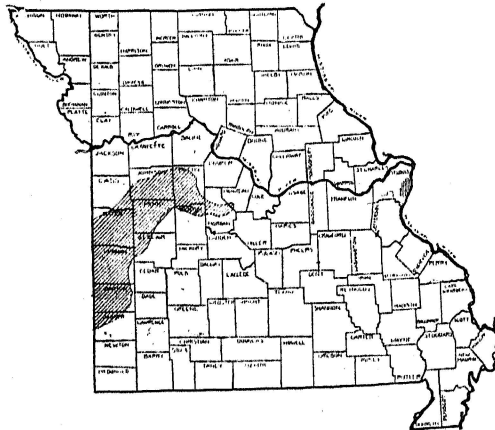


UNIVERSITY OF MISSOURI.

COLLEGE OF AGRICULTURE

Agricultural Experiment Station.

BULLETIN NO. 84.



Shaded Area Shows Territory in
which this Soil Occurs.

Soil Experiments on the Prairie Silt Loam of Southwest Missouri

COLUMBIA, MISSOURI.

January, 1910.

UNIVERSITY OF MISSOURI.

COLLEGE OF AGRICULTURE

Agricultural Experiment Station

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SOIL EXPERIMENTS ON THE PRAIRIE SILT LOAM OF SOUTHWEST MISSOURI.

BY M. F. MILLER AND C. B. HUTCHISON.

The Experiment Station has long felt that its work should reach out to other soils and other regions than those common to the location at Columbia in order to give the farmers all the help possible. It has recognized the fact that if the farmers of Missouri are to receive the greatest benefit from its soil investigations they must be made to cover not simply a single soil or region but ultimately every soil and section of the state. With this end in view a beginning was made in 1905 when the Legislature of that year appropriated a small sum of money for what was termed a "soil survey" of the state. The object was not only to outline in a definite manner the important soil types as they exist but to carry forward such investigations on each of these types as would be of the most benefit to the farmers of the various sections. As a result a number of experiment fields are now being conducted in various parts of Missouri the plan in each case being to determine not only the most immediately remunerative system of fertilization and soil management, but also the system which promises most as a permanent practice. One of the first fields was located near Lamar on the dark gray silt loam of the rather level prairie of Barton, Bates, Vernon, and Northern Jasper, Western St. Clair, Northwestern Dade, Eastern Henry and parts of Pettis, Benton and Morgan counties. The following report has to do with the results of the experiments in that locality.

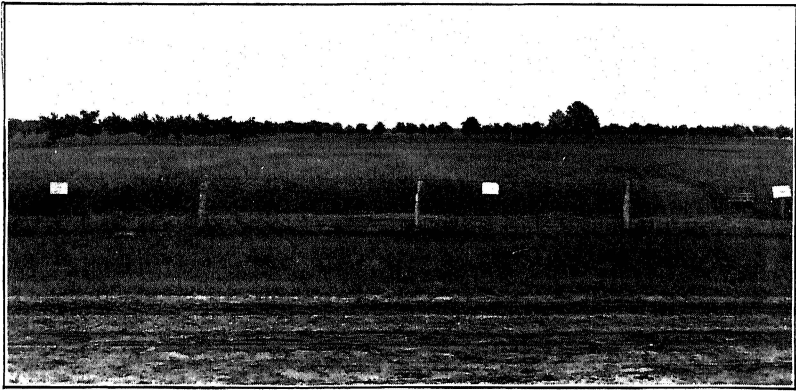
LOCATION OF THE LAMAR FIELD.

The Lamar field is located one-fourth mile southeast of Lamar on the farm of D. A. Beamer (T. 32, R. 30, S. 30.) The prairie soil on which this field is laid out is to be distinguished from the sandy type and the limestone soil of this region by its dark gray color, its fine texture and its rather level topography causing it to lack proper drainage in many cases. It is a dark gray loam to a depth of eight inches, underlaid by a silty clay of yellowish gray color running into a reddish clay at depths varying from two to three feet. It comes between the extreme level areas of this prairie and the more rolling type and would be considered an average of this prairie land.

COMPOSITION OF THIS SOIL.

There are ten chemical elements essential to plant growth. These are, carbon, hydrogen, oxygen, potassium, phosphorus, calcium, magnesium, sulphur, and iron. The first of these, carbon, occurs abundantly in the air while hydrogen and oxygen combine to form water, and plants take these

elements directly from these sources. The other seven are the only ones with which the farmer is concerned, and fortunately the first four—nitrogen, phosphorus, potassium, and calcium—are the only ones in which soils are apt to be deficient. It is to these four alone, therefore, that particular attention is given in soil analysis and in a discussion of soil fertility. Calcium, (often referred to in the form of lime,) is much less apt to be lacking than the other three on ordinary soils so that usually nitrogen, phosphorus (often referred to in the form of phosphate or phosphoric acid) and potassium (often referred to in the form of potash) are the only ones considered. In this particular soil however, lime is also lacking and its quantity is given in the analysis.



