DEEP RIPPING IN SASKATCHEWAN, RESULTS FROM 12 SITES

by

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INTRODUCTION

Deep ripping and/or paraplowing has received much attention in the media over the past 3 years. Deep ripping has been practiced in Alberta with some degree of success (Alubadi and Webster, 1982; Bole, 1986; Lavado and Cairns, 1980). The work in Alberta involves solonetzic soils where impervious Bnt horizons restrict water, air and root penetration. Deep ripping in this case is considered an alternative to deep plowing, which is a considerably more expensive operation. In Saskatchewan, soil disturbance from the installation of pipelines has been found to increase soil productivity of solonetzic soils (De Jong and Button, 1973). Talk amongst the farm community in Saskatchewan regarding the Alberta experience with deep ripping and the pipeline phenomena has led to a number of inquiries by farmers about the feasibility of deep ripping in their areas. This study was set up to investigate the potential for deep ripping in Saskatchewan under a variety of soil and climatic conditions. A deep tillage project was initiated in the fall of 1985 and this report represents year 2 of the research. Results from year 1 were reported at the 1987 Soils & Crops Workshop (Grevers and Tanner, 1987).

MATERIALS AND METHODS

A total of 12 farm sites are included in the study, involving both deep ripping, ranging in depth from 18" to 30" and paraplowing to a depth of 20". The kind of soils and the year and depth of deep tillage operations are listed in Table I. In all cases deep ripping and paraplowing were carried out in the fall. On the majority of sites deep ripping was done with a KELLO-BILT subsoiler, pulled with a

1150 VERSATILE tractor (450 HP). Paraplowing was done with a HOWARD 3-bottom paraplow (courtesy of Agriculture Canada @ Swift Current). The paraplow was pulled with a DEUTSCH DX130 tractor (~120 HP) for most of the sites. At Tisdale, A BELARUS tractor (~250 HP) was used. At most sites, tillage strips were a 1/2 mile in length and 40-60' in width. The treatments were replicated three times. The strips were separated by a control area of similar dimensions. Secondary tillage operations, such as discing and harrowing to smooth down the deep-tilled fields were considerable, in particular at the Tisdale and Arborfield sites. At the Morgan farm,large depressions were left in the field, with subsequent exposed subsoil in some areas. At the Cragg and Chabot farms, secondary tillage operations had left the top 4" to 5" of the soil in a very dry and powdery condition.

Soil chemical criteria used to differentiate solonetzic soils from chernozemic soils are the exchangeable Ca/Na ratio and the % water soluble Na. A soil is considered to be solonetzic if the exchangeable Ca/Na ratio of the B horizon is equal to or less than 10 (Canada Soil Survey Committee, 1978). A solonetzic soil can also be identified chemically, if the % water soluble Na in the B horizon is equal to or greater than 50% (Ballantyne and Clayton, 1962).These chemical values are listed for each site in Table II.

Soil physical parameters that were measured include soil moisture, soil bulk density and soil strength. Soil water content was measured with the neutron access tube method for 10 sites. For the Ackerman and Swenson sites, soil moisture was determined gravimetrically with augers. Readings were taken prior to seeding (1 to 2 weeks) and at harvest time. Soil bulk density was measured with a Depth Density Probe (gamma ray backscattering) at the same time soil moisture readings were taken. Soil strength was measured with a Proctor penetrometer. This method involves pushing a probe into the soil and measuring the force required to do so. Penetrometer measurements were taken at the time of harvest at each crop sampling area.

Crop yield was determined by taking square meter samples, 4 to 6 replicates in each tillage strip. The samples were then transported to the University, where the samples were dried, weighed, threshed and analyzed for protein- or total nitrogen content.

Water use efficiency was determined by dividing crop yield by the sum of the growing season precipitation and the change in soil moisture content over that period.

