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A Comparison of Blast Furnace Slag and Limestone as a Soil Amendment

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INTRODUCTION

Blast furnace slag is defined by the American Society for Testing Materials as "The nonmetallic product consisting essentially of silicates and alumino-silicates of lime, and of other bases, which is developed simultaneously with iron in a blast furnace." Agricultural values of blast furnace slag are generally believed to be a liming material because of its calcium and magnesium content and a potential source of "minor" or "trace" elements.

Farmers in Ohio are requesting information as to the crop-producing value of blast furnace slag and the type and grades to use. This investigation was undertaken to provide that information to answer many of the questions asked relative to its use.

REVIEW OF LITERATURE

In 1916, Ames (1) and Schollenberger (6) compared the relative effects of silicate slags and precipitated calcium carbonate on the growth of red clover and on soil reaction. They concluded that blast-furnace slag was not as efficient as precipitated calcium carbonate in increasing crop yields or in neutralizing soil acidity.

White, et al. (8) in 1937 published results of studies on the agricultural value of blast-furnace slag for Pennsylvania soils. The tests indicated that on the basis of calcium and magnesium applied, 20-mesh granulated slag is somewhat better than 20-mesh limestone. They state that slag is like all forms of basic lime in that its immediate value is dependent upon fineness so that there is a maximum surface exposure over a unit area. MacIntire and associates (3, 4) indicate that granulated slag is a more desirable product for agricultural use than the air-cooled slag as shown by the growth of clover in greenhouse studies.

Tiedjens (7) points out that blast-furnace slag can be used more freely than limestone because it does not raise the pH or sweeten the soil as rapidly as limestone. This would suggest that "over-liming" injury may be avoided by the use of blast-furnace slag. Naftel (5) working on crimson clover in Alabama obtained similar results and attributed part of the crop increases to the boron content of the slag used. Carter, et al. (2) concluded that on Lloyd and Norfolk soils two tons of slag produced alfalfa yields equal to those from two tons of limestone. Slag used on soils that were boron deficient produced better yields than did limestone without borax.

METHODS AND MATERIALS

Granulated slag (water quenched), air-cooled slag and dolomitic limestone were fractionated into separate size groups and these fractions recombined in three gradings similar to the grading analyses of "agricultural screenings", "agricultural meal", and "agricultural ground", liming materials marketed in the state of Ohio. Sieve analyses of the prepared materials as used are shown in Table 1.

TABLE 1.—Particle Size Distribution of Liming Materials Used in Slag Experiments

	Total percent passing								
	Screenings*			Meal*			Ground*		
Sieve size No.	Granulated slag	Air-cooled slag	Limestone	Granulated slag	Air-cooled slag	Limestone	Granulated slag	Air-cooled slag	Limestone
	Wooster, Wayne County, Ohio								
8	95.4	91.6	92.2	96.6	92.8	94.0	98.4	96.2	96.0
20	54.0	54.6	42.0	67.6	63.6	58.6	83.6	81.6	80.0
40	30.4	35.6	25.0	50.2	50.0	42.4	74.4	73.8	69.5
60	20.6	23.2	18.2	39.6	39.6	33.8	63.6	63.8	58.5
100	14.8	14.6	14.4	29.4	27.8	28.4	48.8	48.2	48.5
	Canfield, Mahoning County, Ohio								
8	97.8	98.2	92.8	98.4	97.8	94.2	99.2	97.6	97.8
20	63.0	56.8	46.0	73.0	65.0	56.4	82.8	76.6	76.0
40	34.0	35.0	26.8	51.0	50.0	41.2	69.2	69.0	66.4
60	21.0	20.4	16.2	39.2	39.2	33.0	60.6	62.8	60.0
100	14.0	11.4	10.8	28.6	28.2	27.6	48.8	50.4	49.6
	St. Clairsville, Belmont County, Ohio								
8	98.8	93.8	92.8	98.8	96.0	96.0	99.4	98.8	97.2
20	68.4	44.4	46.0	75.6	58.0	56.0	87.2	80.4	71.2
40	37.2	28.4	26.8	52.6	46.0	40.6	75.4	73.4	63.4
60	20.8	19.2	16.2	38.6	37.4	32.4	65.0	63.8	55.8
100	13.4	12.6	10.8	28.0	27.6	26.6	50.2	48.6	47.4

*Refers to a grade of liming material defined by Ohio Lime Law.

The chemical analysis of each type of liming material is shown in Table 2. Calcium carbonate equivalence was computed from the lime (CaO) and Magnesia (MgO) content of each liming material.

