

Control of Codling Moth in California Pear Orchards Using Granulosis Virus



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Codling Moth in California

- Primary pest; basis of entire insect management program
- High populations, 2-3 generations
- No effective natural enemies
- Historically controlled by organophosphates
- Increased problem where there are unfarmed trees

Current Control Strategies

- Mating disruption is the foundation
 - Passive emitters
 - Puffers
 - Sprayables
- Supplemented by “reduced risk” insecticides
 - Insect growth regulators
 - Neonicotinoids, other “new chemistry”
 - Biologicals
 - Oils

Organic Orchards – to 2003

- Mating disruption – passive emitters, puffers
- Oil – smother eggs
- Biologicals – BT, *Trichogramma* spp. releases
- Cultural (sanitation)
 - Remove infested fruit
 - Cardboard bands – trap pupae

Current Organic Strategies

- Mating disruption is the base
 - Passive emitters only – 150-400/acre
 - Applied 1-2x/season
- Supplemental Materials
 - Multiple Applications = COSTLY!
 - Spinosad (Entrust®)
 - Oils (OMRI-allowed)
 - Biologicals – BT, neem (poor efficacy)
 - Kaolinic clay (Surround®)
- Sanitation

Codling Moth Granulosis Virus yet to be registered in California

- 3 products currently federally registered
 - Carpovirusine®
 - Cyd-X®
 - Virosoft®
- Registered and used throughout world and in other U.S. states
 - Competitive issue

Granulosis Virus Research in California

- Research began in 1970's – Dr. Louis Falcon, UC Berkeley – industry supported; basis of recent work
- Some commercial use in 1980's
- No activity until 2001 – Virosoft® (Biotepp, Quebec, Canada)
- Field research from 2001-2005
 - 7 northern California counties; all major districts
 - UC campus and Extension personnel
- Funding sources – IR-4 Minor Use Program, Pear Pest Management Research Fund, Gerber Products Inc., registrants (Biotepp, Certis USA, Sumitomo Corp.)

Research Chronology

2001 – Virosoft[®] (Biotepp, Quebec, Canada)

- Replicated trials
- 3 orchards, grower-applied
- Unsuccessful; material inactive

2003

- Replicated trials, 4 locations, grower-applied
- Carpovirusine[®], Cyd-X[®]
- Compared to MD, oil, spinosad (Entrust[®])
- Significantly reduced damage by 70-90% vs. MD alone and 60-90% vs. untreated controls

Treatments

(Varied by location)

Treatment	Company	Rate	No. of sites
Carpovinsine GV+Nufilm17	Sumitomo/ Calliope	13.5oz/acre no max	2
Cyd-X GV +Nufilm17		3-6 oz./acre no max	4
Entrust (spinosad) + oil	DowAgro	2-3 oz./acre 9oz max	3
Oil (Gavicide 90, 415)	Various	1.2 gal /acre	3
CM MD alone	Various	Various	3
Untreated control			2

Research Chronology (Cont..)

2005

- Cyd-X[®], 3 oz./acre
- Demonstration (non-replicated), 5 orchards (all with MD), grower-applied
- Compared to MD, Surround[®], oil, Entrust[®] programs
- Numerical differences during season consistently favored GV
- Results significantly reduced damage in postharvest sample (300 fruit remaining in trees after harvest)

2005 CM Granulosis Virus (GV) Demonstration Trial

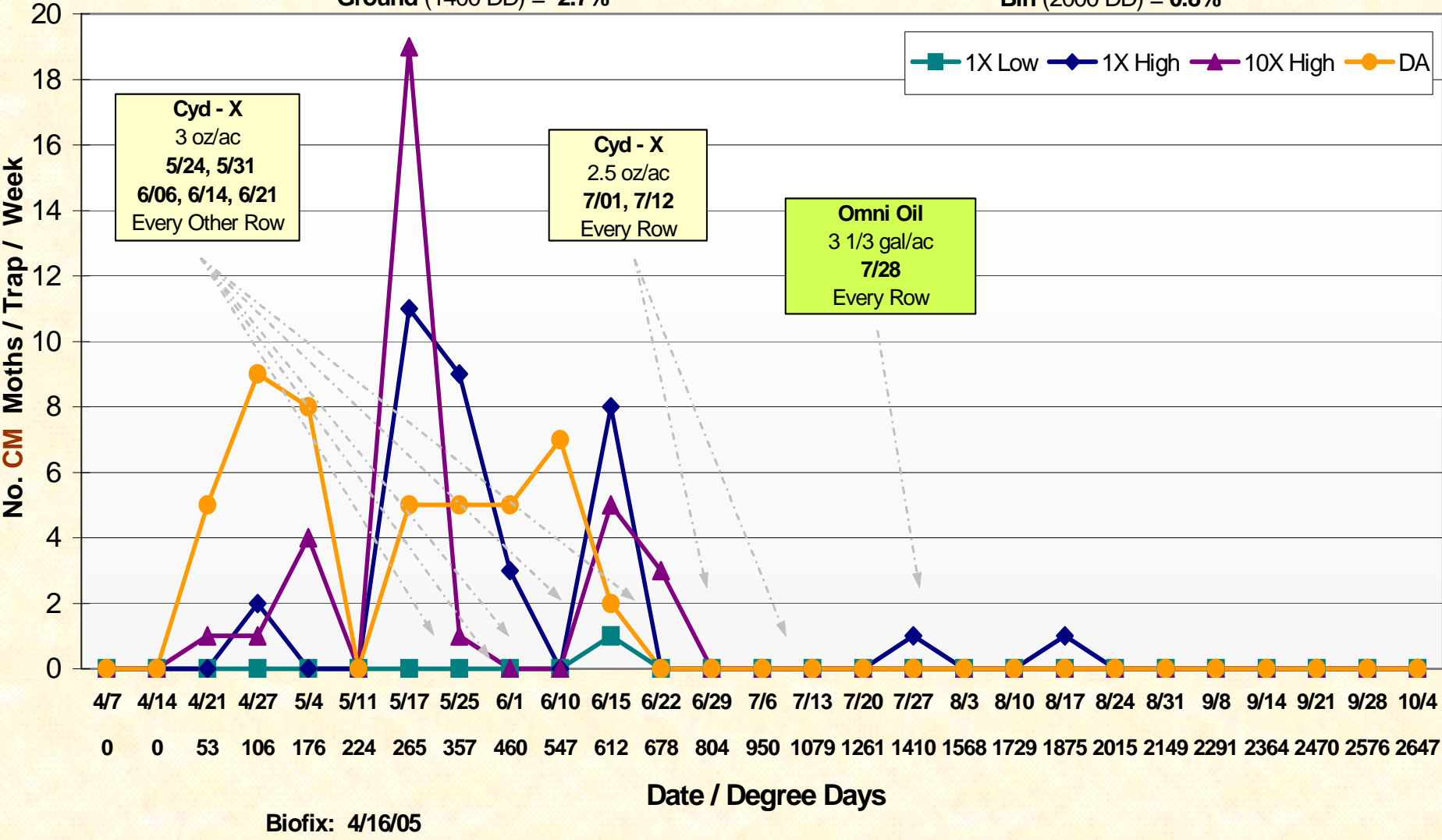
Average Codling Moth Trap Catches of 2 traps

