Every Other Row Furrow Irrigation Trial

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Table of Contents

List of Tables and Figures .................................................................................................................. iii

Abstract ........................................................................................................................................ iv

Chapter One- Introduction .............................................................................................................. 1

Statement of the Problem .................................................................................................................. 1

Objectives of the Experiment .......................................................................................................... 2

Important Terms ............................................................................................................................... 3

Summary of Chapter One .................................................................................................................. 4

Chapter Two- Review of Literature ................................................................................................. 5

The History of Silage Corn ................................................................................................................ 5

Silage Production .............................................................................................................................. 6

Irrigation Methods for Corn .............................................................................................................. 7

Every Other Row Furrow Irrigation ................................................................................................. 8

Chapter Three- Materials and Methods .......................................................................................... 11

Chapter Four- Results ....................................................................................................................... 17

Chapter Five- Recommendations and Conclusions ....................................................................... 20

Conclusions .................................................................................................................................... 21

Bibliography .................................................................................................................................... 23

Appendix .......................................................................................................................................... 24
List of Tables and Figures

Figure 2.1 – An Early Corn Silage Processor................................................................. 6
Figure 2.2 – Krone BiG X 1100.................................................................................. 6
Table 3.1 – The Test Plot Layout.................................................................................. 11
Figure 3.1 – The Seedbed Preparation Equipment......................................................... 12
Figure 3.2 – The Furrowing and Side Dressing Equipment............................................. 13
Figure 3.3 – The First Attempt to Irrigate Every Other Row......................................... 14
Figure 3.4 – Calculating Grain Yield............................................................................ 15
Figure 3.6 – The Chopper and a Truck at work............................................................... 16
Table 4.1 – The Effects of Irrigation Method on Average Grain Yield, Silage Yield, and Plant Height.................................................................................. 17
Figure 4.1 – The Effects of Irrigation Method on Average Grain Yield......................... 18
Figure 4.2 – The Effects of Irrigation Method on Average Silage Yield....................... 18
Figure 4.3 – The Effects of Irrigation Method on Average Plant Height....................... 19
Figure 5.1 – Height Differences Between Two Treatments Shortly After Tasseling.... 20
Appendix A. – The Raw Data from Each Treatment and Replication......................... 24
Abstract

Silage corn yields are limited by irrigation effectiveness in the Central Valley of California. This experiment was conducted to determine if silage yield would suffer after altering irrigation methods and timing. The effects of irrigation method and timing were tested on field corn *Zea mays (DKC 67-86)*. The study was carried out in Denair, California on a Whitney Rocklin sandy loam. Silage tonnage, grain yield, and plant height were compared across four treatments with three repetitions of each treatment. The treatments were every other row, the grower’s standard practice, deficit, and a control. The experiment showed that every other row irrigation does not significantly hurt silage corn yields when compared to the control, with every row irrigated on the same schedule as every other row. Grain yield showed the most variation among the treatments with the control yielding an average of 225.71 bushels per acre, deficit yielding an average of 140.04 bushels per acre, and the other two treatments ranging in between. Overall, the experiment showed that more irrigations results in higher yielding corn, and every other row irrigation could be utilized to speed up the irrigation schedule.

*Additional Index Words: Irrigation, furrow irrigation, every other row irrigation, silage corn, utilizing dairy lagoon water, estimating grain yield, Zea mays (DKC 67-86).*
Chapter One

Introduction

In the Central Valley of California, water has and always will been an issue. California’s agriculturalists use a large quantity of water, but California produces a huge percentage of the world’s food. Farmers need to do their part to conserve water. Farmers around California who practice every other row irrigation have seen greater water savings without a significant reduction in yield. This experiment will test the practicality of every other row furrow irrigation on silage corn in Eastern Denair, California. This experiment should show whether or not the soils in Eastern Denair are suited for every other row irrigation.

Statement of the Problem

Growing corn on the rolling hills East of Denair is not easy. A two-foot deep hardpan layer rests under the topsoil. The local irrigation district provides surface water to some farmers in the area, but all the irrigation water East of Hickman Road must be pumped from the 230-foot deep water table, and pumping well water is slow and expensive. The average rainfall for the area is around fifteen inches each year. About 95% of the rain comes in the winter between November and April; so all summer crops must be irrigated. Corn farmers must irrigate through furrows or center pivots because of the rolling hills. Basin flood irrigation is generally out of the question because of the slopes of the land. Almond farmers, who have mastered the challenges of these rolling hills with drip irrigation, have snatched up almost all the land not growing corn and they are eager to buy more.