RESULTS AND DISCUSSION

Soil water recharge from fall to spring, was evaluated for 7 of the 12 sites (Table III). When results for all the sites are averaged, the gain in soil moisture was 13.4 % in the ripped strips, 23.1 % in the paraplowed strips and 11.3 % in the control strips. The relatively small difference between soil water recharge in the ripped fields and that in the control fields is due partly because 3 of the ripped sites had not been ripped the previous fall, but in the fall of 1985. The paraplowed fields on the other hand were all in their first winter and in a very porous condition. The late winter and early spring period for many of the sites was characterized by little snow cover and little rainfall. Evaporative losses of soil moisture during this period can be substantial once the snow cover is gone (Grevers et al, 1986).It is therefore quite possible that the more porous condition of the deep tilled soils may have resulted in greater water loss due to evaporation, that would have occurred otherwise. The fields at Glenside, Birsay, Lucky Lake and Chamberlain were bare of snow for much of the winter period.

Soil bulk density values at the time of harvest are given in Table IV. For the 25cm and the 40cm depths, both the ripped and the paraplowed fields seemed to be less dense than the control fields. However, these differences are not statistically different. The equipment used to measure bulk density is not sensitive to small differences in density. Hopefully in 1988, bulk density can be measured with equipment that is more sensitive.

Crop establishment was evaluated 3 to 4 weeks after seeding. In most cases there was little difference between the deep tilled and the control strips. At the two Arborfield sites however, crop growth in the ripped strips was definitely poor. The ripped strips could easily be recognized from the control strips by their appearance of bare patches and overall sporadic crop emergence. At the Chabot site non-germinated pea seeds could be found in the powdery dry topsoil. Poor seedbed conditions, as earlier mentioned had resulted in poor contact between moist soil and seed. Relatively dry spring conditions did little to off-set the poor seedbed conditions. Apparently similar problems existed at the Tisdale sites in the spring of 1986. However, timely spring rainfall allowed the ripped crop to establish and to eventually catch-up and out yield the control crop.

The effect of deep tillage on crop yields is shown in Table V. Yield increases due to deep ripping were limited mainly to the solonetzic soils Deep ripping resulted in yield increases of 89%, 14%, and 18% at the Boxall, McEwen and Morgan sites, respectively. Deep ripping decreased yields at the Cragg site. However, this may have been attributable to poor seedbed conditions. Crop production on chernozemic soils was by and large uneffected by deep ripping. One exeption was at the Rice site, where canola yields were apparently greater by 10% in the ripped strips. Paraplowing increased yields at only one site, Boxall's (60%), which is a solonetzic site. At all the other sites paraplowed strips had similar yields to that of the control strips. Some of the farm cooperators are of the opinion that rainfall in their area may have masked the effect of deep tillage on crop growth. Timely rainfall during the growing season can do much to off-set the deleterious effects of shallow hardpan horizons on crop water uptake. Amongst the 12 locations, 6 received normal to above normal precipitation for much of the growing season (Table VI). The above would therefore suggest that results may have been different if 1987 had been a "dry" year for the 6 sites in question. On the other hand, the north-east was relatively dry. A "wet" year in this region could also have led to different results. Obviously continued monitoring of all the sites for at least 3 years is required.

Protein content was not significantly affected by the tillage treatments (Table VII). Levels of nitrate-nitrogen in the spring were similar between the test strips except for 4 sites. At the Rice , Chabot and Jessiman farms, soil N levels in the ripped strips were an average 13 lbs/A higher than in the control strips. At the Cragg farm soil N levels in the ripped strips were 24 lbs/A lower than in the control strips. At the sites where deep ripping and/or paraplowing had resulted in significant yield increases, protein content were only lightly lower in the ripped area crop.

One of the problems with crop production on solonetzic soils, is the variability in crop yield within a field. Deep tillage by breaking up hardpan layers in the soil, should in theory "even-out" the variability in yield. Coefficients of variation in crop yield are listed in Table VIII. Deep ripping reduced yield variability by an average of 7% (excluding the Arborfield sites). At the Arborfield sites, deep ripping increased yield variability by an average of 10%, which is due to seeding problems. Paraplowing reduced yield variability by an average of 2%.

