Sugarbeet Establishment in Living Mulches

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ABSTRACT

The objective of this research was to develop a production system that utilizes a living mulch for wind erosion protection of sugarbeets during establishment. Studies were conducted under sprinkler irrigation from 1989 to 1994 and under furrow irrigation in 1995. Fall seeded winter wheat and rye or spring seeded barley, oats and winter wheat were compared to no cover crop. Cover crops were planted into conventionally tilled seedbeds. Two rows of cover crop were established for each subsequently established sugarbeet row. Herbicides were used to kill the cover crops before they competed excessively with sugarbeet. For the years 1993 to 1995, sugarbeet populations and yields were not different when cover crops were used compared to no cover crop, except when rye was used which produced higher yielding sugarbeet. Cover crop growth was correlated with accumulation of growing degree days [40F (4.5C) base temperature]. Dry matter production was directly related to plant height for each cover crop. Timing of herbicide application to kill the cover crop depends on the crop and should be done before barley is 15 cm (6 inches) tall or before winter wheat is 8 cm (3 inches) tall. Herbicide weed control in sugarbeets was equal with or without cover crops. Furrow irrigation was successful with this system of growing living mulches with sugarbeet.

Additional key words: *Beta vulgaris,* barley, oats, wheat, rye, cycloate, ethofumesate, glyphosate, sethoxydim, desmedipham, phenmedipham

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Maximizing length of growing season has always been a goal of sugarbeet *(Beta vulgaris* L.) growers in the Rocky Mountain area. Sugarbeet is grown in the April-October period, with the length of the growing season determined by temperature. Efforts to extend the growing season included transplanting potted sugarbeet plants which were started in greenhouses (Yonts, et al., 1986). Average growing conditions of seeded sugarbeet with irrigation generally result in a profitable crop. However, if the length of the growing season is significantly shortened, yields are decreased such that no profit margin remains. Many climatic variables shorten the growing season more than normal, including freezes, soil crusting problems and wind erosion. Sugarbeet is most susceptible to wind erosion during establishment when potential wind is the highest. The degree of soil erosion is a function of soil erodibility, soil ridge roughness, a climatic factor, a distance factor and a vegetative cover factor (Skidmore and Woodruff, 1968). Cultural methods that leave residue on the surface appear to have the greatest potential for controlling wind erosion. However, when sugarbeet follows dry bean *(Phaseolus vulgaris* L.), potato *(Solanum tuberosum* L.) or corn *(Zea mays* L.) for silage remaining residue is not sufficient to provide wind erosion protection.

A mulch culture method of growing barley *(Hordeum vulgare* L.) to provide wind erosion protection was developed in the 1970s (Fornstrom and Boehnke, 1976). This system employed conventional tillage followed by a bedding-planting operation in which barley was planted in the area between future beet rows. Sugarbeet was planted about two weeks later. Barley provided wind protection as sugarbeet emerged and then was removed with a rotary tiller. Timely, mechanical removal of the barley was sometimes a problem. Grass herbicides now available should improve this system with regard to removal of the living mulch and extending the period of wind erosion protection.

This research was conducted to develop a sugarbeet production system which utilizes a living mulch for wind erosion protection during establishment. Type of cover crop, timing of planting cover crop and sugarbeet to provide erosion protection, and the timing and method of cover crop removal to limit competition with sugarbeet were studied.

