Liming for Wheat and Barley on a Scott Loam

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Introduction

Soil acidity is not a significant problem in Saskatchewan, and there are no recommendations for liming of agricultural soils.

A substantial acreage of acid soils occurs in the Wilkie-Scott-Unity area of west-central Saskatchewan, and these soils, in a mixture with other soil types, extend westward to the Alberta border. The area is in the Dark Brown soil zone, and at the Experimental Farm, Scott, the soils have been mapped as shallow lacustrine Elstow overlying till, with the predominant texture as loam and have been designated Scott loam. This soil type occurs in a mixture with the deeper lacustrine profile types of the Elstow association and also with the glacial till Weyburn soils. The most acid Scott loams are generally strongly eluviated, with lime accumulation at approximately 18 to 20 inches depth. The surface pH is generally 5.2 to 5.4, but may be as low as 4.8. Some characteristics and analytical data for this soil located at the Experimental Farm, Scott, are given in Table 1.

The Scott loam soil is phosphate-deficient for most crops, and wheat and barley, particularly, respond strongly to phosphate fertilizer application. Alfalfa does not grow well and is relatively short-lived.

Investigations were initiated in 1963 at the Experimental Farm, Scott, to determine the effects of lime application on yields of wheat and barley, their response to phosphate fertilizers, and to longevity of the liming treatments on the Scott loam soil.

Experimental Methods

The lime requirements for given soil pH changes were determined by a titration method as proposed by Dunn (1). Briefly, the procedure is as follows: 10-gram samples of soil are placed into a series of 250 ml erlenmeyer flasks. Increments of 0.04 N $Ca(OH)_2$ are added to the

Table 1

Chemical and physical analysis data for Scott loam

Depth inches	pH	$NaHCO_3^-$ extr. P lb/ac	Exch. K lb/ac	O.M. %	C.E.C. m.e./100g.	Bulk Density	Sand %	Silt %	Clay %	Moisture Capacity, Pw	
										F.C.	P.W.P.
0- 6	5.2	15	600+	4.94	18	1.04	41.6	46.8	11.6	22.0	8.0
6-12	5.6			2.34		1.31				20.5	9.0
12-18	6.8			2.15		1.40				22.0	11.0
18-24*	7.3			1.05		1.58				22.0	10.0

* Lime accumulation at 18-20 inches.

flasks, beginning with 1 ml and increasing by 1 ml for each succeeding flask. The total volumes are made up to 100 ml with distilled water and 3 drops of chloroform added. The suspensions are allowed to stand in stoppered flasks for four days with thorough shaking twice a day. At the end of this period, the pH values of the suspensions are determined and a titration curve is constructed by plotting pH values against tons of lime per acre on the basis of 5 cc of 0.04 N $Ca(OH)_2$ = 1 ton of pulverized limestone per acre. In these experiments, lime was added to field plots in the form of $Ca(OH)_2$ with the rates adjusted according to the relative efficiencies of the two sources, as follows: $Ca(OH)_2$ = 135% efficiency of $CaCO_3$ (limestone). The lime was applied by broadcasting on the soil surface with a fertilizer spreader and incorporating immediately with a rotovator. The lime treatments applied at rates calculated from the titration method described above tended to slightly overestimate the requirements for a given pH change at the lower levels of application. On one series of plots, lime ($Ca(OH)_2$) was applied and incorporated in the spring of 1963 at rates of 4,400 and 6,000 lb/acre, to raise the surface soil pH from 5.2 to 6.5 and 7.0, respectively. One treatment of gypsum was also applied to provide a rate of Ca equal to that in the lower rate of $Ca(OH)_2$. The effects of several rates of phosphate fertilizer and nitrogen on yields of wheat and barley were investigated on these plots during the period 1963-72. On another series of plots, $Ca(OH)_2$ was applied at 4,400 lb/acre and gypsum at an equivalent rate of Ca, on three different sites in a field in the spring of 1965, fall of 1965, and fall of 1967, respectively. Wheat and barley were the test crops with several rates of P and N fertilizers. In order to determine the effects of higher rates of liming, $Ca(OH)_2$ was incorporated at rates up to 8,000 lb/acre on another series of plots in the fall of 1969. The effects on yields of barley and response to fertilizers were obtained in 1971.