Potter Valley Orchard # 1, Mendocino County - Organic

GV Treatment

CM Damage: 1st Generation (1000 DD) = 0.1%,
Ground (1400 DD) = 2.7%

Preharvest (1700 DD) = 0.0%, Post Harvest (2570 DD) = 1.0%
Bin (2000 DD) = 0.8%



2005 CM Granulosis Virus (GV) Demonstration Trial

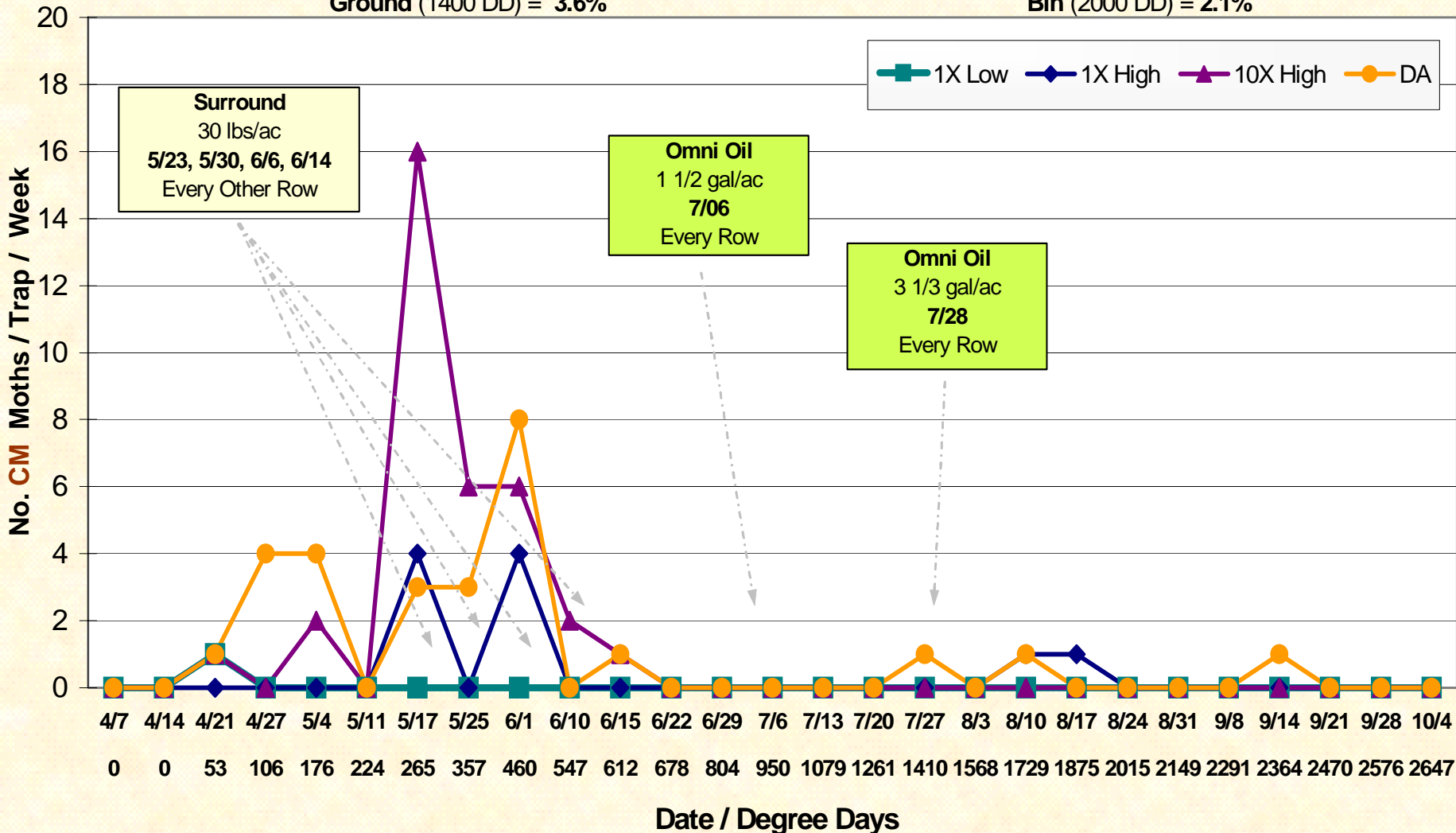
Average Codling Moth Trap Catches of 2 traps

