Alternative Fumigants and Emissions Reduction

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FUMIGATION

+ Reliable; No Residues in Crop; Variable Costs

- **Methyl Bromide, Chloropicrin, MITC Generators, 1,3-D,**
- **DMDS in Cal/EPA registration process**

Conventional Fumigation (Acres, California 2007):

Methyl Bromide/Chloropicrin:	40,000
Telone/Chloropicrin:	17,000
Telone II:	37,000
Chloropicrin alone:	6,000
Metam sodium:	77,000

TOTAL: ~ 180,000 acres annually

Significant Regulatory Pressure:

- **Buffer zones**
- **VOCs regulations**
- **Application rates**

Resulted in development of new film (tarp) technology:

- **"Virtually impermeable (VIF)"**
- **"Totally impermeable (TIF)"**

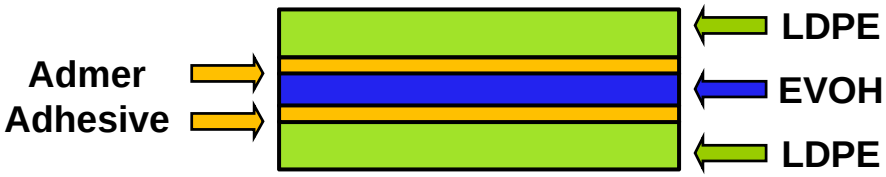
Agricultural Film (tarp) Types

“Standard” polyethylene tarp (HDPE or LDPE)

