Factors Affecting Yield Variations of Various Crops in North-eastern Saskatchewan

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Background

In north-eastern Saskatchewan or elsewhere, one can notice large variations in crop growth during growing season within the same field, with some areas producing much better crop growth than the adjacent areas. These result in low average yields. There can be many factors responsible for this (e.g., landscape position, soil moisture, drought, microclimate, level and availability of nutrients, soil texture, organic matter and other soil properties, etc.). In order to determine the specific reasons for these yield variations within a field, quantitative information on site-specific variability in soil and crop parameters was required. The objective of this field survey study was to determine the effects of site-specific variations in landscape and soil properties on yield (seed, straw and roots) of various crops in north-eastern Saskatchewan.

Materials and Methods

Types of Trials:	Field surveys
Location (year):	Northeastern Saskatchewan (1997-2001)
Sampling Technique:	Surveyed fields with crop growth problems Selected "Good" and "Bad" areas Collected soil samples Collected m^2 plant samples for yield Collected m^2 root samples
Data Collected: Slope:	Seed yield, Straw yield, Root yield, Soil analysis and Plant analysis
Types of Crops:	Canola, Flax, Wheat, Barley, Oat, Peas and Alfalfa

Note: Soil samples for nutrient concentrations were taken at harvest for each crop in each year.

Summary of Results

Landscape Position (Tables 1, 5, 6, 7 and 8)

Landscape is an important factor that affects distribution and redistribution of moisture, nutrients, organic matter and microbial ecological communities in soils, and then leads to variation in soil fertility and crop yield. Water and available nutrients in soil on knolls are readily removed to depression areas, and as a result, drought and nutrient deficiency usually happen on knolls. Field survey trials in North-eastern Saskatchewan showed that grain yield and biomass of crops on knolls (upper slope positions) were much lower than in low lying areas (lower slope positions). Yield of seed and straw, respectively, was reduced by 53.0% and 56.8% for canola, 80.6% and 76.6% for wheat, 34.8% and 36.3% for barley, 87.4% and 71.6% for oats, and 75.5% and 72.8% for peas.

Nutrient Deficiency

S deficiency (Tables 1, 2, 4, 5, 6, 7 and 8)

In north-eastern Saskatchewan, nutrient deficiency is another important factor causing variations of crop yields on farm fields. Sulphur is the element that is deficient or potentially deficient on many soils in this area for high crop yields, especially canola. Data from the survey trials in 1997-2001 showed that seed yield of canola in some fields was decreased by as much as 86.6-99.8% (or even no harvestable seed yield) in the S deficient areas ("Bad areas") compared to the S sufficient areas ("Good areas"), although yield of straw was only decreased by 21.9-81.1%. For cereals, seed yields were also much less in "Bad" area than in "good" area. Yield of grain and straw was decreased by 59.3-91.1% and 12.6-78.0% for wheat, 98.5% and 93.2% for barley and 41.9% and 47.4% for oats, most likely due to S deficiency. Pea was found with reduced growth in "Bad areas", and yields of seed and straw were decreased by 41.4% and 47.9%, respectively.

P deficiency (Tables 2, 8 and 9)

In north-eastern Saskatchewan, in fields where soil tests showed relatively lower levels of P and/or S, seed and straw yields in "Bad areas" were decreased by 55.2% and 61.3% for canola, and 70.1-92.5% and 52.5-55.6% for alfalfa, respectively, compared to "Good areas". In another survey trial on alfalfa where soil was low in soil test P, yield of alfalfa was decreased by 45.6-84.7% for seed and 23.6-34.6% for straw.

B and Mn deficiency (Tables 1 and 6)

In a survey trial at Carrot River, seed and straw yield of canola in "Bad areas" was decreased by 99.5% and 13.8%, respectively, compared to "Good areas". Soil in "Bad areas" had much more sandy texture than in "Good areas". In this field, B deficiency was suspected to affect canola seed yield, as farmer had applied S fertilizer to canola at seeding. In another survey trial on barley in the Carrot River area, growth of barley was found markedly impeded by Mn deficiency (typical Mn deficiency symptoms on leaves were observed in this field), with seed yield decreased by 35.3% and straw yield by only 2.6% .