Potter Valley Orchard # 1, Mendocino County - Organic

Grower Standard Treatment

CM Damage: 1st Generation (1000 DD) = 0.1%,
Ground (1400 DD) = 3.6%

Preharvest (1700 DD) = 0.0%, Post Harvest (2570 DD) = 3.3%
Bin (2000 DD) = 2.1%



Biofix: 4/16/05

2005 CM Granulosis Virus (GV) Demonstration Trial

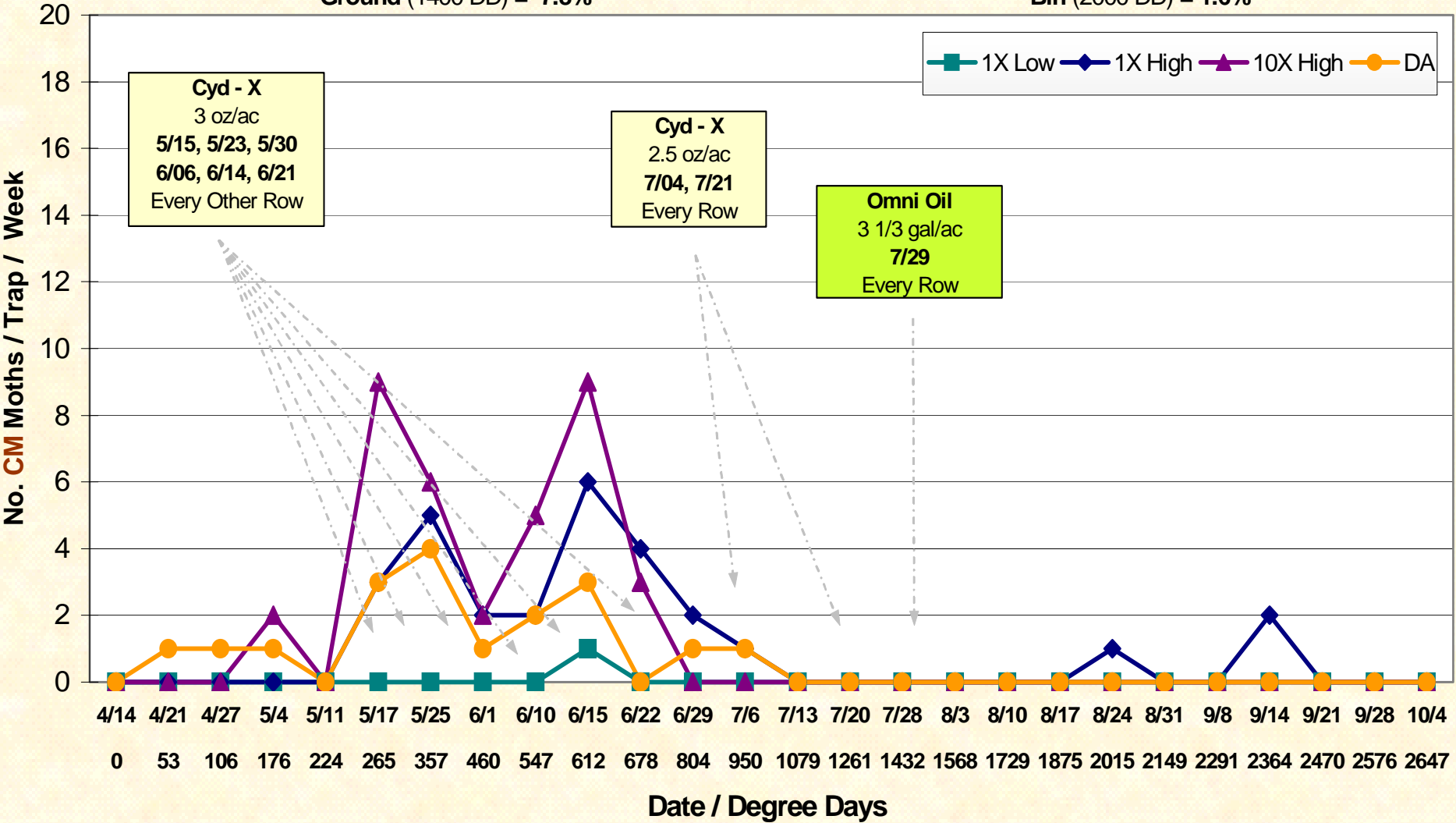
Average Codling Moth Trap Catches of 2 traps

