New Technologies to Study the Biology and Management of Plant Parasitic Nematodes

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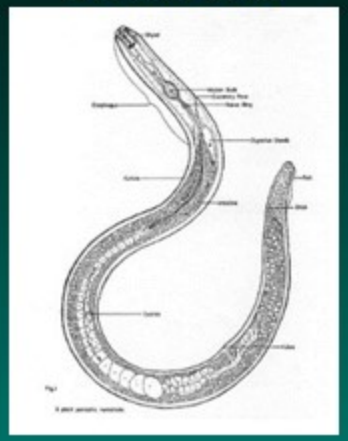
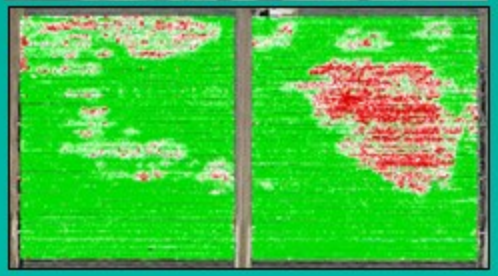
What will I Talk About?

Plant Parasitic Nematodes



Movement & Persistence of Soil Fumigant Gases Using 'New' PID systems

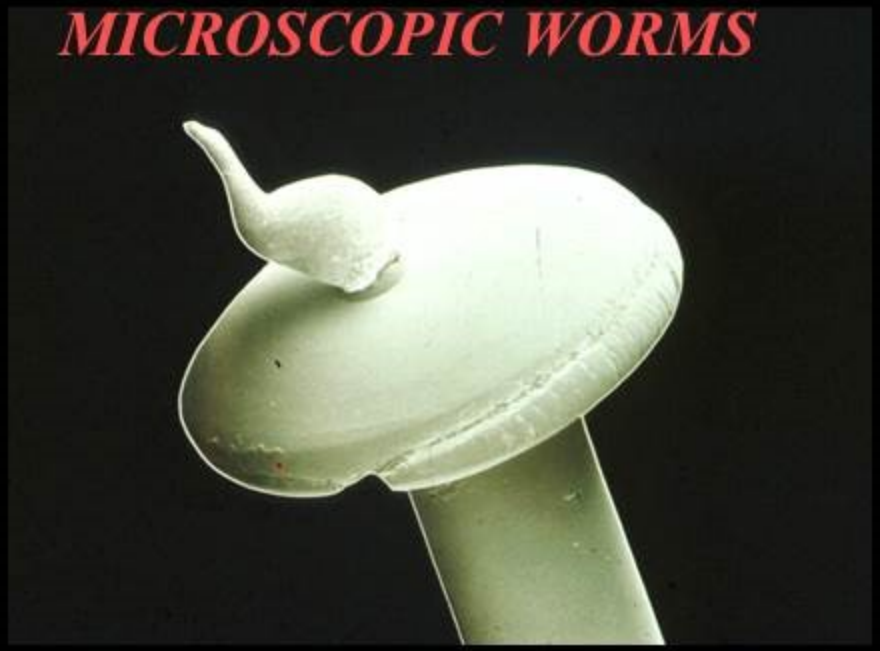
Remote Sensing Crop Yield and Pest Monitoring Systems

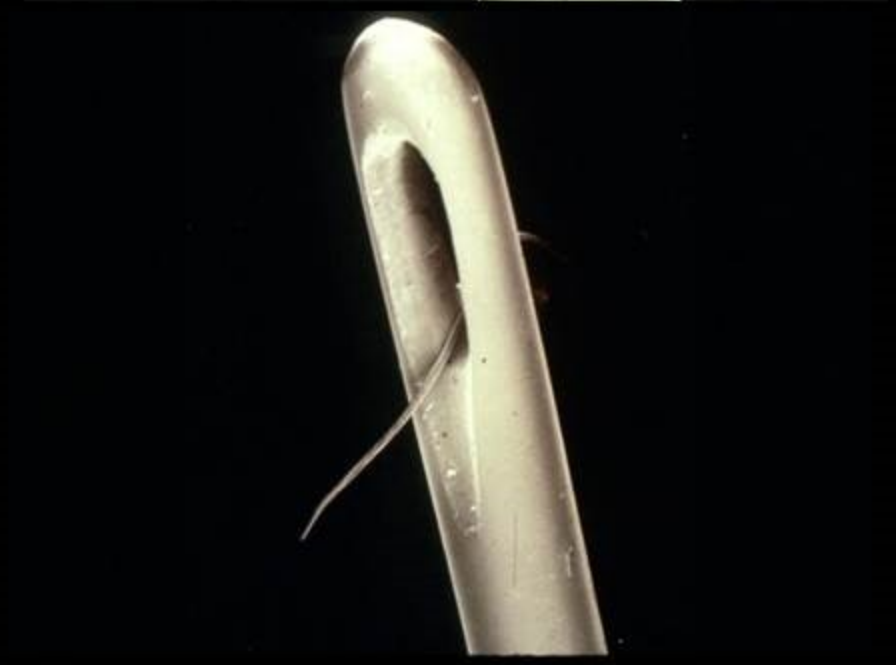


The Probinator: A New New Deep Soil Coring And Exploration Tool

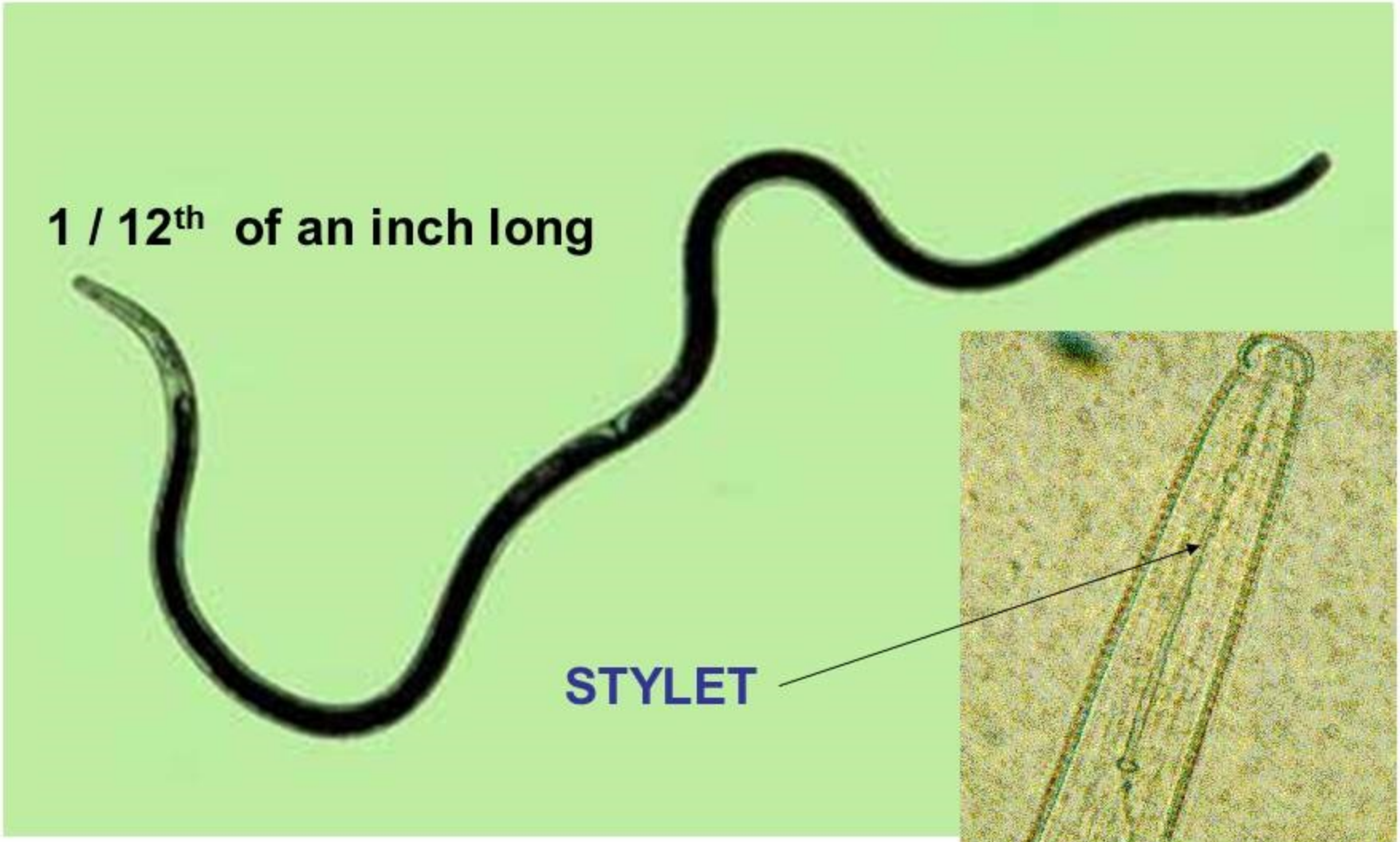
New Deep Placement Fumigant Application Systems

What are Plant Parasitic Nematodes ?.....



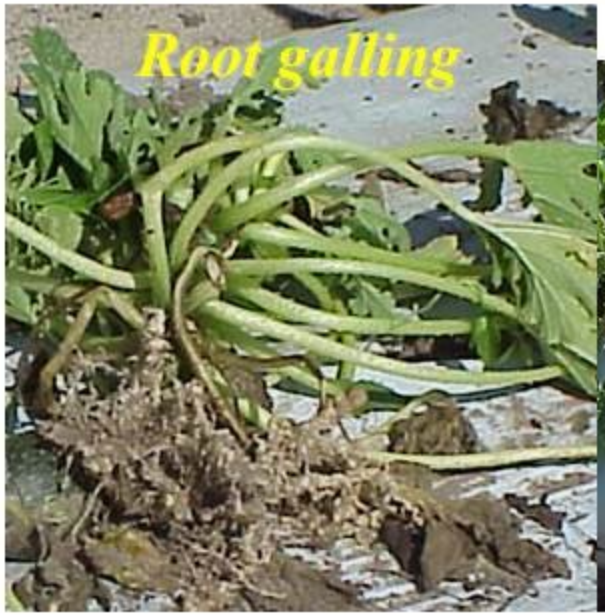


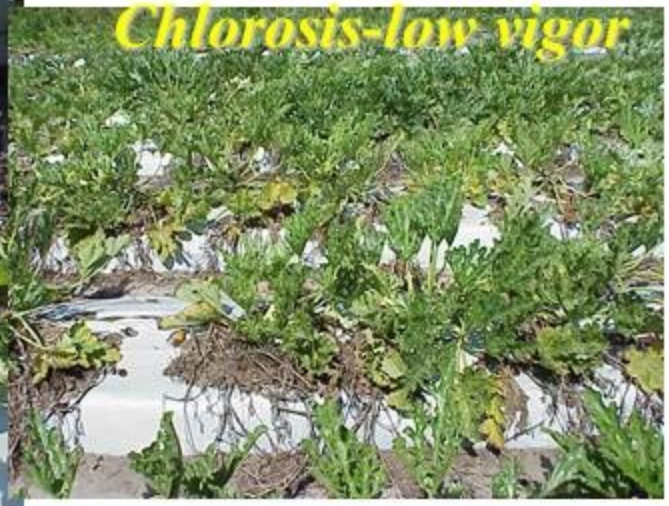
THE STING NEMATODE *Belonolaimus longicaudatus*