Chemically, all the liming materials used are representative products marketed in large quantities in the state of Ohio for soil amendment.

Three types of experiment were conducted:

First: Field Tests. Field experiments were conducted on Canfield silt loam and Meigs and Mahoning clay loam soils. The liming materials described in Tables 1 and 2 were used at different rates on the soil at three locations. Experiments on the Canfield silt loam were started by making a summer seeding of an alfalfa-timothy meadow. This meadow was harvested twice each year for two years and then turned under for corn. Both hay and corn yields were obtained and the soil was sampled for pH determinations.

Field experiments on the Meigs and Mahoning soils, made at the Belmont and Mahoning County Experiment Station Farms, were similar to the Wooster experiment with the exception that higher rates of application of slags and limestones were used. Two experiments were started at the Belmont and Mahoning County Experiment Station Farms in 1946; however, both failed because of soil variation and poor drainage. In 1950 these experiments were successfully established.

TABLE 2.—Chemical Composition of Liming Materials Used in Slag Experiments

Type of Material	Percentage Composition							
	SiO_2	Al_2O_3	CaO	MgO	S	FeO	MnO	$CaCO_3$ equiv.
	Wooster, Wayne County, Ohio							
Granulated slag	34.1	10.6	45.6	6.9	1.0	1.2	0.9	98.5
Air-cooled slag	35.0	11.4	41.7	5.8	1.3	0.8	0.9	88.9
Dolomitic limestone	3.2	0.7	29.8	20.2	—	0.4	—	103.5
	Canfield, Mahoning County, Ohio							
Granulated slag	33.2	12.5	43.8	7.1	1.5	0.5	0.5	95.8
Air-cooled slag	35.6	12.0	41.1	6.4	1.4	0.4	0.9	89.3
Dolomitic limestone	2.1	0.5	33.5	17.6	0.2	0.2	—	103.4
	St. Clairsville, Belmont County, Ohio							
Granulated slag	31.3	12.7	44.8	6.7	1.8	0.4	0.5	96.5
Air-cooled slag	34.5	11.7	42.1	7.2	1.5	0.4	0.6	93.1
Dolomitic limestone	2.1	0.5	33.5	17.6	0.2	0.2	—	103.4

Second: Pot Tests for pH Determinations. Pot tests were conducted in which various rates of each liming material were added to Wooster silt loam. After thoroughly mixing the liming material and soil together, the pots were retained in a fallowed condition at uniform temperature for a period of 20 months. A uniform moisture content was maintained in all pots by weighing and adding water about twice a week. Soil pH determinations were made periodically for 20 months.

Third: Pot Tests for Crop Yields. Experiments were conducted in three-gallon greenhouse pots. Four-, eight- and twelve-ton rates per acre of the liming materials were used on Trumbull silty clay loam soil. Alfalfa was used as the test crop and seven cuttings were made. Soil pH determinations were made at the time of the last harvest.

TABLE 3.—Yields of Mixed Hay from First and Second Year Cuttings on Liming Materials Experiment, Wooster, Ohio

Grade of liming materials	Granulated slag			Air-cooled slag			Limestone	
	Application, Tons per Acre							
	2	3	4½	2	3	4½	2	3
	First year meadow—1947							
	Pounds per acre hay							
Screenings	5952	6671	6504	5139	6126	6457	4995	5259
Meal	6703	6990		5355	6439		5918	6732
Ground	6807	7179		5989	6590		6543	6203
Average	6487	6946		5494	6385		5818	6064
	Check—no lime—lb./A. 4615							
	Second year meadow—1948							
Screenings	7487	8247	7836	7026	7217	7487	6849	7583
Meal	8159	8202		7101	7638		7905	7114
Ground	7889	7734		6909	8050		7572	7682
Average	7845	8061		7012	7635		7442	7459
	Check—no lime—lb./A. 4145							
	Average of 1947 and 1948							
Screenings	6719	7459		6082	6671		5922	6421
Meal	7431	7596		6228	7038		6911	6923
Ground	7348	7456		6449	7320		7056	6942
Average	7166	7503		6253	7010		6630	6751
Total average	7334			6631			6695	
	Check—no lime—lbs./A. 4380							

