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Project Title: Saskatchewan Organic On-Farm Research: Part I: Farm Survey and Establishment of On-farm Research Infrastructure

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(a) Abstract/ Summary

A written management questionnaire, a soil survey, and a weed survey were conducted on 5% of organic farms in Saskatchewan. Nitrogen and sulphur varied between fields; ranging from deficient to optimal levels. Potassium was adequate in all regions. Phosphorus was deficient in all fields. The most abundant weed species was green foxtail, wild oat was fourth and Canada thistle seventh. Annual broad-leaved weeds were the most common group. Buckwheat, lamb's quarters, stinkweed, and wild mustard were the four most abundant. These results are opposite to the trend seen in conventional production where annual broad-leaves have become less abundant (Thomas, 1996).

(b) Executive Summary

This project was the first part of a two-part study designed to address soil fertility management and weed management priorities in organic agriculture. These priorities were identified by Saskatchewan organic growers through a provincial needs assessment survey, conducted by Saskatchewan Agriculture and Food in the winter of 2000. The overall objective of this project was to document agronomic practices used in Saskatchewan organic farming systems as well as soil fertility status and weed populations.

Organic cropping and management practices used by experienced growers were identified and characterized through a written questionnaire aimed at specific fields on their farms. Organic producers identified rotation of crops, growing competitive crops and using green manures as the top three most useful management practices available to them. Delayed seeding, using higher seeding rates, spring and post-seeding tillage along with frequent summer fallow all ranked relatively high. Very few producers used soil amendments of any kind. Cattle manure was the amendment most applied, but was used by only 12% of producers. This was despite the fact that 45% of the producers surveyed raised some livestock.

Soil and weed analyses from the same fields were used to assess soil fertility levels and weed management strategies. This information was summarized by eco-region. The boreal transition eco-region , corresponding roughly to the grey soil zone showed some deficiencies in all four of the nutrients tested (N, P, K, S). This region is at the greatest risk of experiencing yield losses because of widespread nutrient deficiency. All of the other eco-regions had generally good levels of K and S. Each eco-region had some fields that were deficient in N as well as some fields that were optimal for N. That some fields did have optimal levels of N indicates that the tools for managing N in organic systems do exist. It appears that these higher N levels are related to including green manure crops in rotation. Even though green manure crops were identified as the third most important management practices used by organic farmers, only 58% of the producers surveyed had included at least one green manure crop on the survey fields in the last five years. It seems that identifying appropriate green manure crops, along with identifying how frequently they should be included in a rotation is one area that needs clarification.

Available P was detected in very low amounts on all fields. Not a single field in the survey recorded P levels in the optimal range for the top 15 cm. Deeper in the soil, P levels were slightly lower still, but were fairly stable. Very few producers used any amendments aimed at improving soil P; 8% indicated that they had applied some rock P to the soil.

In terms of the weed surveys the most abundant weed species identified was green foxtail, wild oat was the fourth most abundant and Canada thistle seventh. Annual broad-leaved weeds were the most common group and included wild buckwheat, lamb's quarters, stinkweed, and wild mustard. These results are opposite to the trend seen in conventional production where annual broad-leaved weeds have become less abundant, presumably because of the relative ease with which they can be controlled chemically.

This information on soil fertility and weed populations was used to design replicated experiments, which are currently being carried out in the second part of this study. To enable farmer input in this study, an advisory committee was established with representation from organic growers throughout the province, scientists and government officials. To assist farmers in their efforts to develop a farmer-directed on-farm research network, workshops on planning and conducting on-farm research were held in the northwestern and southeastern areas of the province in the winter of 2001.

(c) Technical Report

Introduction

In a recent needs assessment conducted by Saskatchewan Agriculture and Food, of the Saskatchewan organic industry, soil fertility and weed management were identified as the two top priorities concerning production research and development. Of specific concern to producers was the decline in soil phosphorous levels occurring in some organic systems, as well as weed control issues. In addition, the desire for producer input and on-farm agronomic research was identified. This project was developed in response to this needs assessment. The overall objective was to identify the state of soil fertility and weed population on organic farms in Saskatchewan and relate these to organic management practices. This project consists of three distinct parts: a questionnaire, soil sampling and analysis and weed surveys.

Initially, this project was to begin in the summer of 2001. However, this was delayed to the winter of 2001 because of feedback from producers. During this initial telephone contact there was a general reluctance by producers to participate. Overall, it was felt that because of the drought conditions, conditions on their farms were not representative of "normal" years. A decision was made, in conjunction with Saskatchewan Agriculture and Food staff, to delay the field sampling in the project one year, to the Spring and summer of 2002.

Specific Objectives:

1. To identify and characterize current farm practices used for soil fertility and weed management by experienced organic farmers in Saskatchewan.
2. To characterize soil fertility and weed populations on organic farms included in this study.
3. To establish a research advisory committee.
4. To identify organic farms suitable for on-farm research projects (see Part II).
5. To conduct regional workshops on planning and conducting farmer-directed on-farm agronomic research demonstrations.

Objective 1: To identify and characterize current farming practices used for soil fertility and weed management by experienced organic farmers in Saskatchewan.

