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for the
Agriculture Demonstration of Practices and Technologies
(ADOPT) Program

Project Title: Vertical Tillage: Small Plot Demonstration

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Objectives and Rationale

Project Objectives

The objective of this demonstration was to determine if using vertical tillage in fall or spring preceding seeding can increase seedling emergence and grain yield of corn, soybean, wheat or canola compared to no tillage in northwest Saskatchewan.

Project Rationale

Vertical tillage was introduced in corn growing regions to manage excess residue. Previous research has shown that high levels of residue in no-till systems can reduce corn yields caused by cool and wet soils, slowing emergence. Farmers in the north western Prairies are beginning to experimenting with vertical tillage as well. The perceived benefit of vertical tillage is that it may improve yield by blackening soil, causing higher temperatures, improving seedbed quality and emergence. The economic benefits of vertical tillage in traditional northern cropping systems may be minimal for several reasons: **1)** residue in cereal-oilseed rotations is not as excessive as those which include corn, **2)** the cost of the implement and fuel required to operate may outweigh the improvements in yield, **3)** cool-season crops typically grown may not benefit from warmer soil temperatures compared to warm season crops and **4)** the long-term benefit of residue coverage with no-till may preserve soil quality to a greater extent than frequently applied vertical tillage. However, with short season corn and soybeans gaining popularity among farmers in northwest Saskatchewan, a warmer soil temperature early in the growing season may improve yields of these warm-season crops. This demonstration will show farmers the benefit, if any, of using vertical tillage in the preceding fall or spring compared to no tillage for cool-season crops (wheat and canola) and warm season crops (soybean and corn).

Methodology and Results

Methodology

This demonstration was conducted at the AAFC Scott Research Farm in 2014 and 2015. A randomized complete block design arranged as a split-plot with four replicates. The main factors consisted of tillage treatments and sub-plots consisted of crop type (Table 1). Two replicates of each main plot were blocked together (pseudo-replicated) to minimize land required to carry out the demonstration. Vertical tillage was applied using a Salford on October 18th, 2013 and October 23rd, 2014 and May 13th, 2014 and May 8th, 2015 prior to seeding (Figure 1). In 2014, seeding occurred on May 22nd (wheat, canola, corn) and 23 (soybeans) and in 2015 on May 13th (wheat, corn, canola) and May 19th

(soybeans). Tillage was applied perpendicular to stubble and crops were seeded parallel to stubble. Soil moisture was very dry in fall of 2013 when tillage was applied and ideal when tillage was applied in the spring (2014). The fall of 2014 received average precipitation allowing for soil penetration, but spring emergence in 2015 was limited due to lack of moisture. Fertilizer and inoculant was applied at seeding according to soil test recommendations for each crop. Weeds were controlled using a pre-seed burndown and registered in-crop herbicides (See Appendix, Table 1 for complete details of field maintenance activities).

Table 1: Demonstration treatment list for 2014 and 2015 growing seasons

Treatment	Tillage Regime	Crop
1	Fall Vertical Tillage	Canola
2	Fall Vertical Tillage	Wheat
3	Fall Vertical Tillage	Corn
4	Fall Vertical Tillage	Soybeans
5	Spring Vertical Tillage	Canola
6	Spring Vertical Tillage	Wheat
7	Spring Vertical Tillage	Corn
8	Spring Vertical Tillage	Soybeans
9	No-Tillage	Canola
10	No-Tillage	Wheat
11	No-Tillage	Corn
12	No-Tillage	Soybeans

Figure 1. Stubble from main stubble plots on May 22, 2014 prior to seeding. From left to right: Spring vertical tillage, fall vertical tillage, no tillage

Spring plant densities were assessed at three and four weeks after seeding to determine if vertical tillage affects seedling emergence and plant density. Spring plant densities were assessed by counting two 1 m rows in the front and back of the plot for a total of four rows per plot. The average of the four rows was converted to plants m^{-2} based on 10 inch row spacing. Grain yields were also measured to determine if a tillage treatment provided an economic benefit compared to no tillage. Wheat, canola and soybeans were straight-combined using a wintersteiger plot combine. On September 12th, 2014 there was a killing frost so the corn was not harvested in 2014. In 2015, the corn yield was collected by hand harvesting the cobs from 1meter front and back (2 meters total). The cobs were de-husked, dried and then weighed to determine total cob weight- a proxy for grain yield.

