IMPACT OF MID-SEASON WATER STRESS ON SUGARBEET GROWTH

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Background

Due to below normal snow pack and rainfall, much of the Western Sugar Cooperative growing region of the central high plains and Rocky Mountains will likely be facing yet another year of limited water supplies for surface water users. The drought has also put pressure on ground water users. As water levels decline, state and local agencies are implementing pumping restrictions to extend the life of the aquifers and/or maintain stream flow. As a result, many growers are concerned and questioning their ability to grow sugarbeets because of the quantity of water used to produce a crop.

Because the sugarbeet growing season is long in comparison to many other crops, water use is expected to be much greater. But in fact, sugarbeet seasonal water use is similar to that of corn, averaging approximately 24 in./yr. On the other hand, drought tolerant crops such as winter wheat and sunflower can use 20-24 in. of water each year. In the case of wheat and sunflowers, drought tolerance doesn't mean low water use, it merely means the plants are capable of extracting more of the available water from the soil. It also means the plants preform well when subjected to plant water stress. In this case, drought tolerant crops can extract approximately 70% of available water from the soil where the normal recommendation for sugarbeet is to generally allow no more than 50% of the available water to be extracted before irrigation begins.

Previous research on water stress of sugarbeets has been studied during the early and late stages of growth. In those studies, early season water stress tended to impact crop yield more than late season water stress. Part of this is due to the lack of root development early in the growing season. Early in the season water stress can be more significant because roots are near the soil surface and can be subject to water stress in a short period of time. When the crop reaches full cover, the plant has developed a more extensive root system. By harvest time, the plant root system has developed even further providing the plant access to even more water that is being held in the soil.

Preliminary results of induced water stress during mid season have shown that sugarbeets can produce root yield in excess of 30 t/ac. During this evaluation, soil water was at or near the permanent wilting point for a two week period to a depth of 3.0 ft. Irrigation water withheld during the water stress period was approximately 8.0 in. This is approximately one third of the total crop water requirement for sugarbeets. It was theorized that as water stress increased and the surface soil dried, root hairs near the primary root were reduced resulting in a reduction in tare. Whether these plants compensated for the lack of water in the top three feet of the soil profile by effectively using water from greater depths or were simply able to maintain plant health during a period of water stress indicated the need for further research.

Early and late in the growing season, crop water use is less because crop water use requirements are less due to cooler temperature and reduced sunlight. At the same time, the probability for precipitation is greater and allows irrigation systems to more easily keep up with crop water demand. During mid season growth, irrigation demand is high because precipitation is less and crop water use often exceeds what the irrigation system is capable of delivering. To adequately address sugarbeet production with limited water supplies, water management practices for mid season must be studied to compliment the early and late season water management practices.

Objective

Determine the response of sugarbeet when irrigation is limited and water stress occurs during mid-season growth.

Procedures

Mid-season sugarbeet water stress treatments were established at the University of Nebraska Panhandle Research and Extension Center in 2004, 2005 and 2006. Soil type is a Tripp very fine sandy loam with a water holding capacity of approximately 1.8 in./ft. The previous crop was corn harvested for grain and the plot areas were plowed and packed twice before planting. During each of the three years, furrow irrigation was used to establish the plants and to provide early season irrigation. A solid set sprinkler system using Rainbird 3500 Series popup turf sprinklers was installed each year to isolate treatment areas and provide a uniform water application for the balance of the growing season. Sugarbeets were planted in 22 in. rows. Each plot was 12 rows wide and 24 ft long. Nozzles were adjusted manually between irrigation treatments to insure proper coverage of the sprinklers.

To test water treatments, a randomized complete block design was used. Each water stress treatment was replicated six times. Two varieties were selected to be planted in a split plot design but due to weather and seed problems, 2005 was the only year when two varieties were grown. Varieties planted, planting date, plant population, and harvest date are given in Table 1.

Year	Variety	Planting Date	Plant Population	Harvest Date
2004	Betaseed 7310R	April 21	--	October 11
2005	Betaseed 7310R	May 3	33,500	October 17
	Hilleshog 1653 RZ		41,250	
2006	Betaseed 7341R	May 2	45,500	October 10

Table 1. Variety, planting date, plant population and harvest date for 2004, 2005 and 2006 experiment.

