Methods To Increase Chloropicrin Efficacy

NEMATODE CONTROL
DISEASE CONTROL

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Agenda

- What is Chloropicrin
- History of Chloropicrin
- Chloropicrin use in Canadian and US Tobacco
- Douglas Agricultural Services, Inc.
- Strategies to increase efficacy of chloropicrin

What is Chloropicrin?

Chloropicrin is a broad spectrum multi-purpose soil fumigant. It is used all over the world to manage a broad spectrum of fungal, nematode, and soil insect pathogens across a wide variety of crops.






Chloropicrin

Chloropicrin is the soil fumigant identified most often in the search for alternatives to methyl bromide. It can be applied alone or in combination with other fumigants such as methyl bromide, 1,3-D, and DMDS (Dimethyl disulfide).

Chloropicrin Environmental Fate

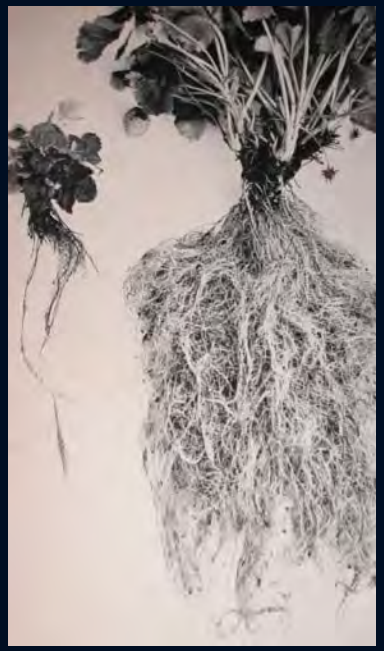
Also known as Trichloronitromethane

- Metabolized in soil to chloride, nitrate, CO_2
- Half-life in soil: 4.5 days (radiolabeled)
- Never been found in G.W. in agriculture environment
- Plant back: 14 days
- STRONG LACHRYMATOR 

Plant residue.

- Chloropicrin has never been detected in crops grown in soil treated with chloropicrin. CO_2 is metabolized by plants.

Chloropicrin



Bio-Nutritional Effects

- Maintains healthy plant/root growth
- Mitigates against infestations
- Allows for sufficient supply of nutrients to plants
- Does not kill beneficial soil fungi and bacteria
- Increases populations of beneficial fungi such as Trichoderma . Actinomycetes populations also increase improving soil structure, tillage and water penetration

Chloropicrin Efficacy

Controls soil-borne root infecting (destroying) fungi within 48 hours of application. This includes:

- **Verticillium:** potatoes, strawberries, tomatoes, cherries, egg plant, peppers, tobacco
- **Rhizoctonia:** onions, tobacco, emerging plant seedlings
- **Pythium:** onions, tobacco, greenhouse crops, turf
- **Phytophthora:** tobacco, strawberries, raspberries, apples, peaches
- **Fusarium:** Strawberries, bananas, onions, sweet potatoes, cantaloupe, Douglas fir tree seedlings.

HISTORY OF CHLOROPICRIN

- 1848 –First systhesized in Scotland by Chemist J. Stenhouse
- 1920-–Rothamsted, EJ Russell cured "Soil Sickness" in Tomato
- 1927-–War Surplus Chloropicrin used in Hawaii to restore productivity of Pineapple lands
- 1935—MD Johnson (Hawaii) discovered that Pythium and Phytophthora, together with Nematodes was the cause of Pineapple Decline.
- 1950—Chloropicrin applications began on California strawberries

CHLOROPICRIN USE: CANADA AND US TOBACCO

- 1960's to 2000 Canadian tobacco was fumigated with mixtures containing Chloropicrin, i.e. Telone C-17, Vorlex CP
- 1969-1970—SK Gayed test Chloropicrin, 3 rates at 6" and 18" depth
- 1985—Field trials in NC with Chloropic
- 1986—2,500 acres of Tobacco fumigated in US
- 1994—24,000 acres Tobacco fumigated in US
- 1997—Pic 100 efficacy trials established in Ontario
- 1999—Pic 100 approved by the PMRA as Class 1

CHLOROPICRIN USE: CANADA AND US TOBACCO

- 2000—Ontario--3 trials were established by Ron Brammall
- 2001--Vorlex withdrawn from Canadian market
- 2002—First commercial PIC 100 fumigations began . Class 5
- 2011-–Telone withdrawn from Canadian market
- 2017—Ontario 18,000 acres fumigated (99%) with Pic 100 and PicPlus
- 2017—NC, SC, VA—148,500 Tobacco acres fumigated with C-17, Pic, and Pic+ 91,200 Acres 60% of the total fumigated acres were Pic and Pic +

