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## Evaluation of Cover Crop System for Sugarbeet Production Under Furrow Irrigation<sup>1</sup>

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### ABSTRACT

Field studies were conducted during 1996, 1997, and 1998 to evaluate the use of cover crop for sugarbeet planted under a furrow irrigation system. Five treatments were replicated in a randomized complete block design including a conventional plow treatment with no cover crop, two fall planted cover crop treatments on beds which were either drilled or broadcast, and two spring planted cover crop treatments on beds which were either drilled or broadcast. Sugarbeet tare, sugar content, root yield and sugar yield were similar among the treatments tested. The plow treatment resulted in the greatest sugarbeet plant populations while the fall planted cover crop treatments resulted in the least population.

**Additional Key Words:** *Beta vulgaris L.*, wind erosion, bed planting

Control of wind induced soil erosion (wind erosion) as a method of reducing crop damage in early spring, has been a research topic for a number of years. Chepil (1955) conducted work that compared the erodibility of soil when vegetative matter was added to the soil. During decomposition, the vegetative matter slightly decreased soil erodibility which meant better protection could be achieved by allowing plant material to decompose on the soil surface rather than mixing the vegetative material with the soil.

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<sup>1</sup>A contribution of the University of Nebraska Agricultural Research Division, Lincoln, NE 68583. Research Bulletin No. 13451. The research was partly funded by the Western Sugar Grower Joint Research Committee Inc.

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Once sugarbeet emerges from the soil, early season plant growth is primarily confined to top growth and the development of a fibrous root system (Loomis et al., 1971). Growth is slow and can take more than six weeks for sugarbeet top growth to reach heights of 20 cm or more to begin to provide protection from wind erosion. For this reason, wind erosion during sugarbeet establishment is a major concern in many of the sugarbeet producing areas. It was estimated that during the period 1997 - 2001 approximately 18 percent, of the 13,300 hectares of sugarbeet lost in the Western Sugar Company growing region, was lost due to wind erosion. (J. Darnall, personal communication, 2001) This amount of crop was lost from production but additional sugarbeet fields were damaged by wind erosion with resulting loss of yield potential and increased vulnerability to injury or competition from weeds, insects or disease.

As an alternative to relying on crop residue from the previous year, Fornstrom and Boehnke (1976) developed a system of planting barley as a cover crop between sugarbeet rows. The cover crop was planted about two weeks before the sugarbeet and was intended to provide wind erosion protection for the sugarbeet crop. Once sugarbeet was established, the cover crop was mechanically removed. In a later but similar study, Fornstrom and Miller (1996) established sugarbeet in a living mulch but in this study relied on herbicides to stop cover crop growth. In this case, the dry plant material was left standing to extend the crop protection period.

In many cases, sugarbeet is planted following crops that have little carryover plant residue after harvest. This rotation sequence is partly by design to allow more accurate planting and cultivation without the interference of surface crop residue. In both of Fornstrom's studies, sugarbeet was successfully grown in cover crop systems. Timing of the mechanical removal of the cover crop was sometimes a problem in the 1976 study. Because herbicides were used to remove the cover crop in place of tillage for the 1996 study, soil water content could be maintained more effectively during a critical time period. Similar production practices were used by growers in England (Hollowell, 1982 and Jackson, 1982). These studies in England used cover crops to control wind erosion on fields dependent on precipitation for meeting crop water requirements. Sugarbeet was irrigated using a sprinkler system for both studies conducted by Fornstrom.

Variations of these cover crop systems have been used on a production basis in the sugarbeet growing region near Alliance, NE. In one example, small grain is planted as a cover crop in the fall of the year. The cover crop is planted either in rows or broadcast. When planted in rows, the fall seeded cover crop is spaced such that sugarbeet can be planted between the rows of grain in the spring. After planting but prior

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to sugarbeet emergence, the cover crop is killed with a amino acid synthesis inhibitor. If the cover crop is broadcast planted, the herbicide is used to kill a strip of the cover crop prior to sugarbeet planting. The remaining strips of living cover crop between the planted rows of sugarbeet are sprayed with herbicide when the cover crop is about 15 cm tall but before sugarbeet emergence. The dead cover crop is left standing in both cases to provide protection from the wind until such time that cultivation is necessary. When cultivation occurs, sugarbeet is of adequate size to be resistant to wind erosion. These production systems are used successfully to protect sugarbeet from wind erosion early in the season on fields under center pivot irrigation in Nebraska.

These cover crop systems have been further refined and used over the past ten years by growers that use center pivot irrigation systems to supply needed water for plant growth. Furrow irrigation systems still comprise a significant portion of the sugarbeet production acres in western Nebraska, eastern Wyoming and northeast Colorado, and these fields are just as vulnerable to wind erosion damage. Cover crop systems have not been adapted where furrow irrigation is used because of several concerns. The cover crop between the sugarbeet rows may interfere with constructing furrows and irrigating. Furthermore, the cover crop may deplete limited soil water and retard or limit sugarbeet emergence. With a center pivot irrigation system, water can be replaced more easily to maintain early sugarbeet growth, and may explain the popularity of cover crops in center pivot irrigated cropping regions.

