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Soil Physical Properties and Residue Cover in Intensive Broadleaf Crop Rotations for the Parkland

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Introduction

Development of economically viable, and environmentally sustainable cropping systems for the sub-humid Parkland requires a balance between soil management and crop diversity. The climate of the region supports a wide diversity of crops, and an abundance of spring moisture generally reduces any benefit of conservation tillage in soil moisture, however producers perceived a need for intensive tillage to manage heavy crop residues as part of seedbed preparation. The objective of this research was to determine the impact of reduced tillage systems and broadleaf crop intensity on crop residue decomposition, soil erodibility and physical properties in the sub-humid Parkland.

Methods

Experimental trials were established in May 1994 at Melfort (Black, silty clay soil) and Tisdale (Gray, heavy clay soil). Plot size was 15.2 m x 18.3 m at Melfort and 7.6 x 15.2 m at Tisdale. A four replicate split plot experimental design was established, with tillage as the main plot and rotation-phase as the sub-plot treatments. The tillage treatments included conventional tillage (fall + spring tillage with field cultivator, harrow-pack prior to seeding), minimum tillage (spring tillage only, harrow-pack prior to seeding), and no-till (no preseeding tillage). All treatments were seeded using a 3.7 m pneumatic plot seeder, with all fertilizer side banded (2.5 cm to the side and 6.4 cm below the seed) at seeding. The crop rotations included R1: canola - wheat - barley - barley, R2: canola - barley - pea - wheat, and R3: canola - pea - flax - barley. The cultivars grown and seeding rates used were AC Excel canola (*B. napus*) at 7.8 kg/ha, Express pea at 202 kg/ha, AC Taber CPS wheat at 134 kg/ha, and Harrington barley at 123 kg/ha. Fertilizer N was applied based on a target rate less soil residual N. The target rates for canola were 110 N kg N/ha, 100 kg N/ha for wheat and barley, 70 kg N/ha for flax and no N on the peas. Peas were inoculated with either liquid or granular inoculant. Phosphorus, potassium and sulphur were added as required.

Residue cover was measured in each plot with a grid count of 144 counts in two one square meter quadrats. Percent cover was calculated from frequency of points, which intersected standing and fallen crop residue. Soil temperature was measured, from mid April to the beginning of seeding in may, at 2.5, 5 and 10 cm depths in two replicates of the canola and wheat phases of the canola - wheat - barley - barley rotation, pea phase of the canola - barley - pea - wheat rotation, and flax phase of the canola - pea - flax - barley rotation for conventional and no-tillage treatments at Melfort. Air temperature was also measured at 1.5 m height.

Aggregates, bulk density and soil moisture were sampled from the 0 to 5 cm depth increment shortly after seeding in 1995, 1996 and 1997. Aggregate samples weighing approximately 2.5 kg were dry sieved with a rotary sieve. Bulk density and oven dry soil moisture (105 degrees C) were measured in a soil core taken at the same time. Samples were collected from selected phases of rotations with 50 and 75% broadleaf crops. Saturated hydraulic conductivity, using the standing-head technique, was conducted on soil cores collected from selected phases of rotations with 50 and 75% broadleaf crops. A Guelph infiltrometer was also used to measured saturated infiltration under zero and conventional tillage following barley, flax and peas in fall 1997.

Statistical analyses were conducted for the soil and crop variables in each year of the study. Significance of effects were calculated using Genstat version 3.2 with a general linear model for preceding crop nested within tillage treatments. Separate error terms were calculated for nested effects and degrees of freedom were adjusted for the correct linear combinations of mean squares. Significant effects are reported when $P<0.05$.

Results and Discussion

Aggregate size distribution

The proportion of aggregates in the fraction with the lowest sieve opening (>0.5 mm) varied, though it was higher in plots planted into broadleaf compared to cereal stubble for three of the six site years (1995-97). This fraction makes up a large proportion of erodible aggregates (<0.84 mm), but the amounts measured in this study are low and do not represent significant potential for erosion.

In 1995, there was a higher proportion of large aggregates (> 68.8 mm) under no-tillage at Melfort (32.6%) and Tisdale (26.1%) after seeding compared to conventional and minimum tillage. This is most likely due to crusting at the surface in no-tillage. Large aggregates in the same fraction were higher at Melfort in plots cropped to flax (26.2%) the previous year compared to barley (18.5%), peas (16.7%) and canola (14.9%). A high proportion of large aggregates may affect germination and emergence. Flax crops may affect soil structure based on the predominance of large aggregates. The later may be due to lignin in flax residue, which increases aggregate stability

Residue cover

Residue cover was a function of either tillage or preceding crop in three of the four site years of the study. In a combined analysis by year for treatments with 50 and 75% broadleaf crops in rotation, no-tillage resulted in higher residue cover, followed by minimum and conventional tillage respectively (Tables 1, 2, 3, 4). Low residue cover in minimum and conventional tillage were attributed to the burial of residue during tillage operations, though productivity in these systems should also be considered.

Residue cover was highest following barley and wheat compared to canola flax and peas. Residue cover was lower at Tisdale than Melfort due to lower production of straw. Tillage interacted with previous crop at Melfort in 1995 (P=0.038). Cereals produced more residue than broadleaf crops, and decomposition was slower for these residues. Levels of residue cover are low following flax and peas at Tisdale, and the potential for erosion following these crops is highest under conventional tillage if a guideline of 30% is used.

