

# Summary of Pre-Plant Herbicide Carryover Study in Buried Drip Tomatoes

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Kurt Hembree and Tom Turini  
Farm Advisors, UCCE Fresno County



# Today in western Fresno County:

- Buried drip with beds in-place for multiple years
- Preplant and/or preemergent herbicides used
- All fields are transplanted
- Cultivated
- Worked shallow after harvest in prep for next crop
- Surface moisture limited to subbing-up and rainfall



# What led to this study?

- ⇒ Responded to numerous farm calls in 2009-2012
- ⇒ Weak plants with stubby roots (DNA herbicide symptoms)



Department of Pesticide Regulation  
 2009 Annual Statewide Pesticide Use Report Indexed by Commodity  
 Fresno County

Commodity Chemical	Pounds Applied	Agricultural Applications	Amount Treated	Unit Type
<b>TOMATO, PROCESSING</b>				
OXYFLUORFEN	1,323.52	27	3,297.60	A
PARAQUAT DICHLORIDE	5,064.29	97	7,030.60	A
PENDIMETHALIN	26,062.54	142	17,916.36	A
PERMETHRIN	222.02	11	1,396.29	A
PETROLEUM DISTILLATES	239.24	10	1,116.00	A
TRIETHANOLAMINE	14.14	32	2,029.12	A
TRIFLOXYSTROBIN	22.75	4	364.00	A
TRIFLURALIN	22,960.69	331	36,632.38	A
ALPHA-UNDECYL-OMEGA-HYDROXYPOLY(OXYETHYLENE)	1,256.02	113	10,950.55	A
UREA	594.47	133	19,057.35	A

16%

33%

Department of Pesticide Regulation  
2012 Annual Statewide Pesticide Use Report Indexed by Commodity  
Fresno County

Commodity Chemical	Pounds Applied	Agricultural Applications	Amount Treated	Unit Type	
<b>TOMATO, PROCESSING</b>					
PACLOBUTRAZOL	177.78	3	319.02	A	
PARAQUAT DICHLORIDE	2,489.00	22	2,244.11	A	
PENDIMETHALIN	17,580.34	218	26,713.55	A	27%
PERMETHRIN	232.09	27	3,190.79	A	
PEROXYACETIC ACID	42.47	6	166.17	A	
TRIETHANOLAMINE	19.42	36	2,465.00	A	
TRIFLOXYSTROBIN	29.50	2	296.00	A	
TRIFLURALIN	21,370.53	315	33,402.20	A	34%
ALPHA-2,6,8-TRIMETHYL-4-NONYLOXY-OMEGA-HYDROXPOLY(OXYETHYLENE)	48.71	22	533.34	A	

# Factors most common to the fields showing tomato damage:

1. Prowl H<sub>2</sub>O applied PPI (+ usually in prior crop)
2. Beds in-place with buried drip
3. Shallow bed tillage in prep for tomatoes
4. Mostly shallow plantings, but some normal (4-5")
5. Below-normal winter rainfall

# Question?

Given the “new” way we farm tomatoes with buried drip and shallow tillage, is there a risk of increased herbicide carryover, particularly with pendimethalin. If so, might this explain what we are seeing in damaged fields?





- ⇒ Analyze soil (0-3” and 3-6”) before study.
- ⇒ Apply herbicides to preformed beds in spring.
- ⇒ Analyze soil (0-3” and 3-6”) after incorporation.
- ⇒ Initially, apply pre-irrigation water to drip-only plots and sprinkler irrigate other plots after planting. All plots were then irrigated with buried drip, with a total of 28-32 acre-inch.
- ⇒ Take tomatoes to harvest.
- ⇒ Analyze soil (0-3” and 3-6”) after harvest and again before next spring’s herbicide treatment.
- ⇒ Data collected included plant growth (shoot/root DW), stand, visual growth, yield, and fruit quality.

## Soil herbicide levels (ppm) in 2013 using HPLC

		4/23	4/23	4/23	4/23	8/25	8/25	8/25	8/25
Irrigation	Herbicide	Treflan (0-3")	Treflan (3-6")	Prowl (0-3")	Prowl (3-6")	Treflan (0-3")	Treflan (3-6")	Prowl (0-3")	Prowl (3-6")
Drip	None	0.00 b	0.00	0.00 b	0.00 b	0.00	0.00	0.00 b	0.00
Sprinkler/drip	None	0.00 b	0.00	0.00 b	0.00 b	0.00	0.00	0.00 b	0.00
Drip	Treflan	<b>0.21 a</b>	<b>0.00</b>	0.00 b	0.00 b	<b>0.00</b>	<b>0.00</b>	0.00 b	0.00
Sprinkler/drip	Treflan	<b>0.18 a</b>	<b>0.00</b>	0.00 b	0.00 b	<b>0.00</b>	<b>0.00</b>	0.00 b	0.00
Drip	Prowl H2O	0.00 b	0.00	<b>1.15 a</b>	<b>0.10 a</b>	0.00	0.00	<b>0.18 a</b>	<b>0.03</b>
Sprinkler/drip	Prowl H2O	0.00 b	0.00	<b>1.40 a</b>	<b>0.14 a</b>	0.00	0.00	<b>0.19 a</b>	<b>0.04</b>
<i>Statistical not. P=0.05</i>	<i>CV (%)</i>	73.89	0.00	73.70	122.32	0.00	0.00	70.92	293.94
	<i>LSD</i>	0.116	<i>n.s.</i>	1.29	0.192	<i>n.s.</i>	<i>n.s.</i>	0.131	<i>n.s.</i>