So why even try to grow corn on this ground? In twenty-two square miles East of Hickman Road there are eight dairy farms, all who depend on corn silage to feed their cows. The value of corn silage is increasing, so purchasing it is difficult and trucking corn silage from a distance greater than a mile adds a surcharge. Meanwhile more and more acres of land get planted with almonds,
effectively removing the possibility for those acres to ever grow corn again because almonds are a long-term crop. So, the eight dairy farmers in Denair need to harvest more corn silage off fewer acres, at a price they can still afford. It is important for the farmers to utilize water and soil nutrients to their fullest extent. Dairies naturally produce an abundance of nutrients, in the form of manure. That manure is utilized to fertilize the crops the dairyman grows to feed his cows. The manure cycle works well, but it can lead to a buildup of salts in the soil, which can negatively affect corn yields. Corn farmers need an efficient way to irrigate their crop and also manage soil salts. In other areas of California, every other row irrigation has successfully corrected these problems. This experiment will reveal whether or not every other row irrigation could work to help correct these problems in Denair.

The purpose of this experiment is to grow better quality corn at D & M Ag. D & M Ag is a dairy farm in Eastern Denair. Over the past few years, D & M Ag has had trouble producing the amount and quality of corn silage they need to feed their cows. If successful, the information learned in this experiment will help D & M Ag understand what they can do to save water without sacrificing their production.

Objectives of the Experiment

1. To compare water saving irrigation methods and discover how silage corn responds in the soils in Eastern Denair, California.

2. To determine if every other row irrigation can produce quality corn silage without a reduction in yield as compared to deficit irrigation, the grower’s standard practice, and a control.
Important Terms

1. Silage – Fermented plant material that is fed to cattle. Silage can be made from many crops but is generally made from small grains or corn. The plant material is chopped into small pieces and packed in a pile. It is then covered to prevent exposure to oxygen and allowed to ferment.

2. Chopping – The act of harvesting plant material and cutting it into small enough pieces in order to make silage. Chopping is done with a forage harvester, otherwise known as a chopper.

3. Furrow – A trench pulled up next to a row of plants to deliver water to the crop.

4. Furrower (Also known as a Lister) – A tool bar with shovels that is attached to a tractor and designed to cut furrows.

5. Lagoon – Pond designed to store processed wastewater generated by a dairy.

6. Lagoon Water – Water in the lagoon. Lagoon water is a great fertilizer and can be delivered through an irrigation system.

7. Tail Water – Irrigation water that runs off the end of the field once the irrigation set is complete.

8. Tail Pond – Pond designed to catch tail water so it does not go to waste. Tail ponds have a pumping system to return water to the top of the field for reuse.

9. Levee – A long mound of soil designed to hold or direct water.

10. Short Levee – Levee pulled up to help water move from the irrigation valve to the furrow. A short levee will feed three to six furrows. An irrigation valve will feed two short levees.
Summary of Chapter One

Corn is an important crop to dairymen throughout the world. Irrigation water is a key resource and should be conserved as much as possible. The land in Eastern Denair presents a number of challenges, but every other row furrow irrigation presents a solution to some of those problems. I expect the difference in corn yields will be null between the grower's standard irrigation practice and every other row irrigation, however I expect every other row irrigation will irrigate quicker than the rest of the treatments. This experiment will determine whether or not every other row furrow irrigation is practical for D & M Ag and other farmers in Eastern Denair.
Chapter Two

Literature Review

This literature review will help the reader understand what information is available regarding silage corn and irrigation. It will briefly discuss the origins of silage and advancements in producing corn silage. It will address what a grower needs to consider in regards to silage production. It also reviews the need to irrigate and a few general methods of irrigating corn in California. Finally, this literature review will look into every other row irrigation with the goal of reducing the amount of water utilized.

