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The Rational Improvement of Cumberland Plateau Soils

University of Tennessee Agricultural Experiment Station

Charles A. Mooers

BULLETIN

OF THE

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COWPEA AND MILLET HAY

Sown at last cultivation of Irish potatoes and harvested before potatoes were dug

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THE RATIONAL IMPROVEMENT OF CUMBERLAND PLATEAU SOILS

CONCLUSIONS FROM SIX YEARS OF FIELD EXPERIMENTS WITH VARIOUS FARM CROPS

(SECOND EDITION, SLIGHTLY REVISED)

BY

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KNOXVILLE, TENNESSEE

The Agricultural Experiment Station

OF THE UNIVERSITY OF TENNESSEE

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*Deceased Jan. 28, 1919.

The Experiment Station building, containing the offices and laboratories, and the plant house, and part of the Horticultural Department, are located on the University campus, 15 minutes walk from the Custom House in Knoxville. The experiment farm, the barns, stables, dairy building, etc., are located one mile west of the University, on the Kingston Pike. The fruit farm is adjacent to the Industrial School, and is easily reached by the Lonsdale car line. Farmers are cordially invited to visit the buildings and experimental grounds.

Bulletins of this Station will be sent, upon application, free of charge, to any farmer in the State.

PREFACE

The Cumberland Plateau has an area in Tennessee of about 5000 square miles. The average elevation is in the neighborhood of 1800 feet, or nearly 1000 feet above either the East Tennessee Valley on the east or the Highland Rim on the west. This section is practically undeveloped from an agricultural point of view, and lands are very cheap—$2.00 to $10.00 per acre. The soils are fine sandy loams, which support a varied growth but, unaided, are light producers under cultivation. The cultivated soils are apt to be shallow, two to five feet being a common depth to the underlying sandstone. The rainfall, however, is ample, being in the neighborhood of 55 inches per annum, and is well distributed throughout the year, and crops appear to suffer less here from dry weather than on the deep limestone soils of the East Tennessee Valley.

At Erasmus, Cumberland County, with an altitude of nearly 1900 feet, the average date of the last killing frost in the spring is April 21, and of the first killing frost in the fall October 15.

The experimental work done by the Station for the past six years in this section was under the care of Mr. J. E. Converse, to whom thanks are due for efficient service and for valuable suggestions.

Numerous experimental results with various crops have been reported in detail in Bulletins 86 and 92, which may be obtained upon request.

THE RATIONAL IMPROVEMENT OF CUMBERLAND PLATEAU SOILS

CONCLUSIONS FROM SIX YEARS OF FIELD EXPERIMENTS FROM VARIOUS FARM CROPS

PRINCIPLES OF SOIL FERTILITY WITH SPECIAL REFERENCE TO THE CUMBERLAND PLATEAU

THE PLANT-FOOD ELEMENTS

Plants need food of different kinds, very much as do animals. That is, a plant will starve if deprived of any one of several substances in the soil, just as a man will starve if he tries to live on fat meat alone, or on starch alone, or on sugar alone, or, for that matter, on all three of these articles of food, because they lack the elements that make blood and lean meat and which are found in eggs, milk, beans, and the like. To state the case another way, a person to be well fed, not only must get enough food to satisfy his hunger, but also the food must contain in proper amount the elements needed to renew all parts of the body. In like manner, plants, to be well nourished, require an abundance of each of a number of elements.

The elements necessary

The elements found in the soil which are necessary to plants are nitrogen, phosphorus, calcium, potassium, magnesium, sulphur, and iron. Those that come wholly from air and water are carbon, hydrogen, and oxygen. The latter group makes up the bulk of the dry substance of plants, or 90 to 99 parts out of 100. The element nitrogen can be given an intermediate place between the two groups, because the original source of the soil nitrogen is the air. Also certain kinds of plants, the legumes, are able to utilize atmospheric nitrogen, though this is done indirectly, through the nodule-forming bacteria found in their roots.

To the farmer the discovery of the elements that plants must have, meant much, for as long as they were unknown there was no way to tell exactly what could be used to help make poor land rich. Since this knowledge was obtained the world has been searched for minerals and refuse that supply these elements; soils have been analyzed to find out how much of each they contain; and it is now possible to take almost any soil and make it fertile.

The four elements of most importance

Of the seven soil elements mentioned, only four have been found to be especially important in practical farming. That is, they are the only ones which are apt to be deficient in the soil, and which generally make the difference between a rich and a poor soil, so far as plant food is concerned. These four elements are nitrogen, phosphorus, calcium, and potassium. The last three are sometimes called the "minerals" and are generally referred to under the names of "phosphoric acid," "lime," and "potash."

Principles of soil fertility must be applied to the Plateau

One of the prime objects of this bulletin is to show the special plant-food needs of the Cumberland Plateau soils, what fertilizers to buy, and, as far as possible, how much to use on different crops in order to get the best practical results. The writer may be allowed to say that he believes that this part of the State will become, in the course of time, a prosperous agricultural section; but this condition will be brought about only when the people understand the fundamental principles of soil fertility and apply them with special regard to their soil needs.

PHOSPHORIC ACID AND LIME NATURALLY VERY DEFICIENT IN PLATEAU SOILS

Chemical analysis tells much about a soil's supply of plant food, and if the evidence furnished by the analysis is supported by the results of field trials there can be little doubt as to the correctness of the conclusions. In the case of the Cumberland Plateau soils we have both kinds of evidence to prove that they are naturally very poor in two important mineral substances, phosphoric acid and lime. According to the chemical analyses made at this Station, an average acre of Cumberland County soil to the depth of one foot contains only 1600 pounds of phosphoric acid and 3100 pounds of lime that can be dissolved out by the aid of strong, hot hydrochloric acid, as compared with 8000 pounds of phosphoric acid and 11,000 pounds of lime in the rich Central Basin soil. The results of experiments made chiefly in Cumberland County have demonstrated repeatedly that lime and phosphoric acid are greatly needed. Since the relative values of these two elements is a matter of practical importance, the writer will state at the outset that Plateau soils are in greater need of phosphoric acid than of lime, but the need of both is so great that there is no occasion for surprise that in the past many farmers have become discouraged and failed in the attempt to get satisfactory crops from such a soil. Fortunately, these two substances are easily obtained, and can be profitably used from the beginning. The soils of the greater portion of the eastern United States are deficient in these same elements, and little more is required by the Plateau soils than should be used elsewhere outside of a few favored localities.

