

A Growing Mulch Tillage System To Reduce Wind Erosion Losses of Sugar Beets¹

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Received for publication March 8, 1976

Wind erosion is a major problem in the establishment of sugar beets in some areas of Wyoming as well as other parts of the Great Plains. Sugar beets are most susceptible during the establishment period when potential wind is the highest, i.e., May and June. Cultural methods which leave residues on the surface appear to have the greatest potential for combating this erosion problem.

The objective of this study was to develop a tillage system which would protect sugar beets during their stand establishment period of growth. During the study comparisons of wind erosion potential, stand establishment, yield, water use, and energy requirements were made between the conventional tillage practices now in use and the mulch tillage method under study.

The mulch system used in this study is based on a system used in Eastern Colorado (3)³ which employs rotary strip tillage. In this Colorado area sugar beets generally follow corn which was harvested for grain and thus there is an abundance of remaining residue for erosion protection.

With preceding crops of sugar beets, potatoes, beans, or corn for silage, there is not enough remaining residue to provide erosion protection. Establishment of a satisfactory mulch has thus also been a goal of this project.

The area in which this study was conducted is near Pine Bluffs, which is in the southeastern corner of Wyoming. Irrigation of the areas in the study was by sprinkler, mostly center pivot. Conventional tillage practices for establishment of sugar beets under sprinkler irrigation in this area generally consist of: plowing, roller harrowing, bedding (starter fertilizer applied), planting (pre-emergence herbicide also applied and incorporated), and an early cultivation to control wind erosion. Many of the soils of the area are quite sandy and thus formation of clods for erosion protection by cultivation is not always successful since the clods are broken down by sprinkler irrigation or precipitation.

¹Published with the approval of the Director, Wyoming Agricultural Experiment Station, as Journal Article 825.

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³Numbers in parentheses refer to literature cited.

Initial Mulch Culture Methods

In 1972, a field seeded to fall rye was used for the mulch. The rye was 10-12 inches high when sprayed with Paraquat two days before the sugar beets were planted. A 10 inch band was rotary tilled and the beets were planted in this band.

Two problems were encountered in using the fall seeded rye. First, the rye was not completely killed and severe competition with the sugar beets resulted. Problems with control of a fall seeded crop were also found by Carey et al., in Idaho (1). Second, a compacted layer was evident which hindered root development of the sugar beets.

In 1973, two types of tillage procedures were tried with spring seeded barley used as the growing mulch. The barley was solid seeded in a field which had been spring-plowed and in a field which had only been disked after the previous year's potato crop. Strip rotary tillage and planting were done in one operation. The barley between the rows was removed with a powered rotary tiller when the beets were in the four to six leaf stage.

The barley did successfully protect the sugar beets from wind erosion losses during 1973. Using Woodruff's (7) method of calculating potential soil loss, the conventionally tilled fields had a soil loss rate of 49 tons/A/yr as compared to 17 tons/A/yr for the mulch tilled fields. The wind erosion was severe enough that the beets in approximately 25% of the adjacent conventionally tilled field were lost.

Although wind protection was obtained in the 1973 plots, several other problems were encountered when using the barley as a mulch. Control of the barley in the beet row was a major problem. The strip tillage at planting did not remove all the barley, due to unevenness of barley germination time, insufficient tillage depth and perhaps transplanting some of the small seedlings. The barley in the row competed with the beets for water and nutrients causing a poor beet stand, increased labor for removal, and decreased yields. A problem was also encountered in using a selective thinner. The flat planting method left the sugarbeet row in a depression and thus it was difficult for the thinner knives to cut the beets out. Compaction seemed to again be a problem in the plots which were not plowed.

Stands and yields of the 1973 plots are shown in Table 1. Yields were depressed in the mulch plots due to the barley competition and compacted layer which restricted root growth.

Barley Mulch Method

The method of mulch culture, which evolved from the early studies, employs conventional tillage followed by a bedding-barley planting operation in which the barley is planted in the area between the future beet rows. Conventional tillage is used to reduce the com-

Table 1. — Stand counts and sample yield for 1973 and 1974 sugarbeet conventional and mulch tilled plots, Pine Bluffs, Wyoming.

Treatment	Final stand count (beets/100 ft of row)	Yield (tons/A)
<u>1973</u>		
Mulch (1)	82	8.7
Mulch (2)	126	13.7
Average Mulch	104	11.2
Conventional (1)	140	19.6
Conventional (2)	138	19.1
Average Conventional	139	19.3
<u>1974</u>		
Mulch (1)	120	16.0
Mulch (2)	120	17.4
Average Mulch	120	16.7
Conventional (1)	92	16.5
Conventional (2)	64	10.7
Average Conventional	78	13.6

pacted layer formed during the harvest operation of the previous crop. The barley is planted between the rows for ease of removal, and a bed is formed for ease of cultivation and thinning. Spring barley is used so that water and nutrient competition is not severe during time of emergence.

