LIMING ACID SOILS IN WEST CENTRAL SASKATCHEWAN

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INTRODUCTION

Liming of acid soils is not a common practice in Saskatchewan. Areas of acid soils in the province are limited in their extent and, therefore, do not draw province-wide attention like a problem such as salinity. In the past number of years, attempts have been made to determine the extent of acid soils in the province and the yield response of certain crops to applications of lime.

Documenting the extent of acid soils in West Central Saskatchewan was completed by Rostad (1981) in a preliminary survey of the area. Surface pH was characterized on a provincial scale by Rostad et al. (1983). These surveys indicated the extent of acid soils in Saskatchewan with a pH at or below 5.9 at approximately 1 143 000 hectares.

Fertility and liming research undertaken by H. Ukrainetz at the Scott research farm has supplied the majority of yield data to date for this province. Results by Ukrainetz (1984) showed an increase in barley yields ranging from 284 kg/ha to 426 kg/ha, increases in wheat yields of 210 kg/ha to 321 kg/ha and increases in rapeseed yields of 240 kg/ha. These yield increases were obtained when soils with a initial pH of 4.8 to 5.4 were limed at rates 4480 kg/ha and fertilizers were applied.

In recent mapping of soils by the Saskatchewan Soil Survey Unit in West Central Saskatchewan, particular interest was taken in the determination of pH values for the soils in the area. A group of liming experiments were conducted on moderately acid soils to determine yield response of cereals and pH change of soils to various applications of lime.

Using yield results obtained from the liming research and soil survey data collected in the past five years, the distribution of soils which may benefit from liming was calculated for a block of six rural municipalities comprising one of the recognized acid soil regions of the province.

METHODS AND MATERIALS

Liming Plots

In 1981, sites for the liming experiments were established in the Dark Brown soil zone in the west central region of Saskatchewan. The plots were located on soils previously identified as being acid although varying in their degree of acidity. Considerations were made for topographic uniformity, accessibility and land use when site selections were made. They were located in the Rural Municipalities of Reford (379), and Tramping Lake (380) (Table 1).

Table 1. Liming Plot Site Information

SITE ID	LOCATION	INITIAL pH	SOIL MAP UNIT
A.J.	NE19:38:19	5.1 - 6.1	EwSt3
L.H.	SE28:38:21	5.1 - 6.3	St3

The sites were surveyed in blocks 72 meters wide by 50 meters long. Sites were then subdivided into treatments 50 meters long by 6 meters wide. Ground agricultural limestone (Calcium Carbonate Equivalent = 98) was applied to the treatment strips at rates of 0, 2, 4, 8 and 12 tonnes per hectare with a dribble lime applicator.

Lime applied was immediately incorporated after application at all sites with a discer, first down the length of the treatments, then across all treatments. Incorporation and mixing occurred to depths of 10 to 15 cm.

The sites were not given any special consideration by the co-operating farmers with regards to fertilizer applications, seeding rates or cultivation. All sites were included in the regular cropping rotation.

The plots were established in August, 1981 on fallow fields, with the following crops being grown over the next five years (Table 2).

Table 2. Crop Selection Information

YEAR	SITES	
	A.J.	L.H.
1981	PLOTS ESTABLISHED	
1982	BARLEY	CANOLA
1983	BARLEY	BARLEY
1984	FALLOW	WHEAT
1985	WHEAT	WHEAT
1986	WHEAT	WHEAT

All sites were sampled for surface pH in the spring and at the time of harvest each year. Sampling depth was 15 cm or the depth of A horizon, whichever was less. As well, all sites were soil tested in the fall for standard analysis.

The pH was determined by using approximately 50 grams of soil (field moisture level) and adding 0.01 m $CaCl_2$ until a 2:1 $CaCl_2$ to soil ratio was attained. The samples were mixed and allowed to equilibrate. pH was measured using an electronic meter and a glass combination electrode. A standard soil, dried and stored in the laboratory, was used to calibrate the pH meter to ensure consistency of pH readings.

