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Field Experiments With Fertilizers on Some Iowa Soils

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with the assistance of
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AGRONOMY SECTION

SOILS

AMES, IOWA

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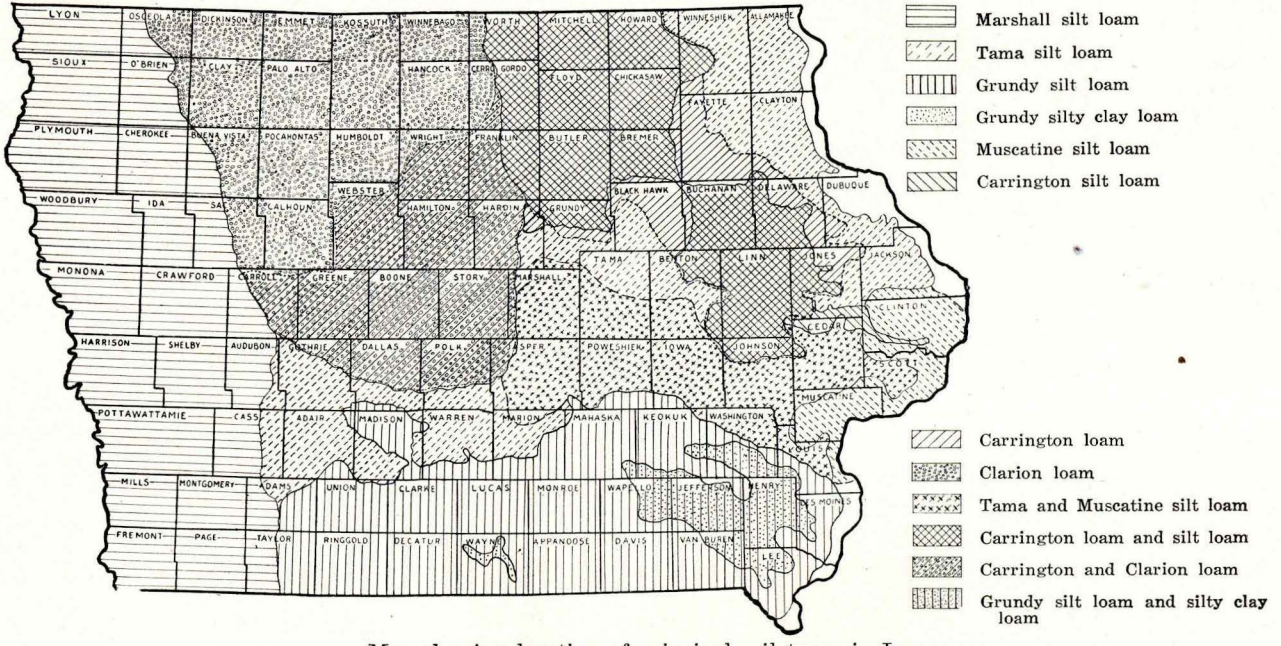

Map showing location of principal soil types in Iowa

Summary and Conclusions

Many of the experiments carried out in the field in cooperation with Iowa farmers on some of the more extensive soil types in the state have been under way for 10 or more years. The average results secured on the Carrington loam, the Clarion loam, the Carrington silt loam, the Grundy silt loam, the Grundy silty clay loam, the Tama silt loam, the Muscatine silt loam, the Clinton silt loam, the Marshall silt loam and the Waukesha silt loam are presented and discussed in this bulletin.

The results secured show that crop yields may be increased on many Iowa farms by adopting better methods of management and treatment of the land. **The Iowa system of soil management,** which has been developed from extensive experimental work and has been tested on many farms, points the way toward **securing greater crop yields per acre** and keeping the land permanently productive.

The fertilizing value of farm manure and green manures is well known, but the results given in this bulletin and in other publications emphasize the importance of keeping up the supply of organic matter in soils.

Liming is shown by these results to be important on all these soils. It greatly increased legume yields and brought about considerable gains in the yields of general farm crops. Farmers should have their soils tested and apply lime as needed if they expect to secure the best results.

The use of a phosphate fertilizer is shown to be worth while on all these soil types. Either superphosphate or rock phosphate may be employed to advantage. Farmers should test both phosphate fertilizers on their own farms to determine which may be employed most profitably, because sometimes one and sometimes the other gives the greater increase. Rock phosphate usually gives the larger effect the second year, while superphosphate acts more quickly and gives returns the first year. The comparative tests must, therefore, be carried over at least one rotation, before conclusions can be drawn.

Muriate of potash has not been tested sufficiently to permit of conclusions. It may be used with value on some soils for certain crops. Interested farmers should test this fertilizer under their own farm conditions, on a small area before applying it to any extensive areas.

Complete commercial fertilizers may be applied to some Iowa soils profitably, but it seems that superphosphate may give quite as good results and even greater profits. Farmers are

urged to test complete fertilizers on small areas in comparison with superphosphate before applying them extensively. The only way to be sure of the effects of the many complete fertilizers is to test them on the farm.

If Iowa farmers will use farm manure or green manures and apply lime and a phosphate fertilizer, following also the other requirements of the **Iowa system of soil management,** including drainage, cultivation and the use of a good crop rotation, they may profit materially in increased crop yields and they will also be building up and maintaining the fertility of the land.

Field Experiments With Fertilizers on Some Iowa Soils

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More than 100 cooperative soil experiment fields are now maintained in various parts of the state by the Soils Section of the Iowa Agricultural Experiment Station, in order to study the needs of the more extensive soil types and to determine the value of certain fertilizer applications.

These fields are laid out on land which is representative of particular soil types. They have been located in counties in which soil surveys have been made and hence there is a definite knowledge of the soil conditions. The experiments are carried out in cooperation with interested farmers, who provide the land and perform the usual operations in connection with seeding and cultivation. The Soils Section lays out the plots, furnishes and applies the fertilizers and harvests the crops.

Experiments Planned to Test the Iowa System of Soil Management

The experiments are planned to test the Iowa system of soil management in a practical way on typical farms in the state. The treatments involved in this plan of soil management include:

1. Drainage and cultivation.
2. Manuring and green manuring.
3. Liming.
4. The use of phosphates and other fertilizers.
5. The rotation of crops.

The importance of drainage is generally recognized, and no special tests of its value are included in these experiments. In locating the plots, precautions are taken, however, to insure their adequate drainage. If the soil is not naturally well-drained, artificial drainage must have been provided on the land selected. Proper cultivation of the soil is common practice on well managed farms. The plots are located on such farms and, hence, this factor is taken care of.

Good farmers practice a rotation of crops, and, since many rotations are quite satisfactory in Iowa, no attempt is made to carry on the experiments under a fixed rotation system. Instead the tests are located on farms with any good rotation, and thus the results are secured under a variety of rotations. In all cases, however, arrangements are made so that a legume crop is included in the rotation. A substitute crop is employed if the regular legume crop fails.

The plan of the experiments provides for the testing of manure, lime, rock phosphate, superphosphate and a complete commercial fertilizer on the livestock farms. The manure and the lime, when needed on the soil, serve as basic treatments. On the grain farms, crop residues serve as the basic treatment with lime, when necessary, and the other fertilizers are used in addition.

Most of the fields include 13 plots, with three checks. The arrangement of the plots is as follows:

1. Check
2. Manure
3. Manure + lime
4. Manure + lime + rock phosphate
5. Manure + lime + superphosphate
6. Manure + lime + complete commercial fertilizer
7. Check
8. Crop residues
9. Crop residues + lime
10. Crop residues + lime + rock phosphate
11. Crop residues + lime + superphosphate
12. Crop residues + lime + complete commercial fertilizer
13. Check

In some fields under the livestock system of farming nine-plot series are laid out. The arrangement of the plots in these series is as follows:

1. Check
2. Manure
3. Manure + lime
4. Manure + lime + rock phosphate
5. Check
6. Manure + lime + superphosphate
7. Manure + lime + superphosphate + potassium
8. Manure + lime + complete commercial fertilizer
9. Check

The manure is applied at the rate of eight tons per acre once in four years. In the grain system, the crop residues are employed as a basic treatment, the corn stalks being cut with a disc or stalk cutter and plowed under, and at least the second crop of clover is plowed down. In some instances the first crop of clover is clipped and allowed to remain on the land to be plowed under with the second crop. Lime is added in amounts shown to be necessary by laboratory tests. Tests are made once in the rotation preceding the legume crop, and the lime is added only as needed.

Until 1925, the rock phosphate was applied at the rate of one ton per acre once in a four-year rotation. The application was then reduced to 1,000 pounds once in four years. It is plowed under in the fall. Superphosphate was added at the rate of 200 pounds per acre annually until 1923, when the application was reduced to 150 pounds per acre annually, three years out of the four in a four-year rotation. This phosphate is disced in just prior to seeding. It is not applied to the legume crop.

Originally the old standard 2-8-2 complete commercial fertilizer was employed at the rate of 300 pounds per acre, disced in before seeding. Since 1923, the 2-12-2 brand has been employed, 200 pounds per acre being applied, thus providing an amount of phosphorus equivalent to that supplied in the 150 pounds of 16 percent superphosphate. When muriate of potash is used, it is applied at the rate of 50 pounds per acre annually, three years out of four in the four-year rotation.

Field Results Secured

Many of these experiment fields have now been in operation for 10 or more years. As there are a number of fields on each of the more extensive upland soil types, it is felt that the average results from the various fertilizer treatments will indicate quite accurately the effects of the fertilizers used. The data from all fields and on all types are not included here as some fields have not been in operation long enough to yield dependable results, and on some of the minor types there are not a sufficient number of fields nor a large enough accumulation of data.

The average crop yields and the increases for the treatments are given for the Carrington loam, the Clarion loam, the Carrington silt loam, the Grundy silt loam, the Grundy silty clay loam, the Tama silt loam, the Muscatine silt loam, the Clinton silt loam, the Marshall silt loam and the Waukesha silt loam. In each case the tables show the number of crops and the number of fields involved in each set of average figures. The yields of all the crops, including those for 1928, are figured in the averages. No attempt is made in this report to calculate the economic value or profit from the treatments. These may easily be determined from the increases given, with a knowledge of the cost of the fertilizers and an assumption of an average market price of the individual crops.