Potter Valley Orchard # 2, Mendocino County - Organic

GV Treatment

CM Damage: 1st Generation (1000 DD) = 0.1%,
 Ground (1400 DD) = 7.8%

Preharvest (1700 DD) = 0.3%, Post Harvest (2570 DD) = 1.7%
 Bin (2000 DD) = 1.6%



Biofix: 4/16/05

2005 CM Granulosis Virus (GV) Demonstration Trial

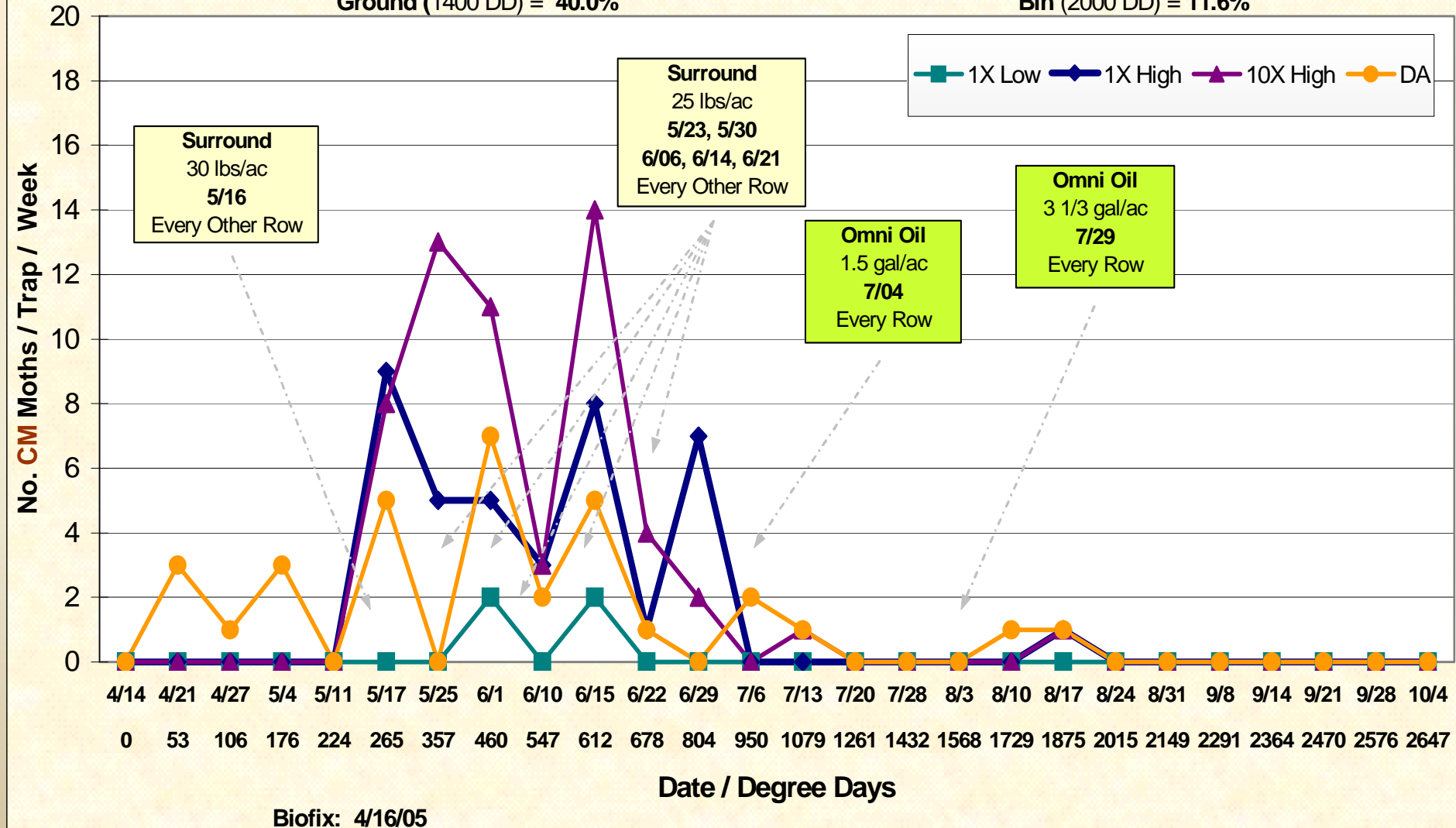
Average Codling Moth Trap Catches of 2 traps