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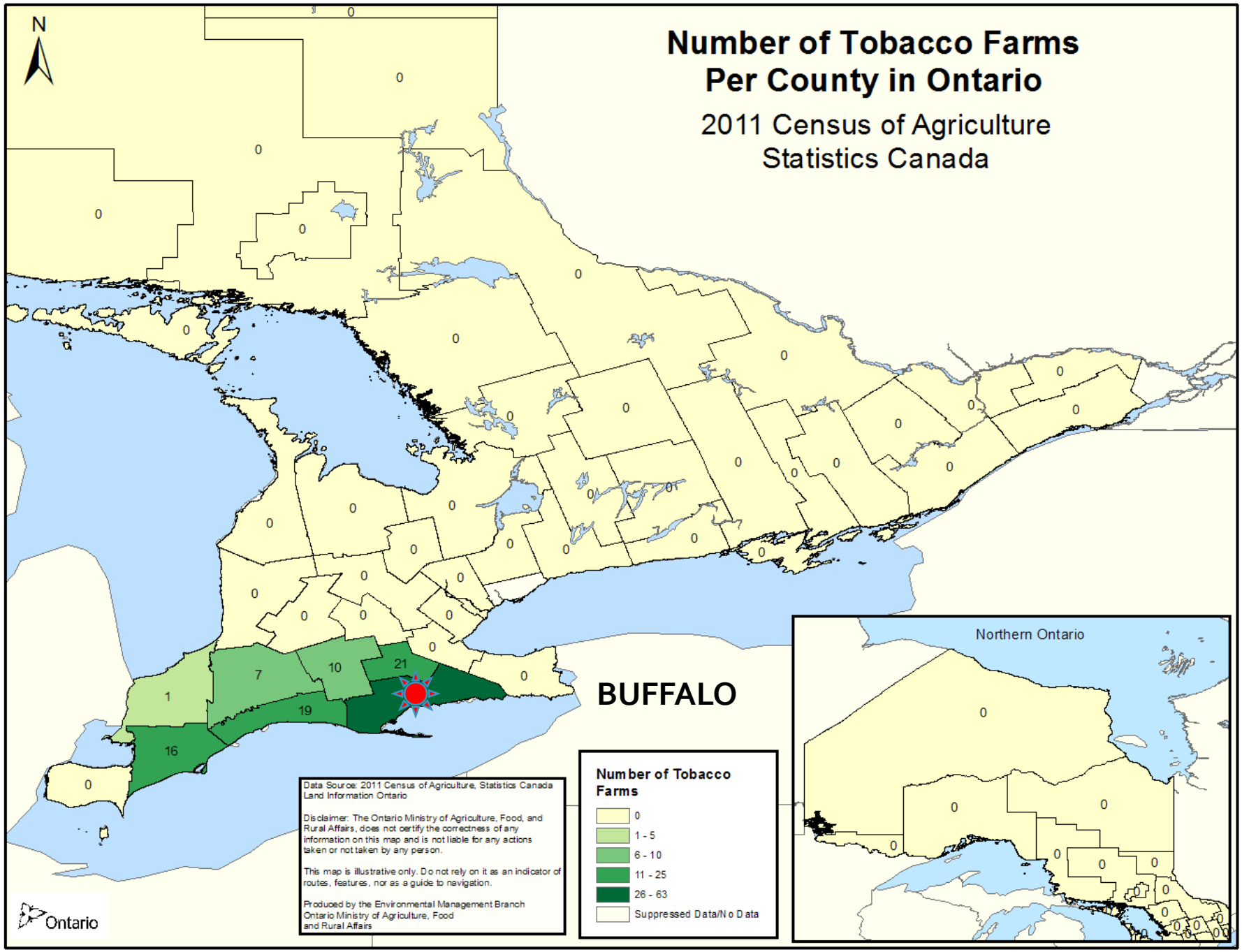
SIMCOE, ONTARIO

- 2003—Formed to be the Canadian Distributor of Chloropicrin in Canada for Hendrix and Dail (Later TriEst Ag Group) TOBACCO
- 2004-2016--Added potato, strawberry, carrots, onions, tomato, pepper, orchard replant, and ginseng
  - Added Quebec, New Brunswick, Nova Scotia, Manitoba
- Since its formation, Douglas Ag has used the **"EXTENSION MODEL"** for market introduction and sales of Chloropicrin.

Douglas Inc.
AGRICULTURAL SERVICES



STRATEGIES TO INCREASE EFFICACY OF CHLOROPICRIN

- Pic mixed with solvent or Telone
- Closing the chisel trace.
- Shaping and packing the bed.
- Fumigation timing
- Deeper dual depth application
- Sealing the soil surface

Pic Plus vs PIC 100

Pic Plus…

1. Contains a solvent that slows the volatilization of chloropicrin in the soil
2. Slower soil movement:
    1. Reduces the risk of off-gassing under adverse conditions
    2. Increases the "T" (Time of exposure) in the CT equation
    3. Improves pest suppression when soil conditions are not perfect for soil fumigation, i.e. sandy knolls, moisture, temperature.
3. Often, a lower rate of PIC Plus (a.i.) can be used compared to PIC 100 without a loss in pest suppression efficacy.

Table 1. Tuber production statistics for *all* treatments in the Pic-Plus evaluation trial in Hastings, FL in 2004.