The pH readings were converted to pH ratings in water using the following formula:

$$pH(H_2O) = pH(CaCl_2) *0.882 + 1.013$$

Factors (.882) + (1.013) were determined by reading the pH in both $CaCl_2$ and water for selected series of soil samples taken from the liming sites.

Sites were harvested 2 to 3 days before the farmer swathed the field. Five 1-m^2 samples were cut from each treatment. Samples were cut at ground level with each sample being bagged, dried, threshed, and weighed separately. Grain and straw yields were recorded for all treatments. Soil samples for pH were taken at the time of harvest from within each square meter site harvested.

Application of Yield Results to Block of Six Rural Municipalities

Six rural municipalites containing some of the more acid soils in the west central region of the province were chosen as an area where yield results obtained from liming trials could be applied. The selected R.M.'s and area covered by each is provided in Table 3.

Table 3. Rural Municipalities in Study Area

RURAL MUNICIPALITY	ACRES	HECTARES
379 - REFORD	187,385	75 864
380 - TRAMPING LAKE	165,043	66 819
381 - GRASS LAKE	211,448	85 606
409 - BUFFALO	210,598	85 262
410 - ROUND VALLEY	210,080	85 052
439 - CUTKNIFE	193,787	78 456
TOTAL STUDY AREA	1,178,341	477 059

The Soil Survey data files were accessed to provide a breakdown of all soil mapping units used in each rural municipality and the pH distribution of soils within each map unit.

RESULTS AND DISCUSSION

Applications of all rates of lime have increased and maintained pH levels above 6.5 (Table 4). Rates of 12 t/ha and 8 t/ha increased pH levels above 7.0. Increases in pH for all rates of applied lime were statistically significant over the check. Increasing rates of applied lime from 8 to 12 tonne/hectare had no effect on increasing pH values.

Table 4. Soil pH vs Rates of Applied Lime pH Values After 5 Years

RATE (tonnes/ha)	A.J.	L.H.
0	5.8 ± .3	5.8 ± .5
2	6.6 ± .4	6.7 ± .5
4	6.8 ± .4	7.1 ± .4
8	7.4 ± .4	7.5 ± .3
12	7.3 ± .4	7.3 ± .3

Table 5 represents the yields of wheat and barley for different rates of applied lime (5 years data).

Table 5. 5 Year Yield Averages for Wheat and Barley

RATE OF LIME TONNES/HA	GRAIN YIELD KG/HA BARLEY	WHEAT
0	2 690 ± 522	2 555 ± 581
2	2 905 ± 652	2 757 ± 681
4	2 582 ± 697	2 690 ± 610
8	2 905 ± 441	2 690 ± 475
12	2 798 ± 632	2 622 ± 572

No significant yield increases were observed in either wheat or barley, although limed treatments tended to outyield unlimed treatments. Standard deviations for both wheat and barley at all rates of lime were quite high resulting in yields not being significant. Using a Tukey critical range test, differences of 292 kg/ha wheat and 357 kg/ha barley were required between rates of applied lime in order for yields to be statistically significant.

Available Phosphorus

Phosphorus levels for 1986 were significantly higher in the 8 and 12 tonne/hectare treatment strips than the check strip (Table 6). Phosphorus levels were also higher in the 2 and 4 tonne/hectare treatments but values were not significant.

Table 6. Lime Applied vs Available Phosphorus

YEAR	RATE (KG/HECTARE) 0	2	4	8	12
1981	14.0	15.7	14.0	14.0	11.2
1984	20.5	29.5	22.4	23.9	21.6
1986	28.6	31.6	34.5	43.1	43.7

pH - Yield Response Relationship

Using criteria developed from the liming plot results and previous work by Ukrainetz (1984), the following pH classes were established:

1) pH < 5.5 - substantial yield increases for wheat and barley when limed at a 4.4 tonne/hectare rate (Ukrainetz, 1984).

2) pH 5.5 - 6.0 - no significant yield increase for wheat and barley when limed.

- possible yield increase for alfalfa and sweet clover.

3) pH > 6.0 - no yield increase for cereals or forages with liming.