Statistical Analysis

An analysis of variance (ANOVA) was conducted on all variables using the Mixed Procedure in SAS 9.3. Tillage was considered fixed effects and replications (nested within years) and years was considered a random effect. The assumptions of ANOVA (equal variance and normally distributed) were tested using a Levene's test, and Shapiro-Wilks. The data fitted to the ANOVA assumptions. Therefore, the 2014 and 2015 data was analysed and presented together. Treatment means were separated using Fisher's Protected LSD test and considered significant at $P < 0.05$. Weather data was estimated from the nearest Environment Canada weather station (Table 2).

Results

Growing season weather conditions

In 2014, Scott saw slightly lower than average temperatures in May and June, but summer and fall were at or slightly above average temperatures. Scott received 123 % of normal precipitation, most of which fell in July. The first fall frost at Scott, SK occurred on September 12th, damaging corn plots and ceasing ear development at that time.

In 2015, the early growing season was very dry with only 4.1 and 19.4 mm accumulated precipitation during the month of May and June, respectively. In contrast, August received approximately 39 % more moisture compared to the long-term average. The mean monthly temperatures were comparable to previous years; however, the lack of moisture in the early growing season resulted in a challenging growing season. Furthermore, there was an increase in precipitation during August (74 mm), an increase of 27 % compared to the long term average.

Table 2. Mean monthly temperature, precipitation and growing degree day accumulated from May to September 2014 and 2015 at Scott, SK

Year	May	June	July	August	Sept.	Average /Total
-------------Temperature (°C)-------------						
2014	9.3	13.9	17.4	16.8	11.2	13.7
2015	9.3	16.1	18.1	16.8	10.9	14.24
Long-term^{z}	10.8	15.3	17.1	16.5	10.4	14.0
-------------Precipitation (mm)-------------						
2014	23.1	60.4	128.0	30.1	23.6	265.2
2015	4.1	19.4	46.4	74.5	49.6	194.0
Long-term^{z}	36.3	61.8	72.1	45.7	36.0	215.9
-------------Growing Degree Days-------------						
2014	144.5	264.8	384.5	363.4	188.0	1345.2
2015	140.3	332	405.1	365.8	179.8	1423.0
Long-term^{z}	178.3	307.5	375.1	356.5	162.0	1379.4

^{z}Long-term average (1981-2010)

Plant Emergence

Plant density was similar for both sampling dates for the cool season crops, wheat, indicating it likely had already reached maximum plant density at the first sampling date (Table 4; Appendix A). Canola emergence appeared to decrease from the first to the second count (Table 4), but this is likely associated with the presence of red turnip beetles as there was a high infestation during the month of May and June. Earlier, more frequent sampling may have been required to identify differences in emergence rates among tillage treatments for cool season crops. Plant density increased for both soybean and corn from the first to the second sampling date (Table 4), suggesting warmer temperatures may have been required to initiate/complete germination. Sampling dates four weeks after seeding may have been required to capture the point at which seedling emergence ceased for warm season crops, which could have also revealed differences among tillage treatments. Based on our analysis, the effect of spring, fall and no till did not have an effect on plant density or grain yield (Table 4).

Grain Yield

Tillage did not have a significant effect on corn, wheat, canola and soybeans grain yield (Table 4). There may be several possible explanations why tillage treatments did not affect grain yield in this demonstration. The vertical tillage implement used is a relatively light-duty model, with coulters running on a 90° angle, thus minimizing residue incorporation. The barley and wheat stubble which the demonstration was located on was not excessive; therefore, the use of the vertical tillage implement as a residue management tool may be negligible. In a situation where there would be more crop residue, such as after a corn crop, vertical tillage may have demonstrated more benefits in terms of plant emergence and grain yield. Results of the non-significant effects of tillage on crop yield agrees with that of Adee (2015) of Kansas State University who found no significant effect of tillage systems on corn and soybean yield in 2012, 2013 and 2014.