MATERIALS AND METHODS

Studies were conducted from 1989 through 1995 at the Torrington, WY Research and Extension Center on a Bayard sandy loam soil (coarse, loamy mixed Mesic Torriorthentic Haplustoll; 78% sand, 13% silt and 9% clay with 1.4% organic matter and pH of 7.6). All studies were sprinkler irrigated, except those in 1995 which were furrow irrigated. Data presented in this paper will generally be for best management practices, although other sub-studies were conducted. Four replicates were arranged in a split plot randomized complete block arrangement with cover crops as main plots and spray dates and/or planting dates as sub-plots. Cover crops included fall seeded winter wheat *(Triticum aestivum* L., 1990-1995) and rye *(Secale cereale,* 1991 and 1993-1995) or spring seeded barley (1989-1995), oats *(Avena sativa* L.,1990 and 1992-1995) and winter wheat (1989 and 1993-1995) compared with no cover crop. Cultural practices varied slightly from year to year but generally included the following: conventional tillage in September; fall seeding of cover crops the first week of October; spring seeding of cover crops about March 20; spraying fall cover crops, applying preplant herbicide and planting sugarbeet in mid April; spraying spring seeded cover crops the first week of May; and cultivation the end of May. Dates when each cultural operation was performed are shown in Table 1. Each plot was four rows wide with rows spaced 76

Table 1. Dates cultural operations were performed for management of cover crops (CC) and sugarbeet. Torrington, WY Research and Extension Center, 1989-1995.

Operation	Date of operation						
	1989	1990	1991	1992	1993	1994	1995
Fall CC planted (previous fall)	——	10-12	9-27	9-26	10-1	9-30	9-15
Spring CC planted	3-22	3-21	3-19	3-24	4-1	3-17	3-23
Sugarbeet planted	4-12	5-1	4-16	4-15	4-23	4-14	4-13
Fall CC sprayed	——	5-2	4-16	4-9	4-24	4-15	4-4
Spring CC sprayed	5-1	5-2	5-2	4-23	5-12	5-7	5-25
First cultivation	5-31	6-1	5-20	5-15	5-25	5-23	5-31

cm (30 inches) apart and sub-plot lengths were generally 15m (50 ft). Two rows of grain were planted with unit planters for each row of sugarbeet. Grain rows were 15 cm (6 inches) on either side of the future sugarbeet row and this created a grain row spacing of 30 and 45 cm (12 and 18 inches). Wheat 'Buckskin' was planted at a rate of 80 kg/ha (71 lb/A), rye 'Rymin' at 84 kg/ha (75 lb/A), barley 'Steptoe' at 109 kg/ha (97 lb/A) and oats 'Olathe' at 92 kg/ha (82 lb/A). Best management practices were followed for sugarbeet stand establishment and weed control (Miller et al., 1992) and included planting to stand and preplant incorporated and postemergence herbicides. 'Monohikari' sugarbeet was planted to stand at 168,000 seeds/ha (68,000 seeds/A). Ethofumesate [(+)-2-[4-[(6-chloro-2--benzoxazolyl)oxy]phenoxy] propiaonic acid] was applied at 2.24 kg/ha (2 lb ai/A) broadcast rate in an 18-cm (7-inch) band and incorporated with a rotary power incorporator during the planting operation. Fall cover crops were sprayed broadcast with glyphosate [N-(phosphonomethyl)glycine] at 0.84 kg/ha (0.75 lb/A) + 0.25% v/v non-ionic surfactant and spring cover crops were sprayed broadcast with sethoxydim [2-[1-(ethoxyimino)butyl]-5-[2-(ethylthio)propyl]-3-hydroxy-2-cyclohexen-1-one] at 0.31 kg/ha (0.28 lb/A) + 2.3 l/ha (1 quart/A) crop oil concentrate. Desmedipham [ethyl[3-[[(phenylamino)carbonyl]oxy]phenyl] carbamate] plus phenmedipham [3-[(methoxycarbonyl)amino]phenyl(3-methylphenyl)carbamate] was sprayed broadcast postemergence two to three times during May. The first application of desmedipham plus phenmedipham was applied at 0.28 kg/ha (0.25 lb/A), the second application at 0.37 kg/ha (0.33 lb/A) and the third application, if needed, at 0.37 kg/ha (0.33 lb/A). The first cultivation was with disks and knives which removed any remaining cover crop. Sugarbeet roots were harvested in the time period from September 28 to October 5.

