Strategic Tillage - Evolution or Devolution of Zero Tillage?

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Abstract

Producers who practice zero tillage are concerned that a single tillage operation will cause serious negative long term impacts to their system. However, evidence for this is limited and this belief conflicts with certain disease management recommendations which indicate the value of burying blackleg infested crop residue and leaving it buried for several seasons to reduce the levels for spore release. This study was conducted to determine if strategic **tillage** could be used to lower disease in canola. **Strategic tillage** is a “planned occasional tillage” which occurs for a purpose other than seedbed preparation.

The study was established in 1999 on a clay loam soil near Brandon Manitoba with 2 rotations: canola-wheat-pea and canola-wheat-flax. While all crops were sown each year and tillage occurred each yield the impact of tillage in subsequent seasons could not be measured until one or two years following the tillage operation. The objective was to determine the impact of tillage in a long term zero tillage system on crop yields, weed numbers, foliar disease and nutrient uptake.

Tillage just prior to planting flax or pea resulted in lower yields of that crop in that season possibly due to higher weed pressure and the inability to control weeds at an early stage with the herbicides used. In 2003 barley yields were greater on plots which had received tillage in any of the previous seasons. While this suggests the potential for improved growth by mixing of the surface residue layer with the lower levels of the soil this must be confirmed and tillage should not be practiced until the mechanism, timing and frequency of response can be determined.

While total weed numbers were up to 30% greater in the year of tillage and the subsequent season the levels had return to the same level the second season after tillage. High disturbance prior to planting reduced control of dandelions and had little impact on Canada thistle.
Strategic tillage did not impact blackleg or sclerotinia levels in the years of the trial. Likewise there were no significant differences between the yield of canola in the rotation with pea and with canola. Given the low levels of disease found it this trial it is difficult to draw the conclusions that occasional planned tillage has a major impact on canola or wheat diseases.

Aggregate size was reduced by tillage but there was little or no impact on soil carbon, nitrogen, bulk density, potentially mineralizable nitrogen or any other soil property measured. In the seasons subsequent to tillage aggregate size began to return to the pretillage size.

Strategic tillage did not have long term negative impacts on crop yields, or weed pressure. Thus tillage could be used in the subhumid black soil zone to control difficult weeds or level a rough field without long term negative impacts on crop yields, disease or soil quality.

Introduction

Strategic tillage is a planned tillage operation in an otherwise direct seeding system. The reasons for this management may be to reduce field roughness, control certain weeds, increase soil temperature or bury crop residues in an attempt to manage disease. There has been concern that this management would cause serious negative impacts in zero tillage systems and thus a trial was conducted to evaluate the impacts of **strategic tillage** on crop yields

Methodology

Design and analysis

This trial was begun in 1999 on Newdale clay loam which had been direct seeded since 1990. The trial was a 4 replicate randomized complete block with all phases of each rotation present in each year. Individual years were analyzed using SAS GLM and the multi year analysis to compare tillage systems across years with SAS MIXED. Since variances between crops are heterogeneous analysis was conducted on the current crop. .

Crop Rotations and tillage treatments

The following 2 crop rotations were established in 1999.
Wheat-canola-pea
Wheat-canola-flax (flax straw was removed from all flax plots as is the normal farm practice in this area).

In 2003 no tillage was done and the entire area was planted to Robust barley at 100 kg ha^{-1} with 40 kg ha^{-1} of nitrogen as urea plus 50 kg ha^{-1} of monoammonium phosphate sidebanded at planting.

The following tillage systems were applied to each rotation such that each phase of the rotation and all phases of each rotation are included in each season. However, it is not possible to have strategic tillage occur 0, 1 and 2 years previously until 2002. Therefore there are many more low disturbance plots in 2000 than will be the case in 2003 and beyond.

The code HD2*** indicates that high disturbance occurred in 2001 and the other letters indicate the crop. W=wheat, P=pea, F=flax, C=canola.

1. LD= Low disturbance (seeded with double shoot hoe opener with preceding Roundup for weed control)
2. HD = Planned-limited tillage with heavy duty cultivator in the spring (prior to each crop in the sequence, with low disturbance planting in the other 2 years
3. HHLD=Planned-limited tillage (heavy harrows in the fall to stimulate residue decomposition and weed seed germination with cultivation or glyphosate prior to seeding to control weeds) done every year.
4. PHX=Phoenix rotary harrow in the fall to stimulate residue decomposition and weed seed germination with cultivation or glyphosate prior to seeding to control weeds) as #2 this will occur once in 3 years with low disturbance seeding in the remaining years. This change was made and used in <u>the flax rotation only</u> since heavy harrows tended to drag residue from the plots into the pathways and since flax residue is always removed the impact in this rotation would be less than if pea residue was removed. In addition flax is not a significant host for sclerotinia and thus more flax plots are desirable to ensure that direct and indirect tillage impacts can be determined.