Soil Organic Matter (Table 9)

Soil organic matter is an important factor that affects soil structure/quality, moisture, nutrient availability, and crop yield. In a survey trial at Hudson Bay, yield of alfalfa was found significantly lower in low organic matter soil than in high organic matter soil in the same field, and the decrease was 89.4-97.3% for seed and 65.2-75.5% for straw.

Soil Structure/Subsoil Problem (Table 1)

Hard layer in the subsoil is another factor that can cause crop yield variation in farm fields. In a survey trial of canola field at Birch Hill, yield of seed and straw was decreased by 87.8% and 74.4% respectively. The reduced crop yield in "Bad" area compared to "Good" area was most likely due to presence of hard layer in the subsoil in the "Bad" area.

Conclusions

The result of survey trials indicated that factors resulting in crop yield variations in farm fields in north-eastern Saskatchewan include landscape (knoll and depression position), nutrient deficiency, soil organic matter, soil structure/subsoil problem, etc. Landscape was found to affect yield of almost all kinds of crops in this area, such as canola, wheat, barley, oats, peas, and alfalfa etc. For S sensitive crops like canola, S deficiency was found more common to reduce seed yield than other nutrients in this region. Yield reduction of pea caused by S deficiency was not as serious as that of canola or cereals. Phosphorus deficiency was also observed to cause yield reduction of alfalfa in fields. Boron deficiency on canola was suspected to cause decrease in seed and straw yield in one field on a sandy soil near Carrot River. Manganese deficiency was found to reduce barley yield in one field near Carrot River. Soil organic matter and subsoil problem/soil structure were found to result in reduced crop yield.

Table 1. Seed, straw and root yield (kg ha^{-1}) of canola in "Bad" and "Good" areas in fields at various locations in northeastern Saskatchewan in 1997-1998

Year	Location	Parameter	Seed	Straw	Root	Reasons
1997	Gronlid	Bad	600	2423	478	Landscape (moisture problem). Upper slope (knoll). 41 mg P, 135 mg K and 3.0 mg SO_4-S/kg soil.
		Good	1277	5606	800	Lower slope (depression). 66 mg P, 260 mg K and 8.5 mg SO_4-S/kg soil.
	Carrot River	Bad	17	11692	922	B deficiency? 0.36 mg B/kg soil
		Good	3242	10277	821	0.64 mg B/kg soil
	Birch Hills	Bad	207	1799	477	Subsoil problem. Hard layer
		Good	1693	7099	911	
	Melfort	Bad	8	5653	944	S deficiency. 7.1 mg SO_4-S/kg soil
		Good	2187	7239	691	5.7 mg SO_4-S/kg soil
	West of PFRA Dam	Bad	83	3352	458	S deficiency. 3.6 mg SO_4-S/kg soil
		Good	1311	5658	501	4.0 mg SO_4-S/kg soil
	Melfort (Highway)	Bad	21	6040	977	S deficiency. 6.5 mg SO_4-S/kg soil
		Good	2055	7781	779	5.9 mg SO_4-S/kg soil
	Porcupine Plain	Bad	29	5525	825	S deficiency. 2.9 mg SO_4-S/kg soil
		Good	2152	7273	605	8.2 mg SO_4-S/kg soil
	Mean	Bad	138	5212	726	
		Good	1988	7276	730	
1998	Sylvania	Bad	4	2504		S deficiency. 1.6 mg SO_4-S/kg soil
		Good	1572	3753		
	Tisdale I	Bad	6	4270		S deficiency. 2.0 mg SO_4-S/kg soil
		Good	1275	4075		
	Tisdale II	Bad (-S)	56	2752		S deficiency. 1.2 mg SO_4-S/kg soil
		Good (+S)	418	3439		6.4 mg SO_4-S/kg soil
	Mean	Bad	22	3175		
		Good	1088	3756		
	Mean1997-1998	Bad	103	4601	726	
		Good	1718	6220	730	