The History of Silage Corn

Fermentation of plant tissue has been a preservation technique for a long time. Today this fermented plant tissue is referred to as silage, which is fed solely to livestock. According to the dictionary, the word silage comes from the word silo, which was derived from Greek word siros which means cornpit. Early methods of storing and harvesting silage date back to as early as 1500 - 1000 B.C. Ancient murals show that Egyptians were familiar with harvesting and ensiling whole crop cereals, and early silos were found in the ruins of Carthage (Pandey & Larroche, 2008). Ensiling corn has now become a modern practice. Western Civilization stumbled upon corn when Columbus landed in Cuba in 1492. It quickly became a popular crop (Gibson & Benson, 2002). Harvesting corn silage has always been a challenge. Corn silage processors from early nineteenth century used rollers to feed corn stalks into spinning knives that would cut the corn into pieces (Circle Rock Inc., 2012),(Figure 2.1). Methods of harvesting and processing corn silage have made significant progress over the years.
Today the Krone BiG X 1100 Forage Harvester (Figure 2.2) totes 1,078 horsepower, and can cut fourteen rows of corn in one pass (Krone-North America, 2012). Harvesting corn silage today is easier than it used to be, but there is still a lot of labor and inputs that must go into a corn crop to produce good quality corn silage.

Silage Production

Lots of factors contribute to the production of silage. Good corn silage can be compared to a three-legged stool. It takes crop management, silage management, and good weather to have a successful harvest (Lee, Herbek, Lacefield & Smith, 2005). If one leg breaks, disaster will ensue. The production process starts with selecting a corn hybrid (Lee, et al., 2005). It is important to
choose a hybrid designed for silage corn. Factors to consider when choosing the hybrid include, but are not limited to: the time it takes the crop to reach maturity, herbicide resistance, insect resistance, and disease tolerance (Lee, et al., 2005). Even the very best hybrid will fail if silage management principals are not maintained, and bad weather cannot always be avoided, even with the best management. Other management factors that must be considered for successful crop include: planting date, planting depth, and seed rate, tillage and soil chemistry (Lee, et al., 2005).

Irrigation Methods for Corn

Although there are lots factors involved with corn silage production, the biggest factor is water. Corn requires somewhere between 25 and 29 inches of water (Frate & Schwankl, 2008). In California the average rainfall is 22.99 in, and almost all of that rain comes during the colder months, October through April (USA.com, 2012). Corn will not grow between October and April, which means that the water needed to grow corn must come from irrigation. There are a number of irrigation methods currently used in California, some of which work better than others.

Border irrigation is widely used in the Central Valley. Border irrigation is possible when the field is level and square (Tacker, 2003). A border is pulled up around the field, and the field is flooded (Tacker, 2003). Border irrigation is popular because it provides excellent results. A field can be watered very quickly, easily, and evenly. There are, however, negatives to border irrigation. A lot of water is required in order to flood the field, and it is easy to overwater the crop. The field must initially be laser leveled in order to set up a proper borderer irrigation system (Brown, 2008). Laser leveling can be costly if the land is not close to level to start with. The soil type must be taken into consideration with border irrigation because slow drainage can cause issues (Brown, 2008).

Furrow irrigation is another method of flood irrigation, but it does not require level land. Hundreds of parallel furrows direct the water down the field so the entire field gets flooded (Rogers, 1995). The shear volume of water needed is less than border irrigation. Crops can be
planted onto the furrow, or the furrow can be pulled up around the growing crop, but both options have their own sets of problems. Planting into furrows can cause excessive wheel tracks (compaction) in the same row, but pulling up furrows around the growing crop is difficult and requires a skilled equipment operator, and it is very easy to destroy the crop.

Using, overhead center pivots is another irrigation method. A center pivot is a sprinkler system on wheels with a pivot in the center. This sprinkler system works well on slopes and does not require any special tillage. Center pivot irrigation resolves some of the problems of border and furrow irrigation, but the center pivots come with their own set of issues. Only a circular part of the field can be watered and the system has a very high initial set up cost (Brown, 2008).

Drip irrigation is another way to irrigate the entire field. This method does not require having to install a massive pivoting sprinkler system. Drip irrigation operates when a hose with perforations is run down every row and water is pumped through the hose. Drip is widely used in vegetables, but is still somewhat of a new idea in corn. Drip hose is expensive, and can generally only be used for one season, however drip irrigation provides the exact amount of water needed exactly where it is needed (Zhu, Lan, Lamb & Butts, 2007). As water gets more expensive, farmers will be more inclined to switch to drip irrigation.