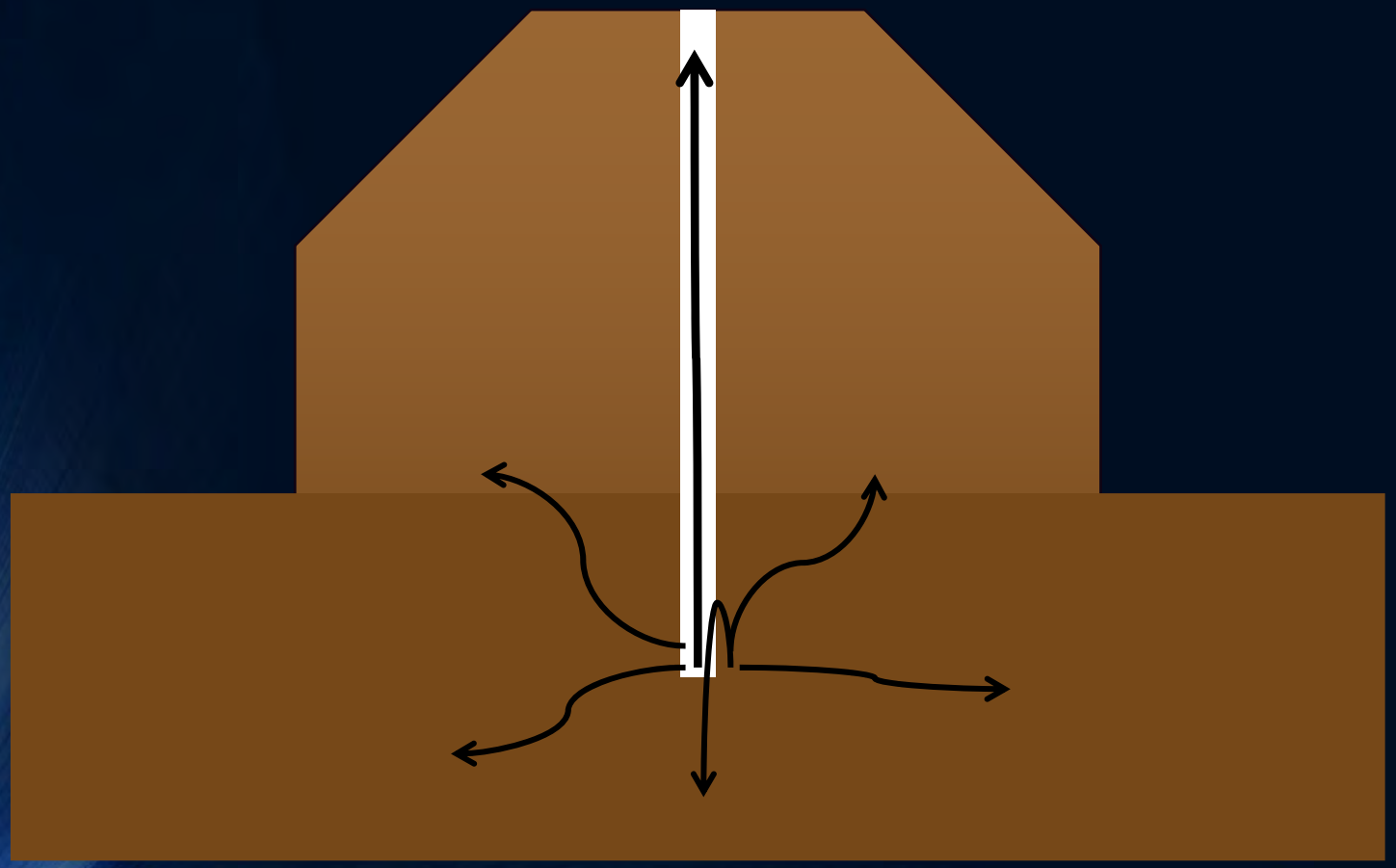
Main Effects and Interactions[2]	Total yield (cwt/A)	Marketable yield[1] (cwt/A)	Size class range (%)[2] A1 to A3	Size class range (%)[2] A2 to A3	% Total culls	Specific gravity[3]
Fumigant						
Control - No Fumigation	354 b[4]	248 cd	70	2	3	1.072
Telone 6 gpa	362 b	241 cd	65	2	2	1.071
Chloropicrin 40 lb a.i./A	388 ab	256 b-d	66	2	2	1.071
Chloropicrin 60 lb a.i./A	385 ab	274 a-d	71	1	2	1.067
Chloropicrin 80 lb a.i./A	385 ab	270 a-d	70	1	2	1.071
Pic-Plus 40 lb a.i./A	411 a	291 a-c	71	3	2	1.070
Pic-Plus 60 lb a.i./A	428 a	313 a	73	4	2	1.072
Pic-Plus 80 lb a.i./A	420 a	307 ab	73	2	1	1.071
Experimental 1	347 b	222 d	63	1	2	1.073
Expermental 2	353 b	249 cd	70	4	2	1.069
Application Method (AM)						
Single Shank	390	272	69	2	2	1.072
Double Sweep	376	262	69	2	2	1.069
Bed Preparation (BP)						
Not Packed	360 b	240 b	67 b	2	3 a	1.070
Packed	406 a	294 a	72 a	2	1 b	1.072

