EVALUATION OF ZONE TILLAGE FOR SUGAR BEET PRODUCTION IN ALBERTA

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Introduction:

In southern Alberta, reduced tillage in sugar beets has contributed to improved control of wind erosion. In recent years a sugar beet grower near Taber Alberta developed and used a 24-row zone tillage implement to further manage crop residue and erosion. In fall 2004, the Ag Tech Centre in Lethbridge, Alberta built a 6-row research zone tillage implement with guidance and financial support from the Alberta Sugar Beet Growers/ Lantic Inc. research department and Alberta Agriculture and Food. The 6- and 24-row units operate on the same principle, tilling a narrow strip where sugar beets will be seeded while leaving the inter-row area undisturbed.

Early season soil temperature and sugar beet production were evaluated for this zone tillage system in comparison with conventional tillage over a 4 year period. In 2004 and 2005 soil temperatures and speed of sugar beet emergence were evaluated in a commercial field where conventional tillage was compared to tillage using the 24-row zone tillage implement. In 2005 through 2007, small plot experiments that evaluated soil temperature, speed of sugar beet emergence and sugar beet production were conducted using the 6-row research zone tillage implement.

Methods:

Commercial field experiments had 2 treatments (zone and conventional tillage) in a randomized complete block design with 8 replications in 2004 and in a strip trial that utilized a paired T-test with 4 replications for analysis in 2005. All small plot experiments were identical and used a randomized complete block factorial design with 6 replications and 4 treatments. This summary will only discuss the conventional versus zone tillage comparisons in the small plot trials, although other treatments were present.

All experiments followed a cereal crop and all straw was left on the field where the commercial 24-row implement was evaluated. Straw was baled and removed prior to conducting the small plot experiments. In the small plot experiments, conventional tilled plots were worked 2 or more times in fall and once in spring with the objective of reducing the amount of surface residue to below 25%. The rate of fertilizer applied was identical in zone and conventionally tilled areas in all tests.

Hobo H8 4-channel data loggers were installed to assess soil temperatures at hourly intervals. Below-ground logger sensors were inserted at 5 cm depths. Below-ground sensors were located in-row and halfway between seed rows in zone tilled treatments, while sensors were only located in-row in conventional treatments. In the 2006 and 2007 small plot trials above-ground logger sensors were also installed in the seed rows 2.5 cm above soil level.

Sugar beet stand was counted in all treatments at intervals between emergence and the 4-leaf stage. Measurements to quantify percent ground cover from cereal stubble were conducted in each treatment of the small plot trials using the line-transect method. Plant canopy vigour was rated on a 1-9 scale between the 4 and 8-leaf stage of sugar beet development for all small plot trials, with higher numbers indicating better vigour.

Results:

A summary of speed of emergence results for all trials is presented in Table 1. The speed of emergence and final established plant stand were not significantly different for 20 of 25 plant counts conducted for zone and conventional tillage treatments over a 4 year period. In 4 of 5 cases where significant differences occurred, stands were higher in conventional treatments.

In the commercial field trial in 2004, conventional and zone tillage operations were conducted in the spring prior to seeding, with no significant precipitation occurring until 14 days after seeding. In these conditions zone tillage treatments had significantly greater emergence 21 days after seeding; however, final stand was similar to conventional tillage. In the commercial field trial in 2005, zone tillage was conducted in the fall while conventional strips were worked in the spring. Significant precipitation was received the day after spring conventional tillage operations were performed in this test. The speed of sugar beet emergence in the 2005 commercial field was faster with conventional tillage than with zone tillage, although final plant count was not significantly different. In the 2006 small plot trial the initial sugar beet emergence count was significantly higher in conventional tillage treatments than in zone tillage treatments; however, counts for the remainder of the emergence period were not significantly different.

The final established stand count was significantly higher for conventional tillage than for zone tillage in 1 of the 5 trials conducted. The established stand was significantly higher for conventional tillage in the 2005 small plot trial; however, the actual stand achieved for zone tillage plots was still considered in the optimum range for sugar beet production.

Results over 4 years indicate that in most cases it was possible to achieve emergence stands with zone tillage that were comparable to conventional tillage stands.

Table 1. Summary of speed of emergence results for zone tillage trials (2004 – 2007).

Treatment		Sugar beet stand (plants/100ft of row)				
2004 (Commercial Field)	**DAP[a]**	**21**	**24**	**26**	**39**	**70**
Conventional tillage		32	79	120	147	143
Zone tillage		63	87	116	133	137
LSD (.05)		*23*	*NS*	*NS*	*NS*	*NS*
2005 (Commercial Field)	**DAP**	**14**	**17**	**19**	**21**	**27**
Conventional tillage		26	151	162	172	195
Zone tillage		3	55	100	141	186
Significance (5% level)		*NS*	*	*	*NS*	*NS*
2005 (Small Plot Trial)	**DAP**	**11**	**14**	**17**	**21**	**29**
Conventional tillage		0	94	118	138	172
Zone tillage		0	90	117	131	158
LSD (.05)		*NS*	*NS*	*NS*	*NS*	*12*
2006 (Small Plot Trial)	**DAP**	**12**	**14**	**17**	**20**	**33**
Conventional tillage		21	90	117	126	130
Zone tillage		10	79	114	125	130
LSD (.05)		*8*	*NS*	*NS*	*NS*	*NS*
2007 (Small Plot Trial)	**DAP**	**9**	**12**	**14**	**16**	**33**
Conventional tillage		1	80	143	151	156
Zone tillage		2	77	140	143	152
LSD (.05)		*NS*	*NS*	*NS*	*NS*	*NS*

[a] DAP = Days after planting

Average hourly early season soil temperatures are reported in Table 2. In-row soil temperature differences were small when zone and conventional tillage were compared. In the 5 trials conducted, zone tillage resulted in in-row soil temperatures that averaged 0.4^{o}C lower than temperatures measured in conventional residue. In-row soil temperature was either the same or slightly lower for zone tillage than for conventional tillage in individual experiments.