A questionnaire (Appendix 1) was developed in the summer and fall of 2001 to distribute to organic farmers. The questionnaire was specific to one or two fields on the producer's farm. These fields were to be seeded to wheat (preferably), or another cereal crop in the Spring of 2002. Wheat was identified as the test crop because the majority of organic producers grow wheat and the weed surveys performed on these same fields would be more meaningful, since the host crop affects the types of weeds occurring in a field. The questionnaire was aimed at identifying equipment, organic amendments, seeding and tillage practices and other management practices used by the producer on those specific fields.

Lists of potential survey candidates were obtained from cooperating certification bodies including OCIA Chapters 2, 3, 4, 5, 6,and 8. Contacts were made with other certification bodies, who chose not to participate. Sixty-five cooperators were selected based on years of farming experience, soil zone representation, and willingness to participate. Cooperators were required to have a minimum of 2 years of full certification status.

Of the 65 cooperators who agreed to participate and were sent surveys, 43 returned completed surveys in time to be included. Contact was established with all cooperators who failed to return their surveys. In total, 46 growers, with 84 survey fields, participated in this study (Figure 2). Where possible, two wheat fields from each farm were surveyed. If two wheat fields were not available on the cooperator farm, other cereal crops were deemed suitable. All surveying processes (written, soil, and weed populations surveys) were based on these specified fields.

Returned surveys were entered in to a database for data summary and analysis.

Results and Discussion

A total of 46 organic producers with 84 fields were included in this survey (Figure 2). The surveyed producers account for a total of 47,887 certified organic acres in

Saskatchewan, with an average farm size of 1,081 acres. Of the total number of acres, 55%, or 26,545 acres, are in annual production. The annual production average per farm was 603 acres.

Surveyed farms comprised a large, diverse range of commodity production (Table 1). Of the farms surveyed, 97% reported cereal production. Forages (64%), pulses (63%), and oilseed crops (59%) displayed moderately high production percentages. Flax composed all of the oilseed crop production. Specialty crop production, such as buckwheat and coriander, was reported from 9% of the surveyed farms. Cattle (49%) accounted for the majority of livestock production on surveyed farms, with specialty livestock (mostly sheep, horses, chickens, and goats) at 18% and hog production at 3%.

TABLE 1. Commodity production on surveyed organic farms (expressed as the percentage of surveyed farms that produce each commodity).

Commodities	**Farm Production** -----------(%)----------
Cereals	97
Forages	64
Pulses	63
Oilseeds	59
Cattle	49
Other livestock	18
Other crops	9
Hogs	3

Fifty-eight percent of surveyed producers incorporate green manure crops into their management regimes. Sweet clover was the predominate choice for a green manure plow down, consisting of 60% of all green manure crops grown over the past five years on surveyed farms (Table 2). Alfalfa, peas, Indianhead lentil, red clover, and chickling vetch were among the other green manure choice crops, ranging from 2 to 27% of production. Incorporation dates were generally implemented during the early stages of crop growth; at pre- and early bloom stages (20% and 53%, respectively) (Table 3).

TABLE 2. Type of green manure crop (%) used by surveyed producers over the past five years

Green Manure Crop	Usage among producers that include green manure crops in rotation[1]	Total Producer Usage[2]
	(%)	
Sweet clover	60	35
Alfalfa	27	15
Peas	16	9
Indianhead Lentil	9	5
Red Clover	2	1
AC Greenfix	9	5
Other	4	3

[1]Based on the total number of producers using green manures
[2]Based on total number of producers surveyed

Eighty-two percent of producers indicated that they grew green manure crops to both improve soil fertility and provide weed control. While 18% reported soil fertility alone as the main reason for using green manure crops. No producers identified weed control alone as the main reason for using green manure crops. All of the major green manure crops identified (Table 2) were nitrogen fixing crops. Other crops like fall rye, for example, have been reported to have allelopathic affects on weeds, but are not in wide usage in the province.

TABLE 3. Green manure crop stage at time of incorporation.

Incorporation Stage	Usage among producers that include green manure crops in rotation	Total producer usage
	(%)	
Early bloom	53	31
Pre-bloom	20	12
Late bloom	9	5
Unspecified	9	5

The application of soil amendments was a limited practice among producers. Only 26% of surveyed producers had applied amendments over the past five years, while only 12% reported manure application. This number is surprisingly low considering 49% of the surveyed farms raised cattle. However, it may be that the limited amount of manure produced was applied to fields other than the fields included in the survey. Soil amendments other than manure included rock phosphorus, kelp, humic carbon, gypsum, and *Penicillium bilaiae* (Table 4). The majority of applied manure came from cattle (97%), with sheep accounting for the remaining 3%. Ninety-three percent of applied manure was from on-farm sources, and the average compost period was 8 months.

Producers also were asked to identify the most useful and important management practices utilized on their farms (Table 5).

TABLE 4. Type of soil amendments (%) used by surveyed producers over the past five years.

Soil Amendment	Usage among producers that apply amendments[1]	Total producer usage[2]
	(%)	
Cattle manure	41	12
Rock phosphorus	27	8
Gypsum	9	3
Humic carbon	9	3
Sheep manure	5	1
Kelp	5	1
P. bilaiae	5	1

[1]Based on the total number of producers using some type of soil amendment
[2]Based on total number of producers surveyed

TABLE 5. Producer Prioritization of Management Practices.