## Soil herbicide levels (ppm) in 2013 using HPLC (by irrigation)

	4/23	4/23	4/23	4/23	8/25	8/25	8/25	8/25
Irrigation	Treflan (0-3")	Treflan (3-6")	Prowl (0-3")	Prowl (3-6")	Treflan (0-3")	Treflan (3-6")	Prowl (0-3")	Prowl (3-6")
Drip	0.07	0.00	0.62	0.04	0.00	0.00	0.07	0.01
Sprinkler/drip	0.03	0.00	0.71	0.10	0.00	0.00	0.07	0.02
<i>LSD</i>	<i>n.s.</i>	<i>n.s.</i>	<i>n.s.</i>	<i>n.s.</i>	<i>n.s.</i>	<i>n.s.</i>	<i>n.s.</i>	<i>n.s.</i>

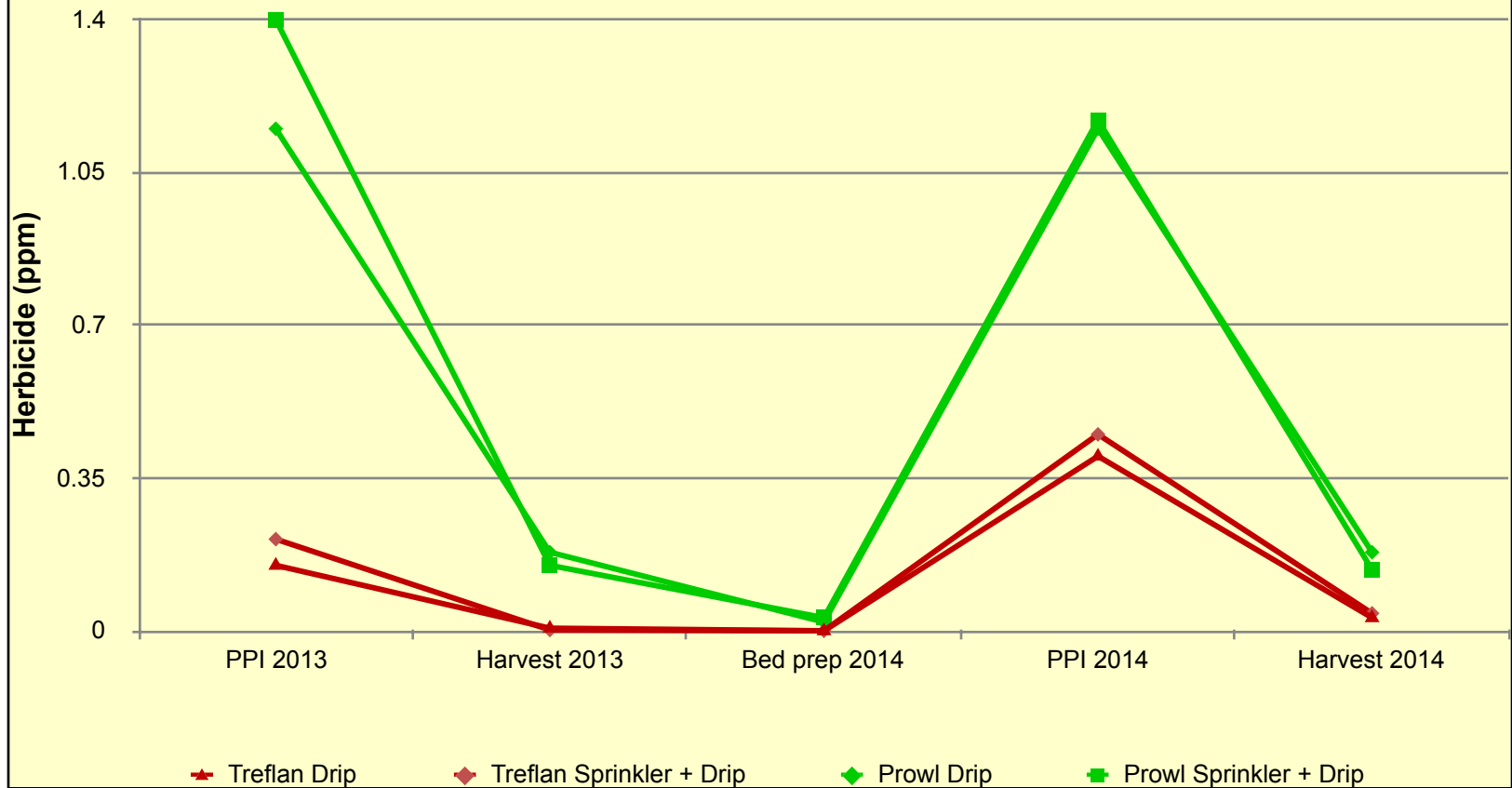
# Final soil analysis of year-1:

## Soil herbicide levels (ppm) in 2014 using HPLC

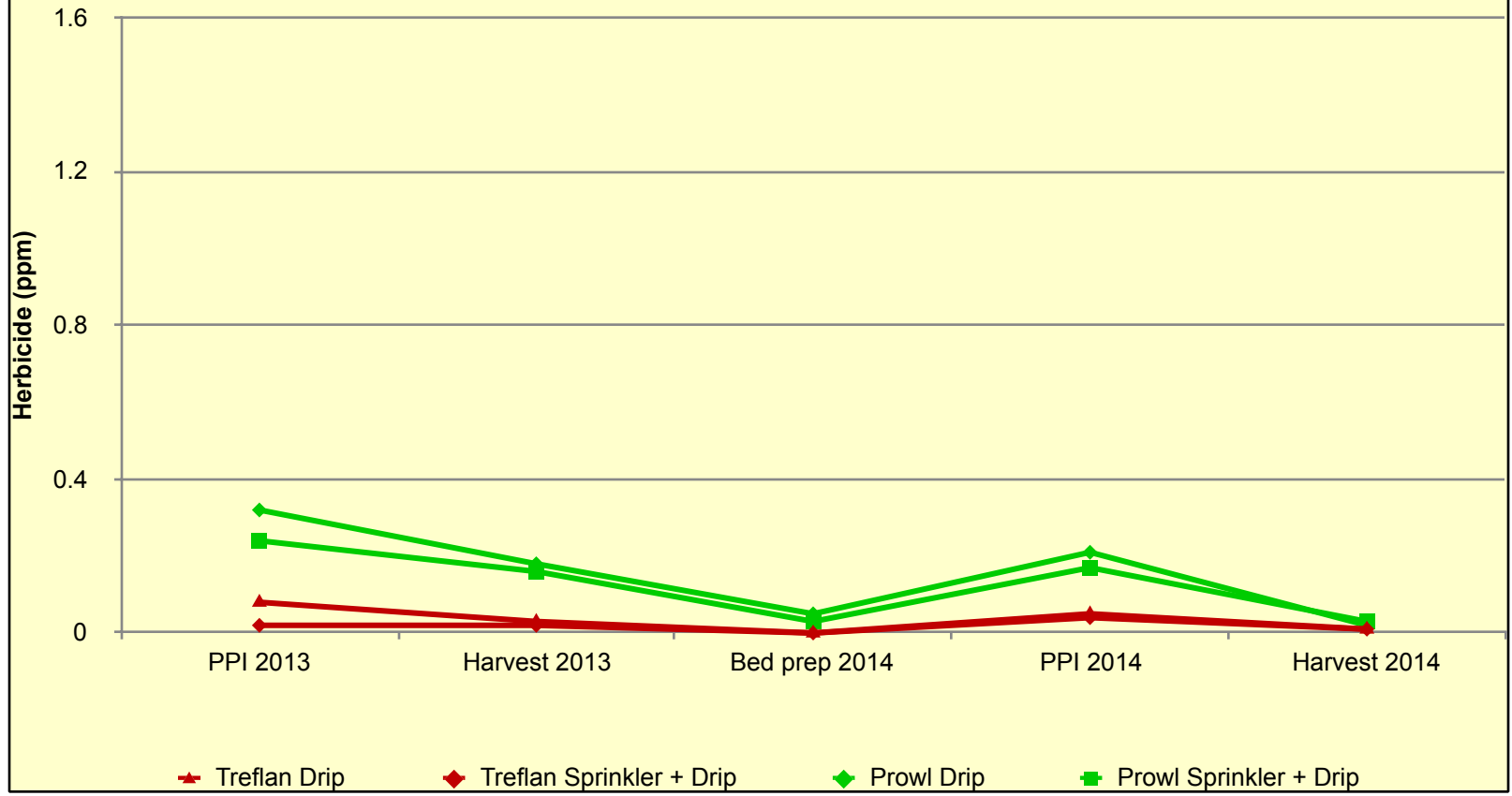
		4/18/14	4/18/14	4/18/14	4/18/14
Irrigation	Herbicide	Treflan (0-3")	Treflan (3-6")	Prowl (0-3")	Prowl (3-6")
Drip	None	0.00	0.00	0.00	0.00
Sprinkler/drip	None	0.00	0.00	0.00	0.00
Drip	Treflan	<b>0.00</b>	<b>0.00</b>	0.00	0.00
Sprinkler/drip	Treflan	<b>0.00</b>	<b>0.00</b>	0.00	0.00
Drip	Prowl H2O	0.00	0.00	<b>0.04</b> <b>(0.08 lb ai)</b>	<b>0.01</b> <b>(0.02 lb ai)</b>
Sprinkler/drip	Prowl H2O	0.00	0.00	<b>0.02</b> <b>(0.04 lb ai)</b>	<b>0.02</b> <b>(0.04 lb ai)</b>

