Seeding Systems and Cropping Trends in Saskatchewan
Results of a PFRA Survey, 1997-2002

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Abstract

From 1997 to 2002, Agriculture & Agri-Food Canada's (AAFC) PFRA Branch conducted a survey of over 4000 annually cropped fields in Saskatchewan. Each year the same fields were visited shortly after crop emergence to collect information on crop type, row spacing, opener type, packing system, amount of previous crop residue, orientation of previous crop stubble, and adoption of low soil disturbance seeding. Key results are the increasing trend toward lower soil disturbance seeding, and the high incidence of pulse crops associated with low disturbance seeding. In depth analysis of trends on individual fields suggest that very few producers are able to maintain low disturbance seeding every year on the same field. This suggests that some flexibility is required to allow for periodic soil disturbance to address issues such as perennial weeds.

Introduction

Between 1997 and 2002 Prairie Farm Rehabilitation Administration (PFRA) conducted an annual spring survey of over 4000 annually cropped fields across Saskatchewan. Each year the same fields were visited, shortly after crop emergence in mid June. The objectives of the survey were to gather information on seeding systems and crop rotations used in Saskatchewan. This information is useful to assess the adoption of annual cropping practices which help to conserve soil and water resources, and protect quality of water and air in the environment. This report provides results on crop types, crop rotations, seeding systems, and interrelationships between these variables. To our knowledge the PFRA survey is the most extensive survey of its kind in Saskatchewan, and possibly Canada.

Crop Types

The major crop types on annual cropland are cereals, oilseeds, pulses, and fallow. Figure 1 shows the percentage of fields in each crop type from 1997 - 2002, and compares the PFRA survey data with other data obtained from Statistics Canada, based on extensive farmer questionnaires. The generally close agreement between these two datasets provides a significant degree of credibility to PFRA's survey.

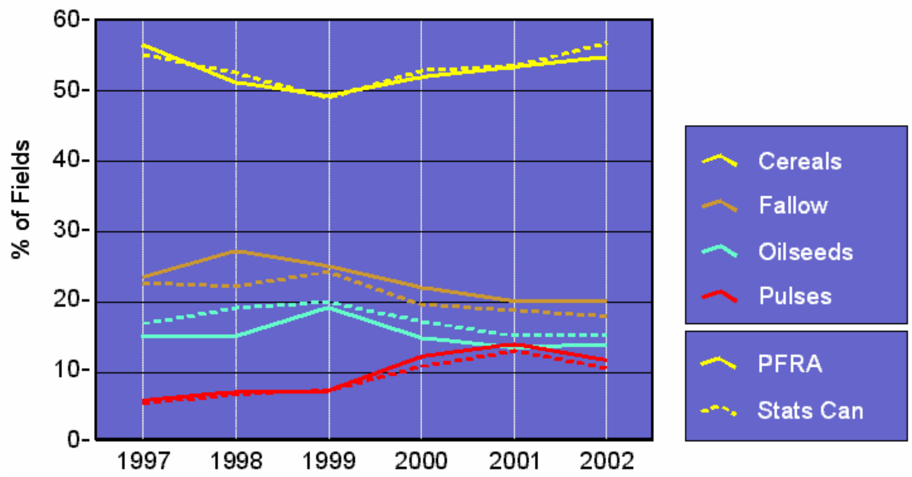


Figure 1. Crop type distribution from two data sources: PFRA and Statistics Canada

Over this six year period cereal acreage fell from 56% to 49%, and then rebounded back to its original level. This seemed to correspond with an opposite trend for oilseeds which initially rose from 15% to 19%, and then fell back down to about 14%. Fallow acreage declined gradually from about 23% to about 19% over this period, while pulses increased more dramatically from 5% to 11% of.

Seeding System Definition

One of the most important types of data collected on the survey is seeding system. Seeding system is a measure of the degree of soil disturbance that has occurred from the previous crop's harvest to after the current crop is seeded. Lower soil disturbance results in a number of key economic and environmental benefits, which relate to soil moisture conservation, crop residue conservation, lower soil erosion risk, greater soil carbon sequestration, and reduced negative impacts on water quality. Three classes of seeding system were developed for this survey and are defined in Table 1.

Seeding system is a some times difficult to assess, because it is not always certain what management has occurred. The proportion of standing stubble remaining is a key indicator of soil disturbance. The amount of crop residue is not a good indicator because there are variable amounts of crop residue produced by the previous crop, depending on the crop type, weather conditions, etc. Other observations such as row spacing, opener type, and packing system were also used to assess seeding system. For example, narrow openers, wider row spacing, and on row packing contribute to lower disturbance seeding.