Results on the Carrington Loam

The Carrington loam is found on much of the upland in north-central Iowa. The sketch map (fig. 1) shows roughly the area of the state in which this soil type occurs.

The Carrington loam, when typically developed, is a dark

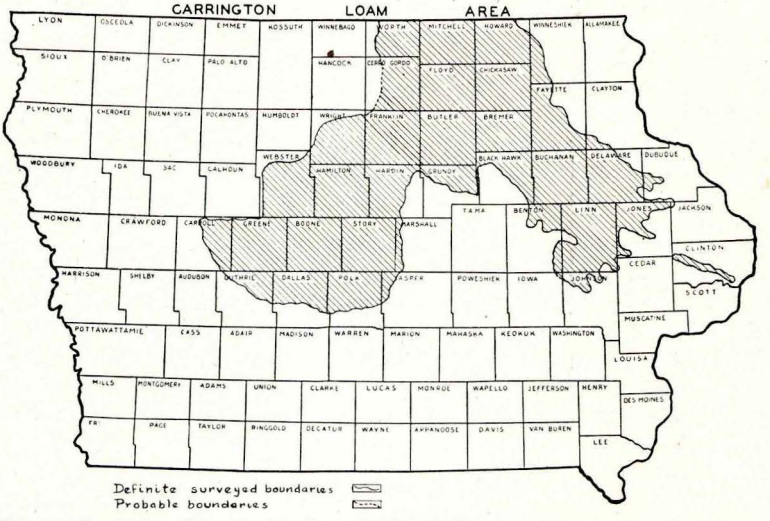

Fig. 1. Carrington loam is found on much of the upland in north-central Iowa.

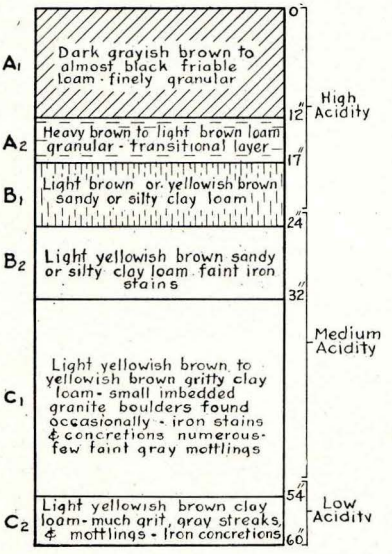

Fig. 2. Soil profile of Carrington loam.

grayish-brown to black loam, 8 to 18 inches in depth, averaging about 10 inches. The subsoil is a brownish-yellow to light yellow sandy or silty clay loam. There is usually an intermediate layer of a light brown friable heavy loam, grading into the lighter colored subsoil. Much glacial material is usually present. A typical Carrington loam profile is shown in fig. 2.

There are 12 experiment fields on this type in various counties, and the results given in table I are averaged from these fields. Some of the treatments are not represented on all the fields. These exceptions are noted in the footnotes to the table.

The manure increased all crops on this soil. The increase was 8.0 bushels for corn, 5.8 bushels for oats, 0.27 ton for hay, 0.12 ton for sweet clover and 0.65 ton for alfalfa. Lime with

TABLE I. CARRINGTON LOAM. AVERAGE CROP YIELDS AND INCREASES DUE TO FERTILIZER TREATMENT. IOWA EXPERIMENT FIELDS.

Treatment	Corn[1]		Oats[2]		Hay[3]		Sweet clover[4]		Alfalfa[5]	
					Clover, timothy and clover or timothy					
	Av. yield bushels per acre	Increase for treatment bu. per acre	Av. yield bushels per acre	Increase for treatment bu. per acre	Av. yield tons per acre	Increase for treatment tons per acre	Av. yield tons per acre	Increase for treatment tons per acre	Av. yield tons per acre	Increase for treatment tons per acre
Check[6]	45.5	.....	47.4	.....	1.16	.....	1.11	.....	0.71	.....
Manure	53.5	8.0	53.2	5.8	1.43	0.27	1.23	0.12	1.36	0.65
Manure + lime	56.3	10.8	57.3	9.9	1.54	0.38	2.32	1.21	2.27	1.56
Manure + lime + rock phosphate	58.3	12.8	60.4	13.0	1.87	0.71	2.51	1.40	2.66	1.95
Manure + lime + superphosphate	59.3	13.8	64.7	17.3	1.96	0.80	2.73	1.62	2.57	1.86
Manure + lime + superphosphate + potassium	61.1	15.6	67.5	20.1	.....	.....	.....	.....	.....	.....
Manure + lime + complete commercial fertilizer	58.2	12.7	65.0	17.6	2.11	0.95	2.86	1.75	2.59	1.88
Crop residues	42.5	.....	44.5	.....	1.10	.....	0.62	.....	0.89	0.18
Crop residues + lime	46.5	1.0	50.5	3.1	1.27	0.11	2.93	1.82	1.74	1.03
Crop residues + lime + rock phosphate	51.0	5.5	53.9	6.5	1.51	0.35	3.02	1.91	1.83	1.12
Crop residues + lime + superphosphate	51.8	6.3	57.5	10.1	1.73	0.57	3.02	1.91	2.04	1.33
Crop residues + lime + complete commercial fertilizer	51.6	6.1	58.9	11.5	1.79	0.63	2.96	1.85	2.33	1.62

1 Corn yields averaged from 42 crops on 12 fields, except the manure + lime + superhphosphate + potassium plot, which is averaged from 15 crops on six fields, and the crop residue plots, which are averaged from 25 crops on six fields.

2 Oat yields averaged from 29 crops on 12 fields, except the manure + lime + superphosphate + potassium plot, which is averaged from 10 crops on six fields, and the crop residue plots, which are averaged from 18 crops on six fields.

3 Hay yields averaged from 15 crops on seven fields, except the crop residue plots, which are averaged from 14 crops on six fields.

4 Sweet clover yields averaged from two crops on two fields, except the crop residue plot, which involved only one crop on one field.

5 Alfalfa yields averaged from three crops on one field.

6 The yields given for the checks are the average of the yields on all check plots on all fields.

manure increased appreciably the yields of corn, oats and hay, and it doubled the increase in the alfalfa and increased the sweet clover yield tenfold. Rock phosphate with the manure and lime considerably increased all crops and especially the hay and alfalfa. Superphosphate with the manure and lime had a somewhat greater influence than the rock phosphate on the corn, oats, hay and sweet clover but showed a slightly less effect on the alfalfa. The difference in favor of the superphosphate was quite appreciable with the oats and sweet clover but was not so large with the corn and hay. Muriate of potash with the superphosphate, manure and lime increased the corn and oats yields when compared with the superphosphate, manure and lime treatment. The complete commercial fertilizer with the manure and lime had a smaller effect than the superphosphate on the corn, about the same influence on the oats and the alfalfa and gave an appreciable increase in the hay and sweet clover.

The crop residues showed no effect except on the alfalfa. Lime with the residues increased all the crops, the increases being small on the corn, oats and hay but large on the sweet clover and alfalfa. Rock phosphate with the crop residues and lime gave large increases on the corn, oats and hay but showed little effect on the sweet clover and alfalfa. Superphosphate with the residues and lime showed no greater effect than the rock phosphate on the sweet clover but gave much greater effects on the corn, oats, hay and alfalfa. The complete commercial fertilizer with the residues and lime produced greater yields than the superphosphate with all crops except the corn and sweet clover. The influence was much greater on the oats and alfalfa than on the hay.

Evidently on the Carrington loam yields of general farm crops may be increased considerably by applications of manure, lime and a phosphate fertilizer. Lime had its greatest influence on the legume crops, as would be expected. Rock phosphate and superphosphate both increased crop yields, the superphosphate generally showing somewhat superior effects both with manure and lime and with the crop residues and lime. The muriate of potash gave some indications of value. The complete commercial fertilizer had somewhat greater effects than the phosphates but hardly enough more to warrant its use, due to its higher cost.

Results on the Clarion Loam

The Clarion loam is an important upland soil in northwestern Iowa. The occurrence of this type in the state is shown in fig. 3.

The Clarion loam is a dark brown to deep black loam, averag-

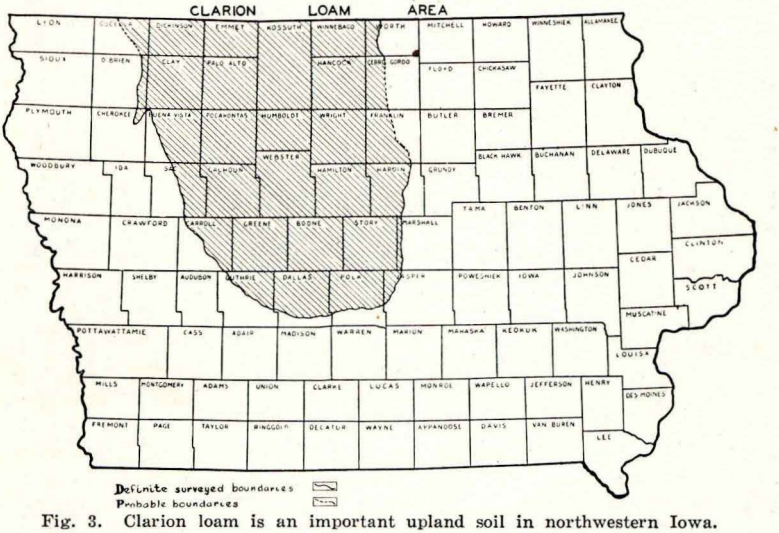

Fig. 3. Clarion loam is an important upland soil in northwestern Iowa.

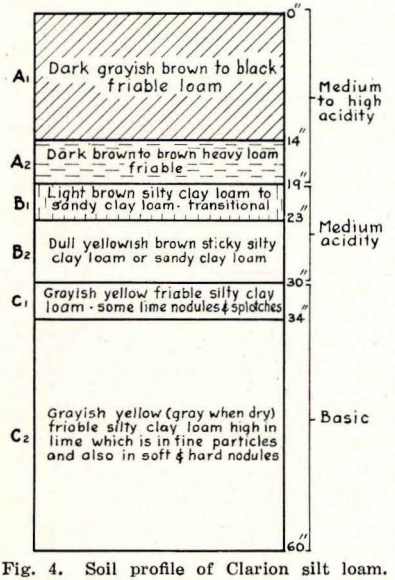

Fig. 4. Soil profile of Clarion silt loam.

ing 12 to 14 inches in depth but ranging from 10 to 20 inches. The subsoil is a light brown to yellow or grayish-brown silty clay loam to sandy clay loam. The subsurface soil is a dark brown to brown friable heavy loam to silty clay loam. It is very similar to the Carrington loam except that there is usually lime in the subsoil. This, however, does not prevent a need for lime in the surface soil, which is generally distinctly acid in reaction. A typical Clarion loam profile is shown in fig. 4.

