

# Evaluation of Two Materials to Increase Drought Tolerance and Growth of Permanent Crops



By: Garrett Gilcrease

# Background



- ❧ Grew up on a farm in Central California
- ❧ Small town of Lemoore, right in the middle of the San Joaquin Valley
- ❧ Attended California State University Fresno
  - ❧ B.S. in Plant Science – Agronomy
  - ❧ Have both a PCA and CCA Licenses
- ❧ Worked as an Independent Agronomist from 2007 to early 2012 specializing in permanent and high value crops
- ❧ Current a Technical Service Representative for Syngenta Crop Protection

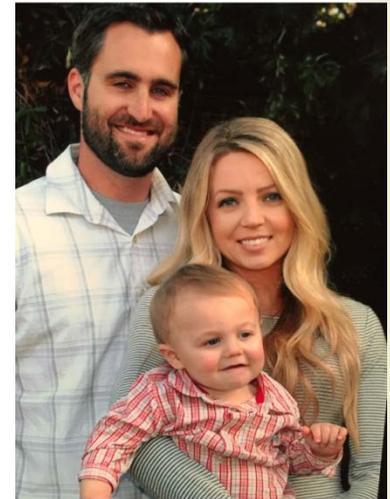


# Background



## Family

- Wife of four years, Leah and my son Reid (1)
- Still heavily active on the family farm
  - +/- 1,000 acres of Almonds, Tomatoes and Wine Grapes
  - Been in the family since the late 1800's
- I enjoy all aspects of agriculture and find it truly rewarding when I can be of help to anyone in that field.



# Overview



- ❧ Agriculture in California
  - ❧ The Past and Future
  - ❧ History of Permanent Crops in the Valley
  
- ❧ Chapter(s) outline
  - ❧ Treatments
  - ❧ Plot area
  - ❧ Crop / Pest info
  - ❧ Materials and Methods
  - ❧ Data Collection
  - ❧ Results and Discussion



# Agriculture in California



- ❧ California has a rich history of Agriculture
  - ❧ Great climate, large land area and ample water (at one time)
  - ❧ The SJV has become known as the breadbasket of the world since farmers first settled there
  - ❧ Has an economy which ranks 8<sup>th</sup> in the world in terms of GDP
  - ❧ \$37 Billion in Ag, \$100 Billion in related economic activity
- ❧ Initially wheat in the 1800's
  - ❧ Began to outgrow consumption in the 1850's but tapered in the early 1900's
- ❧ Fruit came on the scene in the late 1890's
  - ❧ Fruit Production only expanded in the early 1900's as advancements in agronomics came along

# Agriculture in California

## Continued

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- By 1919, California Produced over 50% of the oranges, 80% of the grapes and virtually all apricots, almonds, walnuts, olives and lemons in the United States
- By 1950, Cotton was king becoming the most valuable crop for years to come (peak of 1.5 million acres in 1980)
- Cotton has now faded to an all time low and has been replaced with higher value crops such as
  - Vegetables, Tree Nuts, Vines and Citrus

# California Agriculture Today

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- ☞ Today, consistent reductions in irrigation allocations and other fixed costs have changed the face of Ag.
- ☞ Forces many to abandon crops like cotton in favor of higher value crops:
  - ☞ Almonds - +/- 1 Million Acres
  - ☞ Walnuts - +/- 315,000 Acres
  - ☞ Pistachios - +/- 200,000 Acres
  - ☞ Citrus - +/- 270,000 Acres
- ☞ All higher value but all permanent thus requiring a constant water source year after year

# Drought



- ❧ California is no stranger to drought
  - ❧ Historic droughts in the late 70's and mid to late 80's
- ❧ Annual crop matrix allowed for fallowing to manage water supplies
- ❧ Permanent crops take this flexibility away
- ❧ The last reservoir was completed by the state in 1959
  - ❧ Population in 1959 = **15 Million**
  - ❧ Current Population = **38.8 Million**
  - ❧ Proj. Population(2025) = **50 Million**

❧ Census.gov and  
CaliforniaWatchdog.org



# Chapter One



❧ Evaluation of a soil applied irrigation additive designed to maximize water efficiency and availability within the root zone

- ❧ The product is called RainDrops and was sold by Watermax LLC now called MorWater Solutions LLC
- ❧ Originally created for the construction industry to keep roads wet longer and to arrest dust