All seeding was conducted with “Conservapak” openers on 9” (22.7 cm) centers. Nutrient application and weed control measures were applied according to the best management practice for that crop, with all phosphorus and urea nitrogen being applied as a sideband. High disturbance plots were cultivated twice at a depth of 7-8 cm, in the spring, prior to seeding.

Weeds were counted in 10 locations per plot prior to herbicide application and about 5 weeks later (residual).

Soil quality estimates were made in the fall of 2002 on specific plots comparing continuous low disturbance (LD) with continuous heavy harrow (HH) to high disturbance in the spring of 2002 (HD3) and high disturbance in the spring of 2001 (HD2).

Fusarium head blight was measured on wheat plots from 2000 to 2003. Sclerotinia and blackleg were measured in the same time period.

Results and Discussion

Yields

While wheat yields were about 2% greater when low disturbance seeding was used compared to low disturbance after cultivation or heavy harrowing this was not significantly different. Heavy harrowing and phoenix harrows had little or no impact on wheat yield. Flax, pea and canola yields over the 3 years tended to be lower when planted after strategic tillage rather than low disturbance seeding however this was significant only with dry pea. In the year subsequent to the year to tillage only pea yields were lower on land which had received tillage (Table 1, 2). These differences may be due to larger number of prespray weed numbers in tilled ground. Data from other studies indicates that weeds generally emerge more rapidly and uniformly on tilled soil and thus may require earlier control. Differences in growth stage of the weeds were not large and the variability in numbers and stage of weeds makes it difficult to determine if this was true based on this data set. The entire area received preharvest glyphosate in the fall of 2002 to control perennial broadleaved weeds and sown to barley in 2003. Under these test conditions barley yields were 8, 16 and 22% higher than continuous direct seeding when tillage had occurred 1, 2 or 3 years previously (Table 3). We are awaiting the results of plant nutrient analysis to determine if this is the reason for the improved yields in 2003.

Weeds

Prespray weed numbers were about 30% higher in the year where tillage occurred. These numbers remained at this level in the year following tillage and were similar to continuous low disturbance planting 2 years after the tillage event. In 2001 wild oat and wild buckwheat numbers were lower (over all crops) when tillage had occurred in the year previous while in 2002 wild oat and wild buckwheat numbers were equal or greater where tillage had occurred in the previous season. Dandelion numbers were variable and not associated with a specific treatment indicating that a short term tillage regime is not an effective management system in zero tillage systems and that fall applications of products to control dandelions will be more effective.

Residual weed counts (weeds after spraying) were lowest in wheat. Treatments which were heavy harrowed had slightly lower residual weed numbers which may indicate greater uniformity of emergence of weeds and thus improved control by the application of pest control products. Low disturbance seeding had similar or higher residual weeds counts to treatments where high disturbance had occurred in this or the previous season.

Diseases

Neither previous crop nor tillage had significant impacts on disease levels. This trial was established on a land base where the canola was last grown was 1991 with pea in 1993 and 1997. We planted the blackleg resistant canola cultivar Invigor 2573 from 2000-2002. Blackleg levels were low due in part to the high level of genetic resistance as well as conditions not conducive to the development of the disease. Sclerotinia levels were low as a result of low levels of inoculum resulting from a limited number of susceptible crops in the rotation and the relatively dry conditions during flowering.

Soil quality measurements in the fall of 2002

Bulk density (0-5 cm) was not affected by tillage or crop. Penetration resistance (kPa) was similar in high and low intensity tillage at 0-5 cm and 5-10 cm. No significant differences were observed between types of crop stubble.

There was a greater proportion of large aggregates (38 mm to 68.8 mm) under low (LD) compared to high disturbance in the spring of 2001 or the spring of 2002. High disturbance resulted in a correspondingly higher proportion of small aggregates less than 0.5 mm. No significant difference was observed in organic carbon and nitrogen of soil aggregates due to tillage or crop. High disturbance tillage and crop stubble had no significant effect on wet stable aggregates (1.3-2.0 cm). However, stability of wet sieved aggregates increased with the concentration of organic carbon in the aggregates ($r=.3006$ all data, $r=0.4731$ with two outliers removed, $P<0.0001$).