An analysis of variance (ANOV) was performed on all data and means were separated by Fisher's protected LSD at the 0.05 probability level (Sendecor and Cochran, 1967). Regression analyses were performed on cover crop growth parameters using methods of Weischberg (1980).

RESULTS AND DISCUSSION

Temperature variation. Soil moisture requirements of the cover crops and sugarbeets were generally met with precipitation or irrigation. Temperature provided the main climatic variation from year to year in the study. Weekly growing degree days accumulated from

March 1 to June 13 at the Torrington, WY Research and Extension Center for the study years 1989 to 1995 and the long term average (Pochop, 1977) are shown in Table 2. The mean accumulated growing degree days for the 1989 to 1995 study was near the long term average [study 1138 (633C) vs. long term 1109 (617C)]. The range of growing degree days was larger for the study [range of 826 to 1415 (459 to 787C)] than for the long term average which was calculated for the 1941 to 1970 period [range of 840 to 1296 (461 to 721C)]. Thus it appears that the range of temperature conditions expected at Torrington was encountered during the study. The wide variation in growing degree days also suggests that timing indicators other than calendar date are needed to time cover crop growth to provide protection of sugarbeets during emergence.

Table 2. Accumulated growing degree days (40F base temperature). Torrington, WY Research and Extension Center, 1989-1995.

Week Beginning	Long Term Avg†	Growing degree days 1989	1990	1991	1992	1993	1994	1995
					°F-day			
Mar 1	6	0	10	31	38	0	31	0
Mar 8	18	42	10	45	55	1	52	48
Mar 15	30	45	25	60	83	4	108	101
Mar 22	54	115	36	92	112	71	122	130
Mar 29	93	138	75	128	148	85	145	140
Apr 5	138	160	99	205	224	127	150	204
Apr 12	188	231	134	221	295	156	222	243
Apr 19	254	390	245	259	327	194	379	251
Apr 26	333	426	260	298	454	263	395	268
May 3	427	516	343	350	606	371	502	329
May 10	533	640	403	522	751	487	656	416
May 17	656	792	520	659	921	624	850	496
May 22	796	930	665	799	1002	781	1018	564
May 31	947	1056	820	948	1135	910	1227	713
Jun 7	1109	1225	1020	1121	1317	1044	1415	826

† Pochop, 1977

Sugarbeet response. All five cover crops were grown simultaneously only between 1993 to 1995. Sugarbeet harvest populations and yields with and without cover crop for these three years are shown in Table 3. These data are typical of the other years of study except that, occasionally, sugarbeet populations were reduced when cover crops were sprayed too late and lack of soil water (less than 11 percent for the sandy loam soil) would reduce sugarbeet stand. Harvest stands for the 1993 to 1995 period averaged 77,300 plants/ha (31,300 plants/A) which is in the optimum range (Fornstrom and Jackson, 1983). Sugarbeet yields were similar when cover crops were used compared to no cover crop, except when rye was used which produced higher yielding sugarbeets for the 1993 to 1995 period.

Table 3. Sugarbeet response with and without cover crops. Torrington, WY Research and Extension Center, 1993-95.

Comparison	Harvest Population	Yield	Sucrose
	1000 pl/ha	Mg/ha	%
Year:			
1993	75.9	53.4	15.5
1994	60.5	61.0	17.0
1995	95.6	57.8	15.0
LSD (0.05)	10.6	4.5	0.5
Cover crop:			
Barley	68.7	52.7	15.8
Oats	75.9	54.9	16.1
SWW†	83.5	58.1	15.7
W. Wheat	85.5	59.4	16.0
Rye	79.8	64.3	15.9
None	70.4	55.4	15.6
LSD (0.05)	NS	5.4	NS
Mean	77.3	57.4	15.8

†SWW = spring planted winter wheat.

