

Pic-Clor 60

Zone 1

traffic pan

Zone 2

How to deal with the 'uprising' and insurgency.....

What is Needed: NEW TECHNOLOGY for DEEP APPLICATION

Auto Reset – Deep Drip

Auto Reset - Deep Shank w/ Wings

Totally UNTREATED CONTROL

Nothing In Bed or Below

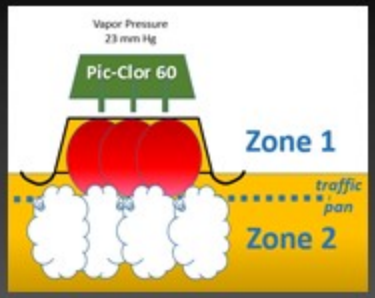
73% increase

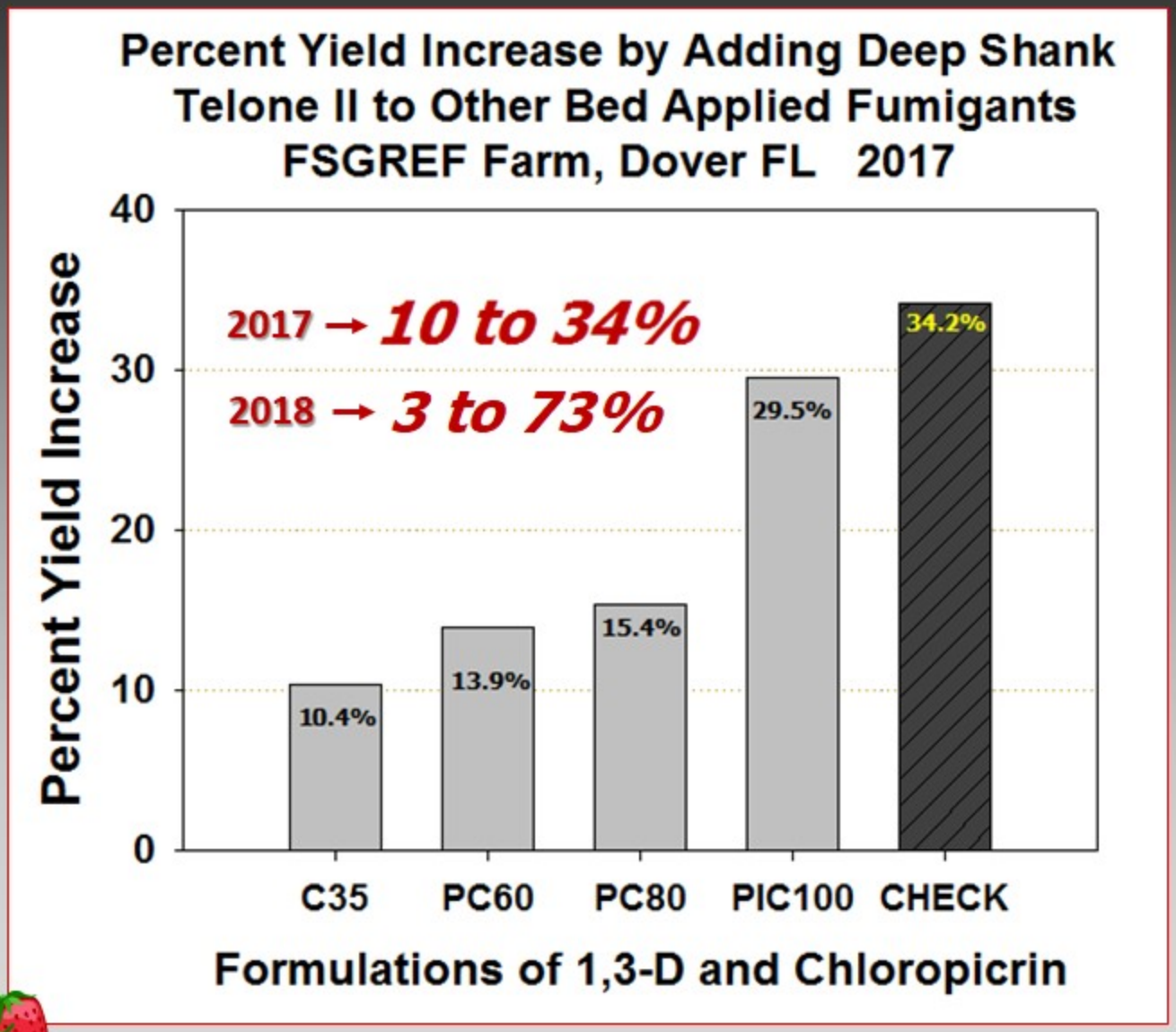