HOW MUCH AND WHAT KIND OF LIME TO USE

Ground limestone, fresh burnt lime, air-slacked lime, and wood ashes may be used for liming the land. Any one of them will "sweeten" the soil; and the Plateau soils are generally "sour," a condition that is unfavorable to most farm crops. A reasonable application of ground limestone for this section is two tons per acre; and if it is evenly distributed this amount will probably be ample for five, or perhaps ten years. One ton of burnt lime is equal to two tons of ground limestone, and where the hauling is an important item may be used to advantage. About one and one-third tons of air-slacked lime is equal to one ton when freshly burnt, and three tons of wood ashes are required to equal about two tons of ground limestone. Any of these materials can be advantageously applied for almost any crop. The crops most benefited are the legumes, such as clovers, cowpeas, and soybeans, but according to our field experiments corn, sorghum, millet, oats, and the like are nearly always helped to a marked extent, so that the expense of liming is often more than met the first year by the increased yields. Even as little as half a ton of ground limestone per acre, or of a corresponding quantity of any one of the other materials mentioned, may be sufficient, if evenly distributed, to supply the immediate lime requirement, even for a crop like red clover.

Why is lime little used?

The question may now arise, If lime is highly beneficial to Plateau soils, why has it not been extensively used? There are, doubtless, several reasons, such as the expense and labor of hauling and applying, but in particular a lack of knowledge in regard to its true value. The fact must be remembered that in addition to making "sour" land "sweet" lime adds only one element of plant food to the soil, and that it does not take the place of phosphoric acid, or potash, or nitrogen. The writer has little doubt that if lime were the only deficiency it would have been extensively used long ago, but the fact that other things were needed complicated the matter and obscured its true value. Lime the land, but do not expect this to take the place of phosphate, manure, soil-improving crops, or any good method of soil improvement. For further details and experimental data of different kinds, reference may be made to Bulletin 97 of the Tennessee Experiment Station, "Liming for Tennessee Soils."

PHOSPHATES

Phosphoric acid is the valuable constituent of a number of commercial materials which are known as "phosphates." Some kind of phosphate is necessary in order to lay the foundation for a fertile and durable Plateau soil. At present either acid phosphate or basic phosphate is advised as the most profitable for general use. Bone meal might be used, but is too expensive. Raw phosphate rock is recommended by some writers, but, according to numerous experiments by this Station its effect is uncertain and it is of doubtful value for Plateau soils. Unlike an application of lime, which need be made only once in several years, acid phosphate should be used in small quantity and applied for almost every crop. Two to three hundred pounds per acre is a practical amount for a common farm crop, such as corn, sorghum, millet or cowpeas, and will more than replace the phosphoric acid which the crop removes.

Composition and grades of acid phosphate

Since acid phosphate is the basic material of the commercial fertilizer mixture, its composition and properties should be understood by every farmer. Briefly stated, acid phosphate is made by mixing about equal parts by weight of ground phosphate rock and sulphuric acid. The acid unites with the lime of the rock phosphate and forms the sulphate of lime, or land plaster, which makes up about one-half of the acid phosphate. In addition, the phosphoric acid is changed from insoluble to soluble forms, so that plants can readily make use of it. Fertilizer dealers generally handle two grades of acid phosphate. One is guaranteed to contain 16 per cent of available phosphoric acid, and the other is a "low-grade," guaranteed to contain 14 per cent of available phosphoric acid. The "high-grade," with 16 per cent guarantee, is nearly always the most economical to buy. In fact, the 14 per cent goods is apt to be made, in response to a demand for a cheap fertilizer, by mixing sand, soil or some such material, with a high-grade goods to reduce it to a low-grade. Any such reduction costs something to make, and the freight on the material added must be paid, so that for these, as well as other reasons that may be thought of, the really expensive and least profitable kind is the low-grade phosphate.

Some properties of acid phosphate

If kept under cover acid phosphate can be held over for any length of time, as it does not lose strength on standing. It should not be mixed with either lime or ashes, but even then its value is by no means destroyed. It is not lost from the soil by leaching, but in a short while combines with lime, iron, or other bases in the soil, which reduce the readiness with which plants can make use of it. This is one reason for the advice to make a light dressing to suit each crop. Wherever needed an application of acid phosphate produces an especially noticeable effect in the increased yield of grain and fruit, though an increase of stem and leaf growth is also marked. Only a relatively small quantity of phosphoric acid is needed even by a large crop, but a great deficiency in the soil, such as is the case on the Plateau, will almost make successful farming impossible until the deficiency is remedied.

Not enough manure

At this point some one is sure to think of a vegetable garden or other piece of land which was made highly productive by the application of manure and where neither commercial phosphate nor lime had ever been used. Manure is a complete fertilizer, containing lime, phosphoric acid, potash, and nitrogen. It is also an alkaline substance, and tends, therefore, to "sweeten" a soil. The great value of manure is unquestioned. If every farmer had all he was willing to haul for, say, four or five miles, the soil fertility problem would be solved; but unfortunately this is not the case, except possibly in the vicinity of a town or city. Furthermore even if the manure could be obtained, a good liming of the land and an application of phosphate would be profitable at the outset of the soil upbuilding, for the manure would give better returns and clover could be grown at once. The writer recalls a very successful farmer who bought land with deficiencies similar to those of the Plateau, and brought it up to a high state of productiveness during his lifetime by buying corn from his neighbors and feeding it, along with whatever he could raise, to cattle. He considered the manure as about the chief profit, and thereby succeeded in enriching his land. The necessary phosphoric acid was obtained in the corn grown on other lands, which were thereby impoverished. All the manure that can be obtained should be used, but to get the crops that can be fed to make the manure, both lime and phosphate are very important.

POTASH

Potash is not much needed by the Plateau soils, so that if the major part of the crops grown is fed on the farm and the manure returned to the land, little attention need be given to this element. At the same time the soils are only moderately well supplied, and if large crops, by the aid of liming, phosphating, and good methods of culture, are grown, and especially if crops like Irish potatoes are raised for shipment, then postash salts should be used in moderate quantity along with acid phosphate.

Muriate of postash

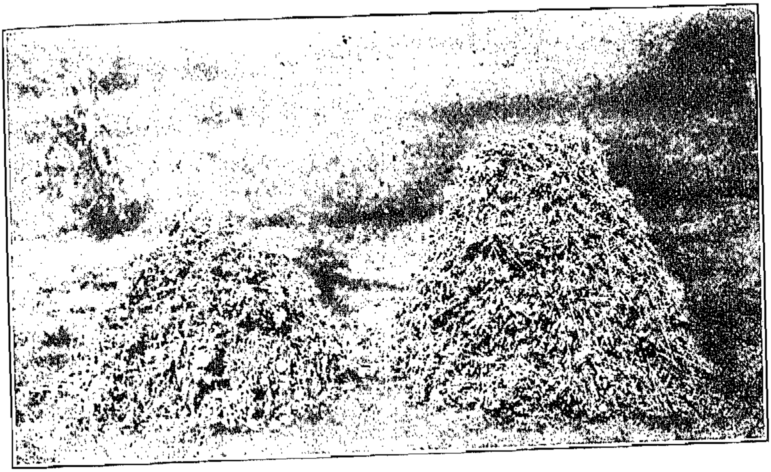
The cheapest of the commercial salts is the muriate of potash, 100 pounds of which contains about 50 pounds of potash.