For the remainder of this publication low disturbance seeding is referred to as LD, moderate disturbance seeding as MD, and high disturbance seeding as HD. In many cases we have combined the rate of low and moderate disturbance seeding into one variable called conservation seeding system or CSS.

Table 1. Seeding System Definition

Seeding System	*Management Scenarios*					*Impacts*	
	All Tillage	*Seeding Disturbance*	*Post Seeding Disturbance*		*Specific Examples*	*Residue Conserved*	*Stubble Standing*
LD	none	low	none		LD into untilled stubble	> 3/4	> 2/3
MD	some *	low	none	or	LD into once tilled stubble	1/2 to 3/4	1/3 to 2/3
	none	moderate *	none	or	MD into untilled stubble		
	none	low	some *		MD operation after LD seeding		
HD	none	high **	none	or	HD into untilled stubble (eg. discer)	< 1/2	< 1/3
	some *	some *	none	or	MD into once tilled stubble		
	none	some *	some *	or	MD operation after MD seeding		
	high **	low	none		LD after HD tillage (eg. after fallow or after fall and spring tillage)		

Notes: * indicates relative degree of soil disturbance
Residue conserved is not a fixed amount, but the proportion that remains compared to the original amount after harvest
There is a tendency to underestimate LD and MD on fields that were previously in chemical fallow or pulse crop. Standing stubble that has been chemical fallowed tends to flatten even when LD seeded. Since pulse crops are cut very low to the ground it is often very hard to find standing stubble even after they have been LD seeded.

Typical examples of LD and MD seeding are shown in Figures 2 and 3, respectively.

Figure 2. Typical Low Disturbance

Figure 3. Typical Moderate Disturbance

Seeding System Trends

The rate of CSS has steadily increased from about 18% of all seeded fields in 1997 to 39% in 2002, as shown in Figure 4. The only exception was in 1999, when wet spring weather resulted in more soil disturbance under wet soil conditions. There could have also been an increase in preseeding tillage or use of wider seed openers to achieve better weed control, especially when seeding was delayed.

The rate of CSS is much higher on fields that were seeded into previously cropped land as opposed to fallow. It should be noted that the survey probably underestimates the rate of CSS on fields that were seeded into chemical fallow. Standing chemical fallow stubble is easily destroyed even under low disturbance seeding, due its weathered and fragile nature after being exposed to two winters and one summer period.

Despite the significant growth in CSS, the potential for further growth is still tremendous.

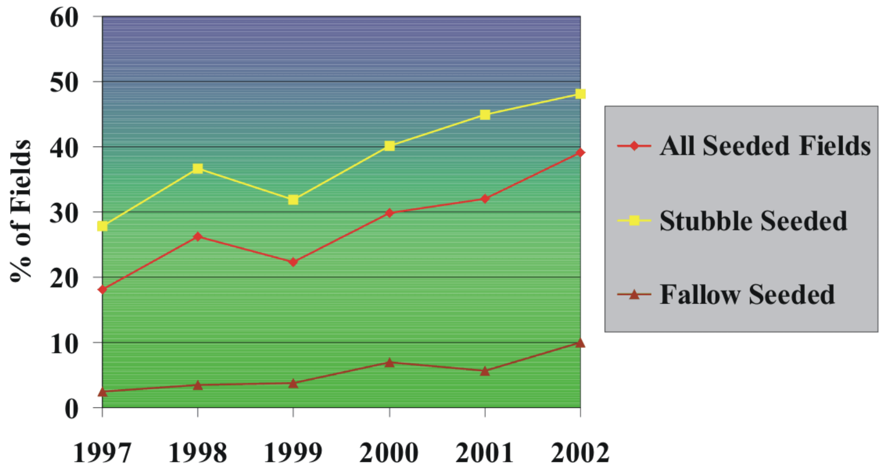


Figure 4. Rate of Conservation Seeding Systems (CSS)

Comparison of PFRA Seeding System with Census of Agriculture Data

The Census of Agriculture is possibly the only other comprehensive data source for seeding systems in Saskatchewan. It is based on farmer's responses as reported in a written questionnaire once every five years. The two data sets are somewhat comparable because they are both based on soil disturbance. However, it could be argued that the PFRA data is more objective as it is determined from field measurements taken by technicians that have been trained to use a consistent set of criteria. The Census data is less objective since farmer's responses may be affected by their interpretation and perception of the question.