40% of Strawberry Acreage

Root-knot Nematode Symptomology

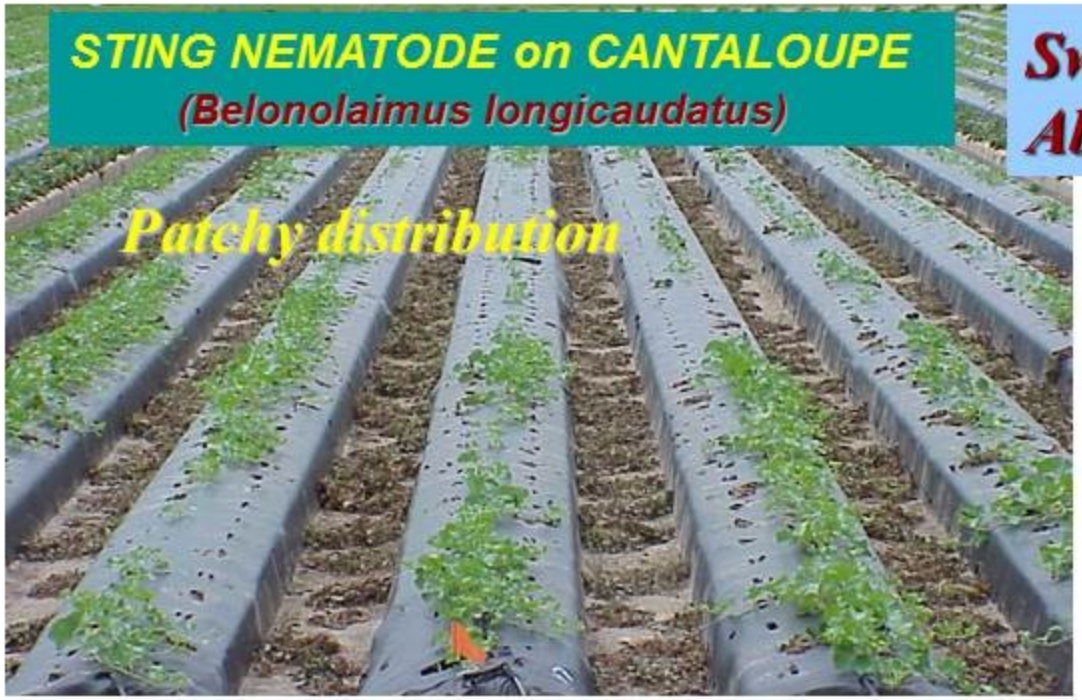




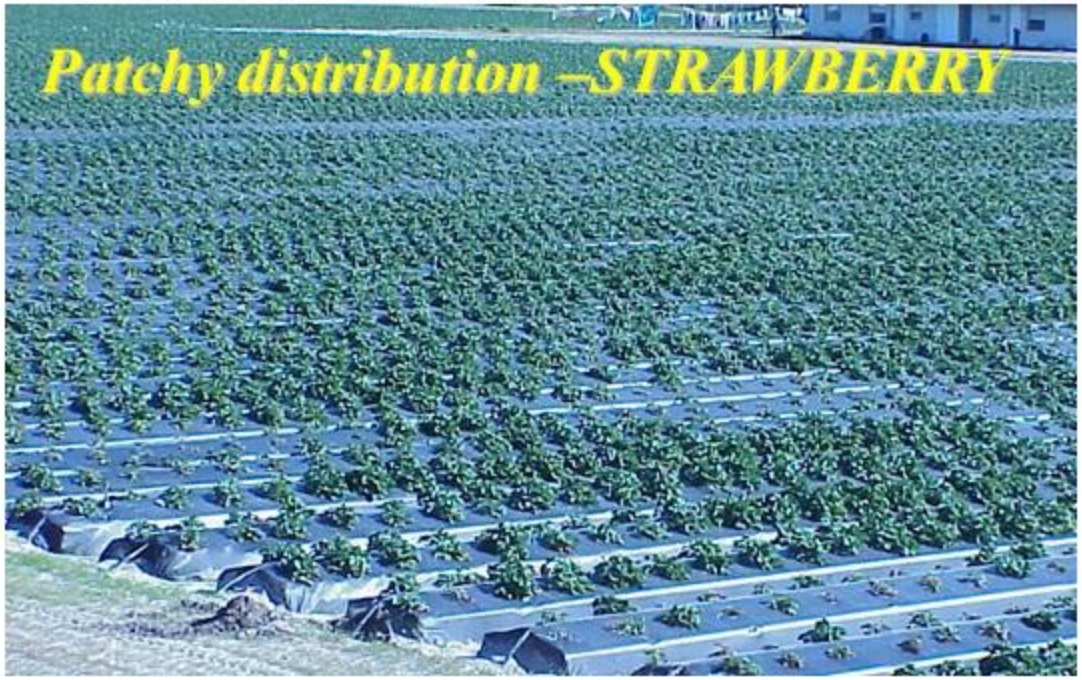
Root-knot Nematode Symptomology

Root-Knot Nematode of Tomato
Meloidogyne spp.

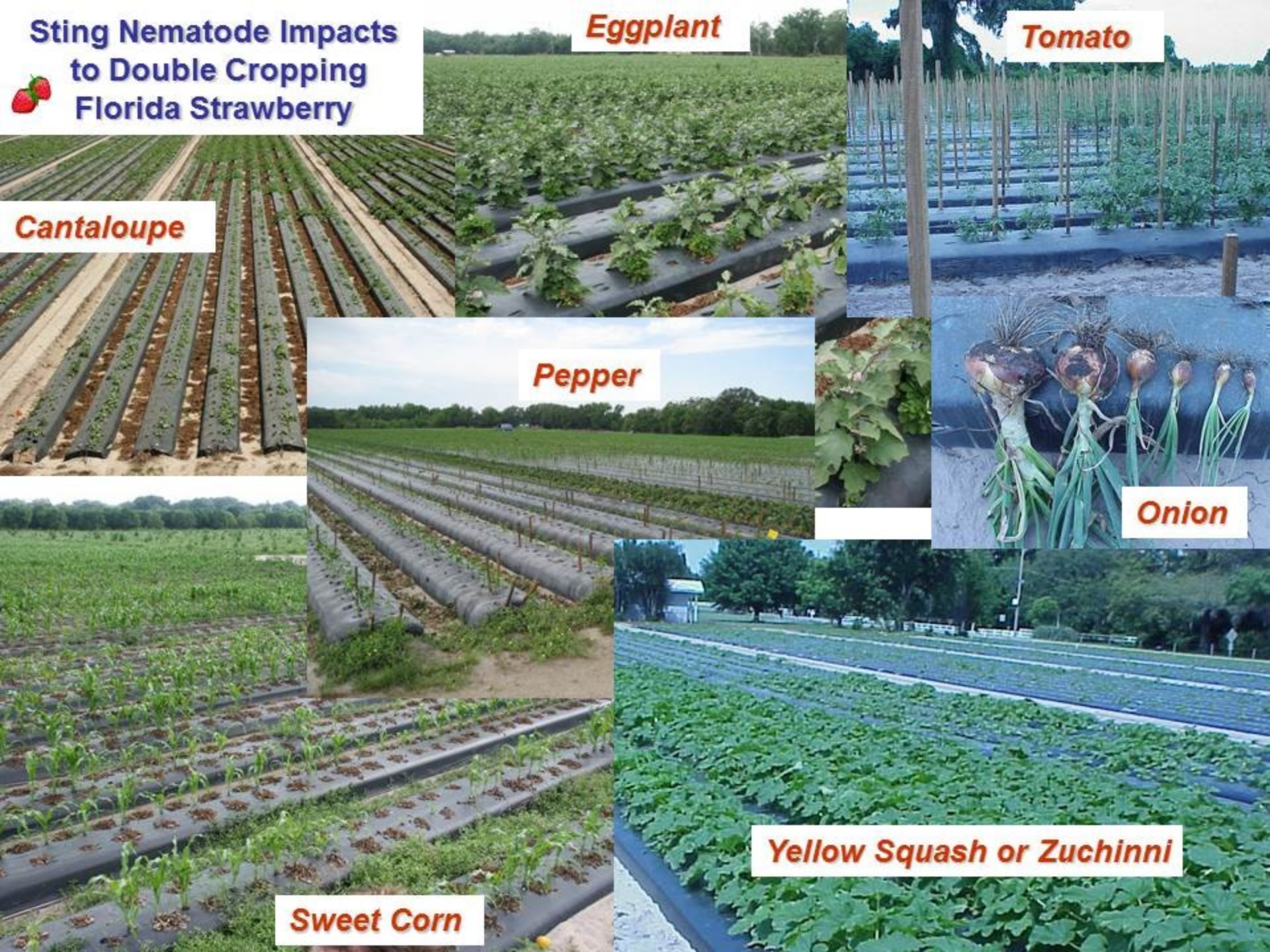
- Root Galling
- Patchy Distribution
- Interaction with Fusarium


STING NEMATODE on CANTALOUPE
(Belonolaimus longicaudatus)
Patchy distribution


Swollen Terminals,
Abbreviated Roots


Patchy distribution –STRAWBERRY

Sting Nematode Impacts to Double Cropping Florida Strawberry



Problems with Nematodes, Oftentimes problems of considerable scale ! -The entire farm-

Root-knot Nematode
(Meloidogyne spp.)
on Pepper
(Immokalee, FL)

Dover – Plant City, Florida - Strawberry fields. Acreage presented is ≈ 7000 of 10,000 acres
Google Earth Imagery Date March 4, 2013 at an Eye Altitude of 37, 316 feet
Map is used to indicate Sting nematode infested strawberry fields expressing severe stunting.

Shank Telone II (15 gpa) fb KPam (62 gpa) 1 tape

MB Farm, Labor Camp Field, Dover , FL. - Imagery Date March 3, 2013
Methyl Bromide Alternative treatment:
Shank Telone II (15 gpa) fb Drip Metam Potassium (62 gpta)
Areas of severe stunting by the Sting Nematodes indicated by arrow. Curved lines

Vapam (75 gpa) 1 drip tape per bed

Goodson Farm, McIntosh Road Field, Dover , FL. - Google Earth Imagery Date March 3, 2013
Methyl Bromide Alternative treatment: Vapam HL (75 gpa) via 1 drip tape per bed.
Areas of severe stunting by the Sting Nematodes indicated by arrow.

Shank Telone II (15 gpa) fb KPam (62 gpa) 1 tape

MH Farm, Bethlehem Road Field, Dover , FL. - Imagery Date March 3, 2013
Methyl Bromide Alternative treatment:
Shank Telone II (15 gpa) fb Drip Metam Potassium (62 gpta). Note Severe Stunting.

Impacts & IPM

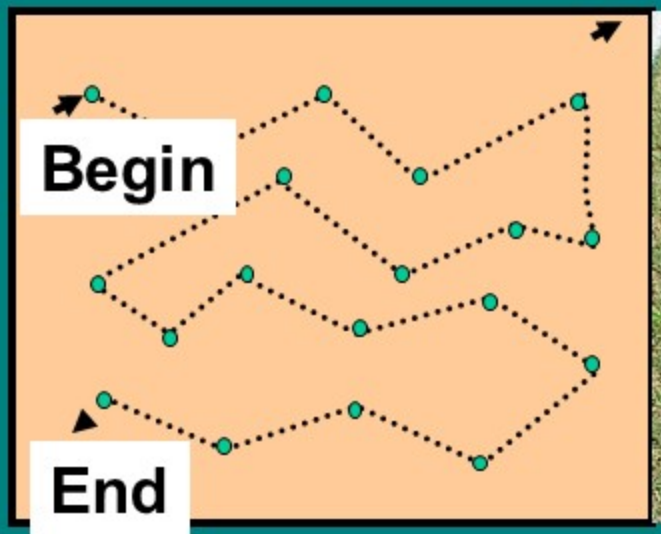
It is the Expected Damage caused by nematodes, which forms the basis for sampling and nematode Management !

To assess the potential threat to crop protection, some **SYSTEM** of soil/plant tissue sampling is required.