Limited soil moisture in the fall of 2013 may have also affected the effectiveness of the fall tillage treatment. The fall vertical tillage pass did not penetrate the ground, as the land had experienced a dry late summer/fall with little precipitation. Without proper penetration of the implement into the soil, the implement is not able to achieve the proper residue incorporation/chopping and soil fracturing capabilities it is designed for. Although the spring tillage treatment was better able to penetrate the soil compared to the fall tillage treatment (2013), there was no observed advantage in plant density or grain yield compared to either the no-tillage or fall vertical tillage treatment. Furthermore, the fall tillage treatment in 2014 was able to penetrate the ground, and although moisture was limiting in the early growing season of 2015, the plants were able to bounce-back as rainfall occurred sporadically. The plot seeder used in this demonstration is designed for use in a no-till system which, in the case of this experiment, allowed for desirable soil to seed contact and hence, tillage may not have provided any seed-bed advantages.

Table 4. Least squares means for main effects of vertical tillage and crop type on plant density and grain yield at Scott, SK in 2014 . Main effect means followed by the same letter do not significantly differ (Fisher's protected LSD test; $P \leq 0.05$)

	Plant Density		**Yield**
	19 DAS	**26 DAS**	
Corn			
P values	0.5608	0.6183	0.2740
	-------------------- ***# plants m^{-2}***	------------------------	------- ***kg ha^{-1}*** -------
Fall Vertical Tillage	7	9	6912
Spring Vertical Tillage	7	10	8825
No- Tillage	6	10	6912
Canola			
P values	0.5845	0.8592	0.9947
	-------------------- ***# plants m^{-2}***	------------------------	------- ***kg ha^{-1}*** -------
Fall Vertical Tillage	65	55	2380
Spring Vertical Tillage	70	59	2280

No- Tillage	55	51	2275
Wheat			
P values	0.6832	0.8212	0.9726
	-------------------- ***# plants m^{-2}***	------------------------	------- ***kg ha^{-1}*** -------
Fall Vertical Tillage	168	166	3513
Spring Vertical Tillage	181	168	3527
No- Tillage	176	175	3559
Soybean			
P values	0.7260	0.3747	0.5390
	-------------------- ***# plants m^{-2}***	------------------------	------- ***kg ha^{-1}*** -------
Fall Vertical Tillage	26	40	1038
Spring Vertical Tillage	22	34	1016
No- Tillage	20	37	1124

Conclusions and Recommendations

Fall and spring tillage using a light-duty vertical tillage implement with moderate levels of barley and wheat residue did not improve plant emergence or yield of crops when compared to a no-till system. There was a slight increase in soybean and corn emergence at the sampling dates 19 DAS, but the increase is likely attributed to warmer soil temperatures. The increase in plant density did not affect grain yield. In situations where crop residue is heavier, such as after silage corn or soft white wheat, a light-duty implement may have more of an effect on plant emergence and ultimately yield. Under no-till, low residue cereal-oilseed-pulse systems typical of northwest Saskatchewan, vertical tillage does not appear to improve plant density or seed yield for warm or cool season crops. We anticipate that it will take several years for any characteristics of a given tillage to build up to the point of influencing yields.

Supporting Information

Acknowledgements

We would like to thank the Ministry of Agriculture for the funding support on this project. We would like to acknowledge Tristan Coelho, Herb Schell, Mike Sittler and our summer staff for their technical assistance with project development and implementation. The demonstration was featured at the 2014 Scott Field Day. This report will be distributed through WARC’s website and included in WARC’s annual report.

Appendices

Appendix A – Agronomic information specific to 2014 demonstration
Appendix B – Photographs of the vertical tillage implement used in 2014 demonstration

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Abstract

Abstract/Summary

As soybeans and corn increase in acreage across northwest Saskatchewan, farmers may experiment with various tillage implements in an effort to manage crop residues and improve seedling emergence under cool spring conditions. Excessive crop residue in no-till systems has been shown to reduce yield of crops due to reduced plant emergence. The objective of this demonstration was to demonstrate the residue incorporation/chopping capacity a light-duty vertical tillage implement and its effect on seedling emergence and grain yield compared to no tillage. Three tillage treatments (no-till, fall vertical tillage and

spring vertical tillage) considered and the plots were seeded to four crops (canola, corn, soybeans, wheat). The fall and spring treatments did not provide any increase in plant emergence or enhance crop yield. There was an increase in soybean and corn emergence after the 19 DAS likely due to warmer soil temperatures. The higher plant density did not persist and did not affect grain yield. The lack of soil moisture in the fall of 2013 hindered the light-duty implement in properly penetrating the soil and thus soil fracturing or residue incorporation/chopping capabilities were likely negligible. Although the 2014 spring vertical tillage pass was conducted under optimal conditions, our current seeding system, designed for no-till residue situations, provides excellent soil-seed contact without seed-bed preparations. Under no-till, low residue cereal-oilseed-pulse systems typical of northwest Saskatchewan, vertical tillage does not appear to improve plant density or seed yield for warm or cool season crops. This demonstration was featured at the 2014 Scott Field Day which hosted approximately 175 attendees. This report will be distributed through WARC's website and included in WARC's annual report.