Selected Rural Municipalities

The six rural municipalities in the study area covered approximately 477 000 hectares. Using the pH classes determined above, the area in each class is as follows:

1) 128 800 hectares have a pH less than 5.5

2) 139 200 hectares are between pH 5.5 and 6.0

3) 209 000 hectares have a pH above 6.0

A yield increase for wheat and barley can be expected from liming on 128 800 hectares or on 27% of the soil in the study area.

Data on Scott-Weyburn 3 Map Unit

To determine how pH varies throughout the landscape, individual map units were studied, with one map unit being chosen for a detailed study. The Scott-Weyburn 3 map unit was the most common map unit covering 1/6 of the total study area and was characterized by 1,035 pH samples (Table 7).

Table 7. Characteristics of StWr3 Map Unit

pH Classes	% of Each Class	# of Samples
< 5.5	38.6	399
5.6 - 6.0	27.4	284
> 6.0	34.0	352

Mean pH: 6.0
Total Area: 88 867 hectares

Yield increases can be expected for wheat and barley by liming on 38.6% of this map unit.

pH Variability as Shown by Three Transects

The pH can vary greatly within and between fields even when classified in the same map unit. Figures 1, 2 and 3 show the variability in pH values in fields where the mean pH values ranged from 5.4 to 6.3.

Figure 1 show the variability of pH when the average pH is 5.4. In this field, approximately 75% of the sites sampled had a pH less than 5.5. Compare this value to Figure 2 (ave. 5.8) and Figure 3 (ave. 6.3) where only 50 and 10% of the sites, respectively, fall below pH 5.5. These figures indicate not only the variability of pH between fields but also within fields.