PROS & CONS

SOIL SAMPLING STRATEGIES

- Time & Labor Intense
- Expensive
- Subject to Error
- Requires LAB Analysis
- Reporting is SLOW
- RISKY to Implement



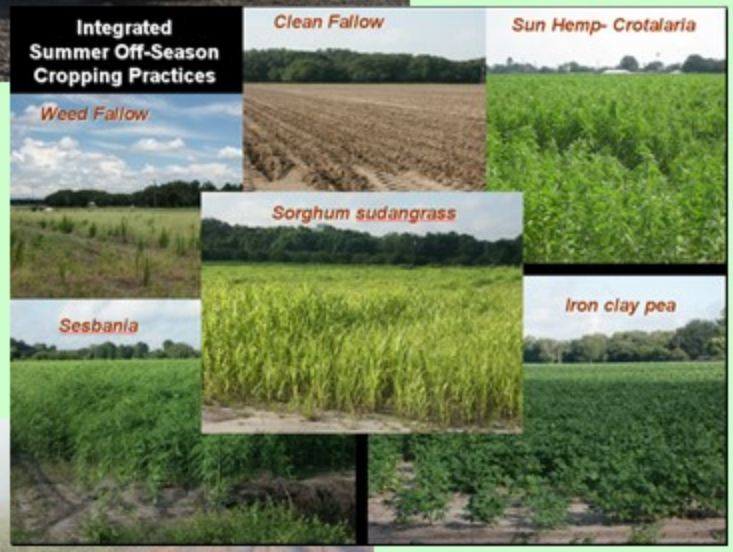
In-Field ROOT BIOASSAY

- Time & Labor Intense
- Should be Less Costly
- Subject to LESS Error
- NO LAB Required
- Results IMMEDIATE
- SAFER to Implement

Sting Nematode Management – A Season Long, Integrated Strategy

Fall

PrePlant Soil / Drip Fumigation
(no crop rescue)



Summer

- NonHost Cover Cropping
- Broadcast Fumigation

Spring

Early Crop Destruction
/ Crop Termination Treatment

The Importance of Early Crop Destruction

Foundation Tenet of IPM And MBr Replacement

(incrementally reduce)

- *Ease of Application*
- *Captive Audience*
- *Removal of Food Source*
- *Minimize Pest Reproduction*
- *Reduce Soil Densities*
- *Benefits to Subsequent Crop*

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) Telone C35	Good to Excellent	Good to excellent	Poor-Good
7) Potassium N-Methydithiocarbamate (K-PAM)	Poor to Good	Poor to Good	Good-Excellent[3]
8) Allyl isothio-cyanate (Dominus)	Still in Assessment	Still in Assessment	Still in Assessment

[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 of above, consistency determined by chemical, cultural, physical, and environmental condition

Preplant Soil Fumigation as the IPM Foundation

Different Products, Rates, Timings & Methods of Application

TELONE (1,3-D) – nematode

CHLOROPICRIN – disease

Dimethyl Disulfide – n,d,w

VAPAM & other - weeds

Complimentary Herbicides

Properties of Soil Fumigants

Fumigant	Boiling Point °C	Vapor Pressure 20° C	Solubility In Water	Soil Half Life
Methyl Bromide	4	1420	13400	12-22
Iodomethane	42	400	12400	4- 40
Chloropicrin	112	18	2270	1-2
1, 3-D	120	28	2250	3-5
Metam Sodium	112	0.04	578290	4–5*
Metam Potassium	114	24	complete	4-5*
Dimethyl Disulfide	110	28.7	3000	?

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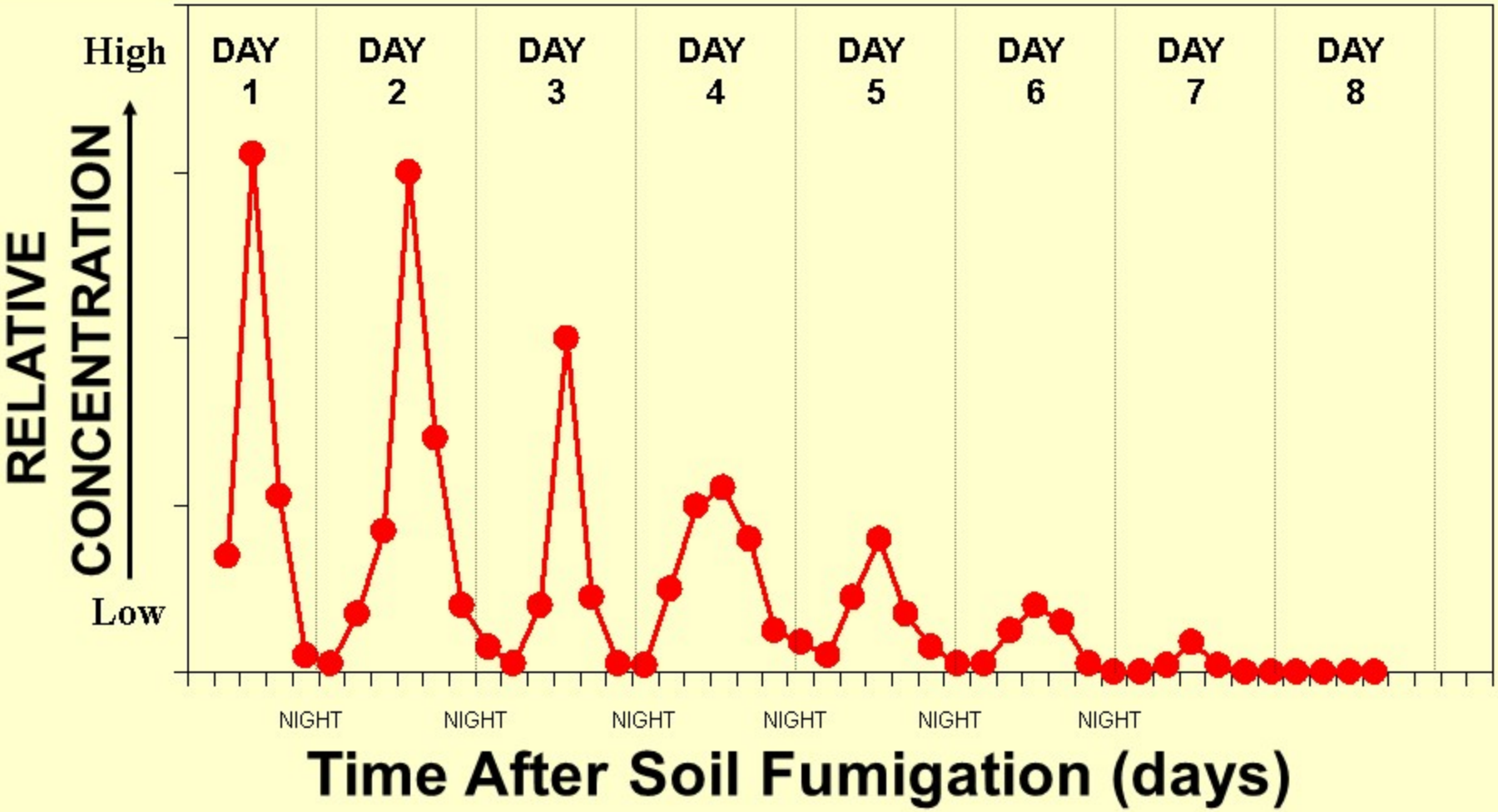
They require higher temperature and volatilize to gases much more slowly, and then move thru soil much slower than MBr

New Technologies for MEASURING SOIL AIR FUMIGANT CONCENTRATION

MINIRAE VOC METER

DOSAGE AS A FUNCTION OF TIME and AUC

Generalized representation of the relative concentration of a fumigant out gassing through a low density plastic mulch cover with time after fumigation.



AUC=Area Under Curve

Fumigant Dose: $\Sigma_{t=1}$ (Concentration x Time)

Fumigant Dosage

Definition: Soil fumigation is a preplant chemical treatment of soil, using a pesticide product that converts from a liquid to form a volatile gas, that is able to diffuse through open pore space throughout the soil (bed) to provide soilborne pest and disease control.

Objective: Establish a lethal concentration in the target pest zone and maintain the concentration for sufficient time to kill the organism.

Fumigant Dose: $\Sigma_{t=1}$ (Concentration x Time)

Nematode Management and Soil Fumigant Research: Prefumigation Soil Moisture Conditions

J.W. Noling, Marjie Cody, Danny Johns, Steven Lands, Mark Warren
UF/IFAS/CREC
Lake Alfred, FL

2013 Society of Nematology Mtg
Knoxville , TN July 13-17, 2013

Many, many thanks to Doug Gergela and field crew, Danny Johns for being such good, enthusiastic cooperator

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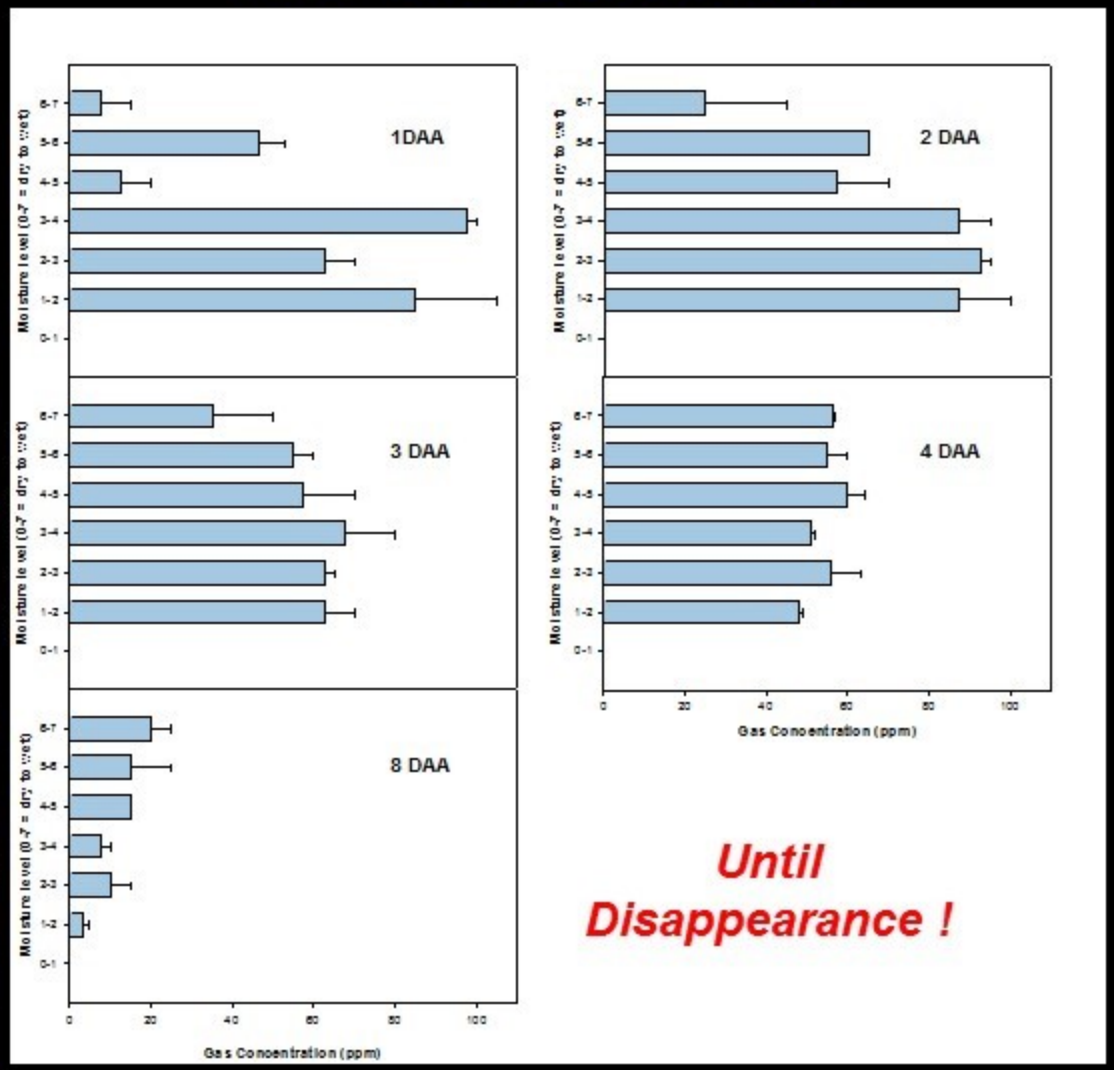
Prepared by J.W. Noling


Creating the Moisture Gradient....
Prepared by J.W. Noling

Applying the fumigants (Telone II, C17, C35, PC60) in replicate thru the H_2O gradient