This system was successfully employed in the 1974 plots (average size of 7 acres). The barley was planted about two weeks before the beets were planted using a converted grain drill. The single disk openers were changed so that they threw the soil toward the future beet rows. The openers thus threw up a small bed while planting the barley between the future beet rows. A close-up of one row of the converted grain drill is shown in Figure 1.

The barley planted in rows coinciding with the beet rows provided wind protection for the beets and was much easier to cultivate out with the rotary cultivator. A beet row with the adjacent barley rows is shown in Figure 2. The cultivation operation to remove the barley is shown in Figure 3. No barley was planted in the "guess" rows and it would have been helpful if none had been planted in the middle row which coincides with the rotary cultivator's gearbox.

One plot of the conventionally tilled beets had about 90% of its area destroyed by wind erosion in 1974. The other conventionally tilled plot was not destroyed because of its small size while the barley mulch provided protection of the mulched plots. The potential soil loss rates were 22 tons/A/yr and 17 tons/A/yr, respectively, for the conventional plots while the soil loss rates for the mulch plots were 6 tons/A/yr and 5 tons/A/yr. These observations when using Woodruff's method of



Figure 1. — Close-up converted grain drill used to apply starter fertilizer, form a small bed and sow barley adjacent to the future sugarbeet row.



Figure 2. — Emerging sugar beet seedlings with adjacent wind-protective barley mulch.



Figure 3. — Powered rotary cultivator removing wind protective barley mulch.

loss calculations would indicate that a rate of soil movement greater than 17 tons/A/yr would damage the emerging sugarbeet seedling.

Emergence percentage was superior in the mulch-tilled plots, i.e. 60% vs 39%. The smaller emergence percentage also reflects the losses incurred by wind erosion, even though the replanted conventional plots had fully emerged at the time of the initial stand count. Yields of the 1974 mulch plots were equal to the conventional plot which did not have to be replanted (16.3 tons/A) while the plot which was replanted was significantly less (10.7 tons/A) than the other three plots. Comparing tillage methods, the mulch plots averaged 16.7 tons/A while the conventional plots averaged 13.6 tons/A. Final stand counts and yields are given in Table 1.

Two fields of beets were grown by the cooperator in 1975 using the barley-mulch system. These two erosion-prone fields were compared with two similar size fields (approximately 35 acres each), on which conventional methods were employed. The barley-mulch system will prevent wind erosion losses as shown in 1974, but careful management of the barley as well as of the beets is required. In 1975, the interseeded barley failed to prevent sugarbeet losses due to wind erosion as the barley did not have sufficient growth by the time the beets were emerging and damaging winds occurred. Comparison of heat units (40°F base temperature) indicated that only 175 heat units had been attained for barley growth by the time the beets were emerging in 1975, compared to 300 heat units in 1974 when the barley did successfully prevent losses. Clod management in the conventional fields successfully protected them from losses although their erosion potential was also less. The yield differences were mainly a reflection of the loss of

stand in the mulch fields (one field was replanted one month after the original planting). The mulch fields averaged 9.0 tons/A while the conventional fields averaged 13.1 tons/A. All fields suffered hail damage.

Water Requirements

In conjunction with development of the barley-mulch method, Settemeyer (5) studied the water requirements for the conventional and mulch systems. His objective was to correlate the water requirements of the conventional and mulch systems to determine the competition between the sugar beets and barley for the available water.

The amount of actual evapotranspiration was estimated by use of soil moisture readings and rainfall and/or irrigation water data for the periods between soil moisture readings (approximately one week intervals).

The evapotranspiration for the 1973 conventional and mulch plots is shown in Table 2. When the barley was still growing in the mulch plots, the mulch plots used about 0.02 in./day more water than the conventional plots. Due to the early competition from the barley in the beet row the mulch beets were delayed in their growth and had poorer yields. The total water use by the mulch plots was about equal with the conventional plots.

The evapotranspiration for the 1974 conventional and mulch sugarbeet plots as well as barley alone is also shown in Table 2. Again

Table 2. — Evapotranspiration (inches) for 1973 and 1974 sugar beet (conventional and barley mulch) and barley plots, Pine Bluffs, Wyoming (5).

Date	Conventional sugar beets	Mulch sugar beets	Barley
1973			
(5-1)		(Barley planted)	
(5-14)	(Beets planted)	(Beets planted)	
6-1 to 6-25	2.36	2.87	
(7-1)		(Barley removed)	
6-26 to 7-26	4.76	4.41	
7-27 to 8-28	6.69	6.26	
8-20 to 9-26	3.46	4.26	
Total, 6-1 to 9-26	17.27	17.83	
1974			
(4-16)		(Barley planted)	(Barley planted)
(5-1)	(Beets planted)	(Beets planted)	
5-14 to 5-19	1.46	1.54	1.69
(5-30)	(1 plot replanted)		
(6-14)		(Barley removed)	
5-30 to 6-25	4.34	6.34	5.47
6-26 to 7-26	6.50	6.50	5.71
7-27 to 8-23	5.04	4.02	3.98
8-24 to 10-11	6.30	5.24	3.07
Total, 5-14 to 10-11	23.67	23.64	19.92

the early season water use was higher for the mulch plots but the total water use was the same for both tillage methods. It thus appears that the barley does not increase the total water use if it is kept out of the row and is eliminated before the boot stage of growth, and that early water management is more critical to prevent loss of beet emergence.