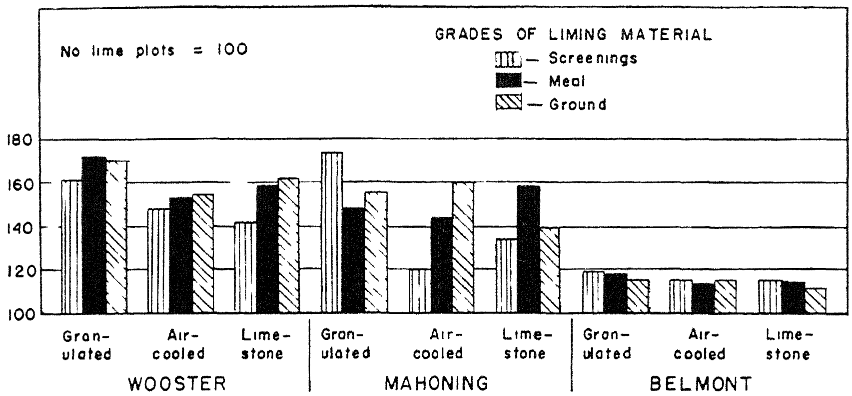


FIG I —— Relative Hay Yields from Applications of Equal Amounts of Granulated Slag, Air-cooled Slag and Limestone.

EXPERIMENTAL RESULTS AND DISCUSSION

Field Experiments with Various Liming Materials

In all experiments granulated slag, air-cooled slag and dolomitic limestone were compared at various rates and gradations of liming materials. Both corn and hay yields were obtained at the Wooster location, whereas only hay was taken at the Belmont and Mahoning

TABLE 4.—Corn Yields in Bushels per Acre. Slag Experiment, Wooster, Ohio

	Granulated slag		Air-cooled slag		Limestone	
	Tons/A.	Bu./A.	Tons/A.	Bu./A.	Tons/A.	Bu./A.
Screenings	2	99.2	2	90.6	2	96.4
	3	102.2	3	107.3	3	93.9
	4½	101.1	4½	102.8		
Average of 2 & 3 tons		100.7		99.0		95.1
Meal	2	102.3	2	94.6	2	101.4
	3	108.4	3	114.8	3	107.6
Average		105.3		104.7		104.5
Ground	2	102.2	2	91.5	2	101.9
	3	104.8	3	110.7	3	93.9
Average		103.5		101.1		97.9
Total average		103.2		101.6		99.2

Check—no lime—Average bu./A. 102.6

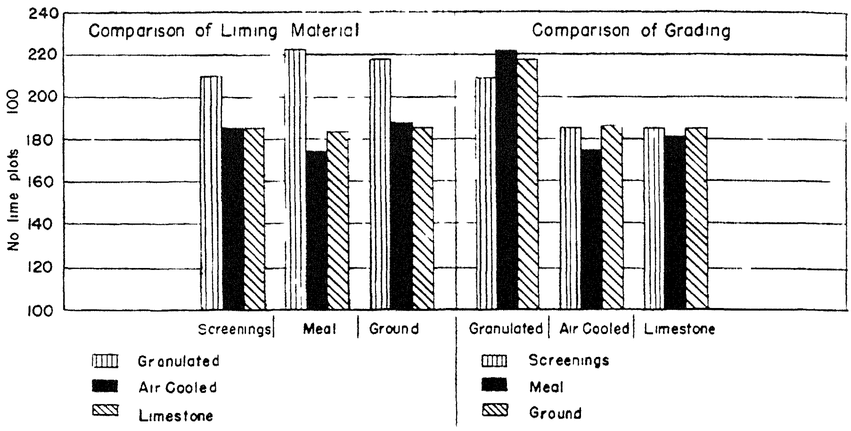


FIG 2 — Yields of Alfalfa in Greenhouse Pot Experiment Comparing Slags and Limestone, 4 and 8 Ton Rates — Wooster, Ohio 1949.

County locations. The results of the field experiments are shown in Tables 3 to 8, inclusive, and on Figure 1. Alfalfa yields in greenhouse pot experiments are shown in Table 9, and on Figure 2.