Every Other Row Furrow Irrigation

Water usage and water conservation is becoming a big deal, and it is only going to get bigger. One water saving method for farmers who flood irrigate will be every other row furrow irrigation. “In one study comparing alternate and every-row furrow irrigation in corn on different soil types, yields were equivalent for the two methods. With alternate furrow irrigation, 29% less water was applied than was applied with every-row irrigation” (Frate & Schwankl, 2008). Using less water is less expensive, more environmentally friendly and can improve crop yields by improving soil air to water ratios. In some situations every row irrigation oversaturates the soil
(Frate & Schwankl, 2008). Reducing the amount of water applied solves this problem. In other situations, it is important to cover the whole field quickly (Rogers, 1995). Some farmers do not have the pumping system or irrigation district supply they need in order to cover their fields in a timely matter. Every other row irrigation is a good way to accelerate the irrigation of the entire field.

Saving water and reducing the amount of time it takes to irrigate a field are two great reasons to only irrigate every other row, but every other row irrigation has other benefits as well. If soil has a salinity problem, irrigating every other row can improve salt movement through the soil (Ludwick et al., 2002). When irrigating every row, the center of the furrow contains the driest soil. Water is pushed from wet areas into dry areas, and salts are pulled along with the water (Ludwick et al., 2002). The plant takes up the water surrounding its roots and the sun dries the soil, leaving the salts behind. The salts accumulate in the root zone, and over time this can hurt yields, by having an adverse affect on the growth of the crop (Ludwick et al., 2002). Irrigating every other row can alleviate this salinity problem by pulling the salts into the non-irrigated furrow, instead of the plant’s root zone (Ludwick et al., 2002). The center of the non-irrigated furrow is the driest soil, and water moves through the root zone and into the dry furrow. The water pulls the salts right past the roots and the salts accumulate in the dry furrow. This same principle also allows saline irrigation water to be used without as serious of side effects (Ludwick et al., 2002).

Farmers must consider soil type when trying every other row irrigation. Sandy, coarse textured soils with poor lateral water movement are not suited for every other row irrigation (Rogers, 1995). Every other row irrigation will not be able to supply enough water to these soils to provide for the crop need. These soils will not have a problem with the crop getting waterlogged, so farmers of sandy, coarse soils need to look for other ways to conserve water.

In conclusion, silage has been around for a long time. There has been lots of progress in the silage industry, but growing corn for silage still can be a challenge. A lot of effort is required to
produce high quality corn silage. There is no such thing as a perfect irrigation method, but some methods are better than others. Every other row irrigation could help a lot of farmers save water. This will become more important as water becomes scarcer.
Chapter Three

Materials and Methods

On May 28th, 2012 a field irrigation trial was started at D & M Ag in Denair, CA on a Whitney Rocklin sandy loam. 117-day maturity silage corn was planted in the back 120 acres that surround D & M Ag. The variety used was DeKelb 67-86. In the field, twelve strips with ten rows each were marked out. This allowed for four different treatments with three replications of each treatment. The harvested area of each trial was one half acre (Table 3.1).

Table 3.1 – The Test Plot Layout

<table>
<thead>
<tr>
<th>Field Position</th>
<th>Treatment</th>
<th>Number of Irrigations</th>
<th>Number of Acres</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>Every Other Row</td>
<td>11</td>
<td>0.5</td>
</tr>
<tr>
<td>A2</td>
<td>Every Row Deficit</td>
<td>8</td>
<td>0.5</td>
</tr>
<tr>
<td>A3</td>
<td>Grower’s Standard Practice</td>
<td>9</td>
<td>0.5</td>
</tr>
<tr>
<td>A4</td>
<td>Control</td>
<td>11</td>
<td>0.5</td>
</tr>
<tr>
<td>B1</td>
<td>Every Row Deficit</td>
<td>8</td>
<td>0.5</td>
</tr>
<tr>
<td>B2</td>
<td>Control</td>
<td>11</td>
<td>0.5</td>
</tr>
<tr>
<td>B3</td>
<td>Every Other Row</td>
<td>11</td>
<td>0.5</td>
</tr>
<tr>
<td>B4</td>
<td>Grower’s Standard Practice</td>
<td>9</td>
<td>0.5</td>
</tr>
<tr>
<td>C1</td>
<td>Every Row Deficit</td>
<td>8</td>
<td>0.5</td>
</tr>
<tr>
<td>C2</td>
<td>Every Other Row</td>
<td>11</td>
<td>0.5</td>
</tr>
<tr>
<td>C3</td>
<td>Control</td>
<td>11</td>
<td>0.5</td>
</tr>
<tr>
<td>C4</td>
<td>Grower’s Standard Practice</td>
<td>9</td>
<td>0.5</td>
</tr>
</tbody>
</table>