Check + DEEP SHANK

Nothing In Bed With only Telone Deep

FSGA 2017

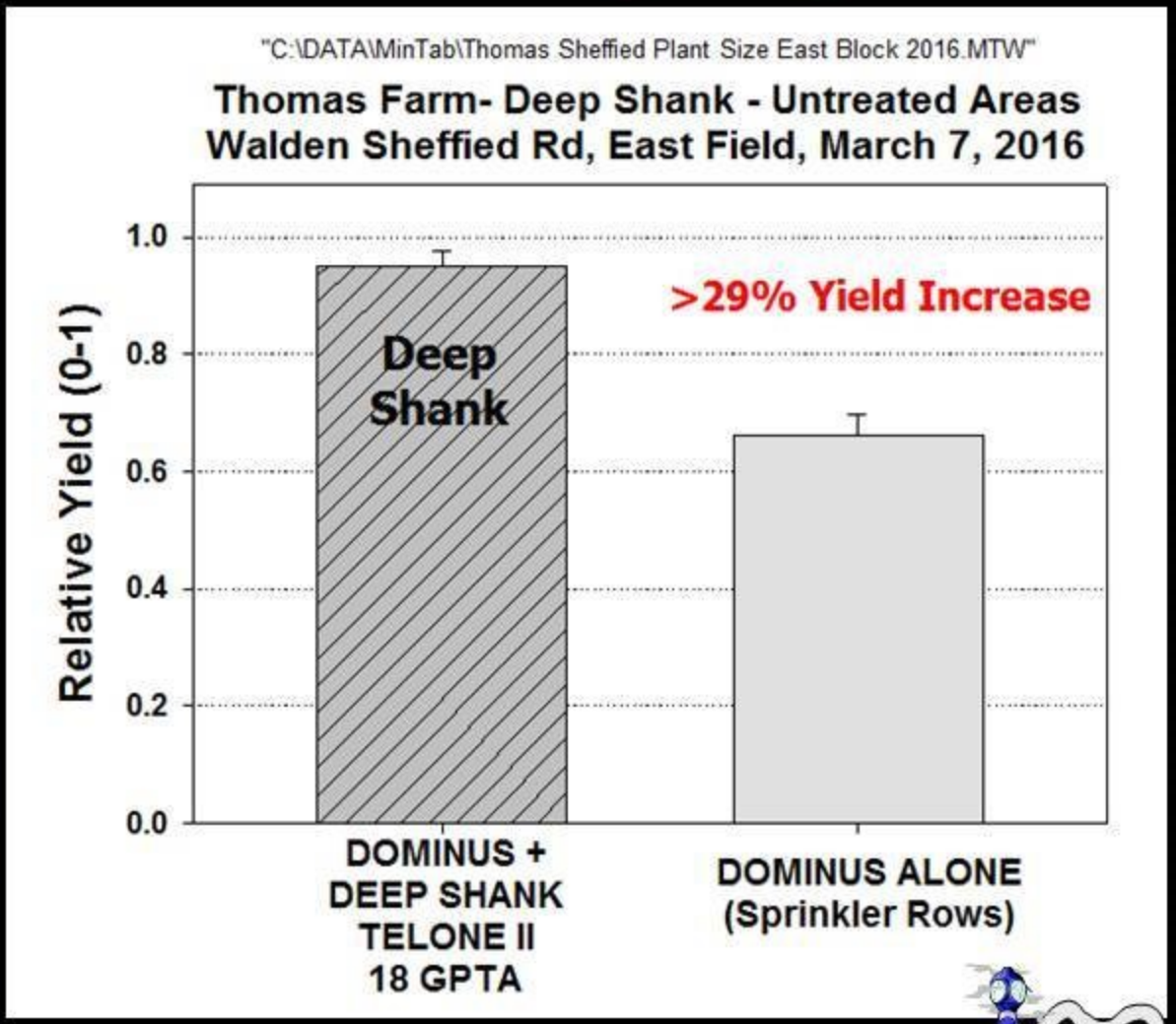
How Well Did We Do 2017 and 2018……





The response often related to the nematicidal activity possessed by the fumigant used within the Bed

Deep Shank - Summer Broadcast
Thomas East Field WS - Spring 2016



29% Increase in Yield

Does Deep Shank Work?