GENERAL VIEW OF LAMAR EXPERIMENT FIELD.

These elements exist in the soil largely in insoluble forms and for them to be made available to plants these insoluble forms must gradually be made soluble by certain soil processes so that plants can make use of them. In virgin soils these elements are usually available in abundance but after long continued cultivation and the growing and removing of crops, the available supply becomes low and hence the yield of crops is materially decreased. The total amount of these elements varies in different soils. The soil of one region may be comparatively well supplied with one and deficient in another while in the soil of another region the relative amounts present may be reversed.

Plants always use these elements in definite proportions and cannot substitute one for another. If a soil in question be especially deficient in one of these, in available form, this becomes the limiting element and the yield of crops produced on this soil is limited by the available amount of this element present. For instance if the supply of available phosphorus is sufficient for the production of only one-half an average crop of corn, there can be only half a crop, no matter how much potassium and nitrogen may

be present. Many soils in Missouri have been depleted in soil fertility to such an extent by exhaustive methods of farming that the application of these elements to the soil in the form of manure, commercial fertilizers, or green manure crops, has been found to be a profitable operation. It is for the purpose of determining in which of these elements this soil is deficient and whether it will pay the farmer to supply them to the soil that these experiments are planned.

The question will doubtless be raised by many readers of this report why the soil analysis itself is not sufficient to tell at once the exact soil treatment necessary. It is a common opinion among those not familiar with soil experiments that a chemical analysis will tell the exact kind and amount of fertilizer to apply and at first thought this would seem perfectly possible. The difficulty in doing this lies in the fact that plant food is taken up by the plant only as it is dissolved from the more or less insoluble soil grains, and the amount that is thus dissolved during any given season depends not only upon the total amount of the various elements present but upon the form in which they occur in the soil, upon the quantity of humus in the soil, upon the texture of the soil, upon the season and upon the way the soil is handled. It will readily be seen therefore, that a determination of the amount of each of the plant foods present does not tell how much will be made available each season and it is therefore impossible to tell exactly the amount and kind of fertilizer to apply. The analysis does tell in what plant foods the soil is most deficient and suggests the proper systems of farming for the building up of such elements. In this it is of much value. It should be said also that usually the amount of plant food made available is somewhat proportional to the total amounts of each present so that the analysis does help in determining fertilizer treatments.

In the table given below the analysis of this soil is shown in comparison with that of a very fertile soil as a standard. This standard is obtained by averaging the results of the analyses of a large number of fertile soils from various parts of the United States and Europe.

	Nitrogen.	Phosphorus.	Potassium.	Lime
The top 7 inches of an acre of very fertile soil contains	6000 lbs	2000 lbs.	5300 lbs.	7000 lbs.
The top 7 inches of an acre of Lamar soil contains	2480	445	3835	4960

From this analysis the soil will be seen to contain less than one-half the nitrogen, about one-fifth the phosphorus, about two-thirds the potassium, and two-thirds the lime found in a very fertile soil. It would, therefore, be expected that the addition of all of these elements to the soil

would be very beneficial to the growth of crops and the results of the field experiments substantiate this statement.

This analysis does not show the amount of organic matter, usually called humus, contained in the soil but as the nitrogen is contained in the humus the low nitrogen supply clearly indicates a lack of humus also. The lack of humus in a soil more than any other one factor limits the production of crops since upon its presence depends to a large degree the availability of the various plant foods to the plant. Usually, therefore, the building up of this humus supply in the soil is of fundamental importance. As a matter of fact even on a soil as deficient in the mineral elements as this



EFFECT OF SOIL TREATMENT ON CORN.

Plot on left received no treatment and yielded 19.3 bushels per acre.

Plot on right received Cowpea-Phosphorus-Potassium-Lime treatment and yielded 45 bushels per acre.

one is shown to be, if the humus supply is built up to a large amount, sufficient mineral elements will be made available for a time to bring large crop yields, but with the low amount of humus present it is only on the most favorable seasons that maximum crops result without special soil treatments.

PLAN OF EXPERIMENT.

This experiment field as originally laid out consisted of three series of one-fifth acre blocks, seven blocks to the series. On each of these series a three-year rotation of corn, wheat, and clover was followed, so arranged that one series was put in corn each year, one in wheat, and one in clover. In 1907 this rotation was changed to one of corn, cowpeas,

wheat, clover and a fourth series of blocks was added. Each series of seven blocks receives the following soil treatment:

- Block 1. Cowpeas and phosphorus.
- Block 2. No soil treatment.
- Block 3. Cowpeas and potassium.
- Block 4. Phosphorus and potassium.
- Block 5. Cowpeas, phosphorus, and potassium.
- Block 6. No soil treatment.
- Block 7. Cowpeas, phosphorus, potassium, and lime.