Wood ashes

Wood ashes as a rule contain about 5 pounds of potash to the 100, but if kept dry and unleached may contain twice this amount. In addition the wood ashes contain a large amount of lime—to which the writer would attribute its chief value—some phosphoric acid, and, in fact, all of the mineral elements of plant food.

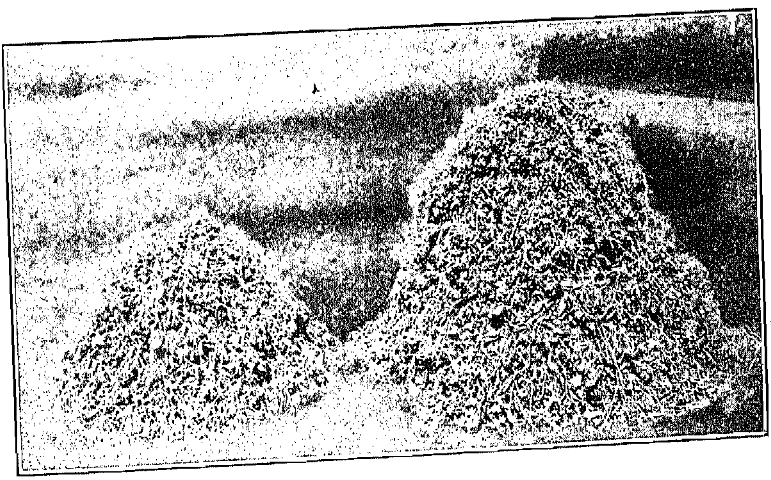
Soybean Hay

From Fertilizer Experiments on the Lemmert Farm
Cumberland County



No Fertilizer
0.46 ton hay per acre

Phosphate and Potash
1.16 tons hay per acre



Lime Alone
0.66 ton hay per acre

Phosphate, Potash and Lime
1.72 tons hay per acre

NITROGEN

As a rule the most marked difference between rich and poor land or between "new" and "old" land lies in the content of nitrogen and humus, which are abundant in the rich soil but deficient in the poor soil.

Cost of nitrogen

Nitrogen is by far the most expensive to buy of the plant-food elements. A pound of available phosphoric acid costs at the present time about 5 cents; a pound of potash costs nearly 6 cents; and a pound of nitrogen costs in the neighborhood of 20 cents. Moreover, plants require two or three times as much nitrogen as phosphoric acid For example, the nitrogen needed in the production of a bushel of corn would cost about 33½ cents, while the phosphoric acid would cost only 3 cents and the potash 7½ cents. This high cost of nitrogen prohibits more than a small amount being used for field crops and limits the amount that can be used profitably on even high-priced garden crops. It is this high cost of nitrogen that prevents the so-called "complete fertilizer" from being well balanced and containing its due proportion of nitrogen. In fact, 100 pounds of the average complete fertilizer, as commonly sold on the market, contains enough phosphoric acid for 18 bushels of corn, but enough nitrogen for only one bushel. With these facts before us, and also in view of the poverty in nitrogen of nearly all long-cultivated soils, not only on the Plateau but everywhere in the Eastern States, it is evident that the problem of really building up the soil in this element must be solved in some way other than by buying nitrogen in commercial fertilizer form. It is very important to understand that fertilizers in and of themselves must fail to keep up soil fertility because they do not furnish enough nitrogen. This explains why they have so often fallen into disrepute.

Nitrogenous materials

There are a number of nitrogenous materials which are much used for fertilizer purposes, such as ammonium sulphate, dried blood, and tankage, but the two that are the most easily obtained and are in other respects best adapted to general use are nitrate of soda, and cottonseed meal. Nitrate of soda contains 15 pounds of nitrogen per 100 and "prime" cottonseed meal about 6½ pounds. For Plateau soils neither is advised to be used alone, but only in connection with an application of acid phosphate.

LEGUMES AS A SOURCE OF NITROGEN

Fortunately there is a family of plants that are able to get nitrogen from the air through the aid of bacteria which live in their roots. This family is known as legumes. Those of most importance are as follows: Red clover, alsike clover, white clover, crimson clover, Japan clover, alfalfa, sweet clover, cowpeas, soybeans, garden beans and peas, and vetches. A complete fertilizer for these crops need not contain nitrogen; hence, the usual recommendation, after the land has been limed, is to use a mixture of only acid phosphate and muriate of potash. For Cumberland Plateau soils the following is a moderate application for an acre of land:

200 lbs. high-grade acid phosphate
20 lbs. muriate of potash

The two ingredients should be well mixed by shoveling together so that they may be applied at the same time.

SOIL INOCULATION

On the roots of all kinds of legumes are normally found small growths resembling warts, which are called "nodules." These nodules are produced by exceedingly small forms of plant life, the nodule-forming bacteria, which can be seen only by the aid of a powerful microscope. These bacteria take plant food of the various kinds needed from the root sap of the plants in which they live and in turn they supply the plant with more or less nitrogen, which they have the power to get from the air. If a legume is grown in a soil which does not contain these bacteria it can make use of only the soil supply of nitrogen, like other plants, such as corn or wheat. Clover, for instance, can enrich a soil in nitrogen only when the proper bacteria are present, because the latter are the true nitrogen gatherers from the inexhaustible supply of the air. It has been found that widely different kinds of legumes require different bacteria. For example, cowpeas may thrive on a certain soil, the nodules proving that the right kind of bacteria are present, but alfalfa sown on the same soil may produce only yellow-looking and unhealthy plants and no nodules be found even though the soil be limed and well fertilized. In such a case the proper bacteria must be supplied before alfalfa can be grown successfully. This is usually done by scattering 200 or 300 pounds of earth per acre, taken from some field where alfalfa was grown successfully and was well inoculated. Also, inoculation usually follows the repeated seeding of the legume desired, and for this reason a small amount of alfalfa or of sweet clover seed is sometimes advised to be sown with clover and grass.

Some precautions

In this connection there are a few precautions which should be mentioned. First, it is not worth while to inoculate soil that is in great need of lime and phosphate until these substances have been supplied. Second, direct rays of the sun can kill the germs, so that the best results are obtained if the inoculating soil be either drilled into the ground or scattered broadcast on a cloudy day and then harrowed in. Third, undesirable weed seeds may be brought to the land along with the desirable bacteria. It may also be mentioned that after a soil has once become thoroughly inoculated a second inoculation is seldom if ever needed.

The Plateau soils have proved to be rather poorly supplied with bacteria, and if vetch, crimson clover, soybeans, Canada field peas, sweet clover, or alfalfa be grown soil inoculation may be required in order to get the best results. For the last two crops in particular inoculation should always precede the first seeding.

