Sugarbeet Response to Irrigation Method and Polymer Placed in the Seed Furrow[1]

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ABSTRACT

Furrow or sprinkler irrigation is often used to enhance sugarbeet (*Beta vulgaris*) plant establishment, yet little information is available comparing the two methods. Furrow irrigation saturates the seedbed from the bottom up, leaving the soil surface undisturbed. Sprinkler irrigation saturates the seedbed from top down and contributes to the break down and consolidation of soil particles near the surface. Adding synthetic compounds, such as polyacrylamide, to the soil is a method being explored to enhance plant emergence by retaining soil water near the seed and/or reduce soil crusting. The objective of this study was to determine the most effective method(s) of irrigating sugarbeet to enhance emergence. Sugarbeet was planted at two sites in 2001, 2002 and 2003. Irrigation treatments were no irrigation, furrow irrigation and two levels of sprinkler irrigation (light and heavy) applied after planting. The effect of polyacrylamide added to the seed furrow at planting was examined. Polyacrylamide did not influence final sugarbeet emergence for any of the irrigation treatments. Emergence was greater with furrow irrigation than with no or light irrigation. Furrow irrigation also produced significantly greater sucrose yield, when compared to no, light, and heavy sprinkler irrigation treatments.

Additional key words: *Beta vulgaris* L., sugar beet, germination, emergence, polyacrylamide, soil conditioner

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In the irrigated sugarbeet (*Beta vulgaris* L.) production regions of the U.S., irrigation is often needed to obtain acceptable emergence when spring rain is not adequate. To reduce seeding and thinning costs, most growers are planting the crop to stand. When planting sugarbeet to stand, it is necessary to have good weed control, proper seeding rate and consistent emergence rate (Fornstrom, 1980). Planting to stand requires a sugarbeet emergence rate of at least 70% to assure adequate plant population and yield (Durrant, 1988). In a Nebraska study, harvest populations between 40,000 and 100,000 plants/ha resulted in greater sucrose yield than populations of 25,000 and 150,000 plants/ha (Yonts and Smith, 1997). Burcky and Winner (1986), in a study of the effect of plant population on yield at different harvest dates, found that sucrose yield increased as population increased from 31,000 to 71,000 plants/ha. In order to successfully plant to stand, growers must prepare seed beds so that water stored in the soil during the winter and fall is conserved for spring germination. However, if precipitation during the off season is not adequate or excessive pre-plant tillage drys the soil, irrigation will be needed to obtain a desirable plant population.

When soil conditions are dry, applying water with either furrow or sprinkler irrigation systems often improves sugarbeet stand establishment. Until recently there has been little information to compare the effect of the two irrigation methods on the emergence of sugarbeet. Kaffka and Hembree (2004) found that transient increases in soil salinity, formed when using furrow irrigation, did not influence sugarbeet emergence when compared to sprinkler irrigation conditions having lower average electrical conductivity. In a three-year regional sugarbeet variety trial, emergence counts were collected from approximately 40 varieties at twenty field sites in Colorado, Nebraska, and Wyoming (Smith et. al, 2000). Of the twenty sites, fifteen were irrigated for emergence. Six of these sites were furrow irrigated and nine were sprinkler irrigated using a center pivot. Sites that were furrow irrigated averaged 75% emergence while sprinkler irrigated sites averaged 62% emergence. Water application amount and frequency was not recorded, but it is important to note that center pivots replaced the labor associated with irrigating furrow systems but resulted in reduced seedling emergence. Plant stand can be reduced with sprinklers, in part, because of the difference in how water is applied by the two types of irrigation systems.

When water is applied for germination using furrow irrigation, the seed bed is saturated from below and the soil surface remains undisturbed. Sprinkler irrigation saturates the seed bed from above and the impact of the water droplets can cause the soil structure near the surface to break down and consolidate, forming a dense soil layer over the seed. A dense soil layer near the surface can also develop as a result of a high intensity rain storm (Tackett and Pearson, 1965). When irrigation or rainfall that breaks down the surface soil aggregates and forms a dense soil layer is followed by warm sunny weather, the potential for developing a surface crust is increased. A crust on the soil surface makes it difficult for sugarbeet to emerge, and as a result can reduce sugarbeet stand.

