2002 Soil and Weed Survey Conducted on Saskatchewan Organic Cropland.

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Abstract

A soil survey and a weed survey were conducted on 5% of the organic farms in Saskatchewan, in the four major agricultural eco-regions in the 2002. Soil tests were taken in April and May prior to planting. Phosphorus levels were deficient in all regions. Nitrogen and sulphur varied between fields but were lowest over all in the boreal transition eco-region. Potassium was high in all regions. The weed surveys were conducted in July on the same fields as the soil survey. The most abundant species was green foxtail (*Setaria virids* (L.) Beauv.), wild oats was the fourth most abundant and the seventh most abundant species was Canada thistle (*Cirsium arvense* (L.) Scop.). Annual broad-leaved weeds were the most common weed group in the survey. Buckwheat (*Polygonum convolvulus* L.), lamb's quarters (*Chenopodium album* L.), stinkweed (*Thlaspi arvense* L.), and wild mustard (*Sinapis arvensis* L.) were four of the six most abundant weeds in the organic survey. These results are opposite to the trend seen in conventional production where annual broad-leaves have become less abundant according to the surveys conducted from 1976 to 1995 (Thomas, 1996).

Introduction

The area of cropland managed organically has increased rapidly in Saskatchewan. Saskatchewan Agriculture and Food (SAF) estimated that there were 1000 organic producers in the year 2000 (SAF, 2000); a 64% increase from 1999 (Macey, 2002). As organic production becomes more popular there is more interest in understanding this unique production system. The Agricultural Development Fund (ADF) is funding a large project to study various components of organic production. The goal of this larger project is to identify management practices that maintain soil fertility and reduce weed populations. To achieve this goal data was collected on organic agricultural practices, weed populations, and soil fertility in the different regions of Saskatchewan. This paper will present the quantitative soil and weed survey data gathered during the 2002 growing season.

Fields were surveyed in each of the four major agricultural eco-regions of central and southern Saskatchewan. Eco-regions are classified because of 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 rain and lowest temperature of these four eco-regions and has the shortest growing season. 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 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 south west corner; it is characterized by brown chernozemic soils.

This study provides a 'snapshot' of nutrient levels and weeds present on organic farms in Saskatchewan in 2002. The soil nutrient levels are presented for each of the eco-regions. The mean, maximum and minimum are listed for N, P, K, S, pH and salinity. The weed species with high relative abundance in the province are presented along with the species abundance for each of the four eco-regions represented in this study.

Materials and Method

Organic producers from each eco-region were selected randomly from the chapter lists of the Organic Crop Improvement Association (OCIA). The producers were contacted and asked to participate by identifying one or two fields to be surveyed. In order to qualify a field must: have been certified organic and planted to a cereal in the 2002 growing season. The producers agreed to complete a written questionnaire identifying management practices and agreed to allow soil sampling and weed survey to be conducted on their fields in spring and summer respectively. Sixty-three producers responded but only 46 returned surveys giving a 73% return rate. From these 46 producers, 76 fields were identified and surveyed. Seventeen fields were sampled in the mixed grassland eco-region, 14 in the moist mixed grassland, 23 in the aspen parkland and 22 fields in the boreal transition eco-region.

Soil Survey

The soil survey data was collected prior to planting in 2002. Sampling was performed in a "W" pattern across a field. Care was taken to ensure that anomalies such as, shoulder and foot slopes, potholes, ditches, bluffs, saline regions, oil wells, power lines, and paths were not sampled. On a uniform field, the first encountered corner of the field was the starting point. One hundred paces along the field edge and 100 paces into the field marked the first weed counting site. A hydraulically driven soil probe was used to collect soil samples. Each arm of the "W" contained of four sampling sites for a total of 16 sampling sites per field. Soil cores were separated into 15 cm sections up to 45 cm and each of the 15 cm cores were bulked for each field.

Weed Survey

The weed survey data was collected in mid July to early August 2002. Weeds that were larger than the first true leaf stage were identified and counted in order to ensure that only the weeds that would be competitive with the standing crop would be included. Sampling later in the growing season also ensured that any management practices implemented had time to manifest their effect on the weed populations. The method used to obtain and analyse the weed survey data was based on Thomas' (1985) system of surveying weed. Sampling was performed in a "W" pattern, like the soil sampling method ensuring that anomalies were avoided. Quarter meter square frames were used and weed species identified and quantified. Each arm of the "W" contained five sampling sites for a total of 20 sampling sites per field.

Analysis of the data also followed Thomas' (1985) protocol. Relative abundance is obtained by the summation of three descriptive components: density, frequency, and uniformity.

Density measured the number of a species counted in each 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 for a density value for each species present. Frequency was the number of fields in which a weed species occurred expressed as a percentage of the total fields surveyed. Uniformity was 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 76 fields). These three measures when summed provide a measure of relative abundance. The maximum value for relative abundance is 300% (table 4). The measure of relative abundance is without units but allows for a comparison tool between 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

Seventy-six fields were sampled. The results are presented in groupings using the eco-region classification. The boreal transition eco-region had the lowest mean levels of N, P, K and S (table 1). Where as the moist mixed grassland eco-region had the highest mean values for N, P and K; the aspen parkland eco-region had the highest S value.