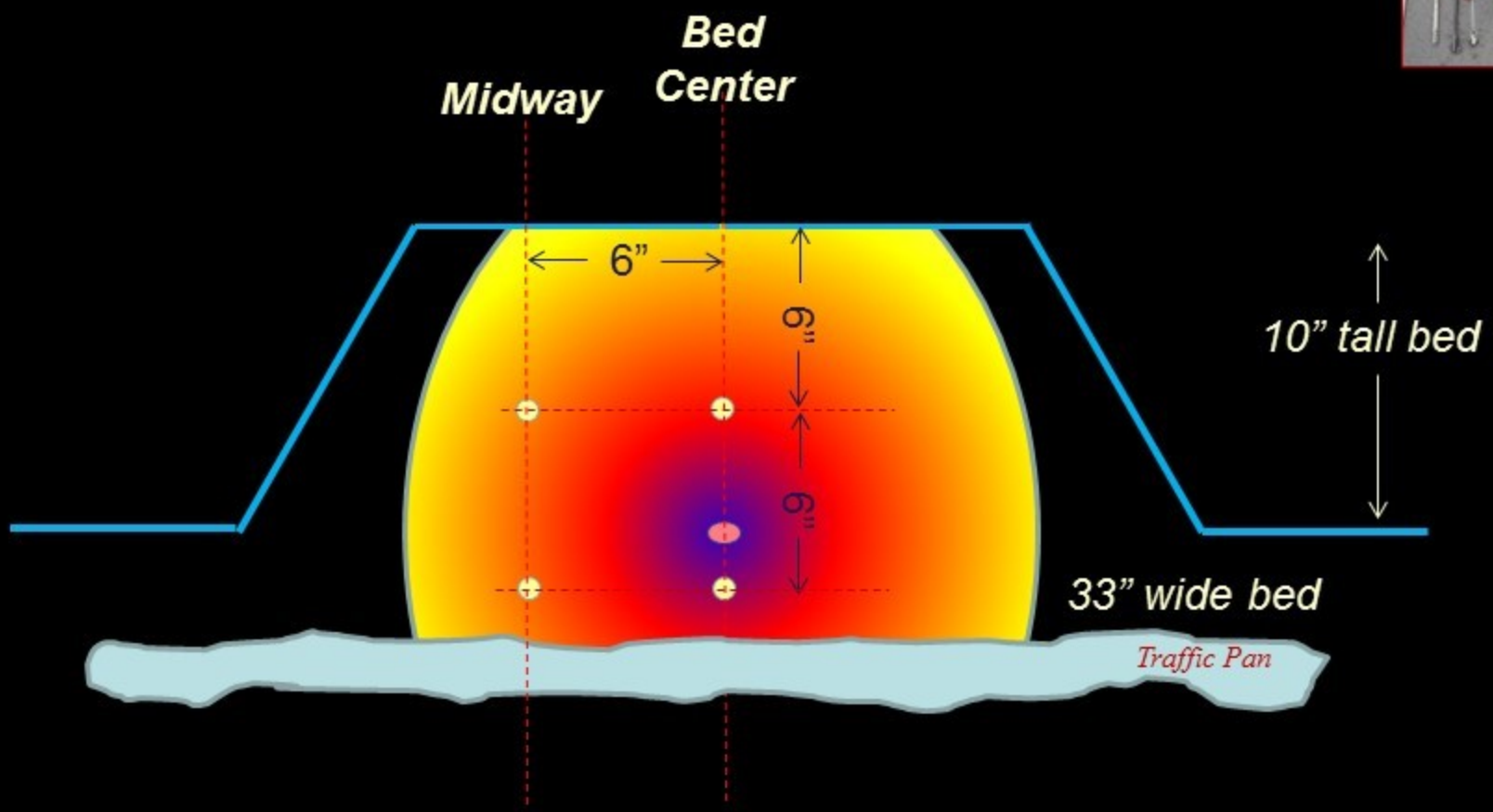
Measuring Concentration and Persistence of Fumigant gases w/in a wet - dry moisture gradient

And as a demo tool !



Until Disappearance !

Where did we monitoring gas concentrations in the bed…..



4 - MiniRae Gas Sampling Locations

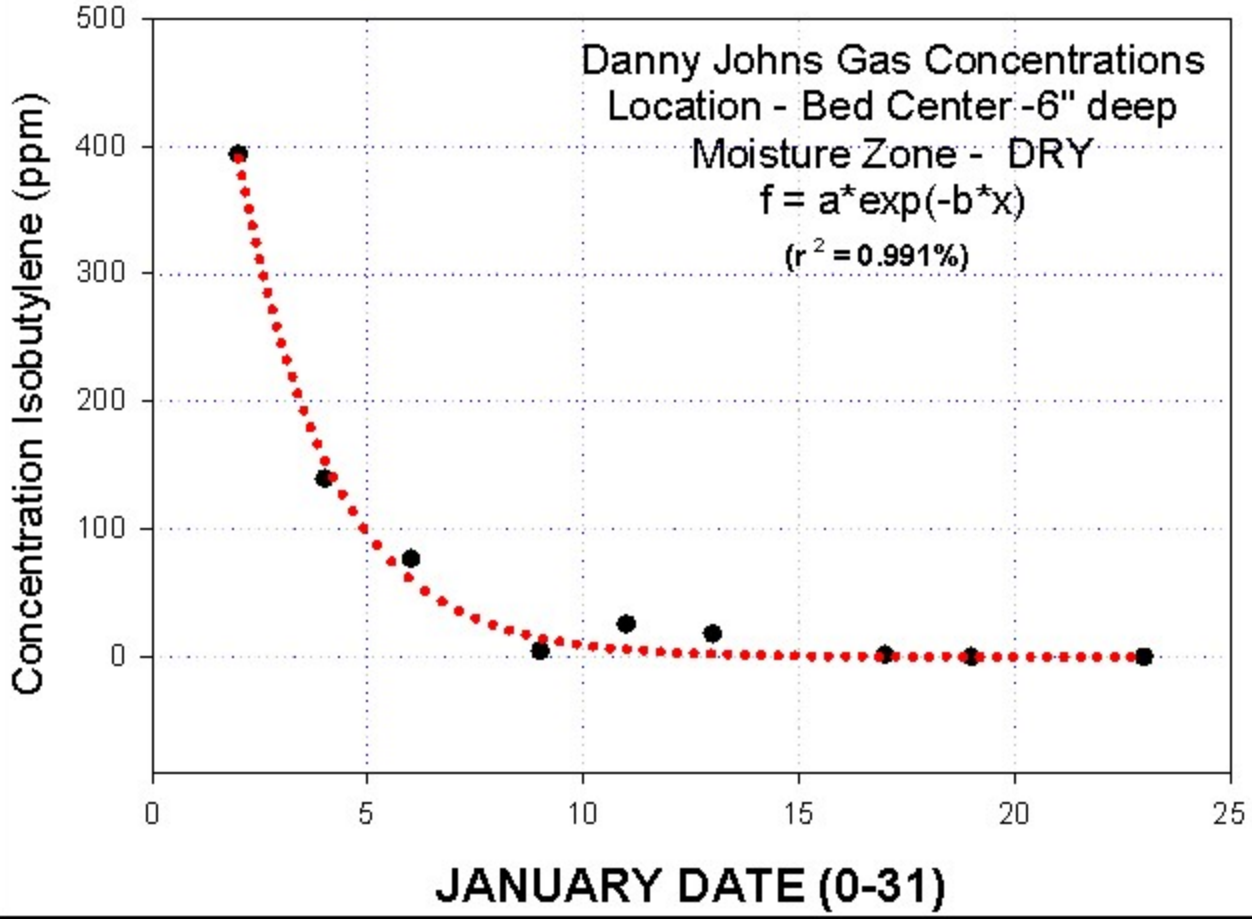
Fumigant injection (10-12” deep)

Prepared by J.W. Noling

A NEED TO SUMMARIZE THE INFORMATION FOR OVERALL EXPOSURE TO SOIL GASES

Area Under the Soil Dissipation Curve (AUDC)

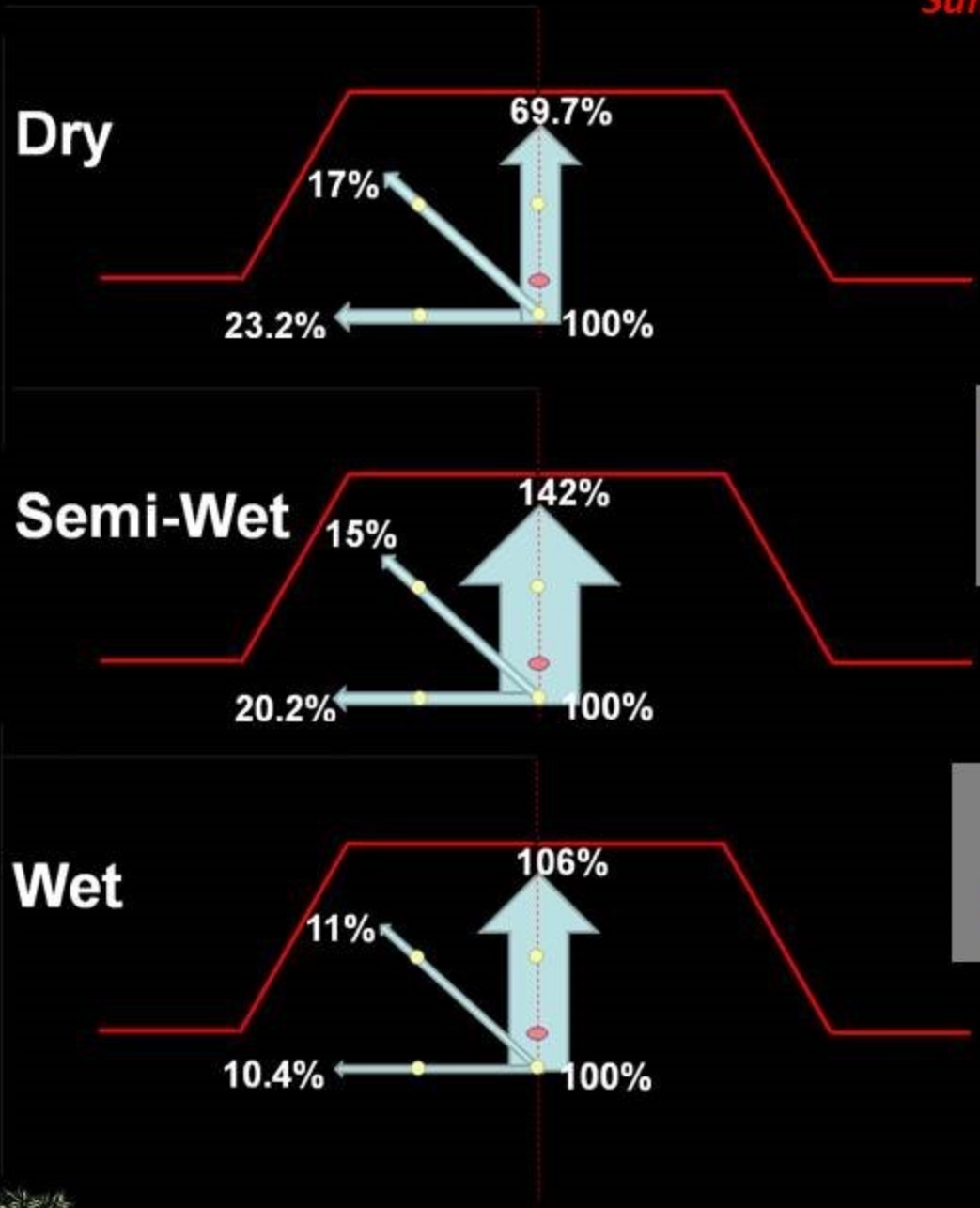
(Concentration X Time)



Moisture gradient

Summary Danny Johns / Arlie Smith

Monitoring of Grower Farms
Hastings, Florida
January 2012, 2013,2014



Highest proportion of gases move up and out thru top of Bed !

