2.2 Field Monitoring and Economic Assessment of Deep Ripping in Saskatchewan

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INTRODUCTION

The feasibility of deep tillage under Saskatchewan conditions has been studied since 1986 in a number of field experiments (Grevers 1989). The purpose of this project is to determine the longevity of these improvements and to determine the economic feasibility of deep tillage of Solonetzic soils. This report involves the monitoring of soil conditions and crop production in the third and the fourth year following deep ripping at two locations in Saskatchewan. Monitoring will continue in 1991, and an economic assessment of the feasibility of deep ripping on 15 farm sites will be subsequently be carried out.

MATERIALS AND METHODS

A total of 4 farm sites are included in the study, involving both deep ripping and deep plowing. The deep ripping sites include the Chabot farm and the Cragg farm at Arborfield, and the Norrish farm and the Warner farm at Carrot River. The deep ripping sites involve both Solonetzic and Chernozemic soils, representing the Dark Gray soil zone. Details of the soil descriptions and legal land locations are listed in the 1989 S.I.P. Field Research Report.

The experimental plots consisted of 6 strips; each strip was between 15 and 30 m wide and 800 m long. Alternate strips were selected to be deep ripped, while the other strips remained non-ripped (control). The tillage strips were divided into 3 replicate blocks; each block consisting of one ripped and one adjacent control plot. In this manner, some of the effect of field variability could be isolated from possible deep tillage effect on soil properties and crop growth. Deep ripping was carried out in the fall of 1987 at the Arborfield sites and in the fall of 1988 at the Carrot River sites. Deep ripping was done with a KELLO-BILT subsoiler, pulled with a 1150 VERSATILE tractor (450 HP), travelling between 5 and 6 km per hour. Approximate cost of the deep ripping and subsequent secondary tillage operations were: $50 per acre on Solonetzic soils and between $15 and $25 per acre on Chernozemic soils.

Soil chemical criteria used to differentiate Solonetzic soils from Chernozemic soils showed that two of the sites (the Cragg farm and the Warner farm) are Solonetzic, one site is partly Solonetzic (the Chabot farm), and one site is non-Solonetzic (the Norrish farm). The soil at the Norrish farm was diagnosed as having compaction problems, which could therefore benefit from deep tillage.

Soil physical parameters that were measured include soil moisture and soil bulk density. Soil water content was measured by neutron thermalization, using a DEPTH MOISTURE GAUGE (Troxler Electronic Laboratories Inc.). Soil bulk density was measured by gamma backscattering using a DEPTHPROBE CPN 501 (Hoskins Scientific). The scanning zone of the CPN probe has a vertical dimension of approximately 15 cm and is therefore not sensitive to "picking up" thin dense layers in the soil. Aluminum access tubes (2 per tillage plot) had been installed to a depth of 120 cm to facilitate the measurements of the soil bulk density and the soil moisture content *in situ*, using the depth probes. Soil water content measurements were taken monthly during the growing season. Soil density readings were taken prior to seeding (1 to 2 weeks) and at harvest time.

Crop yield was determined by taking square meter samples in a series of paired row samples, 6 pairs in each tillage strip. The crop samples were transported to the University of Saskatchewan, where the samples were dried, weighed, threshed and grain weights were taken. Crop water use (mm) was determined from the difference between the soil moisture content at seeding and at harvest, plus the growing season precipitation (using rain gauges installed in the field plots). Crop water-use efficiency was determined by dividing the grain yield by the total crop water use (kg/ha/cm).

RESULTS AND DISCUSSION

Soil Bulk Density

The soil bulk density in the deep tillage plots in 1989 and 1990 is listed in Table 2.2.1. The significant differences in soil density were limited to the 40 cm depth at the Cragg site, where the density in the deep ripped plots was lower than that of the control plots. However, there were some general trends in the data that will be discussed. The density of 25 and 40 cm depths in the deep ripped plots at the Cragg and Warner sites appears to be less dense than that of the control plots. Similar differences were not found at the Chabot and Norrish sites. This trend in density data suggest that some soil loosening effect persisted 2 years after the initial deep ripping of the two Solonetzic soils.

Soil-Water Recharge

Over-winter soil-water recharge was calculated from the soil moisture readings taken at harvest time (Aug/Sep) and in spring (April). The relative amount amount of soil-water recharge during this period therefore is indicative of differences in soil-water infiltration from rainfall and from melting snow, and of soil-water conservation during this period. The relative gain (cm H_2O) in soil moisture in the deep tillage plots was 7.8 cm, while the average gain in soil moisture in the control plots was 5.6 cm (Table 2.2.2). The above represents a 4% increase in soil-water recharge from to deep ripping.