❧ Due to its lower cost than other alternatives I wanted to see if it actually worked

- ❧ Chose almonds as the crop to test it on due to the needed stress during hull split - often irrigated at only 50% of ET to reduce hull rot (image on the right)



I have studied RainDrops a few times and a “grower report” is available online @watermaxllc.com

# Desired Outcome and Treatments

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- ❧ By the end of this study, the hope was that we could determine the effect, if any, that RainDrops had on soil moisture and overall crop stress
- ❧ The Treatments were:
  - ❧ 100% Irrigation (the same amount of water applied to the entire field)
  - ❧ 100% Irrigation with RainDrops (the above with RainDrops added)
  - ❧ 50% Irrigation (the amount of water applied to the field but cut by 50%)
  - ❧ 50% Irrigation with RainDrops (the above with RainDrops added)

# The Field



- ❧ Lemoore, CA , Kings County
- ❧ 5 Year old Almonds
  - ❧ NP, Monterey and Fritz varieties
  - ❧ Double line drip irrigation
  - ❧ Sandy to medium texture soils
  - ❧ Kimberlina Fine Sandly Loam



Map Unit Legend			
<b>Kings County, California (CA031)</b>			
Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
130	Kimberlina fine sandy loam, saline-alkali	89.8	100.0%
<b>Totals for Area of Interest</b>		<b>89.8</b>	<b>100.0%</b>

**Report – Map Unit Description**

**Kings County, California**  
**130–Kimberlina fine sandy loam, saline-alkali**

**Map Unit Setting**

National map unit symbol: hhjh  
 Elevation: 190 to 3,500 feet  
 Mean annual precipitation: 4 to 8 inches  
 Mean annual air temperature: 61 to 64 degrees F  
 Frost-free period: 210 to 300 days  
 Farmland classification: Farmland of statewide importance

**Map Unit Composition**

Kimberlina and similar soils: 85 percent  
 Minor components: 15 percent

*Estimates are based on observations, descriptions, and transects of the mapunit.*

**Description of Kimberlina**

**Setting**

Landform: Alluvial fans  
 Landform position (two-dimensional): Footslope  
 Landform position (three-dimensional): Tread  
 Down-slope shape: Linear  
 Across-slope shape: Linear  
 Parent material: Alluvium derived from igneous and sedimentary rock

**Typical profile**

Ap - 0 to 8 inches: fine sandy loam  
 C - 8 to 60 inches: fine sandy loam

**Properties and qualities**

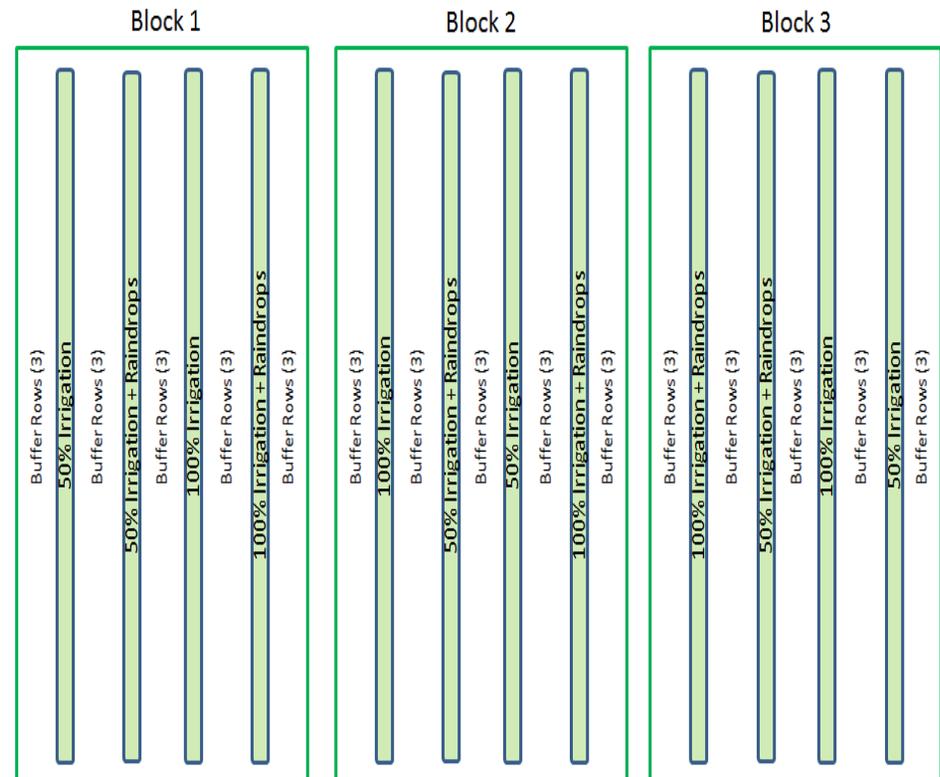
Slope: 0 to 2 percent  
 Depth to restrictive feature: More than 80 inches