Soil strength values for the depth of 2" are given in Table IX. Soil moisture content of the soil layer tested for soil strength, was taken into consideration when evaluating significant differences in soil strength. Deep ripping reduced soil strength by an average of 14%, while paraplowing reduced soil strength by an average of 6%.

Water-use-efficiency (w.u.e.) values are listed in Table X. Deep ripping increased w.u.e. by an average of 11%, while paraplowing increased w.u.e. by 8%. For all wheat crops, deep ripping increased w.u.e. by an average of 17% and paraplowing by 10%. For all the flax crops, deep ripping increased w.u.e. by 14% and paraplowing by 11%. The increased w.u.e. due to deep tillage could be due to a number of factors such as improved soil physical and chemical (fertility) conditions. Soil nitrate-nitrogen levels in the spring were an average of 5 lbs/A greater in the ripped strips and 8 lbs/A in the paraplowed strip compared to the control areas.

CONCLUSIONS

The effect of deep ripping and/or paraplowing on soil conditions and plant growth, was evaluated on 12 farm sites. The sites represent 3 solonetzic soil sites, 3 sites where some of the area is solonetzic and 6 chernozemic soil sites. The results are summarized as follows:

1) Over-winter recharge was greater following either deep tillage operation. Greater recharge occurred following paraplowing than following deep ripping.

2) Soil structure was characterized by lower soil strength at the 2" depth for either deep tillage. Deep ripping was more effective than paraplowing. There was only a trend apparent in soil bulk density, suggesting lower density for the 10" and 16" depth for either deep tillage.

3) Crop establishment was uneffected by either deep tillage operation for 10 of the 12 sites. For 2 of the sites poor seedbed conditions due to deep ripping resulted in poor crop growth.

4) Deep ripping increased yields at 4 sites, decreased yields at 1 site and had no significant effect at 7 sites. Paraplowing increased yields at only 1 site. The most dramatic yield increases occurred on solonetzic soils. Timely rainfall in some areas may have reduced the impact of improved soil physical conditions on crop growth.

5) Variation in crop yield within a field was reduced by either deep tillage operation, but more so with deep ripping than with paraplowing

6) Water-use-efficiency was increased with either deep tillage treatment.

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Table 1. Soil types and depth and year of tillage.

Site	Farm	Soil Assn.	Soil Order	Year*	Depth of	
					Rip	Ppl
					---- cm	----
Moose Jaw	Swenson	Haverhill L	Chernozem	1986	76	
Chamberlain	Ackerman	Weyburn L	Chernozem	1986	50	
Lucky Lake	Jessiman	Sceptre HC	Chernozem	1986	50	50
Birsay	Millar	Fox Valley CL	Chernozem	1986		50
Glenside	Harrington	Tuxford C	Solonetz	1986		50
Cut Knife	Foisy	Oxbow L	Chernozem	1986	50	50
Tisdale	Boxall	Arborfield C	Solonetz	1985	76	50
	McEwen	Arborfield C	Solonetz	1985/6	76	50
	Morgan	Arborfield C	Solonetz	1985	76	
	Rice	Tisdale C	Chernozem	1986	76	
Arborfield	Chabot	Arborfield C	Solonetz	1986	76	
	Cragg	Arborfield C	Solonetz	1986	76	

* Year that the deep tillage operation was carried out. Ripper shanks were 56cm apart for the Tisdale and Arborfield sites and 112cm apart for the other sites. Paraplow bottoms were spaced at 50cm intervals.

Table II. Soil chemical characteristics of the B horizons of all 12 soils.