The cowpea treatment is given for the purpose of building up the nitrogen and humus supplies of the soil. As is well known, all legume crops such as clover and cowpeas have the property of adding nitrogen to the soil from the air, through the medium of the bacteria in the tubercles of their roots. It is to this property that the fertilizing effect of such crops is due. This treatment is given by the growing of cowpeas between the regular crops of the rotation wherever possible, particularly by sowing them between the rows of corn at the last cultivation. In actual practice they may be pastured off with cattle or sheep. In these experiments it is impractical to pasture them off so that they are turned under to add nitrogen and humus for succeeding crops. As it was impossible to grow a crop of cowpeas before corn the first year of the experiments (1906) the corn plots of this year which were intended to receive the cowpea treatment received instead an application of 50 lbs. of dried blood per acre as a source of nitrogen.

The phosphorus treatment consists in applying finely ground beef bone meal before corn and before wheat, 150 lbs. per acre being used at each application, plowed under, or broadcasted and well worked into the soil before the corn is planted, or drilled in with an ordinary fertilizer drill.

The potassium treatment consists in applying 50 lbs. per acre of muriate of potash before corn and before wheat, putting it on in the same way as bone meal.

For the lime treatment 2000 lbs. per acre of ground limestone is applied before corn once in every other round of the rotation. This lime is broadcasted immediately after plowing for corn, allowing the after preparation of the seed bed to work it into the soil.

EXPERIMENTS WITH CORN, 1906 (LAMAR FIELD).

SOIL TREATMENT.		Yield bu. per acre.	Increase bu. per acre.	Value of increase per acre.	Cost of treatment.	Net Return.
1	Nitrogen, Phosphorus	40.5	5.0	\$2.50	\$2.30	\$.20
2	No treatment	35.5				
3	Nitrogen, Potassium	38.5	2.0	1.00	1.71	-.71
4	Phosphorus, Potassium	47.5	12.0	6.00	2.67	3.33
5	Nitrogen, Phosphorus and Potassium	44.0	8.5	4.25	3.34	.91
6	Fertilizer in hill	49.5	14.0	7.00	1.40	5.60
7	Nitrogen, Phosphorus, Potassium, Lime	51.0	15.5	7.75	3.84	3.91

1907.

SOIL TREATMENT.		Yield bu. per acre.	Increase bu. per acre.	Value of increase per acre.	Cost of treatment.	Net Return.
1	Cowpeas, Phosphorus	25.2	5.9	\$ 2.95	\$ 3.00	\$-.05
2	No treatment	19.3				
3	Cowpeas, Potassium	32.5	13.2	6.60	2.34	4.26
4	Phosphorus, Potassium	41.3	22.0	11.00	4.00	7.00
5	Cowpeas, Phosphorus, Potassium	41.3	22.0	11.00	4.67	6.33
6	Cowpeas, Phosphorus, Potassium, Lime	45.0	25.7	12.85	5.17	7.68

AVERAGE FOR 1906-1907.

SOIL TREATMENT.		Yield bu. per acre.	Increase bu. per acre.	Value of increase per acre.	Cost of treatment.	Net Return.
1	Cowpeas, Phosphorus	32.9	5.5	\$ 2.75	\$ 2.65	\$.10
2	No treatment	27.4				
3	Cowpeas, Potassium	35.5	8.1	4.05	2.03	2.02
4	Phosphorus, Potassium	44.4	17.0	8.50	3.34	5.16
5	Cowpeas, Phosphorus, Potassium	42.7	15.3	7.65	4.01	3.64
6	Cowpeas, Phosphorus, Potassium, Lime	48.0	20.6	10.30	4.51	5.79

Note.—No corn was grown on the regular series in 1908, owing to a change in the system of rotation. The yields of the corn plats for 1909 had not been secured at time of going to press.

BASIS FOR CALCULATION.

Corn—50 cents per bushel.

Nitrogen (in 1906) dried blood 50 lbs. per acre costing \$2.50 per 100 lbs.

Cowpea treatment cost \$2.00 per A.