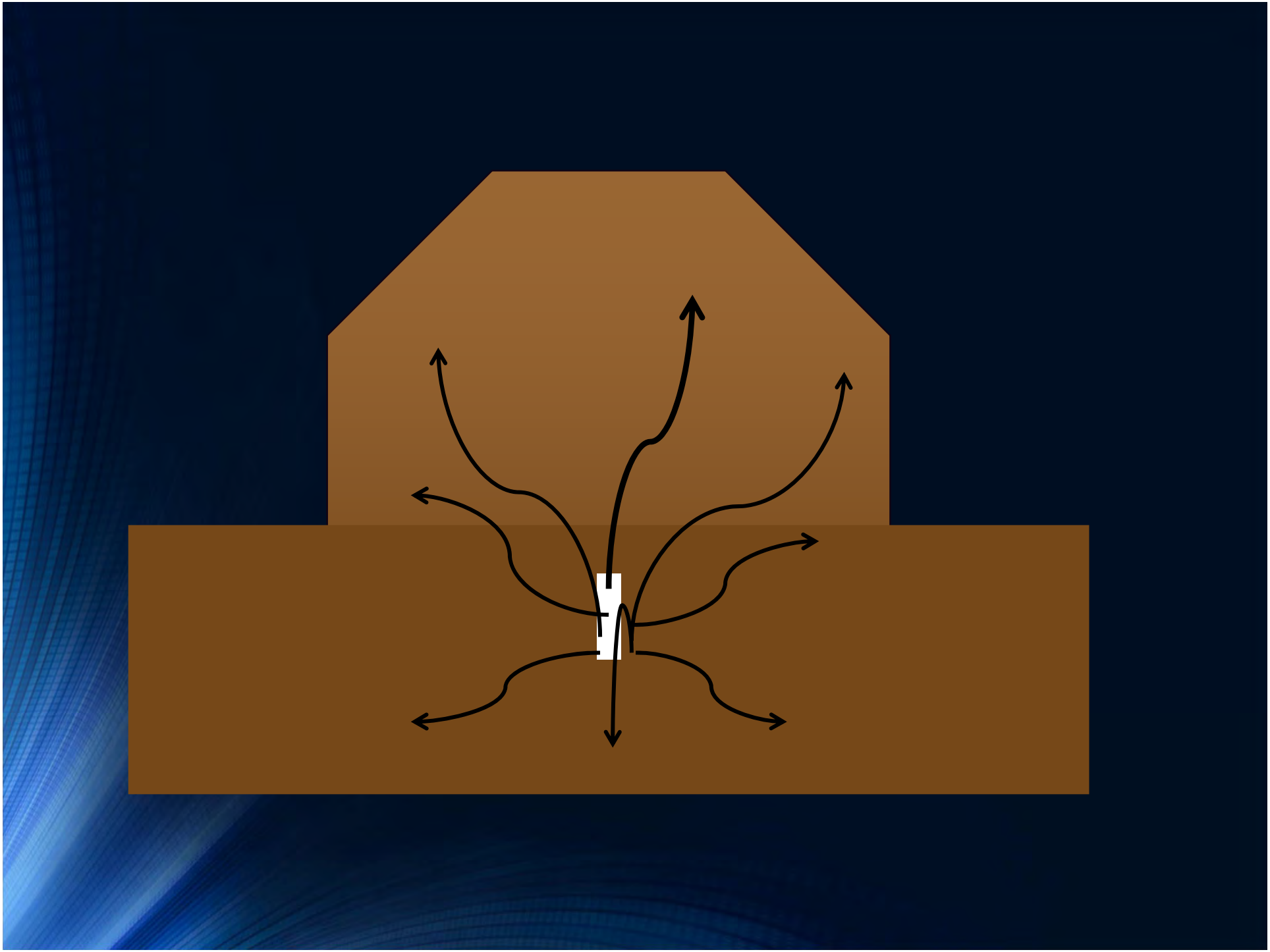
Pic vs Pic+

- Research with Bill Carey, Auburn University Forest Nursery Cooperative demonstrated the when Pic 100 was placed under tarp the efficacy was statiscally better that Pic broadcast bare ground but Pic Plus Broadcast bare ground was equivalent to both Pic 100 under tarp and Pic Plus under tarp.
- Canadian Tobacco growers can visually see loss in efficacy of Pic 100 on the sandy knolls. Pic plus solves much of that issue.

CLOSE THE CHISEL TRACE

CHIMNEY EFFECT





CLOSING THE CHISEL TRACE

MOLE KNIFE

SHAPING AND PACKING THE BED

+ Raised Row +

30% Soil Compression

70% Field Capacity
USDA hand test

Low Trash

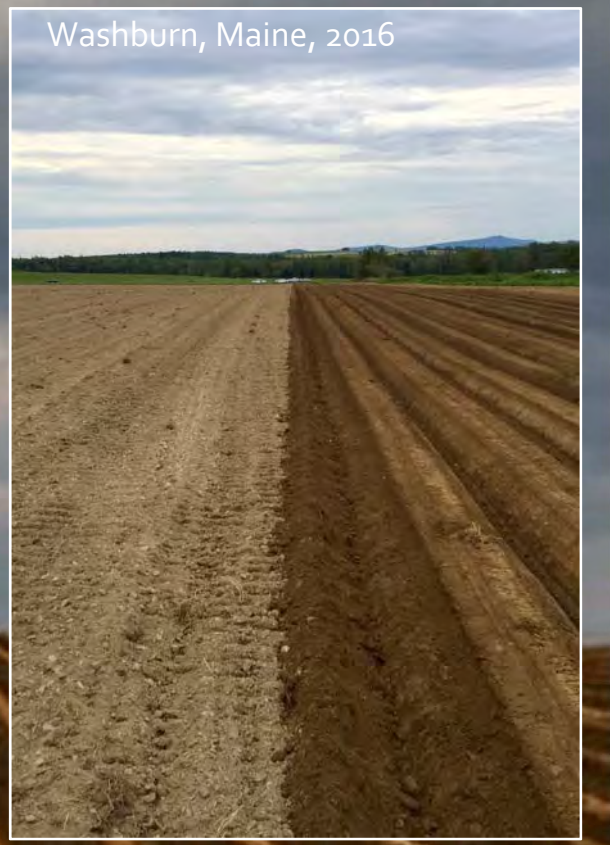
Self-Sealing Shanks

Saint Agatha, Maine 2016

Agronomics

Benefits of Row Shaping – No Fumigation

Hastings Florida, 2004			
Not Packed 324 cwt/A	→	Packed 384 cwt/A	18%
Presque Isle Maine, 2016			
Not Packed 391 cwt/A	→	Packed 426 cwt/A	9%