There are seven fields on this type, and the average results are given in table II.

TABLE II. CLARION LOAM. AVERAGE CROP YIELDS AND INCREASES DUE TO FERTILIZER TREATMENT. IOWA EXPERIMENT FIELDS.

Treatment	Corn[1]		Oats[2]		Hay[3]		Sweet clover[4]		Barley[5]	
					Clover, timothy and clover or timothy					
	Av. yield bushels per acre	Increase for treatment bu. per acre	Av. yield bushels per acre	Increase for treatment bu. per acre	Av. yield tons per acre	Increase for treatment tons per acre	Av. yield tons per acre	Increase for treatment tons per acre	Av. yield bushels per acre	Increase for treatment bu. per acre
Check[6]	43.2	.....	47.7	.....	1.34	.....	1.00	.....	32.8	.....
Manure	49.1	5.9	55.3	7.6	1.16	.....	1.11	0.11	35.2	2.4
Manure + lime	50.8	7.6	57.3	9.6	1.33	.....	1.64	0.64	44.4	11.6
Manure + lime + rock phosphate	54.0	10.8	56.7	9.0	1.82	0.48	1.71	0.71	42.6	9.8
Manure + lime + superphosphate	53.2	10.0	61.3	13.6	2.11	0.77	1.82	0.82	46.6	13.8
Manure + lime + superphosphate + potassium	54.1	10.9	69.4	21.7	.....	.....	2.23	1.23	46.4	13.6
Manure + lime + complete commercial fertilizer	54.1	10.9	63.8	16.1	1.98	0.64	2.09	1.09	43.7	10.9
Crop residues	47.7	4.5	54.7	7.0	2.05	0.71	1.52	0.52	39.3	6.5
Crop residues + lime	50.4	7.2	55.4	7.7	2.10	0.76	1.68	0.68	42.4	9.6
Crop residues + lime + rock phosphate	53.1	9.9	58.3	10.6	2.56	1.22	1.50	0.50	37.9	5.1
Crop residues + lime + superphosphate	52.9	9.7	64.9	17.2	2.41	1.07	1.44	0.44	40.9	8.1
Crop residues + lime + complete commercial fertilizer	53.1	9.9	66.6	18.9	2.59	1.25	1.29	0.29	42.4	9.6

1 Corn yields averaged from 22 crops on seven fields, except the manure + lime + superphosphate + potassium plot, which is averaged from 11 crops on five fields, and the crop residue plots, which are averaged from eleven crops on two fields.
2 Oat yields averaged from 13 crops on six fields, except the manure + lime + superphosphate + potassium plot, which is averaged from seven crops on four fields, and the crop residue plots, which are averaged from six crops on two fields.
3 Hay yields averaged from six crops on five fields, except the crop residue plots, which are averaged from three crops on two fields.
4 Sweet clover yields averaged from four crops on four fields, except the manure + lime + superphosphate + potassium plot, which is averaged from three crops on three fields, and the crop residue plots, which involved only one crop on one field.
5 Barley yields averaged from three crops on three fields, except the manure + lime + superphosphate + potassium plot, which is averaged from two crops on two fields, and the crop residue plots, which involved only one crop on one field.
6 The yields given for the checks are the average of the yields on all check plots on all fields.

On this soil, manure increased the yields of corn, oats, sweet clover and barley but not of hay. Lime with manure increased the yields of all the crops, except the hay, showing large effects on the corn, oats, sweet clover and barley. Rock phosphate with the manure and lime increased the corn considerably and had a large effect on the hay crop. Small increases occurred on the sweet clover, but there was a decrease in the oats and the barley, probably due to some abnormal condition. The superphosphate with the manure and lime showed less effect than the rock phosphate on the corn but had a much greater effect on the oats, sweet clover, hay and barley. The muriate of potash with the superphosphate, manure and lime showed an increase on the corn, a large increase on the oats and sweet clover and no effect on the barley. The complete commercial fertilizer with the manure and lime had the same effect as the superphosphate on the corn, it increased the hay crop and had no effect on the oats, sweet clover or barley.

The crop residues increased the yields of all the crops. Lime with the residues increased the corn and barley and had some effect on the oats, hay and sweet clover. Rock phosphate with the residues and lime still further increased the corn, oats and hay yields but had no effect on the sweet clover and barley. Superphosphate with the crop residues and lime showed a much greater effect than the rock phosphate on the oats and barley but had slightly less influence on the corn, hay and sweet clover. The complete commercial fertilizer with the residues and lime had a somewhat greater effect than the superphosphate on the oats, hay and barley, showed about the same influence on the corn and had less effect on the sweet clover.

This soil apparently responded in much the same way as the Carrington loam to additions of manure, lime and a phosphorus fertilizer. Lime was of large value, especially for the legumes. Rock phosphate and superphosphate gave very similar effects, altho the superphosphate usually proved slightly superior. Muriate of potash seemed of some value. The complete commercial fertilizer in general gave only slightly greater effects than the superphosphate.

Results on the Carrington Silt Loam

The Carrington silt loam is an important soil type in east-central and northeast-central Iowa. Its location is shown roughly in fig. 5.

The Carrington silt loam is a dark grayish-brown to nearly black friable silt loam, extending to a depth of 10 to 14 inches. The subsurface soil is a grayish-brown to dull brown rather compact silt loam to silty clay loam. The subsoil at 20 to 24 inches is a light brown or yellowish-brown silty clay loam to

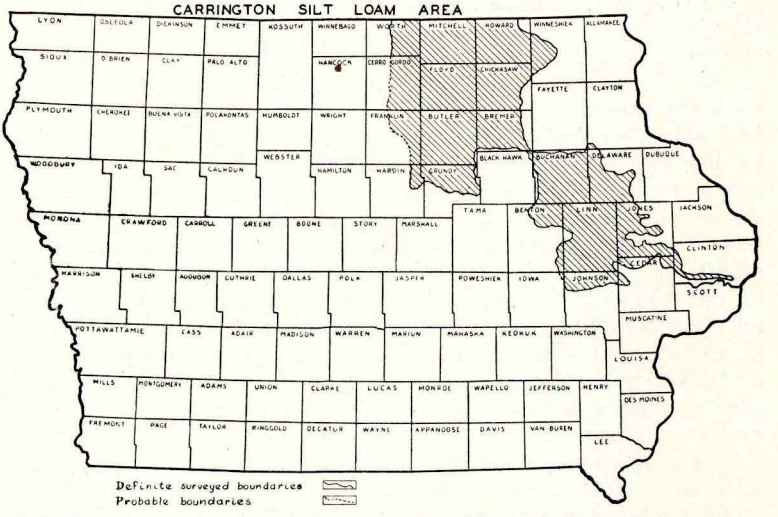

Fig. 5. Carrington silt loam is an important soil type in east-central and northeast-central Iowa.

sandy clay loam. Much glacial material often occurs in the subsoil. A typical Carrington silt loam profile is shown in fig. 6.

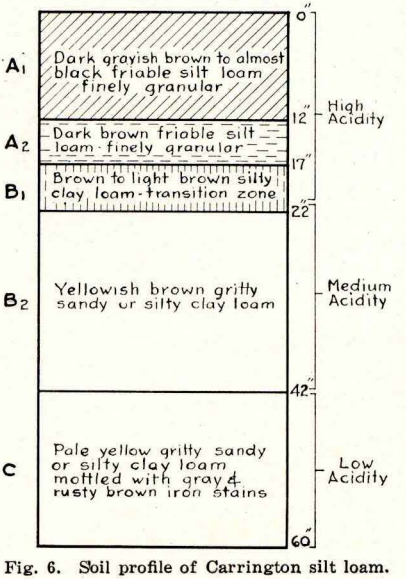

Fig. 6. Soil profile of Carrington silt loam.

There are five fields on this type, and the average results are given in table III. Manure gave large increases in the corn, oats and hay, and small effects on barley. Lime with manure showed large effects on all the crops, having the greatest influence on the grain crops. Rock phosphate with the manure and lime increased the yields of all crops. Superphosphate with the manure and lime had less effect than the rock phosphate on the corn and oats but showed greater effects on the hay and barley. The muriate of potash with the superphosphate, manure and lime showed a large effect on the corn crop.

TABLE III. CARRINGTON SILT LOAM. AVERAGE CROP YIELDS AND INCREASES DUE TO FERTILIZER TREATMENT. IOWA EXPERIMENT FIELDS.

Treatment	Corn[1]		Oats[2]		Hay[3]		Barley[4]	
					Clover, timothy and clover or timothy			
	Av. yield bushels per acre	Increase for treatment bu. per acre	Av. yield bushels per acre	Increase for treatment bu. per acre	Av. yield tons per acre	Increase for treatment tons per acre	Av. yield bushels per acre	Increase for treatment bu. per acre
Check[5]	43.9	.....	44.0	.....	1.37	.....	34.2	.....
Manure	53.1	9.2	51.7	7.7	1.64	0.27	37.8	3.6
Manure + lime	57.1	13.2	57.8	13.8	1.76	0.39	44.5	10.3
Manure + lime + rock phosphate	63.8	19.9	66.2	22.2	2.22	0.85	48.9	14.7
Manure + lime + superphosphate	61.5	17.6	62.8	18.8	2.39	1.02	51.6	17.4
Manure + lime + superphosphate + potassium	73.5	29.6	.....	.....	.....	.....	.....	.....
Manure + lime + complete commercial fertilizer	62.0	18.1	66.3	22.3	2.21	0.84	51.5	17.3
Crop residues	45.7	1.8	53.1	9.1	1.63	0.26	35.8	1.6
Crop residues + lime	51.2	7.3	57.1	13.1	1.81	0.44	38.1	3.9
Crop residues + lime + rock phosphate	53.7	9.8	63.2	19.2	2.05	0.68	42.9	8.7
Crop residues + lime + superphosphate	54.9	11.0	62.2	18.2	2.09	0.72	42.5	8.3
Crop residues + lime + complete commercial fertilizer	53.4	9.5	64.7	20.7	2.11	0.74	44.9	10.7

1 Corn yields averaged from 23 crops on five fields, except the crop residue plots, which are averaged from 15 crops on three fields, and the manure + lime + superphosphate + potassium plot, which involved only one crop on one field.