The grower’s standard practice was irrigated on the same schedule as all the other corn on the ranch. It ended up receiving nine irrigations total. Every other row and the control were irrigated eleven times. These two trials were designed to show the difference between irrigating every row and every other row on the same schedule. The final trial (every row deficit) had every row furrowed and irrigated, but water deliberately was held back, and the corn was water stressed between irrigations. This trial was irrigated eight times. The trials were ten rows wide to allow for easy harvest, since the forage harvester used chops ten rows at a time. All the corn was given the
same fertilizer rates and everything was kept constant except for the irrigation schedule and the spacing of the rows irrigated.

Planting the crop was the easy part. In fact, the equipment operator running the planter did not have to do anything special in order to accommodate for the experiment. All he was told was, “Make sure you do not mix up the seed varieties, and try to keep the rows straight here. We are going to do an experiment.” The planter used was a six row John Deere Max Emerge with thirty inch row spacing. D & M Ag has never owned a corn planter. Instead they hire a custom operator, Ron Macedo, who owns all the planting equipment and takes care of the planting. This makes some aspects of planting simple, because D & M Ag does not have to worry about maintenance or breakdowns. Other aspects are more complicated because of hiring a custom operator. Ron Macedo has lots of other customers, and cannot always come plant a field right when the conditions are perfect. This year however, everything went very smoothly, and planting went better than ever before.

Something that helped planting go smoothly was the groundwork that was done before planting. For the first time D & M Ag used a spring tooth cultivator to prepare the seedbed instead of a disc (Figure 3.1). Cal Mast, the owner of D & M Ag, did all the tillage prior to planting.

![Figure 3.1 – The Seedbed Preparation Equipment](image-url)
The spring tooth helped because it is lightweight, unlike the disc harrow that was used in the previous years. Even though the soil was still very moist, the tractor was able to pull the spring tooth without making ruts or getting stuck. The extra soil moisture made a big difference with helping the crop germinate evenly. Bifenture, a common insecticide, was applied during the same pass as the seedbed preparation. This insecticide was sprayed into the soil and incorporated by the spring tooth. It was used to control armyworm and cutworm. D & M AG’s Pest Control Advisor, Eric Muller, recommended this insecticide.

At planting, twenty pounds of nitrogen was side dressed as a starter fertilizer to give the crop a jumpstart. At furrowing, 85 pounds of nitrogen was side dressed to keep the crop going. The fertilizer used was UAN-32. Eric Muller recommended this fertilizer and application rate. The crop was furrowed when it was about two feet tall (Figure 3.2). Each row was fertilized, and the fertilizer was placed four inches deep and four inches to the side of the row of plants. The fertilizer was placed in the irrigated row on the Every Other Row treatment. D & M Ag owns a John Deere 7630 set up for row-crop tillage. All the fieldwork was done with the 7630 (Figure 3.1, Figure 3.2).

![Figure 3.2 – The Furrowing and Side Dressing Equipment](image)

The first crop irrigation was on June 27th, 2012 (Figure 3.3). All the different treatments were watered with fresh water from the main irrigation well at D & M Ag. It was interesting to note
how much easier it was to irrigate every other row. D & M Ag has irrigation valves spaced every fifteen feet. One valve irrigates six to eight rows depending on the field. The opening of each row must be shoveled out by hand in order to get water to flow to it. Every other row took less shoveling than the other treatments, and the water flow was greater in each row, which resulted in better irrigation timing throughout the field.

![Image](image.png)

Figure 3.3 – The First Attempt to Irrigate Every Other Row

The actual irrigating itself was quite simple. The crop had to be monitored to make sure it was getting water at the proper intervals and record keeping was a never-ending job. An interesting note about irrigating every other row was that the water ran to the end of the field much quicker than the other trials. Significant over run is required in order to get the water to soak all the way through the root zone, so a tail water return system is mandatory with this irrigation practice. D & M Ag has tail ponds and return pumps for all its fields, so this was not an issue.