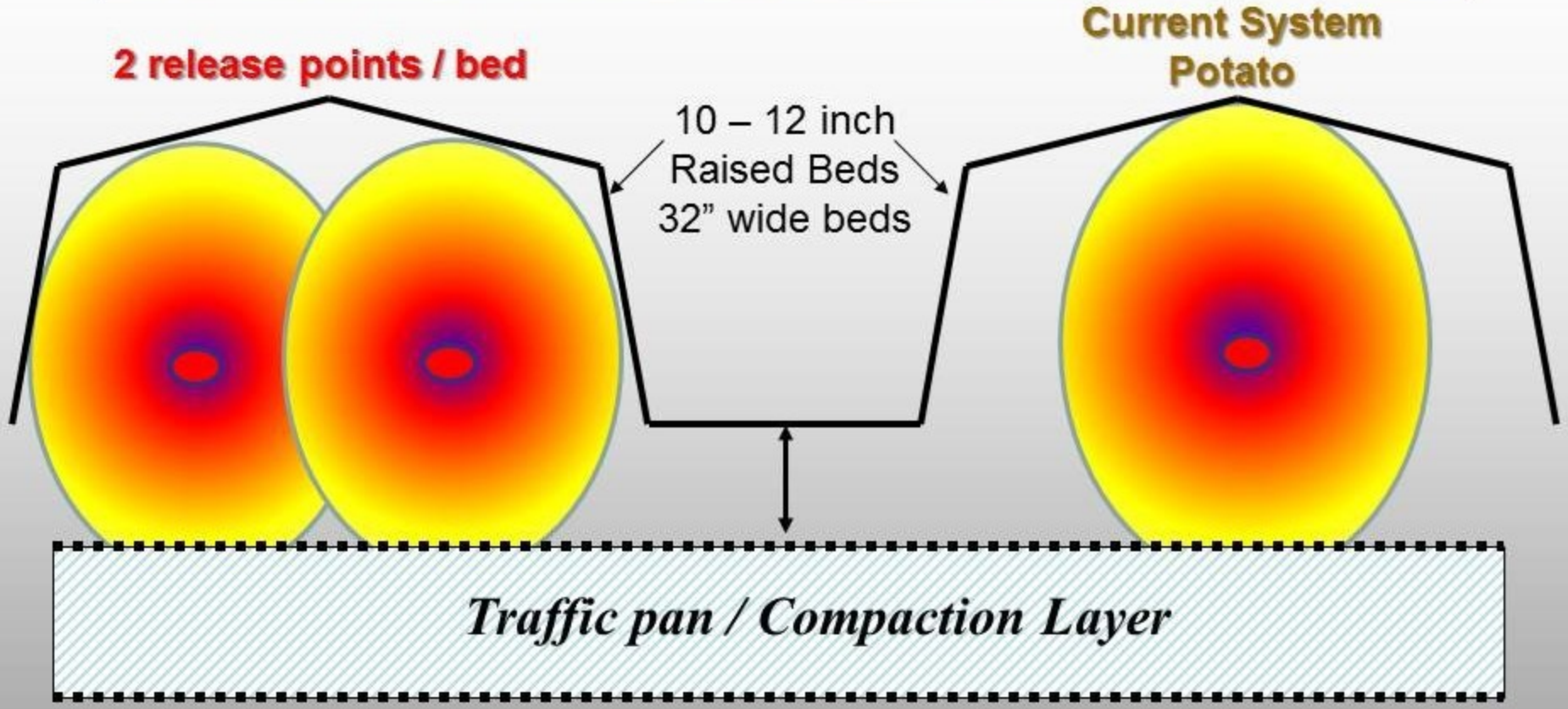
AUDC Concentrations have declined 77 to 90% radially 6 inches of soil injection site !

Arrow sizes above Proportional to reference AUDC for Bed Center 12"

Reference
100%

- Fumigant Plume
- Sampling locations

If Lateral Movement is Not Sufficient, and Wetter Soils Must be Present Prefumigation then….



Could this be beneficial ?

Prepared by J.W. Noling

Many, many credits to Triest Ag Group Inc., Tifton GA- William/Jimmy Upchurch for development

Prepared by J.W. Noling

Bottom wings allowing
Multi-stream distribution

Avenger
Shanks

New Application Technology Addressing & Improving:

- Fumigant Distribution in Soil
- Containment and Dose
- Deep shank 1,3-D and Pic

Strawberry SUBSOILING Experiments 2010-2013

Fields Subsoiled to Destroy / Disrupt TRAFFIC PAN to enhance fumigant diffusion and to compare Plant Growth, Nematode Control Efficacy, and Source of Nematode Problem

California Practices

24'' Subsoiler Applications to Destroy the Traffic Pan and Kill Nematodes deep

Many thanks to Jimmy Moden-Hendrixs & Dail

Evaluating a New Subsoil Applicator Using NDVI Maps

normalized difference vegetation index (NDVI)

The effect of subsoil delivery of:

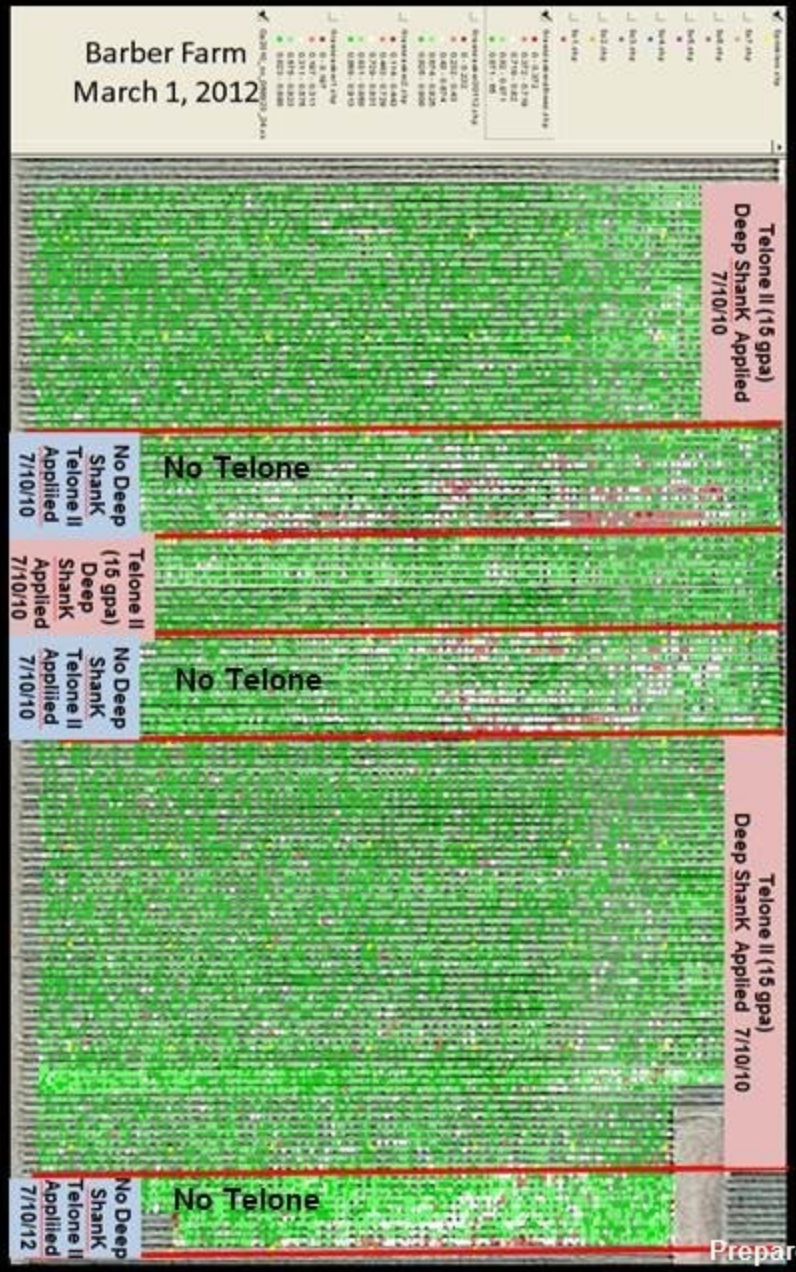
Telone II (18 gpa)

Injected 20 inches deep

2 years after application

Prepared by J.W. Noling

Evaluating New Subsoil Applicator with NDVI Mapping



The effect of subsoil delivery of:

Telone II (18 gpa)

Injected 20 inches deep

2 years after application

Prepared by J.W. Noling

This is what one of the fields looked like after 3 separate fumigations:

- Spring Crop Destruct Treatment (75 gpa Vapam)
- Summer Fallow Followed by Subsoil (15-18 gpa Telone II)
- Fall Drip Fumigation 2 tapes / bed (Pic Clor 60 EC- 300 lb/a)

It picked about a third (33% of 27,000 lb/a) of what it should have picked !

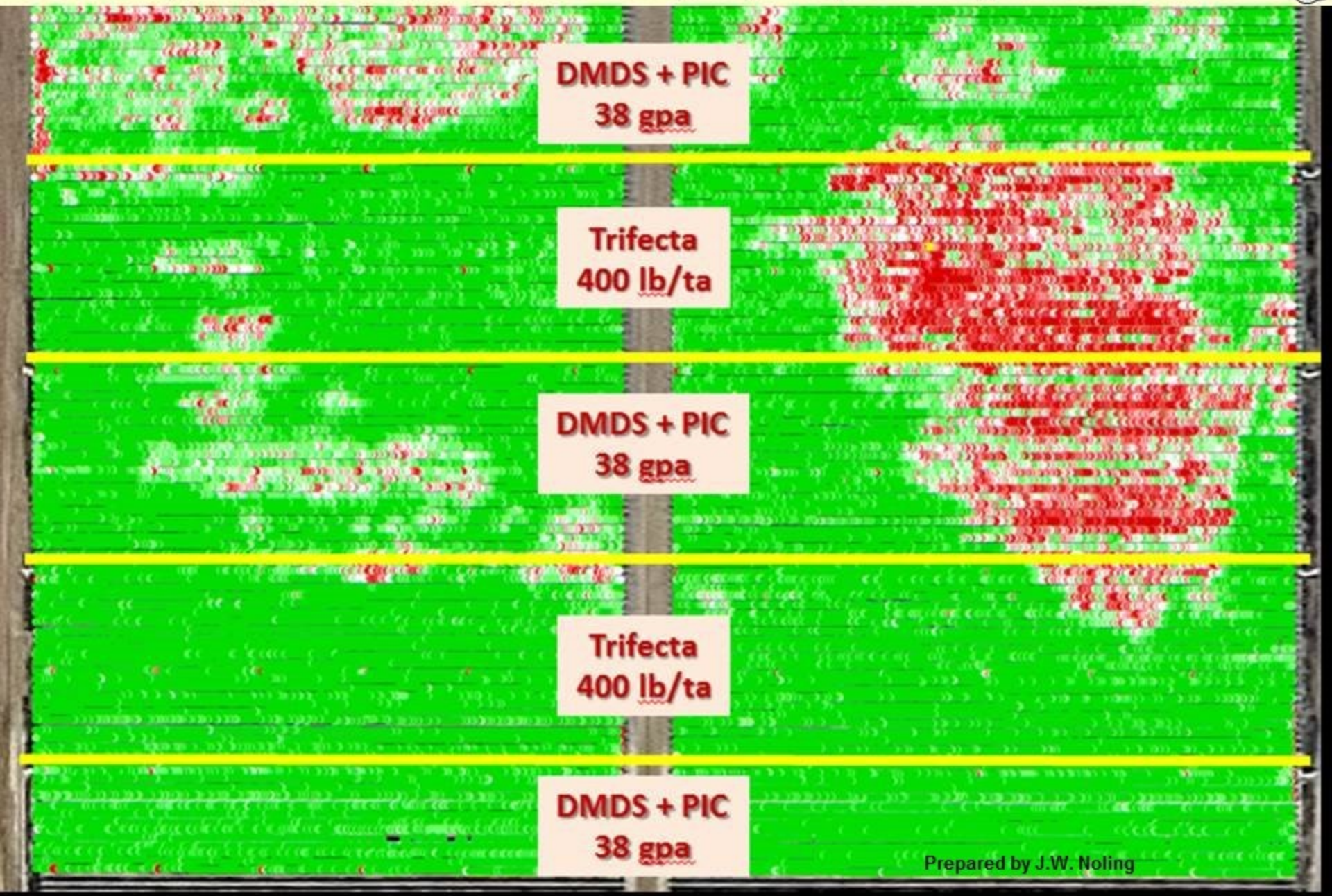
Prepared by J.W. Noling

New Technologies for Nematode Management
Highlights of Recent Findings

NDVI field analysis showing distribution of Sting nematode, *Belonolaimus longicaudatus*, stunted plants (red areas) in two large scale commercial strawberry field trials in Dover, FL. March 20, 2014.

Prepared by J.W. Noling

None of the Paladin, Chloropicrin or Telone II combination treatments completely and acceptably resolved problems and crop impacts from Sting nematode.