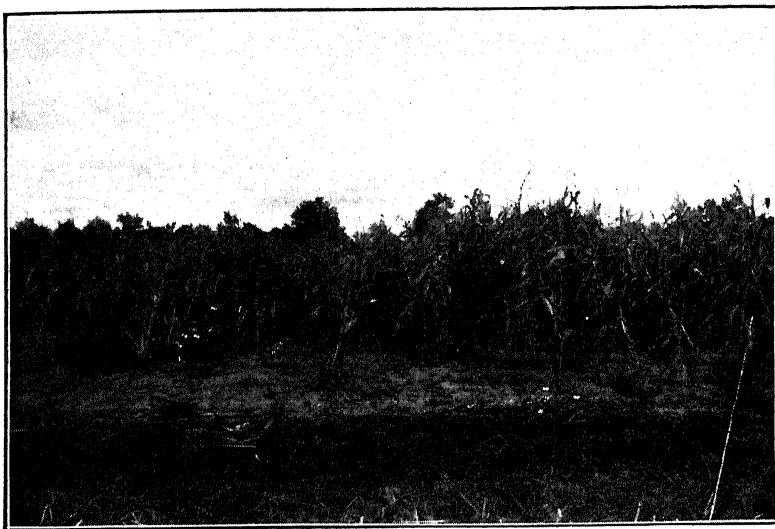
Lime—2000 pounds applied every eighth year, cost 50 cents an acre per year.

Phosphorus—Beef bone meal 300 lbs. applied in four-year rotation, 150 lbs. before corn, 150 lbs. before wheat, cost \$1.40 per 100 pounds.

Potassium—100 pounds potassium chloride applied in four-year rotation, 50 lbs. before corn, 50 lbs. before wheat Cost \$2.50 per 100 pounds.

Total cost of treatment per plot divided between crops grown.

It will be seen that as the analysis of this soil would indicate it is in need of all three of the elements—nitrogen, phosphorus, and potassium—while lime is also needed as a corrective of acidity. The largest increases have come, therefore, where all fertilizer elements were added. It will be noticed that in 1906 one of the plots planned to receive no soil treatment was treated with a complete fertilizer in the hill put in with a fertilizer planter. This fertilizer contained approximately 2½% nitrogen, 10% available phosphoric acid, and 3% of potash, and the return was very large.



EFFECT OF SOIL TREATMENT ON CORN.

Plot on left received no treatment and yielded 19.3 bushels per acre.
Plot on right received Cowpea-Potassium treatment
and yielded 32.5 bushels per acre.

The use of phosphorus and potassium has brought the largest increase for any two elements although this increase has been exceeded both by the complete treatment, including lime, and by the use of fertilizer in the hill. When the financial return is considered it will be seen that the fertilizer in the hill easily leads with a net return of \$5.60 per acre, with the complete treatment second, and the combination of phosphorus and potassium third. Nitrogen and potassium combined gave but little increase.

In 1907 it will be observed that while the actual yield of corn is less, the relative increase from the treatments is much greater, the yield having been more than doubled on three of the treated plots. The net return is also seen to be much greater in 1907, all the treatments having paid well, excepting cowpeas-potassium, which shows a small loss. The complete

treatment leads with a net return of \$7.68 per acre with phosphorus-potassium second, nitrogen-phosphorus-potassium third, and nitrogen-potassium fourth. An average of the two years shows the results in the same order as in 1907.

EXPERIMENTS WITH WHEAT (LAMAR FIELD).

SOIL TREATMENT.	Yield bu. per acre.	Increase bu. per acre.	Value of increase.	Cost of treatment.	Net return.
1907.					
No treatment	12.0				
Cowpeas, phosphorus	15.3	3.3	2.64	2.07	+ 0.57
Cowpeas, potassium	14.0	2.0	1.60	1.92	— 0.32
Phosphorus, potassium	19.1	7.1	5.68	2.65	+ 3.03
Cowpeas, phosphorus, potassium	21.0	9.0	7.20	3.32	+ 3.88
Cowpeas, phosphorus, potassium, lime	26.0	14.0	11.20	3.82	+ 7.38
1908.					
No treatment	9.0				
Cowpeas, phosphorus	15.4	6.4	5.12	2.30	+ 2.82
Cowpeas, potassium	11.2	2.2	1.76	1.71	+ 0.05
Phosphorus, potassium	19.8	10.8	8.64	2.67	+ 5.97
Cowpeas, phosphorus, potassium	15.9	6.9	5.52	3.34	+ 2.18
Cowpeas, phosphorus, potassium, lime	19.1	10.1	8.08	3.84	+ 4.24
AVERAGE OF EXPERIMENTS WITH WHEAT.					
1907-1908.					
No treatment	10.5				
Cowpeas, phosphorus	15.4	4.9	3.92	2.19	+ 1.73
Cowpeas, potassium	12.6	2.1	1.68	1.82	— 0.14
Phosphorus, potassium	19.5	9.0	7.20	2.66	+ 4.54
Cowpeas, phosphorus, potassium	18.5	8.0	6.40	3.33	+ 3.07
Cowpeas, phosphorus, potassium, lime	22.6	12.1	9.68	3.83	+ 5.85

BASIS OF CALCULATION.

