DROUGHT TOLERANCE OF SUGARBEET

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Background

Drought and ground water depletion continues to impact growers throughout much of the Western Sugar Cooperative growing region of the central high plains and Rocky Mountains. The region is entering its sixth growing season where water supplies will be limited due to drought. Surface water supplies have been limited due to the lack of mountain snow pack and local precipitation. Those sugarbeet growers dependent on ground water are seeing ground water levels decline as withdrawals from the aquifers exceed recharge rates. In an effort to sustain ground water, many governmental regulations have been put in place to restrict new well development and limit the amount of water that can be pumped during the growing season.

Sugarbeet is normally considered a high water use crop. Growers are concerned that crop water use for sugarbeet is high and the ability to grow or continue to grow sugarbeet in the future may be questionable if drought conditions continue or worsen. Because the sugarbeet growing season is long in comparison to many other crops, water use is expected to be much greater. 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. The difference between drought tolerant crops such as winter wheat and sunflowers and sugarbeet is the ability of those crops to aggressively extract water from the soil profile and the ability of the plant to produce even though water is a limiting factor. Drought tolerant crops can extract approximately 70% of available water from the soil where a recommendation for sugarbeet is generally considered to be a minimum of 50% extraction of soil water.

Much of the previous work on the impact of water stress on sugarbeet yield has dealt with early and late season irrigation management.

Objective

Determine the production of sugarbeet when irrigation is a limiting factor and water stress occurs during mid-season growth.

Procedures

A preliminary field study was initiated in 2003 to establish a method for evaluating water stress from mid July to mid August. Based on those results, a redesigned long term field study was started in 2004. Procedures and results are given for both years of study. In 2003, the experimental design was a strip plot with three replications. The variety Monohikari and some test varieties were planted on April 15. Plots were three 22 inch rows wide by 30 ft. long. There was 30 feet of border between each irrigation treatment to insure surface or ground water movement was not occurring among the treatments. A sideroll irrigation system was used to apply the water treatments.

Five levels of water stress were established by varying the amount of irrigation water applied during the month of July. The five irrigation treatments included: 1) irrigated each week from July 1 to July 28 (five irrigations), 2) irrigation off July 21 and on July 28 (four irrigations), 3) irrigation off July 14 and on July 28 (three irrigations), 4) irrigation off July 7 and on July 28 (two irrigations) and 5) irrigation off July 1 and on July 28 (one irrigation). During the month of July, there was 0.47 inch of precipitation. All treatment plots were irrigated the same until July 1 when irrigation treatments were started. On July 28 all plots were again irrigated the same and this continued until harvest. Plots were hand weeded during the growing season.

Stand counts were determined on May 15 and again on June 6. Plots were harvested on October 20 by mechanically topping and digging three rows of roots, 30 ft in length. A rototiller was used to mark the end of each plot so samples could be collected in the center of the irrigation treatment area. Two sugarbeet sub samples were collected at harvest and taken to the Western Sugar Cooperative to determine tare and percent sucrose.

Based on the results obtained in 2003, a similar study was established in 2004. In 2004, the experimental design was a randomized complete block. The variety Betaseed 7310R was planted on April 21. The plot area was furrow irrigated prior to and after the water stress treatment period, July 21 through August 20. Water was applied during the water stress treatment period using a small plot sprinkler irrigation system to insure accurate and uniform water application. Approximately 2.8 in. of water was applied for each irrigation event, July 27, August 3 and August 10. This amount was used to fill the soil profile to a point that would stop any further plant water stress and provide adequate water to meet the future demands of the crop. Water stress treatments and corresponding irrigation dates are given in Table 1.

Treatment	Irrigation date				
No Stress	7/21	7/27	8/3	8/10	8/20
Stress Level 1	7/21		8/3	8/10	8/20
Stress Level 2	7/21			8/10	8/20
Stress Level 3	7/21				8/20

Table 1. Irrigation dates for water stress irrigation treatments in 2004.

The only significant precipitation impacting this experiment occurred when the experiment started. Precipitation during the water stress treatment period is given in Table 2. Plots were harvested October 11 by mechanically topping and digging 4 rows of roots, 25 ft in length.