Results

The average results from the experiment in which only one rate of

$Ca(OH)_2$ was applied are shown in Table 2. With both wheat and barley, the check (no lime) yield data show a strong response to phosphate fertilizer and a small additional response to N. The yield increase from the lime treatment without fertilizer was essentially equal to that from 4.0 lb P_2O_5 without lime, but the additional increase from phosphate was considerably less than on the unlimed plots. There

Table 2

Effect of lime and fertilizer treatments for wheat and barley on Scott loam

Fertilizer treatment lb/ac		Grain yield - bu/ac		
N	P_2O_5	Lime**	Gypsum	Check
			Wheat	
5	20	31.1	28.7	28.0
5	40	31.8	30.0	29.5
20	40	31.8	30.6	31.3
0	0 (Check)	29.1	25.5	22.9
			Barley	
5	20	55.9	49.5	50.0
5	40	55.5	51.9	52.9
20	40	58.2	54.0	54.5
0	0 (Check)	52.4	41.0	39.0

* Average of 9 trials on three different sites during 1966-72.

** $Ca(OH)_2$ at 4,400 lb/acre.

appeared to be a small increase in yields from the gypsum treatment, but the efficiency of the phosphate fertilizer may have been slightly decreased.

The average yields of wheat and barley on fallow with and without phosphate fertilizer on the series of plots which received a single application of lime at two rates at the beginning of the experiment are shown in Fig. 1. As in the previous experiment, phosphate fertilizer produced higher average yield increases on the unlimed plots. Yields were further increased substantially by the higher rate of lime, and increases from phosphate fertilizer were approximately equal to the increases at the lower rate of lime. There was a small beneficial effect from gypsum.

The yields obtained in 1972 show a continuing substantial beneficial effect of the lime treatment in the tenth year following application (Fig. 2). However, it would appear that, with barley, the response to phosphate fertilizer is beginning to increase on the limed plots. As shown in Table 3, the percent increase in yield of barley from the phosphate fertilizer treatment was greater than from the lime treatment in 1972. The reverse was observed with wheat.

Table 3

Effect of lime and fertilizer treatments on yields of wheat and barley on Scott loam, 1972

Fertilizer treatment lb/ac		Wheat grain (lb/ac)			Barley grain (lb/ac)		
N	P_2O_5	No Lime	Lime*	% Incr.	No Lime	Lime*	% Incr.
0	0 (Check)	805	1406	74.5	1626	2178	34.0
5	40	1334	1692	26.5	2373	2778	17.2
% Increase		65.7	20.5		46.0	27.5	

* $Ca(OH)_2$ applied at 6,000 lb/ac in spring of 1963.

