The Effect of Lime and Various Fertilizers on Winter Barley In A Rotation With Sweet Clover

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The Effect of Lime and Various Fertilizers on Winter Barley In A Rotation With Sweet Clover

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This publication reports a 21-year study of the effect of various fertilizers and lime on grain and straw production of winter barley grown in a four-year rotation with biennial sweet clover. During seven of these years, data also were taken on the effect of superphosphate and rock phosphate on production of forage for winter grazing.

The experimental plots were located on the Oklahoma Station's Perkins Farm, nine miles south of Stillwater.

Experimental Plan and Conditions

Soil

The plots were located on Norge loam, a moderately deep, medium textured soil with a moderately permeable subsoil. The available mineral phosphate was low. Organic soil phosphorus had been high under virgin conditions, but had been reduced under cultivation to a level below the quantity needed for the maximum yield of many cool season crops.

This series of plots had been used in 1931 and 1932 to study the effects of different phosphate fertilizers on the production of biennial sweet clover. In that study, basic slag, rock phosphate, superphosphate, and mixed fertilizers had been applied at rates of 200 to 400 pounds per acre. These phosphate treated plots were used for the various phosphate treatments in this experiment. The unfertilized plots in the earlier experiment were used as checks.[2]

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[1]S. C. Wallen, foreman at the Perkins Farm supervised the planting and harvesting of the crops grown in this experiment after 1937.

[2]In the intervening years, corn had been planted in 1933, oats in 1934 and corn in 1935, on all plots. The 1933 season was very unfavorable for corn, and the maximum yield was 3.4 bushels per acre. No yield data were taken in 1934 and 1935.

Research reported herein was conducted under Oklahoma Station Project No. 169.

Fertilizer Treatments

Six fertilizer treatments were compared. Two checks were used, one limed and the other with no treatment. Thus there was a total of eight, as follows:

Checks:

(1) No treatment.

(2) Limestone only.

Fertilizer Treatments:

(1) Superphosphate.

(2) Rock phosphate.

(3) Barnyard manure.

(4) Barnyard manure and superphosphate.

(5) Barnyard manure and rock phosphate.

(6) Superphosphate and muriate of potash.

All plots except the untreated checks were limed in July, 1936, using two tons of agricultural limestone per acre. This treatment was repeated in 1946. About 40 percent of the lime would pass through a 60-mesh sieve. All fertilizer treatments were applied in the fall of 1936 and repeated every fourth year thereafter. The fertilizers were always applied in the fall, before the barley was planted.

Superphosphate and rock phosphate were applied with a fertilizer drill at the rate of 120 pounds of P_2O_5 per acre, and disked into the soil. The muriate of potash was broadcast at the rate of 200 pounds per acre.

Barnyard manure was applied at the rate of 60 pounds of nitrogen per acre, usually before the land was plowed.

About two tons of sweet clover residue per acre was returned to the soil every fourth year on the fertilized plots. The production of sweet clover was low on unfertilized plots and on plots treated only with lime. Usually the sweet clover residue was disked or plowed into the soil soon after the seed had been harvested with a combine.

Rotation, and Plot Plan

The plots were arranged in four blocks, with one block being in second-year sweet clover every fourth year. Barley was planted in all blocks in the fall of 1936. In three of the blocks, it was seeded in 7-inch

drill rows. In the fourth, the drill rows were spaced 14 inches apart and sweet clover was planted the following spring.

Within each block, each fertilizer treatment was replicated twice. Consequently the effect of each treatment could be observed on six plots each year.

Varieties Grown

Michigan Winter barley was planted from 1937 through 1953.[3] Harbine barley was grown during the last four years of the experiment.

The sweet clover was biennial Madrid Yellow.

Methods of Planting and Harvesting

In plots where sweet clover was to be planted the following spring, barley was seeded in 14-inch drill rows to provide a more favorable condition for growth of sweet clover seedlings.[4] Seeding rate in these plots was one bushel per acre until 1941, when it was increased to 1½ bushels because the lower rate had not provided a sufficient number of tillers to produce a good grain yield during some seasons. Barley was planted in 7-inch drill rows on the other plots, at the rate of 2 bushels per acre.

The time of planting barley usually was the first week in October. It was planted parallel with the terraces to provide a better utilization of runoff water.

All plots were harvested with a binder except in 1957, when a combine was used. Straw weights were obtained by subtracting the weight of grain from the total weight of grain and straw harvested from each plot.