Cover crop growth. Cover crop residue was sampled throughout the spring period for the first five years of the study. Cover crop height and dry matter, when sampled in 1993, is shown in Table 4 for the spring crops and Table 5 for the fall crops. For spring seeded crops, barley and oat heights were very comparable but oats produced less dry matter. Spring planted winter wheat grew about half as tall as barley and oats, and produced dry matter comparable to oats. For the fall seeded cover crops, rye was much more vigorous than wheat, reaching a given height and dry matter one to two weeks earlier than wheat.

Table 4. Spring cover crop (seeded 4-1-93) height and dry matter as a function of sampling date and growing degree days (GDD——40°F base temperature). Torrington, WY Research and Extension Center, 1993.

Date	Accum.	Height			Dry Matter		
Sampled	GDD	Barley	Oat	SWW†	Barley	Oat	SWW†
	°F-day	cm			kg/ha		
4-22	94	6.1	4.8	4.1	39	22	26
5-3	198	8.9	8.4	4.3	207	99	105
5-11	309	12.4	12.4	4.3	677	322	289
5-19	470	23.9	25.1	7.9	1470	900	1078
5-25	574	34.8	30.2	18.8	2220	1190	973

† SWW = spring planted winter wheat.

Table 5. Fall cover crop (seeded 10-1-92) height and dry matter as a function of sampling date. Torrington, WY Research and Extension Center, 1993.

Date	Height		Dry Matter	
Sampled	WW†	Rye	WW†	Rye
	cm		kg/ha	
11-19	5.1	4.1	63	149
4-9	5.6	7.9	197	454
4-22	11.2	15.7	529	1200
5-3	27.7	34.0	1410	2610
5-11	33.0	45.0	2600	4540
5-19	50.8	70.4	4160	5600
5-25	62.0	98.6	4360	6330

† WW = winter wheat.

For other years, cover crop height and residue production varied among crops similar to that shown for 1993. However, year to year prediction of the growth achieved by a particular crop on a particular date was difficult. Growing degree day units also varied greatly from year to year, as shown in Table 2. Thus, accumulated growing degree days was used as the independent variable for regression equations to predict spring cover crop height and dry matter production. Regression coefficients and coefficients of determination for barley, oats and spring planted wheat are shown in Table 6. Correlations for dry matter and crop height as a function of growing degree days were very good with barley and oats (R^2 range 0.88 to 0.97). Correlations were not as good for spring planted winter wheat, but only 2 years of data were available. Dry matter and height both influence the amount of wind erosion protection (Skidmore and Woodruff, 1968). However, accumulation of growing degree days from time of planting the cover crop is a cumbersome indicator. Regression coefficients for predicting dry matter as a function of height for all five crops are also shown in Table 6. Coefficients of

Table 6. Regression coefficients (for equations of form: $Y = a_i + b_i X + c_i X^2$) and coefficients of determination (R^2) for equations relating cover crop height (cm) and dry matter (kg/ha) to growing degree days (40°F base temperature) and cover crop dry matter to cover crop height. Torrington, WY Research and Extension Center.

Equation	Crop	Years	a_i	b_i	c_i	R^2
Height (Y) as a function of growing degree days (X):						
	Barley	5	1.852 E+0	2.391 E-2	2.939 E-5	0.88
	Oats	3	4.354 E+0	4.206 E-3	7.285 E-5	0.97
	SWW	2	2.878 E-1	2.789 E-2	1.235 E-5	0.60
Dry Matter (Y) as a function of growing degree days (X):						
	Barley	5	2.294 E+2	-2.526 E+0	9.236 E-3	0.95
	Oats	3	4.838 E+1	-9.911 E-1	5.361 E-3	0.95
	SWW	2	-1.814 E+2	1.167 E+0	8.405 E-4	0.72
Dry Matter (Y) as a function of height (X):						
	Barley	5	8.430 E+1	-1.057 E+1	2.727 E+0	0.92
	Oats	3	-4.916 E+2	3.170 E+1	4.595 E-1	0.90
	SWW	2	-5.560 E+2	1.682 E+2	-4.399 E+0	0.51
	W. Wheat	3	-3.189 E+2	1.182 E+2	-6.691 E-1	0.88
	Rye	2	-2.841 E+2	1.404 E+2	-1.571 E-1	0.93

determination were high for all cover crops (0.88 to 0.93), except spring planted winter wheat (0.51). Thus, height appears to be a good indicator of cover crop dry matter production.