Potter Valley Orchard # 2, Mendocino County - Organic

Grower Standard Treatment

CM Damage: 1st Generation (1000 DD) = 0.4%,
Ground (1400 DD) = 40.0%

Preharvest (1700 DD) = 7.8%, Post Harvest (2570 DD) = 8.7%
Bin (2000 DD) = 11.6%



2005 CM Granulosis Virus (GV) Demonstration Trial

Average Codling Moth Trap Catches of 2 traps

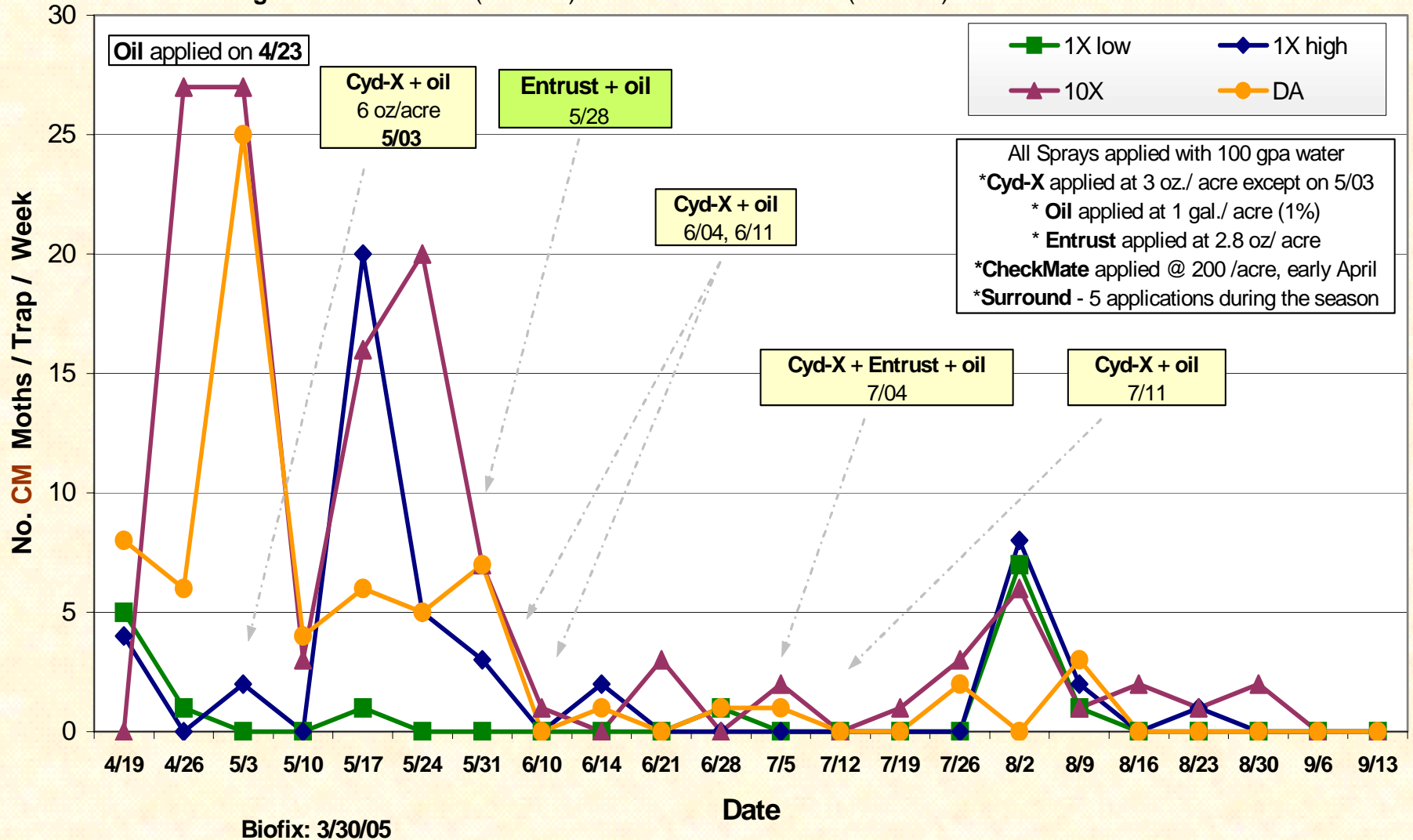
Orchard # 1, Sacramento County - Organic

GV Treatment

CM Damage: 1st Generation (1000 DD) = 1.7%

Ground (1000 DD) = 14.4%

Preharvest = 4.3%



2005 CM Granulosis Virus (GV) Demonstration Trial

Average Codling Moth Trap Catches of 2 traps

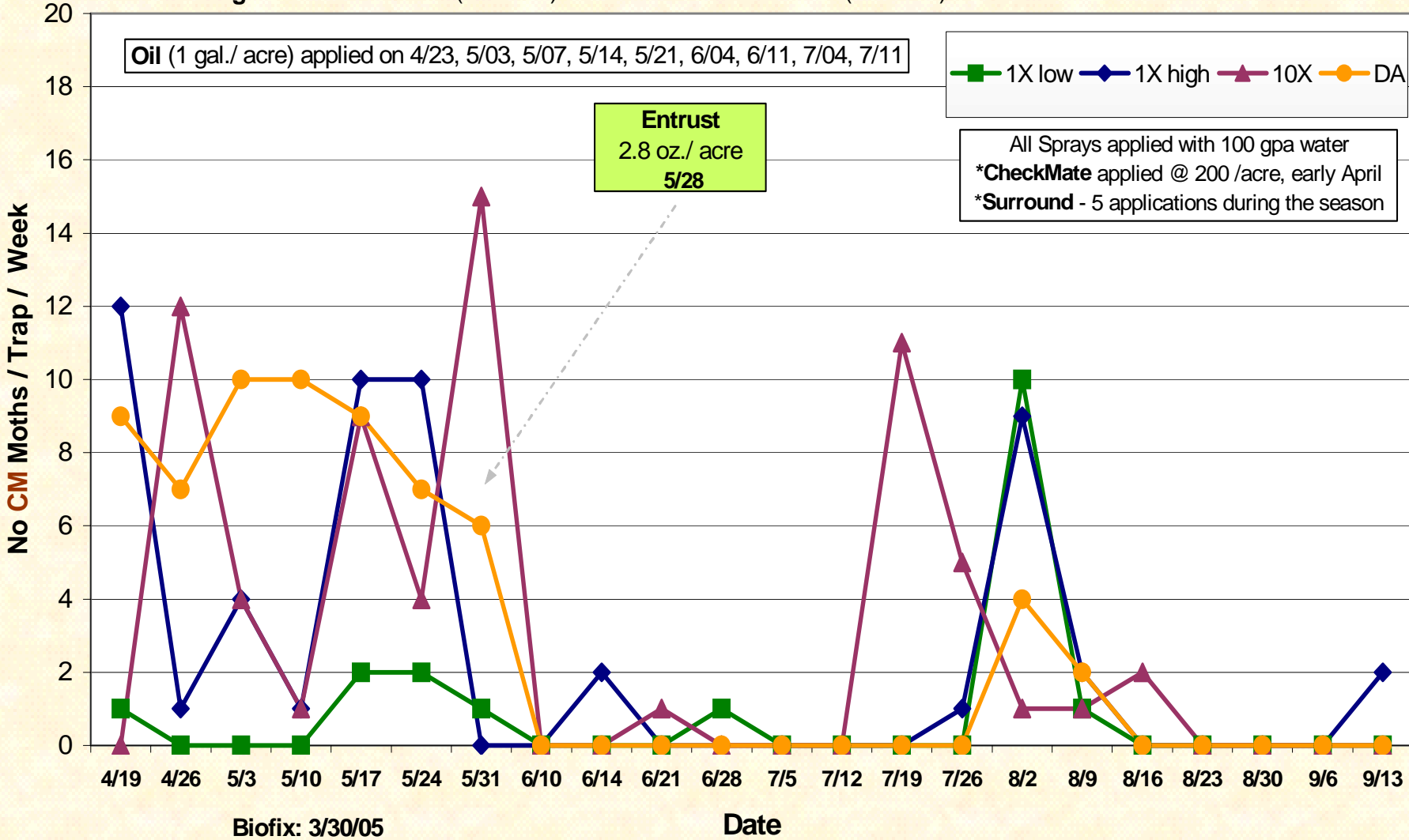
Orchard # 1, Sacramento County - Organic