AZOTOBACTER

There is another and very important group of bacteria called azotobacter which supply the soil with nitrogen from the air, and appear to be present nearly everywhere. Unlike the nodule-forming kinds, azotobacter are independent of the higher forms of living plant life. The conditions favorable to their best development are abundant supplies of lime, phosphoric acid, air, and some kind of organic matter, such as would be furnished by rye or other green crop turned under, the carbon of which they use as a source of energy. Meadow land conditions seem to be favorable to them, for meadows are found to gain in nitrogen even when no legumes are present.

HUMUS

One of the soil constituents which are well known to decrease under usual cultivation is humus, as the dark-colored organic substances resulting from the decay of vegetable matter are called. The value of vegetable matter in the soil is not apt to be overestimated, for the humus produced from it increases the water-holding capacity of the soil and improves the texture, so that the soil is less inclined to bake and be cloddy. Also its importance in connection with different kinds of necessary bacteria is very great.

GREEN-MANURE FARMING

The growing of a legume, to be turned under and followed with a money crop, is known as green-manure farming and has been practiced very successfully both in some parts of Europe and in this country. New Jersey farmers have grown crimson clover to be turned under and followed with either potatoes or corn, not only getting large crops, but also building up the soil at the same time. Crimson clover is being grown in various parts of Tennessee and may be used to advantage on the Plateau as soon as the soil conditions are made right. This requires liming and the use of the acid phosphate and muriate of potash mixture previously mentioned, and attention to the proper inoculation of the soil. Many soils, however, are too poor in vegetable matter for any of the clovers, in which case cowpeas followed by rye may be used as green-manure crops at first.

CROP ROTATION

A proper rotation, or change of crops, has much to do with soil fertility. In the most prosperous and longest organized farm communities definite crop rotations are followed year after year with little variation. The kind of crops grown must of course be suitable to the climate, the soil, and the market conditions, but there are certain essentials to be kept in mind.

Cultivated crops There should be one or more cultivated crops in every rotation so that weeds may be kept in check or eradicated. Good crops for this purpose are Irish potatoes, cowpeas or soybeans planted in rows, sorghum, and corn.

Grass and legumes To put vegetable matter into the soil and increase its water-holding capacity and productiveness in general, a grass crop is very important. An essential for most soils, and for the old and worn Plateau soils in particular, is one or more leguminous crops to bring nitrogen from the air. For this purpose cowpeas are the most easily grown, but in order to be of much benefit the crop must be either pastured off or turned under. To prevent loss of nitrogen by leaching, a winter cover crop of rye or wheat is necessary. This in turn could be grazed, but should be plowed under when about one foot high in preparation for a money crop, such as potatoes or corn. Soybeans resemble cowpeas as soil improvers, but neither is equal to red clover, which should be the one crop especially sought; for once the conditions for its satisfactory growth have been secured the problem of getting at least moderately profitable crops of corn, potatoes, etc., has been solved.

A crop rotation for new land Most of the Plateau section remains to be cleared, and there appears to the writer no reason why the new lands should not be put at once under a rotation that, with the aid of liming, phosphating, and the careful saving and use of farmyard manure, will maintain a high state of productiveness. Generally speaking a long rotation, covering a period of five or more years, is better than a short two or three-year rotation. The following is given as an example of a good, practical rotation:

1st year—Corn, followed by cover crop of rye sown at last working.

2d year—Cowpeas or soybeans
3d year—Rye, wheat or oats
4th year—Clover and grass (chiefly clover)
5th year—Clover and grass (chiefly grass)

This means that the cultivated part of the farm is divided into five fields and that each year, as soon as the rotation is fully going, there is one field in corn, one in cowpeas or soybeans, one in a small grain, one in first-year clover and grass, and one in second-year clover and grass. To suit potato growers the grass may be omitted and potatoes take the place of the second year's clover and grass, or, potatoes may take the place of a part of the corn.

For a complete scheme of crops to be grown in order to reach this rotation, and the fertilizers, etc., suggested, see page 135.

THE RELATION OF THE POTATO CROP TO SOIL IMPROVEMENT—WHAT MAY BE EXPECTED OF THE FERTILIZER

The Cumberland Plateau soils are mainly fine sandy loams. This kind of soil is easily cultivated, allows an excess of water to escape readily, is adapted to a great variety of crops, and contains enough clay to make it retentive of manure and fertilizer.

Conditions favorable to potatoes

From a physical point of view they are the best adapted of all the soils in the State to the production of Irish potatoes and resemble in this respect the celebrated potato soils of Northern Maine. The climatic conditions are also favorable to potato growing. There remains, therefore, only one serious problem, so far as the getting of yields is concerned, and that is the enrichment of the soil. Fortunately, this crop is one that can be liberally fertilized. It not only responds well to fertilizers, but also the value of the plant food removed by a bushel of potatoes is small as compared with the value of that removed by a grain crop. For example, a bushel of corn (grain only) contains about 22½ cents' worth of plant food, but a bushel of potatoes only 6½ cents' worth. The cultivation of this crop also leaves the soil in nice condition for a crop to follow, whether it be crimson clover to enrich the soil in nitrogen or a winter cereal, such as rye or wheat, to prevent the loss of plant food by leaching during the winter and early spring. There is, therefore, an opportunity to utilize potatoes both as a money crop and as a start toward building up the soil fertility.

Fertilizer for potatoes

From what has just been said, too much might be expected from the fertilizers that may be used, so that we need again a clear understanding of their capacity to enrich the soil.

According to the Station's experiments, a good, practical fertilizer mixture for one acre of potatoes is as follows:

300 lbs. high-grade acid phosphate
50 lbs. muriate of potash
400 lbs. cottonseed meal

Increase from fertilizer

Now, let us see what theoretical increase in yield may be expected from the 750-pound application. Four hundred pounds of cottonseed meal contains as much nitrogen as is required in the production of 100 bushels of potatoes, but all the nitrogen applied is not taken up by the crop, and as a matter of fact an increase of 50 bushels would be considered high. This means that if the phosphate and potash supplies are ample and the soil is poor in nitrogen, an increased yield of only 50 bushels could be expected even under very favorable seasonal and cultural conditions.

Let us suppose, on the other hand, that the nitrogen supply of the soil is good, and that the great need is phosphoric acid. In this case there is, according to theory, enough phosphoric acid supplied by the 300 pounds of acid phosphate for 500 bushels, but according to field trials only about one-third can be expected to be used by the immediate crop, so that in reality an increase of 170 bushels might be obtained. In a similar way it may be shown that there is enough potash for 80 bushels, but that only about two-thirds may be taken up by the crop for which it is applied.

As a matter of fact the 750 pounds per acre has, in our experiments in Cumberland County, given an increase in the neighborhood of 75 bushels over the unfertilized check plot. The soil cannot, therefore, be said to have been materially enriched in any element except phosphoric acid.