Plant population was low in 2004 due to disease and in 2005 due to hail and freezing temperatures. Water stress duration was extended in 2005 and 2006 due to the lack of significant difference among the water stress treatments tested in 2004. Approximately 2.5 in. of water was applied for each irrigation event. This amount was used to fill the soil profile to a point that would stop any further plant water stress. Subsequent irrigations were intended to meet future water demand of the crop. Water stress treatments and corresponding irrigation dates for all years are given in Table 2.

2004	Treatment	Irrigation date					
	Stress level 1	7/21	7/27	8/3	8/10	8/20	-
	Stress level 2	7/21	-	8/3	8/10	8/20	-
	Stress level 3	7/21	-	-	8/10	8/20	-
	Stress level 4	7/21	-	-	-	8/20	-
2005	Stress level 1	7/21	7/27	8/3	8/10	8/17	8/24
	Stress level 2	7/21	-	8/3	8/10	8/17	8/24
	Stress level 3	7/21	-	-	8/10	8/17	8/24
	Stress level 4	7/21	-	-	-	8/17	8/24
	Stress level 5	7/21	-	-	-	-	8/24
2006	Stress level 1	7/21	7/27	8/3	8/10	8/17	8/24
	Stress level 2	7/21	-	8/3	8/10	8/17	8/24
	Stress level 3	7/21	-	-	8/10	8/17	8/24
	Stress level 4	7/21	-	-	-	8/17	8/24
	Stress level 5	7/21	-	-	-	-	8/24

Table 2. Irrigation dates for water stress irrigation treatments in 2004, 2005 and 2006.

Precipitation did not play a significant role in providing supplemental water during the water stress treatment periods of any one of the years. The only significant precipitation during the treatment periods occurred in 2004 when the experiment first started. Precipitation during the water stress treatment period is given in Table 3.

2004	Date	7/21	7/22	7/23	7/24	7/29	8/2
	Precipitation(in.)	0.47	0.53	0.71	0.06	0.07	0.05
2005	Date	6/11	6/22	6/24	7/4	8/26	9/15
	Precipitation (in)	0.76	1.26	0.21	0.18	0.65	0.17
2006	Date	6/11	6/22	6/24	7/4	8/26	9/15
	Precipitation (in)	0.76	1.26	0.21	0.18	0.65	0.17

Table 3. Precipitation during water stress treatment period in 2004, 2005, and 2006.

Plots were harvested by mechanically topping and digging 25 ft in the middle of each plots. In 2004, four rows were harvested. In 2005 two rows of each variety were harvested. In 2006, two rows were harvested. Tare samples were collected and transported to Western Sugar Cooperative for analysis of tare, percent sucrose and SLM.

Soil water content was measured in each plot for each year of the experiment. In 2003, soil water content was measured using gravimetric sampling methods to a depth of three feet. In 2004 and 2005 neutron scattering method was used to measure soil water content to a depth of five feet. Leaf area index was determined in each plot by collecting a series of four readings at two locations to determine the amount of intercepted light near the ground surface. Plant height was also determined in each plot by measuring the height of the plant canopy from the top of the soil ridge to the average height of surrounding plants. Four locations were measured in each plot to determine an average height per plot. Leaf area and plant height were measured to determine influence of water stress on canopy development and architecture.

Results

Results of plant height, leaf area index, tare, sugar content root yield and sugar yield are given in tables 4, 5 and 6 for 2004, 2005 and 2006, respectively. In 2004 and 2006 plant height decreased as water stress increased. Only in 2006 was there significant difference among the yield parameters tested.

Treatment	Plant Height (in)	Leaf Area Index	Tare (%)	Sugar Content (%)	Root Yield t/ac	Sugar Yield (lbs/ac)
Stress level 1	19.0 a	6.2a	5.9a	15.8a	26.2a	8280a
Stress level 2	18.4 a	6.0a	7.0a	15.8a	26.1a	8260a
Stress level 3	17.8 a	6.1a	6.2a	15.9a	27.1a	8610a
Stress level 4	15.8 b	6.3a	6.6a	15.9a	26.9a	8560a

Values followed by the same letter indicate no significant difference at the 5% probability level.