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

Table 2. Precipitation from July 20 through August 27, 2004.

Results

In 2003, plant stand was 65,800 on May 15 and dropped to 61,800 on June 6. There was no statistical difference among the five irrigation treatments tested. In 2003, sugarbeet root yield and sugar content were similar for the five water stress treatments used. Stressing the sugarbeet plant in mid-season did have an affect on sugarbeet root hairs or shape since percent tare was influenced by stress. Stressed plants had less tare while no stressed plants had significantly higher tare.

Four test varieties were included in this initial trial along with the variety Monohikari. Table 3 gives the yield results for the five varieties tested. Percent tare tended to decrease with greater level of water stress. Root yield and sucrose yield increased with increased water stress. Table 4 gives results for the variety Monohikari only. No statistical analysis was conducted but the overall trend of yield and tare was similar to that found for all varieties combined.

Treatment	Percent Tare	Root Yield ton/ac	Percent Sucrose	Sucrose Yield lb/ac
No Stress	8.2	32.0	16.8	10700
Water off 7/21 on 7/28	8.0	35.3	16.6	11700
Water off 7/14 on 7/28	7.1	35.5	16.9	12000
Water off 7/7 on 7/28	5.0	39.1	16.7	13000
Water off 7/1 on 7/28	4.4	39.1	16.8	13100
LSD at 5%	1.9	3.4	N.S.	1300

Table 3. Influence of water stress on sugarbeet yield, 2003.

Treatment	Percent Tare	Root Yield ton/ac	Percent Sucrose	Sucrose Yield lb/ac
No Stress	8.3	30.5	17.5	10700
Water off 7/21 on 7/28	8.4	31.4	17.8	11200
Water off 7/14 on 7/28	8.4	29.9	18.0	10800
Water off 7/7 on 7/28	5.3	37.4	17.4	13000
Water off 7/1 on 7/28	3.8	37.0	18.0	13400

Table 4. Influence of water stress on yield of Monohikari variety sugarbeet, 2003.

Figure 1 shows soil water content determined from gravimetric samples collected during the water stress treatment period. For the irrigation off July 1 and on July 28 (one irrigation) treatment, soil water content was at or near 10% for a three week period. This would indicate that soil water was depleted to a point at which the sugarbeet could extract very little additional water from that portion of the soil profile.

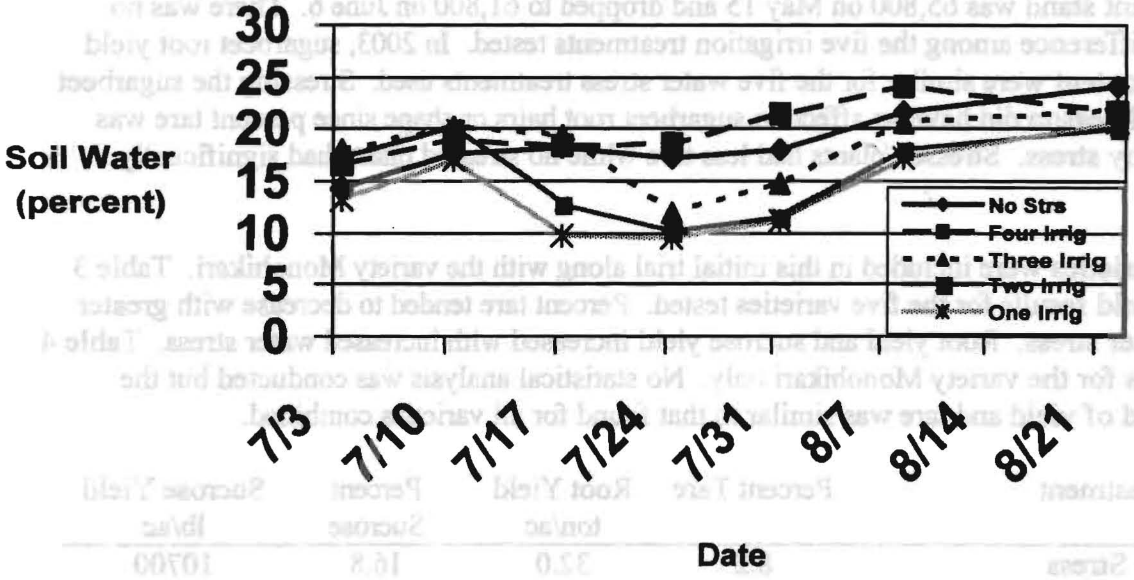

Figure 1. Soil water content (percent) in 3 foot soil profile from July 2 through August 22, 2003.