SOME RESULTS OF FIELD EXPERIMENTS

FERTILIZERS FOR IRISH POTATOES

QUANTITY OF COMPLETE FERTILIZER

Table 1 gives the results obtained in nine series of experiments conducted on as many different soils of varying fertility. The fertilizer used consisted of the mixture previously mentioned. The approximate cost of 750 pounds of the mixture was $9.90. In one-third of the trials this amount per acre proved more profitable than twice the quantity, and is recommended as a conservative application. Fifteen hundred pounds per acre proved, however, to be on the average the more profitable, and would, of course, leave a larger residue for the benefit of the succeeding crop. The results were obtained in different seasons, but probably represent rather favorable conditions for this crop.

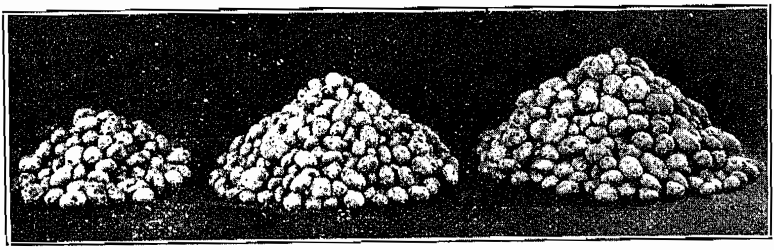
TABLE 1—*Fertilizer experiments with Irish potatoes, testing two rates of application, 750 and 1500 lbs. per acre, of a complete fertilizer—results of nine series, each conducted on a different farm*

Series	Yield per acre without fertilizer		Yield per acre with 750 lbs. complete fertilizer		Yield per acre with 1500 lbs. complete fertilizer	
	Total	Salable	Total	Salable	Total	Salable
	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.
1	61	52	104	81	136	122
2	57	36	101	80	109	92
3	37	17	96	76	108	88
4	24	4	109	54	158	91
5	32	20	142	131	191	180
6	73	63	123	110	136	121
7	54	46	164	147	198	177
8	155	139	193	180	221	205
9	110	90	167	151	228	199
Average	67	52	133	112	165	142

COTTONSEED MEAL VERSUS NITRATE OF SODA FOR POTATOES

Table 2 gives the results obtained on seven different farms where experiments were made to compare the effect of nitrogen from cottonseed meal with that from nitrate of soda for Irish potatoes. Four hundred pounds of the meal was assumed to contain the same amount of nitrogen as 160 pounds of the nitrate. Acid phosphate and muriate of potash were used in every case in sufficient quantity to make the nitrogen fully effective. The average of the series show that nitrate of soda was only slightly more efficient than the cottonseed meal, the average total yield being 145 bushels where the nitrate was used, as compared with 140 bushels where meal was used; but the average quantity of salable potatoes was the same for each. Nitrate of soda has the advantage of being somewhat cheaper than cottonseed meal, but the disadvantages that it cannot be so generally obtained, is apt to be lumpy and needs pulverizing, and is preferably applied separately from the phosphate and potash as a surface dressing.

TYPICAL RESULTS FROM EXPERIMENTS WITH POTATOES



No Fertilizer	12 Tons Manure Per Acre	12 Tons Manure and 600 Lbs. Acid Phosphate Per Acre
44 Bu. per acre	130 Bu. per acre	179 Bu. per acre

FARMYARD MANURE ALONE AND REINFORCED WITH FERTILIZERS

Farmyard manure can be used with extra good chance of profit on the Irish potato crop. According to the results of Table 3, 12 tons of manure per acre gave, as the average of six series of experiments, an increase of 92 bushels of salable potatoes, or 7⅔ bushels per ton of manure. Farmyard manure is considered to be a complete and well-balanced fertilizer for a soil that is fairly well supplied with the mineral elements, phosphoric acid and potash, but for Plateau soils an additional supply of phosphoric acid in particular is needed in order to make the manure most efficient. The average of

TABLE 2—*Fertilizer experiments with Irish potatoes, with special reference to a comparison between cottonseed meal and nitrate of soda as sources of nitrogen—results of seven series, each conducted on a different farm*

Series	Yield per acre without fertilizer		Yield per acre with phosphoric acid and potash No nitrogen		Yield per acre with phosphoric acid, potash and nitrogen from cottonseed meal		Yield per acre with phosphoric acid, potash, and nitrogen from nitrate of soda		Notes
	Total	Salable	Total	Salable	Total	Salable	Total	Salable	
	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	
1	24	4	(33)	(6)	82	71	105	59	400 lbs. meal vs. 160 lbs. nitrate
2	32	20	93	82	162	150	156	146	400 " " 160 "
3	81	64	150	127	164	150	157	148	600 " " 240 "
4	73	63	96	84	130	115	129	116	450 " " 180 "
5	89	79	93	83	85	74	102	89	300 " " 120 "
6	155	137	167	152	179	164	190	177	800 " " 320 "
7	110	90	(153)	(131)	181	162	173	153	400 " " 160 "
Average	81	65	112	95	140	127	145	127	480 " " 192 "

TABLE 3—*Fertilizer experiments with Irish potatoes. Manure alone versus manure reinforced with commercial fertilizers—six series conducted on six different farms*

Series	Yield per acre without fertilizer		Yield per acre with 12 tons manure		Yield per acre with 12 tons manure and 600 lbs. acid phosphate		Yield per acre with 12 tons manure, 600 lbs. acid phosphate, 100 lbs. muriate of potash, and 320 lbs. nitrate of soda		Yield per acre with 12 tons manure, 600 lbs. acid phosphate, and 320 lbs. nitrate of soda	
	Total	Salable	Total	Salable	Total	Salable	Total	Salable	Total	Salable
	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.
1	50	45	153	126	212	179	---	---	---	---
2	42	22	195	150	---	---	315	266	---	---
3	24	4	196	140	248	208	286	251	286	254
4	32	20	128	116	209	201	215	206	---	---
5	110	90	212	193	237	213	244	228	242	223
6	83	62	109	76	139	111	159	127	145	114
Series 1-6 averaged	57	41	166	133	---	---	---	---	---	---
Series 1, 3-5 averaged	60	44	160	130	209	182	---	---	---	---
Series 2-6 averaged	58	40	168	135	---	---	244	216	---	---
Series 3, 5, 6 averaged	72	52	172	136	208	177	230	202	224	197

five series of experiments gives an increase of 138 bushels of salable potatoes from an application of 12 tons of manure, reinforced with 600 pounds of acid phosphate, as compared with an increase of only 86 bushels from 12 tons of manure alone. As the average of three trials, the application of 320 pounds per acre of nitrate of soda, in addition to 12 tons of manure and 600 pounds of acid phosphate, resulted in a further increase of 20 bushels of salable potatoes per acre. The results of the experiments in which 100 pounds of muriate of potash per acre were used in connection with 600 pounds of acid phosphate and 320 pounds of muriate of potash as a supplement to the manure, are not favorable to the use of the potash salt.

VARIETY TRIALS OF IRISH POTATOES

Several variety trials were made with Irish potatoes, but they were neither as extensive nor as long continued as is necessary in order to get conclusive results, but the late white type are especially recommended. According to the results obtained, Burbank and Green Mountain were the best late varieties, and Early Rose and Irish Cobbler the best medium-early. Bliss Triumph was found to be one of the lowest yielders.