In addition, it should be noted that the Census questions, as shown in Figures 5 and 6, use a somewhat different definition of seeding systems. The 1996 question focuses primarily on field operations that have taken place prior to seeding, and does not include the seeding operation itself. Therefore, a producer could consider his management as "No Till" if he/she didn't do any tillage prior to seeding, regardless if considerable soil disturbance occurred during or after seeding. Some change is made in the 2001 question by removing the words "prior to seeding" and "prepared for seeding". However, by keeping the focus primarily on "Tillage", many producers may still not consider the degree of soil disturbance that occurs during or after seeding.

What is the area of land prepared or to be prepared for seeding using the following practices: Include the area that was prepared last fall or this spring

___ Tillage that incorporates most of the crop residue into the soil

___ Tillage prior to seeding that retains most of the crop residue on the soil surface (include minimum tillage)

___ No tillage prior to seeding (include direct seeding into stubble or sod, or ridge tillage)

For the land seeded or to be seeded this spring, report the area of each of the following practices. Include the area that was prepared last fall or this spring

___ Tillage that incorporates most of the crop residue into the soil

___ Tillage that retains most of the crop residue on the soil surface (include minimum tillage)

___ No-till seeding or zero-till seeding (include direct seeding into stubble or sod

Figure 5. Census question, 1996, Statistics Canada **Figure 6.** Census question, 2001, Statistics Canada

Therefore, if one compares the "Minimum Till" category with PFRA's MD group, and the "Zero Till" category with PFRA's LD group, one would expect significantly higher values with the Census data. This is clearly revealed when making this comparison, as shown in Figure 7.

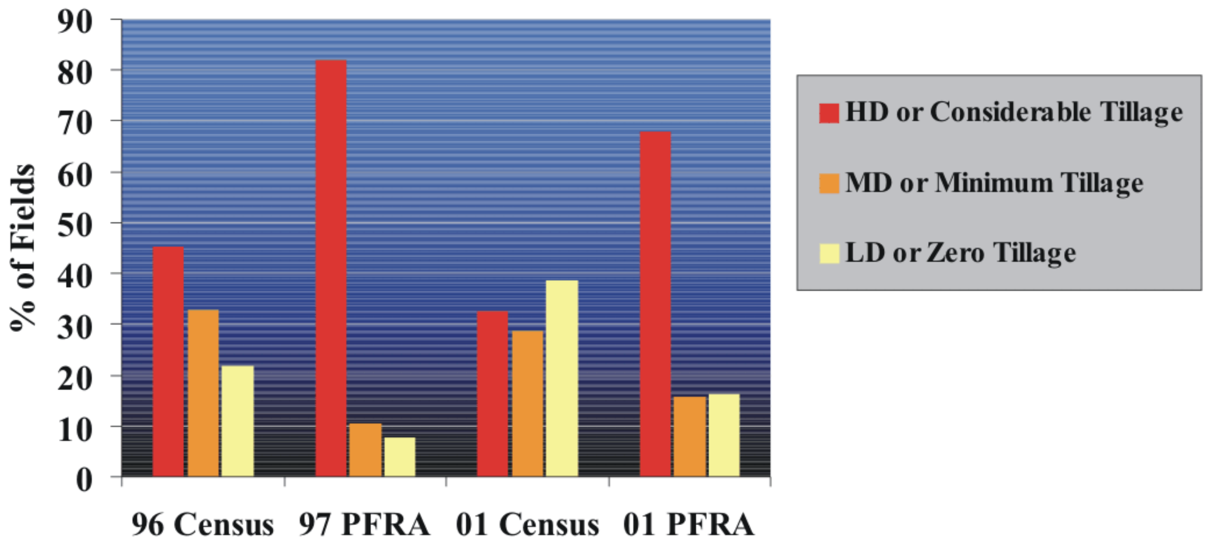


Figure 7. Comparison of seeding systems from PFRA Survey and Statistics Canada's Census of Agriculture

Crop Sequences

So far this paper has reported summary or aggregate data on an annual basis. From now on we want to consider trends on individual fields. This is a much more powerful level of analysis as it allows one to consider management trends of individual producers.

The first item to consider is the order or sequence of crop types on the same field. Research and producer experience has clearly shown that it is advantageous to vary the types of crops that are grown in consecutive years. Benefits include suppression and more effective control of diseases and weeds, more efficient use of soil moisture and nutrients, and maintaining crop residues on the soil surface for erosion control.