Polyacrylamide (PAM) is an environmentally safe industrial flocculent widely used in municipal water treatment and the food processing industry. In addition, anionic PAM used in agricultural waters are considered to be safe and result in low toxicity levels for both mammal and aquatic organisms (Barvenik, 1994). PAM mixed with water that is to be used to furrow irrigate has the potential to significantly reduce furrow irrigation induced soil erosion. Studies in Idaho found PAM to reduce irrigation induced soil erosion by as much as 94% (Sojka and Lentz, 1997).

Norton and Dontsova (1998) found that water infiltration increased and soil loss due to runoff decreased when PAM was surface applied to five soils in the corn belt. A study by Lehrsch, et. al (2005), found sugarbeet emergence increased from 48.4 to 58.3 percent when using a cationic organic polymer. Sugarbeet emergence was also improved when Johnson and Law (1967) and Robbins, et. al (1972), sprayed sulfuric and phosphoric acid on the soil surface to reduce soil crusting. In a similar study aimed at improving sugarbeet emergence, a synthetic organic polymer sprayed on the soil surface had no affect (Lehrsch et. al, 1996). In yet another study to establish alfalfa (*Medicago sativa* L.) and Russian wildrye (*Elymus junceus* Fish.), Waddington (1977) applied dry polyacrylamide gel in the row. Seedling year establishment was not affected in sandy-loam soil, but in a sandy-clay loam soil as the gel rate increased, seedling establishment decreased.

Conversion from furrow to center pivot irrigation is occurring in many areas. The prime reasons for conversion are improved water application efficiency and reduced labor. As an example, in the North Platte Valley of Nebraska and Wyoming it is estimated that conversions are occurring at the rate of approximately 4,000 hectares each year (B. Pierce, personal communication, April 2005). Irrigators are left in a quandary. As was the case with Smith et. al (2000), if water is available for irrigation during sugarbeet planting and emergence, why is plant establishment less with sprinkler irrigation than with furrow irrigation? More information is needed to determine the best time for applying water and the amount of water to be applied.

This research was initiated to begin the process of establishing proper irrigation water management techniques that will allow center pivot operators to obtain the same or improved levels of sugarbeet emergence as previously achieved with furrow irrigation systems. The objective of this study was to determine the method(s) of irrigating sugarbeet at planting time that will maximize germination and emergence.

MATERIALS AND METHODS

The study was conducted at the University of Nebraska, Panhandle Research and Extension Center near Scottsbluff, Nebraska. The soil type was a Tripp very fine sandy loam (Coarse-silty, mixed, superactive, mesic Aridic Haplustolls) with a water holding capacity of 0.15 - 0.17 mm/mm. Four irrigation treatments applied after planting were compared in combination with Polyacrylamide applied in the seed furrow at planting. The irrigation treatments were: 1) No irrigation at planting time (No); 2) Low intensity sprinkler irrigation to maintain adequate soil water content at seeding depth (Light); 3) High intensity sprinkler irrigation that would result in soil surface breakdown (Heavy); and 4) Furrow irrigation to fill the soil profile to a depth of at least 0.6 m and saturate the seed furrow (Furrow). Following planting time irrigation treatments, all plots were irrigated for the balance of the growing season using a center pivot system. Cultural practices were the same for all treatments through the growing season.

The ”Light” sprinkler treatment was designed to simulate the situation in which adequate soil water is available just below seeding depth at the time of planting. After planting, one or two light applications of water, approximately 6.0 mm, could be sprinkler applied and used to maintain soil water around the germinating seed. In contrast, the “Heavy” sprinkler treatment was designed to simulate a situation in which soil water is deficient at and below seeding depth at the time of planting. In this case, greater water application amounts, approximately 13.0 mm, would be needed after planting because soil water applied near the seed would quickly be evaporated into the atmosphere or pulled into the dry soil layer below the seed. To prevent rapid loss of soil water resulting in seed desiccation, more frequent and greater quantities of irrigation water would be required to meet both evaporative demand and for replenishing soil water below the seeding depth.