Seasonal Variations

Yields in 1941 were low, especially in that part of the field where a 14-inch row-spacing was used. The vitality of the barley seed was weakened by hot water treatment before planting, to control loose smut; and cold weather in November killed many of the young plants.

Greenbug damage was severe in 1951. In other years portions of some plots were affected by this insect. Chinch bugs caused some damage in 1946.

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[3]Year dates used throughout this publication are year of harvest unless otherwise specified; e.g., 1937 refers to the crop planted in the fall of 1936 and harvested in 1937.

[4]See Okla. Agri. Exp. Sta. Bul. 298, "Wide row planting of small grains to establish sweet clover and lespedeza," by Horace J. Harper (June, 1946).

Poor crops of barley were produced on all plots in 1943 and from 1954 through 1956 because of below average rainfall in fall, winter and early spring.

Results and Discussion

Table 1 shows the annual yields of barley grain on the variously fertilized plots. Table 2 contains information on the average yields of barley straw for the same treatments. These are averages of 6 plots per treatment except in the case of the superphosphate-and-potash treatment, which is the average of 18 plots.[5]

Fertilizer Effects With and Without Sweet Clover

Since the rotation was not established on all four blocks until after 1940, it was possible during the period 1937 through 1940 to compare the effect of the various fertilizer treatments before sweet clover residues were returned to the soil. The data are shown in Table 3. These yields are high because 1937 through 1940 happened to be a succession of good barley years. Weather was favorable for plant development, and there was little or no insect injury. However, the relative differences among the fertilizer treatments were similar to those obtained after sweet clover had been established in the cropping system, with one exception. Rock phosphate, prior to the growth of sweet clover, showed only a slight advantage over limestone (0.2 bushels per acre, or less than 1 percent).

[5]These plots were replicated six times in each block to permit addition of treatments using commercial nitrogen and/or minor elements if they appeared to be needed. However, high yields in favorable seasons indicated that soil organic matter and sweet clover residues were providing adequate nitrogen, and that the soil was not seriously lacking in any trace element.

Table 1.—Average yields of barley grain over a 19-year period on limed plots variously fertilized in a four-year rotation with sweet clover; Perkins Farm, 1939-1957.

(Bushels per acre)

Year	No treatment	Lime only	Superphosphate	Rock phosphate	Barnyard manure	Manure and superphosphate	Manure and rock phosphate	Superphosphate and potash
1939*	19.7	28.6	28.9	29.1	28.9	29.8	24.3	31.2
1940**	14.4	25.4	41.6	39.2	39.7	45.2	41.8	41.0
1941†	8.3	10.4	15.5	14.5	11.9	11.0	12.5	14.1
1942	13.8	19.9	35.5	27.8	39.6	45.8	42.2	39.7
1943	1.7	3.0	7.5	7.7	6.5	8.9	8.1	7.6
1944	12.1	18.5	35.7	37.6	37.5	46.9	44.7	39.1
1945	16.5	24.9	33.8	32.2	34.8	39.1	34.6	36.7
1946	4.7	4.3	10.9	9.2	9.6	13.0	12.5	10.3
1947	8.2	8.6	15.2	14.3	16.5	21.3	19.8	18.9
1948	4.8	4.8	14.6	20.6	12.8	26.8	27.8	18.0
1949	27.3	18.2	48.9	39.9	46.2	51.8	46.1	49.9
1950	15.3	14.1	26.5	28.0	28.5	30.4	33.7	26.2
1951	4.8	4.4	9.8	10.4	10.9	14.5	12.5	11.5
1952	16.3	15.3	30.2	28.9	28.4	34.3	32.2	29.7
1953	14.7	17.0	38.3	29.8	31.4	40.0	35.7	33.5
1954	6.0	5.6	5.0	6.0	7.2	6.1	6.3	6.5
1955	5.7	6.2	6.1	5.0	6.9	5.0	4.2	5.3
1956	7.5	8.2	10.5	10.1	11.1	9.8	9.0	11.2
1957	34.5	35.8	40.0	39.5	41.4	38.7	38.7	42.3
Avg.	12.4	14.4	23.9	22.6	23.7	27.3	25.6	24.9

*Average of 2 plots.
**Average of 4 plots.
†Average of 6 plots in 1941 and all following years.

Table 2.—Average yields of barley straw over an 18-year period on limed plots variously fertilized in a four-year rotation with sweet clover; Perkins Farm, 1939-1956.