More nutrients were applied to all the treatments in the form of dairy lagoon water during the second, fourth, and fifth irrigation. This lagoon water is high in potassium and phosphorus. It also has a good amount of nitrogen and sulfur, and it makes a great fertilizer for corn. According to the calculations for the California Water Board report, 246 pounds of nitrogen were applied per
acre to the entire field. Nitrogen levels are always a consideration since the Water Board takes them very seriously.

On July 4th, 2012 another custom operator (Ottman Farms) came to spray all of D & M Ag’s acreage, including the experiment. Miticide, weed spray, and a micronutrient fertilizer were all applied in one pass. Oberon was the miticide of choice to control spider mites. The weed spray used was Honcho, to control pigweed. Honcho is a generic version of Round Up. Zinc and Boron were also applied with the sprays. These nutrients were applied with the spray because a foliar application is more effective and much cheaper than a soil application. Eric Muller was also responsible for these recommendations.

Before the corn was chopped, ten plants from each trial were selected at random. They were then used to determine an estimated grain yield, and average plant height. The Yield Component Method was used to calculate the grain yield (Figure 3.5).

![Figure 3.5 – Calculating Grain Yield](image)

The Yield Component Method is one of the most popular methods to measure yield because it can be used at an earlier stage than other methods. Ear population is calculated by counting every plant with a harvestable ear in a 17.4-foot row. 17.4-feet is 1/1000 of an acre on thirty-inch row spacing. Then, every fifth ear is randomly sampled. The number of kernel rows and the number of kernels in each row are counted. These two numbers are multiplied together to get the
total number of kernels per ear. The numbers are then averaged with all the plants sampled, and the average is divided by the number of kernels (in thousands) per bushel (Nielsen, 2011). This gives an estimated yield in bushels per acre. A tape measure was used to calculate plant height, and the plot size was determined using a measuring wheel.

September 12, 2012 was the chopping day. D & M Ag used LaFollette Chopping for all their forage harvesting (Figure 3.6). They handled everything except for weighing the trucks. D & M Ag has a scale to weigh each load. The trials were set up into ten row blocks, and the chopper harvests ten rows at a time. Each trial was chopped into its own truck, and weighed to determine the silage tonnage.

Figure 3.6 – The Chopper and a Truck at work
Chapter Four

Results

Irrigation has an effect on the growth and yield of corn. This trial shows that proper irrigation timing and spacing can contribute to the overall health of the crop. Every other row, and the control received more applications of irrigation water, which resulted in higher grain yield, and taller plants, however it is interesting to note that silage yield was slightly lighter than the grower's standard practice (Table 4.1).

<table>
<thead>
<tr>
<th>Irrigation Treatment</th>
<th>Grain Yield (Bu/Acre)</th>
<th>Silage Yield (Tons/Acre)</th>
<th>Plant Height (Inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EOR</td>
<td>206.15 a</td>
<td>22.53 a</td>
<td>129.8 a</td>
</tr>
<tr>
<td>Control</td>
<td>225.71 a</td>
<td>22.94 a</td>
<td>132.8 a</td>
</tr>
<tr>
<td>GSP</td>
<td>197.53 a</td>
<td>23.00 a</td>
<td>122.5 a</td>
</tr>
<tr>
<td>ERD</td>
<td>140.04 b</td>
<td>20.99 a</td>
<td>123.8 a</td>
</tr>
</tbody>
</table>

The estimation of grain yield had the largest variation between the treatments. The Control was the largest average at 225.71 bushels per acre, while every row deficit was the smallest average at 140.04 bushels per acre. Every other row yielded an average of 206.15 bushels per acre, and the grower's standard practice yielded an average of 197.53 bushels per acre (Figure 4.1). The number of kernels on an ear of corn is determined early in the plant's life, and if the crop is stressed early, it will decrease the total number of kernels set on the ears. That immediately decreases the yield potential for the crop. Every row deficit was stressed between the first and second irrigations, which resulted in significantly lower kernel numbers and less yield because of this.
Silage yield patterns were slightly different than estimated grain yields. The heaviest tonnage was the grower’s standard practice, weighing in at 23.00 tons, and the control came in second at 22.94 tons (Figure 4.2). Third was every other row at 22.53 tons, and last was every row deficit at 20.99 tons (Figure 4.2). Overall, there was not a significant difference between any of the treatments.

Height followed a yet different pattern from the other two measurements. The control topped out the measurements at 132.8 inches. Every other row was the second tallest measuring
129.8 inches. Every row deficit was the third tallest at 123.8 inches, and the grower’s standard practice was the shortest at 122.5 inches. Though the graph shows a clear top and bottom pair in height, the statistical analysis revealed that there was not a significant statistical difference.