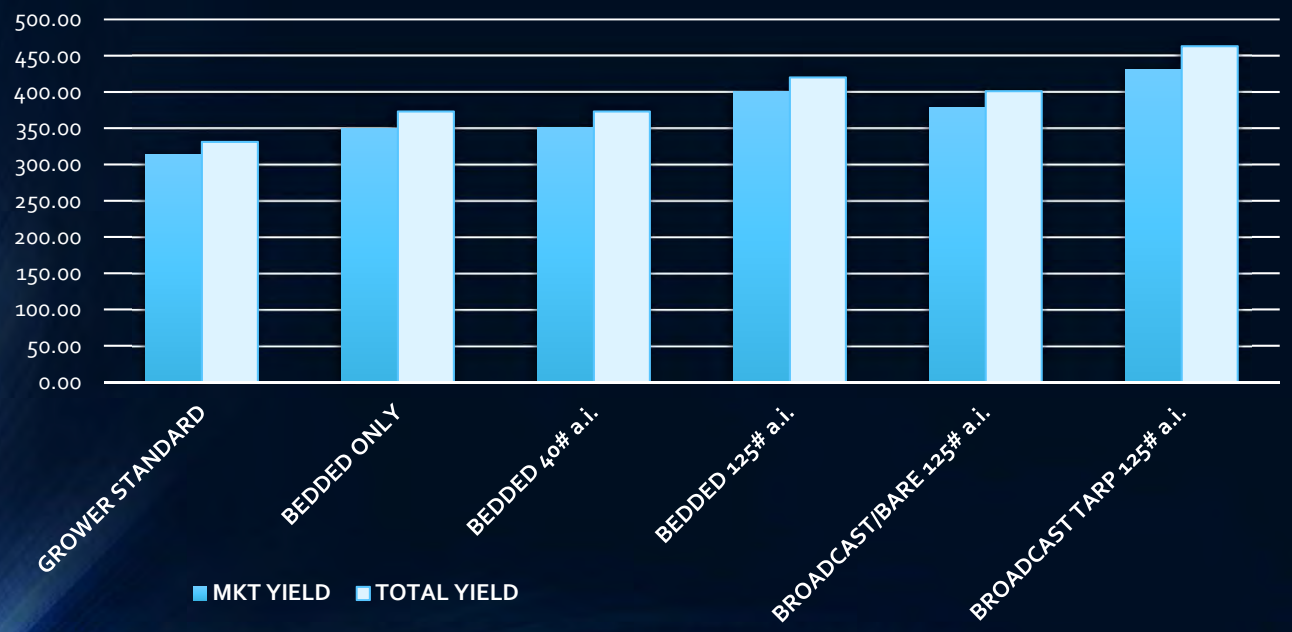


Bedded PIC Plus vs Broadcast Bare ground vs Broadcast Tarp all with the same amount of a.i./A

ROI was best with Bedded - 125 lb ai PIC Plus/A

Table 1. Russet Yield Data (cwt/planted A) for the Soil Fumigation Trial - Maine Farm, 2017

Treatment	Stems/ Plant	Specific Gravity	Culls	< 1 7/8"	1 7/8" - 6 oz	6 - 10 oz	Bonus > 10 oz	Grade 1 1 7/8 - 10 oz	Mkt Yield	Total Yield
Grower Standard	2.7	1.085	0	19	176	117	20	293	313	331
Bedded, Non-Fumigated	2.3	1.084	0	23	158	145	48	303	350	373
Bedded - 40 lb ai PIC Plus/A	2.2	1.083	0	22	170	143	39	313	351	373
Bedded - 125 lb ai PIC Plus/A	2.3	1.083	0	20	202	156	42	357	400	420
Broad/Bare, 125 lb ai PIC Plus/A	2.2	1.082	1	22	207	149	22	355	378	401
Broad/Tarp, 125 lb ai PIC Plus/A	2.6	1.080	0	29	210	187	36	397	434	463



2005

2005

FUMIGATION TIMING

- Fall or spring
- Fall advantages
  - Longer application window
  - Soil temperature optimum
  - Disease and nematode populations are highest and most receptive for control by the fumigant
  - Reduces work load in spring
    - Often too cold and wet until planting time
  - Beds warm up faster in spring and drain allowing earlier planting

FALL DISADVANATAGES

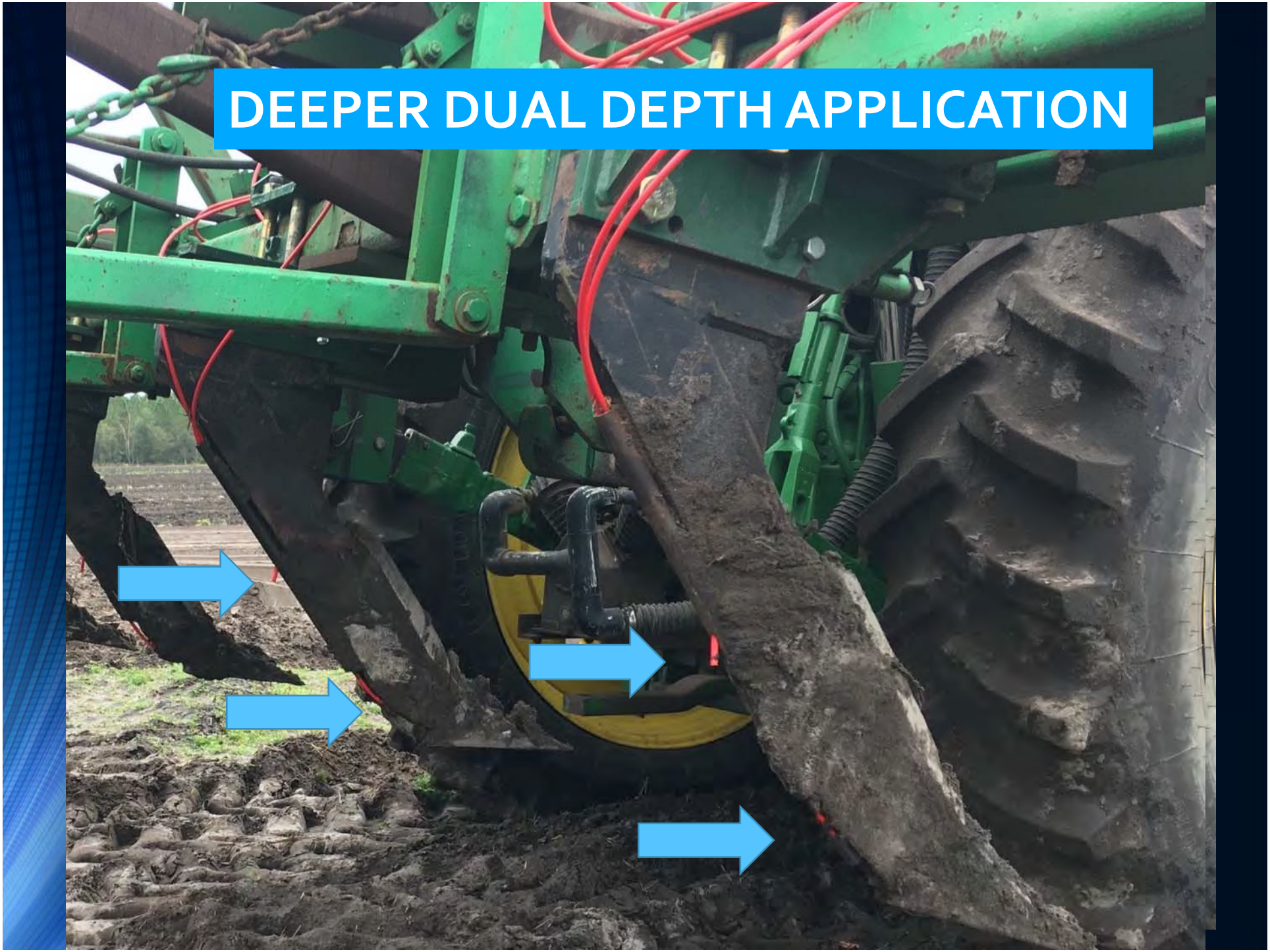
- Soil loss from winter rains
- Need to plant cover crop
- Cover crop burndown
- Pre-plant bed freshening