pH VARIABILITY ACROSS A QUARTER SECTION SCOTT-WEYBURN 3 MAPUNIT

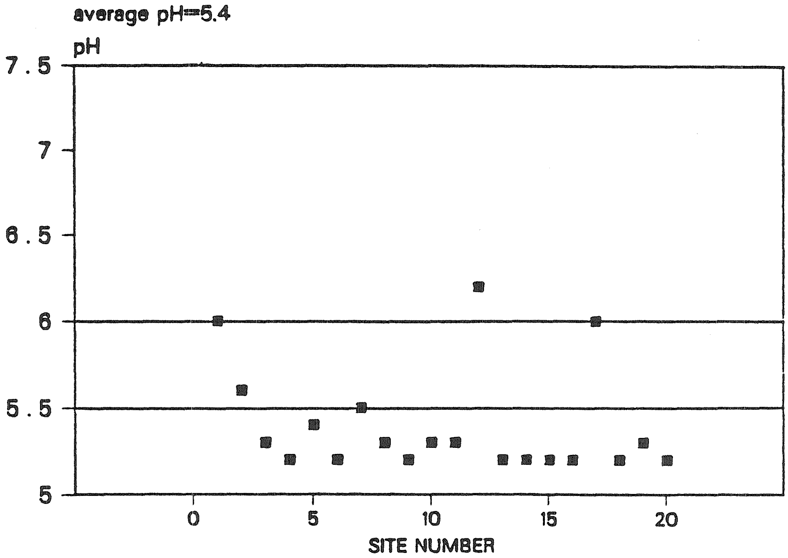

Figure 1. Average pH of field = 5.4

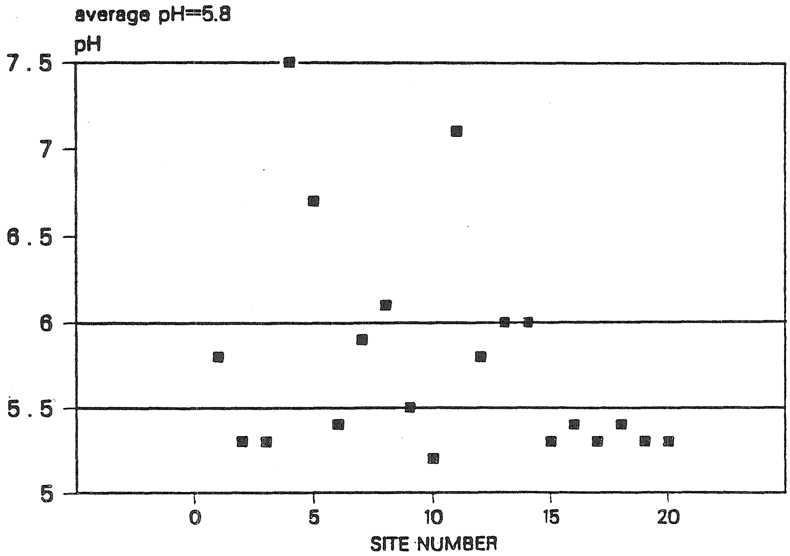

Figure 2. Average pH of field = 5.8

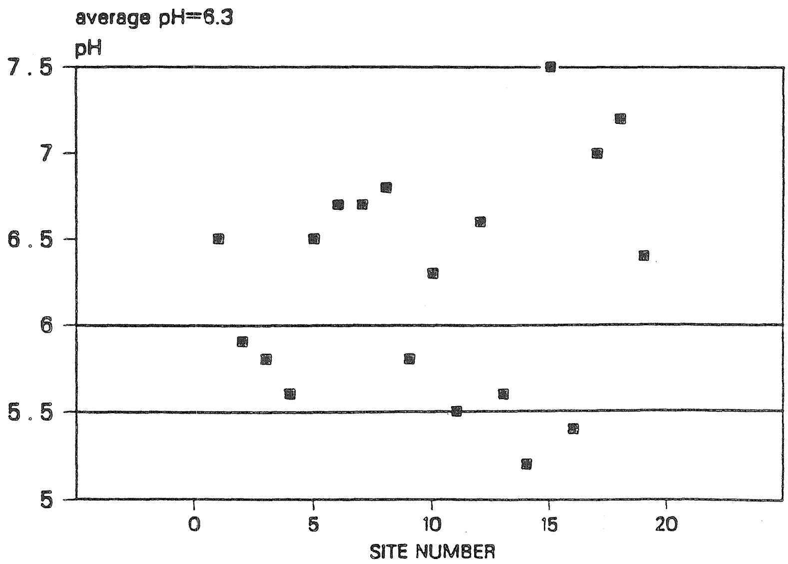

Figure 3. Average pH of field = 6.3

These scatter graphs emphasize the need to carefully ascertain the pH distribution in individual fields. If a pH of 5.5 or less is used to indicate soils which will provide a yield response for wheat and barley when limed, Figures 1, 2 and 3 will show increased yields on 75, 50 and 10% of the soils in each field respectively.

If a field is properly sampled, average pH values may also be a good indication of the overall distribution of pH values in a field.

Summary and Recommendations

Yield Summary:

1) Soils with an initial pH above 5.5 (measured in water) show no significant yield increase for wheat and barley when lime is applied at recommended rates.

2) Soils with an initial pH below 5.5 show substantial yield increases for wheat and barley when lime is applied at recommended rates (Ukrainetz, 1984).

3) Soils with an initial pH above 6.0 show no yield increase in wheat and barley when lime is applied at recommended rates.

Recommendations Regarding Liming

When deciding if and where to lime:

1) Identify the extent and severity of acid soils. Careful sampling of fields is required to determine the proportion of each field that will respond to applications of lime.

As a guide for composite sampling, such as used for soil testing:

- for average pH < 5.5 - 50 to 75 percent of the field will benefit from liming (wheat and barley).

- for average pH 5.5 to 6.0 - 25 to 50 percent of the field will benefit from liming.

- for average pH > 6.0 - less than 25 percent of the field will benefit from liming.

2) Use soil tests to determine the pH of the soil as well as the rate of lime required to raise pH to required levels for crops being grown.

3) Estimate crop response along with the cost of liming to decide if the economics allow for such applications. An application of lime under West Central Saskatchewan conditions may last from 15 to 20 years (Ukrainetz, 1984).

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