SOIL FERTILITY ISSUES

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In 1991, the Saskatchewan soil testing laboratory established programs to address some of the concerns and questions raised by producers. With the cooperation of fertilizer dealers, the lab established 12 strip trials on various fields involving yield responses to various fertilizer treatments. Fertilization with copper, boron, sulfur, phosphorus, potassium, and chloride was evaluated on one or more of the following crops: canola, wheat, alfalfa, and barley.

1. Introduction

The Saskatchewan Soil Testing Laboratory (SSTL) provides analytical services and agronomic information to the farming community. As part of its efforts to keep in contact with its customers, the lab tries to address producer concerns about the laboratory's fertilizer recommendations by supplying analytical support for trials which will answer the questions raised. With the assistance of ESSO Petroleum Canada and Central Canada Potash, SSTL established 14 demonstration sites across Saskatchewan to address some fertility issues raised by fertilizer dealers and producer crop clubs. In addition to the strip trials, SSTL provided support services for inquiries about nutrient deficiencies and soil sampling techniques. This paper will report the results of the 14 field sites.

2. Methodology

Fourteen experimental sites were established with four in the Gray-Black soil zone, seven in the Black soil zone, and one each in the Gray, Dark Brown, and Brown soil zones (Table 1).

Table 1. Experimental sites for demonstration strips conducted in 1991.

Location	Legal location	Soil Zone	Type of Test	Crop
1. Leoville	SW-12-54-11-W3	Grey	$CuSO_4$	Canola
2. Prince Albert	SW-4-46-27-W2	Grey-Black	$CuSO_4$	Wheat
3. Spiritwood	NW-13-51-13-W3	Grey-Black	$CuSO_4$	Wheat
4. Laporte	W-2-25-26-W3	Brown	KCl	Wheat
5. Bruno	SW-33-38-25-W2	Dk Brown	KCl	Barley
6. Cudworth	SW-28-41-26-W2	Thin Black	KCl	Wheat
7. Cudworth	SW-28-41-26-W2	Thin Black	KCl	Barley
8. Wynyard	NE-15-31-18-W2	Dk Brown	K_2SO_4	Barley
9. Wishart	SW-36-31-15-W2	Thin Black	K_2SO_4	Canola
10. Wynyard	NW-25-31-17-W2	Thin Black	K_2SO_4	Canola
11. Shellbrook	NE-21-49-3-W3	Grey-Black	Sulfur	Canola
12. Turtleford	NE-13-51-21-W3	Grey-Black	Sulfur	Canola
13. Glenside	SW-5-27-5-W3	Dk. Brown	Phosphate	Alfalfa
14. Brooksby	SE-27-48-17-W2	Grey Black	Boron	Canola

The fertility issues addressed in this year's projects included the following:

1. Response of barley and canola to K_2SO_4 fertilization (3 sites).
2. Response of wheat and barley to KCl fertilization (4 sites).
3. Response of canola and wheat to $CuSO_4$ fertilization (3 days).
4. Response of alfalfa to phosphate fertilization (1 site).
5. Response of canola to several sulphur sources (2 sites).
6. Response of canola to boron fertilization (1 site).

Test strips were placed in the cooperator's field to evaluate the fertility practices. The cooperator performed all field operations including the application of the fertilizer treatments. Whenever possible, an agronomist from the lab was present during field operations to assist in layout of the fertilizer strips and application of fertilizer. The fertilizer strips were arranged in two blocks with the treatments randomized within each block. In some cases, a local fertilizer dealer provided some fertilizer materials and application equipment. A typical strip was one or two widths of the cooperator's seeding and harvesting implements.

A composite soil sample of 40 cores was collected from the 0-6" and 6-12" depths for each of the strips prior to fertilization application. These samples were air-dried and analyzed for available nutrients by the standard procedures followed by the SSTL. Nitrogen and sulfur were determined by flow injection analysis of 0.001 M $CaCl_2$ soil extracts. Phosphorus and potassium were determined by auto analyzer and flame emission spectophotometry respectively on 0.5 M $NaHCO_3$ soil extracts. The micronutrient cations were determined by inductively coupled plasma spectrophotometry (ICP) on 0.005 M DTPA soil extracts. Boron was determined by ICP on 1N NH_4OAc soil extracts.