# Plot Area



- Almonds are planted in rows with two drip lines, one on either side of the row in this particular field
- Nonpareil was the variety chosen due to
  - It being the most popular almond variety
  - It is planted in alternating rows to 50% of the block
  - It is the most prone to hull rot and harvest is usually driven around this variety

Aerial View of the different blocks within the field site or treatment area.



# Why Almonds?



- ❧ I have been asked why I chose Almonds and not an annual crops such as Tomatoes or Cotton?
  - ❧ Almonds represent a large acreage footprint in CA therefore I thought there would be mass acceptance
  - ❧ Almonds cannot sustain prolonged drought like pistachios and grapes can and survive
  - ❧ As mentioned before, almonds are prone to hull rot which is a yield robbing disease linked to humidity/moisture
  - ❧ Being a permanent crop in CA, they need a long term, secure water source and are prone to drought periods they have to sustain

# What an Almond Orchard Looks Like

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# A Common California Irrigation System

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# Materials and Methods



- ❧ Chemical injectors were used to inject the product over an irrigation cycle to the specified Rows / Treatments
- ❧ Emitter plugs were used to plug of every other emitter within the 50% Applied Water treatments
  - ❧ Blocking every other emitter accomplishes a few things:
    1. It allows for a reduced irrigation rate on only portions of a block or field
    2. It is much more uniform than just pinching off one entire line on one side of the tree (only  $\frac{1}{2}$  of the root system is used)
    3. Outside of the plot area, the field can remain the same as the intended design



# Materials and Methods

## Continued



- ❧ A leaf pressure chamber to measure leaf water potential in each treatment
- ❧ Soil moisture sensing equipment
  - ❧ Logger boxes
  - ❧ Soil moisture probes put at 12, 24 and 36 inches in each treatment
  - ❧ Pressure switches and data shuttles to enable data collection and irrigation system monitoring

# Materials and Methods

## Continued



- ∞ The trial lasted for a total of eight weeks beginning at hull split and ending when the Nonpareil variety was harvested.
- ∞ RainDrops was injected five times and every other week after an initial dosing period during weeks one and two.
  - ∞ 20 oz. was used to “pre load the soil”

Rain Drops Treatment Table

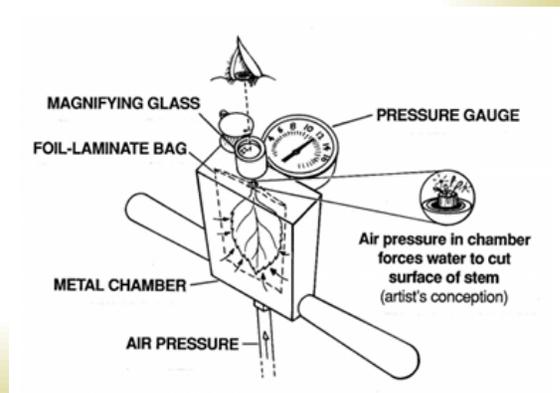
Week Number	Injection Rate Per Acre
1	20 oz.
2	16 oz.
3	None
4	16 oz.
5	None
6	16 oz.
7	None
8	20 oz.
	<b>88 oz. Total Per Acre</b>

# Data Collection



- Every week, leaf moisture potential was measured using a leaf pressure chamber
  - Only leaves in the shade (often within canopy and at eye level) were used
  - Taken between 11 a.m. and 1 p.m. Must be done at this time to get accurate and confident results.
  - 10 leaves from each treatment/rep were measured and results averaged for that field visit.

 [pmsinstrument.com](http://pmsinstrument.com)



# Data Collection

## Continued

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- Soil moisture was collected automatically and electronically
  - Use of soil moisture probes installed at depths of 12, 24 and 36 inches within each rep. Each probe was separated by 42 inches to limit as much emitter interference as possible
  - The probes were read and recorded every 15 minutes for the duration of the trial
  - The data was pulled off of the logger box and inputted into a program where it was converted to a CSV file what could be read in Excel.