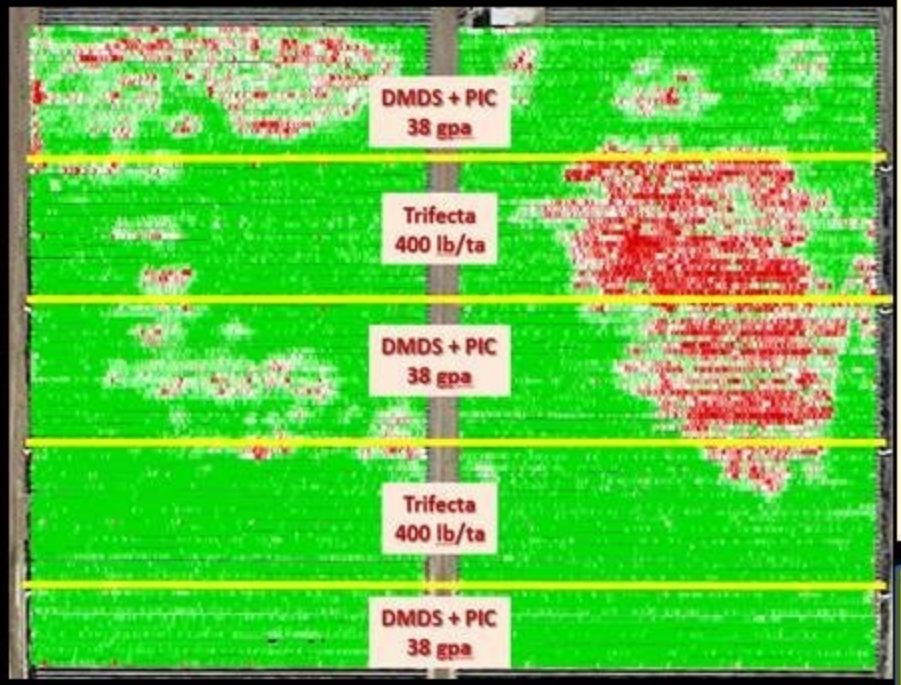


This is what one of the fields looked like after 3 sequential fumigations:

- Spring Crop Destruct Drip Fumigation Treatment (75 gpta Vapam)
- Summer Fallow Followed by Subsoil Fumigation (15-18 gpa Telone II) to destroy traffic pan (soil compaction zone) enhance downward diffusion
- Fall Drip Fumigation 2 tapes / bed (Pic Clor 60 EC- 300 lb/a)

It picked about a third (33% of 27,000 lb/a) of what it should have picked !

Prepared by J.W. Noling



What is Going On?

IS IT ANY WONDER WE STILL HEAR TALK ABOUT METHYL BROMIDE & REVIVING CRITICAL USE?

This is what one of the fields looked like after 3 separate fumigations:

- Spring Crop Destruct Drip Fumigation Treatment (75 gpa Vapam)
- Summer Fallow Followed by Subsoil Fumigation (15-18 gpa Telone II)
- Fall Drip Fumigation 2 tapes / bed (Pic Clor 60 EC- 300 lb/a)

It picked about a third (33% of 27,000 lb/a) of what it should have picked !

Addressing Causes of inconsistency

Prepared by J.W. Noling

- Understanding constraints to fumigant movement
- New technologies for Studying Vertical Distributions of Nematodes within the soil profile
- New Deep Shank and Drip Application Technologies for Soil Fumigants to address the hidden enemy ☺

LETS BEGIN DISCUSSION OF NEW TECHNOLOGY with ....

Prepared by J.W. Noling

Introducing the new deep soil exploration tool ☺

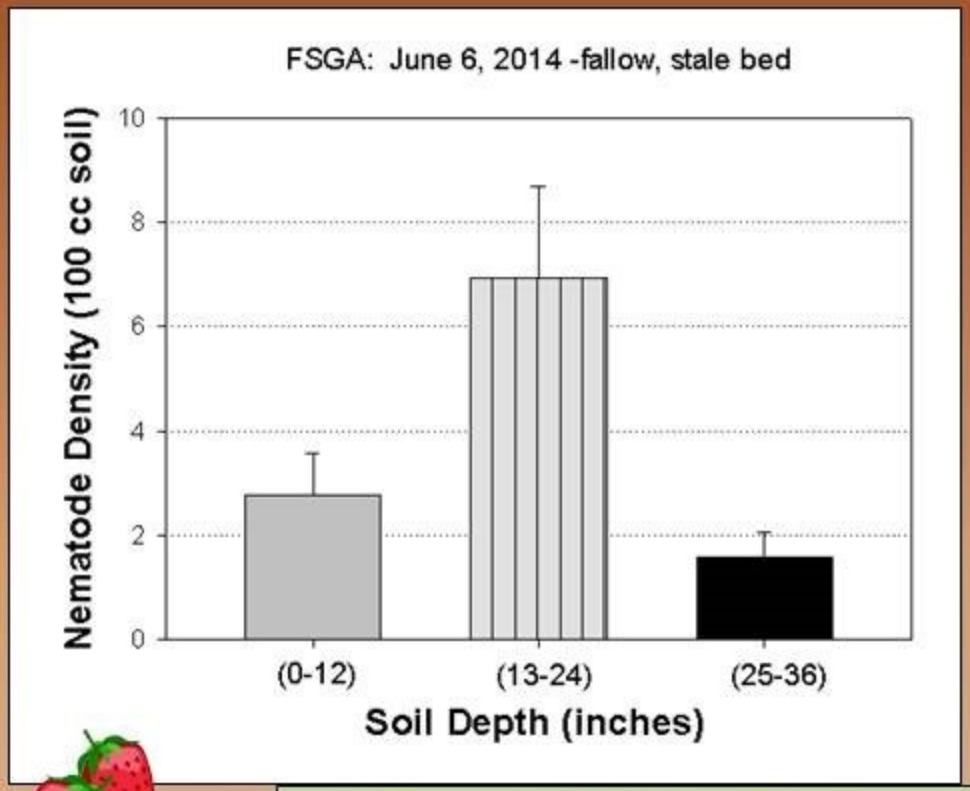
The Probinator

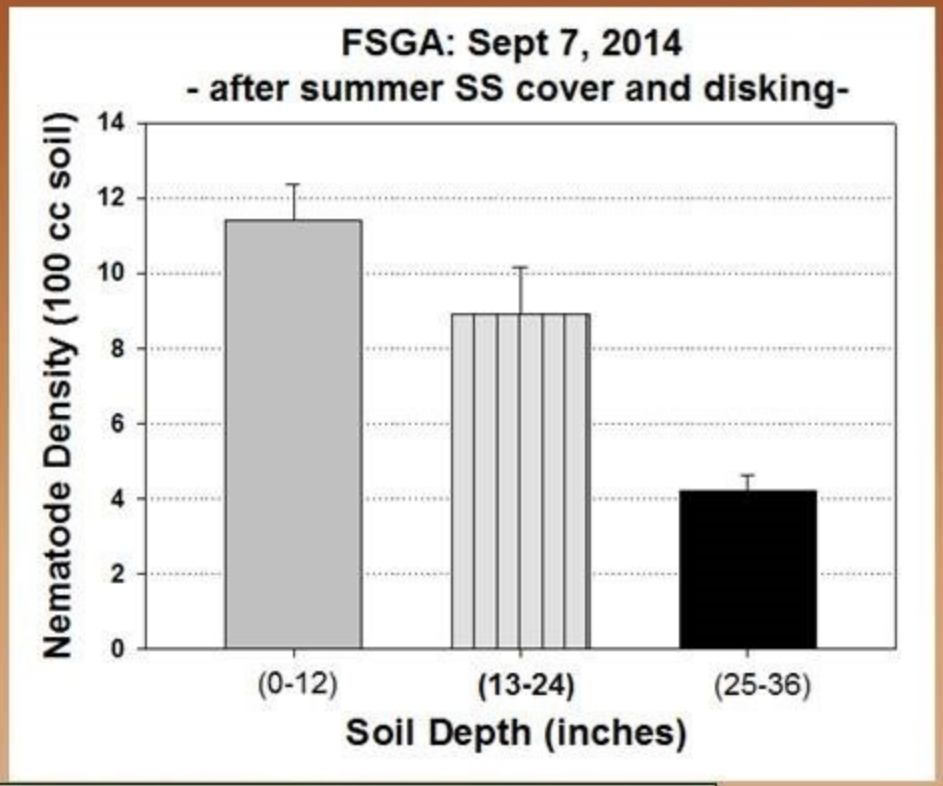
- *Seasonal depth distribution of Sting nematode*
- *Fumigant treatment impact & inconsistency (measure soil air [conc]*
- *Identify origins of bed recolonizing populations of Sting Nematode*

http://www.crec.ifas.ufl.edu/extension/soilipm/videos/video.zip

The Probinator has allowed us to conveniently ask:

Where does Sting nematode occur in the soil profile?





Nematode Numbers and their Depth Distribution are very Important Management Considerations !

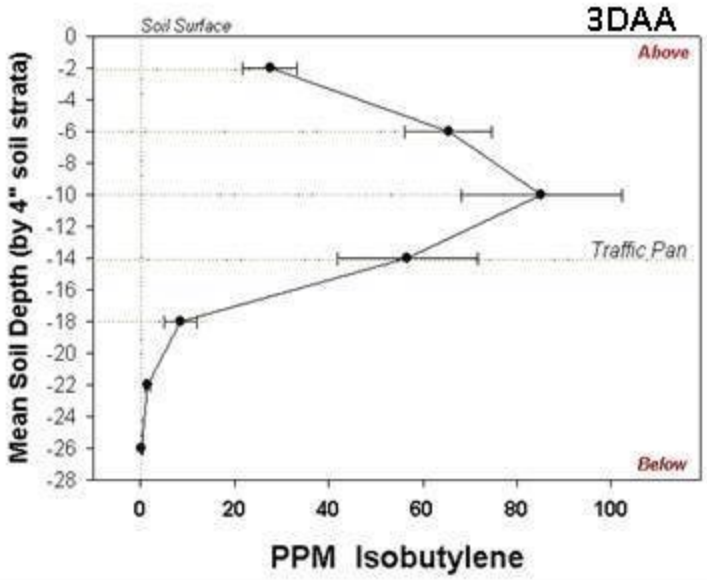
Sting nematodes reported to move 3 feet in 30 days

Prepared by J.W. Noling

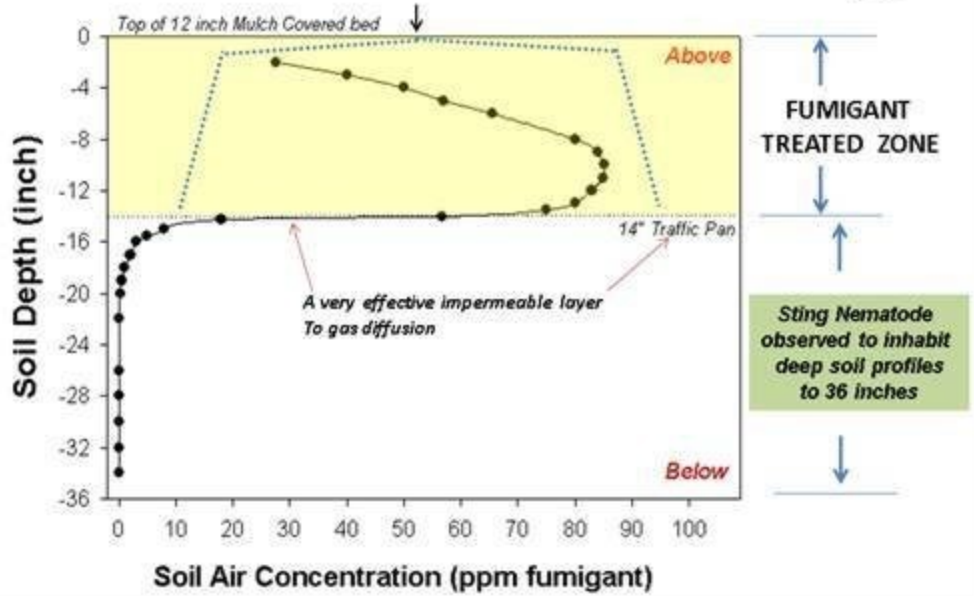
Crop Termination Drip Fumigation Treatment Results…

Measuring where Fumigants go, and Don't go !

Fig. 1. Concentration Isobutylene in soil strata above and below a 14 inch traffic pan. Soil air measurement obtained thru center of a 12½" raised, mulch covered bed 3 days post application Telone EC (12 gpa). Data points are means & S.E. 8 reps MB farm, Dover, FL



Illustrated example of fumigant gas concentrations above and below a strawberry traffic pan shortly after soil injection to a depth of 10-12"



Why is this significant ?