Wheat 80 cents.

Cowpea treatment cost \$2 per A.

Lime—2000 lbs. applied every eighth year costs 50 cents a year.

Phosphorus—Beef bone meal 300 lbs. applied in four-year rotation—150 lbs. before corn, 150 lbs. before wheat, cost \$1.40 per 100 lbs.

Potassium—100 lbs. potassium chloride applied in four-year rotation. 50 lbs. before corn, 50 lbs. before wheat, cost \$2.50 per 100 lbs.

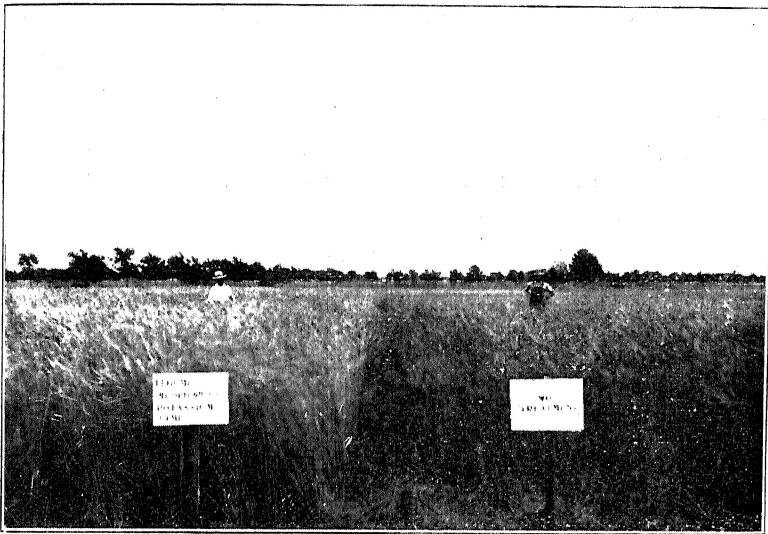
Total cost of treatment per plot divided between crops grown.

The results with wheat are on the whole very much the same as those for corn, showing the largest return from the phosphorus-potassium, from the nitrogen-phosphorus-potassium, and from the complete treatments. The greatest net return is derived from the complete treatment where the effect of the lime is very apparent. All of the treatments have paid well except that of nitrogen-potassium which has shown a loss both seasons. It will also be seen that the use of phosphorus shows a greater return with wheat than with corn, while the reverse is true in the case of potassium.

When results on both corn and wheat are compared it will be seen that the four elements are almost equally beneficial in the return which they bring; the more complete the treatment the larger the increase and usually the larger the net return.

EXPERIMENTS WITH COWPEAS AND CLOVER.

Cowpeas have been grown in both 1907 and 1908 as a regular crop but accurate weights of the various crops were not secured. The cowpeas showed some differences to the eye from the various treatments although



EFFECT OF SOIL TREATMENT ON WHEAT.

Plot on right received no treatment and yielded 12 bushels per acre.

Plot on left received Cowpea-Phosphorus-Potassium-Lime treatment and yielded 26 bushels per acre.

the differences were not nearly so marked as those of the corn and wheat plots, indicating that cowpeas are better adapted to profitable culture on this soil without soil treatment than any of the other common crops.

A crop of clover was produced in 1908 on series A but here again accurate weights were not obtained. The differences were very striking, however, the clover failing to catch except on the plots receiving both cowpeas and phosphorus treatment. On these plots, namely, those receiving cowpeas-phosphorus, the cowpeas-phosphorus-potassium, and the cowpeas-phosphorus-potassium-lime treatments, the stand was good and the yield was estimated from one to one and one-half tons per acre. The two plots receiving the most complete treatments gave the best growth of clover although there was little difference between these two.

There seems little doubt from this experiment that if clover is made to succeed on this soil it will be accomplished through the use of cowpeas and phosphates particularly. Doubtless, the use of potash and lime in addition will be of assistance. It is hoped that further experiments will demonstrate fully the requirements for profitable clover growing on this level prairie land. From this one experiment however, the recommendations that could be made would be to follow a crop of cowpeas with wheat, using 150 lbs. per acre of steamed bone meal, putting it on with the fertilizer drill when the wheat is sown, and sowing the clover on the wheat ground in the spring. The effect of the cowpeas and the bone meal except on the most level pieces of this prairie will go a long way towards giving a profitable growth of clover.

THE NEED OF DRAINAGE.