# Results and Discussion



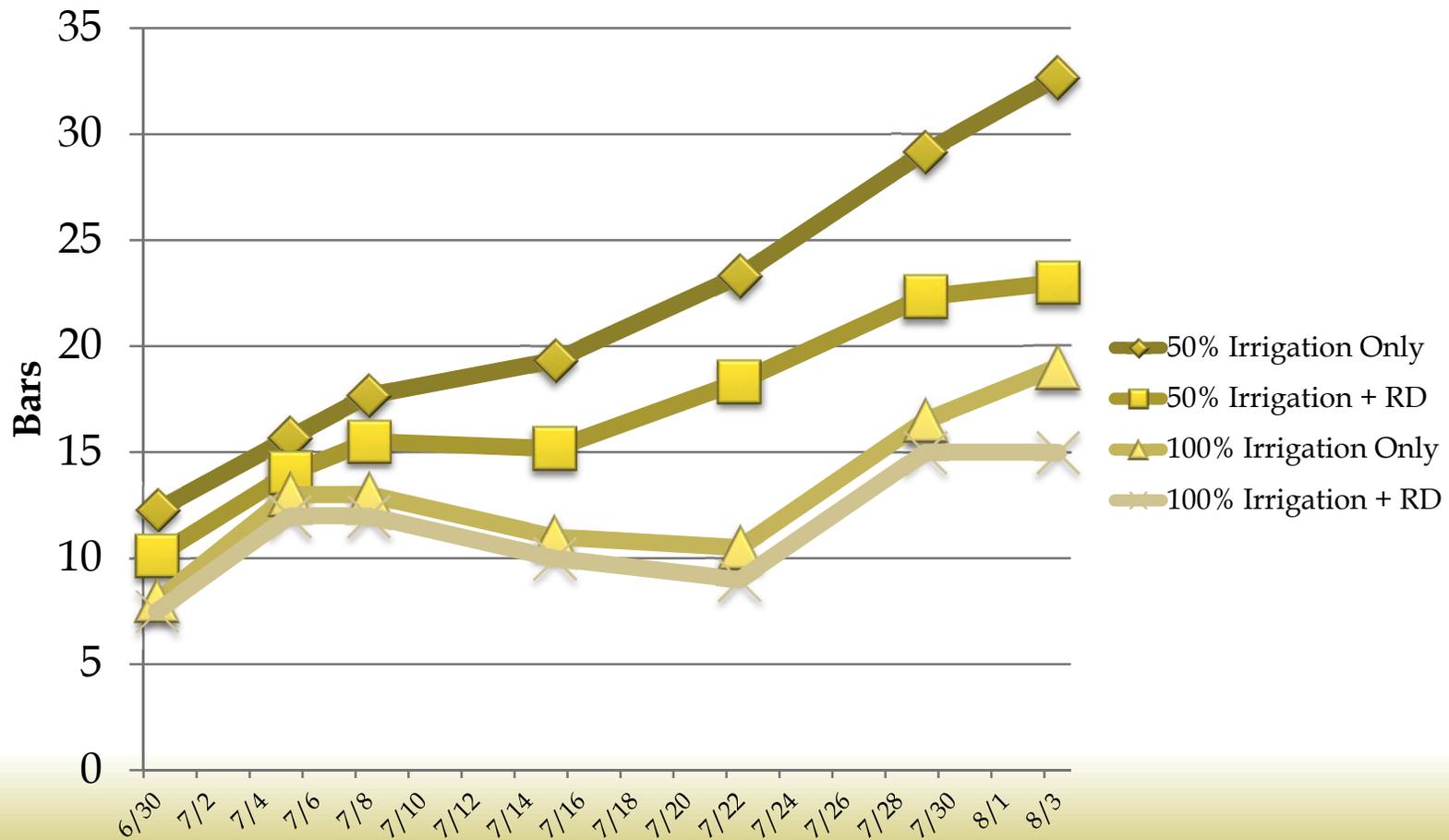
- ☞ Throughout the trial, it became evident early on that there was effect when using this product
  - ☞ Leaf potential readings were consistently lower as was the deficit within the root zone
  - ☞ The rate of hull split was much slower within the treated reps of both application amounts