NORTHERN-GROWN VERSUS HOME-GROWN SEED

Five trials, in which five different varieties were represented, were made between Northern-grown and home-grown seed. The average yield for the Northern-grown seed was 58.7 bushels per acre and for the home-grown seed 63 bushels per acre. This outcome is in harmony with the results obtained elsewhere, which show that good-sized home-grown seed is superior to the Northern-grown seed. Mention should be made, however, of the fact that the continued planting of small seed is very apt to cause the variety to "run out," so that a very inferior strain is the result. On the other hand, the selection of good-sized seed potatoes from productive hills will have a strong tendency to improve the crop.

TIME OF APPLICATION OF NITRATE OF SODA

Nitrate of soda—value and properties

Nitrate of soda furnishes nitrogen in its most available form for plant-food purposes, especially for cereal crops. It is also about the cheapest commercial source of fertilizer nitrogen. These two reasons are sufficient to warrant the study on the part of every farmer of the most important principles concerning its use. Nitrate of soda is very readily soluble in water and may be lost from the soil by leaching, but this chance of loss is much less than might be supposed, as the results of Table 4 show. It may be decomposed and nitrogen be lost into the air by being mixed with acid phosphate, but in practice such loss is likely to be small. Nitrate takes up moisture from the air in considerable quantity, and the mixture with acid phosphate will, if sufficient nitrate be present, soon become sticky, so that there are two reasons against mixing acid phosphate and nitrate of soda. Fertilizer manufacturers have found, however, that they could add a small amount to their mixture without bad results, and this is not an uncommon practice. Because of the chance of loss by leaching and of the possible bad results from mixing with other fertilizer materials, nitrate of soda is usually applied by itself as a top-dressing. The generally accepted rules in regard to its use are as follows:

Rules for use of nitrate

1. If the soil is poor in either phosphoric acid or potash, nitrate should not be used, until the deficiency in these mineral elements is supplied. According to numerous trials on Highland Rim and Cumberland Plateau soils, 300 pounds of acid phosphate and 50 pounds of muriate of potash are ample to reinforce 160 pounds of nitrate.

2. For fall-sown small grains, a very light application—say 40 pounds per acre—may be made at the time of seeding, provided the soil is poor and there is some danger of the crop's freezing out; otherwise all of the nitrate is applied as soon as spring growth starts, or some time in March. For spring and summer crops the nitrate is applied as a top-dressing when the plants are small.

3. Nitrate should not be applied when the leaves of the plants are wet with rain or dew, as burning is apt to follow.

4. With light applications, up to, say, 200 pounds per acre, all the nitrate may be applied at one time, but with heavy applications one-half is often advised to be applied at an early stage of growth and the balance in ten days or two weeks.

EXPERIMENTAL EVIDENCE

For the reason that there is at the present time a wide difference between the recommendations of some writers in regard to the time at which nitrate should be applied, experiments were undertaken on this subject with two crops, corn and Irish potatoes. The soils used were, of course, deficient in nitrogen in each case, and phosphate and potash were applied in ample quantity to make the nitrate effective. Table 4 gives the schemes followed and the results obtained as an average of several trials for each crop.

TABLE 4—*Experimental results relating to time of application of nitrate of soda*

Crop	Exp. No.	Amount of nitrate applied per acre	Time of application of nitrate	Yield per acre		Remarks
				Grain Bu.	Stover Tons	CORN
Corn	1	None	----------	25.7	1.19	The average of three complete sets conducted on three different farms, each in a different section of the State. Phosphate and potash used on all plots alike.
	2	100 lbs.	When plants about 3 in. high	31.2	1.39	
	3	"	" " " 2 ft. "	31.4	1.32	
	4	"	" " " 3½ "	30.0	1.25	
	5	"	As soon as in tassel	24.8	1.26	
				Salable tubers Bu.	Culls Bu.	POTATOES
Irish potatoes	1	None	----------	78	14	Average of four sets on four different farms, three on Cumberland Plateau and one on Highland Rim. Phosphate and potash used in ample amount to balance nitrate.
	2	320 lbs.	Mixed in row before planting	145	22	
	3	"	In one application as soon as plants came up	150	16	
	4	"	In two applications, ½ as soon as plants up and ½ about 12 days later	133	20	

DISCUSSION OF THE RESULTS

Early application best for corn

The results with the corn point very definitely to the application of the nitrate at an early stage of growth, the gain being greatest when the plants were from three inches to two feet high. Of special interest were the results following the application made at tasseling time, for in none of the three series from which the averages were obtained did any increase in yield of grain result from this time of application, the only apparent effect being a deeper green foliage.

Early application best for potatoes

The results of the experiments on Irish potatoes are of special interest, as three of the four sets were made on the fine sandy loams of the Plateau, which might be expected to suffer from leaching. In practically every one of the four sets nearly as good results as any were obtained when the nitrate was mixed with the phosphate and potash applied in the row before planting. This was rather unexpected, for the rainfall at this time of the year is heavy, so that loss of nitrate would be looked for. The result from applying one-half of the nitrate as a top-dressing when the plants were just coming up, and the balance in ten days or two weeks, were unfavorable to this method. As with the corn, the results are, therefore, decidedly in favor of an early application.

FERTILIZERS FOR CORN

PHOSPHATE AND POTASH

Corn is a very important crop, but one that is low-priced, so that the question as to the most profitable fertilizer is not always easy to answer. Fertilizer experiments covering every condition have not been possible, but considerable evidence has been obtained. With regard to phosphate, acid phosphate in moderate quantity, say 200 pounds to the acre, is recommended, and may be used by itself with as good a chance for profit as any other material or combination of materials of equal money value; it may even give greater profit, especially in the case of freshly cleared land. If a light dressing of manure can be made, then the plain acid phosphate is highly advisable as a supplement to the manure, which, as demonstrated in the potato experiments, is strengthened in its weakest point for soils like these. In a similar manner acid phosphate is recommended for a green-manure or pasture crop which is to be followed by corn, the one application in that case answering fairly well for the two crops.

The experimental results do not warrant anything more than a very light application of a potash salt, say 10 pounds per acre of muriate of potash mixed with the acid phosphate.

CAN NITRATE OF SODA BE USED PROFITABLY FOR CORN?

We have now to consider the value of nitrogenous materials when used in combination with acid phosphate and muriate of potash. In particular, the question arises, Can nitrate of soda be used profitably for corn?