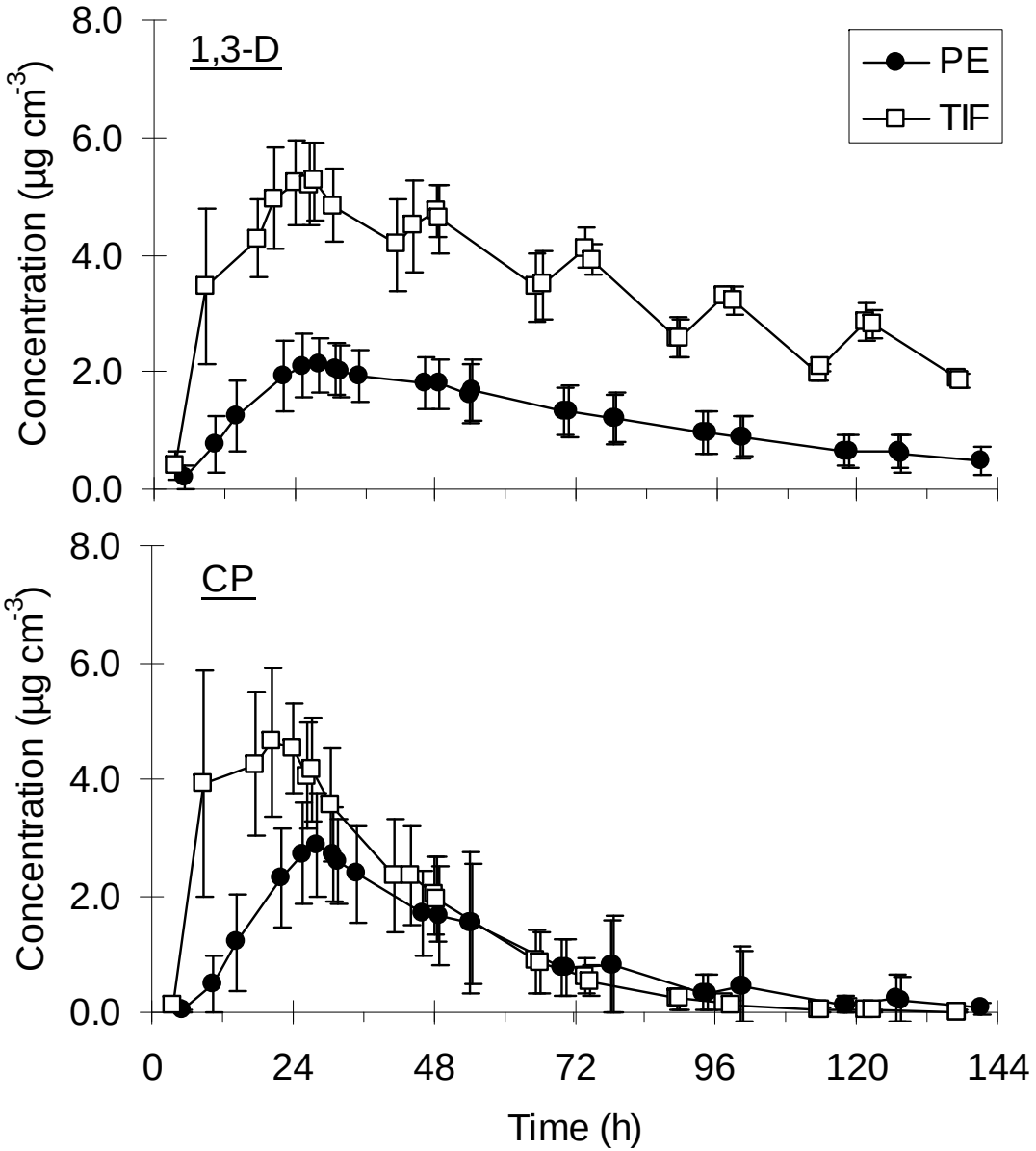
“Semi-impermeable” Tri-extruded LDPE

“Virtually impermeable (VIF)” LDPE + Nylon barrier

“Totally impermeable (TIF)” 5-layer EVOH resin barrier



Fumigant concentration under tarp



Concentration-time (CT) exposure index (µg cm^{-3}·h) of 1,3-D and CP in 2009 Oxnard fumigation trial

Soil depth (cm)	PE field		TIF field	
	1,3-D	CP	1,3-D	CP
0	88	10	353	87
5	97	14	362	86
15	131	28	385	102
25	211	83	392	124
35	332	243	307	108
45	197	122	265	69
55	105	54	54	32
70	n/a	n/a	2	2

Pests controlled with fumigants

- Soil borne diseases
  - Pythium
  - Phytopthora
  - Verticillium
  - Others (Macrophomina, Fusarium, Rhizoctonia, Colletotrichum coccodes,…..)
- Nematodes
- Insects
- Weeds
  - Volunteer crops
  - Annual & perennial weeds


Macrophomina problems are increasing on fields treated consecutively via drip fumigation (or low application rates of alternative fumigants). Growers need to fumigate with methyl bromide or methyl iodide to keep these fields viable for crop production.
Macrophomina (Charcoal Rot)


Fusarium wilt control requires methyl bromide

Alternative Fumigants

Summary of Previous Research:

Fumigant application rates required to control soil-borne fungal pathogens

Summary

Methyl Bromide + chloropicrin (57%MeBr + 43%Pic)

- For control of *Verticillium dahliae*: **300 to 400 lb/a**
- Excellent control of *Phytophthora cactorum, Pythium* sp., and citrus nematode)

- Excellent control of ***Macrophomina*** *and* ***Fusarium***

Summary

Telone C35 or Inline (62% 13-D + 33% Pic)

- For control of *Verticillium dahliae*: 425 lb/a
- For *P. cactorum, Pythium* spp., and citrus nematode: 300 to 400 lb/a)

- *Control of* ***Macrophomina*** *and* ***Fusarium:*** *>400 lb/a under retentive film* ***(VIF/TIF)***

Summary

Chloropicrin (Pic)

- For control of *Verticillium dahliae*: 200 to 300 lb/a
- For control of *P. cactorum, Pythium* sp., and citrus nematode: 300 to 400 lb/a)

- *Control of* ***Macrophomina*** *and* ***Fusarium:*** *300 lb/a under* ***VIF/TIF***

Summary

Pic-Clor 60 (60% chloropicrin + 40% 1,3-D)

- For control of *Verticillium dahliae*: 300 to 350 lb/a
- For control of *P. cactorum, Pythium* sp., and citrus nematode: 250 to 350 lb/a)

- *Control of* ***Macrophomina*** *and* ***Fusarium:*** *350 lb/a under* ***VIF/TIF***

Summary

MITC Generators
(metam sodium & metam potassium)

- For control of *Verticillium dahliae*: >300 lb ai/a
- For *P. cactorum, Pythium* spp., and citrus nematode: 200 to 300 lb ai/a

- Can provide enhanced efficacy of pest control when used in conjunction with other fumigants