The level phases of this prairie land need drainage badly and they will never reach their highest state of productiveness until they are successfully underdrained. An experiment in tile drainage on this land in which a four-acre tract was underdrained with tile laid 6 rods apart and this compared with a similar undrained tract has shown a considerable benefit from the drainage. Only one season's results are available and these on corn, the increase from the drainage being 8.9 bushels per acre. This would indicate that tile drainage is not only feasible but that it would be profitable on this level prairie especially on the flatter areas.

GENERAL RECOMMENDATIONS FOR HANDLING THIS SOIL TYPE.

The Humus and Nitrogen Supplies.

The first essential to permanently increased productiveness on this soil is the building up of the supply of humus or vegetable matter, which has been greatly reduced by the extensive cultivation of corn and small grains. This may be accomplished most easily by the adoption of a systematic crop rotation in which cowpeas or clover shall occur often and in which these as well as practically all other crops shall be fed back onto the land. Since nitrogen is contained in the humus of the soil and since it is also added to the soil by growing legume crops such as clover and cowpeas, this building up of the humus will likewise mean a building up of the nitrogen supply, in which this soil is also deficient.

The Use of Cowpeas.

Red clover does not do well on most of this prairie land because of the acidity, lack of humus and because of its wet compact nature. Cowpeas on the other hand are well adapted and their use both as a regular crop and as a catch crop to be thrown in between other crops is strongly recommended. Most men already appreciate the value of cowpeas in this region but their culture should be greatly extended. It is upon this crop more than upon any other that the future productiveness of this soil depends. As humus and nitrogen builders for the soil, they have no equal in this section; as a leguminous feed they must be the main crop, and the man who is to secure the greatest profit from his land will make every possible use of them. Cowpea hullers should be introduced in order to lower the price of seed and put them in reach of greater numbers of men. Methods of culture should be studied until the best means of handling them are thoroughly understood. There is no crop that can take their place in this region.

Suggested Crop Rotations.

A standard rotation for this region would be one of corn, cowpeas, wheat, each one year, the wheat to be followed with timothy for one or two years. Where clover can be made to succeed it may be used alone for the fourth year of the rotation or mixed clover and timothy may be used and allowed to stand two years. If this gives too small an acreage of corn for the livestock handled, a second year of corn may be inserted the second season, thus making the rotation one of corn, corn, cowpeas, wheat, clover and timothy one or two years.

Cowpeas should be seeded with the corn for a hog or sheep pasture and for soil improvement. A close study of the proper methods of handling them when sown in the corn in this way is necessary or occasional failures will result. They may be sown either with the corn when it is planted or at the last cultivation. In the first case, it is best to use a medium early variety of corn and postpone planting until at least the middle of May. Peas planted in this way make a good amount of seed and are especially valuable for hogging down with the corn. Where the peas are sown at the last cultivation it is necessary to lay the corn by a little early and drill in the peas with a one-horse drill letting this take the place of the last cultivation. Peas sown in this way are best pastured out with lambs or range sheep. On most farms it will be wise to put in a part of the peas one way and part another for the various pasture purposes. Where not pastured at all the benefit to the land will much more than pay for the seed and trouble.

Where two years of corn are used in the rotation it will suit many farmers better to cut up the corn the second season and sow the land to

rye for winter and spring pasture. This rye may be pastured until the last of April when the land can be broken for the regular cowpea crop the third year.

A three-year rotation of corn, wheat, cowpeas, or corn, oats, cowpeas is also to be recommended. Where wheat is used the second year this prevents the seeding of cowpeas in the corn and it also necessitates cutting the corn. It is possible however to follow the wheat with cowpeas the same season where the wheat can be gotten off the ground early and



EFFECT OF SOIL TREATMENT.

Plot on left received no soil treatment and yielded 12 bushels per acre.

Plot on right received Phosphorus-Potassium-Lime treatment and yielded 21 bushels per acre.

where there is sufficient moisture for plowing the wheat stubble. Cowpeas sown by the 10th of July after wheat or oats will make good hay on an average season in this section and will greatly benefit the land. Peas may also follow oats, especially where the oats are cut for hay. For many farmers it may be more satisfactory to follow the wheat or oats with rye for winter and spring pasture to be plowed under for peas the following April.

A good rotation where both oats and wheat are desired is one of corn, one or two years, oats, wheat, cowpeas. Where it is desired to build up the land rapidly peas may be seeded in the corn and they may also be seeded after the wheat if the plowing can be done, thus giving a crop of peas on the ground every year except the one which is in oats. The last year of the rotation may be given to clover where clover grows well although this will necessarily prevent the sowing of peas after the wheat.

Attention should be called to the fact that alsike clover is much better adapted to this land than red clover and for a mixture with timothy it is strongly to be recommended. It will grow readily on soil that is too wet for red clover.