Grower Standard Treatment

CM Damage: 1st Generation (1000 DD) = 5.0%

Ground (1000 DD) = 33.2%

Preharvest = 11.9%



2005 CM Granulosis Virus (GV) Demonstration Trial

Average Codling Moth Trap Catches of 2 traps

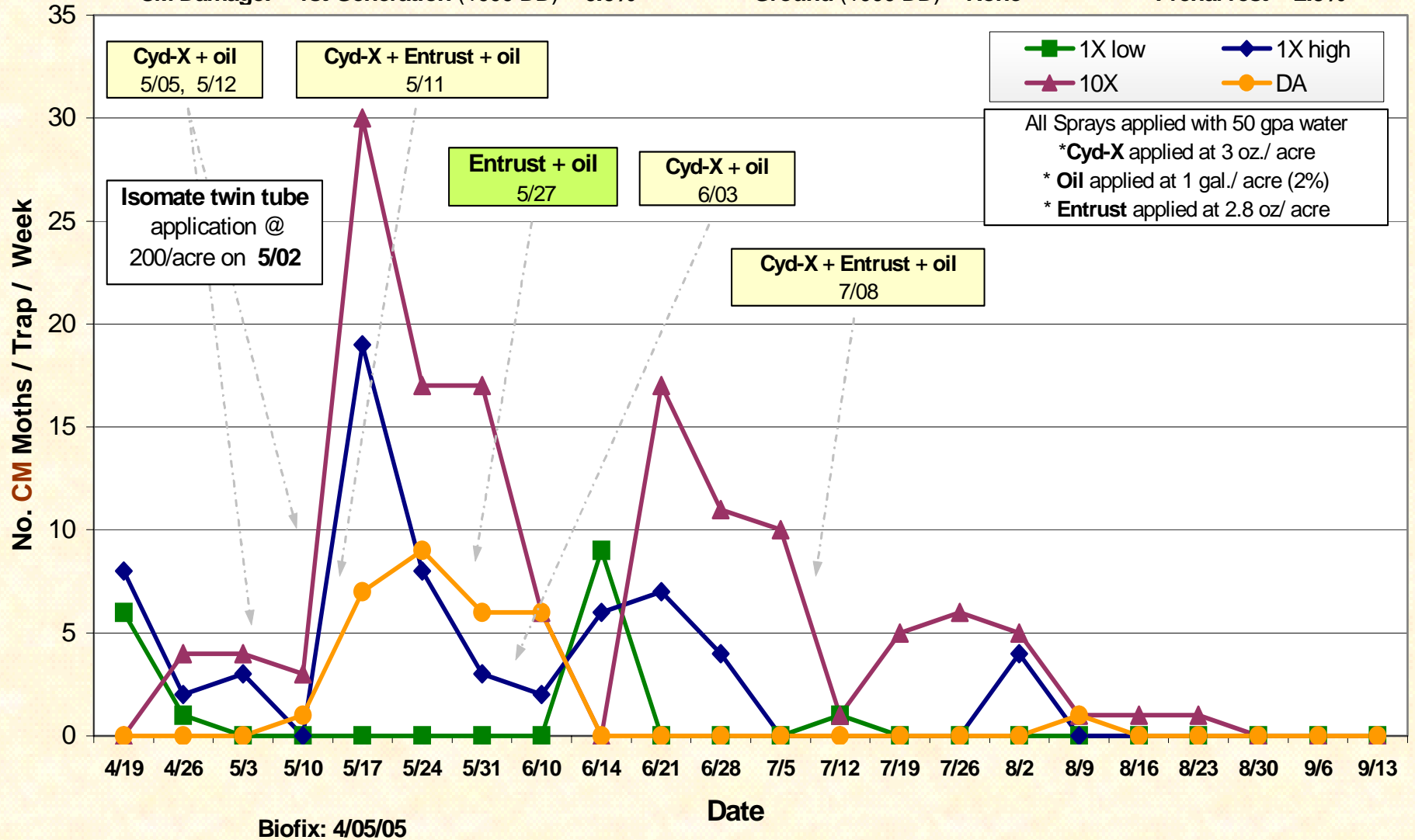
Orchard # 2, Sacramento County - Organic