- *Control of* ***Macrophomina*** *and* ***Fusarium: ???***

Summary

Allyl isothiocyanate

IRF135

April 2013

- *Product Performance Update*
- *Region: USA*

ISAGRO USA

Mike Allan

Summary

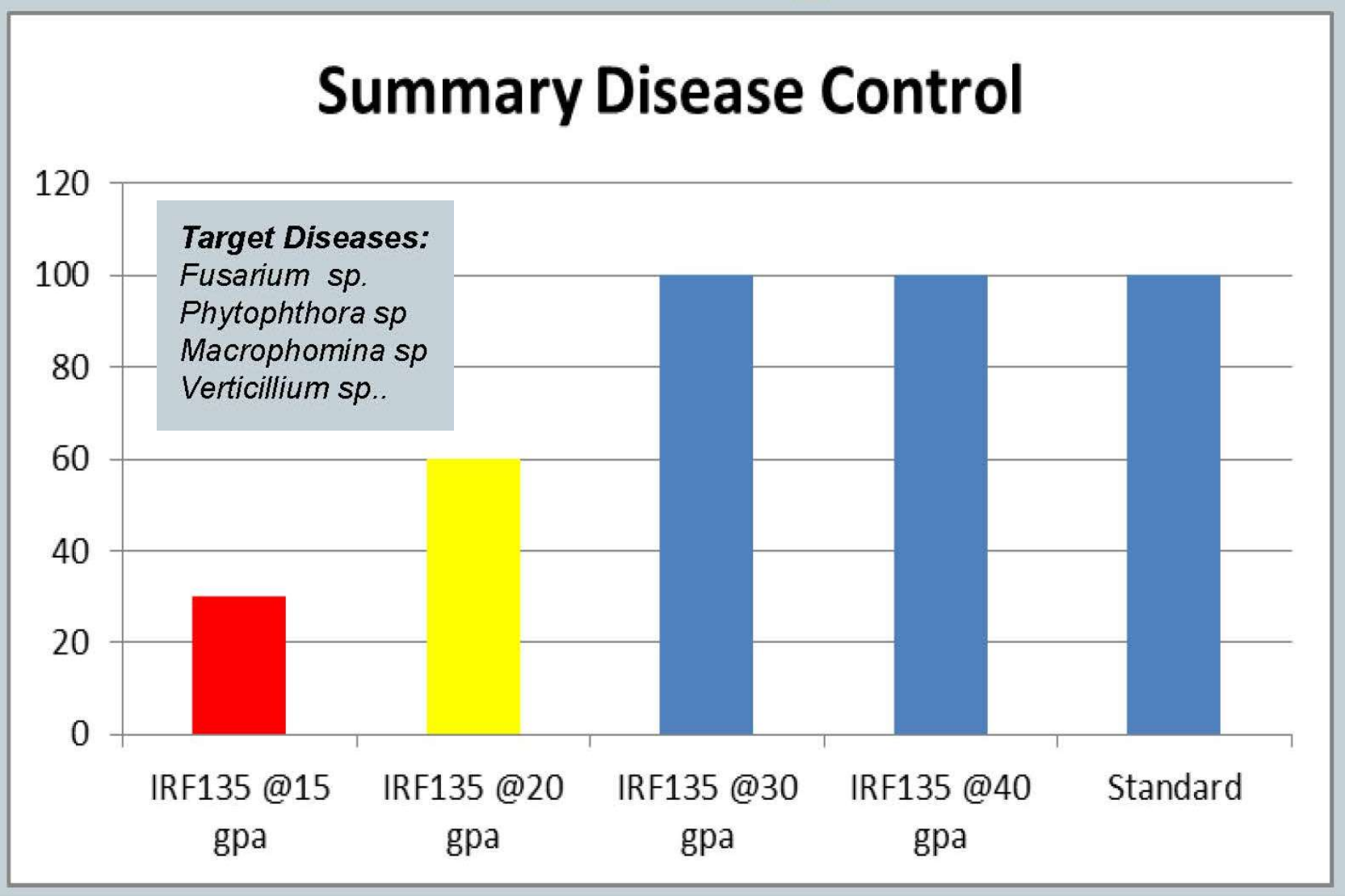
IRF 135 Product Overview

- IRF135 is a pre-plant soil treatment that is patented and licensed to ISAGRO USA for worldwide development and commercialization along with its parent company, ISAGRO SpA located in Milan, Italy

- IRF135 is a synthetically produced *biopesticide* having the active ingredient *Allyl Isothiocyanate* (AITC), with its origins in a naturally occurring plant defense chemical from the plant family, brassicaceae

- IRF135 is a broad spectrum soil treatment alternative having efficacy against many soil borne pathogens, nematodes, weeds and insects that negatively impact yields in high value crops such as strawberries, tomatoes, peppers, ornamentals, turf, trees and vines

Summary


Summary Disease Control
120
100
80
60
40
20
0
Target Diseases:
Fusarium sp.
Phytophthora sp
Macrophomina sp
Verticillium sp..
IRF135 @15 gpa
IRF135 @20 gpa
IRF135 @30 gpa
IRF135 @40 gpa
Standard

Paladin: a new fumigant

Dimethyl disulfide (DMDS)

- EPA Registration was granted in 2010 (Arkema)

Applied only under VIF/TIF

- Used as a flavoring for an onion or garlic taste in some processed cheese and meat (0.02-10 ppm)

- Efficacy?? (Rates: 400 – 650 lb/a)

ODOR

DMDS (PALADIN®) has a strong, objectionable odor which can be detected at concentrations significantly below the levels that can potentially cause harm. The odor is a garlic-like or natural gas and may be confused with the odor of or propane leak.