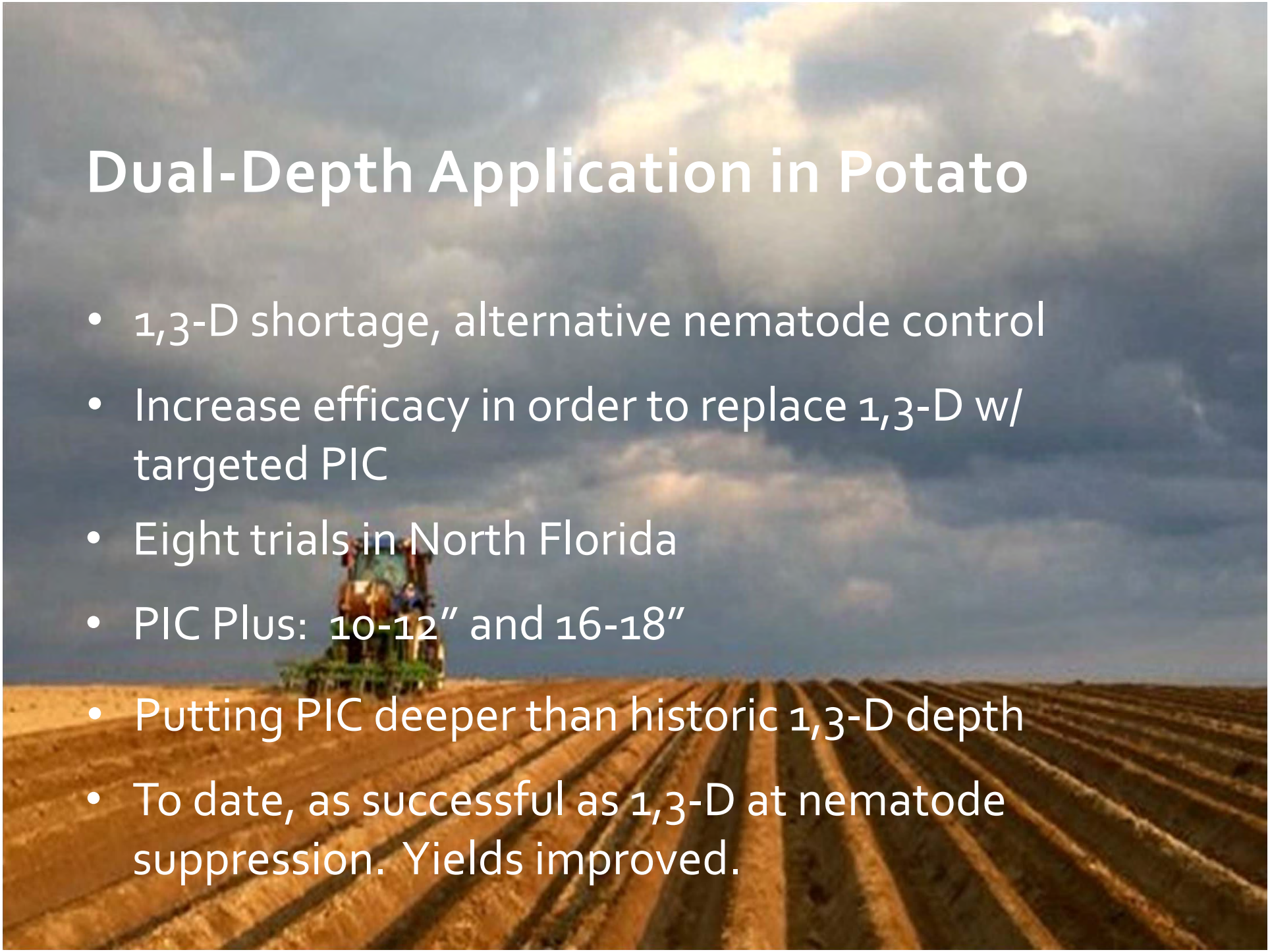
Spring – Bed Freshening

SPRING FUMIGATION

- Advantages
  - Less need to re-work soil
    - Soil already in seedbed condition
  - Less soil loss
  - No cover crop needed
  - Fumigant applied closer to planting time
- Disadvantages
  - May be too cold and wet allowing no time to fumigate prior to planting
  - May be tempted to plant too early after fumigation risking damage to crop

DEEPER DUAL DEPTH APPLICATION





Dual-Depth Application in Potato

- 1,3-D shortage, alternative nematode control
- Increase efficacy in order to replace 1,3-D w/ targeted PIC
- Eight trials in North Florida
- PIC Plus: 10-12" and 16-18"
- Putting PIC deeper than historic 1,3-D depth
- To date, as successful as 1,3-D at nematode suppression. Yields improved.