2 Oat yields averaged from 11 crops on four fields, except the crop residue plots, which are averaged from six crops on two fields.

3 Hay yields averaged from 12 crops on five fields, except the crop residue plots, which are averaged from eight crops on three fields.

4 Barley yields averaged from two crops on one field.

5 The yields given for the checks are the average of the yields on all check plots on all fields.

The complete commercial fertilizer with the manure and lime produced no greater yields than the phosphates.

The crop residues had little influence on the various crops. Lime with the residues increased the yields of all crops but had the greatest effect on the corn and hay. Rock phosphate with the crop residues and lime gave very pronounced gains on all crops, showing the greatest influence on the oats and hay. Superphosphate with the crop residues and lime had a greater effect than the rock phosphate on the corn and hay but showed slightly less effect on the oats and barley. The complete commercial fertilizer had no greater effect than the superphosphate, except on the oats and barley.

The Carrington silt loam seemed to respond in a large way to applications of manure, lime and a phosphate fertilizer. There seemed little choice between the two phosphates. The complete commercial fertilizer did not produce any appreciably greater increases in yields than did the superphosphate either with manure and lime or with crop residues and lime.

Results on the Grundy Silt Loam

The Grundy silt loam is a very extensive upland type in southern Iowa. Its location is shown in fig. 7.

The Grundy silt loam is a dark grayish-brown to almost black friable silt loam, extending to a depth of about 12 inches. The subsurface soil to a depth of 18 to 20 inches is a brown

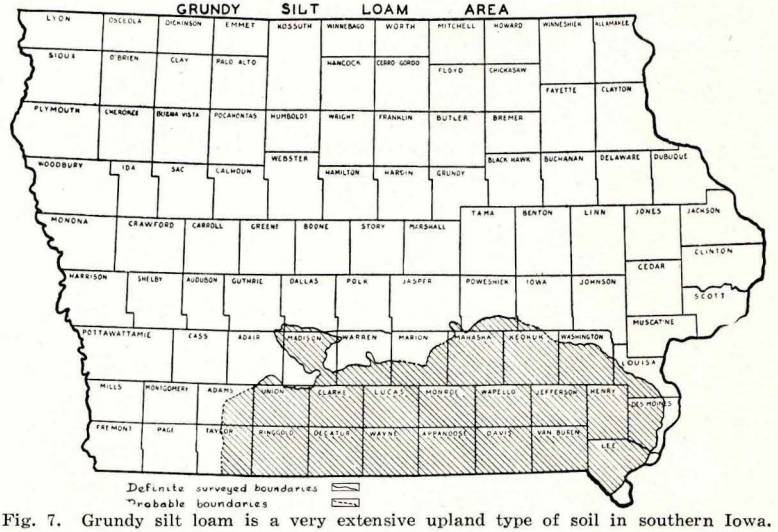

Fig. 7. Grundy silt loam is a very extensive upland type of soil in southern Iowa.

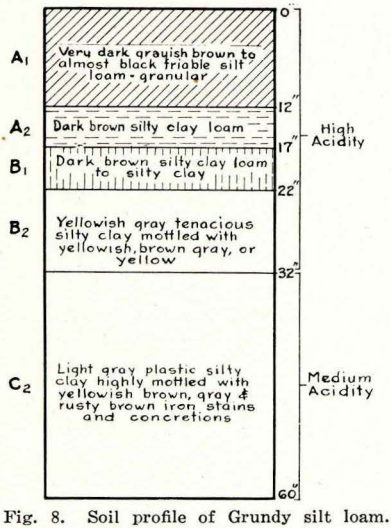

Fig. 8. Soil profile of Grundy silt loam.

to dark brown silty clay loam. The subsoil is a compact heavy silty clay to clay, light brown in color, mottled with gray, yellow or yellowish-brown. A typical profile of the Grundy silt loam is shown in fig. 8.

There are 13 fields on this type, and the average results secured are given in table IV. The application of manure gave definite increases in corn, oats, hay, wheat and alfalfa. Lime with manure more than doubled the increases in hay and alfalfa, which might be expected, but it also almost doubled the increase in corn, which is rather surprising. Furthermore, it increased the oats and wheat yields. Apparently lime may increase not only the legume crops in the rotation but also the grain crops. The lime either has a direct influence on the crop growth, or brings about a secondary effect due to the increased legume residues.

Rock phosphate applied with the manure and lime gave pronounced increases on all of the crops, the greatest effects appearing on the hay and the alfalfa. The superphosphate with the manure and lime showed somewhat larger effects than the rock phosphate on all crops, altho the differences were not great with corn, wheat and alfalfa. The muriate of potash applied with the superphosphate, manure and lime showed no increase over the superphosphate, manure and lime in the case of the corn and hay but gave an increase in the wheat. The complete commercial fertilizer with the manure and lime showed about the same effect on the corn and oats as that brought about by the superphosphate, but it had a greater influence than the rock phosphate in both cases. With the hay and alfalfa it showed much greater effects than the superphosphate, but on the wheat it had less influence than either the rock phosphate or the superphosphate.

The crop residues showed some beneficial effects on the crops grown. Lime with the residues increased the hay crops particularly, but it also increased the yields of all other crops. The lime showed up unusually well on the corn and oats. Rock

TABLE IV. GRUNDY SILT LOAM. AVERAGE CROP YIELDS AND INCREASES DUE TO FERTILIZER TREATMENT. IOWA EXPERIMENT FIELDS.

Treatment	Corn[1]		Oats[2]		Hay[3]		Winter wheat[4]		Alfalfa[5]	
					Clover, timothy and clover or timothy					
	Av. yield bushels per acre	Increase for treatment bu. per acre	Av. yield bushels per acre	Increase for treatment bu. per acre	Av. yield tons per acre	Increase for treatment tons per acre	Av. yield bushels per acre	Increase for treatment bu. per acre	Av. yield tons per acre	Increase for treatment tons per acre
Check[6]	53.0	.....	42.5	.....	1.48	.....	20.6	.....	4.23	.....
Manure	59.1	6.1	47.7	5.2	1.69	0.21	23.9	3.3	4.50	0.27
Manure + lime	64.6	11.6	49.9	7.4	1.96	0.48	26.4	5.8	4.82	0.59
Manure + lime + rock phosphate	67.4	14.4	53.3	10.8	2.19	0.71	29.9	9.3	5.03	0.80
Manure + lime + superphosphate	68.6	15.6	57.6	15.1	2.35	0.87	30.9	10.3	5.11	0.88
Manure + lime + superphosphate + potassium	64.6	11.6	.....	.....	2.25	0.77	32.6	12.0	.....	.....
Manure + lime + complete commercial fertilizer	69.4	16.4	57.2	14.7	2.44	0.96	28.7	8.1	5.29	1.06
Crop residues	58.5	5.5	48.1	5.6	1.59	0.11	26.2	5.6	4.44	0.21
Crop residues + lime	62.7	9.7	52.4	9.9	1.85	0.37	26.6	6.0	4.61	0.38
Crop residues + lime + rock phosphate	64.4	11.4	55.8	13.3	2.03	0.55	27.1	6.5	4.86	0.63
Crop residues + lime + superphosphate	64.2	11.2	57.7	15.2	2.05	0.57	27.6	7.0	5.00	0.77
Crop residues + lime + complete commercial fertilizer	63.3	10.3	56.4	13.9	2.09	0.61	27.7	7.1	4.94	0.71

1 Corn yields averaged from 48 crops on 13 fields, except manure + lime + superphosphate + potassium plot, which is averaged from 18 crops on 7 fields, and the crop residue plots, which are averaged from 30 crops on six fields.
2 Oat yields averaged from 22 crops on 13 fields, except the crop residue plots, which are averaged from 14 crops on six fields.
3 Hay yields averaged from 19 crops on 10 fields, except the crop residue plots, which are averaged from 11 crops on five fields, and the manure + lime + superphosphate + potassium plot, which is averaged from eight crops on five fields.
4 Winter wheat yields averaged from seven crops on five fields, except the manure + lime + superphosphate + potassium plot, which is averaged from three crops on two fields, and the crop residue plots, which are averaged from four crops on three fields.
5 Alfalfa yields averaged from five crops on one field.
6 The yields given for the checks are the average of the yields on all check plots on all fields.

phosphate with the crop residues and lime had a large effect on all of the crops grown. The influence on the hay and alfalfa was particularly noteworthy. The wheat crop was influenced the least. Superphosphate with the crop residues and lime increased all of the crops, and except for corn these gains were slightly larger than those occasioned by the rock phosphate. The complete commercial fertilizer with the residues and lime had less effect than the superphosphate on the corn, oats and alfalfa, but it gave slight increases on the hay and wheat. It had a somewhat greater effect than the rock phosphate on the oats, hay, wheat and alfalfa.

These results as a whole show the value of applying normal amounts of manure to this land, of adding enough lime to neutralize the acidity of the surface soil, and of treating the soil with a phosphate fertilizer. The beneficial influence of lime not only on the legume crops but also on the grain crops is especially noteworthy. The phosphate fertilizers gave appreciable crop increases, the superphosphate generally showing up slightly the better. Apparently either rock phosphate or superphosphate may be used successfully and profitably on this soil type. However, the results may vary under different farm conditions. The complete commercial fertilizer seemed to have no greater effect on this soil than superphosphate. To prove profitable the complete fertilizer should give much greater increases than the phosphate. There is some evidence of effects from the use of muriate of potash, but it is not definite. This material should certainly be tested in the field before it is applied extensively to this soil.

