Evaluation of Salinity Effects on Strawberry Production

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Water Management in Ventura County

- Crops of low tolerance to water stress and salts
- Water availability, quality and price

Crop Year Irrigation Allowance (Reduced 25%)*

Starting August 1, 2014

Acre-Feet/Acre

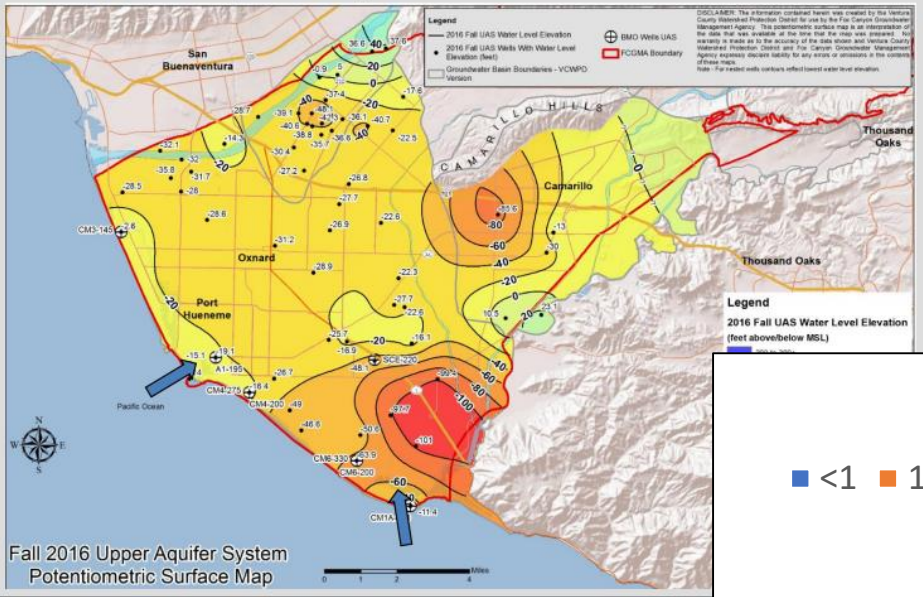
SEASONAL CROPS	# OF CROPS	OXNARD (ZONE 1) DRY[3] Total AF/A	OXNARD (ZONE 1) TYPICAL[1] Total AF/A	OXNARD (ZONE 1) WET[3] Total AF/A	CAMARILLO (ZONE 2) DRY[3] Total AF/A	CAMARILLO (ZONE 2) TYPICAL[1] Total AF/A	CAMARILLO (ZONE 2) WET[3] Total AF/A	SANTA PAULA (ZONE 3) DRY[3] Total AF/A	SANTA PAULA (ZONE 3) TYPICAL[1] Total AF/A	SANTA PAULA (ZONE 3) WET[3] Total AF/A
Celery - Fall[2]	1	1.6	1.5	1.4	1.8	1.7	1.5	1.9	1.8	1.6
Celery - Spring[2]	1	1.6	1.5	1.4	1.8	1.7	1.5	1.9	1.8	1.6
Cover Crop	1	0.9	0.9	0.9	1.0	1.0	1.0	1.2	1.1	1.0
Lima Beans	1	0.8	0.8	0.8	0.9	0.9	0.9	1.0	1.0	0.9
Misc. Vegetable Greenhouse - Fall[2]	1	0.9	0.9	0.8	1.0	1.0	0.9	1.1	1.0	1.0
Misc. Vegetable Greenhouse - Spring[2]	1	1.1	1.0	0.9	1.2	1.1	1.1	1.3	1.2	1.2
Misc. Vegetable Greenhouse - Summer[2]	1	1.2	1.2	1.2	1.3	1.3	1.3	1.4	1.4	1.4
Misc. Vegetable - Fall[2]	1	1.1	1.0	1.0	1.2	1.1	1.0	1.3	1.2	1.1
Misc. Vegetable - Spring[2]	1	1.3	1.2	1.1	1.4	1.3	1.2	1.6	1.5	1.4
Misc. Vegetable - Summer[2]	1	1.5	1.5	1.5	1.7	1.7	1.6	1.9	1.8	1.8
Strawberries - Main Season (October Planting)	1	2.5	2.3	2.2	2.7	2.6	2.4	2.9	2.8	2.6
Strawberries - Summer (July Planting)	1	1.4	1.4	1.3	1.6	1.5	1.4	1.7	1.6	1.5
Tomatoes - Peppers	1	1.7	1.7	1.6	1.9	1.9	1.8	2.1	2.1	2.0

YEAR-ROUND CROPS	# OF CROPS	OXNARD (ZONE 1) DRY[3] Total AF/A	OXNARD (ZONE 1) TYPICAL[1] Total AF/A	OXNARD (ZONE 1) WET[3] Total AF/A	CAMARILLO (ZONE 2) DRY[3] Total AF/A	CAMARILLO (ZONE 2) TYPICAL[1] Total AF/A	CAMARILLO (ZONE 2) WET[3] Total AF/A	SANTA PAULA (ZONE 3) DRY[3] Total AF/A	SANTA PAULA (ZONE 3) TYPICAL[1] Total AF/A	SANTA PAULA (ZONE 3) WET[3] Total AF/A
Year-Round Vegetables - Not Including Celery[2]	>2	3.1	2.9	2.8	3.5	3.3	3.1	3.8	3.6	3.4
Year-Round Vegetables - Including Celery[4]	>2	3.4	3.2	3.1	3.8	3.6	3.5	4.0	4.0	3.8

ANNUAL CROPS	# OF CROPS	OXNARD (ZONE 1) DRY[3] Total AF/A	OXNARD (ZONE 1) TYPICAL[1] Total AF/A	OXNARD (ZONE 1) WET[3] Total AF/A	CAMARILLO (ZONE 2) DRY[3] Total AF/A	CAMARILLO (ZONE 2) TYPICAL[1] Total AF/A	CAMARILLO (ZONE 2) WET[3] Total AF/A	SANTA PAULA (ZONE 3) DRY[3] Total AF/A	SANTA PAULA (ZONE 3) TYPICAL[1] Total AF/A	SANTA PAULA (ZONE 3) WET[3] Total AF/A
Avocado < 20% Ground Shading	1	1.5	1.4	1.3	1.7	1.6	1.5	1.9	1.7	1.6
Avocado 20 - 70% Ground Shading	1	2.2	2.0	1.9	2.5	2.3	2.1	2.8	2.5	2.3
Avocado > 70% Ground Shading	1	3.1	2.7	2.6	3.5	3.1	3.0	3.8	3.4	3.2
Blueberries < 20% Ground Shading	1	1.4	1.4	1.3	1.8	1.5	1.5	1.9	1.8	1.7
Blueberries 20 - 70% Ground Shading	1	2.1	2.0	1.9	2.3	2.2	2.2	2.5	2.4	2.4
Blueberries > 70% Ground Shading	1	2.9	2.7	2.6	3.3	3.1	3.0	3.6	3.4	3.2
Citrus < 20% Ground Shading	1	1.6	1.4	1.3	1.8	1.6	1.5	1.9	1.8	1.6
Citrus 20 - 70% Ground Shading	1	2.0	1.9	1.8	2.3	2.2	2.0	2.5	2.4	2.2
Citrus > 70% Ground Shading	1	2.7	2.6	2.4	3.0	2.9	2.7	3.3	3.2	2.9
Nursery - Non-Greenhouse	1	3.4	3.2	3.1	3.8	3.6	3.5	4.0	4.0	3.8
Nursery - Greenhouse	1	3.5	3.4	3.3	3.9	3.8	3.7	4.0	4.0	4.0
Raspberries - Tunnel	1	3.4	3.2	3.1	3.8	3.7	3.6	4.0	4.0	3.9
Sod	1	3.2	3.0	2.9	3.6	3.4	3.3	3.9	3.7	3.6