Table 2 shows the percentage of 2002 crop types on various 2001 crop type stubbles. Based on the previous discussion it is obvious that crop sequences highlighted in green are desirable, while those in yellow are less desirable. It should be noted that, due to their greater resiliency and residue production, cereals in consecutive years are a lesser concern than other crop types in consecutive years. Also, it is likely that fields in fallow both years were still going to be seeded in 2003 after the survey was done.

The turquoise sequences are also of potential concern, since pulse and oilseeds crops produce low amounts of residue and if fallowed could leave these fields susceptible to severe erosion.

Table 2. Percentage of Fields in All Combinations of 2002 Crop Type on 2001 Crop Type Stubble

2001 Crop Type	2002 Crop Type			
	Cereal	Fallow	Oilseed	Pulse
Cereal	17.5	16.6	9.5	9.6
Fallow	15.4	0.8	3.0	0.7
Oilseed	11.1	1.0	0.5	0.6
Pulse	10.6	1.5	0.9	0.7

Crop Rotations

Crop rotation is defined as the pattern of crop sequence on a particular field. Some producers have a well defined crop rotation where the same pattern of crop sequence is repeated again and again. However, while many producers try to use good crop sequences, they don't necessarily follow set rotations since they want to be able to adjust their cropping decisions to take advantages of varying market conditions.

When looking at the crop sequence trends over a 7 year period from 1996 to 2002, it became clear that there was too much variability in crop sequencing to determine any crop rotation patterns on most fields. It was also virtually impossible to try to classify fields into similar groups that considered both the proportion and sequencing of the four crop types, because of the large number of possible scenarios. Therefore, it was decided to try to classify fields based only on fallow frequency and the proportion of cereals, oilseeds, and pulses. The latter classification was called crop mix.

Crop Mix and Fallow Groups

All fields were classified into one of nine crop mix groups and one of three fallow groups. The percentage of fields that occur in each one of these groups, and in each unique combination of both groups is shown in Table 3. Table 3 also shows the range of percentage values of each crop type that are used to define each crop mix and fallow group.

The overall dominance of cereals is evident by the large percentage of fields in the "primary cereals" group and other groups that include a majority of cereals. There is also a larger percentage of fields in groups that include oilseeds as opposed to pulses. Almost one third of fields have at least 40% fallow, most of which are still in a traditional cereal / fallow rotation.

As one moves from the high fallow groups to less fallow, the dominance of cereals declines, while pulses and oilseeds increase. This result is not surprising, as many producers include pulses and oilseeds to increase rotational benefits that are more important when reducing fallow.

Table 3. Percent of Fields in Various Combinations of Crop Mix and Fallow Group

Crop Mix Definition	% cereal	% oilseed	% pulse	Fallow Group Definition % Fallow			% of Fields Totals
				0	14-33	40-83	
Primarily cereals	80-100	0-20	0-20	3.8	16.1	21.0	41.0
Majority cereals, some oilseeds	67-75	25-33	0	4.4	4.7	3.7	12.8
Majority cereals, some pulses	67-75	0	25-33	1.2	1.9	3.2	6.3
Majority cereals, some oilseeds & pulses	50-71	14-33	14-33	8.1	7.2	0.7	16.0
Mixture of cereals & oilseeds	40-60	40-60	0	4.5	4.7	1.6	10.8
Mixture of cereals & pulses	40-60	0	40-60	1.7	2.2	0.3	4.2
Mixture of cereals, oilseeds, & pulses	14-43	14-43	14-43	4.4	1.4	0.1	5.9
Majority oilseeds	0-33	50-100	0-33	0.4	1.2	0.7	2.3
Majority pulses	0-33	0-33	50-100	0.3	0.4	0.0	0.7
% of Fields Totals				28.8	39.9	31.3	100.0

Crop Mix and Fallow Group Interactions with Seeding Systems

Interactions between these crop mix / fallow groups and seeding systems was determined by first calculating the percent occurrence of CSS for each field, and then calculating the average %CSS for all fields within each unique combination of crop mix and fallow group. These average %CSS values are shown in Table 4.

There are two main trends that are evident. First of all, as one would expect, the average %CSS increases as fallow decreases. This trend occurs within each crop mix group. Secondly, it is interesting that the average %CSS is higher for virtually all crop mix groups that contain pulses. This trend is consistent in all three fallow groups, as shown by the yellow highlighted values in Table 4.