Results on the Grundy Silty Clay Loam

The Grundy silty clay loam is an important soil type in southern Iowa, occurring on the level to depressed uplands in association with the Grundy silt loam. It is much heavier than the silt loam and more difficult to manage. When properly drained and cultivated, however, it is an extremely productive soil. Its location is shown in fig. 9.

The Grundy silty clay loam is a black silty clay loam, 6 to 8 inches in depth. The subsurface soil is a pitch-black, plastic, tenacious silty clay. The subsoil is a bluish-gray to gray silty clay, mottled with yellow, yellowish-brown and rusty brown. A typical profile of this soil type is shown in fig. 10.

There are two fields on this soil, and the average results are given in table V. Farm manure increased the corn and hay crops on this soil and had considerable effects also on the oats and wheat. Lime with manure further increased the corn and oats but had no effect on the hay or wheat. Rock phosphate

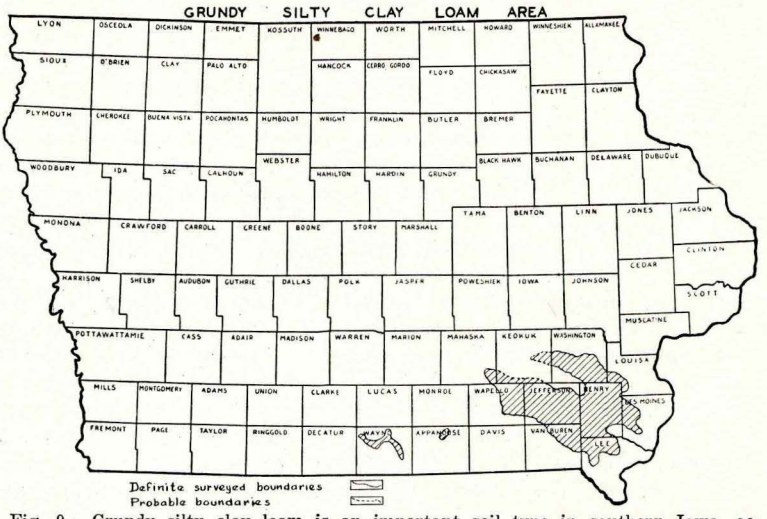

Fig. 9. Grundy silty clay loam is an important soil type in southern Iowa, occurring on the level to depressed uplands.

with manure and lime gave some increase on the corn and wheat but showed a large effect on the oats and hay crops. Superphosphate with the manure and lime was somewhat more effective than rock phosphate on the corn and oats and definitely better in its effect on the hay and wheat. The complete commercial fertilizer increased the corn yields less than did the phosphates and had less effect than the superphosphate on the hay and wheat. It had a slightly greater influence on the oats.

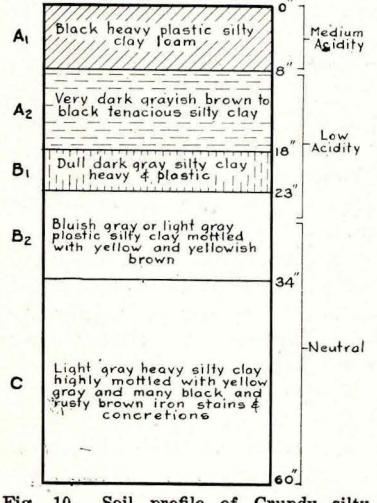

Fig. 10. Soil profile of Grundy silty clay loam.

The crop residues affected the various crops little or not at all. Lime with the residues had no effect on any of the crops. Rock phosphate with crop residues and lime showed little effect on the corn and very slight effects on the oats and wheat. However, it increased the hay crop. Superphosphate had a greater in-

TABLE V. GRUNDY SILTY CLAY LOAM. AVERAGE CROP YIELDS AND INCREASES DUE TO FERTILIZER TREATMENT. IOWA EXPERIMENT FIELDS.

Treatment	Corn[1]		Oats[2]		Hay[3]		Winter wheat[4]	
					Clover, timothy and clover or timothy			
	Av. yield bushels per acre	Increase for treatment bu. per acre	Av. yield bushels per acre	Increase for treatment bu. per acre	Av. yield tons per acre	Increase for treatment tons per acre	Av. yield bushels per acre	Increase for treatment bu. per acre
Check[5]	54.1	.....	46.2	.....	1.85	.....	15.4	.....
Manure	62.9	8.8	50.9	4.7	2.50	0.65	18.1	2.7
Manure + lime	64.5	10.4	51.3	5.1	2.28	0.43	17.7	2.3
Manure + lime + rock phosphate	65.7	11.6	56.3	10.1	2.68	0.83	19.3	3.9
Manure + lime + superphosphate	66.8	12.7	57.1	10.9	2.84	0.99	21.5	6.1
Manure + lime + complete commercial fertilizer	64.9	10.8	57.8	11.6	2.70	0.85	21.4	6.0
Crop residues	54.9	0.8	45.6	.....	1.91	0.06	16.9	1.5
Crop residues + lime	53.7	.....	43.8	.....	1.81	.....	14.9	.....
Crop residues + lime + rock phosphate	55.0	0.9	49.4	3.2	2.74	0.89	17.4	2.0
Crop residues + lime + superphosphate	55.8	1.7	49.9	3.7	2.56	0.71	20.2	4.8
Crop residues + lime + complete commercial fertilizer	58.6	4.5	50.2	4.0	2.23	0.38	19.9	4.5

1 Corn yields averaged from 11 crops on two fields.
2 Oat yields averaged from five crops on two fields.
3 Hay yields averaged from two crops on one field.
4 Winter wheat yields averaged from three crops on two fields.
5 The yields given for the checks are the average of the yields on all check plots on all fields.

fluence than the rock phosphate in all cases except on the hay crop. The complete commercial fertilizer increased the yields of corn and oats more than did the phosphates, showed much less influence on the hay yield but had a greater effect than the rock phosphate on the wheat. It was slightly less effective than the superphosphate for wheat.

These results show that the Grundy silty clay loam was benefited by manure. Lime with manure also proved of value. The phosphate fertilizers increased the yields more when applied with manures than with crop residues. The superphosphate generally seemed slightly superior to the rock phosphate, but the differences often were not very large. Apparently either phosphate may be used successfully on this soil with manure, but rock phosphate does not give as good results when used with crop residues without manure. A complete commercial fertilizer may sometimes be used profitably on the soil, but tests on small areas under individual farm conditions are desirable before extensive applications are made.

Results on the Tama Silt Loam

The Tama silt loam is a rather extensively developed soil in central and eastern Iowa. It occurs on the more gently undulating to slightly rolling uplands, covering extensive areas. A map showing roughly the location and boundary of the area of Tama silt loam in Iowa is given in fig. 11.

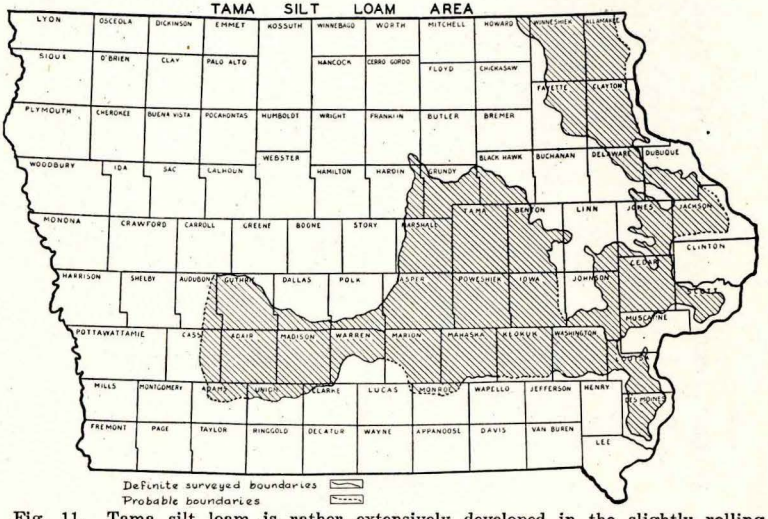

Fig. 11. Tama silt loam is rather extensively developed in the slightly rolling uplands of central and eastern Iowa.

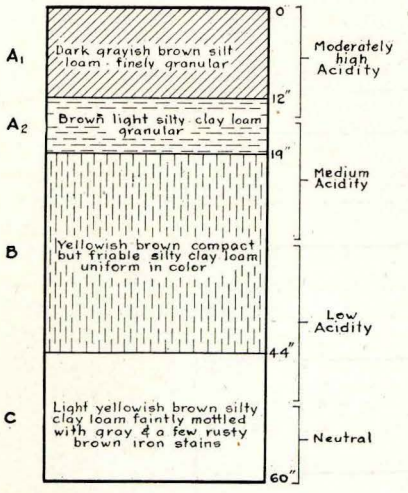

Fig. 12. Soil profile of Tama silt loam.

The Tama silt loam is a dark grayish-brown to almost black friable silt loam, extending to a depth of 12 to 18 inches. The subsurface soil is a brown to light brown heavy silt loam or silty clay loam. The subsoil is a light brown or yellowish-brown compact but friable silty clay loam. Occasionally mottlings of brown and yellow are found in the lower subsoil. A typical Tama silt loam profile is shown in fig. 12.

There are seven fields on this type, and the results obtained are shown in table VI. The application of manure increased the corn and oats crops appreciably and showed small effects on the hay. Lime with the manure increased the various crops; it more than doubled the increase in oats and was much more effective on the corn and hay. Rock phosphate with the manure and lime had little effect on the corn but brought about a large increase in oats and a still larger increase in the hay crop. Superphosphate with manure and lime was more effective than the rock phosphate on the corn and hay crops but had a somewhat smaller influence on the oats. The muriate of potash with superphosphate, manure and lime, showed no effect on the corn but increased the oats and hay yields considerably. The complete commercial fertilizer with manure and lime had more effect on the oats and a slightly greater effect on the corn than did the superphosphate. It had less effect on the hay than either the rock phosphate or the superphosphate.

The crop residues showed little effect on the crops grown. Lime with the residues improved the yields of hay, corn and oats. The rock phosphate with the residues and lime increased the corn crop considerably but had very little influence on the other crops. The superphosphate increased the hay crop more than the rock, but it showed less effect on the corn and much less on the oats. The complete commercial fertilizer had less effect than the phosphates on the corn, but it gave greater increases on the oats and hay yields. The beneficial effect was particularly great on the hay crop.