Note: Total rainfall from harvest (8/25/13) until final sample (4/18/14) was 2.6"

## Herbicide residues at 0-3" depth in 2013/14



## Herbicide residues at 3-6" depth in 2013/14



# Final tomato stand count

## Tomato plant stand at 30 DAT

Irrigation	Herbicide	2013 Number plants/plot <sup>1</sup>	2014 Number plants/plot <sup>1</sup>	2015 Number plants/plot <sup>1</sup>
Drip	No herbicide	142.0	129.8	<b>139.0</b>
Sprinkler, then drip	No herbicide	136.6	159.0	NA
Drip	Treflan	131.2	132.3	<b>135.5</b>
Sprinkler, then drip	Treflan	116.3	154.5	NA
Drip	Prowl H2O	122.3	128.3	<b>136.5</b>
Sprinkler, then drip	Prowl H2O	130.6	168.0	NA
<i>Statistical notation</i>				
	CV (%)	8.94	27.84	NA
	LSD (p=0.05)	n.s.	n.s.	

<sup>1</sup>All healthy plants were counted in each sub-plot (2 rows, 75' long).

NA (data not available)

# Tomato dry weights

Tomato plant dry weight at 30 DAT

Irrigation	Herbicide	2013 Shoot (gm) <sup>1</sup>	2013 Root (gm) <sup>1</sup>	2014 Shoot (gm) <sup>1</sup>	2014 Root (gm) <sup>1</sup>	2015 Shoot (gm) <sup>1</sup>	2015 Root (gm) <sup>1</sup>
Drip	No herbicide	42.31	15.70	28.06	4.05	30.68	5.49
Sprinkler, then drip	No herbicide	34.80	6.40	27.74	4.22	No data	No data
Drip	Treflan	32.00	5.93	27.69	4.90	31.49	6.19
Sprinkler, then drip	Treflan	23.00	8.21	24.95	4.10	No data	No data
Drip	Prowl H2O	26.33	5.70	25.90	4.03	31.90	5.92
Sprinkler, then drip	Prowl H2O	22.88	4.06	25.99	3.90	No data	No data
<i>Statistical notation</i>							
	<i>CV (%)</i>	27.84	62.56	25.39	19.02	NA	NA
	<i>LSD (p=0.05)</i>	<i>n.s.</i>	<i>n.s.</i>	<i>n.s.</i>	<i>n.s.</i>		

<sup>1</sup>Two plants per sub-plot were removed, soil washed off roots, shoots and roots separated, forced-air oven-dried at 120° F for seven days, and weighed.



# Tomato yield and quality

## Tomato yield and quality in 2013

Irrigation	Herbicide	Red (%) <sup>1</sup>	Green (%) <sup>1</sup>	Sunburn (%) <sup>1</sup>	Rot (%) <sup>1</sup>	Red (T/A) <sup>1</sup>	Color	Solids	pH	
Drip	No herbicide	69.6	9.0	0.3	22.1	37.9	23.5	4.0	4.40	
Sprinkler, then drip	No herbicide	72.5	8.8	1.3	15.7	49.3	23.0	4.2	4.41	
Drip	Treflan	70.9	10.5	6.6	12.0	41.4	22.7	4.1	4.43	
Sprinkler, then drip	Treflan	63.1	15.0	0.2	21.6	39.3	24.7	4.3	4.44	
Drip	Prowl H2O	68.5	15.4	0.2	13.8	46.9	24.3	4.1	4.39	
Sprinkler, then drip	Prowl H2O	72.5	10.6	1.8	15.1	44.1	23.7	4.0	4.42	
Statistical notation		CV (%)	9.75	48.37	182.43	37.97	29.01	6.12	5.29	1.21
		LSD (p=0.05)	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.