For each of the three years, the experiment was planted at two different sites on two different days for a total of six site-years. The first site planted each year was grown long enough to collect emergence results. The second site planted each year was used to collect emergence and yield results, including tare, sucrose concentration and

Table 1. Irrigation date and irrigation application amount for each experimental site in 2001 - 2003.

Planting Date	Irrigation treatment					
	Light		Heavy		Furrow	
	Date	Irrigation	Date	Irrigation	Date	Irrigation
		mm		mm		mm
May 8, 2001						
	May 10	12.7	May 10	12.7	May 10	43.2
	May 14	6.4	May 14	6.4		
	May 16	6.4	May 16	6.4		
May 15, 2001						
	-	-	May 17	25.4	May 17	43.2
	May 18	8.9	May 18	8.9		
	May 25	8.9	May 25	8.9		
April 15, 2002						
	April 18	6.4	April 18	12.7	April 18	43.2
	April 24	6.4	April 24	12.7		
	May 9	6.4	May 9	12.7		
	May 16	6.4	May 16	12.7		
April 25, 2002						
	April 26	6.4	April 26	12.7	April 26	43.2
	April 30	6.4	April 30	12.7		
	May 8	6.4	May 8	12.7		

root yield. In Table 1, planting date, irrigation date and irrigation application amount are given for the Light, Heavy and Furrow irrigation treatments in 2001, 2002 and 2003. The No irrigation treatment was planted on the same corresponding day.

Plots were moldboard plowed and standard pre-plant tillage operations were used to prepare the soil for planting. For the first site planted each year, the herbicide cycolate (Ro Neet) was applied preplant incorporated at a rate of 1.7 kg ai/ha. For the second site the herbicide ethofumesate (Nortron) was broadcast and incorporated at a rate of 1.2 kg/ha to control early emerging weeds. For post emergence weed control on the second site, phenmedipham+desmidipham (Betamix) was used in split applications at a rate of 2.2 kg/ha. Triflusulfuron (Upbeet) was added to the last post application at a rate of 0.03 kg/ha. Main plots consisted of six, 56 cm wide rows, each 7.6 m long. Treatments were replicated six times.

A split plot randomized complete block design was used for this study. Statistical comparison was made at the P=0.05 level of significance. A cross linked, potassium-based polymer (Stockosorb AGRO F, manufactured by Stockhausen, Inc.) was applied at a rate of 2.2 kg/ha. The polyacrylamide granules were applied directly in the seed furrow during planting using insecticide boxes attached to the planter units. Polyacrylamide was randomly applied to one pair of the center four rows of each irrigation treatment plot.

For the furrow irrigated treatment, every other furrow was irrigated using small plot irrigation equipment. Sprinkler treatments were irrigated using a center pivot system equipped with low pressure spray devices located approximately 1 m above the ground. Individual sprinkler valves were used to isolate the furrow and sprinkler irrigation treatments.

Regular sized pellets of the sugarbeet variety Beta 4546 were planted each year. Seeds were planted at a greater population, 235,000 seeds/ha, for the early planting date each year and at 126,000 seeds/ha for the second planting date. Stand count measurements were collected at the two to four leaf growth stage to insure that final emergence was complete. Emerged seedlings were counted in both rows of each treatment for the entire plot length. Harvest dates for the second planting date experiment of each year were October 1, 2001; October 14, 2002; and October 16, 2003. Root yield was determined by harvesting the entire length of the two row plots using a conventional sugarbeet harvester converted to harvest small plots. Approximately 7.0 kg subsamples were collected from each plot and taken to Western Sugar Company for determination of tare and sucrose concentration.