In order to answer this question field experiments have been conducted at various places in the State. In some instances the experiments have been rather extensive, embracing 25, and even 30, plots, some of which received no fertilizers, some only phosphate and potash, others only nitrate, and a fourth set receiving phosphate, potash, and nitrate. Such a series was conducted in Warren County for each of three seasons, 1908, 1911 and 1912. In Table 5 are presented the fertilizer scheme and the results of the series conducted in 1912 on the farm of A. P. Titsworth, in Warren County. This series is given by itself for the reason that the results are characteristic of those obtained from nitrating under very favorable seasonal and soil conditions. According to these experiments, the cost of nitrate for each bushel of increase produced by it was 32 cents for the 40-pound application for an acre, 31 cents for the 80-pound application, 37 cents for the 160-pound, and 46 cents for the 240-pound. Under less favorable conditions the increased yield proved insufficient to pay for the nitrate, and in very unfavorable seasons no increase in grain production was obtained. Evidently there is considerable risk run. All things considered, the margin of profit appears at the present time to be too small to permit the recommendation of nitrate of soda for the corn crop, except possibly a very light application under special conditions of nitrogen deficiency.

A COMPLETE FERTILIZER FOR VERY POOR SOILS

In order to get additional data with regard to a practical formula for corn, experiments were undertaken with three different mixtures, each of which was tested at three different rates. Table 6 gives the average results of six sets of these trials, which were conducted in the seasons of 1907, 1910, and 1911. Each set was conducted on a different farm, and the unfertilized plots gave yields ranging from 6.3 to 24.1 bushels per acre, the average being 15.5 bushels per acre. The experiments were made, therefore, under strictly poor-land conditions, but such as are of common occurrence.

The three formulas used were as follows:

Formula 1

1200 lbs. high-grade acid phosphate
100 " muriate of potash
480 " cottonseed meal

This mixture analyzes approximately—
11 per cent available phosphoric acid
1¾ " " nitrogen
3 " " potash

TABLE 5—*Fertilizer experiments on corn, with special reference to nitrate of soda—experiments conducted on farm of A. P. Titsworth, Warren County*

Series	Phosphate and potash per acre	Application of nitrate and increased yields per acre											
		No nitrate		40 lbs. nitrate		80 lbs. nitrate		160 lbs. nitrate		240 lbs. nitrate		Average	
		Grain	Stover	Grain	Stover	Grain	Stover	Grain	Stover	Grain	Stover	Grain	Stover
		Bu.	Ton	Bu.	Ton	Bu.	Ton	Bu.	Ton	Bu.	Ton	Bu.	Ton
1	No phosphate; no potash	*	*	2.4	0.16	0.0	0.14	0.6	0.12	5.1	0.20	2.0	0.16
2	300 lbs. acid phosphate	11.4	0.66	12.6	0.58	15 5	0.64	21.5	0.62	21.7	0.78	16.5	0.66
3	{ 300 lbs. acid phosphate 100 lbs. muriate of potash }	6.4	0.50	9.9	0.62	---	---	20.6	0.78	20.8	0.86	14.4	0.69
4	{ 150 lbs. acid phosphate 100 lbs. muriate of potash }	6.2	0.36	12.1	0.46	12.6	0.44	16.9	0.24	---	---	12.0	0.38
5	{ 600 lbs. acid phosphate 100 lbs. muriate of potash }	8.9	0.56	13 5	0.72	19.6	0.76	25.8	0.84	26.5	0.74	18.9	0.72
	Average of series 2, 3, and 5	8.2	0.52	12.0	0.60	15.9	0.61	21.2	0.62	23.0	0.79	---	---

*Average of five unfertilized plots, 36.5 bushels grain and 1.08 tons stover per acre.

Formula 2

1200 lbs. high-grade acid phosphate
100 " muriate of potash
720 " cottonseed meal
This mixture analyzes approximately—
10 per cent available phosphoric acid
2½ " " nitrogen
3 " " potash

Formula 3

1200 lbs. high-grade acid phosphate
100 " muriate of potash
1440 " cottonseed meal
This mixture analyzes approximately—
8 per cent available phosphoric acid
3½ " " nitrogen
2½ " " potash

OBJECT IN VIEW

Attention is called to the fact that in the experiments the low rate for each formula—135 pounds of Formula 1, 150 pounds of Formula 2, and 200 pounds of Formula 3—contains the same quantity of acid phosphate, or about 90 pounds per acre; also each contains about 6¾ pounds of muriate of potash per acre; so that the differences are due entirely to a variation in the amount of cottonseed meal used. In a similar manner, the medium rates of 202, 225, and 308 pounds each contained the same amounts of acid phosphate and muriate of potash; namely, 134 pounds of the former and 11 pounds of the latter per acre. In the heavy rates of 404, 450, and 617 pounds per acre the amount of acid phosphate for each was 270 pounds and of muriate of potash 22.5 pounds per acre. The experiments, therefore, resolve themselves into only two distinct objects; one to determine the proportion of cottonseed meal which would be the most profitable to use with a given amount of the acid phosphate and muriate of potash, and the other to determine the quantity of the complete mixture which would be the most advisable to use. In all the trials the fertilizer was applied in the row and mixed with the soil by running a shovel plow through it before planting.

RESULTS OF EXPERIMENTS

The results of these experiments seem to justify the use of a complete fertilizer for corn on very poor soils like these. The largest gross profit was obtained where a medium application of 308 pounds per acre of Formula 3 was made. The second largest gross profit was obtained where the medium application of 225 pounds of Formula 2 was used. If the average gross profit of the three formulas be calculated, then Formula 3 ranks highest, with $4.32 per acre; Formula 2 ranks second, with $3.92 per acre; and Formula 1 ranks lowest,

TABLE 6—*Trials of three different fertilizer mixtures for corn—seasons of 1907-1912—average of six sets—four on Highland Rim and two on Cumberland Plateau*

Fertilizer used per acre	Yield per acre		Increase over unfertilized plots		Value of increase @ 60c. per bu.	Cost of fertilizer	Cost of increase per bu.	Profit per acre from fertilizer
	Grain	Stover	Grain	Stover				
	Bu.	Tons	Bu.	Ton				
135 lbs. Formula I	21.0	0.98	5.5	None	$3.30	$1.51	$0.27	$1.79
202 " " "	23.7	1.18	8.2	0.10	4.92	2.26	.27	2.66
404 " " "	29.3	1.40	13.8	0.32	8.28	4.52	.33	3.76
150 " " II	24.7	1.28	9.2	0.20	5.52	1.72	.19	3.80
225 " " "	27.6	1.29	12.1	0.21	7.26	2.59	.21	4.67
450 " " "	29.6	1.41	14.1	0.33	8.46	5.18	.37	3.28
206 " " III	25.2	1.27	9.7	0.19	5.82	2.50	.26	3.32
308 " " "	30.1	1.37	14.6	0.29	8.76	3.74	.26	5.02
617 " " "	35.7	1.49	20.2	0.41	12.12	7.50	.37	4.62
No fertilizer	15.5	1.08	---	----	----	----	----	----

with an average profit of only $2.74 per acre. The question arises, however, Do the results justify the recommendation of Formula 3, which gave both highest yield and largest gross profits? In the writer's opinion they do not, for the reason that the margin of profit which can be attributed to the large proportion of cottonseed meal in Formula 3, is too small to warrant the risks incurred. The moderate application of 225 pounds per acre of Formula 2 is, therefore, advised as both conservative and practical. According to these experiments it raised the average yield of corn from 15.5 bushels to 27.6 bushels per acre, at a cost of only $2.59. It may be of interest to note that 225 pounds of Formula 2 contains as much phosphoric acid as is removed by the grain and stover of a 40-bushel crop, enough potash to replace that removed by 5½ bushels, and nitrogen to equal that removed by only 3 bushels, the stover being included with the grain in each case.