<sup>1</sup>Fruit yield and ripeness determined by hand pulling all tomato plants in the center two rows (20' long) shaking fruit into



# Tomato yield and quality

**Tomato yield and quality in 2014**

Irrigation	Herbicide	Red (%) <sup>1</sup>	Green (%) <sup>1</sup>	Sunburn (%) <sup>1</sup>	Rot (%) <sup>1</sup>	Red (T/A) <sup>1</sup>	Color	Solids	pH	
Drip	No herbicide	84.9	4.4	3.2	7.6	41.28	22.0	5.1	4.40	
Sprinkler, then drip	No herbicide	86.8	3.3	1.3	8.8	41.80	21.8	5.0	4.40	
Drip	Treflan	84.0	3.4	2.8	9.8	36.40	22.8	4.9	4.44	
Sprinkler, then drip	Treflan	85.7	3.4	0.8	10.8	41.44	22.5	4.9	4.40	
Drip	Prowl H2O	78.7	3.1	3.4	16.1	36.32	22.5	5.0	4.44	
Sprinkler, then drip	Prowl H2O	83.8	2.3	2.2	11.6	42.48	22.0	4.9	4.40	
Statistical notation		CV (%)	5.96	62.91	96.23	32.59	18.17	2.59	3.97	0.81
		LSD (p=0.05)	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.

<sup>1</sup>Fruit yield and ripeness determined by hand pulling all tomato plants in the center two rows (20' long) shaking fruit into

# Tomato yield and quality

**Tomato yield and quality in 2015**

Irrigation	Herbicide	Red (%) <sup>1</sup>	Green (%) <sup>1</sup>	Sunburn (%) <sup>1</sup>	Rot (%) <sup>1</sup>	Red (T/A) <sup>1</sup>	Color	Solids	pH
Drip	No herbicide	90.4	3.4	0.6	5.9	62.75	24.3	4.7	4.5
Sprinkler, then drip	No herbicide	NA	NA	NA	NA	NA	NA	NA	NA
Drip	Treflan	88.9	2.1	0.7	8.2	62.12	24.0	4.7	4.5
Sprinkler, then drip	Treflan	NA	NA	NA	NA	NA	NA	NA	NA
Drip	Prowl H2O	87.7	2.4	1.1	9.2	56.32	24.0	4.6	4.5
Sprinkler, then drip	Prowl H2O	NA	NA	NA	NA	NA	NA	NA	NA

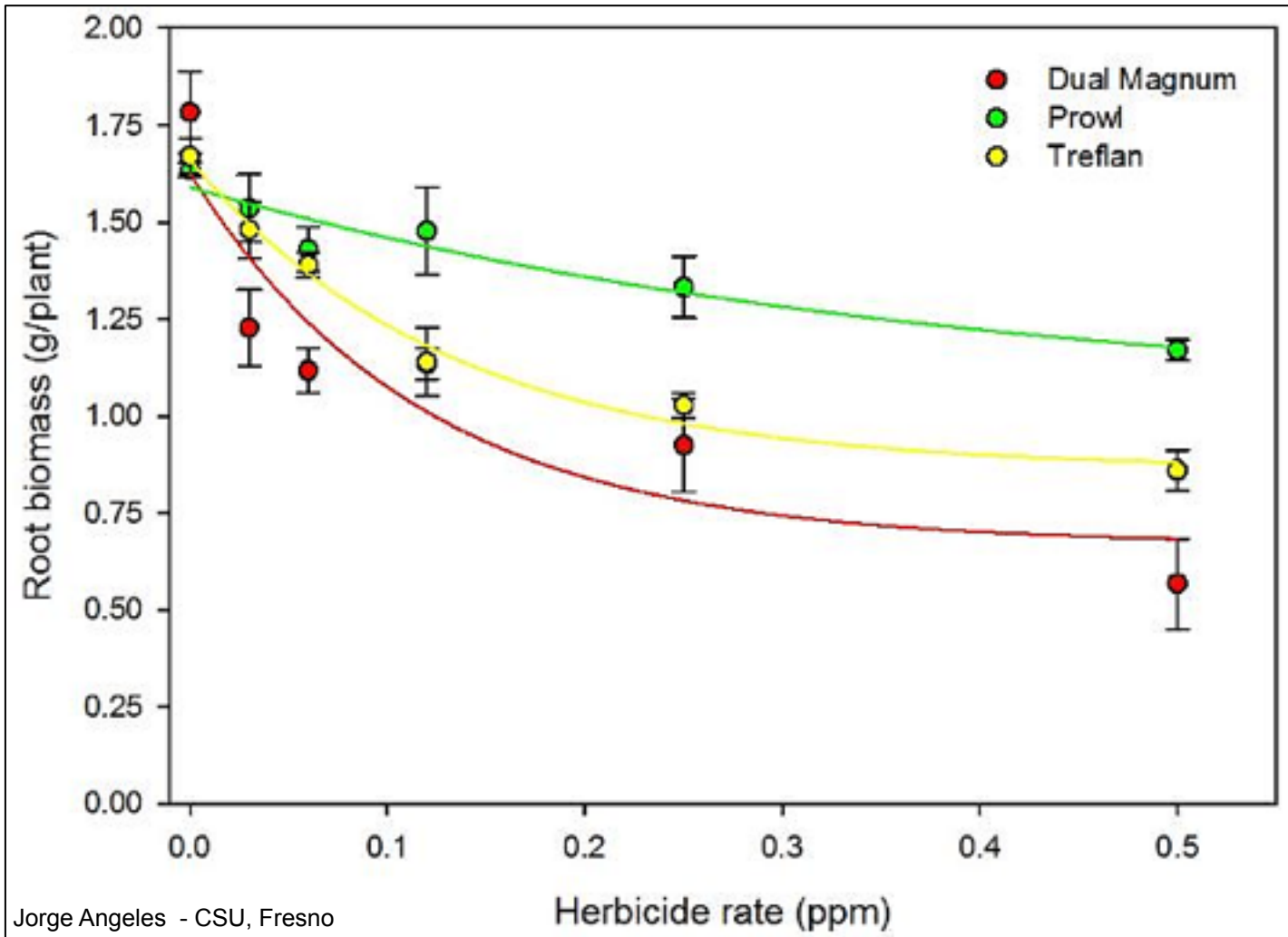
<sup>1</sup>Fruit yield and ripeness determined by hand pulling all tomato plants in the center two rows (20' long) shaking fruit into