The generalized critical nutrient levels (table 2) allow a comparison to understand the general nutrient condition of these organic fields. The mean soil N content for all eco-regions are said to be deficient. Nevertheless the maximum values (table 1) suggest that nitrogen can be managed to optimal levels in an organic system. Phosphorus levels do not have as wide a range. Even the maximum values are not above the deficient level. This nutrient appears to be difficult to maintain at optimal levels. A Manitoba study on 170 fields on 14 organic farms over six years found similar results. Entz, et al. (2001) reported that P levels were low on all field and were particularly low on fields that were managed organically for 30 years or more.

The K mean values are all in the optimal level. Saskatchewan soils are naturally endowed with K deposits. This is especially true in the south and central regions. The boreal transition eco-region was the only region with a minimum value in the deficient range (table 1). Sulphur ranges greatly in all eco-regions but the boreal transition region was is the only region with a deficient mean and a marginal maximum value. The other eco-regions have similar values for their means however the maximum are well in excess according to the critical levels table. The fields with high sulphur values corresponded to field with high salinity levels, since most Saskatchewan salinity is sulphate salts instead of sodium salts.

The mean pH values for all soils were in the neutral range of 7 (table 3). Every eco-region had a minimum value that would be considered slightly acidic. Electrical conductivity (E.C.) is a measure of saturated soil paste extract and a value of greater than four is considered to be moderately saline. None of the soils sampled are highly saline. The boreal transition eco-region had the lowest salinity levels. Organic matter mean values are highest in the aspen parkland and moist mixed grassland. These were followed by the boreal transition and mixed grassland eco-regions which had the lowest average percentage of organic matter.

Weed Survey

From the 76 organically certified fields surveyed a total of 67 weed species were identified. The relative abundance values can be used to determine the weed species that are most abundant in certain defined boundaries, either in the province or in eco-regions. Relative abundance measures for the 15 most abundant species across the whole province and well as the relative abundances of the species in the four different eco-regions range from 60% to 5% (Table 4).

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 1). Wild mustard (*Sinapis arvensis* L.) was rated second in most regions except the boreal transition where it was third most abundant. Wild mustard is interesting because of how close the relative abundance values are for all four eco-regions, with a range of 35 to 41. The range or spread is wider for most other species, which suggests preferential growth regions. Wild buckwheat (*Polygonum convolvulus* L.) and wild oats (*Avena fatua* L.) have a similar even spread of relative abundance but are less abundant than mustard with values lower 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. The large difference in the relative abundance is due to difference in plant densities. When lamb's quarters appeared in the boreal transition region the number of plants found were much higher (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.

The organic fields in this survey show high abundance of annual broadleaved weeds, such as, wild mustard, wild buckwheat, lamb's quarters and stinkweed. This differs from the conventional weed surveys conducted in Saskatchewan in 1976-1979, 1986 and 1995. The summarized data shows trends of a 17% decrease in annual broad-leaved weeds (Thomas et. al., 1996). Most annual broad-leaved weeds are relatively easy to kill with herbicides where as the leaf morphology of grassy can be more difficult for most applicators and herbicides. During these 20 years a major shift in Saskatchewan production with reduced tillage, lower frequency of fallow periods, increased direct seeding and increased crop diversity (Thomas, 1996) may have contributed to reduced annual broad leaved species.

Table 1. 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) for a 0 cm to15 cm sampling depth.

Eco-Region	Measure	N	P	K	S
Aspen Parkland	**Mean**	**33**	**13**	**561**	**25**
	Maximum	159	22	951	284
	Minimum	6	7	209	1
Moist Mixed Grassland	**Mean**	**42**	**19**	**932**	**22**
	Maximum	121	29	1858	316
	Minimum	4	8	461	1
Mixed Grassland	**Mean**	**56**	**19**	**722**	**19**
	Maximum	117	27	1098	290
	Minimum	12	13	425	1
Boreal Transition	**Mean**	**24**	**10**	**318**	**5**
	Maximum	113	14	598	18
	Minimum	4	5	65	2

Table 2. Generalized critical limits from Northwest labs (1994).

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.)

Table 3. Mean, Minimum and Minimum Soil Prosperities Displayed From the Four Eco-Regions in South/Central Saskatchewan for pH, Electrical Conductivity (E.C.) and Organic Matter for the 0 cm to 15 cm depth.

Eco-Region	**Measure**	**pH**	**E.C. (mS/cm)**	**Organic Matter (%)**
Aspen Parkland	**Mean**	**7.23**	**1.05**	**2.09**
	Maximum	7.77	3.11	3.82
	Minimum	5.54	0.29	0.76
Moist Mixed Grassland	**Mean**	**7.21**	**0.92**	**1.86**
	Maximum	7.68	3.31	3.63
	Minimum	6.27	0.44	1.11
Mixed Grassland	**Mean**	**7.11**	**0.74**	**1.66**
	Maximum	7.61	3.34	2.81
	Minimum	5.53	0.23	1.07
Boreal Transition	**Mean**	**7.02**	**0.66**	**1.79**
	Maximum	7.72	1.91	3.96
	Minimum	6.42	0.27	0.61

Table 4. 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.

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