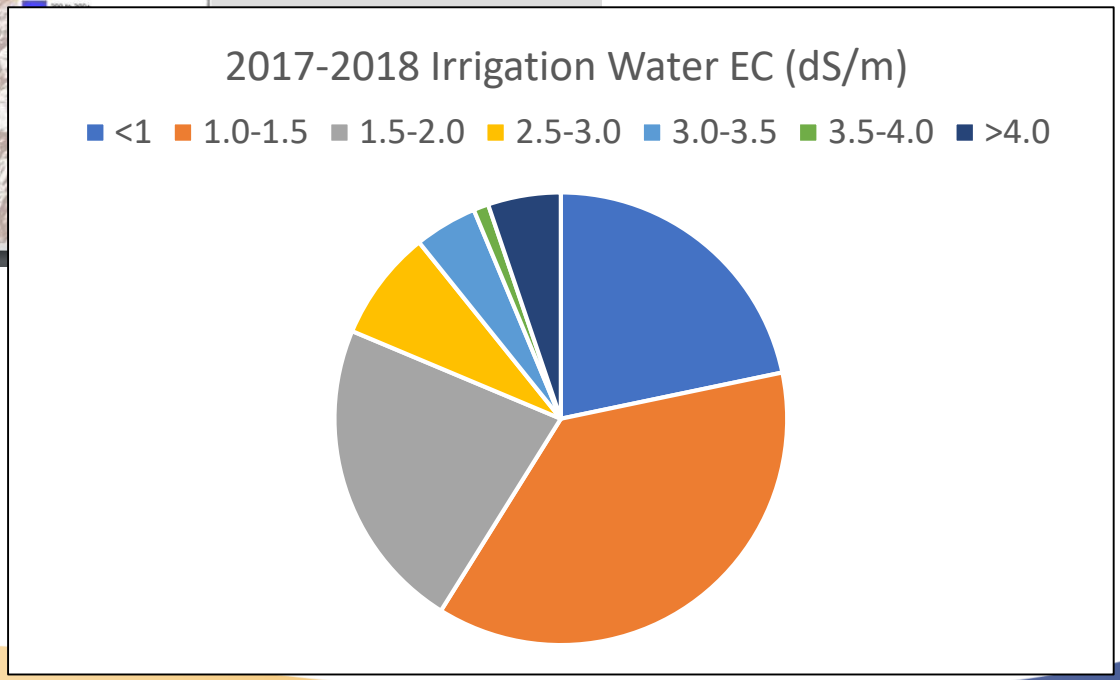
Seawater Intrusion: Oxnard

- Upper Aquifer System

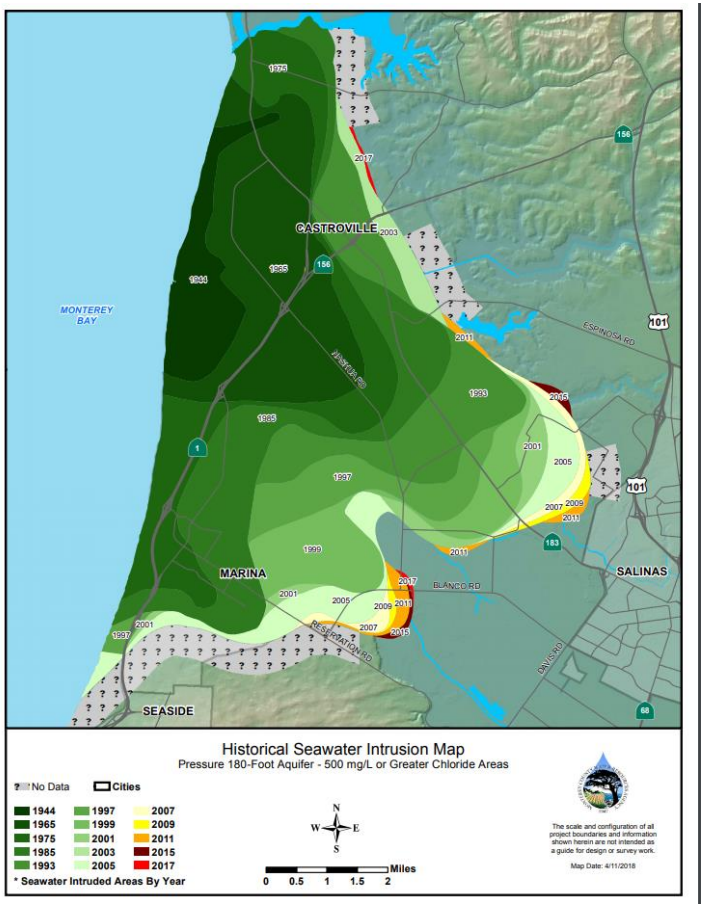


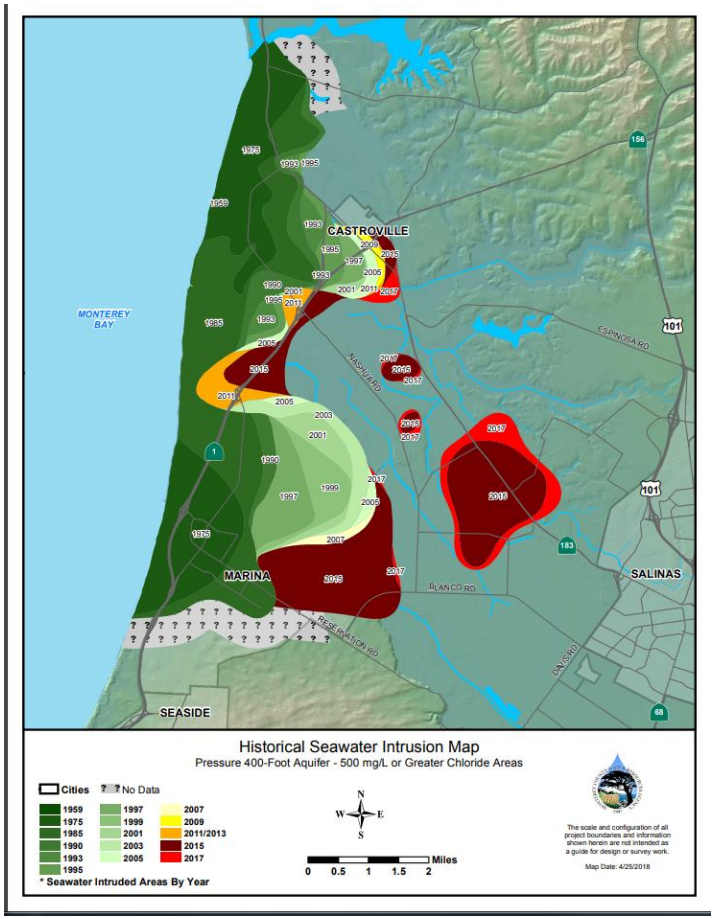
- During periods of drought the gradient along the coast is directed landward

http://fcgma.org



Seawater Intrusion: Monterey County





Monterey County Water Resources Agency

Current guidelines were written decades ago

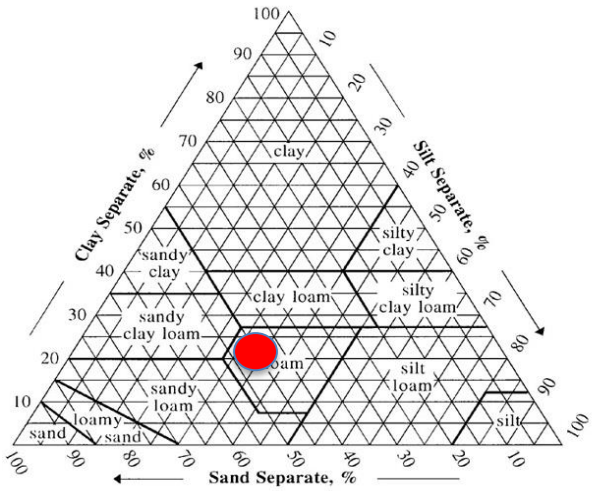
FIELD CROPS	100%		90%		75%		50%		0% "maximum"3	
	EC_e	EC_w	EC_e	EC_w	EC_e	EC_w	EC_e	EC_w	EC_e	EC_w
Strawberry (Fragaria sp.)	1	0.7	1.3	0.9	1.8	1.2	2.5	1.7	4	2.7

FAO 29 – Water Quality for Agriculture
http://www.fao.org/docrep/003/t0234e/T0234E03.htm#ch2.4.3
Maas and Hoffman (1977) and Maas (1984)