Tillage and preceding crop had no significant effect on soil organic carbon (%) and total nitrogen (%) at 0-10 cm, 10-20 cm, and 20-30 cm. Tillage intensity (high and low levels) and preceding crops (peas or canola) had no significant effect on phosphate phosphorus (0-10 cm). However nitrate nitrogen (0-10 cm) was higher in high disturbance tillage and following canola. High levels of nitrate nitrogen and ammonium are attributed to residual nitrogen fertilizer.

Tillage intensity (high and low levels) and preceding crop (peas, flax or canola) had no significant effect on mineralizable nitrogen measured with the amino sugar (mg kg^{-1}) test. All levels of mineralizable nitrogen were above levels (300 mg kg^{-1}) considered to respond to fertilizer nitrogen.

Table 1. Impact of Tillage in spring of current season on seed yield kg ha^{-1}								
	Crop							
	canola	% LD	wheat	% LD	flax	% LD	pea	% LD
Tillage spring current year (HD)	1670	**92.9**	2423	**96.7**	989	**81.9**	1776	**79.6**
continuous low disturbance (LD)	1797	**100.0**	2505	**100.0**	1208	**100.0**	2232	**100.0**
continuous heavy harrow (HH)	1640	**91.3**	2500	**99.8**	1175	**97.3**	1949	**87.3**
Flax-canola-wheat	1762		2484					
Pea-canola-wheat	1644		2469					
prob >F								
rotation	0.33		0.83					
rotation*tillage	0.22		0.69					
tillage	0.40		0.64		0.17		0.05	
Contrast HD vs LD	0.82		0.42		0.09		0.22	
Contrast HD vs LD and HH	0.62		0.37		0.08		0.04	

Table 2. Impact of Tillage in spring of previous season on seed yield kg ha^{-1}								
	Crop							
	canola	% LD	wheat	% LD	flax	% LD	pea	% LD
Tillage spring previous year (HD)	1600	**99.1**	2373	**98.9**	1001	**94.5**	1487	**84.8**
continuous low disturbance (LD)	1615	**100.0**	2400	**100.0**	1059	**100.0**	1753	**100.0**
continuous heavy harrow (HH)	1658	**102.7**	2379	**99.1**	1055	**99.6**	1513	**86.3**
flax canola wheat	1591		2414					
pea canola wheat	1658		2354					
prob >F								
rotation	0.73		0.54					
rotation*tillage	0.26		0.92					
tillage	0.84		0.96		0.67		0.46	
Contrast HD vs LD	0.90		0.81		0.46		0.30	
Contrast HD vs LD and HH	0.71		0.87		0.42		0.47	

Table 3. Impact of tillage in previous seed on barley production in 2003				
Tillage	Rotation	seed yield kg ha^{-1}		yield as
		mean	se	% of test mean
HD2000	cwf	3486	40	108
HD2001	cwf	3562	101	110
HD2002	cwf	3304	58	102
HH	cwf	2887	89	89
LD	cwf	3081	100	95
HD2000	cwp	3486	57	108
HD2001	cwp	3745	108	116
HD2002	cwp	3311	41	103
HH	cwp	2651	127	82
LD	cwp	3025	59	94
HD2000	fcw	3624	55	112
HD2001	fcw	3400	89	105
HD2002	fcw	3269	90	101
HH	fcw	2994	12	93
LD	fcw	2797	77	87
HD2000	pcw	3527	85	109
HD2001	pcw	3365	132	104
HD2002	pcw	3453	69	107
HH	pcw	3204	37	99
LD	pcw	2812	51	87
HD2000	wfc	3615	116	112
HD2001	wfc	3349	83	104
HD2002	wfc	2948	252	91
HH	wfc	3062	48	95
LD	wfc	2863	32	89
HD2000	wpc	3799	76	118
HD2001	wpc	3356	73	104
HD2002	wpc	2804	118	87
HH	wpc	2908	64	90
LD	wpc	3107	96	96

WPC= wheat pea canola   WFC=wheat flax canola
HH= Heavy harrow each fall
LD= continuous low disturbance planting
HD2000=high disturbance in 2000 only
Contrast HD2000&HD2001&HD2002 vs LD& HH prob > F <0.0001