Minimum tarp removal on the label is **14** days. With **VIF/TIF** tarps and for odor mitigation, minimum tarp removal will be based on soil temp and the plant back chart.

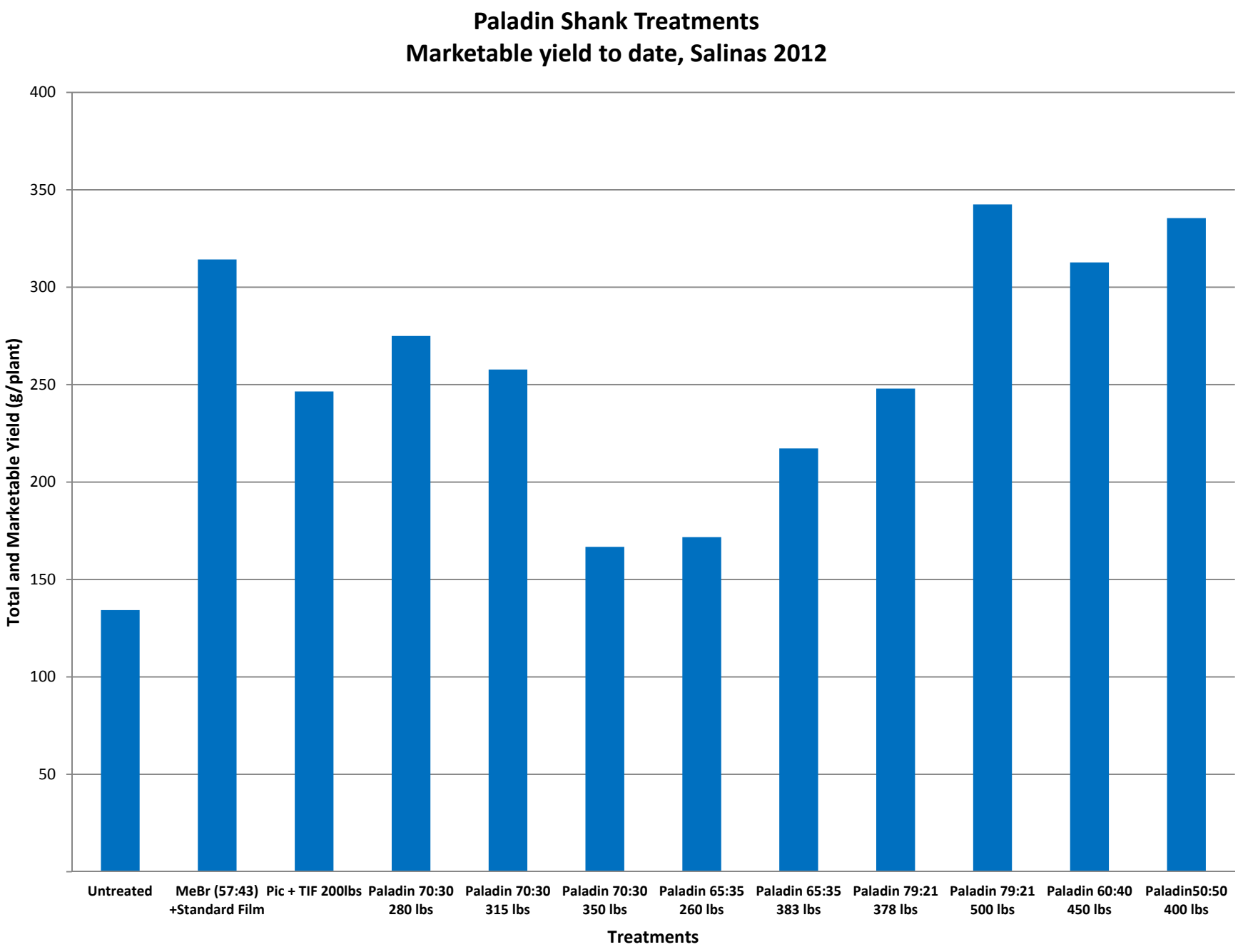
Laboratory dose-response studies

80% inhibitory concentration (MIC_{80})

Soil fumigant	Application rate to control 80% of pathogens population (lbs/ac)				
	Fusarium Oxysporum	Pythium ultimum	Rhizoctonia solani	Tylenchulus semipenetrans	Verticillium dahlia
DMDS:Pic (79:21)	288	144	432	72	370
MBr:Pic (50:50)	150	75	300	38	275

Paladin research, 2012

Treatment	Lbs product/A
Untreated	
MeBr (57:43) +Standard Film	350 lbs
Pic + TIF	200 lbs
Paladin 70:30	280 lbs
Paladin 70:30	315 lbs
Paladin 70:30	350 lbs
Paladin 65:35	260 lbs
Paladin 65:35	383 lbs
Paladin 79:21	378 lbs
Paladin 79:21	500 lbs
Paladin 60:40	450 lbs
Paladin 50:50	400 lbs