Center pivot producers have adapted and refined cover crop systems to improve overall production by eliminating the potential for soil loss and crop injury due to wind erosion and reduce the environmental impact of wind erosion. Cover crops grown under center pivot systems also offer cost reduction opportunities beyond saving soil and reducing crop injury. Labor and equipment costs necessary to control wind erosion in fields left unprotected can be reduced or eliminated. A properly designed cover crop system for furrow irrigated sugarbeet must have the same wind erosion and cost reduction benefits as existing cover crop systems used in center pivot irrigated sugarbeet. Understandably, sugarbeet producers are more reluctant to use a cover crop under a furrow irrigation system because of the unknown problems that may be associated with furrow irrigation and for some areas, the lack of available surface water for irrigation early in the growing season to replace depleted soil water.

Yonts, et al., 1983 determined that the rate of sugarbeet emergence was slowed as soil moisture tension increased. Further, soil moisture tension of less than about 6 atm was needed to insure 60% emergence. Yet now with plant to stand practices being implemented on

a more widespread basis, 70% emergence is desirable in order to achieve the desired final plant population for optimum yield. In many locations of the central high plains sugarbeet growing region, rainfall may not be adequate or timely to provide the soil water necessary for attaining this level of sugarbeet emergence without irrigation.

The objective of this experiment was to evaluate cover crop systems as a method to reduce wind induced soil erosion when using furrow irrigation to produce sugarbeet.

## MATERIALS AND METHODS

A three year field study was initiated in the fall of 1995 at the University of Nebraska, Panhandle Research and Extension Center at Scottsbluff. A one factor randomized complete block design with four replicates and combined over years was used to compare five cover crop treatments.

- 1) Conventional plow treatment with no cover crop
- 2) Fall cover crop drilled on beds
- 3) Fall cover crop broadcast on beds
- 4) Spring cover crop drilled on beds
- 5) Spring cover crop broadcast on beds

The fall cover crop broadcast on beds was conducted only during the second and third year of this study. Statistical analyses were made to compare the four treatments tested over the three year period, 1996 through 1998 and the five treatments over the two year period, 1997 through 1998.

Dry bean was always the crop preceding sugarbeet. Fall bedding and cover crop seeding were completed in October while spring bedding and cover crop seeding were completed by late March of each year. Plots were six, 56 cm rows wide with field length varying from 180 to 250 m. The conventional treatment was 12 rows wide to accommodate the plowing operation and provide a uniform plot area for testing. Soil type was a Tripp very fine sandy loam. Aldicarb was applied at sugarbeet planting at a rate of 32.5 kg/ha on the irrigated side of the planting ridge approximately 6.5 cm below and 5.0 cm beside the planted row of sugarbeet to control nematodes. Because the cover crop plots were narrow and in close proximity, the impact of soil erosion on sugarbeet survival was not measured. Rather, the focus was on the ability of the sugarbeet to grow and yield in a furrow irrigated cover crop system.

### Tillage operations

The conventional treatment was plowed in October of each year. All remaining tillage for the conventional treatment was completed in the spring just prior to planting. During the first year of study no tillage was

conducted between harvest of the previous crop and bed construction. A prototype bedder was used for constructing beds during the first year. In 1996 and 1997 a Till-n-Plant, a zone tillage implement constructed by Schlagel Manufacturing of Torrington, Wyoming, was used in the fall as the primary tillage system. The Till-n-Plant utilizes steel shanks to loosen the soil to a depth of approximately 30 cm in what will be the planted row of sugarbeet. A bedder, also manufactured by Schlagel Manufacturing, follows the Till-n-Plant to construct beds directly over the loosened soil created by the Till-n-Plant.

Beds were spaced 56 cm apart and formed to be approximately 15 cm high. Beds were constructed both in the fall and spring as specified by the treatments.

#### Cover crop seeding

For the drilled cover crop treatments, John Deere 71 planter units were used to seed the cover crop. Two rows of cover crop were planted, one on each side of each bed. The cover crop rows were spaced 28 cm apart on the 56 cm spaced beds. This resulted in a row of cover crop located 14 cm on each side of where sugarbeet would be planted.

For the broadcast treatments, the cover crop was seeded using a hand held broadcast spreader just prior to formation of the beds. The seed was planted at a rate of 56 kg/ha for both the drilled and broadcast treatments. The fall beds were seeded to winter rye and the spring beds were seeded to spring barley. Seeding date for each of the cover crop treatments tested is given in Table 1.