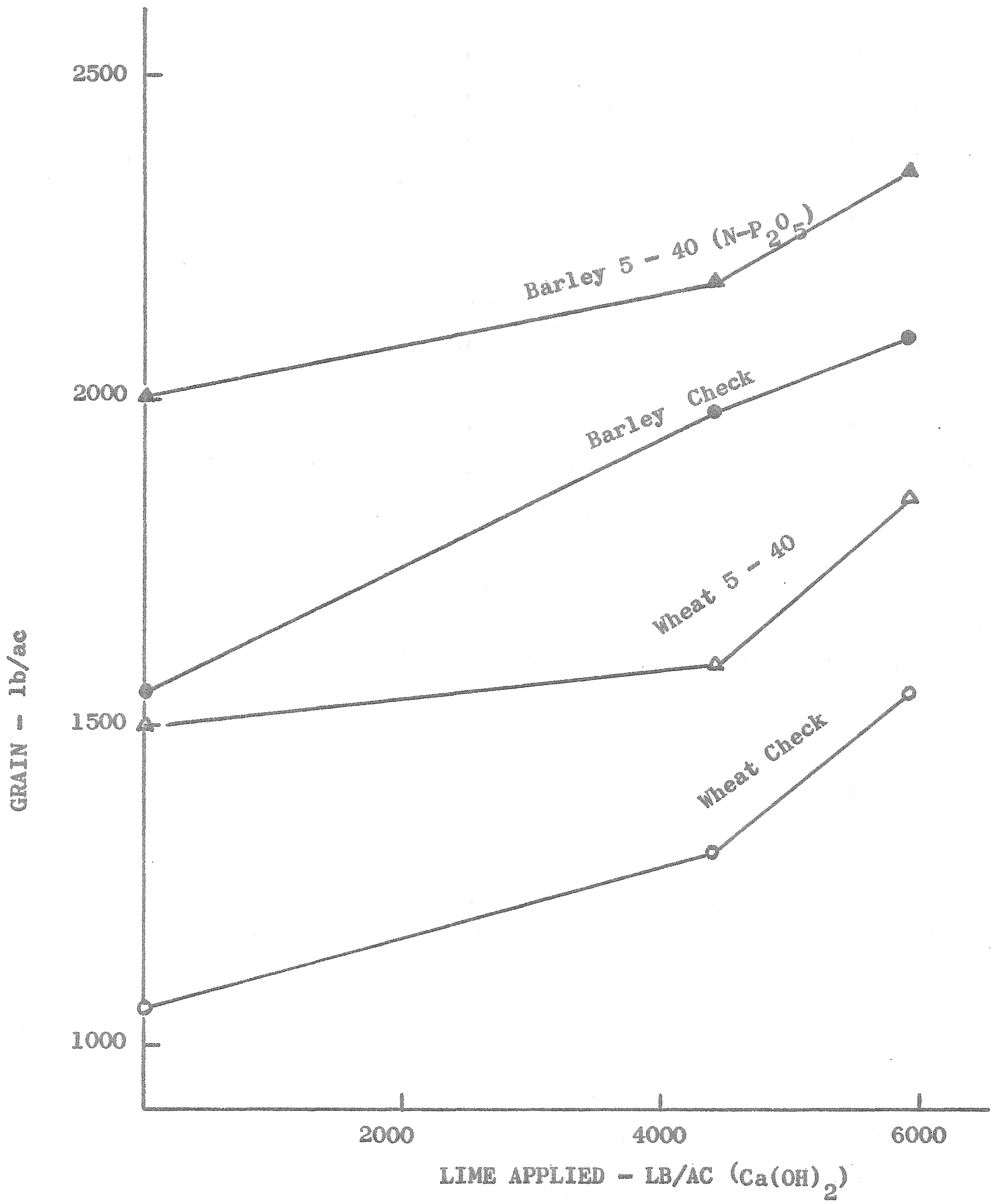

FIGURE 1. The effect of lime and fertilizer application on yields of wheat and barley grain on Scott loam. Average of 5 trials during 1963-72 on fallow.