Table 1. Residue cover (%) measured at Melfort in spring 1995, combined analysis of treatments with 50 and 75% broadleaf crops in rotation. Tillage by previous crop (p=0.038) significant.

Tillage		Previous	Crop		
	Barley	Canola	Flax	Peas	Tillage mean
Zero	89.8	89.6	86.4	84.8	87.8
Minimum	80	81.2	75.1	73.7	77.8
Conventional	76.1	77.5	59.9	63.6	70.6
Previous Crop mean	81.9	82.8	73.8	74	

LSD tillage by previous crop - comparison of tillage in flax 10.1, n = 12; comparison of tillage in barley, canola and peas 8.9, n = 24; comparison of tillage in flax with tillage in barley, canola and peas 9.5, n = 12 and 24

Table 2. Residue cover (%) measured at Melfort in spring 1996, combined analysis of treatments with 50 and 75% broadleaf crops in rotation. Tillage ($p=0.004$) and previous crop($p<0.001$) significant.

Tillage		Previous	Crop			
	Barley	Canola	Flax	Peas	Wheat	Tillage mean
Zero						81.1
Minimum						64.2
Conventional						48.9
Previous Crop mean	72.3	66.5	53.7	58.4	77.5	

LSD for tillage treatments averaged across previous crops - 13.8, n = 28
LSD for previous crops averaged across tillage treatments - comparisons between barley, flax and wheat 6.0, n = 12; comparisons between canola and peas 4.2, n = 24; comparisons between residues in group 1 (barley, flax and wheat) and group 2 (canola and peas) 5.2, n = 12 and 24

Table 3. Residue cover measured at Tisdale in spring 1995, combined analysis of treatments with 50 and 75% broadleaf crops in rotation. Tillage ($p=0.010$) and previous crop($p<0.001$) significant.

Tillage		Previous	Crop		
	Barley	Canola	Flax	Peas	Tillage mean
Zero					59.6
Minimum					57.5
Conventional					44.6
Previous Crop mean	62.4	59.7	39.9	46.7	

LSD for tillage treatments averaged across previous crops - 8.5, n = 28
LSD for previous crops averaged across tillage treatments - comparisons between barley, canola and peas 5.7, n = 24; comparisons between residues in group 1 (barley, canola and peas) and flax 6.9, n = 12 and 24

Table 4. Residue cover measured at Tisdale in spring 1996, combined analysis of treatments with 50 and 75% broadleaf crops in rotation. Tillage (p=0.002) and previous crop(p<0.001) significant.

Tillage		Previous	Crop			
	Barley	Canola	Flax	Peas	Wheat	Tillage mean
Zero						51.1
Minimum						44.4
Conventional						25.4
Previous Crop mean	50	46.7	27.6	28.6	53.8	

LSD for tillage treatments averaged across previous crops - 10.1, n = 28
LSD for previous crops averaged across tillage treatments - comparisons between barley, flax and wheat 7.7, n = 12; comparisons between canola and peas 5.5, n = 24; comparisons between residues in group 1 (barley, flax and wheat) and group 2 (canola and peas) 6.7, n = 12 and 24.

Soil temperature

May 1 to May 15, 1995:

Soil temperatures at Melfort ranged from 1 to 7 degrees warmer under conventional compared to no-tillage. There were 11 nights with subzero temperatures for conventional tillage compared to 14 for no-tillage. It appears that soil temperatures under no-tillage are lower than in conventional tillage, and that there are more freezing nights correlated with lower temperatures.

November 3 to February 7, 1995:

Soil temperatures at Melfort averaged 1 to 2.5 degrees C higher under conventional tillage compared to no-tillage for this period. One freeze thaw event was observed during this period.

Soil moisture

Soil moisture (0-5 cm) was significantly higher under no-tillage than conventional tillage in five of six site years (Table 5). In two of six site years, soil moisture was lowest in plots planted to flax in the previous year.

Table 5. Soil moisture (%) for 0 to 5 cm depth shortly after seeding in 1995-1997.

		Melfort			Tisdale	
	1995	1996	1997	1995	1996	1997
Zero	14.7a	29.8a	23.8a	8.7a	19.7 ns	22.8a
Minimum	10.4b	23.4b	19.4b	6.2b	19.6 ns	20.0b
Conventional	10.9b	24.2b	18.8b	4.8c	17.5 ns	17.7c
LSD	1.3	1.4	2.8	1.2	2.4	1.1

a,b - significant difference within site year
ns - not significant within site year

Bulk density

Bulk density (0-5 cm) did not vary significantly with treatment, generally ranging between 0.75 to 1.0 g cm^{-3} at Tisdale and Melfort.

Hydraulic conductivity

Hydraulic conductivity did not vary significantly between treatments in 1996 (saturated standing head technique) or 1997 (Guelph infiltrometer). In general tillage and rotation did not significantly affect infiltration though it should be noted that experimental error for both methods was high.

Conclusions

Soil moisture was higher at seeding depth (0-5 cm) under zero-tillage compared to conventional tillage in northeastern Saskatchewan. Residue cover may not be sufficient for erosion control under conventional tillage following years of low productivity for broadleaf crops.