**Table 1.** Planting date for sugarbeet and fall and spring seeded cover crop treatments.

Year	Spring Bedded Cover Crop Planting Date	Fall Bedded Cover Crop Planting Date	Sugarbeet Planting Date
1995		October 29	
1996	March 15	October 25	May 3
1997	March 13	October 20	May 1
1998	March 25		April 21

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## Planting

The sugarbeet varieties used in the study were selected to best match field conditions and history. American Crystal Hybrid 184 was planted in 1996, Seedex Halt was planted in 1997 and Betaseed 4546 was planted in 1998. Field plots were planted to stand at a seeding rate of approximately 124,000 seeds per hectare for a seed spacing of 14.5 cm. Seed was planted at approximately a 2.0 cm depth. Planting dates are given in Table 1. A John Deere Maxi-Merge II planter was used in 1996 and 1997. The German-made Kliene planter was used in 1998.

Soil water content was measured on May 10, 1996 prior to sugarbeet emergence in the plow and spring and fall drilled cover crop treatments. Soil water content was determined gravimetrically by collecting a composite of two 3.8 cm soil core samples at two locations from each plot. Plant population was determined for each treatment in mid-June by measuring the number of emerged plants within 3.0 m of row at ten locations within each plot.

## Cover crop and weed control

Control of the cover crops varied based on cover crop growth and climatic conditions. In 1996, clethodim at 0.1 kg/ha was applied May 21 and sethoxyim at 0.4 kg/ha was applied on June 26. In 1997, glyphosate at 0.8 kg/ha was applied April 28 and May 7 to the fall bedded and spring bedded treatments, respectively. To remove cover crop that emerged after these dates, quizalofop-P at 0.05 kg/ha was applied May 23, 1997. In 1998, clethodim at 0.14 kg/ha was applied May 20. Depending on specific weed pressure, split applications of phenmedipham plus desmedipham at 0.18 plus 0.18 kg/ha, phenmedipham plus desmedipham plus triflurosulfuron methyl at 0.18 plus 0.18 plus 0.016 kg/ha or phenmedipham plus desmedipham plus clopyralid at 0.18 plus 0.18 plus 0.1 kg/ha were applied each year beginning at the cotyledon to two true leaf stage of growth. All plots were cultivated twice and hand weeded once.

## Harvest

Plots were harvested October 9, 1996, November 4, 1997 and November 12, 1998 using a mechanical two row plot harvester. Two rows of sugarbeet roots were harvested from a 30.5 m section in the upper one third and lower one third of each plot each year. Root weights were combined from the two samples to obtain a total sample representing 122 m of row from each plot. A sub-sample of roots, approximately 10 kg, was collected from each of the two harvest zones in the field. These sub-samples were taken to the Western Sugar Company tare lab for analysis of sugar content and tare.

## RESULTS

The results of the spring 1996 soil water content measurements are presented in Table 2. Soil water content in the fall prepared beds was

**Table 2.** Soil water content at sugarbeet seeding depth for plow, spring cover crop drilled on beds and fall cover crop drilled on beds treatments. Samples collected May 10, 1996.

Cover Crop Treatment	Soil Water Content (%)
Plow - Conventional Seedbed Preparation	9.4
Spring Cover Crop Drilled on Beds	9.7
Fall Cover Crop Drilled on Beds	6.4
LSD @ 5%	0.9

less than the soil water level in the spring bed preparation treatment and the plow treatment. The plots bedded in the fall had a lower soil water content presumably due to the added time the cover crop was growing and using water. Based on these soil water content measurements, all treatments each year were furrow irrigated as soon as feasible after planting to insure adequate soil water levels for sugarbeet germination and emergence.

Separate analyses were made to compare five treatments over the two year period, 1997 - 1998 and the four treatments tested over the three year period, 1996 - 1998. The results for the two year and three year analyses are given in tables 3 and 4, respectively.

### Plant Population

Plowed plots had the greatest sugarbeet population at 102,300 plants/ha, while the fall broadcast plots had the least population of 81,200 plants/ha in 1997 and 1998 (Table 3). The fall drilled treatment was similar to the fall broadcast treatment and both of the spring planted cover crop treatments. Plant population for all treatments averaged 88,400 plants/ha. Despite irrigation immediately after planting sugarbeet, plant population was less for the spring and fall bedded treatments compared to the conventional plow treatment.

Results over 1996, 1997, and 1998 were similar to results from 1997 and 1998. The plow treatment had the greatest sugarbeet population

**Table 3.** Sugarbeet plant population, tare, sugar content, root yield and sugar yield with cover crop and tillage treatments during 1997 and 1998.