Table 4. Plant height, leaf area index and harvest yield results for 2004.

Treatment	Plant Height (in)	Leaf Area Index	Tare (%)	Sugar Content (%)	Root Yield t/ac	Sugar Yield (lbs/ac)	SLM
Stress level 1	16.8a	4.5a	6.4a	16.9a	21.7a	7370a	1.2a
Stress level 2	18.3a	4.4a	6.4a	17.0a	23.0a	7760a	1.2a
Stress level 3	17.8a	4.4a	6.5a	17.0a	19.4a	6610a	1.2a
Stress level 4	16.5a	4.6a	6.5a	16.8a	24.6a	8250a	1.2a
Stress level 5	17.3a	4.4a	6.8a	16.6a	20.9a	6900a	1.2a

Values followed by the same letter indicate no significant difference at the 5% probability level.

Table 5. Plant height, leaf area index and harvest yield results for 2005.

Treatment	Plant Height (in)	Leaf Area Index	Tare (%)	Sugar Content (%)	Root Yield t/ac	Sugar Yield (lbs/ac)	SLM
Stress level 1	15.3a	5.7a	4.9cde	15,6bc	35.2ab	10960ab	1.5b
Stress level 2	15.8a	5.3ab	4.6de	14.1c	34.2b	10500b	1.5b
Stress level 3	15.3a	5.1ab	5.5bcd	15.8abc	35.1ab	11060ab	1.4b
Stress level 4	13.7b	4.9b	5.7bc	15.5bc	37.4a	11540a	1.5b
Stress level 5	12.7b	5.9a	6.3ab	14.4c	34.3ab	11360a	1.5b

Values followed by the same letter indicate no significant difference at the 5% probability level.

Table 6. Plant height, leaf area index and harvest yield results for 2006.

In each of the three years, there was only minor visual evidence of water stress to the plant canopy observed on hot sunny days. Even then, plant wilt was minimal and could not readily be seen. Only a sample of soil water content results are given with this report. In figures 1 and 2, soil water content, measured with a neutron probe in 2006, is given for water stress level 1 and 5. In figure 1. soil water content at the five foot depth shows an increase in water content from early in the season to late in the season. This increase would indicate that excess water was available to increase water content. In contrast, figure 2 shows the soil water content for water stress level 5. In this case, soil water content early in the season at the five foot depth is greater at the beginning of the season and decreases late in the season. This would indicate soil water is being extracted by the plants. The results of these experiments indicate that sugarbeet can withstand significant water stress during mid season yet still produce good sugar yield.