GV Treatment

CM Damage: 1st Generation (1000 DD) = 0.0%

Ground (1000 DD) = None

Preharvest = 2.9%



2005 CM Granulosis Virus (GV) Demonstration Trial

Average Codling Moth Trap Catches of 2 traps

Orchard # 2, Sacramento County - Organic

Grower Standard Treatment

CM Damage: 1st Generation (1000 DD) = 0.1%

Ground (1000 DD) = None

Preharvest = 2.2%

Oil (1 gal./ acre) applied on 5/05, 5/12, 6/03, 6/08, 6/15, 6/26, 6/30

1X low 1X high 10X DA

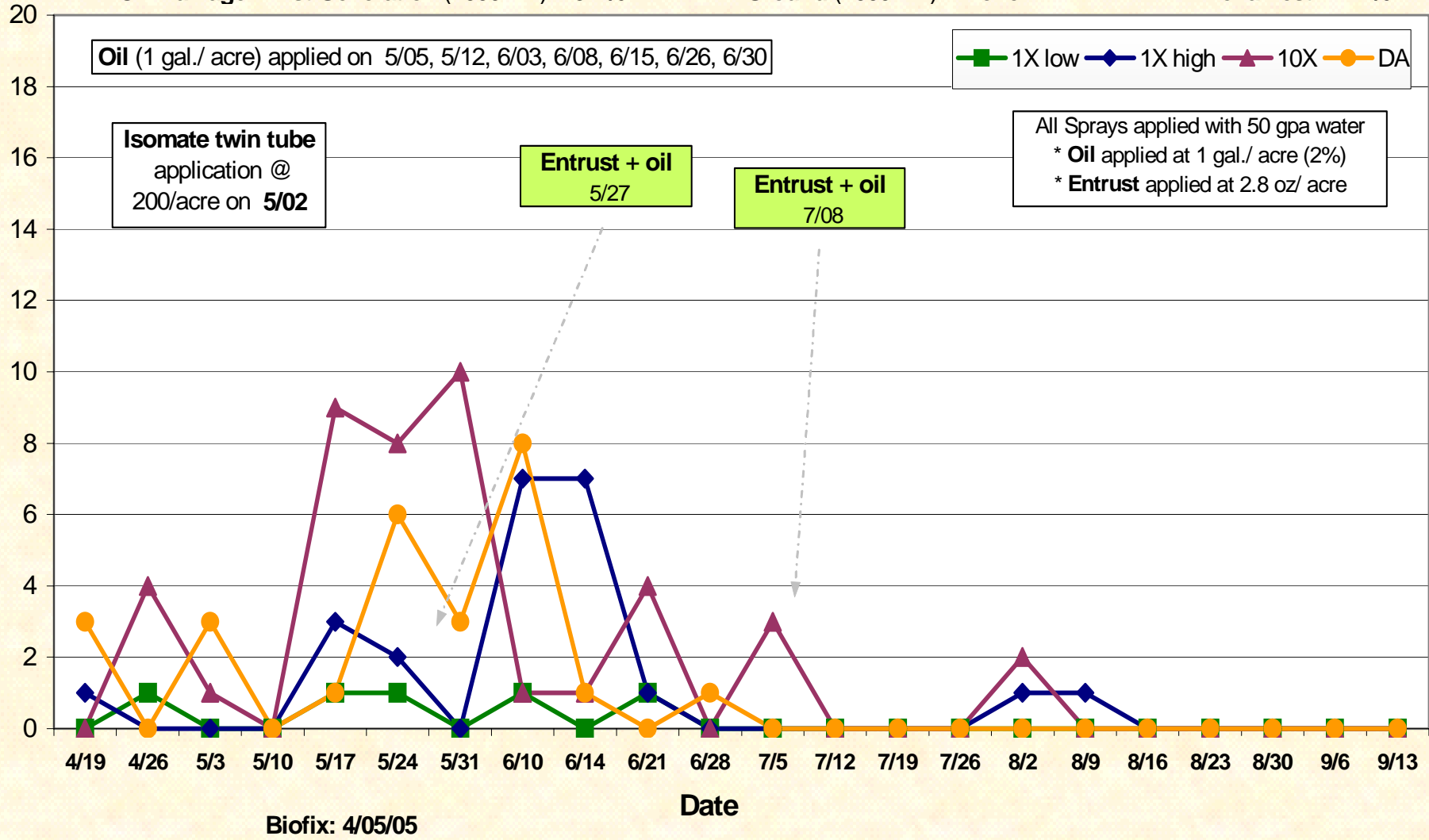
Isomate twin tube application @ 200/acre on 5/02

Entrust + oil 5/27

Entrust + oil 7/08

All Sprays applied with 50 gpa water
 * Oil applied at 1 gal./ acre (2%)
 * Entrust applied at 2.8 oz/ acre

No. CM Moths / Trap / Week



Biofix: 4/05/05

Mean Percent Codling Moth Infected Fruit, 1st Generation, Courtland, CA – 2003

Treatment	Rate	No. Appl.	% Damage ^a	
			Tree (July 23)	Ground (July 1)
MD plus oil	2 gal.	7	0.2 a	1.4
MD+oil+Entrust	3 oz.	7+3	0.2 a	1.0
MD+Cyd-X	6 oz.	7	0.1 a	1.7
MD alone, then oil	-	3	0.8 b	2.3

^a means followed by the same letter within a column are not significantly different (Fishers protected LSD, $P \leq 0.05$).