Management Practice	Priority (%) #1	#2	#3	Weighed sum[1]
Rotate crops	24.4	11.5	12.8	109.0
Grow competitive crops	20.5	6.4	14.1	88.5
Grow green manure crops	14.1	16.7	7.7	83.3
Delayed seeding	9.0	12.8	10.3	62.8
Increase seeding rate	1.3	19.2	7.7	50.0
Use spring tillage	6.4	5.1	14.1	43.6
Summer fallow	10.3	1.3	7.7	41.0
Use post seeding tillage	5.1	11.5	2.6	41.0
Use fall tillage	2.6	2.6	6.4	19.2
Vary seeding date	0.0	5.1	5.1	15.4
Lunar phase Cultivation	2.6	2.6	0.0	12.8
Mow weed patches	0.0	2.6	2.6	7.7
Timing of operations	1.3	0.0	3.8	7.7
Narrow row spacing	1.3	0.0	1.3	5.1
Inter-row cultivation	1.3	0.0	0.0	3.8
Deep tillage in spring & fall	0.0	1.3	0.0	2.6
Fall/spring grazing	0.0	1.3	0.0	2.6
Weed plow down	0.0	0.0	2.6	2.6
Weed clipping	0.0	0.0	1.3	1.3

[1]weighed sum = (%first priority x 3) + (%second priority x 2) + (%third priority x 1)

Rotation of crops, growing competitive crops and including green manure crops were the top three ranked management practices. Various tillage practices (spring tillage, post seeding tillage and summer fallowing) along with using higher seeding rates were also ranked relatively high. The majority of the other management practices were identified by only a few producers as priorities.

Objective 2: To characterize soil fertility and weed populations on organic farms included in this study.

In the spring and summer of 2002, soil tests and weed surveys were conducted on the same organically managed fields that were identified in the management questionnaire. Fields were surveyed in each of the four major agricultural eco-regions of central and southern Saskatchewan; boreal transition, aspen parkland, moist mixed grassland, and mixed grassland corresponding roughly to the grey, black, dark brown and brown soil zones. Eco-regions are classified according to similar climate, soils and natural vegetation (Acton et. al., 1998). The boreal transition eco-region is the northern limit of agricultural land. It is characterized by grey luvisolic soils in the uplands and dark grey chernozemics in the lowlands. It has the most precipitation, the lowest temperatures, and the shortest growing season of the four eco-regions. The aspen parkland is characterized by black chernozemic soils and is warmer and drier than the boreal transition region. Moist mixed grassland is characterized by dark brown chernozemic soils with plains formed by glacial lakes. It is considered a semi-arid region. The mixed grassland eco-region is the warmest and driest area of the province and has the longest growing season. This eco-region is located in the southwest corner; it is characterized by brown chernozemic soils.

Materials and Methods

Soil sampling

Soil samples were collected prior to seeding in the spring of 2002. Samples were collected using a hydraulically driven soil probe. A W-pattern was used for sampling across the field (Thomas *et al.*, 1997) (Figure 1). Efforts were made to avoid anomalies in the fields, such as power lines, roads, ditches, sloughs, and so forth.   In total, 16 soil samples were collected from each field. Each sample was divided into three depths; 0-15 cm, 15-30 cm, and 30-45 cm. Initial attempts to collect samples to a 60 cm depth were abandoned because the severe soil drying prevented the probes from penetrating to this depth. The 16 samples from each field were bulked according to depth resulting in three samples per field. In addition to the three bulked samples per field, three soil cores of known volume were collected for bulk density determination.

Insulated storage containers were used to transport samples from the field to the lab. After sub sampling for soil moisture, samples were air dried and analyzed for soil macro-nutrient levels (N P K S), texture, pH, EC, organic matter and bulk density.

FIGURE 1. Field sampling pattern implemented in soil sampling and weed population surveys. For soil sampling 16 soil cores were collected; for weed surveying 20 quadrats were counted.