The balance is delicate between sufficient cover crop growth to provide erosion protection and excess cover crop growth which competes with sugarbeet growth. Barley is used as an example since it was included in all years of study. Accumulating growing degree days from time of barley planting, barley emerged at about 100 heat units and if the sugarbeet was planted at 150 to 200 (83 to lllC) heat units, barley was 5 to 8 cm (2 to 3 inches) tall and had produced 56 to 84 kg/ha (50 to 75 lb/A) of dry matter. Sugarbeet emerged at 250 to 300 heat units, when barley was 10 cm (4 inches) tall and with 280 kg/ha (250 lb/A) dry matter. Sufficient cover and height for erosion protection (Skidmore and Woodruff, 1968) exist at about 400 heat units [barley 15 cm (6 inches) tall, 730 kg/ha (650 lb/A) dry matter]. Severe competition occurs if barley is left until 500 heat units are accumulated [barley 20 cm (8 inches) tall, 1390 kg/ha (1240 lb/A) dry matter]. With similar dry matter criteria, oats should be sprayed at a height of about 18 cm (7 inches), wheat at 8 cm (3 inches) and rye at 5 to 8 cm (2 to 3 inches).

Consumptive water use estimates (Pochop et al., 1992) appear to agree with these criteria. For the month of April, the long term average consumptive use estimate for sugarbeet is 1.1 cm (0.43 inches) and the mean monthly precipitation is 4.3 cm (1.73 inches). If the cover crop is killed before 2.5 cm (one inch) of water is used, there should be a net water gain for April. The April water use estimate is 5.7 cm (2.30 inches) for winter wheat and 2.3 cm (0.94 inches) for barley. Thus, in an average year, winter wheat should be sprayed in early April and barley sprayed by the end of April to keep water use less than 2.5 cm (one inch). Using heat units for an average year winter wheat will be about 8 cm (3 inches) tall in early April and barley will be 10 to 15 cm (4 to 6 inches) tall by the end of April.

Cover crop spray date. Several studies were conducted to determine the best cover crop spray dates according to cover crop growth. The results were sometimes mixed, depending on the precipitation pattern during the sugarbeet emergence period. For example, early and late spray dates were included in barley and winter wheat studies in 1991 and 1992. The goal was to spray earlier and later than the criteria developed above. As shown in Table 7, 1991 sugarbeet stands were equal with or without cover crops, but in 1992 cover crops reduced sugarbeet stands. Sugarbeet yields were maintained with cover crops, even with the low density stands in 1992. Readings taken during these studies indicate that soil moisture (gravimetric samples) in 1991 did not drop below 12 percent (dry weight basis, data not shown) while soil moisture was in the 10 percent range during sugarbeet emergence in 1992 (Table 8). Thus some flexibility in date of spraying is probably acceptable, if adequate precipitation or irrigation water is available.

Weed control. Weed populations, comparing barley and winter wheat cover crops to no cover crop, just before spraying with desmedipham plus phenmedipham for the years 1990 to 1992 are shown in Table 9. Weed populations tended to be highest when no cover crop was used but differences were not significant. In 1991, hoeing times were measured in addition to weed counts. The average weed population of 8,650 plants/ha (3,500 plants/A) required 5.7

Table 7. Sugarbeet response to cover crop and cover crop spray date. Torrinton, WY Research and Extension Center, 1991-1992.