J Nematol. Apr 1991; 23(2): 162–169. PMCID: PMC2619143

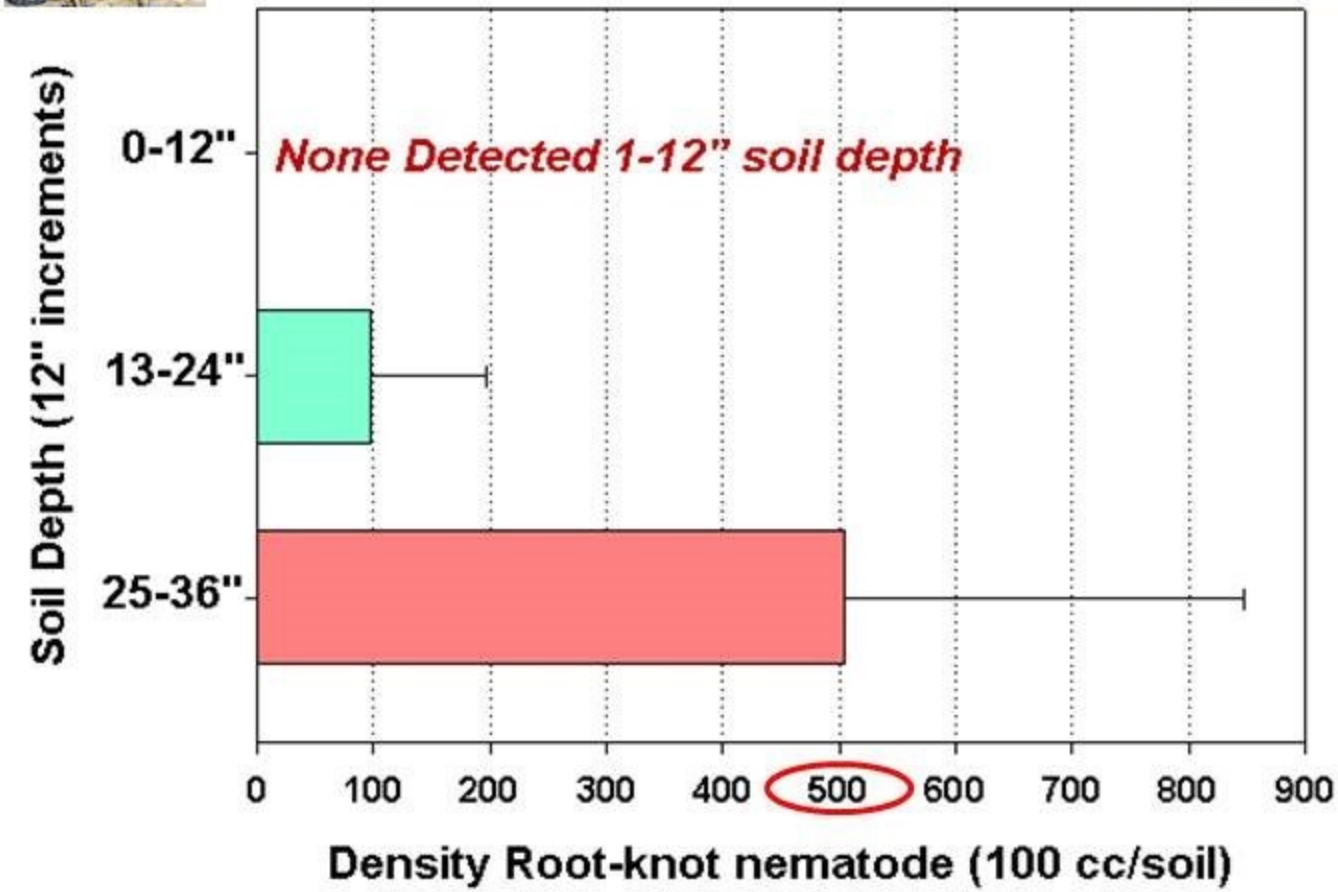
This work says 22 inches in 9 days in a sandy loam (2.4 inches/day)

Seasonal Migration of *Meloidogyne chitwoodi* and its Role in Potato Production

H. Mojtahedi, R. E. Ingram, G. S. Santo, J. N. Pinkerton, G. L. Reed, and J. H. Wilson

THE Probinator allows us to ask: How good of a job are we doing with DRIP Fumigants after months of clean fallow ?

Telone II (18 gpa) Pretreatment Samples
Depth Distribution of Root-knot nematode
Deep core *Probinator* samples
June 26, 2014 Barberbille, FL



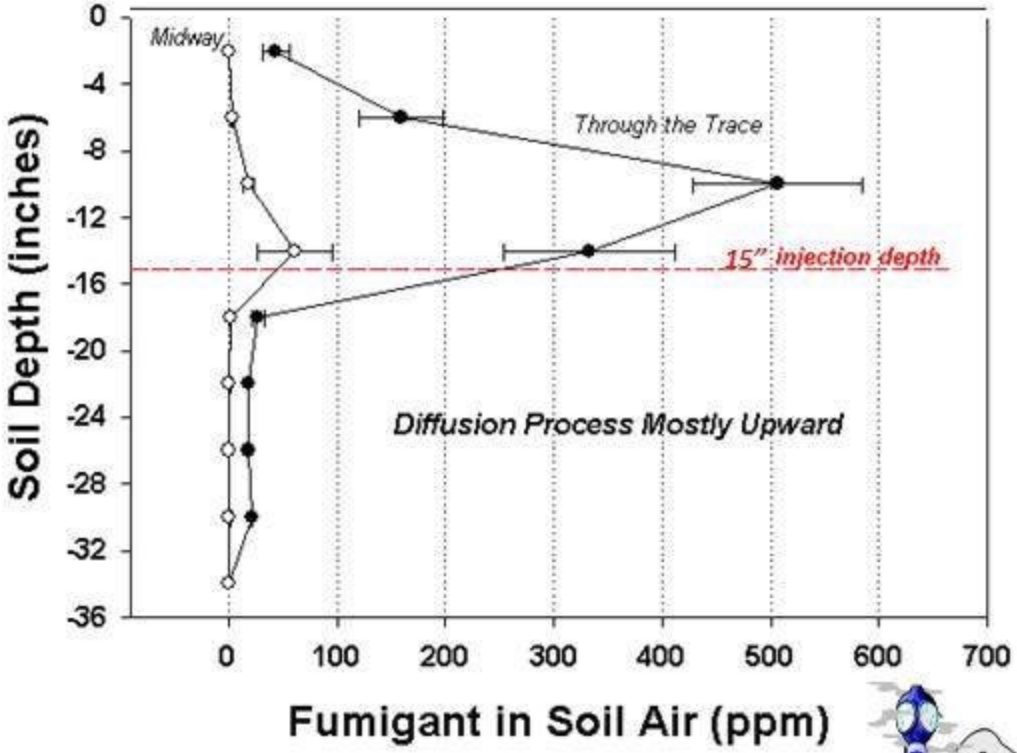
Prior to Ripper Shank Summer broadcast Treatment

Prepared by J.W. Noling

Measuring where Fumigants go, & Don't go even when deep injected!

- Traffic pan destroyed
- Even with deep placement, Telone diffusion process was <u>mostly upward</u>, not to depths where nematodes reside

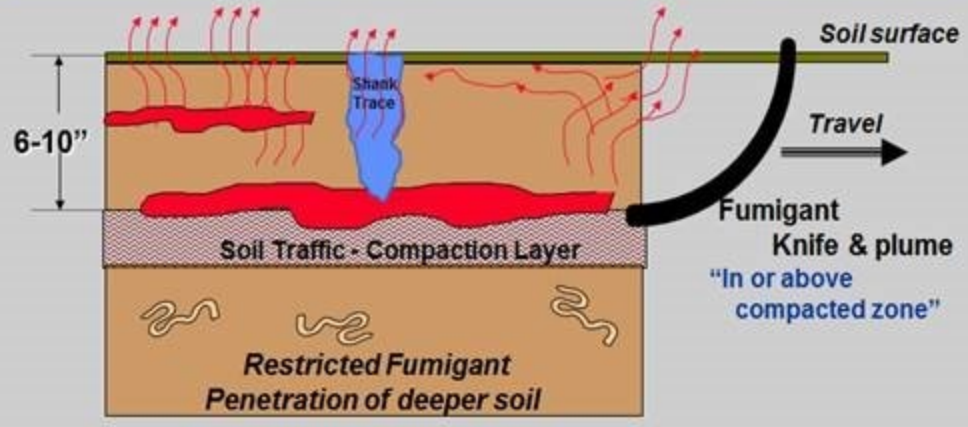
Figure 3. Fumigant Gas Concentration within the Shank Trace and midway between ripper shanks to a soil depth of 36 inches. Fumgant was broadcast applied to a 15 inch soil depth. Datapoints are means and standard errors of 4 replicate observations. Barberville, FL. Telone II (18 gpa) - 1 DAA - July 12, 2014



Prepared by J.W. Noling

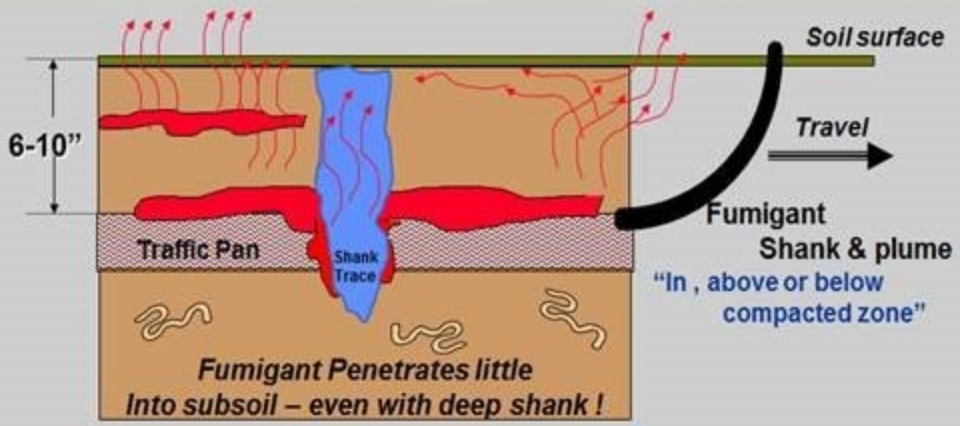
What has the Probinator told us ?

Impact of the Soil Compaction Layer – Traffic Pan- on Fumigant Movement & Nematode Control



the Traffic Pan effectively blocks downward diffusion

Even Deep Placement below Traffic Pan did not Meaningfully Improve Fumigant Penetration into Subsoil



the Shank Trace effectively promotes upward movement

Prepared by J.W. Noling

What is Needed: NEW TECHNOLOGY for DEEP APPLICATION

Auto Reset – Deep Drip

Auto Reset - Deep Shank w/ Wings

DEEP PREBED APPICATIONS

Place the Telone below the traffic pan where nematodes reside, and shortly before where the raised bed will be placed.

Prepared by J.W. Noling

We measured Telone Gases in Soil

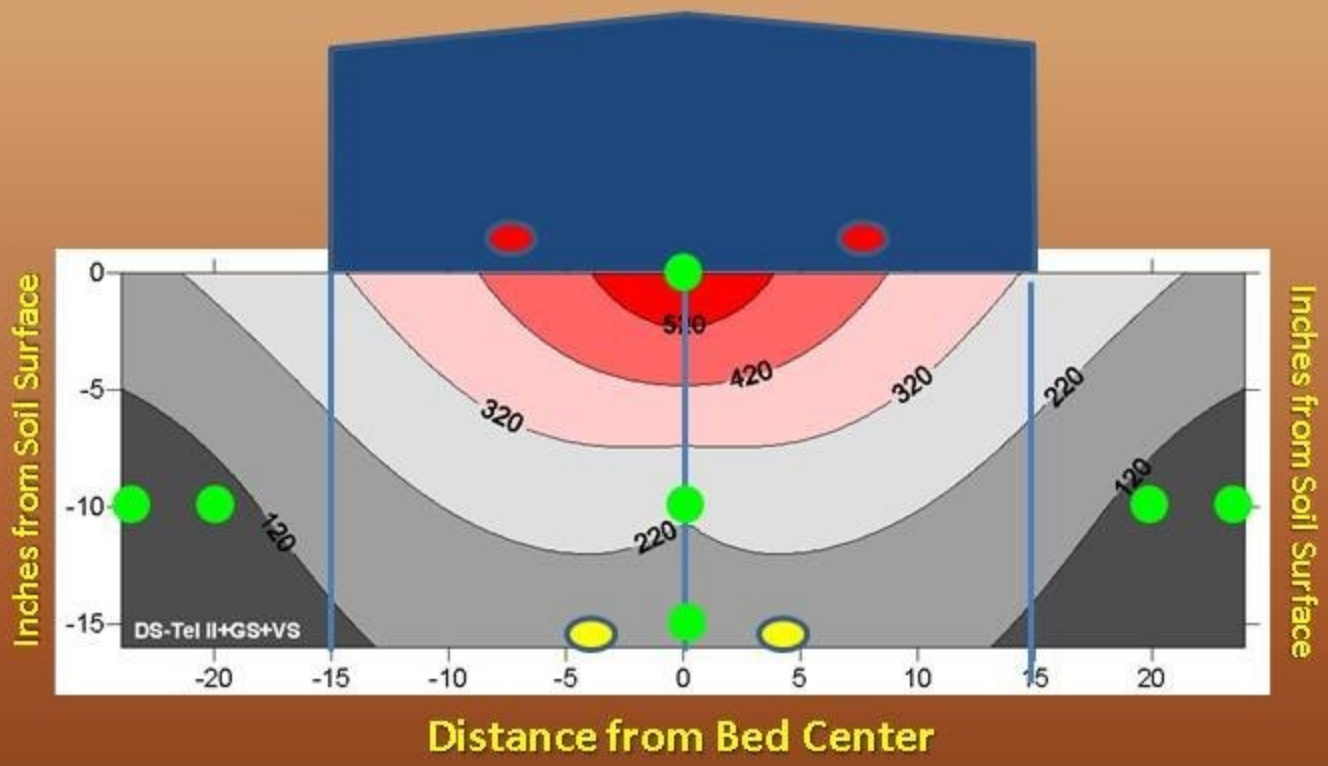
We sampled air concentrations of Telone II at multiple depths and locations using a MiniRae VOC with different soil probes

<u>Objective:</u>

To determine whether disturbing the *Traffic pan* results in a redistribution of a soil fumigant vertically through the soil profile.