(Pounds per acre)

Year	No treatment	Lime only	Superphosphate	Rock phosphate	Barnyard manure	Manure and superphosphate	Manure and rock phosphate	Superphosphate and potash
1939*	1133	1220	1820	1780	1503	1713	1745	1693
1940**	681	1095	1592	1528	1585	1895	1782	1653
1941†	996	840	1553	1470	1376	1746	1647	1538
1942	482	811	1598	1158	1760	2028	1987	1767
1943	90	148	712	661	557	731	727	649
1944	404	654	1323	1396	1306	1788	1798	1380
1945	1426	1499	2512	2382	2664	3052	3012	2480
1946	206	321	575	546	542	729	726	680
1947	450	560	1163	1083	1082	1702	1622	1343
1948	361	306	679	1069	856	1337	1240	898
1949	956	774	2295	1585	2070	2787	2262	2418
1950	881	846	1337	1390	1417	1414	1594	1297
1951	235	236	891	826	874	1263	1050	909
1952	528	544	1466	1140	1289	1526	1544	1407
1953	744	745	1998	1646	1569	2142	1914	1770
1954	220	334	242	235	268	366	362	405
1955	490	420	518	559	414	417	471	577
1956	313	394	445	438	515	552	475	526
Average	588	652	1261	1160	1202	1455	1442	1299

*Average of 2 plots.
**Average of 4 plots.
†Average of 6 plots in 1941 and all following years.

Table 3 contains information on the yields of barley grain and straw before sweet clover was grown in the cropping system; and Table 4 contains information on the yield of barley the first, second and third years following sweet clover.

Table 3.—Average yields of barley grain and straw on limed plots variously fertilized, before sweet clover was grown in the cropping system; Perkins Farm, 1937-1940.

Year	No treatment	Lime only	Superphosphate	Rock phosphate	Barnyard manure	Manure and superphosphate	Manure and rock phosphate	Superphosphate and potash
				Grain (bushels per acre)				
1937*	20.4	19.6	28.1	21.5	25.0	34.0	29.4	29.9
1938*	27.8	30.3	37.7	32.5	40.1	42.0	39.1	38.9
1939**	32.3	38.2	45.8	35.9	41.3	46.5	47.1	48.6
1940†	12.3	17.3	21.3	16.0	18.2	19.7	17.4	17.9
Average	23.2	26.3	33.2	26.5	31.1	35.5	33.2	33.8
				Straw (pounds per acre)				
1937*	945	911	1545	898	1531	1661	1525	1476
1938*	1123	1440	1566	1329	1941	2245	2011	1888
1939**	1221	1405	1851	1399	1495	1959	1728	1948
1940†	696	785	995	765	845	827	855	893
Average	996	1135	1489	1098	1453	1673	1529	1551

*Average of 6 plots.
**Average of 4 plots.
†Average of 2 plots.

Table 4.—Average barley yields the first, second and third year following sweet clover, on limed plots variously fertilized; Perkins Farm, 1941-1957.

(Bushels per acre)

Soil Treatment	Grain Yield First year after sw. clover	Second year after sw. clover	Third year after sw. clover*
None	14.6	12.0	9.5
Lime only	15.1	12.4	10.5
Superphosphate**	23.0	23.9	20.9
Rock Phosphate**	23.6	22.4	18.0
Barnyard manure**	23.8	23.1	20.3
Manure and superphosphate**	27.6	26.7	24.1
Manure and rock phosphate**	25.8	28.2	23.1
Superphosphate and potash**	24.6	23.3	21.8

*Barley planted in 14-inch rows. First-and second year plots in 7-inch rows.
**These plots were limed.

Fertilizer Effects in Rotation With Sweet Clover

After the rotation was established and sweet clover residues had been returned to the soil on all blocks, the advantage of rock phosphate was 8.2 bushels (57 percent) over the limed checks. The advantage for superphosphate was 9.5 bushels (66 percent).

Where manure was used with the phosphate fertilizers, the yields were increased an additional 3.4 and 3.0 bushels per acre for the superphosphate and rock phosphate treatments, respectively. This emphasizes the importance of an adequate supply of available nitrogen for barley production.

Increases in straw production in general paralleled those for grain production, for the various treatments.

Winter Forage Production

Winter forage production on four of the treatments was determined from 1944 through 1950 by clipping the forage from a portion of each plot. Table 5 shows the air-dry forage weights, average protein production, and phosphorus content.

Phosphate fertilization increased both the quantity of forage and the phosphorus content.