Site	Means of all profiles Ca/Na	Means of all profiles % W.S.S. *	Worst profile Ca/Na	Worst profile % W.S.S.
Moose Jaw	61	13	34	19
Chamberlain	47	8	39	7
Lucky Lake	231	10	118	15
Birsay	30	22	27	23
Glenside	35	44	1	63
Cut Knife	28	10	22	12
Tisdale, Boxall	5	31	3	40
Tisdale, McEwen	19	43	14	57
Tisdale, Morgan	2	68	1	71
Tisdale, Rice	133	14	110	19
Arborfield, Chabot	30	46	17	53
Arborfield, Cragg	7	79	6	81

* Ripper shanks were 56cm apart for the Tisdale and Arborfield sites and 112cm apart for the other sites. Paraplow bottoms were spaced at 50cm intervals.

Table III. Over-winter recharge (1986/1987) of soil moisture for 7 sites.

Site	Tillage	Fall 86	Spring 87	H2O gain
		----------cm	H2O----------	
Lucky Lake	Ripped	31.9	35.1	3.2
	Parapl.	33.5	40.0	6.5
	Control	32.2	33.6	1.4
Birsay	Parapl.	26.9	29.9	3.0
	Control	26.7	29.7	3.0
Glenside	Parapl.	25.7	26.9	1.2
	Control	22.2	25.2	3.0
Cut Knife	Ripped	24.4	23.7	-0.7
	Parapl.	21.5	23.6	2.1
	Control	22.3	23.3	1.0
Tisdale, Boxall	Ripped	36.3	42.6	6.3
	Parapl.	30.0	43.6	13.6
	Control	34.5	40.8	6.3
Tisdale, McEwen	Ripped	34.4	45.8	11.4
	Parapl.	34.1	51.3	17.2
	Control	35.4	45.8	10.4
Tisdale,Morgan	Ripped	34.4	37.6	3.2
	Control	34.8	34.0	-0.8
Average % gain	Ripped	13.4%		
	Parapl.	23.5%		
	Control	11.3%		

Table IV. Soil bulk density values for the 25, 40 and 60 cm depths.

Site	Depth	Control	Rip	Paraplow
	cm		----------- gm/cm3 ------------	
Lucky Lake	25	1.605	1.515	1.507
	40	1.470	1.453	1.461
	60	1.478	1.523	1.518
Birsay	25	1.566		1.596
	40	1.478		1.506
	60	1.520		1.518
Glenside	25	1.638		1.578
	40	1.605		1.484
	60	1.660		1.515
Cut Knife	25	1.594	1.562	1.492
	40	1.534	1.529	1.453
	60	1.559	1.544	1.502
Tisdale, Boxall	25	1.605	1.575	1.572
	40	1.438	1.430	1.406
	60	1.459	1.457	1.438
Tisdale, McEwen	25	1.464	1.452	1.401
	40	1.362	1.354	1.340
	60	1.420	1.397	1.420
Tisdale, Morgan	25	1.674	1.681	
	40	1.545	1.523	
	60	1.555	1.553	
Tisdale, Rice	25	1.502	1.428	
	40	1.464	1.446	
	60	1.444	1.475	
Arborfield, Chabot	25	1.564	1.500	
	40	1.417	1.322	
	60	1.451	1.444	
Arborfield, Cragg	25	1.372	1.443	
	40	1.272	1.228	
	60	1.364	1.382	

Table V. Crop harvest yields in 1987.

Site	Crop	Grain yield Cntrl.	Rip	Ppl.	LSD .05
			------------Bu/Acre-----------		
Moose Jaw	Wheat	40.3	47.0		N.S.
Chamberlain	Wheat	18.8	22.4		N.S.
Lucky Lake	Wheat	44.1	44.3	46.4	N.S.
Glenside	Wheat	20.0		19.8	N.S.
Tisdale, Boxall	Wheat	18.4	34.8	29.5	5.3
Arborfield, Cragg	Wheat	41.8	34.9		6.0
Birsay	Flax	34.7		35.0	N.S.
	Flax*	29.4		32.5	N.S.
Tisdale, McEwen I	Flax	21.0	24.0		3.0
Tisdale, McEwen II	Flax	22.5		23.1	N.S.
Tisdale, Morgan	Flax	23.0	27.1		3.2
Cut Knife	Lentils	40.4	41.1	42.3	N.S.
Arborfield, Chabot	Peas	31.2	28.6		N.S.
Tisdale, Rice	Canola **		+10%		?