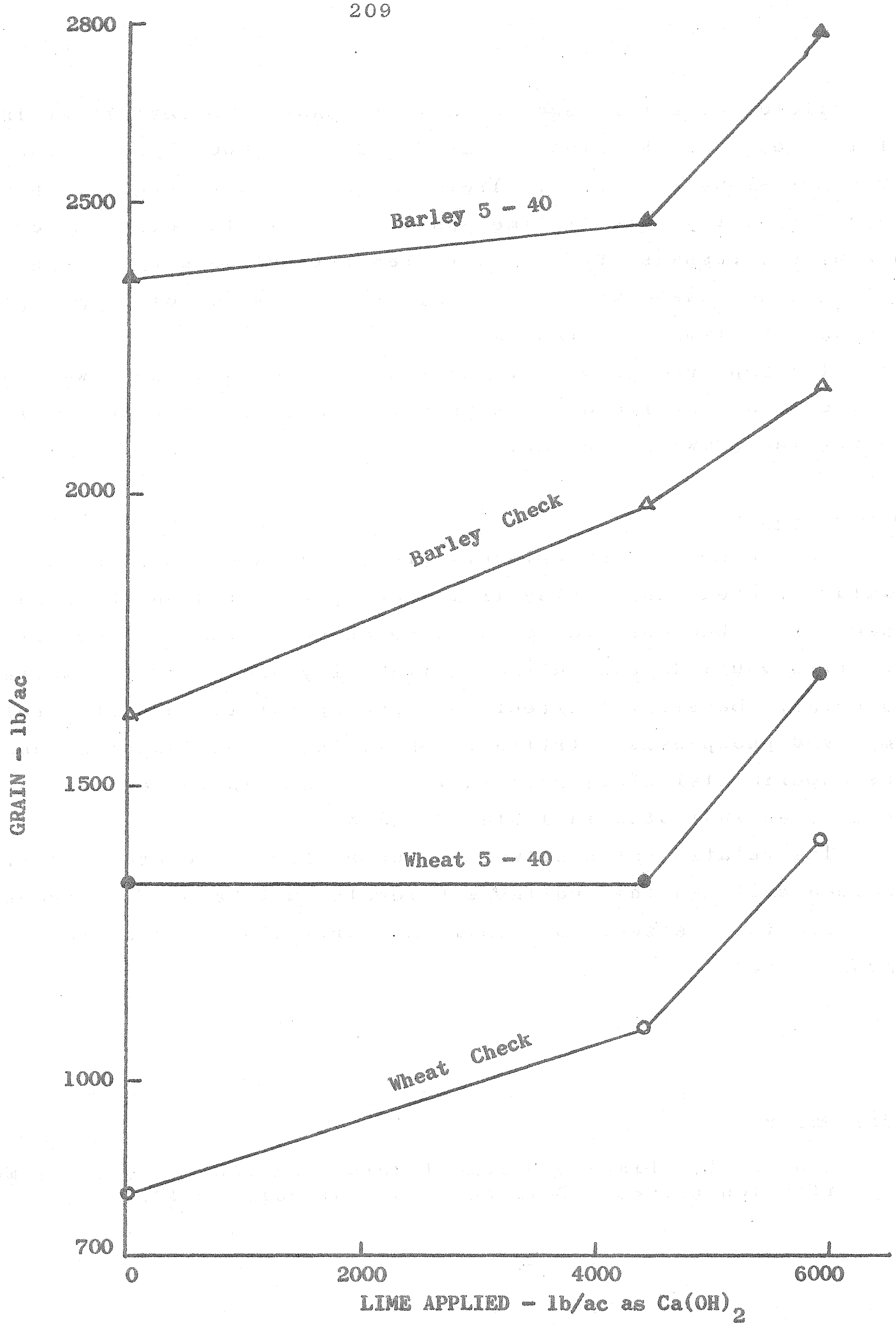

FIGURE 2. The effect of lime and fertilizer application on yields of wheat and barley on Scott loam, 1972. Lime applied in spring of 1963 and wheat seeded on fallow in 1972.

Yields of barley and response to phosphate fertilizer in 1971 on plots treated with rates of $Ca(OH)_2$ up to 8,000 lb/ac in the fall of 1969 are shown in Fig. 3. Yields of barley were sharply increased with each increasing rate of lime applied. As in the other experiments discussed, response to phosphate fertilizer was greatest on the unlimed soil and decreased with the first two increments of lime applied as the response to liming increased.

The improved growth of wheat and barley and the lower response to applied P on the limed plots were generally visible on the field plots during the growing seasons.

Discussion

The results of experiments presented show a marked increase in yields of wheat and barley from lime application on the acid Scott loam soil. Whether liming would be an economical and profitable practice would depend on the availability and cost of a suitable lime material. Beneficial effects of lime appear to be partly related to improved phosphorus nutrition. Analysis of soil samples taken from the experimental plots show that liming has increased available P levels, as indicated in Tables 4 and 5.

The relationships between soluble aluminum content in limed and unlimed soil and the available P levels, uptake of P by crops, and possible toxic effects of aluminum, particularly on barley, are being investigated.