Table 4. Average %CSS for Various Combinations of Crop Mix and Fallow Groups

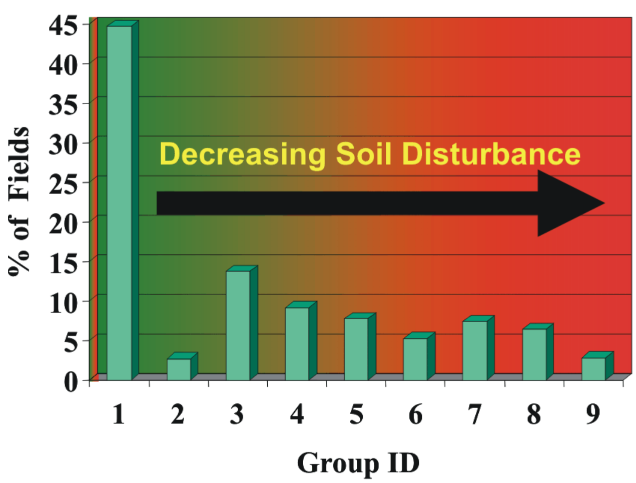
Crop Mix Group	% Fallow Group		
	0	14-33	40-83
Primarily cereals	34.7	25.7	6.9
Majority cereals, some oilseeds	28.8	18.4	6.6
Majority cereals, some pulses	50.0	46.9	19.5
Majority cereals, some oilseeds & pulses	46.2	30.8	16.7
Mixture of cereals & oilseeds	32.2	19.9	8.1
Mixture of cereals & pulses	56.3	40.9	18.6

Mixture of cereals, oilseeds, & pulses	45.9	31.9	0.0
Majority oilseeds	37.0	16.2	8.9
Majority pulses	59.9	42.8	33.3

This suggests a strong correlation between lower soil disturbance seeding and pulse crops. There are a number of possible reasons for this. First of all, since pulses such as chickpeas, lentils, and peas are grown in drier parts of the province it is often necessary to conserve as much moisture as possible through low disturbance seeding to succeed with these crops. Secondly, producers are more concerned with conserving crop residue for erosion protection because of the low amount of residue produced by pulse crops. Thirdly, it may be easier to use low disturbance seeding with pulses because of their lower fertilizer requirements. With oilseeds and cereals, it is often not possible to apply all of the fertilizer requirements in a narrow opener with the seed. Nevertheless, with technological advancements such as mid row and liquid coulter banders it should become more feasible to low disturbance seed crops with high fertilizer requirements.

Seeding System Trends and Variability on Individual Fields

Analysis of individual fields over time was also used to determine more detailed information on adoption rates of CSS. Since we used only two seeding system variables, CSS and HD, it was possible to consider both the proportion and order of these variables. All fields were classified into one of 9 groups, as shown in Figure 8. Almost 45% of fields had never been CSS seeded, while only 3% of fields were always CSS seeded. Over half of all fields fell into groups 2 to 8 which represented increasing degree of CSS adoption. Groups 3 and 4 include fields that were only CSS seeded once. Groups 5 and 7 were fields that were CSS seeded more than once, but had significant variability from year to year. Groups 6 and 8 showed strong conversion to CSS as they were CSS seeded in the two and three most recent years, respectively.



Group	Description of CSS Adoption Trend
1	Never CSS
2	HD in most recent 2 years, and CSS at least 2 times prior
3	CSS once, but HD in most recent year
4	CSS once, in most recent year
5	CSS > once, but < half the time, variable from year to year
6	CSS in 2 most recent years with little previous
7	CSS > half the time but variable from year to year
8	CSS in 3 most recent years with little previous
9	Always

Figure 8. Conservation Seeding System Adoption Trends

In a previous section we showed how the overall rate of CSS has significantly increased. The more detailed analysis in this section suggests that the adoption of CSS on individual fields has not been as strong as expected. There are a number of possible reasons for this. One could be changes in land tenure, which we have not been able to verify. Another reason may be the need to maintain some soil disturbance flexibility from year to year depending on factors such as unique weed, insect, or disease pressures and varying weather. Closer analysis of Groups 5 and 7, which have the highest degree of year to year variability, supports this. For example, in 1998 and 2000 the CSS rate on these fields was around 60%, while in 1999 it was 47%. This corresponds with the overall decline of CSS on all fields in 1999 due to wet weather, as discussed earlier.