# Leaf Water Potential



## Leaf Water Potential



# Leaf Water Potential



Irrigation Level and Treatment		Mean Leaf Moisture Potential in Bars	Date	50% Rain Drops	50% UTC	100% Rain Drops	100% UTC
50% Irrigation		21.40 A	6/30	9.76 A	11.83 A	8.75 A	10.25 A
			7/5	12.33 A	13.66 A	11.00 A	13.50 A
50% Irrigation with RainDrops		16.93 B	7/8	15.50 A	17.66 A	14.50 A	14.50 A
			7/15	15.16 A	19.33 B	12.60 A	13.30 A
100% Irrigation		16.66 A	7/22	18.33 A	23.33 B	14.00 A	15.50 A
			7/29	22.33 A	29.16 B	17.60 A	21.10 A
100% Irrigation with RainDrops		14.27 B	8/3	23.00 A	32.66 B	18.60 A	25.66 B

# Soil Moisture



Irrigation Level and Treatment		Mean Soil Moisture in Centibars	Week Number	50% Rain Drops	50% UTC	100% Rain Drops	100% UTC
50% Irrigation	153.49 A		1	24.50 A	40.83 A	19.16 A	30.00 A
	79.47 B		2	16.66 A	76.66 B	27.50 A	61.33 B
	132.26 A		3	29.16 A	117.52 B	23.33 A	80.83 B
	67.31 B		4	59.16 A	157.83 B	40.83 A	105.00 B
50% Irrigation with RainDrops	79.47 B		5	93.33 A	117.52 B	56.16 A	142.50 B
	132.26 A		6	145.8 A	204.50 B	92.50 A	180.16 B
100% Irrigation	132.26 A		7	158.3 A	227.50 B	128.33 A	206.66 B
	67.31 B		8	132.3 A	212.50 B	125.83 A	215.16 B
100% Irrigation with RainDrops	67.31 B		9	66.66 A	170.83 B	83.33 A	173.16 B
	153.49 A		10	60.00 A	145.00 A	75.00 A	123.33 A

# Chapter One Conclusion

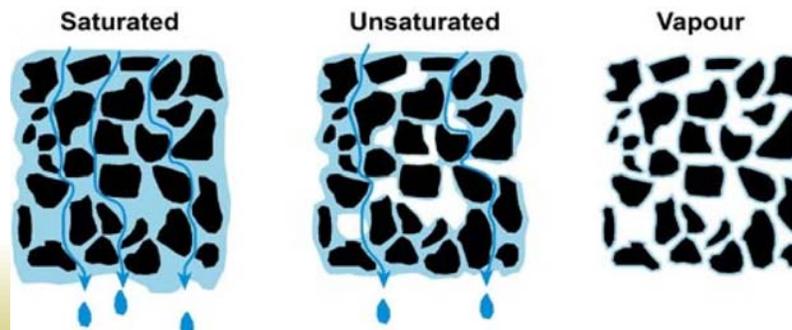


- ❧ The addition of RainDrops did have an effect on both soil moisture and leaf water potential.
  - ❧ Soil moisture was more evident, changed quicker and had longer results compared to leaf water potential
  - ❧ Possible indication that the root zone was nearly full before the study began thus it would take longer to exhaust the large amount of free moisture before tree stress could be measured in leaf water potential.
  - ❧ The effect seemed to increase as deficit irrigation increased in severity but there was some impact even when full irrigation amounts are attained.

# Chapter One Conclusion Continued



- Specifically looking at the data, significant changes in soil moisture happened after the second week but significance did not occur in leaf water potential until week four or five.
  - Indicates that RainDrops was having an effect on the availability of soil moisture within the root zone and the plant ability to extract it from the soil medium.
  - Possibly has an effect on water tension



# Chapter Two

## Introduction

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- ❧ Evaluation of a soil applied fungicide, Ridomil Gold SL, in young permanent tree crops for orchard establishment
  - ❧ Almonds and Pistachios - 5 sites in total in the central valley
  - ❧ Applied once per year in the spring and trunks measured a year later.
- ❧ With new irrigation practices and ever eroding water quality, root health is a constant worry
- ❧ Study was conducted with the help and influence of many Syngenta Employees, some of which are no longer with the company