RESULTS

Precipitation received during the germination and emergence time periods are given in Table 2. Planting dates were delayed in 2001 due to precipitation during April and early May. Because of the precipitation received in 2001, sprinkler irrigation amounts were similar for the Light and Heavy sprinkler irrigation treatments (Table 1). A similar situation occurred in 2003, with precipitation providing sufficient water for germination prior to the two planting dates. In 2002, precipitation was less than in the other two years although precipitation did occur two days

Table 2. Precipitation during treatment period for 2001, 2002 and

Year	Time period	Precipitation
		mm
2001	April 1 - 30	74.2
	May 1 - 5	46.0
	June 2 - 4	46.7
2002	March 1 - March 25	9.4
	April 20	3.0
	April 27 - May 21	17.5
2003	March 1 - April 6	47.7
	April 17 - 18	10.7
	April 30 - May 29	18.0

after planting for the second date. As a result, only a limited amount of water stress during germination and emergence was attained during this three year study. Sugarbeet emergence is also hampered by the formation of a soil crust that often forms when the surface soil structure is broken down during water application followed by sunshine, warm temperatures and drying winds. Weather conditions were not conducive to the formation of a soil crust during the course of these experiments.

There were no significant differences in tare, sucrose concentration, root yield, or sucrose yield, nor in final plant emergence when PAM application was compared to no PAM during 2001-2003, Tables 3 and 4. Therefore PAM treatment values were combined during 2001-2003 to evaluate differences in the irrigation treatments being tested, Tables 3 and 4. No significant difference in tare or sucrose concentration was found among the four irrigation treatments tested. Although not significant, the Furrow treatment had a slightly greater sucrose concentration than did the other irrigation treatments. Root yield was 7.9 and 6.6 t/ha greater for the Furrow treatment than the No and Light irrigation treatments, respectively. Similarly, emergence increased by 10% and 6% for the Furrow treatment, compared to the No and Light irrigation treatments, respectively. Sucrose yield was 1240 kg/ha greater for the Furrow treatment than for the average of the other irrigation treatments.

In the analysis, there was no interaction found between the polymer and irrigation treatments. However, there was significant interaction found between year and irrigation treatment. Irrigation treatments proved to be significantly different only during the 2002 growing season. Individual year results are given in Tables 3 and 4. In 2001 and 2003, rainfall reduced the need for irrigation to achieve germination and emergence. In 2002, irrigation for germination and

Table 3. Tare percent, sucrose concentration, root yield and sucrose yield for the second planting experiment in 2001, 2002, 2003 and combined in 2001-2003.

Year	Treatment	Tare	Sucrose	Root yield	Sucrose yield
		%	%	t/ha	kg/ha
2001	PAM	7.1	14.9	58.9	8785
	No PAM	6.8	15.0	60.2	9002
	LSD @ 5%	N.S.	N.S.	N.S.	N.S.
	No	7.0	14.7	55.0	8080
	Light	6.9	15.2	60.5	9221
	Heavy	7.2	14.9	62.0	9235
	Furrow	6.8	14.9	60.6	9040
	LSD @5%	N.S.	N.S.	N.S.	N.S.
2002	PAM	4.3	15.4	52.6	8134
	No PAM	4.8	15.2	57.1	8677
	LSD @ 5%	N.S.	Sig.	Sig.	N.S.
	No	4.6	15.1	55.3	8357
	Light	4.2	15.4	43.6	6681
	Heavy	4.8	15.0	51.8	7737
	Furrow	4.5	15.8	68.7	10848
	LSD @5%	N.S.	0.8	13.7	2013
2003	PAM	5.7	16.2	74.8	12083
	No PAM	5.4	16.3	73.7	12021
	LSD @ 5%	N.S.	N.S.	N.S.	N.S.
	No	4.9	16.4	69.6	11425
	Light	6.4	15.8	79.9	12624
	Heavy	5.1	16.3	73.3	11912
	Furrow	5.7	16.5	74.3	12247
	LSD @5%	N.S.	N.S.	10.1	N.S.
2001-2003	PAM	5.7	15.5	62.1	9667
	No PAM	5.7	15.5	63.7	9900
	LSD @ 5%	N.S.	N.S.	N.S.	N.S.
	No	5.5	15.4	60.0	9287
	Light	5.8	15.4	61.3	9509
	Heavy	5.7	15.4	62.4	9627
	Furrow	5.7	15.8	67.9	10712
	LSD @ 5%	N.S.	N.S.	6.4	975

of precipitation in the spring. Furrow irrigation produced a greater sucrose yield than any of the other irrigation treatments in 2002. The difference was primarily caused by increased root yield and somewhat by improved sucrose concentration.