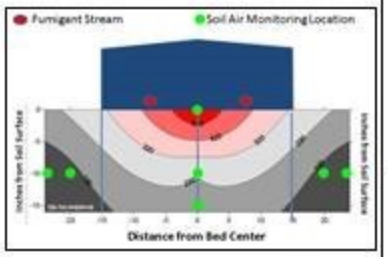
SOIL AIR MONITORING LOCATIONS for DEEP SHANK APPLICATIONS

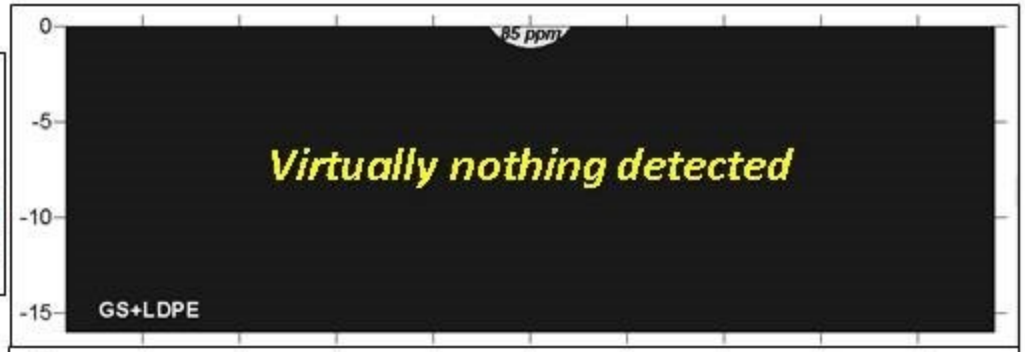
- Grower Standard In-Bed Pic Clor 60 (14.5 gpa) Fumigant Stream
- Deep Shank Telone II (18 gpta) applied 2 fumigant streams 15" deep
- Soil Air Monitoring Location



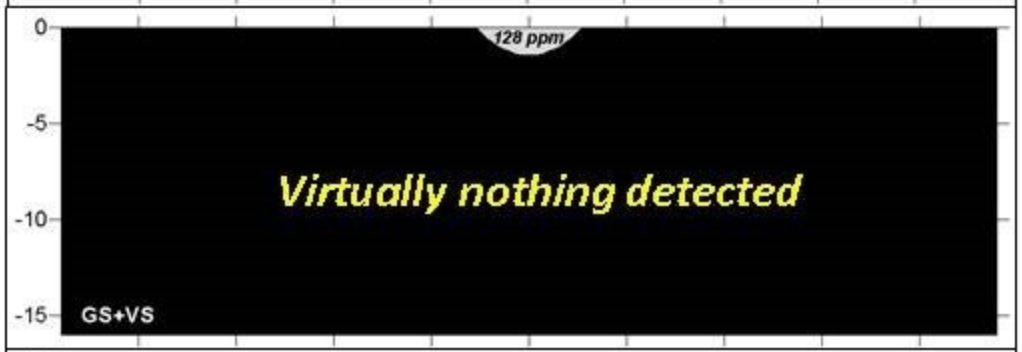
Isolines of 1,3-D (Telone II; 18 gpta) soil air concentrations 2 days post application

Prepared by J.W. Noling

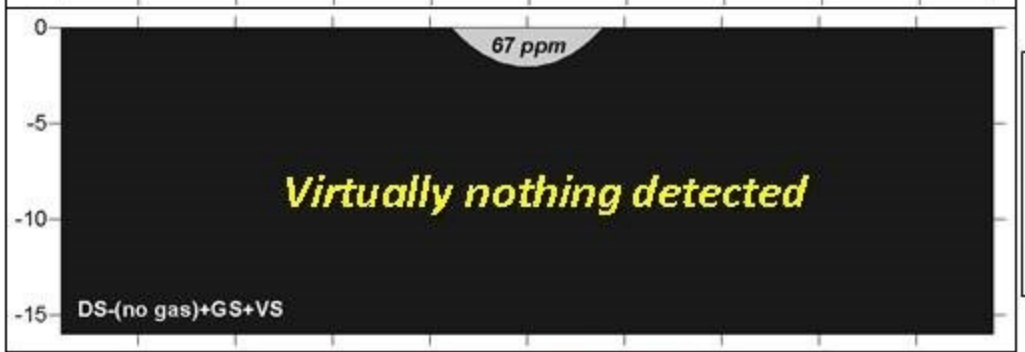




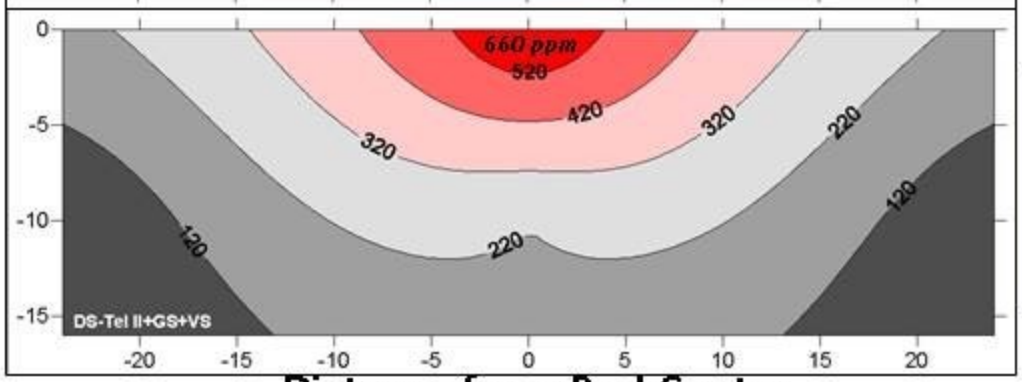
Grower Standard into Bed
(Pic Clor 60: 300 lb/Ta)
Low Density Berry Mulch
85 ppm max bed center



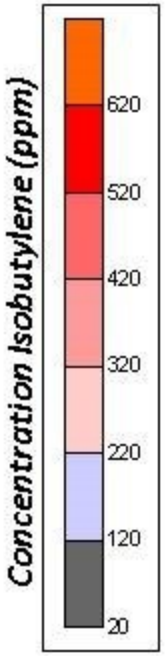
Grower Standard into Bed
(Pic Clor 60: 300 lb/Ta)
Vapor Safe TIF Mulch
128 ppm max bed center



Grower Standard into Bed
(Pic Clor 60: 300 lb/Ta)
Vapor Safe TIF Mulch
Deep Ripper Shanked (no gas)
67 ppm max bed center



Grower Standard into Bed
(Pic Clor 60: 300 lb/Ta)
Vapor Safe TIF Mulch
1,3-d (18 gpta)Deep Shanked
660 ppm max bed center



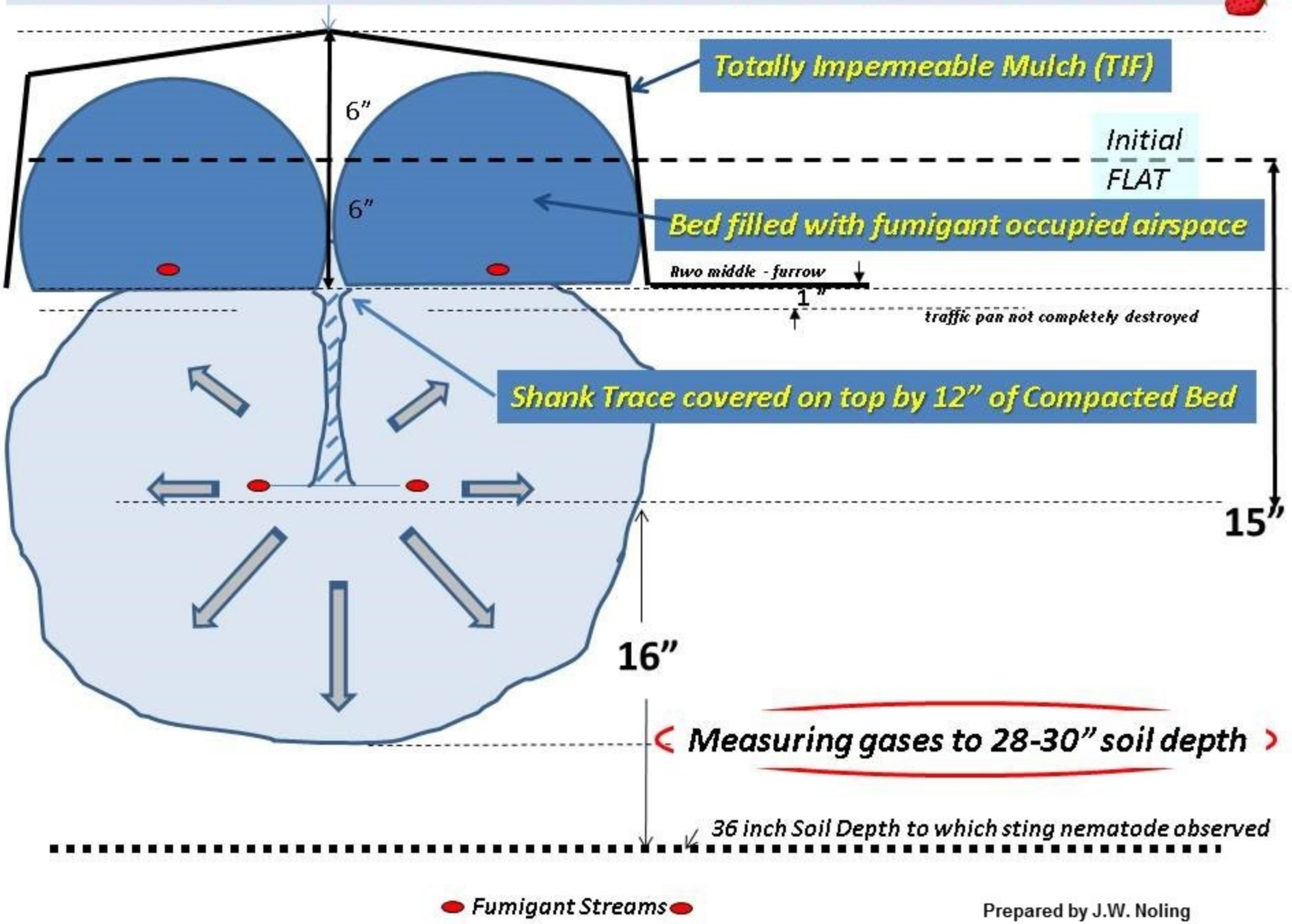
Inches from Soil Surface

Distance from Bed Center

Preliminary Results in Strawberry Look Very Interesting ☺

Dover, FL Jan 2015

3 Reasons why new Prebed Deep Shank Treatment appears to push Fumigants Deeper?



Prepared by J.W. Noling

- ***WHAT ARE ROOT CAUSES of FUMIGANT INCONSISTENCY ?***

Improper Fumigant Placement Contributing to Unacceptable Spatial Distribution

KEY CONCEPTS of Nematode & Fumigant Movement

Nematodes are much more broadly distributed in the deep soil profile than previously recognized

Fumigants (other than Methyl bromide) do not sufficiently diffuse through Traffic Pans

An application method and tarp which provides for satisfactory containment and facilitates uniform soil distribution to the depth of the target pest is highly desirable

Thank you ---- ANY QUESTIONS