Deep Shank Telone II

NO Deep Shank Telone II

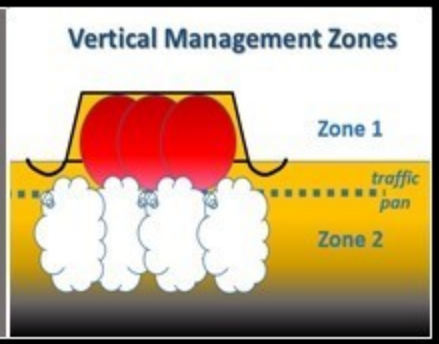
Deep Shank Telone II

PIC CLOR 80

Direction of Application into raised bed

"It contributed nothing"

50 acre field
Pickling Cucumbers
Parrish, FL
Feb 2017



A strip across a field of pickles which received No broadcast Deep Shank fumigate treatment prior to receiving the in-bed applied PIC CLOR 80 fumigant treatment at bedding. Root knot nematode is the causal agent for such death & destruction.

A clear demonstration of the absence of nematodes in the bed, and value of deep shank treatment and origins of nematodes.

Strategy is Gaining Traction!

Flat Land –Broadcast Deep Shank Fumigant Applications

Broadcast Flat Land –Turn Bottom-Switch Pl

All Photos courtesy: Austin Hamilton, Southern Valley

PreBed Flat Land –Deep Shank Fumigant Applications

Grower & Cooperator: Austin Hamilton, Southern Valley Farms

Flat Land –Deep Shank Broadcast Fumigant Applications Dover, FL June, 2016

DOES THE STORY STOP with NOLING ?

"Precision Placement"

SUPPLEMENTAL APPLICATION OF CHLOROPICRIN TO IMPROVE FUSARIUM WILT CONTROL IN TOMATO

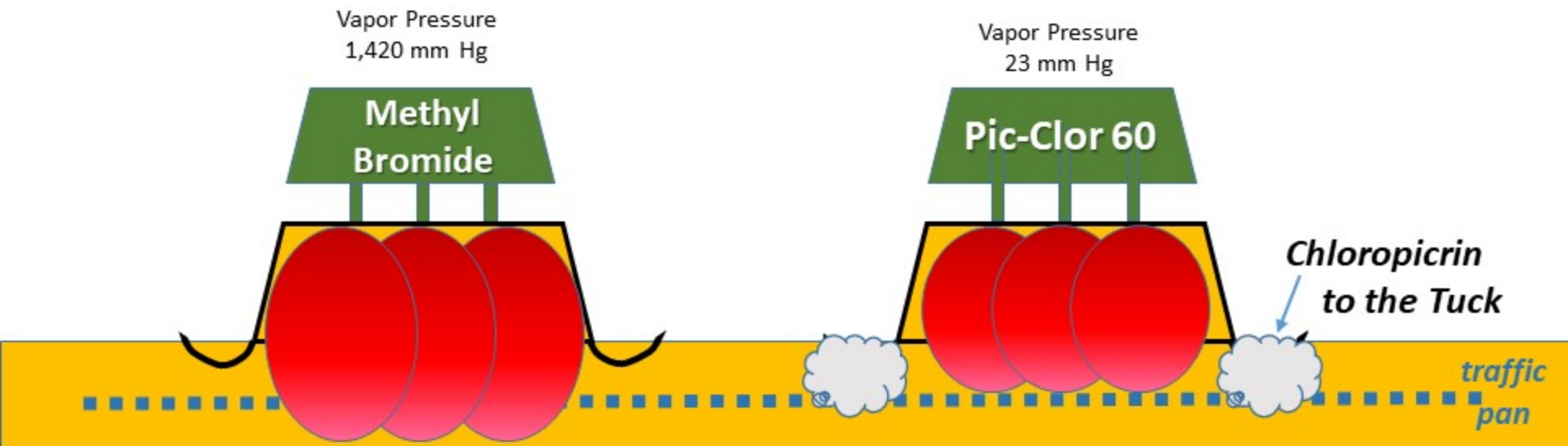
Dr. Gary Vallad –*Pathologist Extraordinaire*