In 2004, soil water was monitored before, during and after the water stress treatment period of July 21 through August 20. Gravimetric samples were collected on July 21, 26, 29, August 6, 12, 18 and 26. Figure 2 shows the gravimetric soil water content in the top three feet of soil during the water stress treatment period. In Figure 3, a similar graph is shown but gives the total inches of water held in the top three feet of the soil profile.

The no water stress treatment maintained the greatest soil water content during the water stress treatment period. As water stress duration was increased, soil water content was reduced. After water was applied to the water stressed plots to stop any further water stress, the soil water content gradually recovered and tracked closely the pattern of the no stress treatment. In Figure 3, stress level 4 used approximately 2.3 in. of water from the soil profile from July 26 to August 18. Estimated crop water use during this time period was approximately 5.4 in. This would mean that stress treatment level 4 used 3.1 in. of water less than did the full irrigation treatment in the top 3 feet of the soil profile. This additional 3.1 inches of water could have been obtained from depths below 3 ft or the plant could have suffered plant water stress.

There was only minor visual evidence of water stress to the plant canopy and this occurred on hot sunny days. Even then, plant wilt was minimal and could not readily be seen. On September 11, leaf area index and plant height were measured to determine influence of water stress on canopy development. Plant height was determined by measuring the average

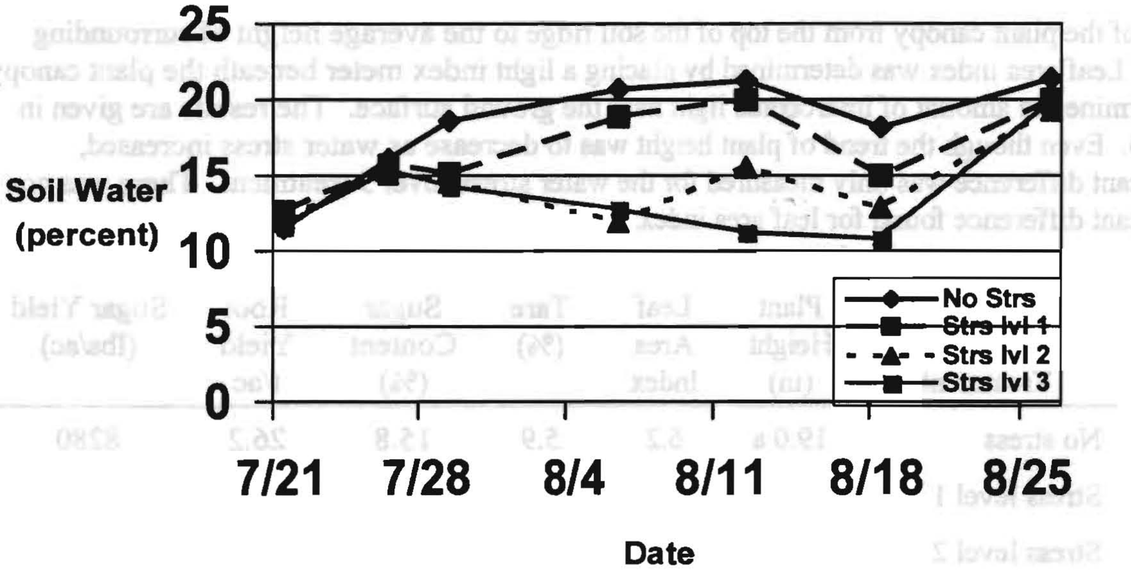

Figure 2. Soil water content (percent) in 3 foot soil profile during water stress treatment period