The Saving of Manure.

If the humus supply is to be built up most rapidly on this soil, every use should be made of farm manure. Manure also contains such large quantities of plant food that no farmer who is interested in the welfare of his soil can afford to allow it to waste. The careful farmer will figure the manure produced on the farm as worth at least \$2.00 per ton and he will get that return from it by its proper use. In this connection it should be said that a manure spreader will pay on practically every stock farm of 100 A. or over where cattle are lot or stable fed, not only from the standpoint of saving labor but more especially from the fact that manure applied evenly and not too heavily gives a much larger return *per ton* than where it is applied irregularly. It can be made to go much further and a greater net return will be secured. This alone will soon pay for the spreader.

A livestock system in which a large use is made of cowpea and grass crops all to be fed back on the land, together with the corn and all roughage will build up this land most rapidly.

The Use of Fertilizers.

The results of these experiments have shown conclusively the benefit to be derived from the use of phosphates and potash on this soil. Consequently the application of fertilizers containing these two elements in proper proportions will be most remunerative. The fertilizer to be recommended is one containing from 10 to 15% available phosphoric acid and from 3 to 4% potash. Unfortunately there are only a few brands on the market having this composition. The bone and potash fertilizers put out by a number of the fertilizer companies have approximately this composition as regards phosphates and potash but they usually contain considerable nitrogen also. The careful farmer will however put the nitrogen into his soil by means of cowpeas and manure as it can be supplied in this way at a cost of from 3 to 6 cents a pound while in commercial form it costs from 15 to 18 cents a pound.

The most satisfactory plan of adding the proper amounts of phosphates and potash will usually be to buy steamed bone meal and muriate of potash mixing them in the proportion of 100 lbs. of the bone to 10 lbs. of the muriate.

The steamed bone contains approximately 30% of phosphoric acid about one-half of which is available. It will thus supply sufficient avail-

able phosphates for the first crop while the more or less insoluble portion will be gradually dissolved for the benefit of succeeding crops. The muriate of potash contains 50% of actual potash all of which is available.

For corn the application of 150 lbs. per acre of the above described mixture, or a prepared fertilizer of this composition, applied with a fertilizer grain drill ahead of the corn planter is recommended. For wheat 150 lbs. per acre should be put on with a fertilizer grain drill at the same time the wheat is sown.

Fertilizers may also be applied in the hill or drill with corn and very good profits secured. In this case from 60 to 75 lbs. of fertilizer of the above composition or a complete fertilizer containing $1\frac{1}{2}$ to $2\frac{1}{2}$ % nitrogen, 10 to 12% available phosphoric acid and 2 to 3% potash is to be recommended. This should be applied with a fertilizer attachment to a corn planter at the time the corn is planted. It is not good practice to use over 100 lbs. as large amounts are very apt to cause the corn to "fire" if the season is dry. It must also be remembered that such a use of fertilizer has practically no effect in building up the land. In fact this is such a cheap method of increasing the corn yield that many times it results in corn being grown too often on the same land to the ultimate injury of the soil. It is a practice for the renter or for the man who must have an immediate crop rather than for the permanent farmer. The permanent farmer should use fertilizer in the hill or drill for corn only in connection with a system of crop rotation and manuring which will maintain a high content of humus in the soil.

The most common fertilizers now on the market in this section of the state are the so called "complete" fertilizers containing usually from $1\frac{1}{2}$ to $2\frac{1}{2}$ % nitrogen, from 8 to 12% available phosphoric acid and from $1\frac{1}{2}$ to 3% potash. Such fertilizers will give good returns on worn land where the immediate crop of wheat or corn is desired, but for the man who keeps his land up well in nitrogen with cowpeas and manure, the fertilizer with a minimum of nitrogen and the maximum amount of phosphoric acid will be most remunerative.

A word should be said regarding the continued use of fertilizers on this land. There is a common opinion that the continued use of fertilizers will ultimately injure the soil. Such an opinion comes from the fact that when fertilizers bring a good money return a man is apt to depend on them too largely for his crop, growing grain crops too often on the same land, with the result that the humus is "burned out" and the land ultimately injured. The injury is however not due to the fertilizer but to the growing of too many grain crops, without sufficient attention being given to maintaining the humus supply through the growing of clover and grass and the return of manure. The only proper use of fertilizers is in connection with the best system of crop rotation, legume growing and manuring that a man can practice. Thus used, they will not only bring good returns but the land will not be injured.

The Use of Phosphates Alone.