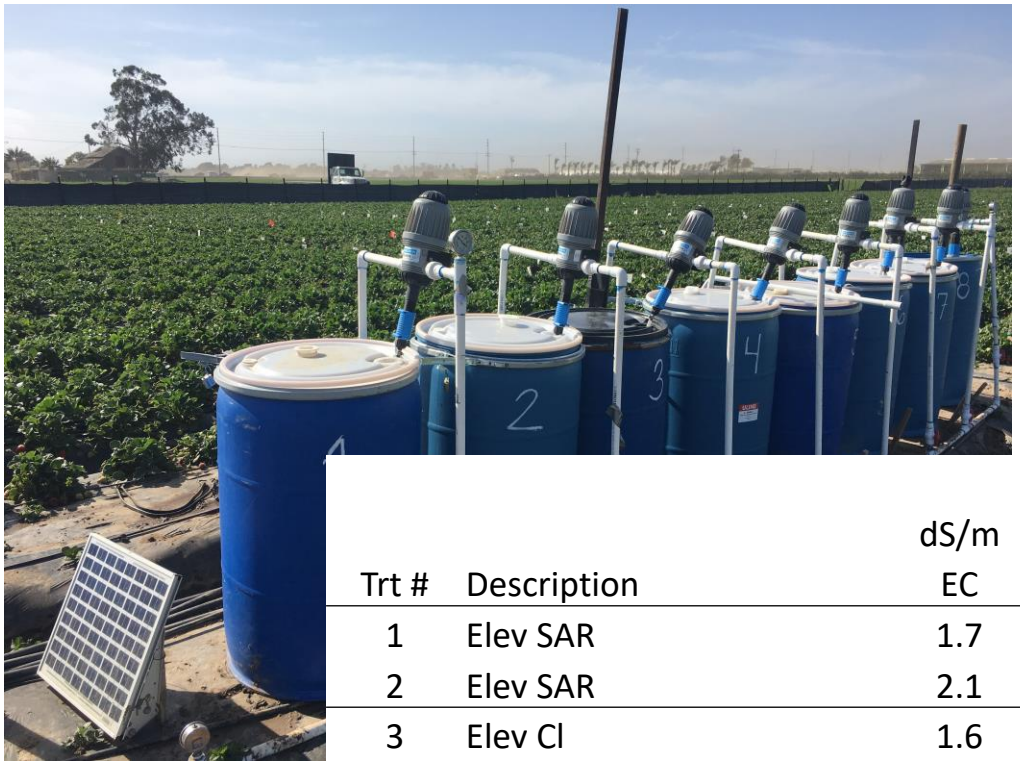
*In gypsiferous soils, plants will tolerate about 2 dS/m higher soil salinity (ECe) than indicated but the water salinity (ECw) will remain the same as shown in this table

Material and Methods

- ✓ Oxnard, CA
- ✓ Oct 2017 – June 2018
- ✓ Cultivars: Fronteras and Monterey
- ✓ Loam soil, limited infiltration rate
- ✓ ET-based irrigation, with soil moisture sensors
- ✓ 60 drip irrigation events (2.0 AF)
- ✓ Two high flow tapes (0.67 gpm/100ft), 64” beds
- ✓ Split-plot design with RCB
- ✓ 54 harvesting events/days
- ✓ Soil and leaf blade samples (3 sampling dates)
- ✓ Marketable unmarketable yield, and berry weight



Treatments

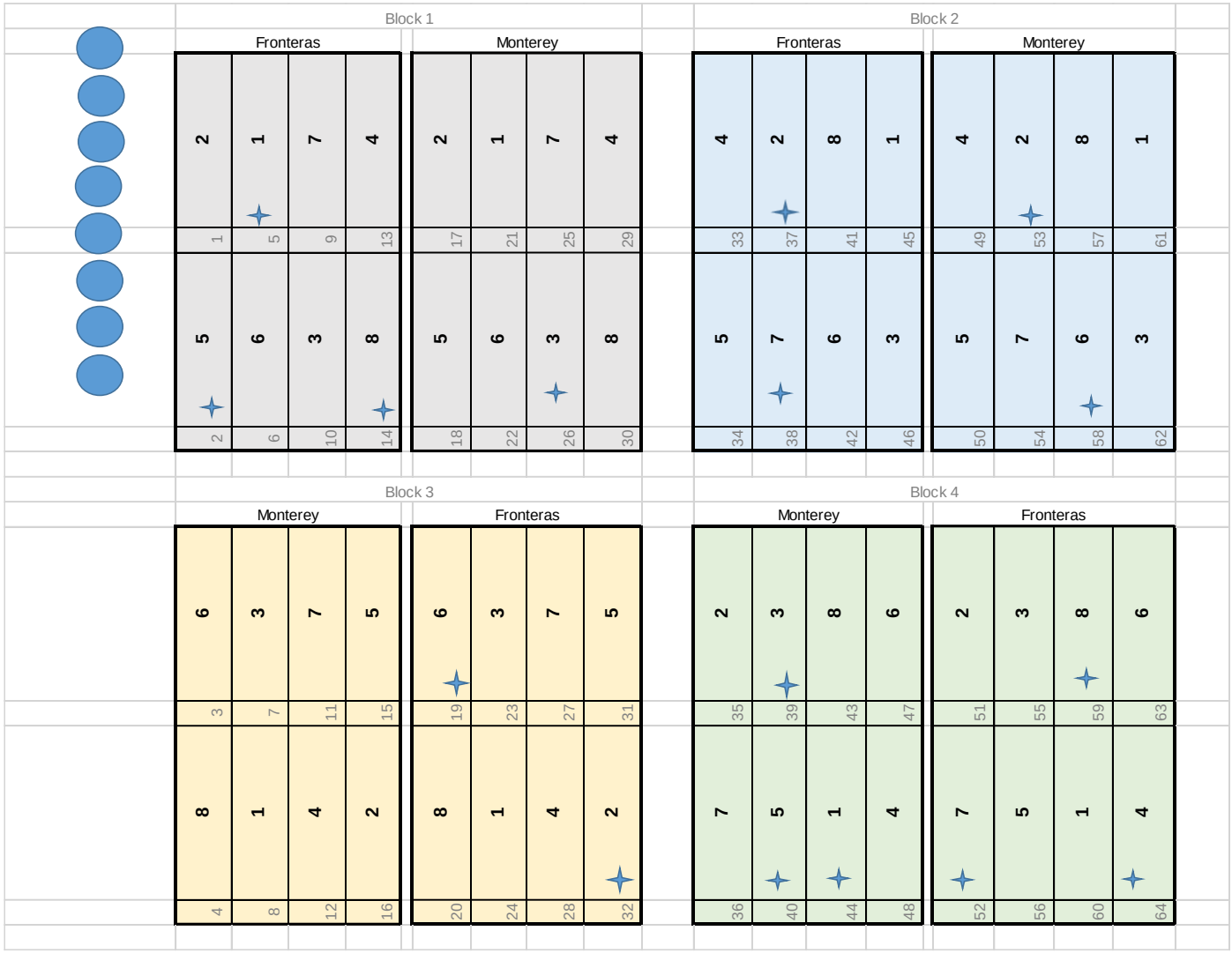


		dS/m		---------- meq/L ----------				
Trt #	Description	EC	SAR	Ca	Mg	Na	Cl	SO4
1	Elev SAR	1.7	4.6	5.6	2.9	9.6	1.2	16.4
2	Elev SAR	2.1	6.6	5.5	2.8	13.6	3.1	18.5
3	Elev Cl	1.6	2.4	7.2	3.6	5.5	4.2	11.7
4	Elev Cl	1.9	2.4	8.7	4.8	6.3	7.7	11.7
5	Elev Cl	2.3	2.4	10.3	6.2	6.9	11.7	11.8
6	Medium SO4	1.8	2.7	5.5	7.9	7.0	2.1	18.3
7	High SO4	2.3	3.1	5.4	12.9	9.3	2.3	26.0
8	Control/United Water	1.3	2.5	5.5	2.8	5.1	1.2	11.9