The fertilizers were applied to the test strips in a variety of methods. The K_2SO_4 fertilizer strips were established at the two Wynyard sites and one Wishart site through broadcast and incorporation of 30 kg/ha before seeding. Seed placed KCl experiments were established at the Laporte, Bruno, and Cudworth sites at 15, 18, and 15 kg K_2O/ ha respectively. Broadcast $CuSO_4$ strips at a rate of 5 lb Cu/ac were applied by a pneumatic applicator prior to pre-seeding tillage operations. The sulfur experiments at the Shellbrook and Turtleford sites were established with four treatments: 1) 0-0-0-95 (an elemental source), 2) 7-0-0-68 (an elemental-S / sulphate-S blend), 3) 20-0-0-24 (ammonium sulphate), and 4) control. At the Turtleford site, the sulfur was broadcast and incorporated before seeding. At the Shellbrook site, sulphur was broadcast after seeding and incorporated by a light harrowing. The alfalfa experiment at Glenside was established on an irrigated stand of alfalfa which was one year old. Mono-ammonium phosphate (11-55-0) was applied at four rates: 0, 100, 200, and 300 kg/ha in early spring. Boron was applied was applied at 1.5 lb B/ac as sodium tetraborate with a rotary fan broadcast spreader prior to seeding at the Brooksby site.

Visual determination of foliar disease control was assessed in mid-July by Agriculture Canada on the potash sites at Bruno and Cudworth. The estimates were made from a sample of 50 pentultimate leaves selected at random from each plot by assessing the percentage of the total leaf area affected with symptoms of disease.

The grain yield for each plot was assessed by threshing a measured distance of swath with the cooperator's combine and weighing the grain in a weigh wagon mounted on the back of a truck.

3. Results and Discussion

3.1 Soil Test Levels

Soil test levels at each site are reported in Table 3. The values reported are the means of the nutrient levels measured in each strip at each site. Nitrate - N and sulfate - S are reported for a 0 - 30 cm depth, and P, K, and the micronutrients are reported for 0 - 15 cm soil depths.

Table 3. Soil test levels at 1991 experimental sites (lb/ac).

Location	NO_3-N†	P	K	SO_4-S†	Cu	Mn	Zn	B
1. Leoville	29	12	85	22	0.2	4.0	3.4	2.2
2. Prince Albert	21	57	410	31	0.4	10.4	3.6	0.6
3. Spirtwood	19	36	280	48	0.9	28.2	6.1	0.4
4. Laporte	54	21	790	45	-	-	-	-
5. Bruno	17	58	640	18	-	-	-	-
6. Cudworth	13	31	525	9	-	-	-	-
7. Cudworth	13	19	465	20	-	-	-	-
8. Wynyard	18	34	465	31	2.0	11.0	2.4	1.8
9. Wishart	41	21	240	25	1.1	7.5	1.8	1.6
10. Wynyard	34	21	240	16	1.9	8.4	1.9	0.9
11. Shellbrook	29	22	175	18	2.3	14.7	5.0	1.8
12. Turtleford	19	28	355	26	-	-	-	-
13. Glenside	19	9	140	21	-	-	-	-
14. Brooksby	16	27	330	14	1.0	13.9	4.0	0.6

† on a 0 - 30 cm basis.

Several nutrient levels were found to be low at the various sites. The phosphorus levels were very low at site #1 and 13. Potassium levels were low at site #1, 11, and 13. Extractable S levels were low for cereal production at site #5, 6,and 7 and were low for canola production at sites #1, 9, 10, 11, 12, and 14. DTPA ext. Cu was found to be low in sites 1, 2, 3, and 14. Boron levels were observed to be low at sites 2, 3, and 14. Iron, manganese, and zinc were all found to be adequate at all of the sites.

3.2 Yield results

The mean yield results of the various treatments in each experiment are presented in Table 5. Yield responses were observed with copper fertilization at Prince Albert, seed-placed potash at Laporte and Cudworth, sulphur at Shellbrook and Turtleford, and boron at Brooksby.

Copper

Only one of the three demonstration sites with copper sulphate strips showed a response to copper fertilization (Table 5). Large concentric areas of Cu deficient wheat were visible in the control strips at harvest at the Prince Albert site. The DTPA soil test correctly predicted the yield response at this site (Table 3).

Table 5. Yield results of strip experiments

Location	Treatment	Rep 1	Rep 2	Grain Yield†† (bu/ac)	Yield Response (% of control)
Leoville	control			22.8	
(Canola)	$CuSO_4$			23.6	104
Prince Albert	control			24.0	
(Wheat)	$CuSO_4$			30.0	125
Spirtwood	control			39.7	
(Wheat)	$CuSO_4$			39.7	100
Laporte	control			36.6	
(Wheat)	KCl			41.0	112
Bruno	control			62.1	
(Barley)	KCl			59.1	95
Cudworth	control			35.6	
(Wheat)	KCl			41.2	116
Cudworth	control			57.3	
(Barley)	KCl			68.1	119
Wynyard	control			23.4	
(Barley)	K_2SO_4			19.9	85
Wishart	control			29.4	
(Canola)	K_2SO_4			30.0	102
Wynyard	control			18.0	
(Canola)	K_2SO_4			19.7	109
		Rep 1	Rep 2	Average	
Shellbrook	control	24.1	20.4	22.3	
(Canola)	0-0-0-95	32.7	22.6	27.7	124
	7-0-0-68	34.9	21.2	28.1	126
	20-0-0-24	32.3	35.2	33.8	151
Turtleford	control			21.7	
(Canola)	0-0-0-95			--	
	7-0-0-68			30.2	139
	20-0-0-24			29.5	136
Brooksby	control			30.9	
(Canola)	Boron			36.8	119