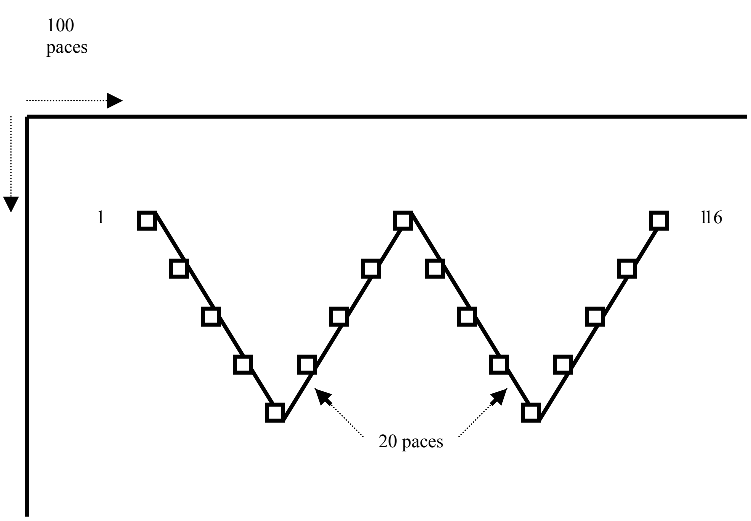
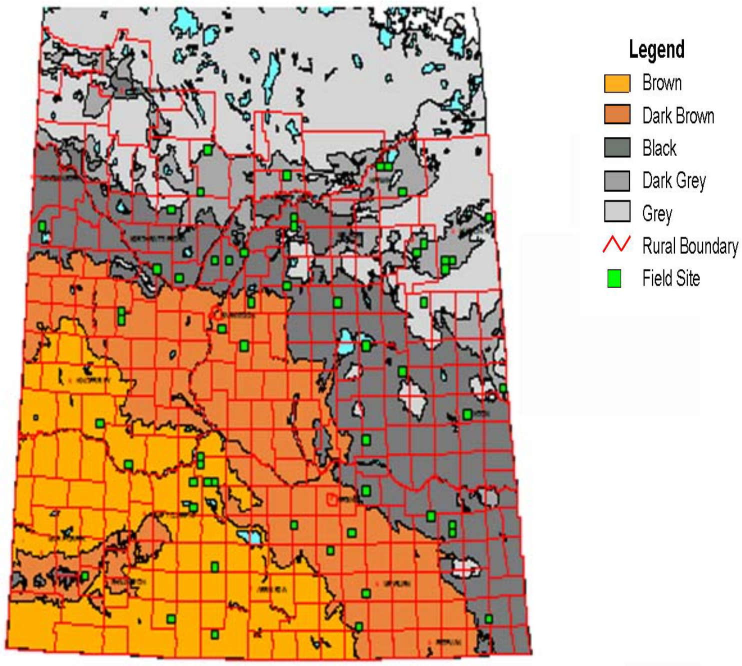


FIGURE 2. Location of Surveyed Field Sites.



Soil analyses

Macro-nutrient levels of total extractable nitrogen (N), phosphorus (P), potassium (K) and sulfur (S) were measured using standard extraction techniques and colorimetric methods. The modified Kelowna method (Ashwoth and Mrazek, 1995) was used for P and K extraction. An auto-analyser was used for quantification of the P fraction, while the K fraction was analysed by atomic absorption spectrometry.

A KCl extraction procedure was performed to obtain the nitrate (NO_3), ammonium (NH_4) and sulphate (SO_4^-) extractable fractions. These fractions were also analyzed colorimetrically with an auto-analyser (Biederbeck et. al, 1996).

Tests for moisture content, bulk density, pH, electrical conductivity, texture, and organic matter followed the Soil Science Society of America *Methods of Soil Analysis* suggested protocol.

The gravimetric method was used to determine moisture content (Gardner, 1986). Soil mass was measured prior to and after a 24-hour drying period in a 105^{o}C oven . Three sub-samples were analyzed. Bulk density also required the mass of oven-dried soil of a known volume to calculate soil density. Three soil cores of known volume were collected from each field and were analysed separately.

pH and electrical conductivity were determined using the saturated paste method (Rhoades, 1996). Because soil saturation levels vary greatly with texture, the least amount of water added to reach saturation allows for a more accurate reading of the solutes in the soil (Rhoades, 1996). Because of the wide array of soil samples collected, the saturated paste method was chosen, as it more accurately represents field capacity than the 1:1 or 1:2 solution methods. pH readings were taken after the soil/water pastes had soaked for 24 hours. The paste samples were then vacuum filtered and the extractant used to measure electrical conductivity with a conductance meter at room temperature (25°C).

Soil texture was determined by the use of a hydrometer. This method uses the principle of sedimentation (Stoke's Law) to determine the sand, silt, and clay fractions. Proportions of sand, silt and clay are then applied to the Canadian classification system referred to as the texture triangle (Gee and Bauder, 1986) in order to determine the soil texture classification.

Organic matter was determined using a combustion method. Because most organic C is present in the soil organic matter and carbon is known to be 48 to 58% of the total weight of organic matter, the determined value of the incinerated organic carbon is converted to organic matter by multiplying organic carbon by an estimated constant (Nelson and Sommers, 1982). Soil samples were ball ground in order to ensure a uniform sample that burnt evenly and quickly at 804^{o}C in a muffle furnace. Samples are weighed before and after incineration and the conversion applied.

Weed surveying

Weed surveying commenced in mid July and was completed by early August. Surveying protocol from Thomas et al. (1997) was used for weed population counts (Figure 1). One-quarter meter quadrats were implemented as the counting area. In total 20 quadrats were counted in a W-pattern across each field. Efforts were made to avoid anomalies in the fields, such as power lines, roads, ditches, sloughs, and so forth.

In order to ensure that only weeds that would be competitive with the standing crop were included, only weeds that were larger than the first true leaf stage were identified and counted. Sampling later in the growing season also ensured that any management practices implemented earlier in the year had time to manifest an effect on weed populations.

Protocol for data analysis was based on Thomas (1985). Relative abundance is obtained by the summation of three descriptive components: density, frequency, and uniformity. Density measures the number of a species counted in each quarter-square meter expressed as a percent of the total number of a single weed species present. The 20 sampling sites in each field are averaged to obtain a density value for each species present. The maximum value for density is 100%. Frequency measures the number of fields in which a weed species occurred and expressed as a percentage of the total fields surveyed. The maximum frequency obtainable is 100%. Uniformity is a measure of the number of quadrats where a species occurred expressed as a percentage of the total number of quadrats in the survey (20 quadrats x 84 fields). It also has a maximum value of 100%. These three measurements when summed provide a measure of relative abundance. The maximum value obtainable for relative abundance is 300. The measure of relative abundance is without units but allows for comparison between unrelated species. The relative abundance measure takes into account whether or not a species is present on a field, and if so how patchy its distribution is, as well as the total number of individual plants present for each species.