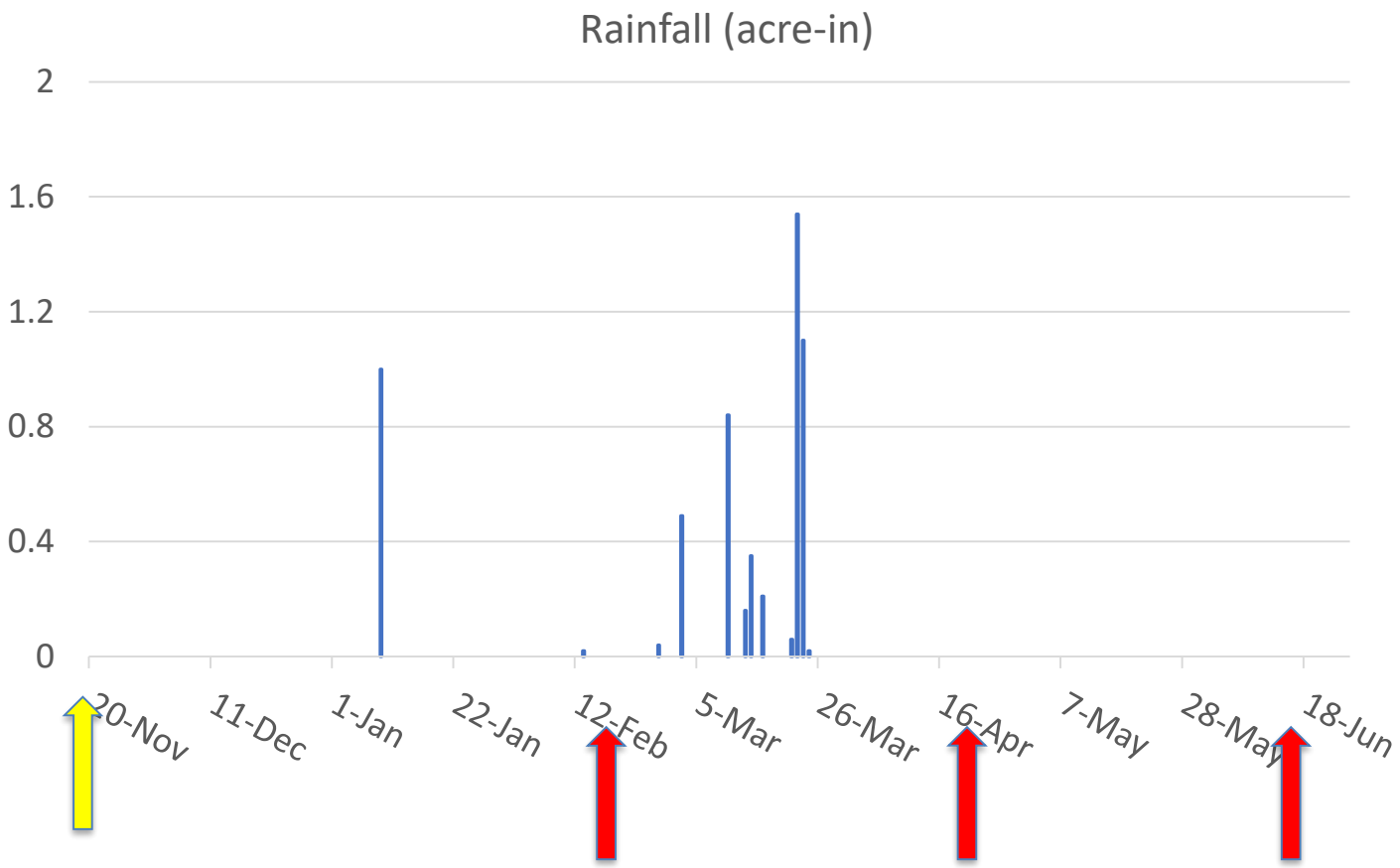
Treatments

		dS/m		--- meq/L ---	
Trt #	Description	EC	SAR	Cl	SO4
1	Elev SAR	1.7	4.6	1.2	16.4
2	Elev SAR	2.1	6.6	3.1	18.5
3	Elev Cl	1.6	2.4	4.2	11.7
4	Elev Cl	1.9	2.4	7.7	11.7
5	Elev Cl	2.3	2.4	11.7	11.8
6	Medium SO4	1.8	2.7	2.1	18.3
7	High SO4	2.3	3.1	2.3	26.0
8	Control/United Water	1.3	2.5	1.2	11.9
	Ventura County Avg	1.4	2.0	1.8	10.3
	Monterey County Avg	1.1	2.5	4.2	1.9