Effect of Type of Liming Material on Crop Yields

The average hay yields were somewhat greater for all degrees of fineness of granulated slag than for either air-cooled slag or limestone on Canfield silt loam. The average hay crop response to the use of air-

TABLE 5.—Yield of Corn Fodder. Slag Experiment. Wooster, Ohio 1949

	Granulated slag		Air-cooled slag		Limestone	
	Tons/A.	Lb./A.	Tons/A.	Lb./A.	Tons/A.	Lb./A.
Screenings	2	6102	2	5590	2	5753
	3	4886	3	6008	3	6019
	4½	5302	4½	5331		
Average 2 and 3 tons/A.		5494		5799		5886
Meal	2	6452	2	5868	2	5336
	3	5602	3	5346	3	5595
Average		6027		5607		5461
Ground	2	4737	2	5964	2	4623
	3	5961	3	5042	3	7740
Average		5349		5503		6181
Total average		5623		5636		5843

Check—no lime—Lb./A. 5105

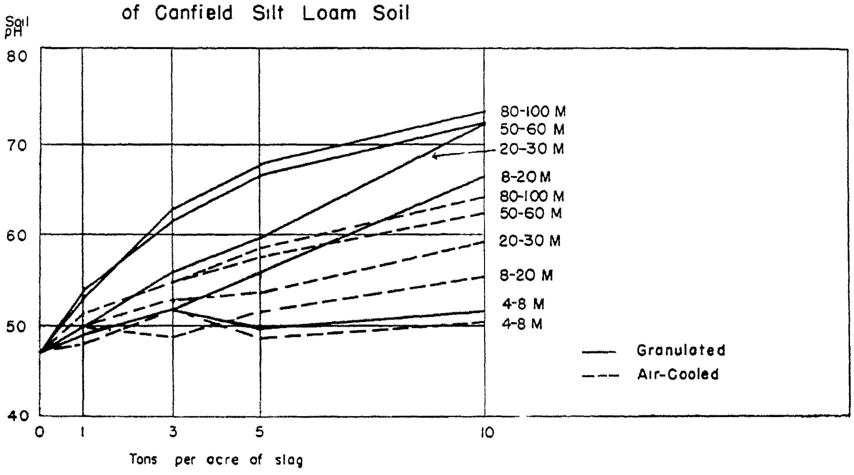
TABLE 6.—Effect of Various Grades and Kinds of Liming Materials on the Reaction of Canfield Silt Loam Soil on Field Plots After One Year

	Tons per acre							
	2	3	4½	2	3	4½	2	3
Grade of liming material	Granulated slag			Air-cooled slag			Limestone	
	pH Values							
Screenings	6.4	6.8	6.9	6.3	6.3	6.4	6.2	7.0
Meal	6.6	6.7		6.0	6.3		6.5	6.5
Ground	6.6	6.6		6.5	6.3		6.8	6.9
	Check Plots—no lime 5.6							

cooled slag and limestone was practically the same in all instances, Table 3.

As an average for the four rates used (i.e., 3½, 5, 7, 10 tons), granulated slag screenings was superior to all other grades of liming material when used on a Mahoning clay loam soil. But this was not true for all rates. For example at the 7 ton rate granulated screenings was exceeded by granulated ground, air-cooled meal and dolomitic limestone meal in both years. There was no apparent difference between the agricultural meal and ground grades for all three types of liming material. Table 7. The application of liming materials

FIG 3 — Effect in Ten Months of Slags of Various Fineness on the Reaction of Canfield Silt Loam Soil



increased the yield by approximately one half ton when used on a Meigs clay loam soil. No apparent significant differences were found between liming materials. Table 8.

The results of greenhouse pot experiments in growing alfalfa are shown in Table 9, and on Figure 2. The results of the greenhouse experiments show that all degrees of fineness of granulated slag gave somewhat larger yields than did the other two materials. This may have been due to minor elements contained in the slag, as the air-cooled slag was somewhat better than the dolomitic limestone in all but two comparisons.

TABLE 7.—The Effect of Liming Materials Applied to Mahoning Clay Loam Soil on Yields of Mixed Hay in Pounds per Acre.
Mahoning County Farm

	Grade of Liming Material					
	Screenings	Meal	Ground	Screenings	Meal	Ground
Tons/A.	1950			1951		
		Granulated Slag				
3½	2801	1589	4406	4223	3217	3997
5	6402	4428	3328	4240	3950	3297
7	3016	3209	4352	3300	4403	4370
10	6902	5152	4734	4857	4403	3477
Average	4780	3595	4205	4155	3993	3785
Average 1950 and 1951				4468	3794	3995
		Air-cooled Slag				
3½	3032	2914	5023	3753	2877	4450
5	1492	3956	2657	3367	3283	3343
7	2935	4433	5211	4147	3870	4710
10	2549	4402	3645	3523	3933	4063
Average	2502	3926	4134	3698	3491	4142
Average 1950 and 1951				3100	3709	4138
		Dolomitic Limestone				
3½	2485	3370	3472	3203	3313	3460
5	3574	3553		3528	3770	3090
7	3794	5270	4406	3477	3420	3497
10	3499	5554	3172	3753	4290	4063
Average	3338	4446	3683	3490	3698	3528
Average 1950 and 1951				3414	4072	3606
Check yields, no lime			2153			2998

Difference required for significance at the 5% level is 1124. This figure applies only to the 2-year average yields.