Results and Discussion

Soil Survey

Soil survey results are grouped according to eco-region classifications. The lowest mean levels of N, P, K and S in the top 15 cm were reported in the boreal transition eco-region (Table 6). The moist mixed grassland eco-region had the highest mean values for N, P and K; while the aspen parkland eco-region had the highest S value. Of the soils analysed in the four eco-zones, soils in the boreal transition zone are at the greatest risk for a range of nutrient deficiencies. In particular, phosphorus and sulphur are alarming low in many of these soils.

Critical nutrient levels (Table 7) compare the general nutrient condition of the surveyed fields. This table gives generalized values; these values will differ depending on the nutrient demand of the planted crop. The mean soil N content for all eco-regions reported deficient levels. Values as low as 4 lb/acre were found. However, values in the optimal range (>100 lb/acre) were not uncommon. The fact that these maximum values were obtained suggests that nitrogen can be managed to optimal levels in an organic systems. There is evidence that the maintenance of soil N levels is related to the inclusion of green manure crops. Of the producers that had marginal to optimum levels of nitrogen, 80% reported the use of green manures in crop rotation.

Unlike nitrogen levels where some fields were deficient and others optimal, available phosphorus levels were extremely low in all fields tested (Table 6). Maximum values did not report above the deficient level. Fields with lower soil pH (5.5) also reported deficient levels of phosphorus, ranging from 16.6 to 22.2 lb/ac. Generally, phosphorus becomes more available under more acidic conditions. The average values on these more acidic soils were generally higher than on the neutral soils but still in the deficient range. These results suggest that available phosphorus is difficult to maintain at optimal levels under an organic farm management. A Manitoba study on 170 fields on 14 organic farms over six years found similar results. Entz, et al. (2001) reported that phosphorus levels were low on all fields and were particularly low on fields that were managed organically for 30 years or more.

Table 6. Mean, Minimum and Minimum Soil Nutrient Levels Displayed in Pounds per Acre From the Four Eco-Regions in South/Central Saskatchewan for Nitrogen (N), Phosphorus (P), Potassium (K) and Sulphur (S) at 0-15cm, 15-30cm, and 30-45cm.

		N			P		
Eco-Region/Soil Zone	**Measure**	0-15	15-30	30-45	0-15	15-30	30-45
Aspen Parkland/	**Mean**	**23.10**	**9.00**	**5.07**	**14**	**10**	**10**
Black	Maximum	69.20	22.92	11.33	23	16	20
	Minimum	2.76	1.16	1.70	7	7	5
Moist Mixed Grassland/	**Mean**	**23.77**	**10.78**	**6.93**	**19**	**16**	**15**
Dark Brown	Maximum	58.46	28.55	13.22	30	26	25
	Minimum	2.80	0.26	1.78	8	7	8
Mixed Grassland/	**Mean**	**22.45**	**12.36**	**7.74**	**19**	**16**	**15**
Brown	Maximum	60.59	33.21	20.94	27	24	23
	Minimum	0.91	3.18	3.64	13	8	9
Boreal Transition/	**Mean**	**15.18**	**6.16**	**5.15**	**10**	**9**	**10**
Grey	Maximum	59.70	23.73	13.22	15	13	30
	Minimum	0.05	1.11	0.55	5	4	4

		K			S		
		0-15	15-30	30-45	0-15	15-30	30-45
Aspen Parkland/	**Mean**	**580**	**340**	**299**	**26**	**332**	**335**
Black	Maximum	951	505	483	284	4125	3384
	Minimum	209	182	184	1	1	1
Moist Mixed Grassland/	**Mean**	**932**	**585**	**524**	**22**	**30**	**85**
Dark Brown	Maximum	1858	1199	1097	317	367	435
	Minimum	461	262	226	0	1	0
Mixed Grassland/	**Mean**	**722**	**477**	**451**	**19**	**23**	**61**
Brown	Maximum	1098	790	732	290	308	507
	Minimum	425	287	264	1	0	0
Boreal Transition/	**Mean**	**315**	**261**	**215**	**5**	**5**	**4**
Grey	Maximum	598	532	443	18	18	15
	Minimum	66	40	10	1	1	1

TABLE 7. Generalized Critical Limits for Soil Macronutrients in the top 15 cm.

Critical Levels	N	P	K	S
Deficient	< 60	< 30	< 160	< 8
Marginal	60-100	30-50	160-250	8-32
Optimal	100-150	50-120	250-1000	32-80
Excess	> 220	> 120	> 1000	> 80

(Norwest Labs. 1994. Agricultural Soils Reference Chart. Norwest Labs: Edmonton, Alta.)