The undisturbed area between zone tilled strips had a greater accumulation of cereal residue than areas where tillage was conducted and this resulted in somewhat lower temperatures in the inter-row area. The inter-row area was 0.7^{o}C lower in temperature than the zone tilled strips and 1.1^{o}C lower than conventional tillage when averaged over the 5 trials.

Table 2. Summary of early season below ground soil temperature (^{o}C) for zone tillage trials (2004–2007).

Average hourly soil temperature (5 cm depth)	Zone tilled		Conventional Tillage
	Between-row	In-row	
2004 (Commercial Field) – April 29 to May 4	10.9	11.9	13.0
2005 (Commercial Field) – April 24 to May 12	8.2	8.9	9.4
2005 (Small Plot Trial) – April 8 to May 11	8.3	8.6	8.8
2006 (Small Plot Trial) – April 19 to May 11	10.2	10.9	10.9
2007 (Small Plot Trial) – April 17 to May 15	10.5	11.0	11.4
Average hourly temperature for all tests	*9.6*	*10.3*	*10.7*

Differences in in-row above ground temperatures for zone and conventional tillage were also assessed in 2 of the small plot trials that were conducted (data not shown). Average hourly above ground temperatures were 0.3^{o}C higher for zone tillage than for conventional tillage. This slight increase in average temperature was a result of a 1.4 ^{o}C increase in the average daily maximum temperature for zone tillage treatments compared to conventional tillage. Although differences were small, minimum above ground temperatures for zone tillage were 0.4 ^{o}C colder than for conventional tillage. Minimum values were also 0.4 ^{o}C colder for zone tillage on days when subzero temperatures occurred at 2.5 cm above the soil surface. This might indicate that zone tilled sugar beets could be slightly more susceptible to early season frost. In general, the temperature data suggests that zone tillage did not have a substantial impact on above or below ground early season temperature compared to a conventional system.

Sugar beet production results are summarized in Table 3. Extractable sugar per acre was not significantly different between zone and conventional tillage in any of the individual small plot trials, although conventional treatments were always slightly higher. In 1 of 3 trials extractable sugar per tonne was significantly higher for conventional tillage. Beet yield was also significantly higher for conventional tillage in 1 of 3 trials. In all small plot trials significantly greater plant vigour was observed in June for conventional tillage treatments. These vigour differences disappeared by mid-summer.

In the 2007 experiment soil nitrate levels and nitrogen supply rates were assessed to try and explain the vigour differences observed. In-row nitrate nitrogen levels to 60 cm depth on June 20 were 24 ppm for conventional tillage and 83 ppm for zone tillage. Nitrogen supply rates were measured using PRS^{TM} probes (Western Ag Innovations, Saskatoon, SK) inserted for 13 days starting on June 20. The total nitrogen supply rate (µg/10cm^{-2}) was 211 for conventional tillage and 267 for zone tillage. Soil samples and PRS^{TM} probes suggested that nitrogen availability was not a contributing factor to the lower vigour observed in the zone tillage treatments in June.

Ground cover measurements in the small plot trials show the level of residue for zone tillage was consistent over years and was significantly higher than residue levels in conventional treatments (Table 3). Conventional treatments were tilled less aggressively in 2007 than in the previous 2 years.

Table 3. Yield and quality results for the small plot zone tillage trials – 2007.

Treatment	Extractable Sugar		Sugar	Molasses Loss	Beet Yield	Vigour (June)	Ground Cover
	kg/acre	kg/t	%	%	t/acre	1-9	(%)
2005							
Conventional tillage	4559	151.2	16.66	1.54	30.22	7.7	13
Zone tillage	4300	157.3	17.24	1.50	27.35	7.1	37
LSD (.05)	*NS*	*NS*	*NS*	*NS*	*1.59*	*0.4*	*6*
2006							
Conventional tillage	5434	173.1	18.74	1.44	31.41	7.5	11
Zone tillage	5156	169.9	18.48	1.49	30.37	6.7	36
LSD (.05)	*NS*	*NS*	*NS*	*NS*	*NS*	*0.3*	*5*
2007							
Conventional tillage	3656	149.1	16.67	1.76	24.47	7.0	23
Zone tillage	3556	142.5	16.13	1.89	24.96	6.7	36
LSD (.05)	*NS*	*4.7*	*0.40*	*NS*	*NS*	*0.2*	*5*

Summary:

Results over 4 years indicate that in most cases it was possible to achieve emergence stands with zone tillage that were comparable to conventional tillage stands. Temperature data suggests that zone tillage did not have a substantial impact on above or below ground in-row early season temperature compared to a conventional system. Visual evaluations of plant vigour in June indicated the leaf canopy was more robust for conventionally tilled treatments and there was also a trend for slightly higher extractable sugar per acre for these treatments. The zone tillage system studied in these trials appears to be a viable option for consideration by Alberta sugar beet producers interested in improving control of wind erosion. Further investigation is continuing through additional small plot research and larger scale strip trials.