TABLE 8.—Yields of Mixed Hay from Meigs Clay Loam Soil Treated With Five Tons per Acre of Different Liming Materials. Belmont County, Ohio

Grade of liming material	Granulated slag		Air-cooled slag		Limestone	
	1950	1951	1950	1951	1950	1951
	Dry weight in pounds per acre					
Screenings	8802	7538	8379	7388	8216	7575
Meal	8764	7425	8226	7350	8110	7575
Ground	8495	7238	8264	7500	8264	7013
Check—no lime	6957	6788				

Tables 4 and 5 show the results of the application of liming materials to Canfield silt loam soil on the yield of corn. It will be noted that the corn yield was unaffected by liming the soil, as the yield from the "no lime" plots was as great as that from the areas which had been treated with liming material. This was true for all types of liming materials used.

TABLE 9.—Yields of Alfalfa in Greenhouse Pot Experiment Comparing Slags and Limestone. Wooster, Ohio, 1949

Grade of liming material	Granulated slag		Air-cooled slag		Limestone	
	Tons/A.	Gms./Pct.	Tons/A.	Gms./Pct.	Tons/A.	Gms./Pct.
Screenings	4	17.2	4	15.7	4	15.7
	8	19.5	8	16.8	8	16.7
	12	18.1	12	11.9	12	12.3
Meal	4	18.3	4	12.7	4	14.9
	8	20.1	8	17.6	8	16.9
	12	16.9	12	17.1	12	16.6
Ground	4	17.7	4	15.9	4	14.6
	8	20.2	8	16.7	8	17.8

Check pot—no lime—Average=8.7 grams.

Average of seven cuttings.

Fertilized with 1000 pounds per acre of 0-12-12 at beginning and after fourth cutting.

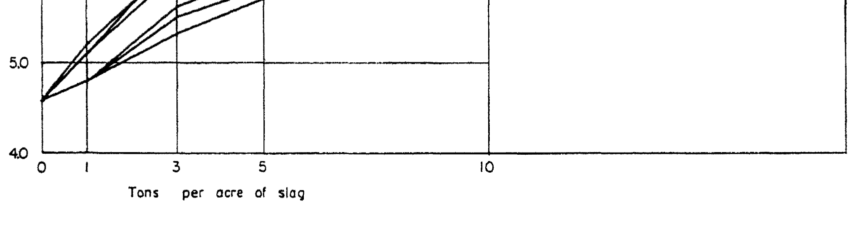
Effect of Fineness of Liming Material on Crop Yields

A study of the data given in Tables 3, 7 and 8 indicates that the crop yields from field experiments are practically the same for the meal and ground grades. In some instances the ground grade did not produce as large a crop as the meal grade, however, on the whole, the results were about the same. The screenings grade of air-cooled slag and limestone was inferior to other grades on Wooster and Mahoning soils. Because of the shape of the particles, granulated slag used in this experiment shows a high surface per unit mass. This particular granulated screening showed a relative surface of 31 while the air-cooled grade showed a relative surface of only 21.

Yields from the use of limestone or air-cooled slag are more affected by the degree of fineness than those from granulated slag due to the large surface per unit mass. Yields from the screenings grade of granulated slag were somewhat higher than those resulting from the meal or ground grades of air-cooled slag or limestone. This is doubtless due to the large surface resulting from the concoid shape of the particles.

Data on alfalfa yields from greenhouse plot experiments are given in Table 9 and Figure 2. In these tests the liming materials were applied at the rates of 4, 8 and 12 tons per acre. Yields from the use of the screenings grade of granulated slag were equal to or better than from any of the grades of air-cooled slag or limestone. The greenhouse pot tests did not show any advantage in the use of the finer materials

FIG. 4.— Effect of Slags on the Reaction of Canfield Silt Loam Soil in Ten Months.