Comparison	Harvest Population	Yield	Sucrose
	1000 pl/ha	Mg/ha	%
Year:			
1991	70.7	56.0	15.4
1992	45.7	56.0	16.3
LSD (0.05)	7.7	NS	0.8
Cover crop:			
Barley	51.9	57.4	15.8
W. Wheat	51.1	55.6	15.9
None	71.4	54.9	15.9
LSD (0.05)	6.7	NS	NS
Spray date†:			
Early	60.5	56.9	16.0
Late	55.8	55.1	15.8
LSD (0.05)	NS	NS	NS
Year x cover crop:			
1991 x barley	71.2	59.4	15.3
1991 x w.wheat	66.7	55.4	15.7
1991 x none	74.1	53.1	15.3
1992 x barley	32.9	55.6	16.2
1992 x w.wheat	35.6	55.6	16.1
1992 x none	68.7	56.9	16.6
LSD (0.05)	9.4	NS	NS
Mean	58.1	56.0	15.9

† Spray dates: Early—April 16, 1991 and April 9, 1992 for wheat and May 2, 1991 and April 23, 1992 for barley,
Late—May 2, 1991 and April 16, 1992 for wheat and May 14, 1991 and May 5, 1992 for barley.

hours/ha (2.3 hours/A), which is very similar to hoe times found for studies without cover crops (Miller and Fornstrom, 1989).

Fall application of preplant incorporated herbicides has the advantage of reducing the need for spring tillage with the accompanying loss of soil moisture and perhaps reducing sugarbeet injury from the

Table 8. Soil moisture in top foot as a function of cover crop, spray date and sampling date. Torrington, WY Research and Extension Center, 1992.

Cover crop	Spray date[†]	Soil moisture			
		3-24	4-16	4-30	5-14
Barley	Early	13.4	12.3	11.6	13.2
	Late	13.5	12.4	10.9	10.6
W. Wheat	Early	12.9	10.6	10.7	13.9
	Late	12.8	9.6	10.3	11.4
None	Early	13.6	12.7	13.4	13.9
	Late	13.8	12.8	13.4	14.0
LSD (0.05)		NS	1.5	1.4	1.4
Mean		13.4	11.6	11.7	12.8

[†] Spray dates: Early—April 9 for wheat and April 23 for barley, Late—April 16 for wheat and May 5 for barley.

Table 9. Comparison of weed populations in sugarbeets with barley, winter wheat and no cover crop. Torrington, WY Research and Extension Center, 1990-1992.

Comparison	Weed Population
	1000 pl/ha
Year:	
1990	9.0
1991	10.1
1992	12.4
LSD (0.05)	NS
Cover crop:	
Barley	9.9
W. Wheat	7.9
None	13.3
LSD (0.05)	NS
Mean	10.4

herbicides. With fall planted cover crops, this practice can be followed without wind erosion concerns. Fall applied preplant herbicide studies with a winter wheat cover crop were conducted with cycloate [S-ethyl cyclohexylethyl-carbamothioate] in 1993 and with cycloate and ethofumesate combinations in 1994 and 1995. Weed control was excellent and sugarbeet injury was reduced with fall applications in 1993 and 1994, but in 1995 injury was as severe with fall applied herbicides as with preplant applied herbicides (Table 10). April to May, 1995 was unusually cool (Table 2) which probably increased sugarbeet injury.

CONCLUSIONS

Our research shows that sugarbeet can be grown successfully using living mulches as cover crops for erosion protection under sprinkler and furrow irrigation. The only additional cultural operation performed for furrow irrigation was to corrugate before planting the fall cover crops. Although sugarbeet populations were slightly lower when cover crops were used, sugarbeet yields were equal to or better than sugarbeet yields grown without cover crops.

Table 10. Sugarbeet injury due to fall or spring applications of preplant incorporated herbicides in a winter wheat living mulch. Torrington, WY Research and Extension Center, 1993-1995.