Plots: 30ft long,
one bed wide

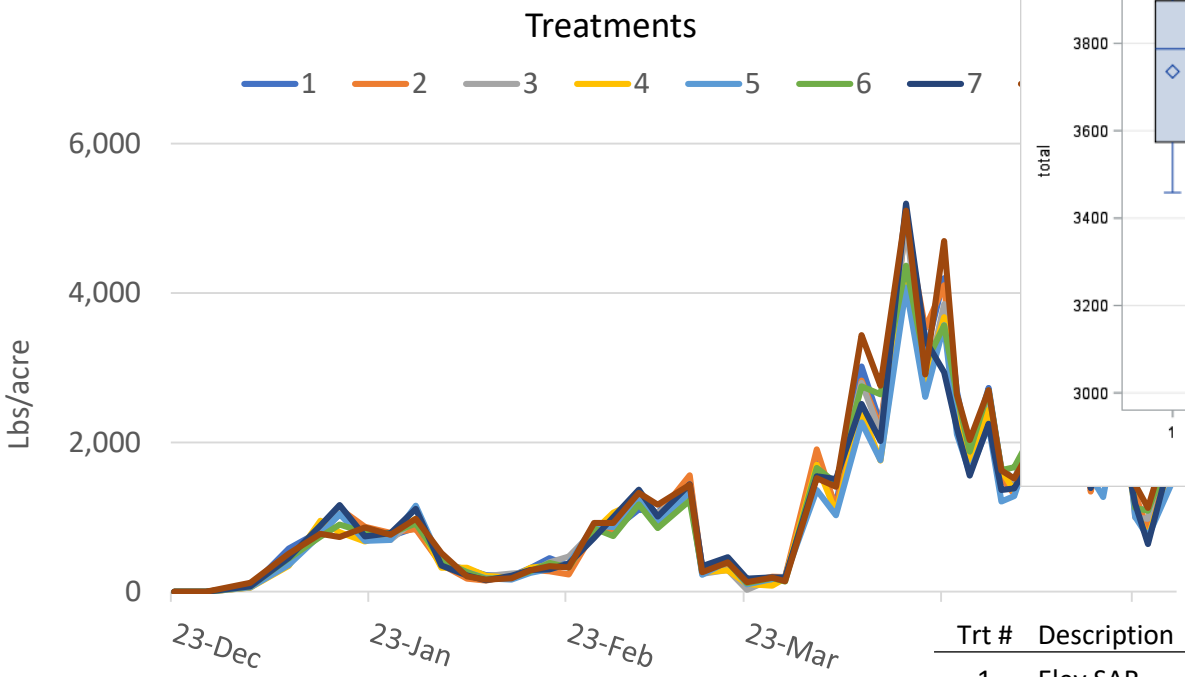


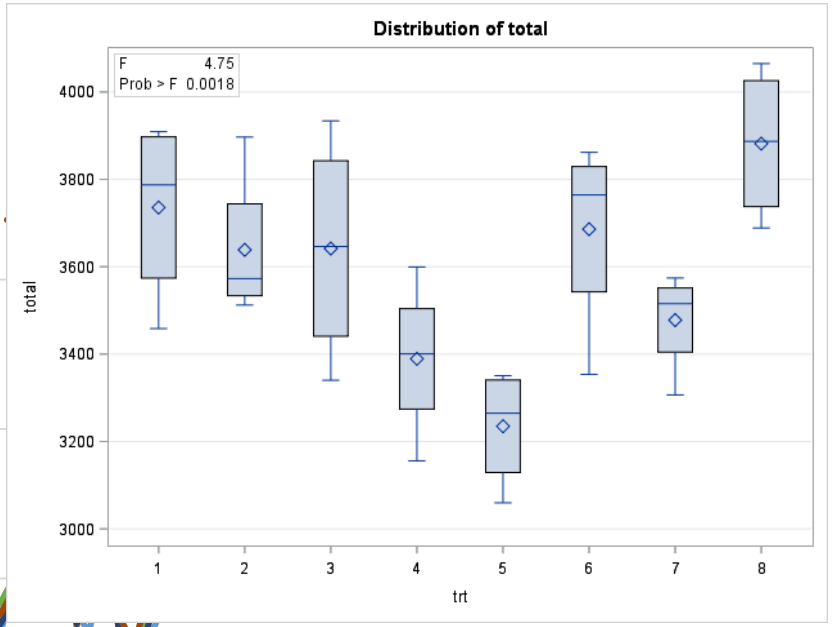
Total rainfall: 5.8in



Results

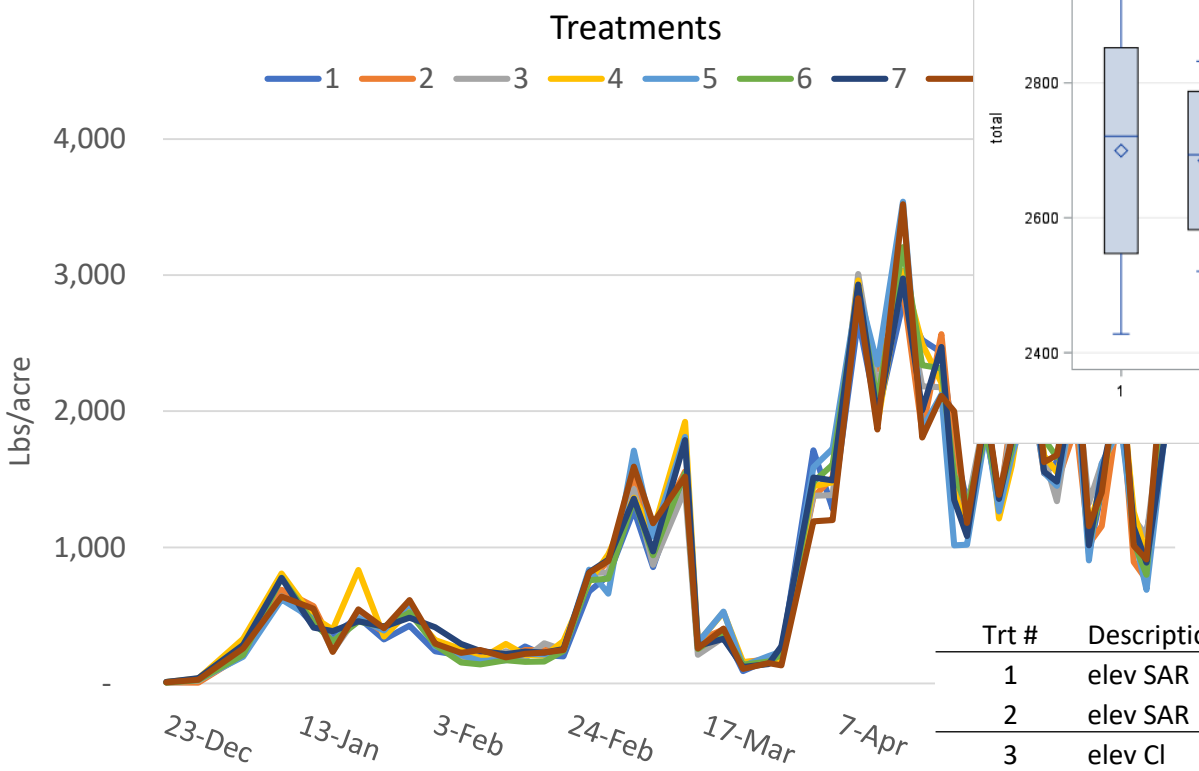
Marketable Yield, Fronteras

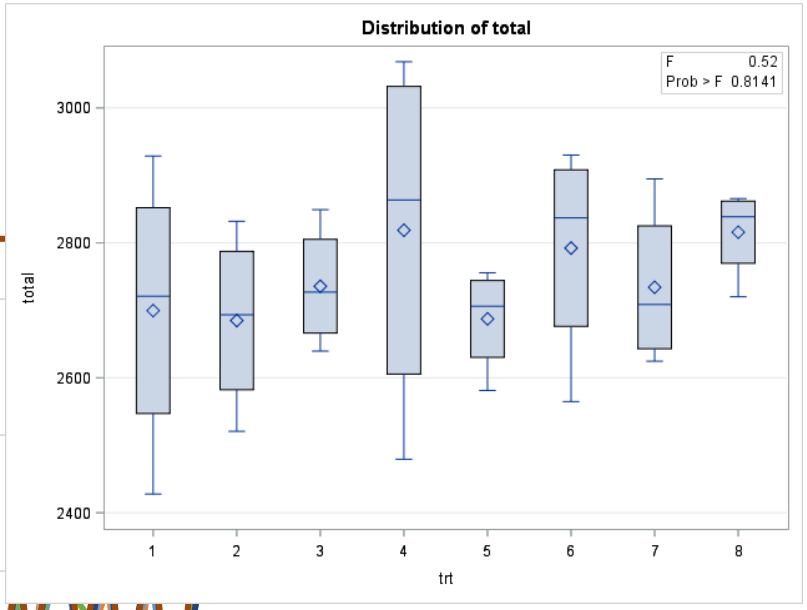




Trt #	Description	lbs/acre	Yield loss	p-value
1	Elev SAR	70,626	4%	0.953
2	Elev SAR	68,795	6%	0.618
3	Elev Cl	68,850	6%	0.632
4	Elev Cl	64,075	13%	0.022
5	Elev Cl	61,160	17%	0.001
6	Medium SO4	69,689	5%	0.820
7	High SO4	65,756	10%	0.094
8	Control/United Water	73,393		

Marketable Yield, Monterey

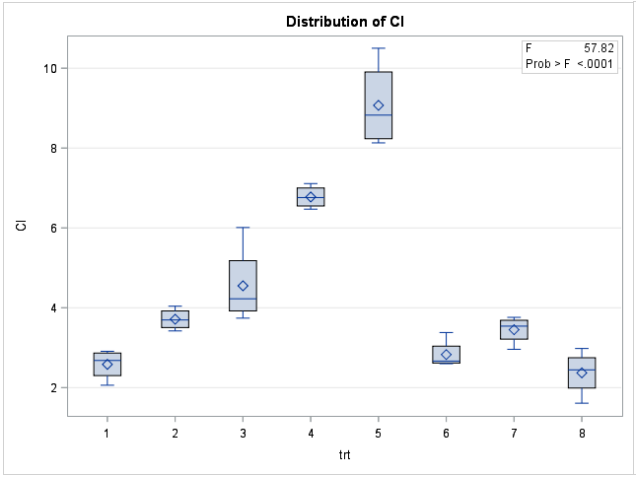


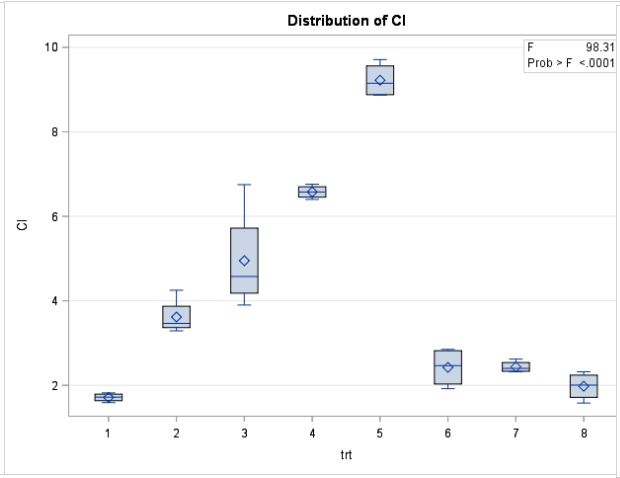


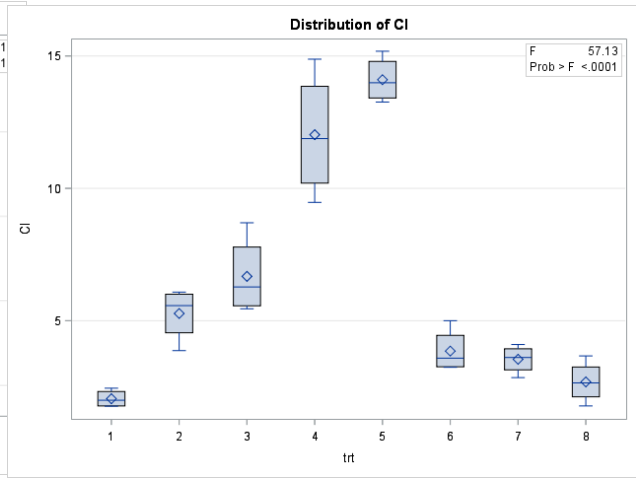
Trt #	Description	lbs/acre	Yield loss	p-value
1	elev SAR	51,040	4%	0.960
2	elev SAR	50,763	5%	0.928
3	elev Cl	51,725	3%	0.995
4	elev Cl	53,296	0%	1.000
5	elev Cl	50,812	5%	0.934
6	Medium SO4	52,797	1%	1.000
7	High SO4	51,700	3%	0.995
8	Control/United water	53,243		