# Introduction Continued



- ❧ Ridomil Gold SL is a soil applied fungicide containing the active ingredient - Mefenoxam
- ❧ It was originally created in the 1970's and is now owned and marketed by Syngenta Crop Protection
- ❧ It has been a mainstay in the oomycete market for a long time and is commonly use in soil and seed treatments for:
  - ❧ Small and large seeded vegetables
  - ❧ Tomatoes
  - ❧ Carrots
  - ❧ Citrus and many other crop groups
- ❧ Main targets are *Phytophthora* and *Pythium* species

# *Phytophthora* in CA and Tree Crops

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- ☞ According to the University of California, *Phytophthora* and *Pythium* are contained at some level within many soils in California.
- ☞ Interactions can be as little as low vigor due to fibrous root damage to rapid tree death
  - ☞ Depends on species and site of infection
- ☞ A very common problem that was gone for a while but has come back in the past few years
  - ☞ We have brought back the environment to the disease triangle

# *Phytophthora* Impact



# Why Tree Nuts?



- ❧ Tree nuts make up over 1.5 million acres in the state of California and contribute billions of dollars to the state economy
- ❧ Once a thing of the past, pathogens such as *Phytophthora* and *Pythium* are making a comeback
  - ❧ Poor quality well water
  - ❧ Irrigation methods
  - ❧ Back to back rotations
  - ❧ Restrictions on fumigation
- ❧ There are a lack of products on the market to combat this issue and many have issues themselves
- ❧ Can enable other infections such as crown gall

# Why Tree Nuts Continued

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- ❧ Permanent crops are long term investments
  - ❧ Often last 25 to 50 years after planting if not longer
  - ❧ Take large amounts of capital to grow and maintain
- ❧ What is done this year, can have long term effects
  - ❧ Unlike annual crops, there is no “do over insurance”
  - ❧ What is done or not done this year, has ties years into the future
- ❧ Tree nuts are at an all time high thus the need to protect your investment.
- ❧ As with other very mobile, systemic products, there is thought to be a growth benefit with this product.

# Three Major Tree Nuts in CA

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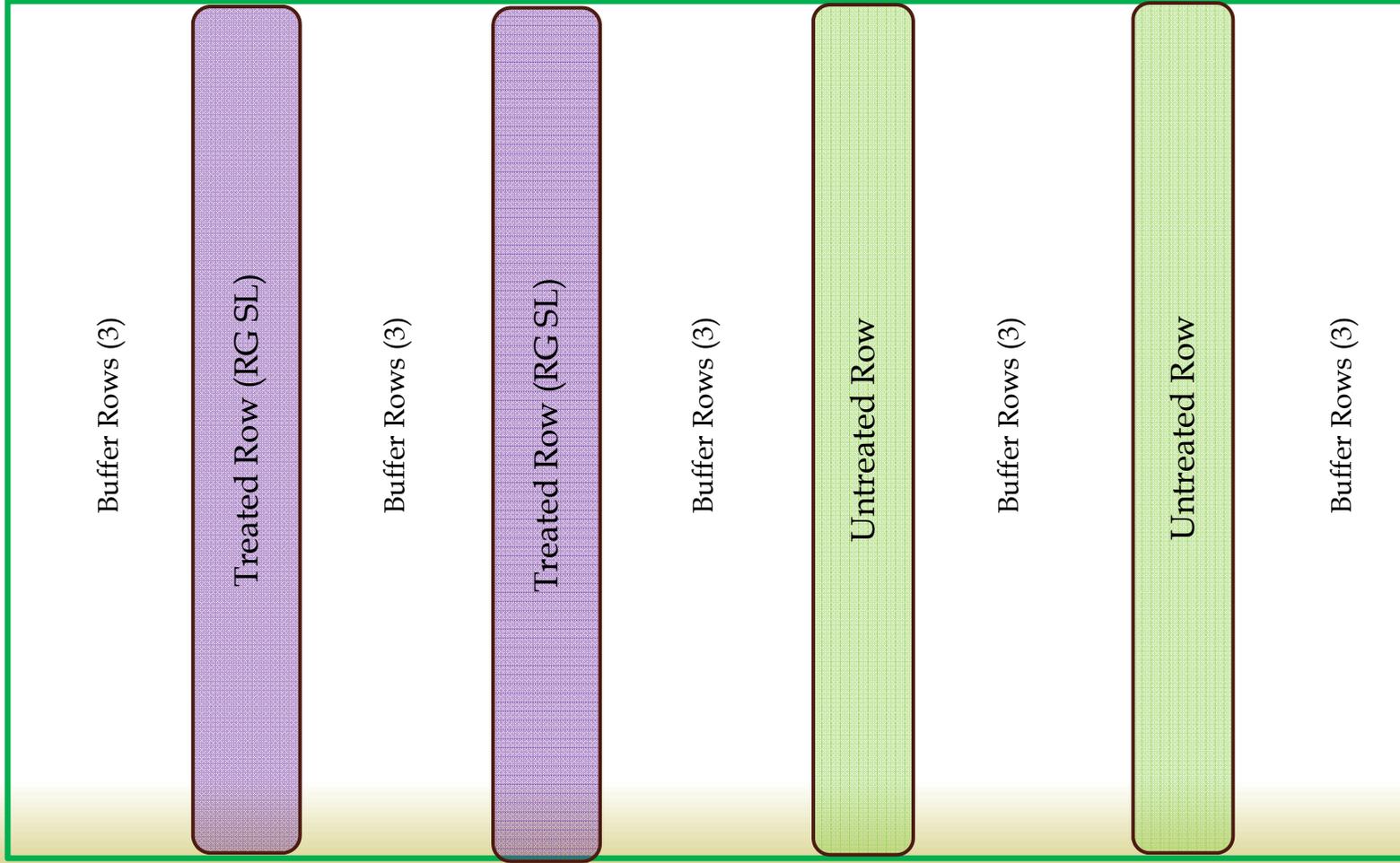