Paladin Shank Treatments
Marketable yield to date, Salinas 2012
Total and Marketable Yield (g/plant)
400
350
300
250
200
150
100
50
Untreated
MeBr (57:43) +Standard Film
Pic + TIF 200lbs
Paladin 70:30 280 lbs
Paladin 70:30 315 lbs
Paladin 70:30 350 lbs
Paladin 65:35 260 lbs
Paladin 65:35 383 lbs
Paladin 79:21 378 lbs
Paladin 79:21 500 lbs
Paladin 60:40 450 lbs
Paladin50:50 400 lbs
Treatments

Summary

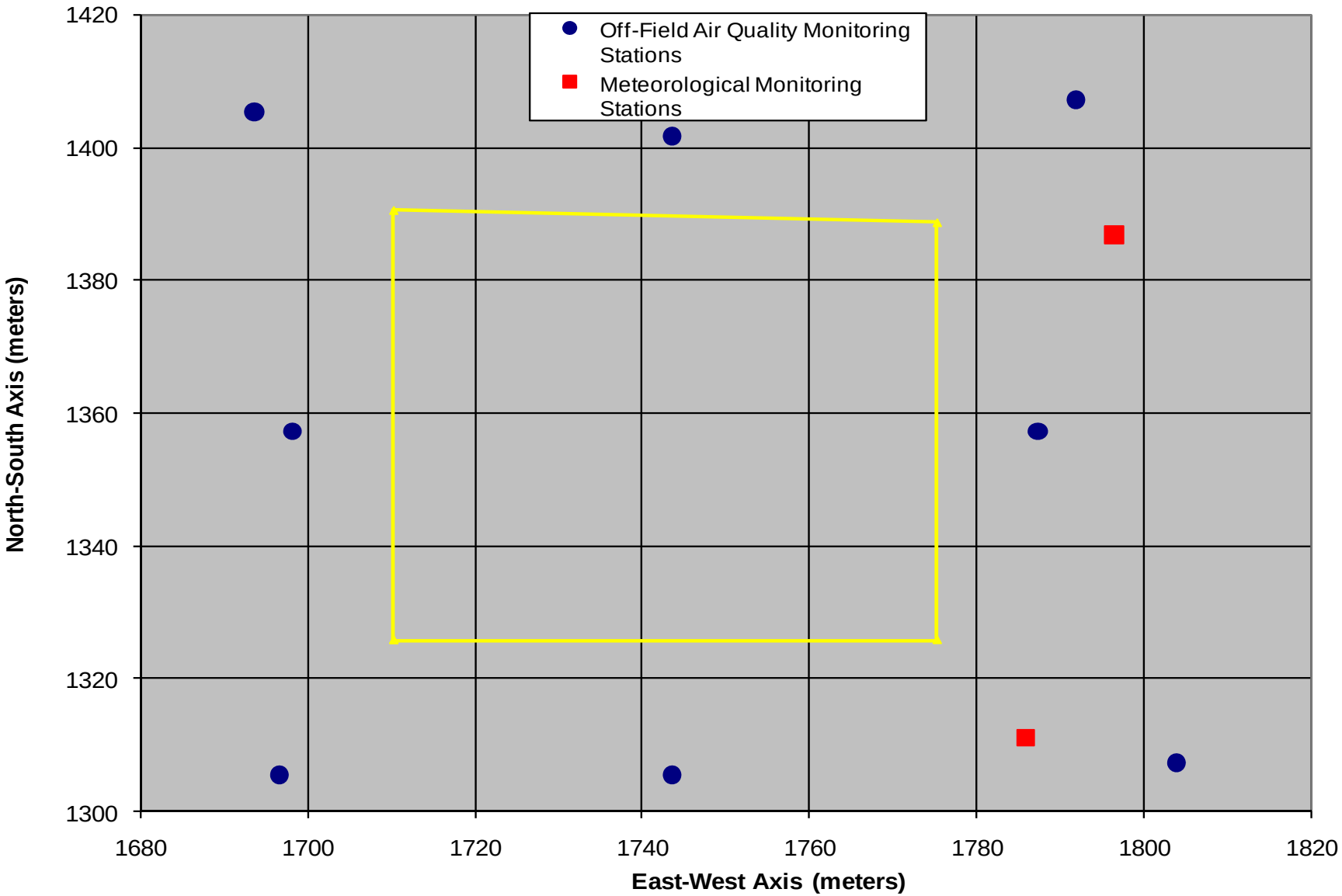
- No phytotoxicity or plant mortality was observed in any of the Paladin treatments.
- Maximum yields were obtained with Paladin 50/50 @400 lbs/ac, Paladin 60/40 @450 lbs/ac, and Paladin 79/21 @500 lbs/ac.
- Undergoing research on shank and drip applications of IRF135 (allyl isothiocyanate).