University of Florida, Gulf Coast Research and Education Center, Balm, FL

Vertical Management Zones

Vallad Contribution

Supplemental Chloropicrin

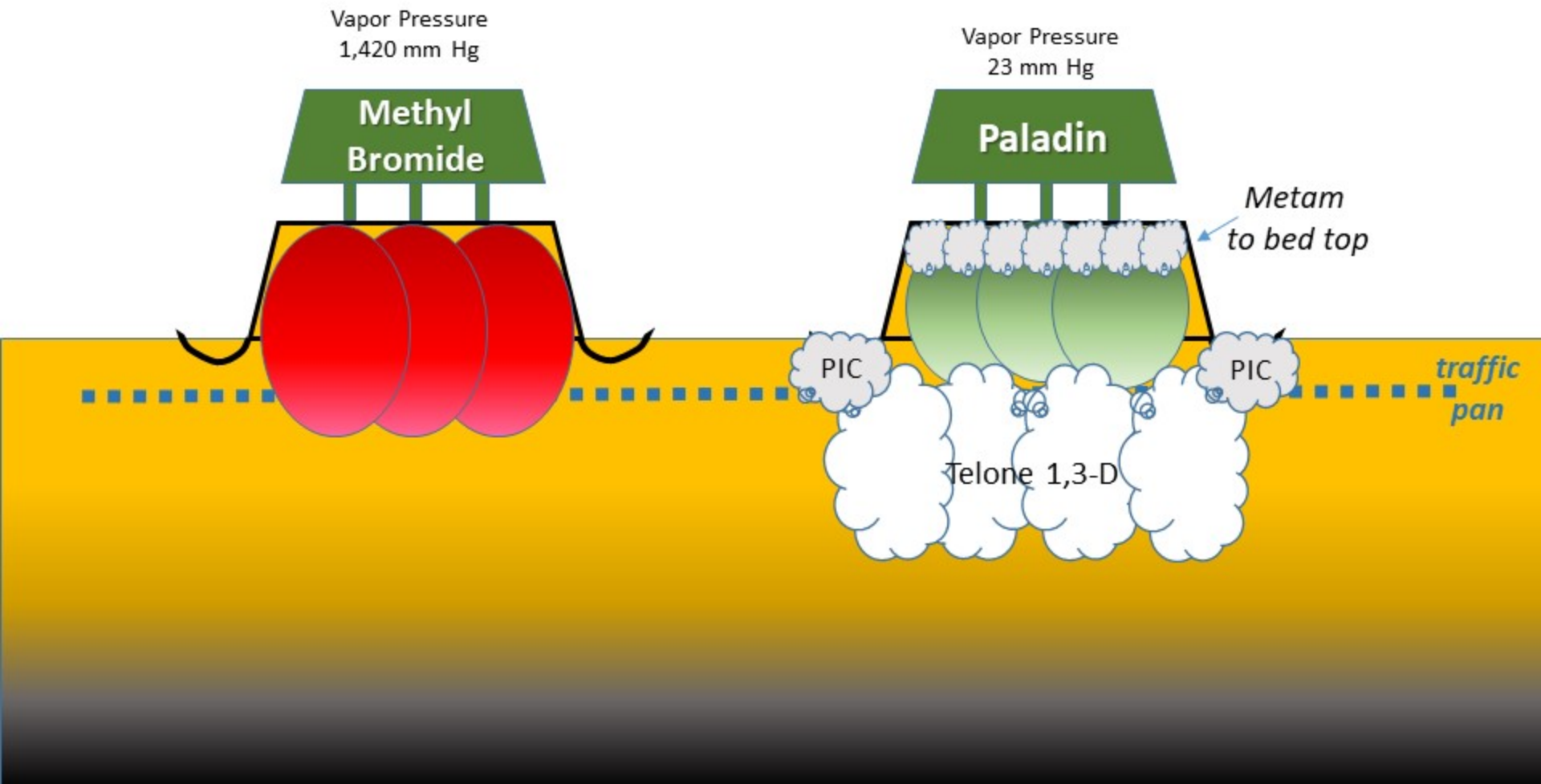


Another Cause of Inconsistency Resolved


Without Supplemental Pic100
With Supplemental Pic100
Does Supplemental PIC Work ?
Is Gary an Observant Guy?

Vertical Management Zones

A summary of Noling, Vallad, & Boyd Contribution



We hope we are on the right path to finally resolve our issues with spatial dimensions

"There are a lot of things that can cause a train wreck, even when things seem to be aligned"

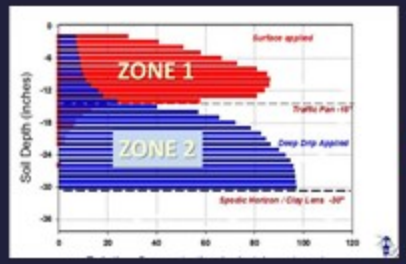
Science Advances from Hard Work, Team Approaches, and Field Observation

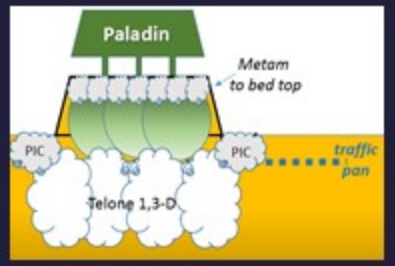
Understanding of barriers to fumigant movement, persistence and cross-bed movement

Dye hit Traffic Pan and then flooded into middles

Increased biological understanding of pest distribution & movement, and of plant needs & root growth

New Approaches of Precision Placement & Enhanced Efficacy





Thank you ----