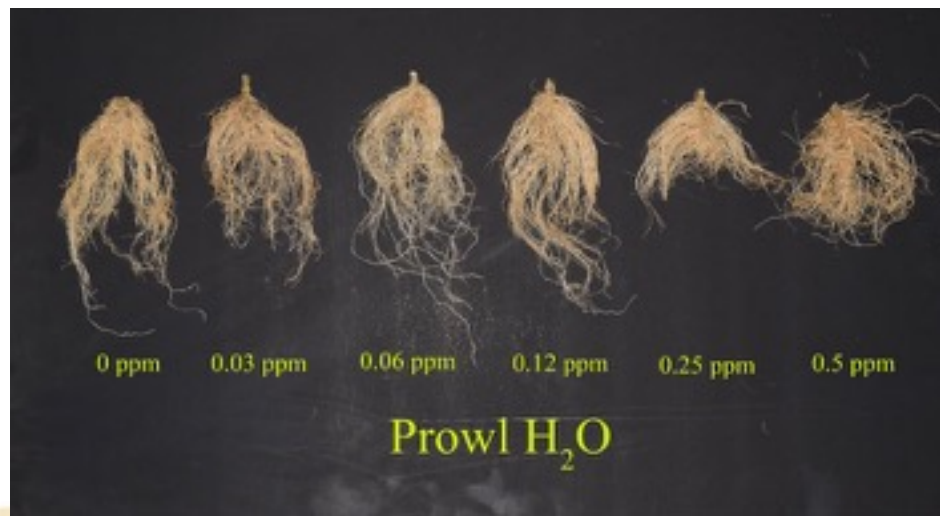
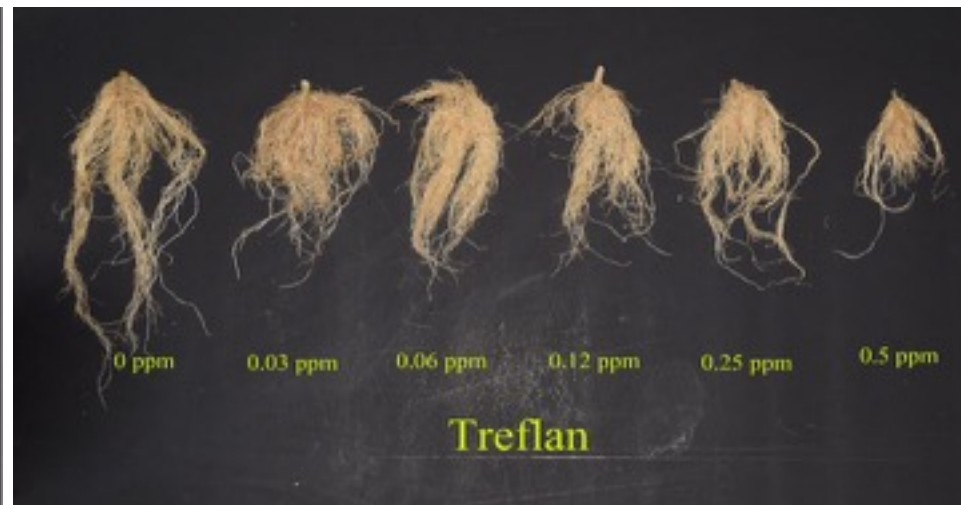
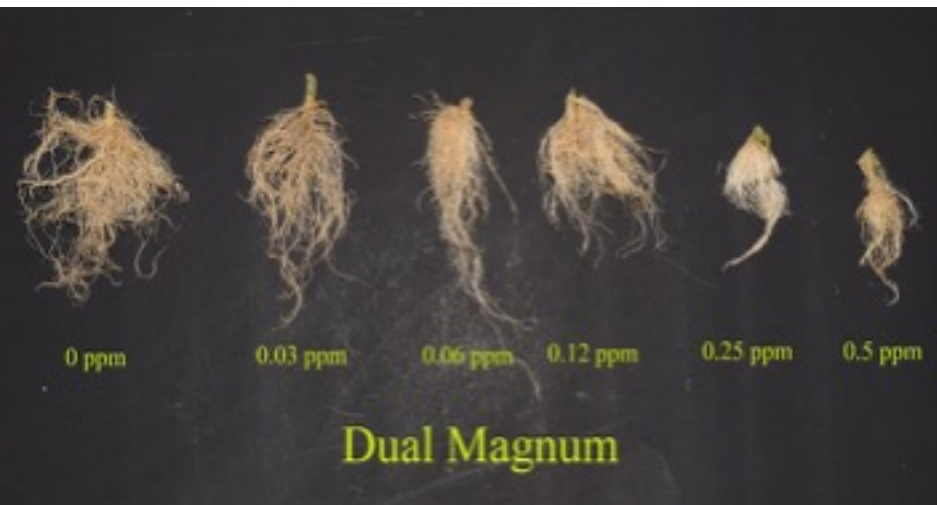
# Approximate values for 50% reduction (GR<sub>50</sub>) in root and shoot biomass