The use of polyacrylamide in the seed furrow again had no influence on sugarbeet emergence (Table 4). It should be noted for the second planting in 2002, emergence was similar for the No and Furrow irrigation treatments and both treatments were significantly greater than the sprinkler irrigation treatments. Improvement in sucrose yield for the No and Furrow treatments could be the result of sprinkler irrigation causing aggregate reduction followed by compaction and crusting.

CONCLUSIONS

Under the conditions of these experiments, polyacrylamide did not improve sugarbeet emergence. Average emergence when combined over years and irrigation treatments ranged from 58.0% to 68.5%. Durrant (1988), indicated that an emergence rate of approximately 70% was needed to achieve maximum yield. Seeding 126,000 plants/ha and having a 58% emergence would result in a population of 73,000 plants/ha. This plant population is the midpoint of the range that Yonts and Smith (1997) found produced the greatest sucrose yield. Therefore, within the range of plant populations obtained in this experiment, only small differences in sucrose production might be expected. Because soil water was generally available at planting time, emergence was not hindered to the extent that may occur when limited soil water reduces stands enough to cause a yield reduction.

Freezing temperatures were recorded during emergence of the second planting date in 2002. Greater emergence for the Furrow treatment could have resulted because the additional water applied after planting saturated the area around the seeds. This additional water held in the soil would provide a larger mass that needed to be cooled before freezing temperatures could damage seedlings. Differences in soil water content could also have allowed the stage of emergence to differ slightly for the irrigation treatments. However, emergence for the No and Furrow treatments were similar and both had greater emergence than the sprinkler treatments. The reason emergence was less for the sprinkler treatments could be, in part, attributed to the downward force of water droplets causing a breakdown of soil particles over the emerging seedlings.

The trend in this experiment was for sucrose concentration, root yield and emergence to be greater for furrow irrigation than for

Table 4. Percent emergence for the first and second planting experiments in 2001, 2002, 2003 and percent emergence for the first and second planting experiments combined in 2001-2003.

Year	Treatment	First planting	Second planting
		%	%
2001	PAM	78.4	73.3
	No PAM	76.1	72.8
	LSD @ 5%	N.S.	N.S.
	No	75.2	68.0
	Light	79.0	76.7
	Heavy	74.2	73.9
	Furrow	80.5	73.5
	LSD @5%	6.3	N.S.
2002	PAM	56.2	40.7
	No PAM	54.6	39.1
	LSD @ 5%	N.S.	N.S.
	No	34.4	48.1
	Light	60.3	21.3
	Heavy	71.8	30.0
	Furrow	55.7	60.2
	LSD @5%	12.4	15.9
2003	PAM	61.8	80.1
	No PAM	55.7	81.0
	LSD @ 5%	N.S.	N.S.
	No	44.1	78.7
	Light	60.2	79.0
	Heavy	72.8	81.6
	Furrow	57.8	83.2
	LSD @5%	22.3	N.S.
2001-2003	PAM	65.1	-
	No PAM	63.2	-
	LSD @ 5%	N.S.	-
	No	58.1	-
	Light	62.8	-
	Heavy	67.4	-
	Furrow	68.5	-
	LSD @5%	5.4	-

root yield and emergence to be greater for furrow irrigation than for sprinkler irrigation. When these factors were combined, the greater sucrose yield for the Furrow irrigation treatment was significant. Furrow irrigation improved emergence over sprinkler irrigation by an average of 3 percent. This difference is much less than the 13 percent reduction found by Smith et. al (2000). However, in this experiment, conditions that contribute to the formation of a crust and the lack of soil water were not present as with the Smith et.al (2000) study.

The proportion of furrow-irrigated land continues to decline as center pivot sprinkler systems are installed. Although center pivots offer many advantages, furrow irrigation and the process of wetting the seed from below without breaking down surface soil structure appears to provide better germination for a shallow planted seed such as sugarbeet. The process of irrigating sugarbeet to insure emergence should continue to be explored with the intent of developing methods and techniques that allow sprinkler irrigation systems to achieve seedling emergence levels that are at least as good as furrow irrigation systems.

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