![Figure 4.3 The Effects of Irrigation Method on Average Plant Height](image)

It took the assistance of Dr. John Phillips from Cal Poly to statistically analyze the data. Dr. Phillips helped run an analysis of variance, which indicated that there was a significant statistical difference in the estimated grain yields. There was no significant difference in silage yield of height between any of the treatments. The Waller-Duncan Bayes LSD was used test to find the statistical difference. Every row deficit’s grain yield was the only treatment within the experiment that stood out statistically from the others. Its yield was significantly less than the others, which would indicate that deficit irrigation is not a good option for growing quality corn. All the other yields and measurements were statistically similar.
Chapter Five

Recommendations and Conclusions

Irrigation method has an impact on the growth of corn. The two extra irrigations that every other row and the control received lead to those treatments to have less stress on the corn plants. Every other row can provide adequate water to the crop, providing sufficient overrun is allowed and time between irrigations is minimized in order to prevent plant stress. A tail water return system is a requirement before considering every other row furrow irrigation. Over run is absolutely crucial since the water must still soak through the soil slightly past the crop row. In order to have an adequate irrigation, every single row in the field must completely finish because one row of water supplies two rows of corn. If a row does not finish, two rows of corn are affected since they cannot get water from the neighboring row like they could with every row irrigation. Furrows need to be deep, or fields need to have little side fall in order for every row to finish completely and evenly throughout the field.

![Figure 5.1 - Height Differences Between Two Treatments Shortly After Tasseling](image)

Differences in height could be seen as early as the fourth irrigation, and these height differences remained through until harvest (Figure 4.3). Silage corn height seems to be quite closely related to the number of irrigations the crop received. This is because a plant that is not
stressed has more potential for vertical growth, and internode elongation. Since more irrigations resulted in taller plants, it seems logical to only irrigate every other row and cover the field quicker. This allows quicker turn around time to start all over again. Getting in two of three extra irrigations can add up to extra plant height by the end of the season.

If repeated, it would be interesting to harvest the crop with a combine in order to get a true grain yield, rather than an estimation. The estimated grain yield gives some data to work with, but a true grain yield would be a good addition to the data. Unfortunately it is not possible to harvest corn as grain and then again as silage. For this experiment, the estimation gave an indication to the quality of the corn silage. Higher grain yield means higher quality silage, and better milk production from the cows that are fed the silage. The experiment essentially showed that more water results in more grain. The control was the treatment that received the most water down every row, and because of this it yielded the most grain. Every other row and the grower's standard practice received similar amount of water, and their yields were very similar. Deficit received the least irrigation water, and the grain yield clearly suffered because of it.

Silage had interesting results. The grower's standard practice was the heaviest, weighing in at 23.00 tons per acre, even though it was the shortest in height of the four treatments. The control came in a close second at 22.94 tons per acre, followed by every other row at 22.53 tons per acre, and finally the deficit at 20.99 tons per acre. The spread between the top three treatments is very small which indicates that every other row irrigation does not hinder the weight of silage corn. Further studies should analyze moisture content to determine silage dry weight and give more accurate results of silage yield.

Conclusions

Growing corn in the Eastern Central Valley is tough. Water is always going to be an issue, and farmers need to continue to look for ways to use less water while still maintaining production.
Silage is a key ingredient in the diet of dairy cows, and farmers have been producing silage for thousands of years. The three aspects to good silage are crop management, silage management, and weather. There are many ways to irrigate corn, but one method of interest in every other row furrow irrigation. Every other row is a way to possibly use less water but not loose yield. It requires less labor, and allows for quicker irrigations, but requires more irrigations per season. In this experiment, every other row was compared to a control that had every row irrigated on the same schedule, as well the grower's standard practice, and deficit irrigation. The experiment shows that every other row irrigation can supply enough water to produce good quality corn silage and still yield in the same range as the control and the grower's standard practice.
Bibliography


Appendix

Appendix A – The Raw Data from Each Treatment and Replication

<table>
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<tr>
<th>Treatment</th>
<th>Grain Yield (Bushels/Acre)</th>
<th>Plant Height (Inches)</th>
<th>Silage Yield (Tons/Acre)</th>
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<td>136</td>
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</tr>
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