Unlike nitrogen, where plants are able to fix atmospheric sources into useable forms, all phosphorus for plant growth is supplied by the soil. Without a means of returning phosphorus back to the soil ,the soil will eventually be unable to supply phosphorus to sustain crop growth. Although many soils do contain relatively good stores of phosphorus, simply making these stores plant available is not the answer. With each harvest of a crop, phosphorus is removed from the system. A priority for organic systems must be to identify acceptable amendments (fertilizers) for replacing phosphorus to the soil. Livestock manures are good candidates because of their high phosphorus contents.

Saskatchewan soils naturally contain high levels of potassium, particularly in southern and central regions of the province. Reported potassium values correspond to these levels as all are in the optimal range. The boreal transition eco-region was the only region with a minimum value in the deficient range (Table 6). This however, was an unusual situation. Potassium is unlikely to present a problem for plant growth in all but possibly the boreal transition.

Soil sulphur levels vary greatly in all eco-regions (Table 6). Except for the boreal transition region, most of the sulphur values fell in the marginal or higher category. Values in the boreal transition tend to report deficiency. In each of the other eco-regions, maximum values fell in the excess category for sulphur. Fields reporting very high sulphur levels were associated with slightly saline fields. The majority of naturally occurring salts in Saskatchewan are sulphate salts ($MgSO_4$, $CaSO_4$, $NaSO_4$), rather than chloride salts. However, high salinity was not a problem in any of the sampled fields as measured by electrical conductivity (EC) (Table 8). Values exceeding 4.0mS/cm are classified as moderately saline. None of the fields reported EC values as high as 4 mS/cm in the top 15 cm, but slightly higher EC values deeper in the profile were observed in all but the boreal transition eco-region. None of the fields surveyed had severe salinity problems however.

One of the reasons for measuring soil nutrients at different depths is to determine if reserves of the nutrient in question are stored deeper in the soil. A decrease in the level of a nutrient with depth usually indicates a stronger potential for a deficiency to develop than if the nutrient level is relatively stable or increasing. In our surveys, nitrogen demonstrated the most defined drop in levels with depth in all of the ecoregions. However, incorporation of green manure legume crops will only affect nitrogen levels in the plough layer and not deeper. In the case of nitrogen this decrease with depth is not as critical because strategies (like green manure incorporation or livestock manure application) exist to combat the problem. In general, potassium and phosphorus levels were slightly lower but stable at depth compared to the top 15 cm and sulphur levels increased.

TABLE 8. Mean, Minimum and Minimum Soil Properties Displayed From the Four Eco-Regions in South/Central Saskatchewan for pH, Electrical Conductivity (EC) and Organic Matter for 0-15cm, 15-30cm, and 30-45cm depths.

		pH			**EC (mS/cm)**			**Organic Matter (%)**	
Eco-Region/ Soil Zone	**Measure**	0-15	15-30	30-45	0-15	15-30	30-45	0-15	15-30
Aspen Parkland/ Black	**Mean**	**7.22**	**7.44**	**7.64**	**1.07**	**1.58**	**2.34**	**4.84**	**2.15**
	Maximum	7.77	7.95	8.05	3.11	4.52	5.05	7.62	3.82
	Minimum	5.54	6.14	6.60	0.29	0.22	0.23	2.19	0.76
Moist Mixed Grassland/ Dark Brown	**Mean**	**7.21**	**7.52**	**7.57**	**0.92**	**0.99**	**1.55**	**2.94**	**1.86**
	Maximum	7.68	7.74	7.84	3.31	3.67	4.78	4.76	3.63
	Minimum	6.27	7.09	7.11	0.44	0.46	0.40	1.87	1.11
Mixed Grassland/ Brown	**Mean**	**7.11**	**7.37**	**7.61**	**0.74**	**0.88**	**1.22**	**2.23**	**1.66**
	Maximum	7.61	7.78	7.89	3.34	3.75	5.75	3.64	2.81
	Minimum	5.53	5.77	7.05	0.23	0.33	0.32	1.47	1.07
Boreal Transition/ Grey	**Mean**	**7.05**	**7.41**	**7.66**	**0.66**	**0.62**	**0.58**	**6.17**	**1.73**
	Maximum	7.72	7.93	8.09	1.91	2.07	1.93	10.96	3.96
	Minimum	6.42	6.50	6.62	0.27	0.24	0.28	2.02	0.61

The mean pH values for all soils were in the neutral range of 7.0 (Table 8). Some acidic soils were identified in each of the eco-regions. The mixed grassland and aspen parkland each had pH values as low as 5.5. The largest affect pH has on soil characteristics is on the availability of nutrients. Phosphorus for example is more available in acidic soils than neutral or alkaline soils. Micronutrient availability is greatly affected by pH, some micronutrients like, copper, iron and zinc are more available in acidic conditions and can reach toxic amounts. Other micronutrients like boron, become less available in acidic conditions and can be a risk of deficiency in these soils.

Not unexpectedly, the highest mean organic matter values exist in the aspen parkland region, corresponding to the black soil zone. Soil zones are classified according to predominant soil color, which reflects the amount of organic matter. The moist mixed grassland (dark brown), boreal transition (grey), and the mixed grassland (brown) values were respectively lower. Any management practice that minimizes the removal of organic matter from the system will increase soil organic matter and will ultimately have positive effects on productivity. Decaying organic matter not only supplies nutrients, it improves water holding capacity, reduces erosion by wind and water and improves the overall structure of the soil.