Cover Crop Treatment	Plant Population (plants/ha)	Tare (%)	Sugar (%)	Root Yield (Mg/ha)	Sugar Yield (Mg/ha)
Plow - Conventional Seedbed Preparation	102,300	9.3	15.6	45.9	7.2
Spring Cover Crop Drilled on Beds	87,000	9.1	15.4	50.2	7.8
Spring Cover Crop Broadcast on Beds	88,500	9.9	15.4	49.3	7.6
Fall Cover Crop Drilled on Beds	82,900	9.5	15.2	51.5	8.0
Fall Cover Crop Broadcast on Beds	81,200	8.9	15.7	45.0	7.1
LSD @ 5%	5,700	NS	NS	NS	NS

at 102,700 plants/ha, while the fall seeded cover crop treatment had the least population at 87,500 plants/ha. Average plant population for all treatments was 93,800 plants/ha, slightly higher than the average plant population for the two year comparison. Plant population from the spring and fall planted cover crop treatments was significantly less than from the plow treatment.

### Sugarbeet Yield

Yield results for 1996, 1997 and 1998 are presented in Table 4. Even though plant populations differ in mid-June, no significant differences were found in the yield parameters of tare, sugar content, root yield or sugar yield among the five treatments. Similar results in the yield parameters were also found for the two year comparison given in Table 3.

## DISCUSSION

The use of fall and spring seeded cover crops drilled in rows and broadcast, as a method to reduce sugarbeet loss due to spring wind erosion, was shown to have no effect on yield parameters. However, the use of



**Table 4.** Sugarbeet plant population, tare, sugar content, root yield and sugar yield with cover crop and tillage treatments during 1996, 1997 and 1998.

Cover Crop Treatment	Plant Population (plants/ha)	Tare (%)	Sugar (%)	Root Yield (Mg/ha)	Sugar Yield (Mg/ha)
Plow - Conventional Seedbed Preparation	102,700	9.5	15.9	43.5	7.0
Spring Cover Crop Drilled on Beds	92,100	8.5	15.5	45.7	7.1
Spring Cover Crop Broadcast on Beds	93,100	8.6	15.4	43.5	6.7
Fall Cover Crop Drilled on Beds	87,500	8.7	15.7	49.3	7.8
LSD @ 5%	4,300	NS	NS	NS	NS

herbicide to control the cover crop must be timely so available soil water can be conserved for use by the sugarbeet seedlings. Because of the variable depth resulting from broadcast seeding, emergence of the cover crop was extended over a longer time period making cover crop control difficult when using a single application of herbicide. Even though the cover crop was controlled with herbicide, irrigation was still necessary after planting each year to obtain good sugarbeet germination, emergence and early seedling growth with the cover crop treatments tested.

Because of the narrow 56 cm row spacing, space was limited for seeding a cover crop, planting sugarbeet and constructing an irrigation furrow free from plant material. The broadcast cover crop in this study resulted in plant material, either living or dead, in the bottom of the irrigation furrow. During the first irrigation after planting, this material slowed water advance and made irrigation difficult. Water advance was more easily attained when the cover crop was seeded with a planter unit because the plant material was on each edge of the furrow. However, as the cover crop grew, plant leaves were still present in the furrow and the flow of water was affected.

To eliminate the problem of residue in an irrigation furrow, a potential solution would be to plant two rows of cover crop between every other row of sugarbeet. This would allow furrow construction and

irrigation in the alternate rows which would be free of cover crop or cover crop residue.

Another aspect that slowed water advance in the field was the loss of surface soil water. Water uptake by the cover crop dried the soil and increased the infiltration of water into the soil. This in turn made advancing water to the end of the field more difficult. Soil water loss was also accelerated due to the 15 cm height of the constructed beds which resulted in more of the soil surface being exposed. Planting the cover crop in alternate rows, as discussed above, could also help to reduce the consumption of soil water.

During the first cultivation, cover crop material was removed and mixed with the soil. The ditching operation that followed cleared furrows of plant material and made irrigation normal for the remainder of the year.

The use of a cover crop in furrow irrigated fields to protect sugarbeet from wind erosion did not influence final yield. However, a major reason was that adequate water was made available through irrigation during sugarbeet germination, emergence and early plant growth. Cover crops can be used in furrow irrigated sugarbeet fields but the producer must establish the cover crop so irrigation immediately after sugarbeet planting is possible during those years when precipitation is not adequate to supply the water needs of both a cover crop and the emerging sugarbeet seedling.

Establishing the optimum time to plant a cover crop is critical and will vary from year to year due to climate. If planted too early, excess soil water is consumed yet if planted too late, adequate cover may not be achieved to provide the protection. Achieving adequate cover is especially a concern when a broadcast treatment is used and planting depth is variable.

The use of a cover crop reduced plant population when used as a method to control soil erosion. However, during the course of this study, the sugarbeet seedlings in the conventional plow treatment were not exposed to the effects of wind erosion, partially due to the close proximity of the cover crop treatment plots to the conventional treatment plots.

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