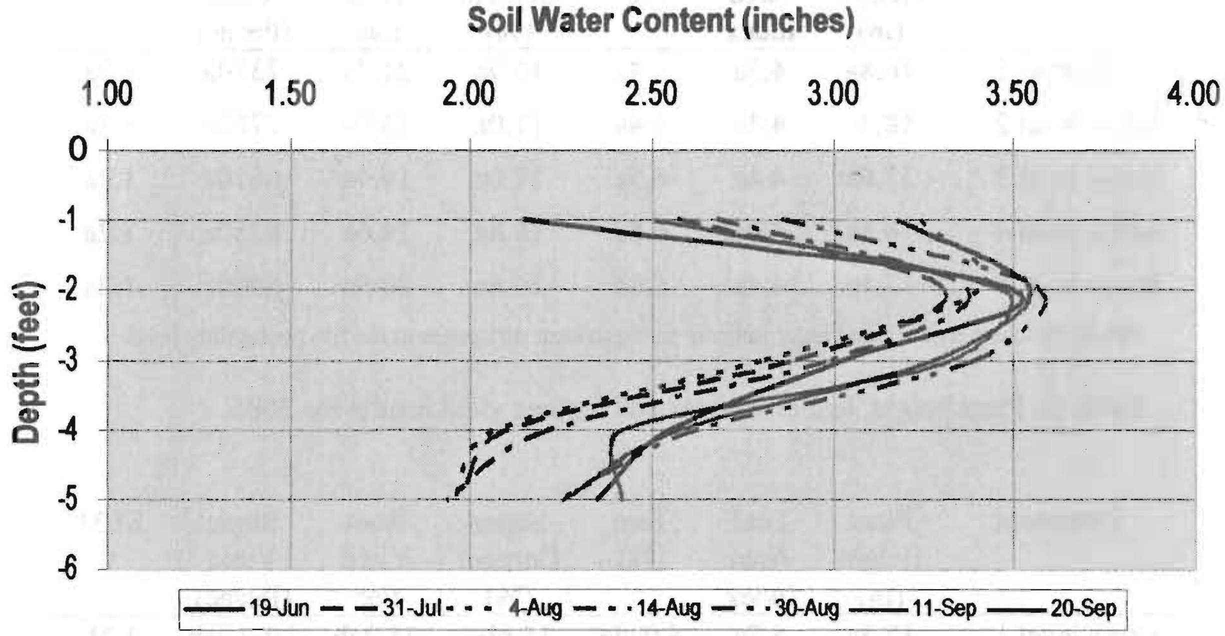

Figure 1. Treatment 1 soil water content profile for 5.5 foot soil profile during 2006 water stress treatment period.

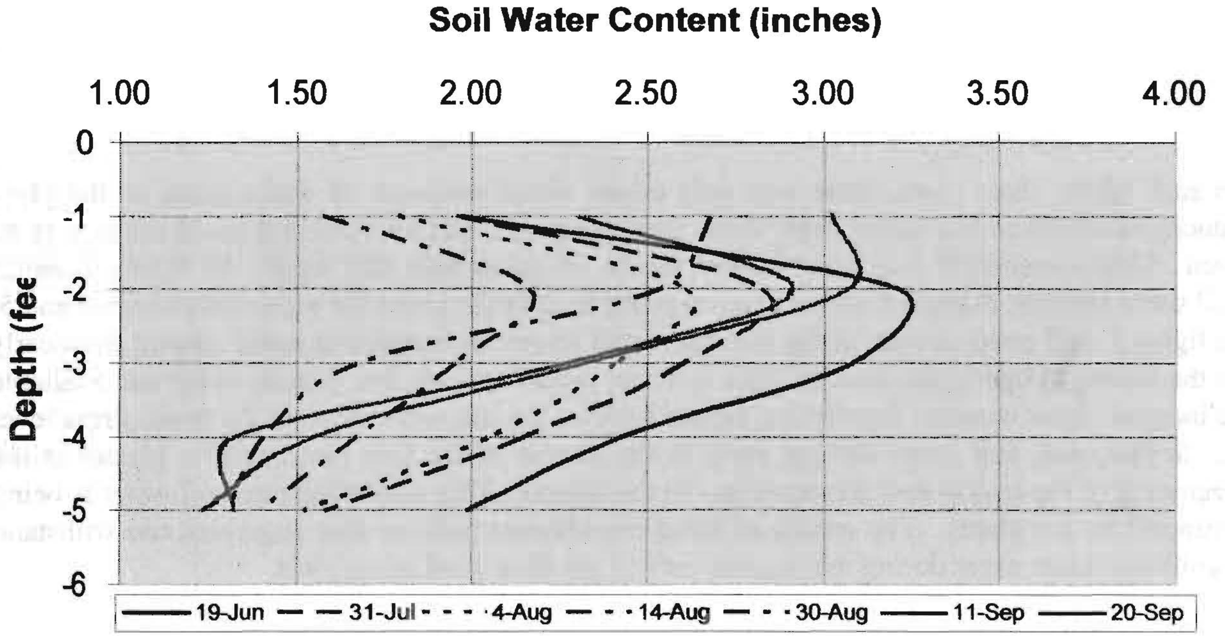

Figure 2. Treatment 5 soil water content profile for 5.5 foot soil profile during 2006 water stress treatment period.