Quantifying water use (Water Use Efficiency) in irrigated barley, wheat, and sugarbeet production on Lihen fine sandy loam soils (Nesson Valley 2014).

James Staricka and Tyler Tjelde

Objectives

The objectives of this project are to investigate different irrigation rates in crop production to improve water use efficiency and refine irrigation scheduling recommendations.

Methods

The experimental design is a Randomized Complete Block Design (RCBD) with four replications of four treatments. Each plot was 50 ft by 60 ft.

The treatments consist of four irrigation rates (100%, 67%, 33%, 0%). The irrigation amounts for the 100% treatment were determined using the soil moisture data collected from the neutron depth moisture gauge and referencing the North Dakota Ag Weather Network (NDAWN) irrigation scheduler (http://ndawn.ndsu.nodak.edu). The NDAWN scheduler is a checkbook system using soil properties (thickness of soil layers and the water holding capacity of each layer), weather parameters (average daily air temperature, daily solar radiation, daily rainfall), crop properties (root depth and water use based on growth stage, planting date and emergence date), and user-supplied irrigation information (dates and amounts). An observation station of the NDAWN system, listed as "Hofflund" on the NDAWN records, is located on the research site.

Soil water content of top two feet was determined within each plot using a neutron depth moisture gauge. These weekly soil moisture measurements were used to calibrate the checkbook irrigation scheduling system.

A data logging rain gauge was placed within each sugarbeet plot and within the 100% treated potato, wheat, and barley plots. Rain gauges were adjacent to the neutron gauge access tube. These logging rain gauges are battery-powered and automatically record the date and time of each 0.01 inch of rainfall or irrigation. Data from the gauges were used to determine rain and irrigation rates and duration. The data also provided a means to verify that each plot received the correct irrigation amount.

Total rainfall amount from May 1 to September 30 was below normal (Table 1). Monthly totals were below normal in May, June, and July but above normal in August and September. The growing season temperatures were below normal for the entire 2014 growing season.

All cultural practices (tillage, fertilizer, planting populations, chemical, and fungicide applications) are the same for all treatments within a crop to minimize the effects of variables other than water amount. Yield and quality analysis for all the crops was done by the WREC except when mentioned otherwise.

Table 1: Rainfall at Nesson Valley.

	Rainfall	
Month	Normal	2014
	------ *inches* ------	
May	2.23	1.29
June	3.08	2.42
July	2.73	1.33
August	1.64	2.43
September	1.22	1.40
Total	10.90	8.87

Results

Sugarbeet

The sugarbeet trial was planted May 23. The emergence date was May 30. There were 12 irrigations between planting and harvest, the first on July 5 and the final on September 18. The amount of water applied to sugarbeet for the four irrigation treatments (100%, 67%, 33% and 0%) was 7.0, 4.6, 2.5, and 0.0 inches, respectively, according to the rain gauges located within each plot. Rainfall recorded from planting through harvest was 7.3 inches, so that the total water received by the four treatments was 14.3, 11.9, 9.8, and 7.3 inches, respectively.

The rainfall and irrigation amounts measured by the recording rain gauges (Fig. 1a) were lower than the total water received. This discrepancy was because the rain gauges were installed on June 16 and rainfall was recorded from planting through harvest.

The soil was slightly wetter than field capacity for all four treatments on July 1 (Fig 1b). Irrigation started on July 5 because of the increasing daily water usage, even though soil water content was still at field capacity. This was to maintain adequate soil water content because once depletion begins it is hard to increase.

By August 5, the soil in the 0% and 33% treatments had dried to wilting point and after that lost only a minimal amount of water until August 23 when the plots received .9 inches of rain. The soil water content in the other irrigation treatments continued to decrease, but at a slower rate than before. The soil water content in the full irrigation treatment was sufficient to meet the water demand.

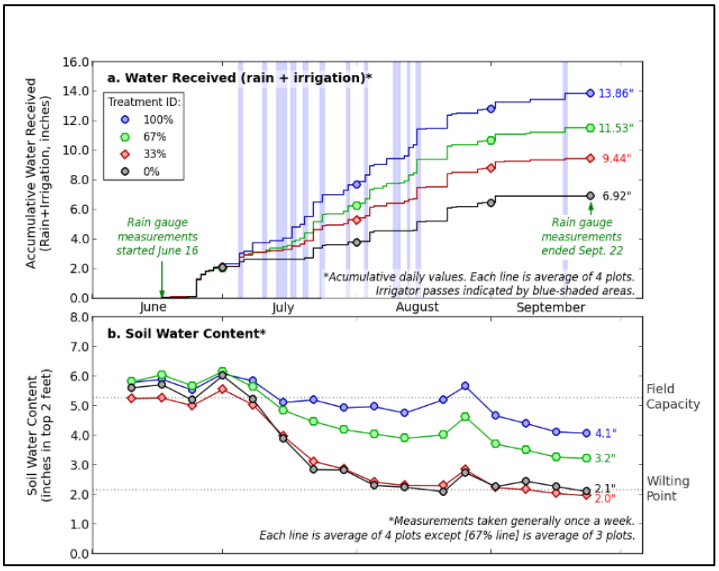

Figure 1: Rainfall, irrigation, and soil water content in sugarbeet.