		Sugarbeet injury		
Treatment	Rate	1993	1994	1995
	kg/ha		%	
Fall:				
cycloate	3.4	0	1	20
ethofumesate	2.2	-	3	21
cycl. E + etho.	1.7 + 1.7	-	4	24
Early preplant:				
cycloate	2.8	2	4	23
ethofumesate	1.7	-	4	19
cycl. + etho.	1.7 + 1.1	-	5	18
cycl. + etho.	1.1 + 1.1	-	4	13
Preplant:				
cycloate	2.2	5	5	15
ethofumesate	1.7	-	8	16
cycl. + etho.	1.7 + 1.1	-	9	25
cycl. + etho.	1.1 + 1.1	-	6	20
Untreated check	-	0	0	5

Cover crops need to be sprayed and killed at the proper time. The spray date depends on the cover crop and yearly climate, but cover crops should generally be sprayed when they are 8 to 15 cm (3 to 6 inches) tall. At this stage of growth, cover crops provide adequate erosion protection without severely competing with sugarbeet. Glyphosate killed the fall cover crops well. Sethoxydim occasionally did not kill spring cover crops when the temperatures were cool. New sugarbeet grass herbicides may help this problem as well as reduce the cost of spring cover crop removal. Conventional sugarbeet preplant and postemergence herbicides provided equal or superior weed control when cover crops were used when compared to sugarbeet grown without cover crops.

Cover crops are now being used commercially for protection of sugarbeet during stand establishment. No data are available for Wyoming, but in the eastern North Dakota-Minnesota area, cover crops were used on 6 % of the sugarbeet acreage in 1994, which is a decrease from 15 % of the acreage in 1992 (Dexter et al., 1995). Reasons for the decrease in area are not known, but cover crops are broadcast and no irrigation is available. Research in eastern North Dakota-Minnesota has also shown that sugarbeet yields can be maintained with cover crops while obtaining erosion protection, except perhaps a slight yield reduction when rye is used as the cover crop (Stordahl et al., 1991).

In two of the seven years of this study, sugarbeet losses due to wind erosion required replanting at least 20 percent of the sugarbeet acreage in the Torrington area. No sugarbeet stand losses due to wind erosion were encountered during this study, but plots were not large enough to replicate the size of commercial fields.

As part of studies conducted in 1994 and 1995, sugarbeet was seeded at different dates during the April through May period. Data for these studies are shown in Table 11 and demonstrate the effect of late seeding. The amount of yield loss is not necessarily related to calendar days lost but rather to the amount of heat lost for the season. For example, a 25 day delay in seeding date in 1994 resulted in a 22 % yield loss compared to seeding on April 14 while a 48 day delay in seeding date in 1995 resulted in a 25 % yield loss compared to seeding on April 13.

Sugarbeet emergence is related to soil heat units with a 40F base temperature (Fornstrom & Pochop, 1974 and Yonts et al., 1983). The growing degree days lost (using a 40F base temperature) from the initial planting date are also shown in Table 11. Yield as a percent of maximum yield (Y) for the two years of data was correlated with growing degree days lost (GDD) as follows: $Y = 103.6 - 0.0802 \times GDD$, $R^2 = 0.96$. Depending on the time of replanting and amount of heat lost, yields of replanted sugarbeets are in the range of 20 % to 40 % less than yields of sugarbeets that don't have to be replanted. Thus the use of cover crops seems to be economically justifiable.

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Table 11. Sugarbeet response to delayed planting dates and growing degree days lost (GDD—40F base temperature) after the initial planting date. Torrington, WY Research and Extension Center, 1994 and 1995.

Year	Planting	GDD	Sugarbeet	
	Date	lost	Yield	Sucrose
		°F-day	Mg/ha	%
1994	Apr 14	0	67.9	16.7
	Apr 20	89	65.7	15.8
	May 2	219	56.5	15.0
	May 9	326	53.1	14.9
	LSD (0.05)		7.1	0.9
1995	Apr 13	0	54.2	14.6
	May 15	176	49.4	14.8
	May 31	361	40.6	15.4
	LSD (0.05)		8.2	NS

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