# Desired Outcome and Treatments



- ❧ The desired outcome is to evaluate Ridomil Gold SL for its efficacy in a young tree care establishment program even when no pathogen testing has been done.
- ❧ There are two treatments:
  1. Ridomil Gold SL at a rate of 1 pint per broadcast acre
  2. UTC or no Ridomil Gold SL added
  3. Total trees in trial - approx. 1,600
- ❧ 1 year later, tree trunk measurements were be taken to measure growth rate
- ❧ Trial has continued on for the past few years

# Aerial View of the Plot Layout(s)



# Plot Locations



- ❧ 5 Sites in total – 1 pistachio and 4 almond
  - ❧ Located within the south valley and in grower fields
  - ❧ Only change from grower standard is the addition of Ridomil Gold SL to the specified rows
  - ❧ No testing has been done to measure for *phytophthora* or *pythium* in these blocks



# Materials and Methods



- ⌘ A chemical injector similar to the previous chapter were used to inject the material
  - ⌘ This injected material throughout the entire drip lines on that row
  - ⌘ Timed towards the end of an irrigation to prevent leaching



# Data Collection



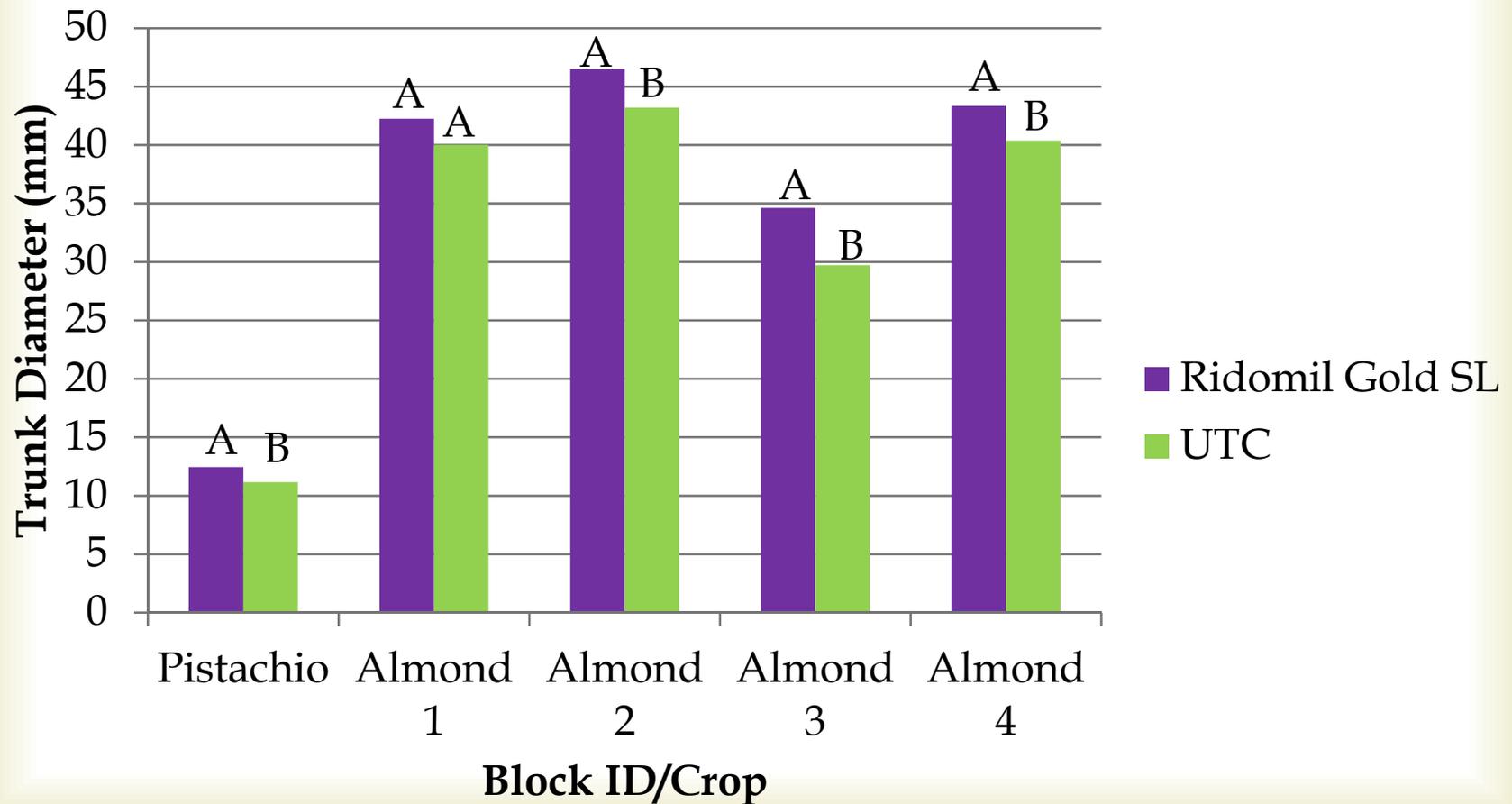
- ❧ At the beginning, initial measurements were taken of the trees
- ❧ A season after the application, trunk measurements were taken using a pair of electronic calipers two feet above the graft union to get the trunk diameters
  - ❧ Usually done in the spring at leaf emergence
- ❧ Another round of Ridomil Gold SL was then injected at the same time at a rate of 1 pint per acre
  - ❧ At which point, another measurement will take place the following spring.
  - ❧ All measurements were taken by some of my colleagues, myself and various interns we have had at the time

# Results and Discussion



- After the initial injections and trunk measurements were taken, the data showed that there were significant differences between the Ridomil Gold SL plots and the untreated