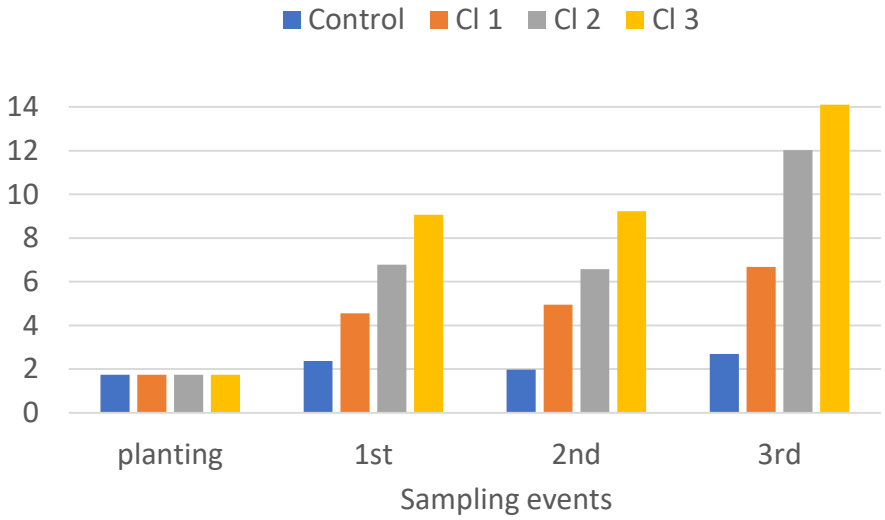
Differences are not statistically significant

Soil Analysis – Cl (meq/L)









Treatment	dS/m EC	meq/L Cl
Control	1.3	1.2
Elev. Cl 1	1.6	4.2
Elev. Cl 2	1.9	7.7
Elev. Cl 3	2.3	11.7

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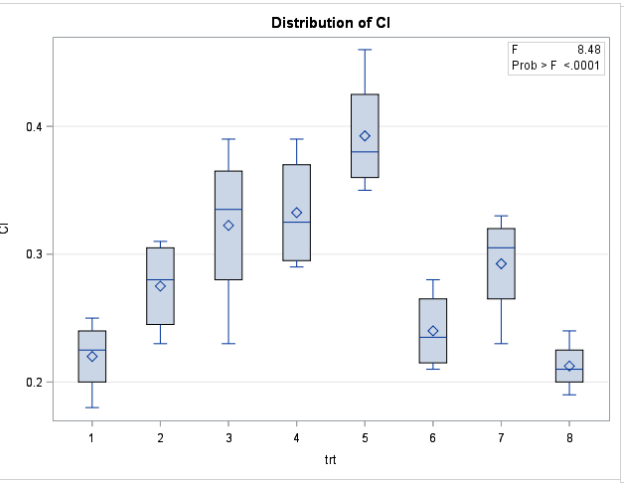
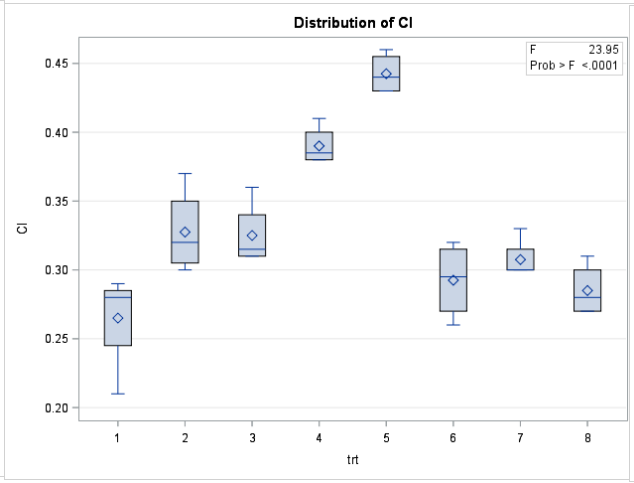
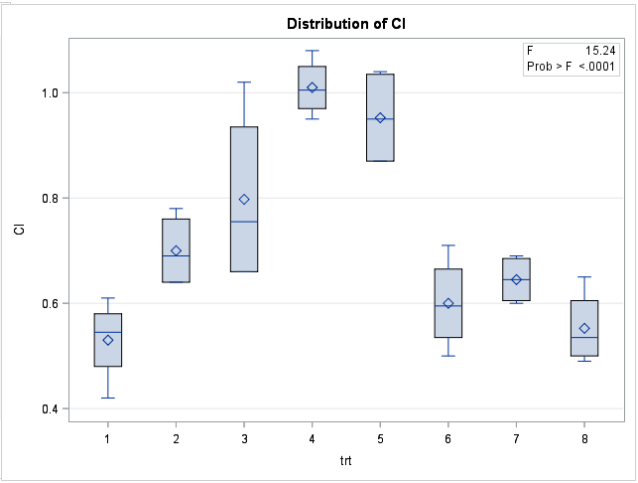
Leaf Blade Analysis, Cl (%)