^b 16 oz. Nufilm 17 applied with Cyd-X.

Mean Percent Codling Moth Infected Fruit, Harvest, Courtland, CA – 2003

Treatment	Rate	No.Appl.	% Damage ^a	
			Tree (July 18)	PH (Sept. 20)
MD plus oil	2 gal.	7	2.5 a	10.0
MD+oil then Entrust	2 gal. + 3oz.	7 + 3	1.6 a	10.2
MD+Cyd-X ^b	6 oz.	7	2.0 a	6.4
MD alone, then oil	2 gal.	3	8.1 b ^b	14.6

^a Means followed by the same letter within a column are not significantly different (Fishers protected LSD, $P \leq .05$).

^b No. strikes significantly higher in lower fruit

**Mean Percent Codling Moth Infested Fruit Inspected after the First Generation,
Ukiah, CA –
July 3 – 17, 2003**

Treatment	% infestation/1000 fruit ^a			
	Emerged from egg, no sting	Sting No worm	Dead worm	Live worm
MD plus Cyd-X ^b	.00	.02	.00	.01
MD plus Carpovirusine ^c	.02	.05	.01	.02
MD plus Assail	.00	.01	.00	.02
MD alone	.00	.00	.00	.00
Difference	NS	NS	NS	NS

^a Means followed by the same letter within a column are not significantly different (Fisher's protected LSD, $p \geq 0.05$). Data analyzed using an arcsin transformation.

^b Treatments contained 0.0625% NuFilm-17.

Mean Percent Codling Moth Infested Pear Fruit Inspected Prior to Commercial Harvest after the 2nd generation, Ukiah, CA – August 7, 2003

Treatment	% infestation/1000 fruit ^a		
	Sting – no worm	Live worm	Worm gone
MD plus Cyd-X ^b	0.4	0.0	0.1 a
MD plus Carpovirusine ^c	0.3	0.1	0.2 a
MD alone	0.4	0.2	1.0 b
MD + Assail	0.0	0.1	0.0 a

^a Means followed by the same letter within a column are not significantly different (Fisher's protected LSD, $p \geq 0.05$). Data analyzed using an arcsin transformation.

^b Treatments contained 0.0625% NuFilm-17.

Mean Percent Codling Moth-Infested Fruit, Potter Valley, CA – 2003

Treatment	Rate	No.Appl.	% Damage ^a	
			1 st Gen. (July 14)	Harvest (Aug. 7)
MD plus 415 oil ^c	2.5 gal.	4	0.5	4.0 ab
MD plus Entrust ^b	2 oz.	4	0.8	3.7 ab
MD plus Cyd-X/ Nufilm 17	3 oz./16 oz.	4	1.0	2.3 a
MD alone	-	-	0.7	7.2 b
Untreated Control	-	-	3.8	34.0 -

^a Means followed by the same letter within a column are not significantly different (Fisher's protected LSD, $P \leq 0.05$). Data analyzed using an arcsin square root transformation.

^b 1 oz. Entrust® applied to all treatments on July 12 to control pear slug.

^c 3 gal. 415 oil applied to all treatments on August 4 to control spider mites.

Mean Percent Codling Moth Fruit Damage

1st Generation, June-July 2005

Tree Fruit Count - Organic

	Tree (%/1000)		Ground (%/500)	
Site	GV	G	GV	G
Lake	0.5	0.3	1.0	4.6
Mendocino				
1	0.1	0.1	2.7	3.6
2	0.1	0.4	7.8	40.0
Sacramento				
1	1.7	5.0	14.4	33.2
2	0.0	0.1	---	---
ANOVA	p=.44		p=.23	

Mean Percent Codling Moth Fruit Damage

2nd generation, July-August 2005
Pre-harvest Tree Fruit Count - Organic

	Damage (%/2000)	
Site	GV	G
Lake	0.8	1.2
Mendocino		
1	0.0	0.0
2	0.3	7.7
Sacramento		
1	4.3	11.9
2	2.9	2.2
ANOVA	p=.34	

Mean Percent Codling Moth Fruit Damage
Late 1st - 2nd generation, August-Sept. 2005
Harvest Bin Count - Organic

	Damage (%/1000)	
Site	GV	G
Mendocino		
1	0.8	2.1
2	1.6	11.6
ANOVA	p= .31	

Mean Percent Codling Moth Damage

2nd - 3rd generation, September 2005
 Post-Harvest Tree Fruit Count - Organic

	Damage (%/2000)	
Site	GV	G
Lake	2.7	5.3
Mendocino		
1	1.0	3.3
2	1.7	8.7
	A	B
ANOVA	p=.02	

CONCLUSIONS FROM 2001-2005

- Granulosis virus is an effective supplement to CM mating disruption
- Applications must be made frequently, at least 2x per larval hatch; @ \$30/acre, this is costly; every other row every week a good strategy
- Population reduction appears to be cumulative through the season
- MD is needed; combine GV with oil, spinosad, and sanitation for total IPM program
- Control should become easier over several seasons (based on post-harvest data)

“Rules to Live By”

Organic Codling Moth Control in California

- Mating disruption is the foundation but is seldom stand alone
- Once damage goes above 20% reducing pressure is very difficult without non-allowed (e.g. OP) insecticides
- Frequent supplemental sprays are likely required
- There are no “panacea” materials
- Sanitation, especially post-harvest, is a must
- Late-season varieties will be more problematic due to exposure to more generations
- Start early and “hit em hard”!

THANK YOU!