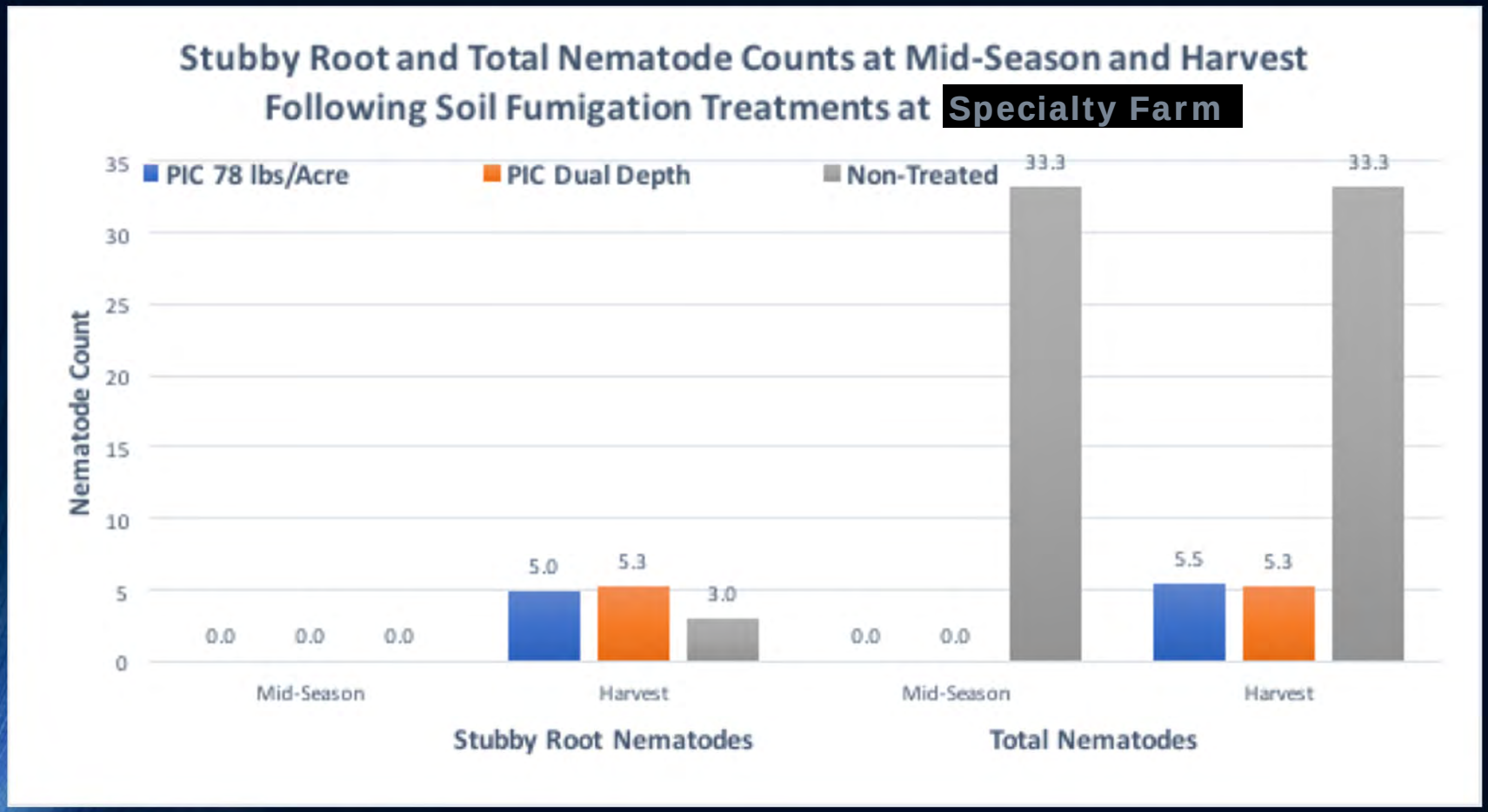
Fumigation Trial: Small, Speciality Potato; 2017

Table 1. Specialty Potato Yield Data (cwt/planted A) for the Soil Fumigation Trial, FL in 2017

Treatment	Culls	< 3/4"	C size 3/4 - 1 5/8"	B size 1 5/8 - 2"	A size 2 - 3"	Chefs > 3"	Mkt Yield[1]	Total Yield
Non-Treated	10	0	79	51	21	0	130	161
PIC Plus (78 lb ai/A)	2	1	113	85	8	0	198	209
PIC Plus Duel Depth (120...)	0	2	112	125	32	0	237	271

Table 2. Specialty Potato Yield Data (1000 tubers/planted A) for the Soil Fumigation Trial, FL in 2017

Treatment	Culls	< 3/4"	C size 3/4 - 1 5/8"	B size 1 5/8 - 2"	A size 2 - 3"	Chefs > 3"	Mkt Yield[1]	Total Yield
	- 1,000 tubers/A -							
Non-Treated	13.5	4.1	133.3	53.8	14.6	0.0	187.1	219.3
PIC Plus (78 lb ai/A)	1.7	12.7	229.3	72.1	4.0	0.0	301.4	319.9
PIC Plus Duel Depth (120...)	1.0	14.8	225.0	99.6	16.1	0.0	324.6	356.5