Appendix A
Agronomic information specific to 2014 and 2015 demonstrations

Table A.1. Selected agronomic information for vertical tillage demonstration at Scott, Saskatchewan.

Seeding Information	2014	2015
Seeder	R-Tech Drill, 10 inch row spacing, knife openers	R-Tech Drill, 10 inch row spacing, knife openers
Seeding Date	May 22, 2014 for Corn, Canola and Wheat May 23, 2014 for Soybeans	May 13th (wheat, corn, canola) May 19th (soybeans)
Cultivar	Corn - DKC 26-25 Canola - L130 Wheat - Vesper Soybean - P001T34R	Corn - DKC 26-25 Canola - L130 Wheat – CDC Shaw Soybean – 23-10RY (DeKalb)
Seeding Rate	Corn - 7.5 seeds m^{-2} Canola - 115 seeds m^{-2} Wheat - 300 seeds m^{-2} Soybean - 60 seeds m^{-2}	Corn - 7.5 seeds m^{-2} Canola - 115 seeds m^{-2} Wheat - 300 seeds m^{-2} Soybean - 60 seeds m^{-2}
Stubble Type	Barley	Wheat
Fertilizer applied for Canola, Corn and Wheat	120 lbs N ac^{-1} as Urea, (balanced with MAP and AS in blend) 25 lbs P_2O_5 ac^{-1} as MAP 20 lbs S ac^{-1} as AS 15 lbs K_2O ac^{-1} as KCl *All fertilizer was blended and applied in the mid-row at seeding	100 lbs N ac^{-1} as Urea (mid row) 89 lbs P_2O_5 ac^{-1} as MAP and S ac^{-1} as AS (blended as a side-band)
Fertilizer applied for Soybean	25 lbs P_2O_5/ac as MAP 20 lbs S/ac as K2SO4 4.3 lbs TageTeam Granular ac^{-1} *All fertilizer was blended and applied in mid-row, and inoculant applied in the seed-row	48 lbs P_2O_5/ac as MAP with K2SO4 (blended and side banded) 4.3 lbs TageTeam Granular ac^{-1}
Treatment Application		
Fall Tillage	October 18, 2013 - Very dry soil conditions (not optimal)	October 23rd, 2014
Spring Tillage	May 13, 2014 - Optimal moisture conditions	May 8th, 2015
Plot Maintenance Information		
Pre-plant herbicide	Glyphosate (May 12) and Glyphosate + Bromoxynil (May 21)	Glyphosate (May 6 and May 11th)
In-crop herbicide	Wheat (June 17) Frontline XL + Axial Canola (June 17) Liberty @ 1.35 L ac^{-1} Corn & Soybean (June 23) R/T 540 @ 0.67 L ac^{-1}	Wheat (June 10) Frontline XL + Axial Canola (June 10) Liberty @ 1.35 L ac^{-1} Corn & Soybean (June 15) R/T 540 @

		0.67 L ac^{-1}
Data Collection		
Emergence Counts	June 10 and June 17, 2014	June 4th and 23rd (later count due to lack of moisture)
Harvest Date	Wheat and Canola - September 22, 2014 Soybeans - October 9, 2014	Wheat - Aug. 27, 2015 Corn - Oct. 14, 2015 Soybean- Sept. 30, 2015 Canola -Sept. 10, 2015

Appendix B
Photographs of vertical tillage implement used in 2014 demonstration

Figure A.1. Vertical tillage implement applying tillage treatments in demonstration plots May 13, 2014

Figure A.2. Salford vertical tillage implement used in demonstration

Reference

Adee, E. A. 2015. “Tillage Study for Corn and Soybean: Comparing Vertical, Deep, and No-Till,” *Kansas Agricultural Experiment Station Research Reports*: Vol. 1: Iss. 2.