* Represent weigh wagon yields taken by Michael Millar
** Crop was estimated to be 6" taller (~10% greater yield) in the ripped strips by Gary Rice

Table VI. Precipitation during the growing season of 1987.

Site	Growing season precipitation	Precip. as a % of normal May	June	July	Aug
	--mm--	----------%----------			
Moose Jaw	243	88	80	123	104
Chamberlain	243	88	80	123	104
Lucky Lake	216	91	80	114	12
Birsay	216	91	80	114	122
Glenside	194	91	80	114	122
Cut Knife	263	90	80	123	120
Tisdale	209	76	49	80	94
Arborfield	274	71	65	92	116

Table VII. Percentage protein in harvested crops.

Site	Crop	Cntrl	Rip	Ppl	LSD .05
			---------------- %	--------------	
Moose Jaw	Wheat	14.9	13.1		N.S.
Chamberlain	Wheat	12.8	11.9		N.S.
Lucky lake	Wheat	12.8	13.2	13.3	N.S.
Glenside	Wheat	12.8		13.2	N.S.
Tisdale, Boxall	Wheat	14.5	14.4	14.5	N.S.
Arborfield, Cragg	Wheat	13.5	13.7		N.S.
Birsay	Flax	19.3		19.4	N.S.
Tisdale, McEwen	Flax	23.6	22.6	23.2	N.S.
Tisdale, Morgan	Flax	22.1	21.2		N.S.
Cut Knife	Lentils	21.6	21.1	21.1	N.S.
Arborfield, Chabot	Peas	20.6	20.3		N.S.

Table VIII. Variability in grain yields (coefficient of variability).

Site	Control	Ripped	Paraplowed
		---------- % ----------	
Moose Jaw	32.0	9.7	
Chamberlain	27.4	19.9	
Lucky Lake	21.1	19.5	21.2
Birsay	12.9		9.7
Glenside	19.6		22.3
Cut Knife	11.9	13.0	12.7
Tisdale, Boxall	35.9	31.2	30.7
Tisdale, McEwen	12.3	8.4	6.8
Tisdale, Morgan	18.0	10.3	
Arborfield, Chabot	17.4	28.7	
Arborfield, Cragg	12.8	20.9	

Table IX. Soil strength values at 2" depth at harvest.

Location	Cntrl	Rip	Ppl	LSD .05
		---------------- p.s.i. ----------------		
Moose Jaw	133	126		N.S.
Chamberlain *	215	165		N.S.
Lucky Lake	144	87	109	13
Birsay	578		718	129
Glenside	390		277	42
Cut Knife	321	341	375	N.S.
Tisdale,Boxall	110	106	93	13
Tisdale, Morgan	425	296		108
Arborfield, Cragg	57	55		N.S.

* Soil moisture content at 2" depth was greater in the ripped area, which reduces soil strength.

Table X. Water-use-efficiency values for the 1987 crops.

Site	Crop	Cntrl	Rip	Ppl
			----------kg/ha/cm	-------
Moose Jaw	Wheat	94.0	112.7	
Chamberlain	Wheat	39.5	43.5	
Glenside	Wheat	49.7		48.2
Lucky Lake	Wheat	126.2	110.6	116.7
Tisdale, Boxall	Wheat	47.2	89.6	69.0
Arborfield, Cragg	Wheat	67.5	53.6	
Birsay	Flax	75.8		78.1
Tisdale, McEwen I	Flax	45.5	49.8	
Tisdale, McEwen II	Flax	38.5		37.7
Tisdale, Morgan	Flax	68.5	81.4	
Cut Knife	Lentils	91.0	94.5	84.9
Arborfield, Chabot	Peas	63.8	52.2	
Averages per crop	All Crops	67.3	76.4	72.5
	Wheat	59.6	74.9	58.6
	Flax	57.1	65.6	57.9