TABLE VI. TAMA SILT LOAM. AVERAGE CROP YIELDS AND INCREASES DUE TO FERTILIZER TREATMENT. IOWA EXPERIMENT FIELDS.

Treatment	Corn[1]		Oats[2]		Hay[3]	
					Clover, timothy and clover or timothy	
	Av. yield bushels per acre	Increase for treatment bu. per acre	Av. yield bushels per acre	Increase for treatment bu. per acre	Av. yield tons per acre	Increase for treatment tons per acre
Check[4]	53.9	.....	55.2	.....	1.51	.....
Manure	58.3	4.4	58.6	3.4	1.59	0.08
Manure + lime	60.6	6.7	63.3	8.1	1.69	0.18
Manure + lime + rock phosphate	60.8	6.9	69.3	14.1	1.85	0.34
Manure + lime + superphosphate	62.2	8.3	67.4	12.2	1.91	0.40
Manure + lime + superphosphate + potassium	61.1	7.2	72.6	17.4	1.95	0.44
Manure + lime + complete commercial fertilizer	62.3	8.4	71.0	15.8	1.84	0.33
Crop residues	55.3	1.4	53.6	.....	1.46	.....
Crop residues + lime	62.7	8.8	61.6	6.4	1.97	0.46
Crop residues + lime + rock phosphate	66.6	12.7	61.4	6.2	2.01	0.50
Crop residues + lime + superphosphate	65.2	11.3	60.4	5.2	2.08	0.57
Crop residues + lime + complete commercial fertilizer	64.4	10.5	63.4	8.2	2.28	0.77

1 Corn yields averaged from 27 crops on seven fields, except the manure + lime + superphosphate + potassium plot, which is averaged from 22 crops on six fields, and the crop residue plots, which are averaged from five crops on one field.

2 Oat yields averaged from 11 crops on seven fields, except the manure + lime + superphosphate + potassium plot, which is averaged from eight crops on six fields, and the crop residue plots, which are averaged from three crops on one field.

3 Hay yields averaged from six crops on four fields, except the manure + lime + superphosphate + potassium plot, which is averaged from four crops on three fields, and the crop residue plots, which are averaged from two crops on one field.

4 The yields given for the checks are the average of the yields on all check plots on all fields.

This soil type was benefited by applications of manure. Lime increased the yields, not only of the legumes but also of corn and small grains. It gave even larger effects with the crop residues than with manure. The phosphate fertilizers increased crop yields in all cases with manure and in all but one case with crop residues. The superphosphate was somewhat superior to rock phosphate for corn and hay when used with manure but was less effective for corn when used with crop residues. The rock phosphate showed up better on the oats. It seems that either phosphate may be used to advantage on this soil, sometimes one proving superior and sometimes the other. The choice must, therefore, be made for individual conditions. Some good complete fertilizer might be used to advantage on the soil, but tests should certainly be carried out in the field before any extensive application is made.

Results on the Muscatine Silt Loam

The Muscatine silt loam is an important soil type in east-central Iowa. It is found in association with the Tama silt loam, occurring on the level areas adjacent to the more rolling Tama. Its location is shown roughly in fig. 13.

The Muscatine silt loam is a dark grayish-brown to black mellow, friable silt loam, extending to a depth of 12 to 16 inches. The subsurface soil is a grayish-brown to light grayish-brown heavy silt loam. The subsoil is a gray compact silty clay loam, mottled with yellow and brown. A typical Muscatine silt loam profile is shown in fig. 14.

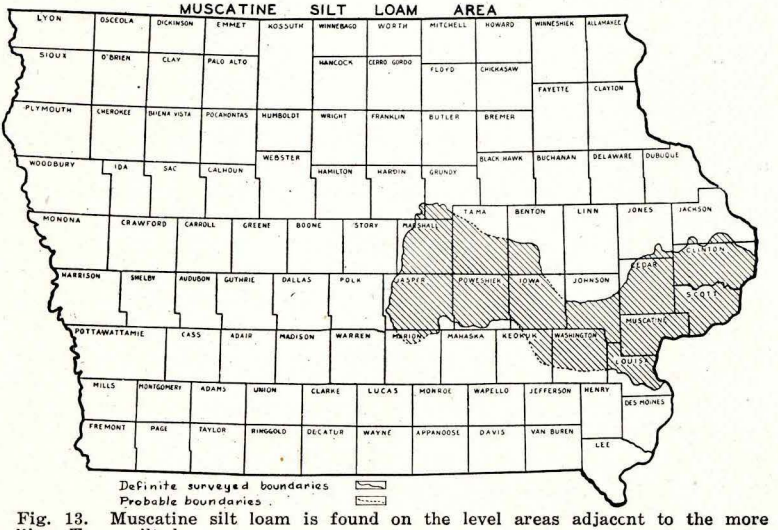

Fig. 13. Muscatine silt loam is found on the level areas adjaccnt to the more rolling Tama silt loam.

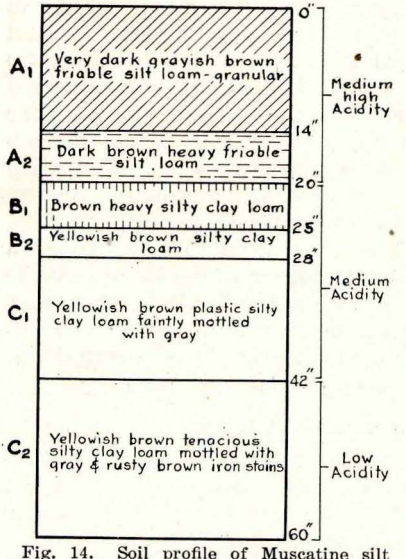

Fig. 14. Soil profile of Muscatine silt loam.

There are four fields on this type, and the results secured are given in table VII. Manure increased the various crops grown on this soil but only to a limited extent in the case of corn, oats, wheat and hay. It had a large effect, however, on the alfalfa. Lime with manure increased the yields of corn, wheat, hay, oats and alfalfa. Rock phosphate with the manure and lime increased the corn, oats, hay and alfalfa crops but had no effect on the wheat. Its influence was most pronounced on the hay crop. Superphosphate with the manure and lime had slightly greater effects than the rock phosphate on the corn, oats and hay but showed less effects on the wheat and alfalfa. Muriate of potash with the superphosphate, manure and lime showed no effect on the oats but gave an increase in the hay. The complete commercial fertilizer with the manure and lime had a smaller effect than the superphosphate on the corn, oats and hay, but showed a greater effect on the wheat and alfalfa.

The crop residues showed little or no effect on the crops grown except on the alfalfa where an increase was noted. Lime with the crop residues increased all crops, its effect being particularly noticeable on the alfalfa where the increase was almost fivefold. The rock phosphate with the crop residues and lime increased the yields of corn, oats, alfalfa and hay. It had no effect on the wheat. Superphosphate with the residues and lime had less effect than the rock phosphate on the corn and alfalfa but a greater influence on the oats, hay and wheat crops. The complete commercial fertilizer increased the yields less than the superphosphate on the wheat but produced greater increases on the oats, hay and alfalfa. It had less effect than the rock phosphate on the corn and alfalfa.

The Muscatine silt loam was somewhat benefited by the use of farm manure, but the effects were much less than those brought about on certain other soil types. Lime either with manure or crop residues increased all crop yields, showing as large effects on the grain crops as on the legumes. The phos-

TABLE VII. MUSCATINE SILT LOAM. AVERAGE CROP YIELDS AND INCREASES DUE TO FERTILIZER TREATMENT. IOWA EXPERIMENT FIELDS.

Treatment	Corn[1]		Oats[2]		Hay[3]		Winter wheat[4]		Alfalfa[5]	
					Clover, timothy and clover or timothy					
	Av. yield bushels per acre	Increase for treatment bu. per acre	Av. yield bushels per acre	Increase for treatment bu. per acre	Av. yield tons per acre	Increase for treatment tons per acre	Av. yield bushels per acre	Increase for treatment bu. per acre	Av. yield tons per acre	Increase for treatment tons per acre
Check[6]	65.8	.....	43.1	.....	1.73	.....	22.7	.....	0.94	.....
Manure	68.7	2.9	45.4	2.3	1.77	0.04	24.5	1.8	1.78	0.64
Manure + lime	72.7	6.9	51.8	8.7	1.91	0.18	29.4	6.7	2.67	1.73
Manure + lime + rock phosphate	75.3	9.5	54.0	10.9	2.20	0.47	29.3	6.6	2.84	1.94
Manure + lime + superphosphate	77.0	11.2	57.8	14.7	2.29	0.56	26.7	4.0	2.75	1.81
Manure + lime + superphosphate + potassium	.....	.....	56.7	13.6	2.43	0.70	.....	.....	.....	.....
Manure + lime + complete commercial fertilizer	76.9	11.1	54.3	11.2	2.17	0.44	32.1	9.4	3.19	2.25
Crop residues	67.3	1.5	44.6	1.5	1.69	.....	19.9	.....	1.29	0.35
Crop residues + lime	71.7	5.9	47.1	4.0	1.90	0.17	26.6	3.9	2.49	1.55
Crop residues + lime + rock phosphate	76.7	10.9	54.0	10.9	2.12	0.39	25.8	3.1	3.03	2.09
Crop residues + lime + superphosphate	74.5	8.7	56.3	13.2	2.15	0.42	27.8	5.1	2.76	1.82
Crop residues + lime + complete commercial fertilizer	74.7	8.9	56.4	13.3	2.19	0.46	25.8	3.1	2.77	1.83

1 Corn yields averaged from 16 crops on four fields, except the crop residue plots, which are averaged from 14 crops on three fields.

2 Oat yields averaged from seven crops on four fields, except the crop residue plots, which are averaged from six crops on three fields, and the manure + lime + superphosphate + potassium plot in which case only one crop on one field is involved.

3 Hay yields averaged from five crops on four fields, except the crop residue plots which are averaged from four crops on three fields and the manure + lime + superphosphate + potassium plot, which involved only one crop on one field.