Weed Survey

A total of 67 weed species were identified from the 84 surveyed fields. Relative abundance values quantified the weed species that are most abundant in certain defined boundaries. Provincially, the 15 most abundant species ranged from 5% to 70% relative abundance in the four different eco-regions (Table 9).

Green foxtail (*Setaria virids* (L.) Beauv.) was the most abundant weed species on sampled organic farms in Saskatchewan. Wild mustard (*Sinapis arvensis* L.) was second, followed by lamb's quarters (*Chenopodium album* L.) and wild oats (*Avena fatua* L.). Wild buckwheat (*Polygonum convolvulus* L.) and stinkweed (*Thlaspi arvense* L.) were fifth and sixth respectively.

Green foxtail (*Setaria virids* (L.) Beauv.) was highest in all eco-regions except for the most northern, boreal transition eco-region, where it was second to lamb's quarters (*Chenopodium album* L.) (Table 9).

Wild mustard (*Sinapis arvensis* L.) was ranked second in most regions, with the exception of the boreal transition where it was ranked third. The range of relative abundance in wild mustard between all four eco-regions was minimal, from 35% to 41%. This range for most other weed species is greater, which suggests preferential growth regions. It also suggests that wild mustard has a greater adaptive ability to persist in differing eco-regions. Wild buckwheat (*Polygonum convolvulus* L.) and wild oats (*Avena fatua* L.) also have a relative abundance range similar to that of wild mustard, but are less abundant, ranging from 19-25 and 19-29 respectively.

The relative abundance value for lamb's quarters in the boreal transition eco-region is more than twice any of the other regions. This can be contributed to differences in plant densities, which were much higher in the boreal transition (23%) than in the mixed grassland (3%), aspen parkland (5%) or moist mixed grassland (14%).

Stinkweed (*Thlaspi arvense* L.) was twice as abundant in the mixed grassland compared to all other eco-regions.

Canada thistle (*Cirsium arvense* (L.) Scop.) was most abundant in the aspen parkland.

Surveyed fields show a high abundance of annual broad-leaved weeds, such as, wild mustard, wild buckwheat, lamb's quarters and stinkweed. This contrasts conventional weed survey results in Saskatchewan in 1976-1979, 1986 and 1995. The summarized data shows a 17% decrease in annual broad-leaved weeds (Thomas et. al., 1996). This decrease may be attributed to a shift in conventional agriculture in Saskatchewan. Over the past 20 years, the frequency of reduced tillage, direct seeding, continuous cropping, and crop diversity has increased (Thomas, 1996). Since most annual broad-leaved weeds are easily controlled with herbicides and management practices, this type of system is likely to have contributed to the reduction of annual broad-leaved weed species. The morphology of a broad-leaved species is also more easily controlled with herbicides than grassy weed species in conventional systems.

TABLE 9. Relative Abundance Values[1] and Ranking (in Parentheses) of the Most Abundant Weed Species are Identified for All of Saskatchewan and the Four Major Agricultural Eco-Regions of Saskatchewan.

Weed Species	Relative Abundance[1] and Ranking in Parentheses				
	Saskatchewan	Eco-regions of Saskatchewan			
		Mixed Grassland	Moist Mixed Grassland	Aspen Parkland	Boreal Transition
Green foxtail *Setaria virids* (L.) Beauv.	60 (1)	51 (1)	58 (1)	70 (1)	41 (2)
Wild mustard *Sinapis arvensis* L.	41 (2)	40 (2)	41 (2)	40 (2)	35 (3)
Lamb's quarters *Chenopodium album* L.	35 (3)	19 (6)	31 (3)	28 (3)	51 (1)
Wild oats *Avena sativa* L.	27 (4)	26 (4)	19 (5)	27 (4)	29 (4)
Wild buckwheat *Polygonum convolvulus* L.	24 (5)	20 (5)	21 (4)	19 (5)	25 (5)
Stinkweed *Thlaspi arvense* L.	19 (6)	37 (3)	16 (6)	9 (8)	16 (6)
Canada thistle *Cirsium arvense* (L.) Scop.	11 (7)	8 (10)	7 (10)	14 (6)	9 (8)
Redroot pigweed *Amaranthus retroflexus* L.	8 (8)	14 (7)	9 (9)	6 (11)	2 (-)
Volunteer Alfalfa *Medicago sativa* L.	8 (9)	0 (-)	10 (8)	7 (10)	11 (7)
Russian thistle *Salsola pestifer* A. Nels.	8 (10)	8 (10)	16 (7)	5 (14)	0 (-)
Dandelion *Taraxacum officinale* Weber	6 (11)	6 (13)	5 (18)	4 (17)	7 (10)
Flixweed *Descurainia sophia* (L.) Webb	6 (12)	13 (8)	5 (15)	3 (18)	2 (-)
Blue bur *Lappula echinata* Gilib.	6 (13)	3 (14)	5 (17)	10 (7)	3 (16)
Perennial sow thistle *Sonchus arvensis* L.	5 (14)	7 (12)	4 (19)	5 (13)	3 (17)
Black medic (*Medicago lupulina* L.	5 (15)	8 (10)	5 (16)	3 (20)	1 (-)

Species 16 to 20 for the Saskatchewan are Cow Cockle (*Saponaria vaccaria* L.), Quackgrass (*Agropyron repens*), Prostrate Knotweed (*Polygonum aviculare* L.), Kochia (*Kochia scoparia* (L.) Schrad.), and Smart Weed species (*Polygonum* spp.) respectively.