The nitrogen in this soil may be maintained by cowpeas, clover and manure. The potash supply is fairly abundant so that after the humus supply is built up, sufficient quantities of this element will usually be supplied. The phosphates however, are strikingly low and they must be supplied from outside sources for best results. For most crops therefore, on lands well supplied with humus, an application of phosphates alone will be very remunerative. For this purpose the application of 150 lbs. of finely ground steamed bone meal applied with a fertilizer grain drill before corn and 150 lbs. with wheat is recommended. Raw rock phosphate may also be used, applying at the rate of 500 to 800 lbs. per acre before corn once in a four or five year rotation. This is an insoluble form of phosphate worth between eight and ten dollars per ton in car lots and must be used on a soil high in humus and preferably plowed in with manure or sod to aid in making the phosphate available. Such an application will be practically as cheap per acre as the bone meal and as it contains the same amount of actual phosphorus pound for pound such an application will tend to continually build up the phosphates of the soil. It is the cheapest form for the permanent livestock farmer with a soil high in humus, but it is not the best form for the man who must have immediate returns.

Raw rock phosphate may either be scattered on the manure in the spreader or mixed with the manure in the lots or stable by scattering it on from time to time as the manure accumulates, or it may be scattered with a special phosphate distributor a number of which are now on the market.

The Use of Lime.

The experiments indicate very strikingly the benefit which will be derived from the use of lime on this soil. It must be remembered that this field is located on a rather level piece of prairie which would doubtless need liming somewhat more than the better drained land of the same neighborhood since it is more wet and probably more acid. The indications are however, that practically all of this prairie will respond to lime. Its use therefore, is recommended on all of this land especially that which is level and inclined to be wet.

The cheapest form of lime to apply in quantity is the ground limestone which is nothing more than finely pulverized limestone rock. It can be secured from two or three firms in the State at a price of \$1.00 to \$1.25 per ton in car lots at the crusher and can be delivered in the vicinity of Lamar at a cost not to exceed \$2.00 per ton.

Lime is best applied broad cast with a lime distributor after the land has been broken for corn or other crops, allowing the further preparation of the seed bed to work it thoroughly into the land. It should not be plowed under as this will not give sufficient mixing with the soil. An

endgate seeder may be used to distribute ground limestone with fair results provided the wind is not blowing but the special lime distributors are very much to be preferred.

The rate at which lime should be applied will naturally depend upon the degree of sourness and this will again vary with the wetness of the land. Usually an application of 2000 lbs. of the ground limestone is sufficient, but on the more level areas, 4000 lbs. is to be recommended. This should be applied preferably before corn once in every six or eight years. It is usually better practice to put it on heavily, and thoroughly mix with the soil at rather infrequent intervals, than to put it on more often in small amounts. In a small way, any sort of lime that is fine enough to scatter may be used except that from gas works which contains compounds injurious to plants. Air slacked lime is frequently available around lime kilns, or it is possible to slack the ordinary burned lime to a powder for agricultural purposes as is commonly done in the East. As a rule however, the ground limestone will be found cheaper than the other sorts where it is to be applied in any quantity.

NOTE.—The names of fertilizer companies doing business in Missouri together with the analysis of the various brands of fertilizers handled is given in Bulletin 82 of the Experiment Station which will be mailed on application. The Station will gladly answer inquiries regarding sources of raw rock phosphate, of ground limestone, etc.

Summary.

- I. This soil is deficient first, in nitrogen and humus, second in phosphates, third in lime and fourth in potash.
- II. The results of the experiments show striking returns from the use of phosphates and potash particularly, with good results from lime and cowpeas in addition.
- III. The recommendations for handling the soil are:
 - (1) Build up the humus and nitrogen supplies by a crop rotation which shall include a wide use of cowpeas.
 - (2) For immediate returns on the worn lands apply 150 lbs. per acre of a fertilizer containing $1\frac{1}{2}$ to $2\frac{1}{2}$ % nitrogen, 8 to 12% available phosphoric acid, and 2 to 4% potash before corn and wheat. On lands fairly well kept up in nitrogen apply 150 lbs. per acre of a fertilizer containing 15% available phosphoric acid and 4 to 5% potash, before corn and 150 lbs. before wheat.
 - (3) For the most immediate remunerative returns on corn, apply 60 to 75 lbs. of a complete fertilizer containing $1\frac{1}{2}$ to $2\frac{1}{2}$ % nitrogen, 8 to 12% available phosphoric acid, and 2 to 3% potash in the hill or row.

- (4) For soils well built up in humus apply 150 lbs. of steamed bone meal before corn and 150 lbs. before wheat or apply 500 to 800 lbs. of raw rock phosphate with manure or sod before corn once in a 4 or 5 year rotation.
- (5) Apply 2000 to 4000 lbs. of ground limestone before corn once in 6 to 8 years.
- (6) Scrupulously save all barnyard manure and return to the land.