References

1. Dunn, L. E. Lime-requirement determination of soils by means of titration curves. Soil Sci. 56:341-351. 1943.

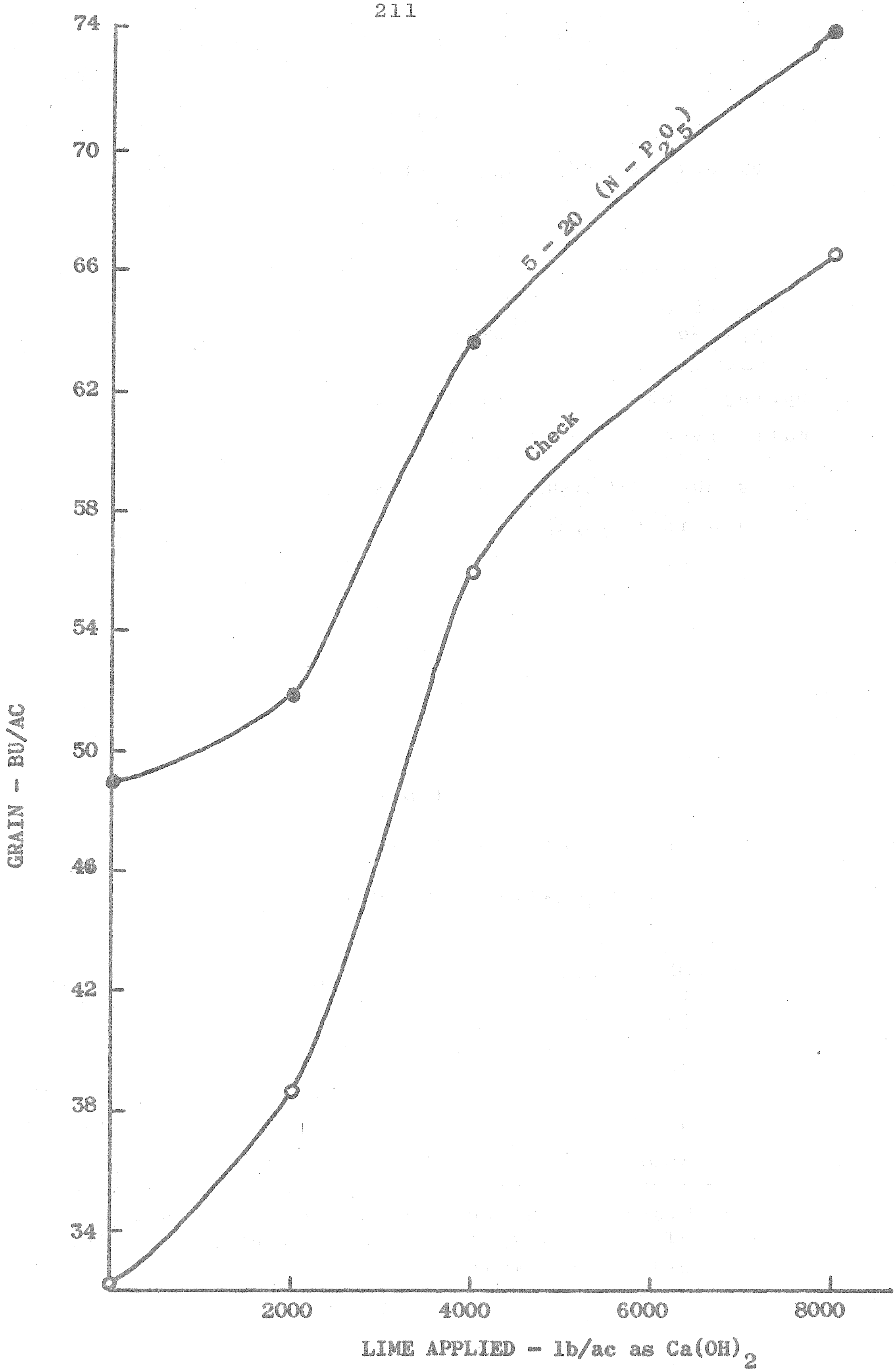

FIGURE 3. The effect of lime rate and fertilizer on yields of barley on Scott loam, 1971.

Table 4

Effect of lime application on $NaHCO_3$-extractable P in Scott loam

Date lime applied	Date samples	lb/ac P*	
		Check	Limed**
Spring, 1965	Spring, 1967	7	32
Fall, 1965	Spring, 1967	19	29

* 4,400 lb $Ca(OH)_2$ per acre.

** 0-6 inch depth.

Table 5

Effect of lime application on pH and $NaHCO_3$-extractable P in Scott loam.*

$Ca(OH)_2$ applied (lb/ac)	pH	lb/ac P
0 Check	5.3	18
2000	5.8	16
4000	6.5	29
8000	7.4	29

* $Ca(OH)_2$ applied and incorporated in fall of 1969; samples taken in spring of 1971; prior to seeding.