There was no yield difference at the Leoville and Spiritwood sites. Although the soil at the Leoville site was very peaty and had a very low soil test value, canola has proven to be less sensitive to copper deficiency than wheat and barley. This points out that a second strategy for combating copper deficiency besides the application of copper fertilizer. Crop rotations may be altered to include less sensitive species or varieties of crops. This strategy would restrict the ability of a producer to respond to market changes in grain prices and may predispose his fields to greater incidence of disease and insects.

KCl and K_2SO_4

Yield increases of 4.4 and 5.6 bu/ac were observed in wheat grown at the Laporte and Cudworth sites respectively (Table 5). Increased resistence to disease is a partial explanation for the difference in yield. The application of potash with the seed reduced the incidence of foliar disease at Cudworth from 4.1% in the no-potash area to 1.4% in the potash area.

The addition of KCl increased barley yields by 10.8 bu/ac at Cudworth and reduced barley yield at Bruno by 3.0 bu/ac (Table 5). The results from the Bruno trial are questionable because of hail damage to the plots. The application of potash reduced the incidence of foliar disease at Cudworth site from 2.6% in the control area to 0.9% in the potash treated area. The Bruno trial showed no difference in foliar disease intensity as both areas had a level of 1% foliar disease.

A small trend towards higher yields of canola with the addition of K_2SO_4 was observed at the Wishart and Wynyard sites (Table 5). Differences were small, but likely reflect the benefit of additional sulphate. Broadcast potassium at the low rates applied to these strips would not explain any difference in yield.

Sulfur

A response to the various sulfur treatments was observed at the Shellbrook and Turtleford sites. The addition of sulfur as $(NH_4)_2SO_4$ and elemental sulfur increased canola yields at both sites. The largest yield increase was observed with 20-0-0-24 (Table 5), but the response to the elemental sulphur sources was very good for two of the three replications. No explanation for the difference in the performance of the elemental sources was evident between the two replicates at Shellbrook. The pH of the soil in Rep 1 was about 1.0 pH unit lower than the soil in Rep 2, but suphur oxidation usually occurs at a higher rate in higher pH soils.

Boron

Canola grown at the Brooksby site responded to boron fertilization. A yield increase of 5.9 bu/ac was observed at harvest as the result of boron fertilization (Table 5). A yield increase from boron was expected in this soil because of its low boron level (0.6 lb/ac) (Table 3). Close examination of the canola seed at harvest indicated large plump seed in the boron treated strip compared to smaller poorly rounded seed in the control area. Boron deficiency is most severe in deficient areas when a wet spring is followed by a dry summer. Weather conditions during 1991 were favourable to observing boron responses for sensitive crops.

Phosphate

The addition of 11-55-0 at 100, 200, and 300 kg/ha increased the yields of the first cut of irrigated alfalfa at the Glenside site. The addition of 11-55-0 at 100, 200, and 300 kg/ha resulted in yield increases of 1.8, 2.4, and 3.2 bales per hectare respectively. The results verify the usefulness of the phosphate test for predicting alfalfa yield responses.

Table 6. Response of alfalfa to application of monoammonium phosphate

Location	MAP (kg/ha)	Bales per hectare
Glenside	0	8.6
(Alfalfa)	100	10.4
	200	11.0
	300	11.8

4. Summary and Conclusions

The results of the 1992 field program provide a basis for improving the fertilizer recommendations provided by the laboratory.

1. Several of the trials indicated a positive response of cereals to seed-placed potassium. Ratings of disease on the foliage of the cereals was consistent with the yield responses.
2. Trials with copper sulphate verified yield responses of wheat to copper fertilizer on sandy soils.
3. A new elemental sulphur source (7-0-0-68) was equally effective as ammonium sulphate for increasing canola yields in one of two experiments.
4. Canola yields can be increased by boron application on deficient soils in Saskatchewan.
5. The phosphate soil test is effective for predicting responses to mono-ammonium phosphate on irrigated alfalfa.