Table 2. Seed, straw and root yield (kg ha^{-1}) of canola in "Bad" and "Good" areas in fields at various locations in northeastern Saskatchewan in 1999 and 2001

Year	Location	Parameter	Seed	Straw	Root	Reasons
1999	Doremy	Bad	80	3996		S deficiency. 7.8 mg SO_4-S/kg soil
		Good	1480	5502		23 mg SO_4-S/kg soil
	Doremy	Bad	1763	5475		S deficiency. 11 mg SO_4-S/kg soil
		Good	2661	6283		23 mg SO_4-S/kg soil
	Hoey	Bad	22	3640		S deficiency. 10 mg SO_4-S/kg soil
		Good	2085	7047		9.6 mg SO_4-S/kg soil
	Pleasantdale	Bad	107	939		S deficiency. 10 mg SO_4-S/kg soil
		Good	2088	4962		12 mg SO_4-S/kg soil
	Bjorkdale I	Bad	105	2503		S deficiency. 6.8 mg SO_4-S/kg soil
		Good	823	3519		7.4 mg SO_4-S/kg soil
	Bjorkdale II	Bad	762	2271		P and S deficiency. 16 mg SO_4-S and 12 mg P/kg soil
		Good	1702	5871		19 mg SO_4-S and 22 mg P/kg soil
	Carrot River I	Bad	85	5282		S deficiency. 6.8 mg SO_4-S/kg soil
		Good	1552	6285		8.2 mg SO_4-S/kg soil
	Carrot River II	Bad	6	4322		S deficiency. 6.2 mg SO_4-S/kg soil
		Good	2713	6399		15 mg SO_4-S/kg soil
	Mean	Bad	366	3554		
		Good	1888	5734		
2001	Holbein	Bad (-S)	0	3325		S deficiency.
		Good (+S)	447	4841		
	Mean1999-2001	Bad	326	3528		
		Good	1728	5634		
	Mean1997-2001	Bad	229	4016	726	
		Good	1723	5943	730	

Table 3. Seed, straw and root yield (kg ha^{-1}) of flax in "Bad" and "Good" areas in fields at various locations in northeastern Saskatchewan

Year	Location	Parameter	Seed	Straw	Root	Reasons
1997	Star City	Bad	400	1807	335	Moisture? Darwin's farm
		Good	2277	5582	667	

Table 4. Response of seed, straw and root yields (kg ha^{-1}) of canola to N and S application in S deficient soil in northeastern Saskatchewan From 1997-2001.

Year	Location	Parameter	Seed	Straw	Reasons
1998	South Tisdale	No Fert.	453	1292	
		N+P	56	2752	
		N+P+S	418	3439	
2001	Holbein	-S	0	3325	
		+S	447	4841	

Table 5. Seed, straw and root yield (kg ha^{-1}) of wheat in "Bad" and "Good" areas in fields at various locations in northeastern Saskatchewan

Year	Location	Parameter	Seed	Straw	Root	Reasons
1997	Star City	Bad	1136	3561	736	S deficiency. 5.8 mg SO_4-S/kg soil
		Good	2791	7519	1073	8.8 mg SO_4-S/kg soil
	Gronlid	Bad	576	1680	213	Landscape. Upper slope (knoll)
		Good	2976	7181	621	Lower slope (depression)
	Mean	Bad	856	2621	475	
		Good	2884	7350	847	
1998	Skjerpen	Bad	384	649		S deficiency. 2.0 mg SO_4-S/kg soil
		Good	1408	2953		
1999	Porcupine Plain I	Bad	427	3000		S deficiency. 1.6 mg SO_4-S/kg soil
		Good	4772	5393		2.6 mg SO_4-S/kg soil
	Porcupine Plain II	Bad	512	4447		S deficiency. 6.6 mg SO_4-S/kg soil
		Good	3736	5089		6.9 mg SO_4-S/kg soil
	Porcupine Plain III	Bad	1534	2863		S deficiency. 5.6 mg SO_4-S/kg soil
		Good	4045	6350		8.4 mg SO_4-S/kg soil
	Mean	Bad	824	3437		
		Good	4184	5611		
Mean		Bad	762	2700	475	
		Good	3288	5748	847	