Energy Considerations

Due to the energy shortage it was of interest to find the energy requirements of the mulch tillage system. Previous work has been done on other tillage operations but very little on the rotary cultivation used in mulch tillage practices.

A one row, fully instrumented, rotary tiller was constructed to measure the energy consumption (Figure 4). The chassis and rotor assembly were similar to the rotary tiller used in the mulch studies. The power train of the instrumented tiller included a hydrostatic transmission so that a wide range of rotor speeds could be obtained for the same forward speed. Instrumentation included a torque meter and revolution counter mounted on the tiller, and drawbar-pull strain gage link, wheel revolution counter and fuel flow meter on the tractor.

The average energy consumption for strip cultivation was 2.1 hp-hr/A, when tilling with similar depth and speed conditions as the large machine. A range of 1.2-3.0 was found using different depths and rotor speeds. The soil type in the study is classified as a sandy loam texture.

Total energy requirements for the two systems were compared by using Hunt's data (4) on field machinery power requirements. Average seasonal energy requirement of conventional tillage amounted to 45 hp-hr/A while for the mulch tillage system the energy requirement amounted to 47 hp-hr/A, i.e., an additional 2 hp-hr/A for powered rotary cultivation. A completely no tillage system would require 23 hp-hr/A for harvesting. For the sprinkler system used in this study, 975 hp-hr/A was required for application of the average water requirement (6). For estimating water application energy, the total head was 270 ft of water (190 ft for pressure), the combined pump and motor efficiency was estimated as 65%, and the irrigation efficiency was estimated as 75%. Thus, it appears that the real potential for reducing field energy under this type of irrigation is not in the actual tillage system itself but rather indirectly by perhaps increasing infiltration such that a lower pressure requirement for the sprinkler system would be required.

Discussion

The growing barley mulch system can be successfully employed to protect sugar beets from wind erosion losses. In the area studied it

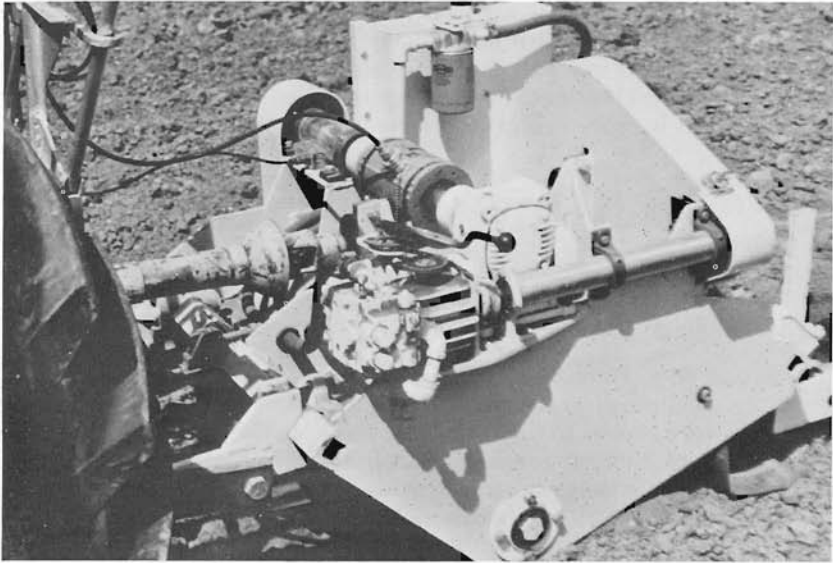


Figure 4. One row, instrumented rotary tiller used to measure energy requirements.

worked best when conventional tillage practices were followed and the barley was planted between the future beet rows. Little extra water or energy were required.

More study of the system does need to be undertaken, however, to define management decisions needed for the system to be practically implemented. In 1975, it was shown that insufficient protection by the barley is obtained if the barley does not have enough growth before the beets are planted. On the other hand, if the grain is too large when the beets are planted, removal and competition are problems. A study of barley growth as a function of heat units may solve this timing problem. A model exists (2) for the heat units required to obtain sugar beet emergence. If the number of heat units required to grow the barley to a stage such that it provided protection was known, the number of heat units required between barley planting and beet planting could then be inferred and used as a management tool. Herbicidal control of the growing mulch was not attempted in this study. If adequate control of the mulch with herbicides were shown, fall seeded crops would be practical. Without this control it is felt that fall seeded crops become unmanageable before the beets are large enough to remove the growing mulch. Nitrogen competition has been observed in other studies (1) and perhaps was present to a small degree in these studies. Future application of growing mulch systems would require definition of the nitrogen competition problem and the additional fertilization requirement.

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