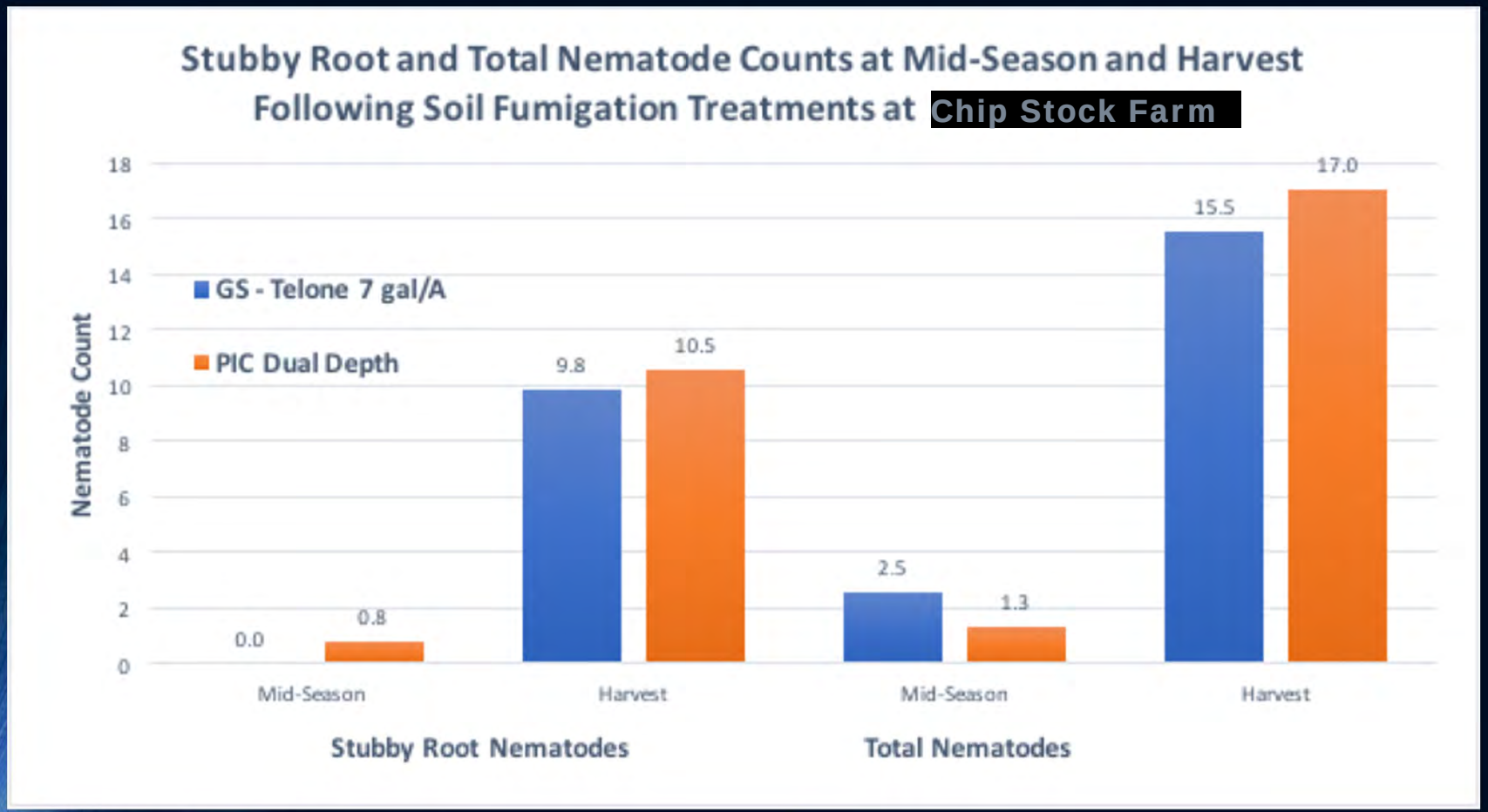
Fumigation Trial: Chip Stock, Elkton, FL - 2017

Table 1. Chip Stock Yield Data (cwt/planted A) for the Soil Fumigation Trial in 2017

Treatment	Culls[2]	< 3/4"	C size 3/4 - 1 5/8'	B size 1 5/8 - 2"	A size 2 - 3"	Chefs > 3"	Mkt Yield	Total Yield
GS Telone II at 7 gal/A	21	0	9	32	232	10	242	304
Dual-Depth (120 lb a.i. PIC Plus/A)	20	0	12	31	314	48	362	425

Table 2. Chip Stock Yield Data (1000 tubers/planted A) for the Soil Fumigation Trial in 2017

Treatment	Culls	< 3/4"	C size 3/4 - 1 5/8'	B size 1 5/8 - 2"	A size 2 - 3"	Chefs > 3"	Mkt Yield	Total Yield
	- 1,000 tubers/A -							
GS Telone II at 7 gal/A	0.0	3.7	18.9	25.4	80.0	1.4	81.5	140.9
Dual-Depth (120 lb a.i. PIC Plus/A)	0.0	5.9	28.9	24.5	102.1	7.5	109.7	177.4



SEALING THE SOIL SURFACE

SUMMARY

- Chloropicrin is a multi-purpose soil fumigant in use since the 1920's
- In both Canada and the US Tobacco areas, it is the dominant soil fumigant
- Several strategies exist to increase the efficacy of chloropicrin when used as the pre-plant soil fumigant in Tobacco.
  - Addition of a solvent or Telone to help slow the volatilization
  - Use of a mole knife to close the chisel trace at the point of injection
  - Shaping and packing the bed
  - Deeper dual-depth application
  - Fall application utilizing cover crop and bed freshener in the spring
  - Irrigation seal after fumigation.

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