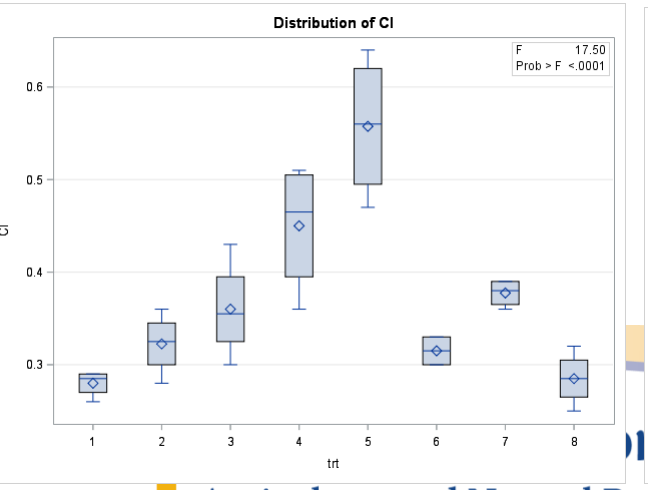
Fronteras

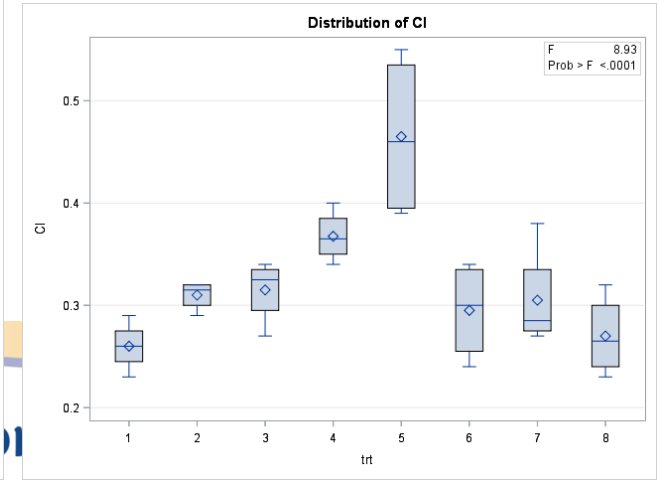


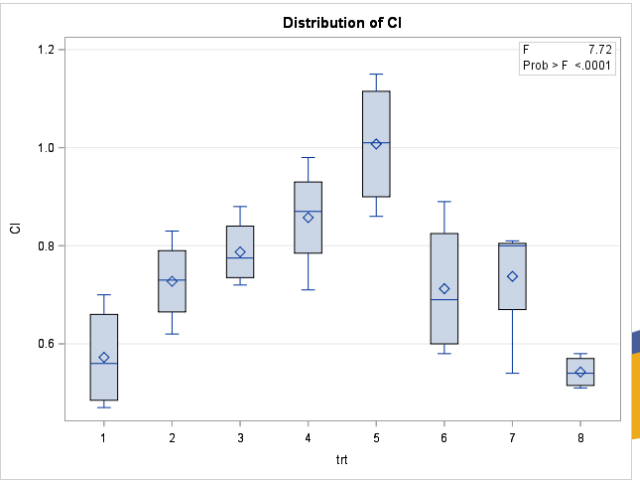




Monterey







Treatment	dS/m EC	meq/L Cl
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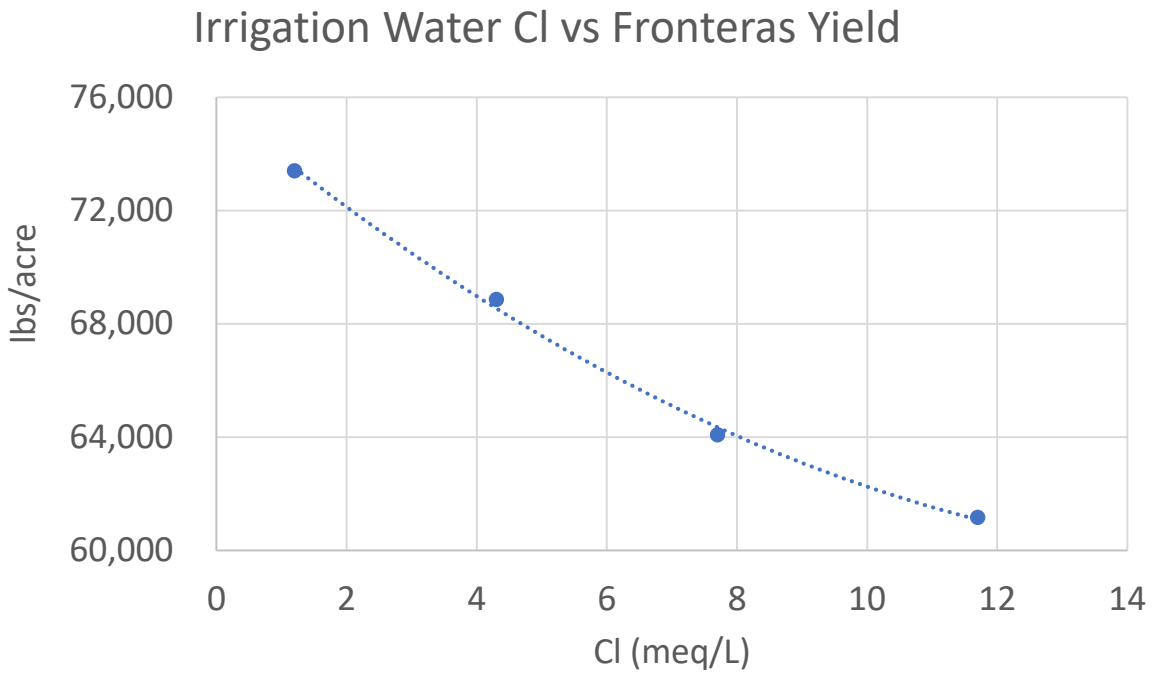
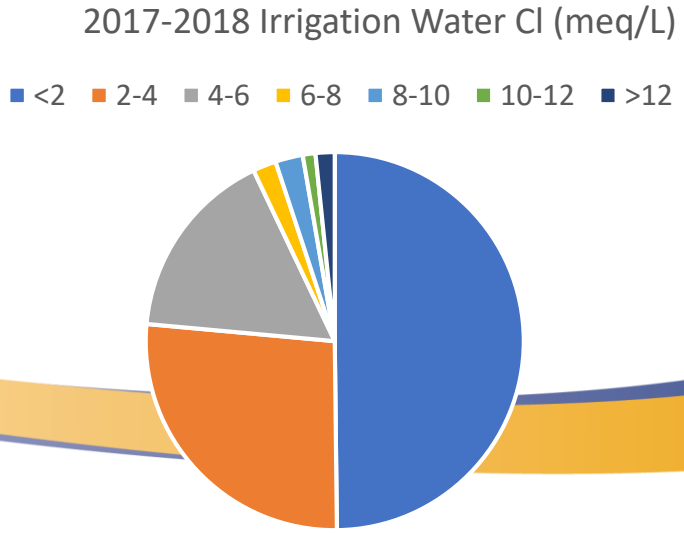
Elev. Cl 1	1.6	4.2
Elev. Cl 2	1.9	7.7
Elev. Cl 3	2.3	11.7





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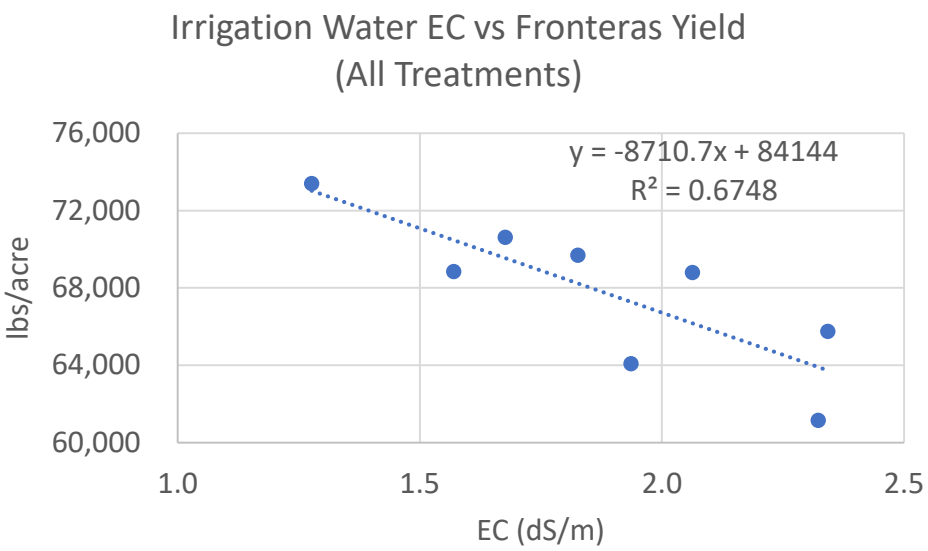