Another interesting discovery was made when calculating the rate of CSS for each combination of crop sequence for all fields over all years in Groups 5 and 7. This is shown in Figure 9. As expected the rate of CSS is much lower on crops seeded after fallow. What is not expected is that the rate of CSS is also less on pulse stubble, than cereal or oilseed stubble. Normally, one would expect even higher rates of CSS on pulse stubble, because of the greater need to conserve the lower amounts of residue that are produced. It is most likely that PFRA surveyors have been unable to correctly judge some fields as CSS because of the lack of stubble and residue produced by the previous crop. This incorrect judgement, which is impossible to avoid without doing follow up questioning with individual producers, is also more likely to occur following years of drought, of which we have had a few. Therefore, the actual rate of CSS on pulse stubble is probably just as high if not higher than other stubbles.

As a result one can conclude that the adoption of CSS is stronger than the data suggests. Also, the association between pulse crops and CSS as reported in an earlier section is also stronger.

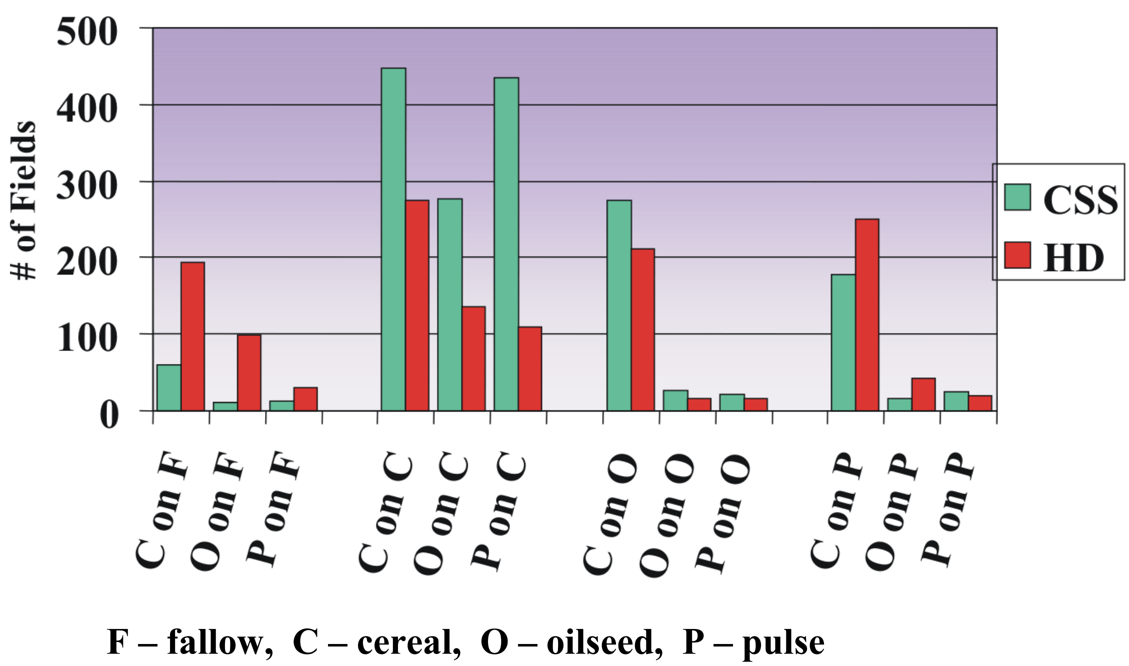


Figure 9. Seeding systems for all combinations of crop sequences occurring on all fields over all years for Groups 5 and 7 from previous section

Conclusions

The close agreement in crop type data from the PFRA survey compared to annual Statistics Canada figures provides credibility for the representativeness of the PFRA survey for all of Saskatchewan. The Census of Agriculture data tends to overestimate low disturbance seeding, because it focuses primarily on what happens before seeding, and doesn't adequately include soil disturbance during or after the seeding operation. The PFRA survey tends to underestimate low disturbance seeding, primarily because of the difficulty in recognizing low disturbance under very low residue and stubble conditions, such as chemical fallow or pulse. There is a very strong association between low disturbance seeding and pulse crops.

The Census of Agriculture data has been extensively used by governments and other agencies to assist in developing and evaluating programs, policies, and other initiatives that seek to promote environmentally sustainable farm practices. This paper has shown that improvements are needed to obtain more accurate data. More accurate data is critical to more effectively develop and evaluate these programs and policies in the future. It is anticipated that such improvements will be developed under the newly formed National Agri-Environmental Health Analysis and Reporting Program (NAHARP), which is part of the federal government's Agriculture Policy Framework.

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