Emission Reduction Research
2011 Flux Research: TIF Cutting Time

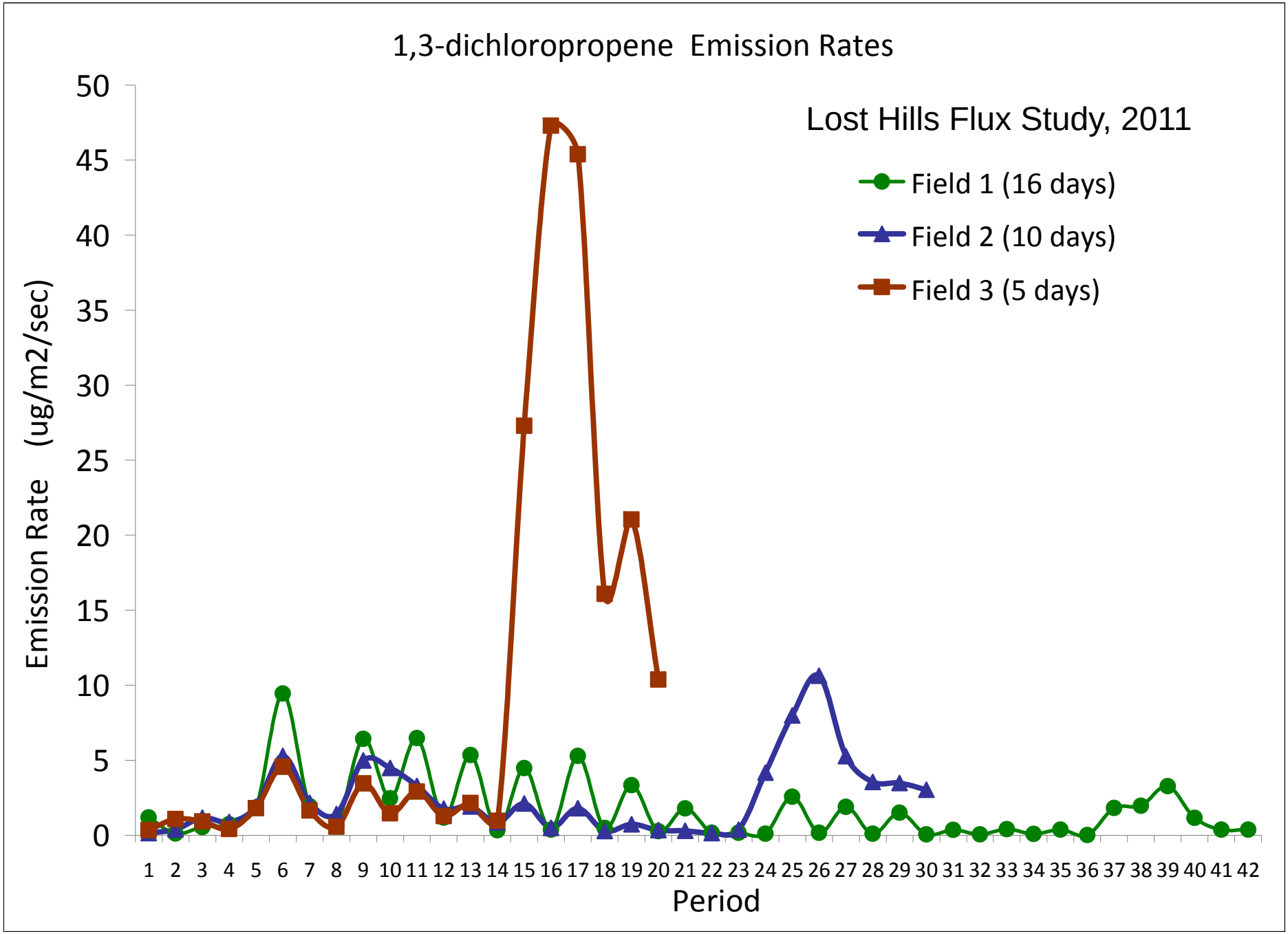
- **To determine the best tarp cutting time, studies were conducted on 3 separate fields (2 or 8 acres) in Lost Hills near Bakersfield in June, 2011.**
- **Pic-Clor 60 soil fumigant (60% chloropicrin and 40% 1,3-D) was applied by shank injection under TIF at 12 inches deep.**
- **Target application rate was 588 lbs/ac of Pic-Clor60 (350 lbs of chloropicrin plus 238 lbs of 1,3-D).**