Table 2.2.1 Soil bulk density values in 1989 and 1990

Site	Depth	Deep Ripped	Control
	cm	------------- gm/cm^3 -------------	
Chabot†	25	1.12	1.24
	40	1.39	1.41
	60	1.47	1.45
	80	1.49	1.50
	100	1.51	1.52
	120	1.50	1.57
Cragg†	25	1.26	1.40
	40	1.37*	1.46
	60	1.48	1.48
	80	1.49	1.49
	100	1.46	1.47
	120	1.45	1.48
Norrish‡	25	1.53	1.52
	40	1.46	1.42
	60	1.41	1.40
	80	1.41	1.43
	100	1.47	1.46
	120	1.50	1.48
Warner‡	25	1.31	1.56
	40	1.36	1.54
	60	1.45	1.48
	80	1.44	1.43
	100	1.42	1.44
	120	1.42	1.44

* Indicates that the means for deep ripped and control are significantly different $P < 0.05$
†, ‡ Represent data from the fall of 1989 and 1990, respectively

Table 2.2.2 Overwinter water recharge in the tillage plots for 1989/1990

Site	Tillage	Soil moisture levels		Gain	% Gain
		Fall	Spring		
			------------ cm H_2O ------------		
Chabot	Control	48.8	58.7	9.9	20
	Ripped	48.3	60.1	11.8	24
Cragg	Control	47.6	52.6	5.0	11
	Ripped	49.0	55.2	6.2	13
Warner	Control	47.9	49.9	2.0	4
	Ripped	49.0	54.3	5.3	11

Soil-water recharge at the Norrish site could not be measured

Crop production over the four-year period following deep tillage.

Deep ripping increased crop yields at the Warner Site, but there was no effect of deep ripping on crop yields at the other Sites (Table 2.2.3). At the Cragg Site, there was considerable variability in crop yield response to deep ripping amongst the replicate blocks; two of the replicate blocks showed substantial yield increases, while the third block did not shown any yield increase. The increased yield at the Warner Site represents the third crop after deep ripping; yield increases were also found in the first and in the second crop. The increased yields involved greater crop water-use efficiency (Table 2.2.3). Possible increased soil NO_3-nitrogen levels which could have resulted from increased soil aeration in the deep ripped plots were not found (Table 2.2.3). The above therefore suggest that the increased water-use efficiency is mainly the result of soil structural differences brought about by deep ripping

Table 2.2.3 Grain yield and water-use efficiency in the tillage plots

Year	Crop	Tillage	Spring seeding		Yield		WUE
			SMC	NO_3-N	Total	Grain	
			(% w/w)	(kg/ha)	(kg/ha)	(Bu/A)	(kg/ha/cm)
			ARBORFIELD: Chabot Site				
1987	Peas	Control	45.9	ND	5979	31.2	64
		Ripped	45.9	ND	6977	28.6	52
1988	Flax	Control	50.9	85	1910	9.8	28
		Ripped	47.9	102	1964	9.8	28
1989	Fallow	Control	39.5	140			
		Ripped	37.5	162			
1990	Canola	Control	58.7	136	7392	45.2	120
		Ripped	60.1	135	6581	40.5	96
			ARBORFIELD: Cragg Site				
1987	Wheat	Control	52.7	ND	6249	41.8	68
		Ripped	51.6	ND	5968	34.9*	54
1988	Barley	Control	52.6	18	4319	23.8	73
		Ripped	53.1	16	5183*	35.4*	102
1989	Fallow	Control	39.3	27			
		Ripped	39.3	32			
1990	Durum	Control	52.6	81	9634	60.7	ND
		Ripped	55.2	101	10269	64.3	ND

SMC = soil moisture content, WUE = water use efficiency, ND = no data available
Note: high values for WUE for some of sites may have been due to soil-moisture recharge from below 130 cm
* Indicates: mean of the deep ripped is sign. different (P <0.05) from that of the control

Table 2.2.3. Continued

Year	Crop	Tillage	Spring seeding SMC	Spring seeding NO_3-N	Yield Total	Yield Grain	WUE
			(% w/w)	(kg/ha)	(kg/ha)	(Bu/A)	(kg/ha/cm)
			CARROT RIVER: Norrish Site				
1988	Canola	Control	49.2	47	5055	30.4	65
		Ripped	51.9	48	4616	25.9	56
1989	Canola	Control	33.8	81	5118	25.7	87
		Ripped	35.4	147	5192	24.8	95
1990	Barley	Control	43.3	29	8878	80.4	ND
		Ripped	42.3	25	9396	79.1	ND
			CARROT RIVER: Warner Site				
1988	Canola	Control	64.6	8	2683	12.8	88
		Ripped	64.7	30	4228	20.2*	132
1989	Barley	Control	42.0	9	3014	25.8	ND
		Ripped	40.7	19	7713	61.1*	ND
1990	Canola	Control	49.9	15	2785	10.9	26
		Ripped	54.3	18	3138	15.0*	36

SMC = soil moisture content, WUE = water use efficiency, ND = no data available
* Indicates: mean of the deep ripped is sign. different (P <0.05) from that of the control

CONCLUSIONS

A total of 4 sites were included in the study, and included two Solonetzic soils one Solonetzic/Chernozemic intergrade and one compacted Chernozemic soil. Deep ripping increased crop production only on the Solonetzic soils, and the effect lasted at least 3 years. Deep ripping had no effect on crop production on the Solonetzic/Chernozemic intergrade, nor on the compacted non-Solonetzic soil.

The increased crop production was the result of greater water-use efficiency of the crop on the deep ripped plot, which in turn was related to improved soil physical conditions.Monitoring will continue in 1991 to determine if the longevity of the deep ripping effects will last beyond four years

REFERENCES

Grevers, M.C.J. 1989. The effect of deep ripping and paraplowing on crop production in Saskatchewan, an up-date. Pages 47-54 *in* 1989 Soils and Crops Workshop. University of Saskatchewan, Saskatoon, Sask.