Table 6. Seed, straw and root yield (kg ha^{-1}) of barley in "Bad" and "Good" areas in fields at various locations in northeastern Saskatchewan

Year	Location	Parameter	Seed	Straw	Root	Reasons
1997	Gronlid	Bad	1305	3488	794	Landscape (moisture). Upper slope (knoll). 40 mg P/kg soil.
		Good	2000	5474	1109	Lower slope (depression). 86 mg P/kg soil
1998	Skjerpen	Bad	35	201		S deficiency. 1.0 mg SO_4-S and 5.8 mg N/kg soil
		Good	2404	2946		
1999	Carrot River	Bad	2235	5308		Mn deficiency.
		Good	3456	5172		
Mean		Bad	1192	2999	794	
		Good	2620	4531	1109	

Table 7. Seed, straw and root yield (kg ha^{-1}) of oats in "Bad" and "Good" areas in fields in northeastern Saskatchewan

Year	Location	Parameter	Seed	Straw	Root	Reasons
1997	Gronlid	Bad	126	746	304	Landscape (moisture). Upper slope (knoll)
		Good	998	2627	553	Lower slope (depression)
1999	Star City	Bad	3369	3492		S deficiency. 9.8 mg SO_4-S/kg soil
		Good	5752	6700		8.4 mg SO_4-S/kg soil
Mean		Bad	1748	2119	304	
		Good	3375	4664	553	

Table 8. Seed, straw and root yield (kg ha^{-1}) of peas in "Bad" and "Good" areas in fields in northeastern Saskatchewan

Year	Location	Parameter	Seed	Straw	Root	Reasons
1997	Gronlid	Bad	589	1502	71	Landscape (moisture). Upper slope (knoll)
		Good	2404	5516	163	Lower slope (depression)
1999	Doremy	Bad	1682	2314		S and maybe P deficiency. 7.2 mg SO_4-S and 12 mg P/kg soil
		Good	2720	3637		7.2 mg SO_4-S and 21 mg P /kg soil
Mean		Bad	1136	1908	71	
		Good	2562	4577	163	

Table 9. Seed and straw yield (kg ha^{-1}) of alfalfa in "Bad" and "Good" areas in fields in northeastern Saskatchewan

Year	Location	Parameter	Seed	Straw	Reasons
1999	Porcupine Plain	Bad	60	8951	P and S deficiency. 8.0 mg SO_4-Sand 2.4 mg P/kg soil
		Good	201	18826	7.8 mg SO_4-Sand 4.4 mg P/kg soil
2000	Tisdale I	Bad	15	1010	P and S deficiency. 9.5 mg SO_4-S and 4.6 mg P/kg soil
		Good	201	2273	27 mg SO_4-S and 7.7 mg P/kg soil
	Tisdale II	Bad	74	1419	P deficiency. 5.0 mg P/kg soil
		Good	136	2170	9.0 mg P/kg soil
	Hudson Bay	Bad	41	1601	Lower OM (77 g/kg) and P (3.0 mg/kg)
		Good	387	4596	Higher OM (160 g/kg) and P (11mg/kg)
	Mean	Bad	43	1343	
		Good	241	3013	
2001	Nikonetz	Bad	15	992	Lower OM (77 g/kg) and P (2.1 mg/kg)
		Good	555	4052	Higher OM (160 g/kg)
	Hollinaty	Bad	101	3399	P deficiency. 3.8 mg P/kg soil
		Good	660	4450	
	Mean	Bad	58	2196	
		Good	608	4251	
Mean		Bad	51	2895	
		Good	357	6061	