On September 3, a hailstorm defoliated 100% of the leaf petioles and September 11 the first killing frost occurred. Sugarbeet were harvested on September 23. A sample of sugarbeet from 10 feet of row was obtained by hand from each plot and the number of beets counted. These counts (beets/10ft) were used to determine final plant populations. These samples were analyzed at the Sidney Sugars laboratory and tons per acre and sugar and nitrate percentages were determined. Statistically significant differences in yield and quality occurred among watering treatments (Table 2). The lower yields were a direct result of the storm on September 3 when comparing previous year's yields (Figure 2).

Table 2. Sugarbeet performance.

Irrigation	Population	Yield	Sugar
	beets/10ft	*ton/a*	*%*
0%	21	15.5	19.7
33%	21	22.9	18.8
67%	19	23.2	17.9
100%	20	24.9	16.7
CV (%)	19.7	13.3	4.1
LSD 5%	ns	5.8	1.5

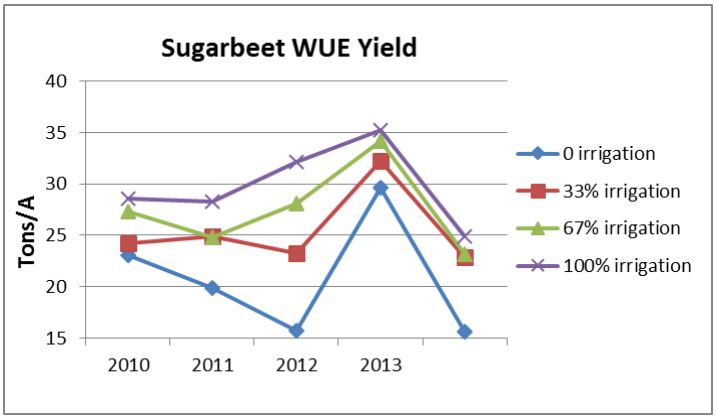

Figure 2

Barley

The Barley was planted May 8. The emergence date was May 15. The first irrigation for barley occurred on June 9 and the final irrigation occurred on July 24. There were nine irrigations, which resulted in 4.1, 2.8, 1.4, and 0. 0 inches of water applied, respectively for the irrigation rates of 100%, 67%, 33% and 0%. Total water received (irrigation plus rain) from planting through harvest was 10.1, 8.8, 7.4, and 6.0 inches, respectively.

The rainfall amounts measured by the recording rain gauges located in 100% treatments (Fig. 3a) were lower than the total water received. This discrepancy was because the rain gauges were installed on June 3 and rainfall was recorded from planting through harvest.

At the beginning of the season soil moisture levels varied (Fig. 3b) between treatments. After the initial measurement, soil moisture in all treatments decreased almost steadily until reaching wilting point. The only exception to this decline was when all treatments increased in soil moisture after a 1.19-inch rainfall on June 26. The two drier treatments reached wilting point on July 22 and the two wetter treatments reached wilting point on August 5.

Barley was harvested on August 20. Yield and quality samples were obtained using a small plot combine. Statistically significant differences in barley yield occurred among watering treatments (Table 3). Yield history can been seen in Figure 4.

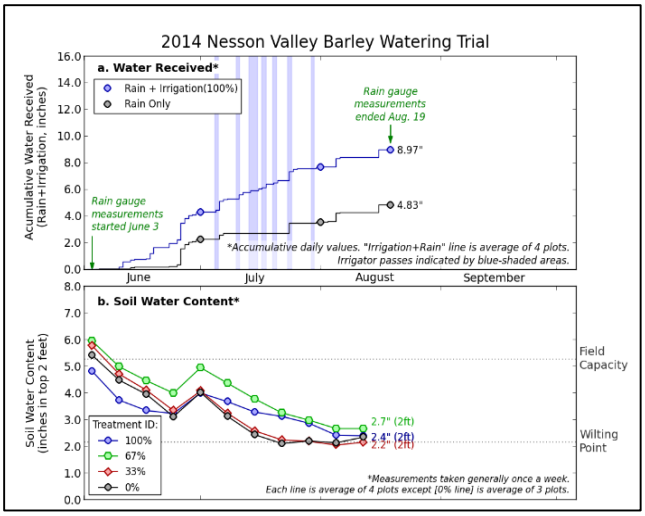

Figure 3: Soil water content in barley.

Table 3. Barley performance.