4 Winter wheat yields averaged from two crops on two fields.

5 Alfalfa yields averaged from two crops on one field.

6 The yields given for the checks are the average of the yields on all check plots on all fields.

phate fertilizers proved of value on this soil. The rock phosphate showed up better in some cases while in others superphosphate gave better results. Either phosphate may be distinctly profitable. Rock phosphate seems to give particularly large effects on this soil, probably due to its high content of organic matter. The use of a complete commercial fertilizer proved profitable on this soil in some cases. In other cases the superphosphate was quite as good. Any complete fertilizer should be tested on a small area before being extensively applied. Tests of different brands of complete commercial fertilizers on this soil are recommended.

Results on the Clinton Silt Loam

The Clinton silt loam is developed to a considerable extent in eastern, central and southern Iowa. It occurs on the more rolling to rough areas of upland. Formerly a wooded soil, it is light in color and relatively low in natural fertility. Its occurrence in Iowa is shown in fig. 15.

The Clinton silt loam is a grayish-brown or gray friable silt loam, extending to a depth of 6 to 8 inches. The subsurface soil is a buff to yellow or yellowish-brown friable silt loam, more compact than the surface. The subsoil is a heavy compact, tough, buff, brown or yellowish-brown, mottled gray and brown silty clay loam to silty clay. A typical Clinton silt loam profile is shown in fig. 16.

Five fields are located on this type, and the results secured on them are given in table VIII. Manure increased all the crops grown on this soil, the greatest influence occurring on the hay. Lime with the manure showed large effects, almost doubling or more than doubling the increases in the corn, oats, hay and winter wheat. Rock phosphate with the manure and lime increased all the crops. It had the largest effect on the corn, oats and wheat. Superphosphate with the manure and lime showed less effect than the rock phosphate on the corn and wheat but had more effect on the oats and hay. The muriate of potash with the superphosphate, manure and lime gave a very large gain in the oats but had no effect on the corn and hay. The complete commercial fertilizer with the manure and lime increased the corn more than did the superphosphate, had about the same effect on the hay and showed less effect on the oats and wheat.

The crop residues gave increases in all the crops but had very little effect on the corn, hay and wheat. Lime with the residues increased all the crops, showing large effects on the corn, wheat and hay. Rock phosphate with the crop residues and lime increased the yields of corn, hay and wheat but had no effect on the oats. Superphosphate with the residues and

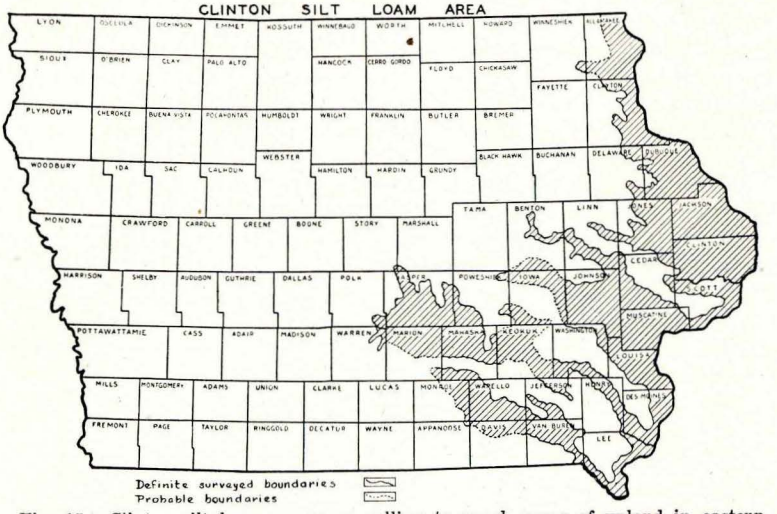

Fig. 15. Clinton silt loam occurs on rolling to rough areas of upland in eastern, central and southern Iowa.

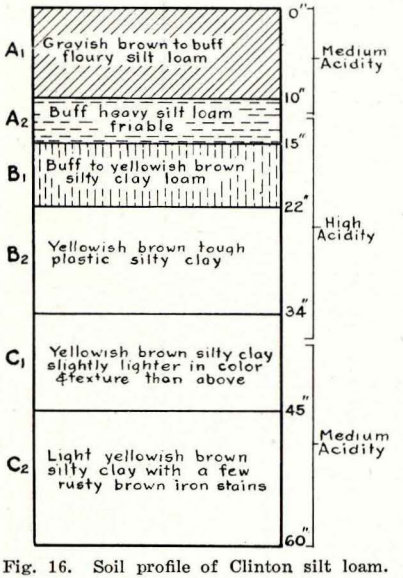

Fig. 16. Soil profile of Clinton silt loam.

lime was less effective than the rock phosphate on the hay and wheat but more effective on the corn and oats. The complete commercial fertilizer had more effect on the corn and wheat than did either of the phosphates. It had less effect on the hay than did rock phosphate but had greater effect on wheat and oats than did the superphosphate.

The beneficial effect of manure on this soil is evident. It is light in color and low in organic matter, and manure would be expected to show large benefits. The crop residue treatment likewise had some effect. Lime gave enormous increases both with manure and with crop residues, on all the crops. The phosphate fertilizers showed especially beneficial effects on the grain crops and some also on the hay. The rock phosphate appeared to give slightly better results than the super-

TABLE VIII. CLINTON SILT LOAM. AVERAGE CROP YIELDS AND INCREASES DUE TO FERTILIZER TREATMENT. IOWA EXPERIMENT FIELDS.

Treatment	Corn[1]		Oats[2]		Hay[3]		Winter wheat[4]	
					Clover, timothy and clover or timothy			
	Av. yield bushels per acre	Increase for treatment bu. per acre	Av. yield bushels per acre	Increase for treatment bu. per acre	Av. yield tons per acre	Increase for treatment tons per acre	Av. yield bushels per acre	Increase for treatment bu. per acre
Check[5]	50.6	.....	35.6	.....	1.25	.....	22.9	.....
Manure	57.1	6.5	41.4	5.8	1.50	0.25	27.9	5.0
Manure + lime	62.3	11.7	50.8	15.2	1.83	0.58	31.6	8.7
Manure + lime + rock phosphate	65.8	15.2	54.2	18.6	1.84	0.59	35.2	12.3
Manure + lime + superphosphate	63.9	13.3	55.1	19.5	2.00	0.75	34.5	11.6
Manure + lime + superphosphate + potassium	61.3	10.7	63.4	27.8	1.96	0.71	.....	.....
Manure + lime + complete commercial fertilizer	66.1	15.5	54.1	18.5	1.99	0.74	32.5	9.6
Crop residues	52.5	1.9	46.1	10.5	1.28	0.03	23.6	0.7
Crop residues + lime	63.4	12.8	46.2	10.6	1.76	0.51	27.8	4.9
Crop residues + lime + rock phosphate	66.4	15.8	45.3	9.7	2.06	0.81	30.9	8.0
Crop residues + lime + superphosphate	67.9	17.3	50.2	14.6	2.02	0.77	29.4	6.5
Crop residues + lime + complete commercial fertilizer	69.4	18.8	49.2	13.6	2.05	0.80	32.3	9.4

1 Corn yields averaged from 13 crops on five fields, except the manure + lime + superphosphate + potassium plot, which is averaged from seven crops on three fields, and the crop residue plots, which are averaged from six crops on two fields.

2 Oat yields averaged from seven crops on five fields, except the manure + lime + superphosphate + potassium plot, which is averaged from four crops on three fields, and the crop residue plots, which are averaged from three crops on two fields.

3 Hay yields averaged from eight crops on five fields, except the manure + lime + superphosphate + potassium plot, which is averaged from five crops on three fields, and the crop residue plots, which are averaged from three crops on two fields.

4 Winter wheat yields averaged from three crops on two fields, except the crop residue plots, which are averaged from two crops on one field.

5 The yields given for the checks are the average of the yields on all check plots on all fields.

phosphate except on the wheat and hay, but the differences were not large. It seems evident that one or the other of these phosphate fertilizers may be used to advantage on this soil. Which one should be chosen cannot be stated definitely at present, but farmers on this soil should test both materials on their farms. This soil varies widely in fertility on different farms, and, hence, the effects of all fertilizing materials may be expected to vary under different conditions. Muriate of potash used on this soil with superphosphate, manure and lime seemed of some value, and farmers may well test this fertilizing material. The complete commercial fertilizer gave better results than the phosphates in several cases, particularly on the grain crops. Tests of any complete fertilizer brand should, however, always be carried out on small areas before extensive applications are made.

Results on the Marshall Silt Loam

The Marshall silt loam is extensively developed in western Iowa, being the chief upland soil in all the western counties. Its occurrence is shown in fig. 17.

The Marshall silt loam is a dark grayish-brown friable silt loam, extending to a depth of 10 to 14 inches. The subsurface soil is a lighter grayish-brown heavy silt loam. The subsoil is a grayish-yellow or yellowish-brown heavy silt loam to silty clay loam. A typical profile of the Marshall silt loam is shown in fig. 18.

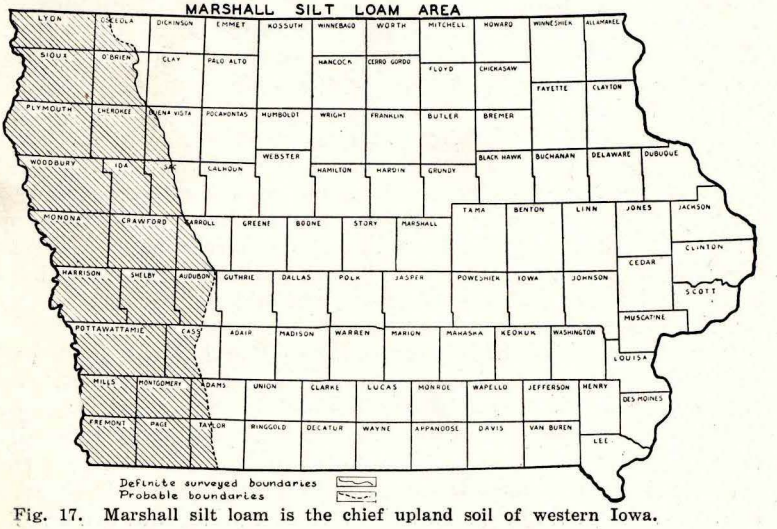

Fig. 17. Marshall silt loam is the chief upland soil of western Iowa.