[1] Relative abundance is a unit-less measure. The maximum value of relative abundance is 300. 300 would occur if the three components have a value of a 100%. 100% occurs in density if all weeds present are of a single species, 100% uniformity occurs if every sampling site had that species present and 100% frequency occurs if every field had the species present.

Objective 3: To establish a research advisory committee.

A research advisory committee has been established with representation from various sectors of organic agriculture. Grower representation consists of four organic farmers located throughout the province. Table**??** presents a detailed member list.

This committee was established to provide growers the opportunity to input, direct, and express current issues to be addressed in field research experiments. The committee is to act in an advisory capacity to assist in identifying possible treatments for the companion on-farm research experiments. In this second project small plot experiments have been established at three sites on organic land. The committee also discussed specific treatments to be established at the sites.

TABLE 10. Research Advisory Committee Members

Name	Title	Association	Location
Blaine Reckseidler	Cereals and Organic Crops Specialist	Saskatchewan Agriculture and Food	Saskatoon
Denis Brodner	Organic Farmer	OCIA 4	Cupar
Dr. Diane Knight	Research Scientist	Dept. of Soil Science, U of S	Saskatoon
Eric Johnson	Soils and Crops Agrologist	Agriculture and AgriFood Canada	Scott
Ian Cuchon	Organic Farmer	OCIA 4	Oxbow
Kevin Beach	Organic Farmer	OCIA 8	Ernfold
Marc Loiselle	Organic Farmer	OCIA 2	Vonda
Dr. Steve Shirtliffe	Assistant Professor	Dept. of Plant Sciences, U of S	Saskatoon
Dr. Stuart Brandt	Soils and Crops Agronomist	Agriculture and AgriFood Canada	Scott

Objective 4: To identify organic farms suitable for on-farm research projects.

Three sites have been identified for the on-farm research projects in Part II and the first year of research has been conducted. These sites include the Agriculture and AgriFood Canada Research Station at Scott (dark brown soil zone), the Loiselle Organic Farm near Vonda (thin black soil zone), and the Richman Homestead Farm near Elbow (brown soil zone).

The sites at Vonda and Elbow have been certified organic for over ten years. Both producers hold certification under OCIA certification bodies, chapters 2 and 4, respectively. Details of the on-farm research projects will not be reported on here.

Objective 5: To conduct regional workshops on planning and conducting farmer-directed on-farm agronomic research demonstrations.

Two “Organic On-Farm Research Workshops” were organized and held in Melfort (January 29, 2002) and in Gull Lake (February 7, 2002). These workshops focused on producer input into issues that are important to them, and planning and conducting on-farm agronomic trials. The workshops were organized with the help of SAF representatives from the area (Leroy Bader, Melfort Workshop; Jay Protz, Pat Gerwing and Darryl Tumbach – Gull Lake Workshop). Each workshop was attended by approximately 25 organic producers from the surrounding area . Discussion groups were organized to obtain information from producers regarding pertinent topics in organic production. Discussion topics included crop rotations, the use of green manure crops, weed management procedures, the use of different varieties, soil amendments, and inoculants. Detailed information on how to conduct on-farm research was presented in the afternoon. A Research Guide was provided to all in attendance (Appendix 2).

Feedback from the workshops indicated that they were very well received. Producer input was very positive and enthusiastic.

Conclusions

This study represents a one of a kind study generating a unique data set. The management practices identified by producers as being the most important to them were rotation of crops, growing competitive crops and green manure crops. However, only 58 % of the farmers surveyed actually had grown a green manure crop on the field in question over the past five years. Identifying appropriate green manure crops for a region as well as the frequency of occurrence in a rotation to obtain maximum economic benefit is one priority area. Determining the effectiveness of the green manure crop on weed control should also be included. At the onset of the study one hypothesis was that organically managed soils would be deficient in phosphorus and this indeed turned out to be the case. Even fields with acidic pHs had deficient soils. Furthermore, very few producers used soil amendments of any kind. Manure application was the most common, but only 12 % of producers had applied manure to the field in question over the last 5 years. A priority of research on organically managed land is to identify amendments and practices that will improve soil phosphorus.

Although overall nitrogen was slightly deficient across the province, a number of fields tested exhibited nitrogen levels in the high optimal range. In many cases this was associated with the use of green manure crops. The observation that these high levels occur indicates that the tools for improving and/or maintaining nitrogen levels exist for organic producers. Of the four ecoregions included in the survey, the boreal transition eco-region is at greatest risk of experiencing yield reductions due to nutrient deficiencies. This soil zone had the lowest levels of all nutrients tested, and was the only region with soils deficient in potassium.

Weed surveys identified green foxtail, wild mustard, lamb's quarters and wild oats as the most serious weeds encountered on organic farms. This contrasts conventional weed survey results from Saskatchewan in 1976-1979, 1986 and 1995 indicating a 17% decrease in annual broad-leaved weeds.

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