Irrigation	Yield	TW	Protein
	bu/A	*lbs/bu*	*%*
0%	81	51.8	12.0
33%	96	51.7	12.0
67%	106	51.7	11.3
100%	112	51.4	11.3
CV (%)	5.7	0.8	4.8
LSD 5%	9.0	ns	ns

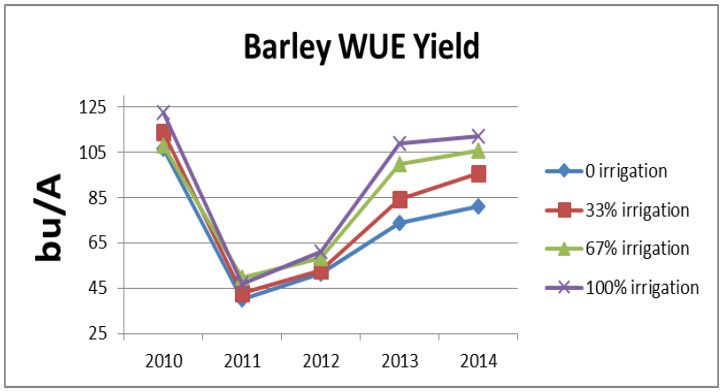

Figure 4

Wheat

The wheat was planted May 2. The emergence date was May 10. There were nine irrigations to wheat. The first on June 9 and the final on July 24. The irrigation rates of 100%, 67%, 33% and 0% resulted in 5.0, 3.4, 1.7, and 0.0 inches of water applied, respectively. Total water received from planting through harvest was 10.8, 9.2, 7.5 and 5.8 inches, respectively. Soil water content in the wheat plots was similar to the barley plots with about 4.5 inches in the top two feet (Fig. 5b). Soil moisture levels were maintained in the three wetter treatments until July 24 when irrigation was suspended due to crop maturity and lodging concern. Soil moisture content declined through crop maturity in the driest treatment. The spread in the soil water content among treatments on the last measurement date was similar to that occurring in barley.

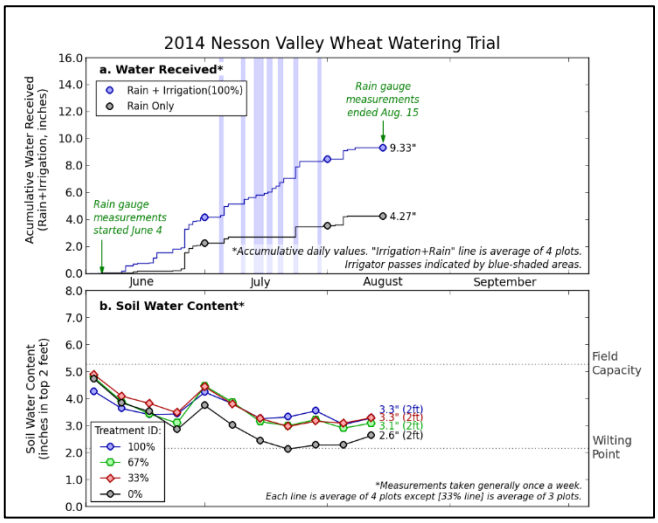

Figure 5: Soil water content in wheat.

The rainfall amounts measured by the recording rain gauges located in 100% treatments (Fig. 5a) were lower than the total water received. This discrepancy was because the rain gauges were installed on June 3 and rainfall was recorded from planting through harvest.

Wheat was harvested on August 15. Yield and quality samples were obtained from each plot using a small plot combine. Statistically significant differences in wheat yield and quality occurred among watering treatments (Table 4). The yields for the previous five years can be found in Figure 6.

Table 4. Wheat performance.

Irrigation	Yield	TW	Protein
	bu/A	*lbs/bu*	*%*
0%	49	59.8	18.3
33%	56	61.1	17.3
67%	83	61.7	16.1
100%	78	61.5	15.7
CV (%)	10.8	0.9	3.7
LSD 5%	14.3	1.1	1.2

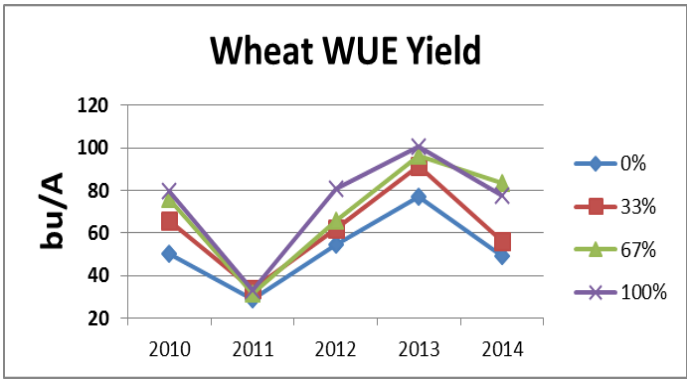

Figure 6