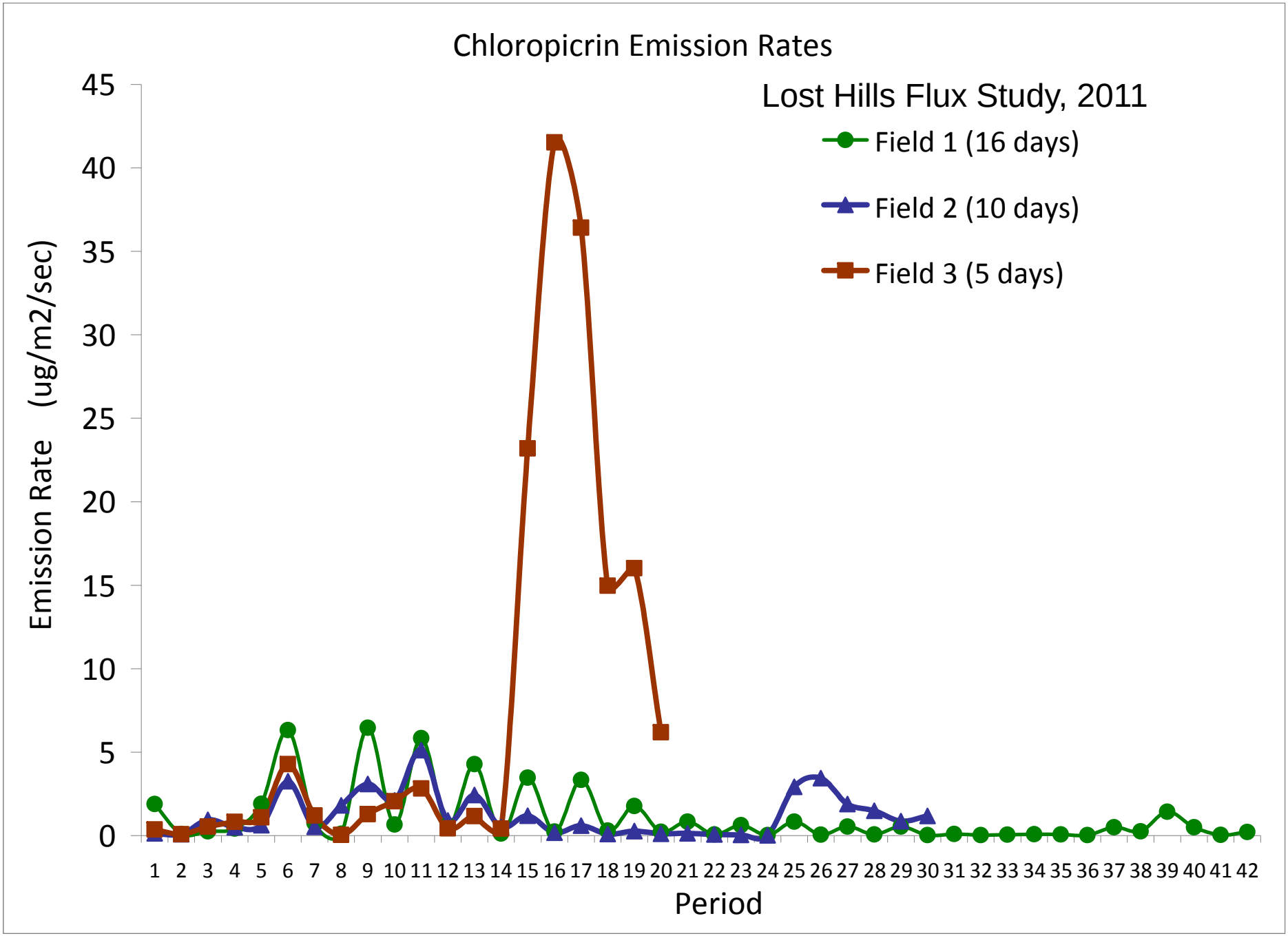
Tarp cutting time
Shank applications, 2 to 8 acres each field