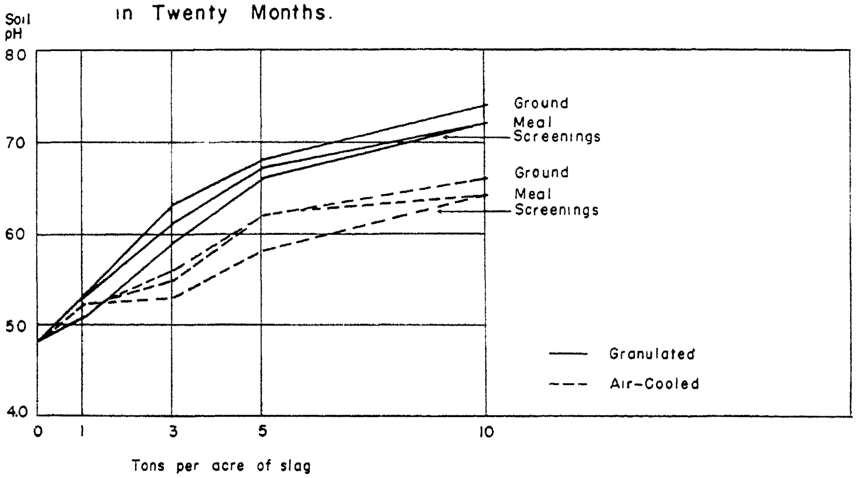
over the screenings of any of the types of liming materials used. This may have been caused by the thorough mixing of the liming materials with the soil.

Effect of Liming Materials on Soil Reactions

The effect of degree of fineness and rate of application of slag on the change in soil reaction was determined by treating soils with various amounts of liming material and then allowing the mixture to come to equilibrium. pH determinations were made periodically throughout a twenty-month period on soil retained in a fallow condition at uniform temperature. The results of the studies are given in Figures 3, 4 and 5.

As shown in Figures 4 and 5, the greater relative efficiency in correcting soil acidity of the granulated slag as compared with air-cooled slag should be noted. This again is probably due to the large surface presented by the granulated slag. A significant pH differential is evident for rates above one ton per acre when comparable rates and degrees of fineness were compared. Consideration should be given to the fact that the air-cooled slag had a 10 percent lower calcium carbonate equivalence than that of the granulated slag. In general, granulated slag finer than 20 mesh was effective in reducing soil acidity. None of the 4 to 8 mesh material was effective in a 10-month period. When screenings, meal or ground grades are compared, the granulated slag was most effective. Figures 5 and 6.

FIG. 5.—Effect of Slags on the Reaction of Canfield Silt Loam Soil in Twenty Months.

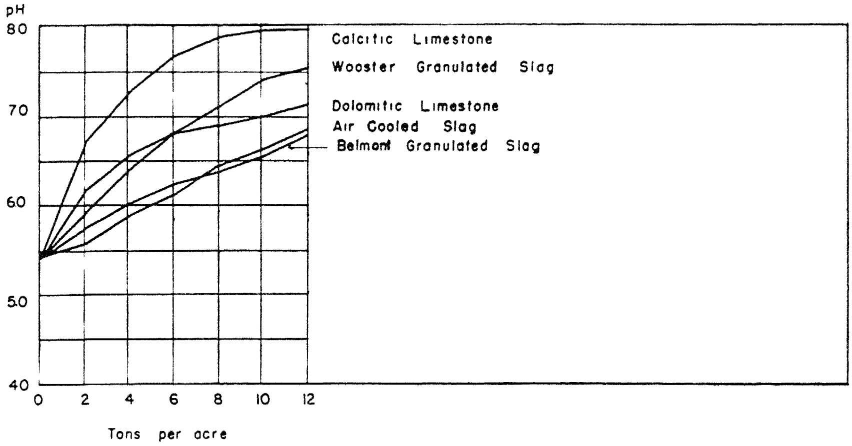


Results given in Table 10 were obtained from a similar experiment, the only exception being that alfalfa was grown on the soil during the period of greenhouse incubation. The pH of the soils was raised to a greater extent by the granulated slag and limestone than by the air-cooled slag (Table 10), although the yields of alfalfa from the greenhouse pots were equally as high with air-cooled slag as with limestone. The greatest affect on pH was obtained by increasing the rate of application of all three liming materials.