Herbicide	Shoot Biomass	Root Biomass
Dual Magnum	0.40 ppm	0.18 ppm
Treflan	0.46 ppm	0.50 ppm
Prowl	> 0.50 ppm	> 0.50 ppm

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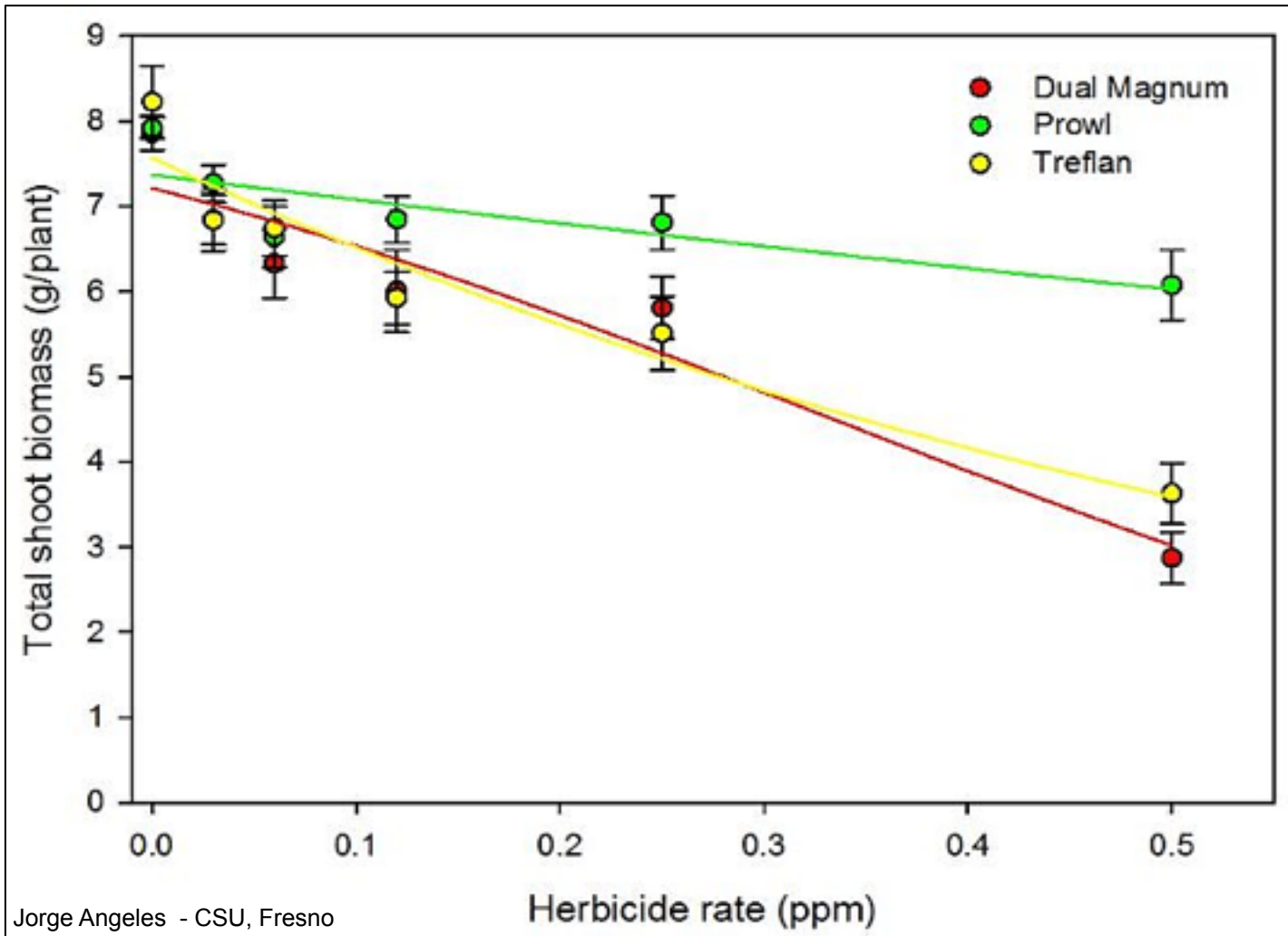
# Root Biomass