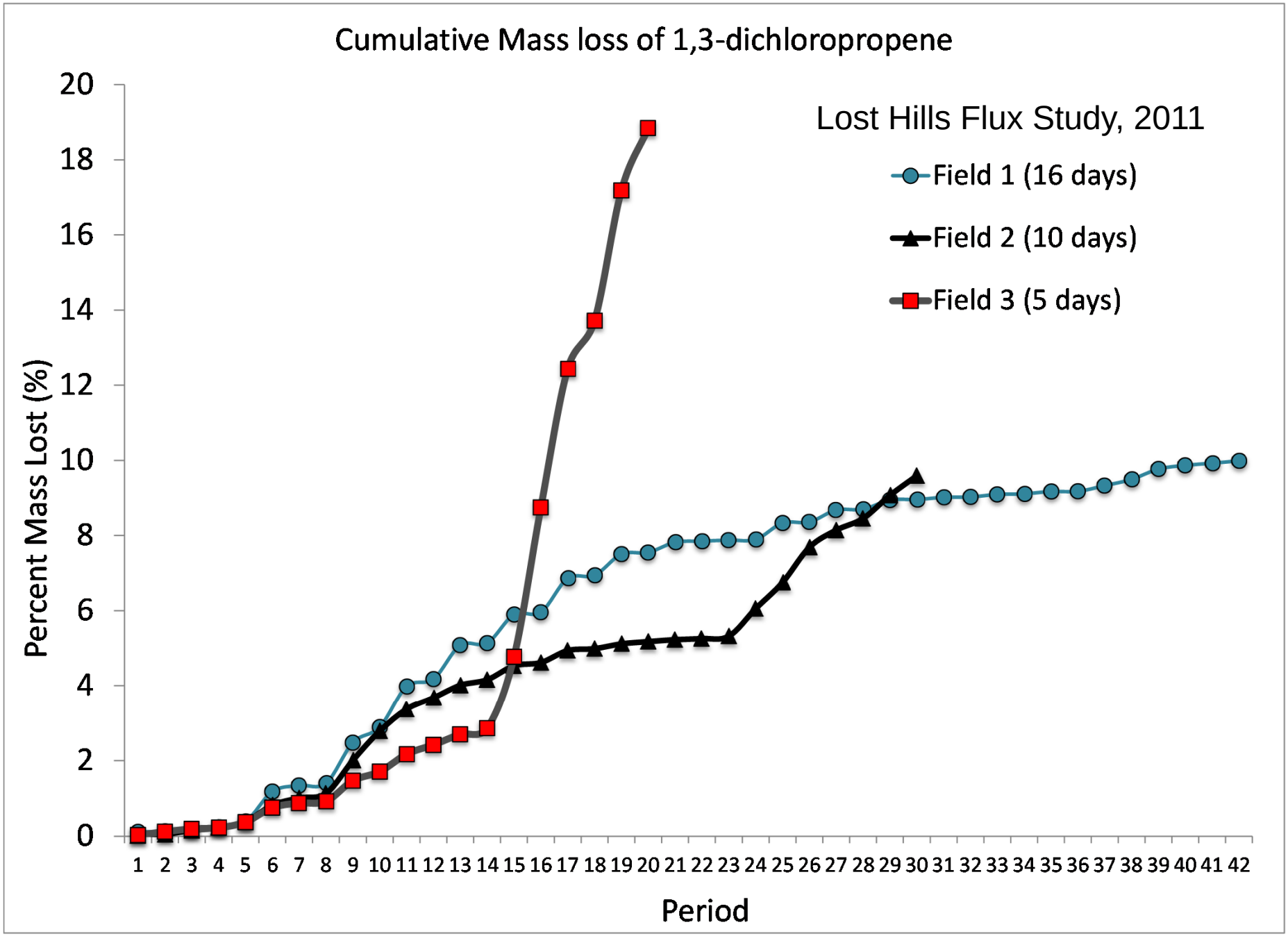
Tarp cutting was done after 5, 10, and 16 days



Field layout showing locations of the monitoring stations


1,3-dichloropropene Emission Rates
Lost Hills Flux Study, 2011
Field 1 (16 days)
Field 2 (10 days)
Field 3 (5 days)
Emission Rate (ug/m2/sec)
0
5
10
15
20
25
30
35
40
45
50
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42
Period


Chloropicrin Emission Rates
Lost Hills Flux Study, 2011
Field 1 (16 days)
Field 2 (10 days)
Field 3 (5 days)
Emission Rate (ug/m2/sec)
45
40
35
30
25
20
15
10
5
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42
Period


Cumulative Mass loss of 1,3-dichloropropene
Lost Hills Flux Study, 2011
Field 1 (16 days)
Field 2 (10 days)
Field 3 (5 days)
Percent Mass Lost (%)
0
2
4
6
8
10
12
14
16
18
20
Period
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42

Summary

- ✓ For chloropicrin, a tarping period of 7 days should be sufficient for application rates of less than 200 lbs/acre. 10 days of tarping might be needed for application rates >300 lbs/acre.
- ✓ For 1,3-D, a tarping period of 10 days should be sufficient for application rates of less than 200 lbs/acre. 14 days of tarping might be needed for application rates >250 lbs/acre.

Summary

- ✓ **TIF significantly reduced total emissions of chloropicrin and 1,3-D. Relative to other flux studies with standard PE tarp, TIF reduced total emissions by 4 to 5 times.**
- ✓ **The use of TIF may allow for smaller buffer zones and/or large fumigant application rates in heavily infested soils.**

Thank you very much

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