TABLE 10.—pH of Soil in Alfalfa Pots in Greenhouse, Planted September 6, 1948. Average of 5 Replications, Wooster, Ohio, 1949

Date	Ground		Meal			Screenings		
	Tons per Acre							
	4	8	4	8	12	4	8	12
			Limestone					
11-28-48	6.3	6.6	6.1	6.4	6.6	6.0	6.2	6.6
1-21-49	6.5	6.7	6.3	6.6	6.7	6.3	6.4	6.8
4- 6-49	6.5	6.8	6.3	6.7	6.7	6.3	6.5	6.7
6-16-49	6.7	6.7	6.4	6.7	6.8	6.4	6.5	6.9
Average	6.5	6.7	6.3	6.6	6.7	6.2	6.4	6.7
			Air-cooled Slag					
11-28-48	6.1	6.2	6.0	6.2	6.3	5.8	6.2	6.5
1-21-49	6.2	6.4	6.1	6.3	6.6	6.0	6.3	6.6
4- 6-49	6.1	6.5	6.1	6.3	6.5	6.1	6.3	6.6
6-16-49	6.2	6.4	6.2	6.4	6.6	6.1	6.4	6.7
Average	6.1	6.4	6.1	6.3	6.5	6.2	6.3	6.6
			Granulated Slag					
11-28-48	6.4	6.8	6.1	6.6	7.0	6.1	6.4	6.6
1-21-49	6.5	7.0	6.3	6.9	7.2	6.4	6.8	6.8
4- 6-49	6.5	6.9	6.3	6.9	7.2	6.4	6.9	6.7
6-16-49	6.6	6.9	6.4	6.8	7.2	6.4	6.9	6.9
Average	6.5	6.9	6.3	6.8	7.1	6.3	6.7	6.7
			Check Pots (No liming material)					
11-28-48	6.1							
1-21-49	6.2							
4- 6-49	6.2							
6-16-49	6.3							
Average	6.2							

FIG 6 – Effect of Various Liming Materials on the Reaction of Canfield Silt Loam Soil as Determined by the CO_2 Equilibration Method

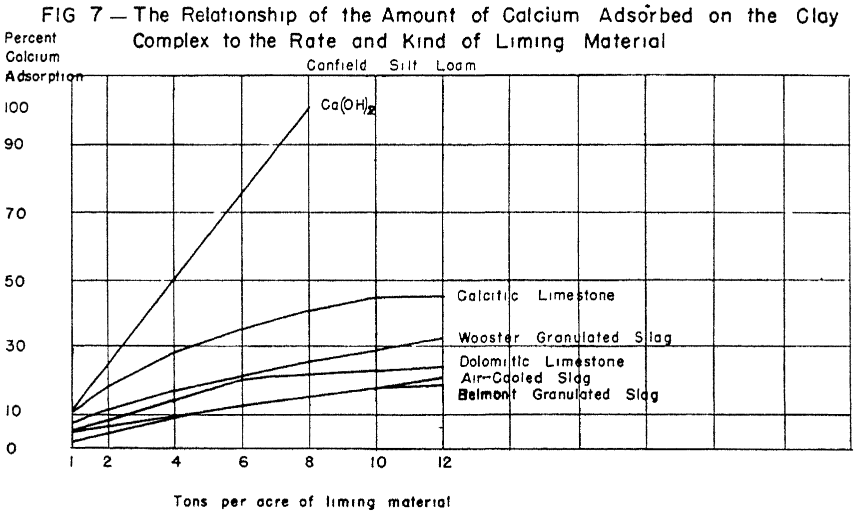


CO_2 Equilibration and Calcium Sorption Values of Soils as Related to Efficiency of Liming Materials

The efficiency of liming materials in neutralizing soil acidity was studied by use of the Naftel method. Forty grams of air-dry 30-mesh soil were added to each of twelve 500 cc. separatory funnels. Increasing amounts of 100-mesh liming material were added to each funnel plus distilled water to bring the soil-water ratio to 1:5. Carbon dioxide was bubbled through the mixtures for one-half hour. All samples were then aerated for five hours before the pH was determined.

FIG 7 — The Relationship of the Amount of Calcium Adsorbed on the Clay Complex to the Rate and Kind of Liming Material