- The increase in trunk diameter and the consistency open the door to the thought that the treated trees were healthier and/or more vigorous than the untreated

# Mean Increase in Trunk Growth After 1 Year



Bars not connected by the same letter are statistically different at p 0.05

# Chapter Two

## Conclusion

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- ❧ The application of Ridomil Gold SL at 1 pint/acre resulted in increased growth over the untreated with the exception of one plot site
- ❧ The increase in growth could be the protection from even the smallest *Phytophthora* or *Pythium* infection or could be attributed to the systemic nature of the A.I. leading to increased vigor.
- ❧ Yield measurement is planned in the future to see if this increase in trunk size can be linked with increased yield later in the future.

# Overall Conclusion



- ⌘ As you can see, California is very diverse and unlike popular opinion, is very agriculture oriented
- ⌘ We produce over 300 different crops, export a majority of that and continue to evolve and adapt to an ever changing agriculture environment
- ⌘ Farming is a continual challenge and now more than ever, the future of farming in CA is uncertain



# Acknowledgements



- ❧ Chapter 1 –
  - ❧ K. Quade and J. Silva
- ❧ Chapter 2 –
  - ❧ S. Downey, M. Mackenna, L. Herne, R. Williams and Various others also had some hand in this as well so a very big thank you to them
- ❧ My Major Professors: Dr. Loynachan and Dr. Moore for being a part of my graduate committee.
- ❧ Dr. Lenssen – Your guidance, words of wisdom and overall positive attitude have been extremely valuable throughout this entire process.
- ❧ Lastly, my wife and entire family for their support during this process.

# Thank You!



Questions?