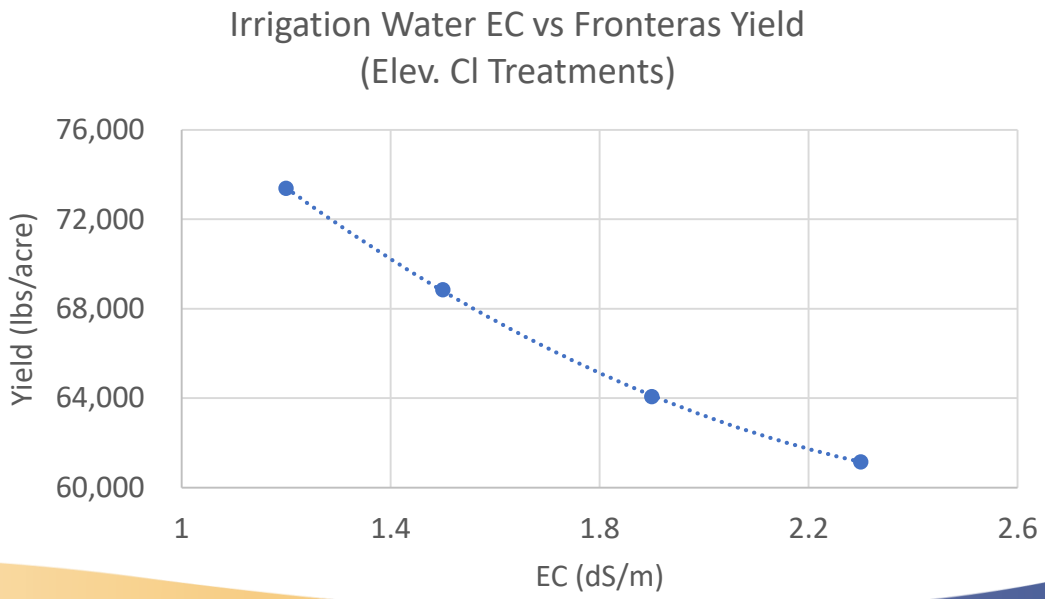

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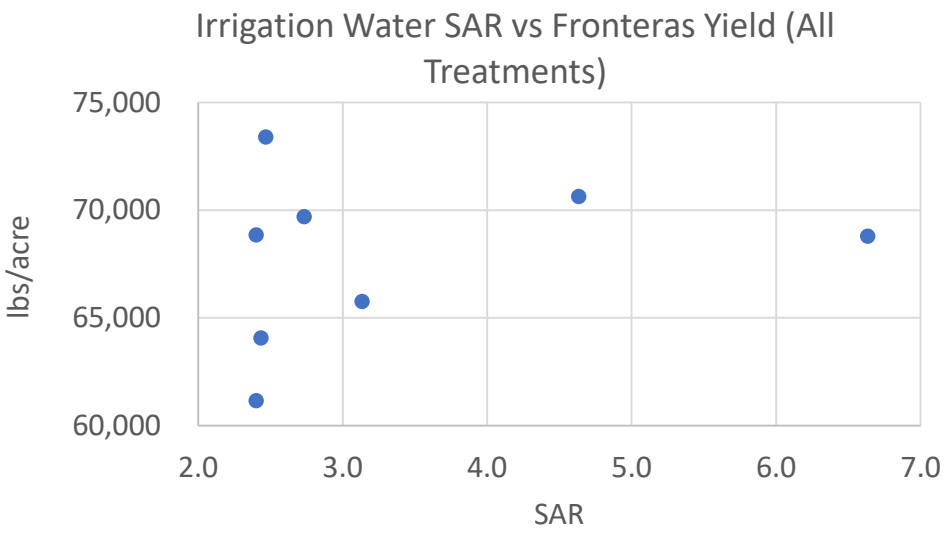
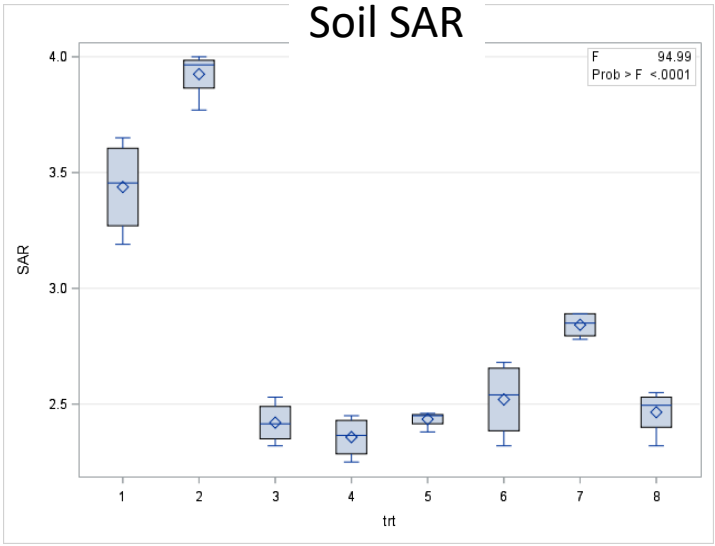
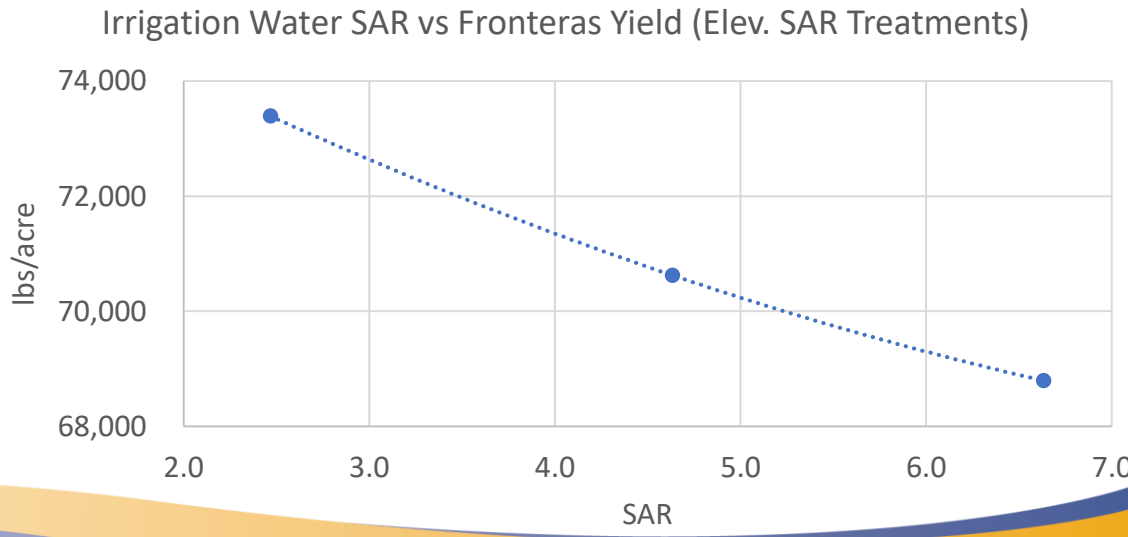
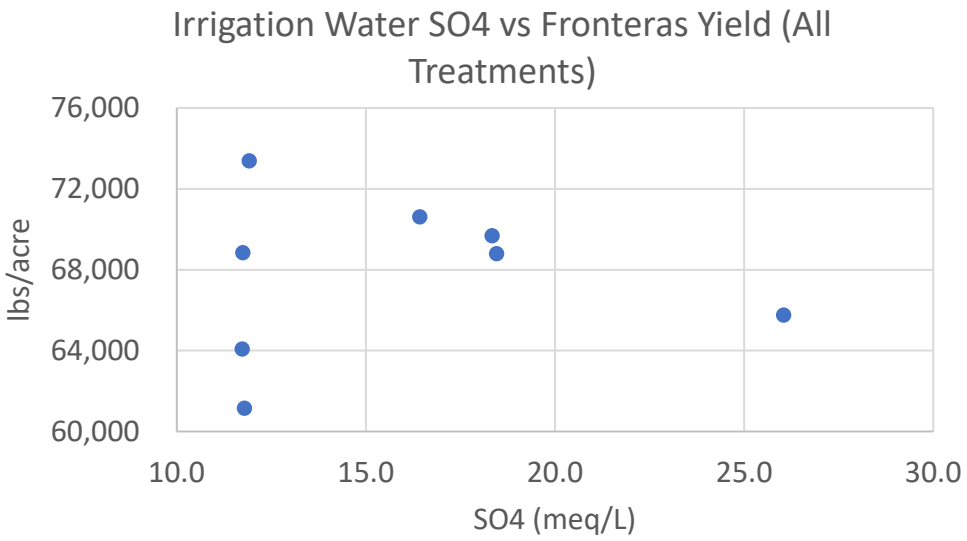
Irrigation Water SAR

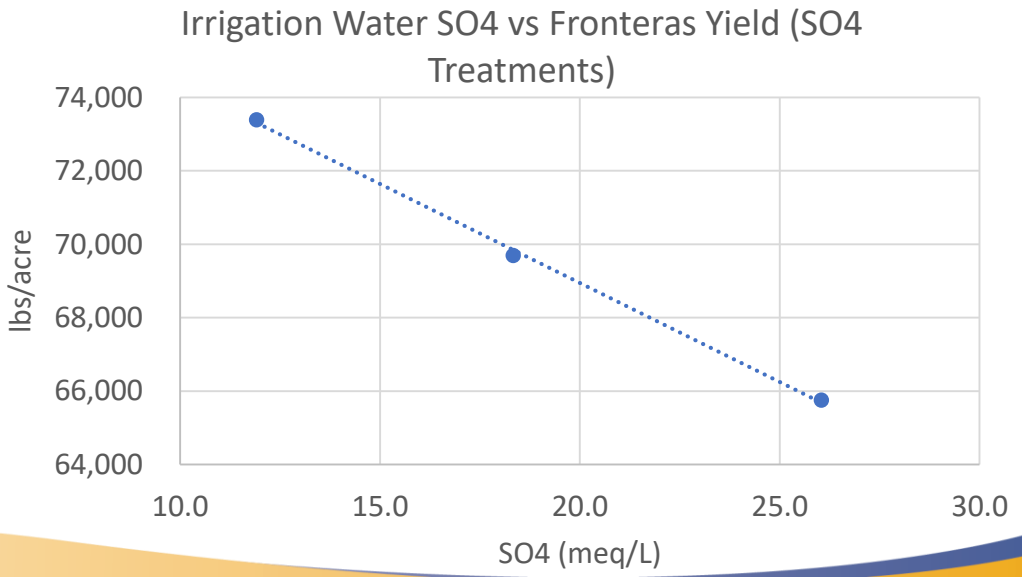






Irrigation Water SO4





Other observations:

- ✓ Yield reduction happened before plant symptoms
- ✓ Plant symptoms not evident until late May
- ✓ Significant effects and trends of treatments on Fronteras yield started to appear in April
- ✓ Cull rates of both Fronteras and Monterey weren't affected by treatments; no trends observed
- ✓ Small effect (up to 6%) of treatments on berry weight of Fronteras; Monterey not affected
- ✓ June yield was highly affected by lygus bug outbreak

Summary

- Fronteras is highly susceptible to salinity, especially Cl
- Salinity effects on Monterey were not statistically significant
- Rainfall between 1st and 2nd sampling emphasize the effectiveness of leaching with good water
- Don't wait for plant symptoms: know your water and soil chemistry
- Research needed for other cultivars

Acknowledgements:

- Crisalida Berry Farms: David Murray, Matt Conroy, Raul Coronado, Ezikiel Ramirez, Constancio Garcia, Luiz and the harvesting crew
- Tim Hartz, UC Davis Extension Specialist
- Michael Cahn, UC Cooperative Extension, Monterey County
- Steve Grattan, UC Davis Extension Specialist
- Nathan Bradford and Kamille Garcia, UC Cooperative Extension, SRAs
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- Thelma Hansen Funds

Questions/comments?

Field Day, June 2018