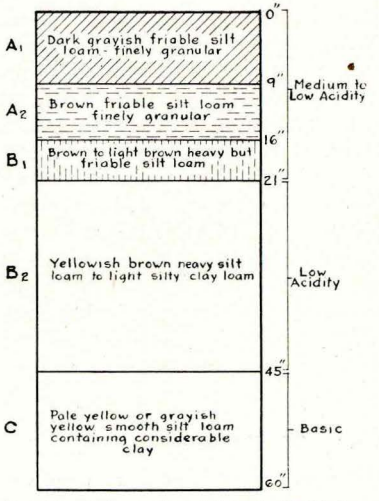

Fig. 18. Soil profile of Marshall silt loam.

There are eight fields on this type and the average results secured are shown in table IX. Manure increased all the crops grown on this soil, except the sweet clover. Lime with manure gave increases on all crops, showing very large effects on the sweet clover, alfalfa, corn and hay. Rock phosphate with the manure and lime showed no effect on the corn and sweet clover but gave increases on the oats, hay, winter wheat and alfalfa. It had the greatest effect on the latter crop. The superphosphate had more effect than the rock phosphate on the corn, oats, wheat, hay and sweet clover but smaller effects on the alfalfa. The complete commercial fertilizer with the manure and lime increased the yields more than the phosphates on the oats, hay and sweet clover crops, but it produced smaller increases than the rock phosphate on the alfalfa. It was less effective than either phosphate on the wheat and about the same as superphosphate on corn.

The crop residues increased the yields of all crops grown but only to a small extent. Lime with the crop residues increased the yields of all the crops except the winter wheat. The largest effect was shown on the sweet clover and alfalfa. The rock phosphate with the residues and lime increased all the yields except that of sweet clover. The superphosphate with the residues and lime had greater effects than the rock on the oats and wheat but showed less effect on the hay and sweet clover and gave about the same results on the corn and alfalfa. The complete commercial fertilizer with the crop residues and lime had about the same effect as the superphosphate on all the crops except the alfalfa. The small increases with the latter crop were undoubtedly due to an abnormal soil condition in the alfalfa plot.

The results as a whole show that the Marshall silt loam will respond to treatments of manure, lime and a phosphate fertilizer. Lime was especially beneficial on the legume crops. This soil is usually not highly acid, and the acidity is generally largely confined to the surface soil. In spite of this fact the application of lime was apparently distinctly worthwhile. Lime benefited the grain crops as well as the legumes, and the effects

TABLE IX. MARSHALL SILT LOAM. AVERAGE CROP YIELDS AND INCREASES DUE TO FERTILIZER TREATMENT. IOWA EXPERIMENT FIELDS.

Treatment	Corn[1]		Oats[2]		Hay[3]		Winter wheat[4]		Sweet clover[5]		Alfalfa[6]	
					Clover, timothy and clover or timothy							
	Av. yield bushels per acre	Increase for treatment bushels per acre	Av. yield bushels per acre	Increase for treatment bushels per acre	Av. yield tons per acre	Increase for treatment tons per acre	Av. yield bushels per acre	Increase for treatment bushels per acre	Av. yield tons per acre	Increase for treatment tons per acre	Av. yield tons per acre	Increase for treatment tons per acre
Check[7]	49.6	.....	44.9	.....	1.61	.....	12.9	.....	0.64	.....	2.73	.....
Manure	53.0	3.4	50.9	6.0	1.88	0.27	20.4	7.5	0.58	.....	2.95	0.22
Manure + lime	54.8	5.2	52.7	7.8	1.90	0.29	20.5	7.6	1.74	1.10	3.47	0.74
Manure + lime + rock phosphate	54.9	5.3	54.3	9.4	1.93	0.32	23.3	10.4	1.53	0.89	4.12	1.39
Manure + lime + superphosphate	56.0	6.4	54.9	10.0	2.04	0.43	25.2	12.3	1.63	0.99	3.84	1.11
Manure + lime + complete commercial fertilizer	56.1	6.5	57.5	12.6	2.25	0.64	21.8	8.9	2.03	1.39	3.97	1.24
Crop residues	53.7	4.1	49.9	5.0	2.06	0.45	18.2	5.3	0.90	0.26	2.74	0.01
Crop residues + lime	56.7	7.1	54.4	9.5	2.18	0.57	18.2	5.3	1.92	1.28	3.22	0.49
Crop residues + lime + rock phosphate	58.1	8.5	56.3	11.4	2.49	0.88	18.3	5.4	1.83	1.19	3.38	0.65
Crop residues + lime + superphosphate	58.0	8.4	60.8	15.9	2.26	0.65	20.4	7.5	1.50	0.86	3.39	0.66
Crop residues + lime + complete commercial fertilizer	57.5	7.9	56.8	11.9	2.62	1.01	20.6	7.7	1.44	0.80	2.88	0.15

1 Corn yields averaged from 28 crops on eight fields, except the crop residue plots, which are averaged from 13 crops on three fields.

2 Oat yields averaged from 14 crops on eight fields, except the crop residue plots, which are averaged from four crops on three fields.

3 Hay yields averaged from three crops on three fields, except the crop residue plots, which are averaged from two crops on two fields.

4 Winter wheat yields averaged from three crops on one field.

5 Sweet clover yields averaged from two crops on two fields.

6 Alfalfa yields averaged from two crops on one field.

7 The yields given for the checks are the average of the yields on all check plots on all fields.

were shown both where manure was employed and where the crop residues were used. Rock phosphate and superphosphate generally gave very similar effects, the rock showing up to the best advantage sometimes and the superphosphate in other instances. The choice between the two materials must, therefore, be made after tests have been carried out under individual farm conditions. The complete commercial fertilizer showed greater effects than the phosphates in some cases, but in general it had no greater influence. Any brand of a complete fertilizer should be tested, therefore, before it is employed extensively on a farm. It may prove more profitable than a phosphate in some instances.

Results on the Waukesha Silt Loam

The Waukesha silt loam is an important soil type in the state, occurring on many high stream terraces or second bottomlands. It is found in all parts of the state in such positions, being most extensively developed, however, in the western counties in association with the Marshall silt loam.

The Waukesha silt loam is a very dark grayish-brown silt loam, extending to a depth of 12 to 15 inches. The subsurface soil is a brown to dark grayish-brown silt loam to heavy silt loam. The subsoil is a yellowish-brown to yellow silt loam, loam or silty clay loam, often containing considerable sand. A typical Waukesha silt loam profile is shown in fig. 19.

There are two fields on this type, and the results secured are given in table X. Manure increased the corn yield considerably, showed small effects on the oats but none on the hay. Lime with manure increased the corn and oats yields. It had no effect on the hay crop. Rock phosphate with manure and lime increased all the crops except the oats, showing a large influence on the hay crops. Superphosphate with the manure and lime had a very similar effect to the rock phosphate on the corn and oats. It showed no effect on the hay. The complete commercial fertilizer with the manure and lime showed less effects than the phosphates on the corn and hay but gave a pronounced increase in the oats.

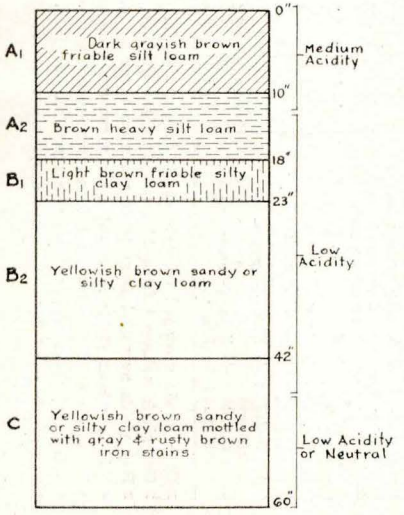

Fig. 19. Soil profile of Waukesha silt loam.

TABLE X. WAUKESHA SILT LOAM. AVERAGE CROP YIELDS AND INCREASES DUE TO FERTILIZER TREATMENT. IOWA EXPERIMENT FIELDS.

Treatment	Corn[1]		Oats[2]		Hay[3]	
					Clover, timothy and clover or timothy	
	Av. yield bushels per acre	Increase for treatment bu. per acre	Av. yield bushels per acre	Increase for treatment bu. per acre	Av. yield tons per acre	Increase for treatment tons per acre
Check[4]	54.7	.....	52.8	.....	1.51	.....
Manure	62.1	7.4	53.5	0.7	1.26	.....
Manure + lime	63.5	8.8	65.5	12.7	1.39	.....
Manure + lime + rock phosphate	64.7	10.0	61.2	8.4	1.92	0.41
Manure + lime + superphosphate	64.7	10.0	62.1	9.3	1.80	0.29
Manure + lime + complete commercial fertilizer	61.7	7.0	68.2	15.4	1.65	0.14
Crop residues	54.8	0.1	54.3	1.5	1.71	0.20
Crop residues + lime	58.6	3.9	54.1	1.3	1.78	0.27
Crop residues + lime + rock phosphate	60.9	6.2	60.9	8.1	1.88	0.37
Crop residues + lime + superphosphate	60.9	6.2	62.1	9.3	1.91	0.40
Crop residues + lime + complete commercial fertilizer	57.5	2.8	62.5	9.7	1.74	0.23

1 Corn yields averaged from 13 crops on two fields.
2 Oat yields averaged from seven crops on two fields.
3 Hay yields averaged from four crops on two fields.
4 The yields given for the checks are the average of the yields on all check plots on all fields.

The residues increased the yields slightly in all cases. Lime with the residues brought about increases in the corn and hay but showed no effect on the oats. The rock phosphate with the residues and lime increased considerably the corn and oats and slightly increased the hay crop. Superphosphate with the residues and lime had about the same effect as the rock phosphate on the corn and hay but had more effect on the oats. The complete commercial fertilizer had less effect on the corn and hay than did the phosphates but showed as good an effect on the oats.

These results show that applications of manure were of value on the Waukesha silt loam for general farm crops. Lime was worth while as a basic soil treatment. A phosphate fertilizer was effective on this soil, and either rock phosphate or superphosphate may be employed with profit. There was very little choice between these two materials according to these tests. It is desirable that tests of the two phosphates be carried out on individual farms. A complete commercial fertilizer did not seem in general to be of any more value on this soil than the phosphates.