Canfield Silt Loam



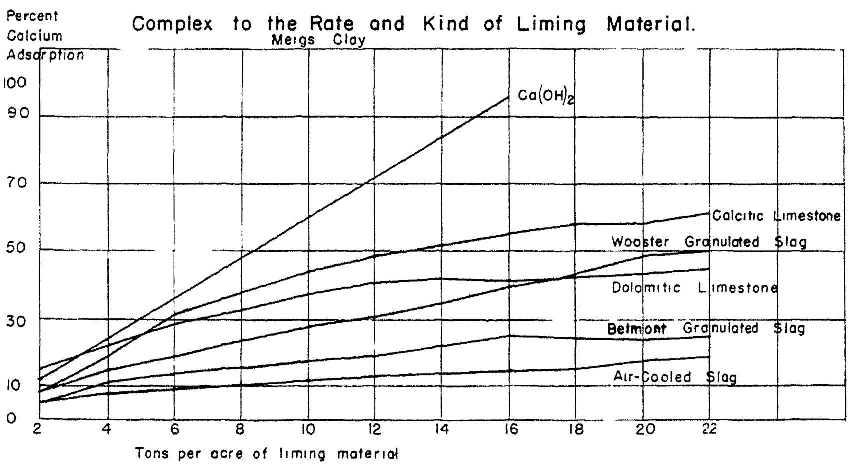
The results of this experiment are given in Figure 6. On Canfield silt loam, calcitic limestone was the most effective, with granulated slag and dolomitic limestone slightly less effective in correcting soil acidity. Air-cooled slag was slightly less effective than the granulated slag and dolomitic limestone. It is also indicated that there may be considerable difference in the effectiveness of slags from various sources as is also shown in the effectiveness of limestones of different sources and compositions. Equilibration curves were also made for Mahoning and Meigs clay loams. The results were similar to those obtained for the Canfield soil with the exception that larger amounts of liming materials were needed to bring the soil-water suspension to a neutral reaction.

After the Canfield and Meigs soils were equilibrated with the CO_2 in air, they were removed from the suspension by filtration and the calcium adsorbed by the soil was determined. The data given in Figures 7 and 8 show the relationship between liming materials as to the amount of calcium adsorbed by the soil exchange complex. The order of calcium sorption is about the same as the order of soil acid neutralization. Calcium hydroxide was highest, with calcitic limestone ranking second. These materials are more soluble than the others and they would be expected to indicate the highest efficiency. The decreasing order of efficiencies of the other liming materials was: granulated slag, dolomitic limestone, and air-cooled slag.

General Discussion

More research work should be done on the value of minor elements; however, there has been no research conducted to support this idea.

FIG. 8—The Relationship of the Amount of Calcium Adsorbed on the Clay Complex to the Rate and Kind of Liming Material.



It should be noted that the calcium carbonate equivalence, given in Table 1, shows the granulated slag used in the Wooster and Mahoning County experiments as 98.5, while the air-cooled slag in the same tests had a $CaCO_3$ equivalence of 88.5 and the limestone, 103.5. The lower neutralizing equivalence of the air-cooled slag may have been a contributing factor to its lower yield results as compared with the granulated, although the Weirton granulated and the air-cooled slag produced slightly lower yields in the Belmont County experiments as compared with this granulated type. The difference in neutralizing equivalence between the slags tested may have contributed to some of the differences in the soil reaction and sorption tests. It may be noted that the granulated and air-cooled slags were somewhat finer in the coarser fraction than similar grades of dolomitic limestone and may have contributed to some of the effectiveness of the slags in neutralizing soil acidity.

The percentage of calcium adsorbed on the clay is not a direct means of predicting the crop response of blast furnace slag. Yield tests exceed the anticipated production from the sorption tests. In Figure 6 it will be noted that for rates under 6 tons per acre the soil reaction

Fig. 9.—In the foreground is a check plot with a plot in the background that received granulated meal at 3T application.

indicates a higher pH for limestones than for slags. These results indicate that crop responses with slags are greater than might be expected from the soil reaction determinations.

Summary

Using granulated and air-cooled blast furnace slags and limestones, comparative studies were made on the yields of alfalfa, mixed hay and corn as influenced by fineness, rate of application, and soil reaction changes. Both field and laboratory experiments were conducted, the former being carried out on Canfield, Mahoning and Meigs soils.

1. There was no significant difference between crop yields from granulated slag screenings of the fineness used and the finer grades of dolomitic limestone and air-cooled slag. This was probably due to the relatively high surface exposed, which by measurement by the oxalate method was shown to be 31, or about the average of a No. 10 limestone meal.

2. Granulated slag screenings were significantly better than the air-cooled slag or limestone screenings.

3. Air-cooled slag and dolomitic limestone were equally effective in increasing crop yields when they were of equal fineness.

4. Under greenhouse conditions, both granulated slag and limestone were slightly more effective in correcting soil acidity than was air-cooled.

5. Since air-cooled slags usually produced crop values equivalent to limestone, it is indicated that crop response with slags is not predictable from soil reactions alone.

6. The equilibration of liming materials and soil by the use of carbon dioxide showed that granulated slag and dolomitic limestone are about equal, and air-cooled slag was less effective.

7. There was a direct relationship between the amount of calcium absorbed and the relative ability of liming material to correct soil acidity. The material most effective in neutralizing soil acidity also shows a greater calcium sorption by the clay complex.

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