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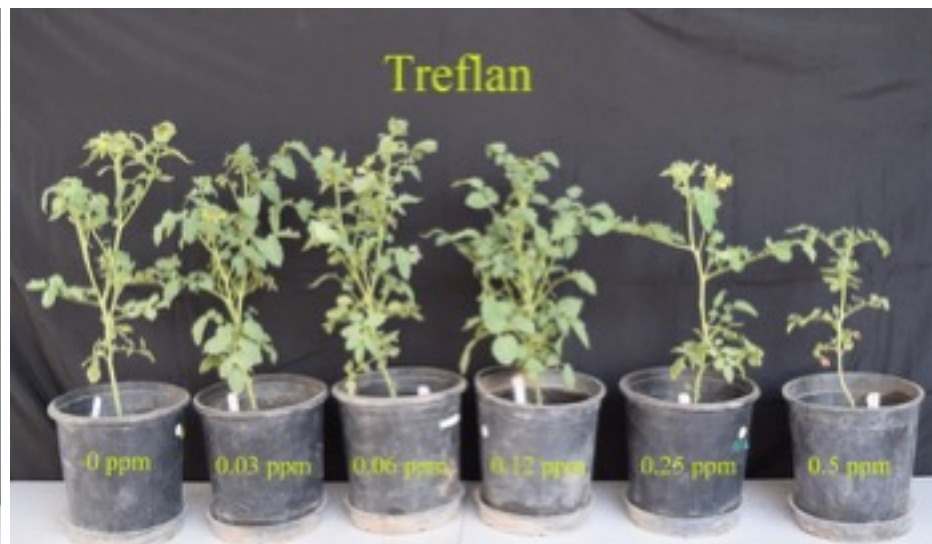
# Shoot Biomass



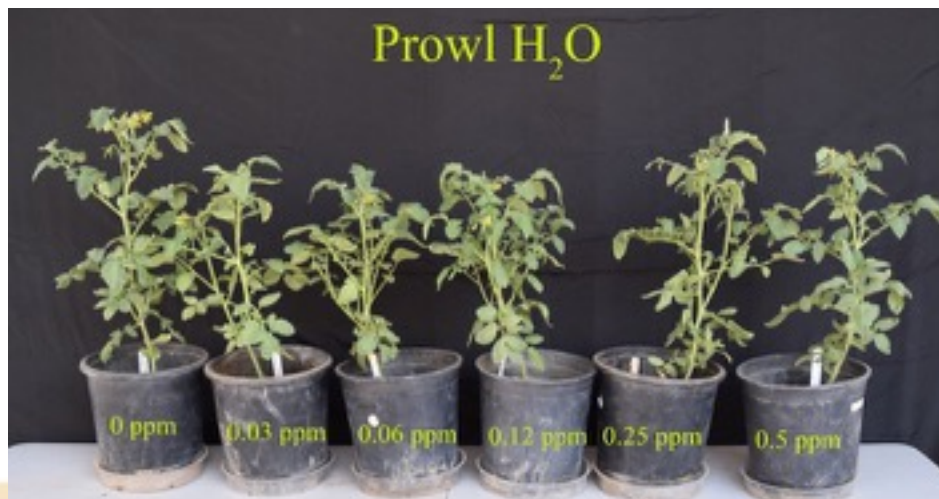
## Dual Magnum



## Treflan



## Prowl H<sub>2</sub>O



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# SUMMARY

1. <0.2 ppm (<8% of original dose) was detected in the soil after two years of back-to-back Prowl H2O treatments. Treflan carryover was virtually non-existent.
2. Using sprinkler irrigation water to supplement drip at planting only aided in herbicide degradation marginally.
3. The residue levels detected did not negatively affect plant stand, dry weights, or yield.
4. Green house studies indicate it would take levels >0.5 ppm of pendimethalin to reduce tomato root and shoot growth by 50%.
5. At this point, it appears that carryover of DNA herbicides is low and is not likely to cause significant plant injury or yield loss. Damage is more likely to come from planting to shallow, where the root plugs are directly exposed to incorporated herbicides.

# Thanks to the many people who helped on this project!