Yields in 7-inch and 14-inch Rows

Table 4 compares the yields obtained in 7-inch rows the first and second year after sweet clover[6] with those obtained in 14-inch rows the third year after sweet clover residues were turned under. The differences between spacings for the various treatments are all statistically significant at the 1 percent level.

Relation of Yield Increases to Costs

Table 6 compares the value of the barley grain yield with the costs of planting, harvesting and fertilizing the crop, for the various treatments. No income from winter grazing was included in making the calculations.

Barley yields on the unfertilized check plots were too low to cover the costs of planting and harvesting in 15 of the 21 years. On the limed checks, it was too low to pay the cost of planting, harvesting and liming in 13 of the 21 years. On the fertilized plots, it was too low to pay the

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[6]No statistically significant difference was obtained at the 1 percent level between the first and second years for any of the treatments.

Table 5.—Relation of phosphate fertilization to winter forage production and composition of Michigan Winter barley; Perkins Farm, 1944-1950.*

Soil Treatment	Average yield of dry clippings (pounds per acre)								Average protein production (lb./A.)	Average phosphorus content (percent)
	1944	1945	1946	1947	1948	1949	1950	Avg.		
None	215	429	343	151	99	286	260	255	60	0.17
Lime only	380	782	259	261	129	276	319	344	80	0.15
Lime and superphosphate	638	1409	815	594	341	1072	625	785	164	0.23
Lime and rock phosphate	555	1263	649	580	333	649	511	649	146	0.21

*Plots clipped once, on March 20.

cost of planting, harvesting, and fertilizing in either 8 or 9 years, for all treatments.

Table 6.—Value of barley grain and costs of planting, fertilizing and harvesting for various fertilizer treatments in four-year rotation with sweet clover; Perkins Farm, 1937-1957.

Soil Treatment	Avg. annual yield needed to pay costs of planting, fertilizing and harvesting (bushels per acre)	Average annual acre value above costs (dollars)	Number of years out of 21 value was less than costs
None	16	- 3.51	15
Lime only*	17	- 3.12	13
Superphosphate**	19	3.88	9
Rock phosphate**	18	3.79	8
Barnyard manure**	18	5.13	9
Manure and superphosphate**	21	5.27	8
Manure and rock phosphate**	18	5.58	8

*Every 10 years, other treatments every fourth year.
**These plots were limed.

Summary

The effect of various fertilizers on the yield of winter barley grown in a 4-year rotation with sweet clover on Norge loam was studied on the Oklahoma Agricultural Experiment Station's Perkins Farm from 1937 to 1957.

The average yield of barley was increased by all fertilizer treatments.

The increase in barley yields obtained from 1937 to 1940 from plots where different fertilizers were applied before sweet clover was grown on them was similar to increases obtained after sweet clover had been grown except on plots fertilized with lime and rock phosphate.

Before the sweet clover was grown, the average yield of barley on the plots fertilized with lime and rock phosphate was only .2 bushel more per acre than was obtained on the limed plot, as compared with 6.9 bushels of grain per acre from plots fertilized with lime and superphosphate. After sweet clover residues were returned to the soil, the average yield of barley on plots where lime and rock phosphate were applied was 8.4 bushels per acre higher than on plots treated with lime alone.

The average yield of barley where sweet clover residues were returned to plots fertilized with lime and superphosphate was 9.1 bushels

per acre. Lime and manure plus sweet clover residue produced an average barley yield that was 9.3 bushels higher than the yield obtained on the limed plot. Superphosphate, manure, and limestone only produced 1.0 bushels more barley per acre than was obtained on plots fertilized with lime and manure.

The yield of barley clippings obtained in late March on plots fertilized with superphosphate and lime for the 7-year period, 1944-1950, was more than three times as high as that produced on unfertilized soil and 21 percent higher than that obtained on plots fertilized with rock phosphate and lime.

The average yield of barley planted in 14-inch rows to obtain a better stand of sweet clover on plots fertilized with manure, lime, and superphosphate was 24.1 bushels per acre the third year after sweet clover as compared with 26.7 bushels per acre from barley planted in 7-inch rows the second year after sweet clover, for the 21-year period.

A similar reduction in the average yield of barley planted in 14-inch rows as compared with 7-inch rows was obtained on limed plots fertilized with superphosphate or rock phosphate, alone and with manure. The root system of barley plants does not efficiently utilize all the soil space in 14-inch rows.

Information is presented on the yields necessary to meet costs of planting, harvesting, and fertilization.

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