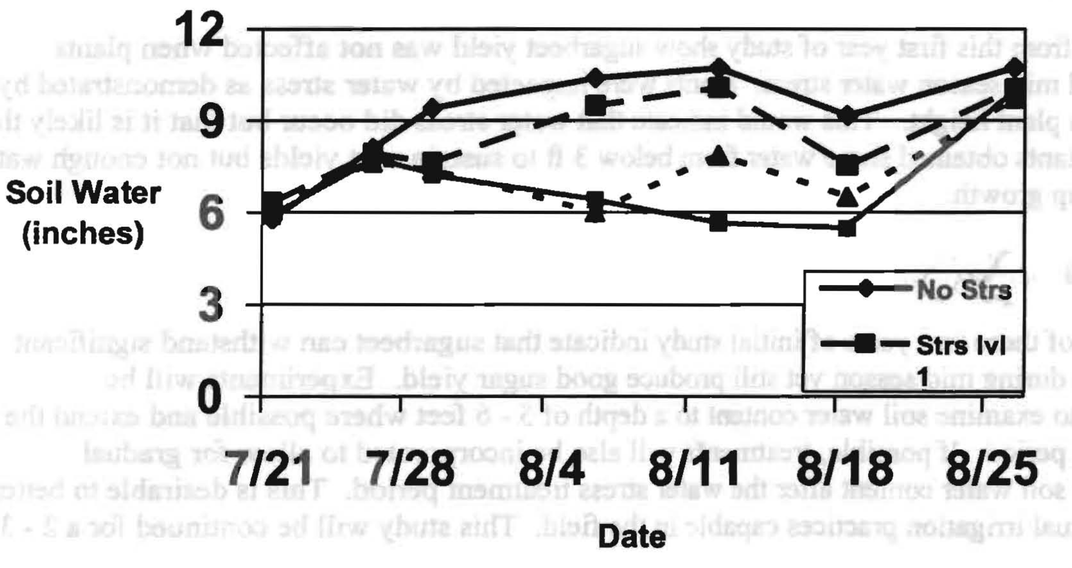

Figure 3. Soil water content (inches) in 3 foot soil profile during water stress treatment period

height of the plant canopy from the top of the soil ridge to the average height of surrounding plants. Leaf area index was determined by placing a light index meter beneath the plant canopy to determine the amount of intercepted light near the ground surface. The results are given in Table 5. Even though the trend of plant height was to decrease as water stress increased, significant difference was only measured for the water stress level 3 treatment. There was no significant difference found for leaf area index.

Treatment	Plant Height (in)	Leaf Area Index	Tare (%)	Sugar Content (%)	Root Yield t/ac	Sugar Yield (lbs/ac)
No stress	19.0 a	6.2	5.9	15.8	26.2	8280
Stress level 1	18.4 a	6.0	7.0	15.8	26.1	8260
Stress level 2	17.8 a	6.1	6.2	15.9	27.1	8610
Stress level 3	15.8 b	6.3	6.6	15.9	26.9	8560

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

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

Harvest parameters of tare, sugar content and root yield along with calculated sugar yield are also given in Table 5. Tare was not influenced by the water stress level even though the smallest amount of tare occurred with the no stress treatment. Sugar content and root yield was not significantly different and showed no distinct trends in relation to the different water stress levels tested. No significant difference was found for sugar yield among the water stress treatments.

The results from this first year of study show sugarbeet yield was not affected when plants experienced mid season water stress. Plants were impacted by water stress as demonstrated by a reduction in plant height. This would indicate that water stress did occur but that it is likely that sugarbeet plants obtained some water from below 3 ft to sustain root yields but not enough water to sustain top growth.

Conclusions

The results of these two years of initial study indicate that sugarbeet can withstand significant water stress during mid season yet still produce good sugar yield. Experiments will be redesigned to examine soil water content to a depth of 5 - 6 feet where possible and extend the water stress period. If possible, treatments will also be incorporated to allow for gradual increases in soil water content after the water stress treatment period. This is desirable to better simulate actual irrigation practices capable in the field. This study will be continued for a 2 - 3 year period.