VARIETIES OF CORN

Table 7 gives the results obtained in the variety trials of corn. Hickory King, which was taken as the standard of comparison, is only fairly well adapted to this section, somewhat earlier varieties being desirable, such as those which have been grown for a number of years on the Plateau and are known by local names like Rains, Ramsey, and Morrow. The variety which has given decidedly the highest yields and seems least suited to this section is Piedmont White Dent, a variety originated by the U. S. Department of Agriculture. Rank-growing and late varieties, such as Huffman, Webb Improved Watson, Cocke Prolific, and Albemarle Prolific, are evidently not adapted to the average soils. The last two mentioned may, however, be used for ensilage purposes on improved land.

TABLE 7—*Variety trials of corn on Cumberland Plateau (1907-1912)*

Hickory King in comparison with—	Number of trials made	Number of trials in favor of Hickory King	Average yield in favor of (+) or against (—) Hickory King
			Bu.
Albemarle	7	7	+10.0
Bigg Seven Ear	6	4	— 2.1
Iowa Silver Mine	5	3	+ 5.2
Jarvis Golden Prolific	6	5	— 2.1
Leaming	14	8	+ 2.3
Morrow	6	4	+ 0.9
Piedmont White Dent	8	7	— 5.0
Rains	3	2	— 0.6
Ramsey	5	3	+ 1.9
Shepherd	2	2	+ 4.2
Webb Improved Watson	7	7	+ 9.7

ALFALFA

The question is often asked as to whether the Plateau is adapted to alfalfa. This crop should be considered a rich-land rather than a poor-land crop and is, therefore, not naturally suited to this section. However, with proper attention to the requirements of the crop there appears to the writer no important reason why it can not be grown profitably to a limited extent. A fraction of an acre rather than acre lots is advised for initial tests.

Success with alfalfa has been found to depend largely on the fulfillment of the following conditions:

1. Thorough preparation of the soil, begun some months previous to seeding.

2. The cleansing of the soil from weeds by frequent harrowing, so that no weeds go to seed, at least during the summer when the alfalfa is sown.

3. A dressing of lime, either one ton of burnt lime or two tons of ground limestone per acre.

4. A heavy application of phosphate, say, under Plateau conditions, 1000 pounds of acid phosphate per acre, one-half applied before plowing and one-half afterward, to get it well mixed throughout the soil, also 100 pounds of muriate of potash, is advised.

5. At least moderately heavy manuring, say not less than 12 tons of manure per acre, which should be done early in the summer so that weed seeds may sprout and the weeds be gotten rid of before seeding to alfalfa.

6. Inoculation of the soil, for which 300 pounds per acre of inoculated soil from an old alfalfa field is recommended.

7. Liberal seeding—24 pounds per acre of the best Kansas or Nebraska seed—to be done early in August.

8. Thorough harrowing of the alfalfa after each cutting in order to get rid of crab-grass, etc. This may be done with a disc harrow, but a specially constructed, spring-tooth harrow, such as is now on the market, has been found in the Station's trials to give better results than any other implement tested.

"CLOVERS"

RED CLOVER

Of all the legumes red clover may well be considered as the most valuable for soil-improvement purposes, and although Plateau soils may not be naturally adapted to this crop the aim of every farmer should be to get his soil into the proper condition for its production. In the case of freshly cleared land, liming and phosphating are the main requirements. For old land, at least a light dressing of manure, or the turning under, for one or more seasons beforehand, of such green-manure crops as can be grown to most advantage, is essential.

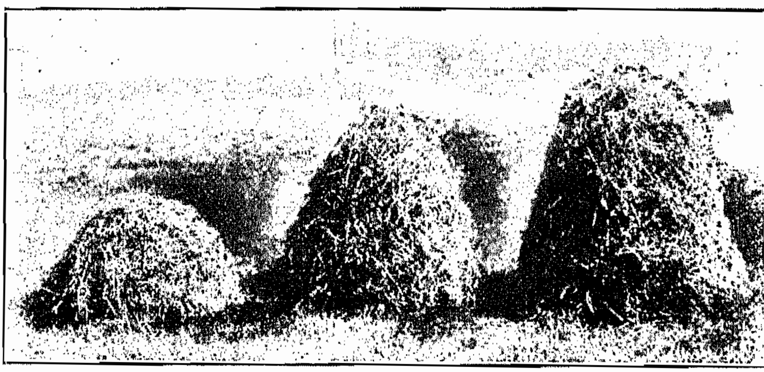
The usual time of seeding is the early spring, with some nurse crop, such as spring oats or fall-sown rye. Under favorable conditions it may also be sown with buckwheat in July. Where the success of clover is less certain, seeding by itself the latter part of the summer is recommended. Indeed, in this way the best crops can be obtained on almost any soil.

Inoculation of the soil for the common clovers may be of considerable importance, and should not be overlooked. Special investigation of this subject has, however, been neglected.

ALSIKE

Alsike clover is not as robust as red clover, and is, therefore, not as well suited to poor land. It has, however, done very well in our experiments, and has some advantages over red clover, especially in that it is completely resistant to the common red clover disease, which has done great damage throughout the State during the past twenty or more years. Only about two-thirds as much seed is required as for red clover.

ALSIKE CLOVER, FROM EXPERIMENTS ON FARM OF J. MORROW, CRESTON, CUMBERLAND COUNTY



NO FERTILIZER	FERTILIZER	FERTILIZER AND LIME
0.44 ton hay per acre	1.08 tons hay per acre	1.14 tons hay per acre

WHITE CLOVER

White clover, like red and alsike, responds to liming and phosphating, and should not be overlooked as an addition to the pasture and a means of soil improvement. One and one-half pounds of seed per acre is suggested to be mixed with the clover and grass wherever the land is to be used for pasture purposes.

CRIMSON CLOVER

Crimson clover is a valuable green-manure crop, but only rather fertile soils are adapted to it. To get best results it should be sown by itself in midsummer, but it may be sown with buckwheat under favorable conditions. It has a much lower lime requirement than red clover.

LESPEDEZA

Lespedeza, or Japan clover, is not a true clover, but may be included with the others for practical purposes. This plant has spread over a large part of the Plateau and should be welcomed both as an addition to the pasture and a not insignificant means of soil improvement. Although found growing almost everywhere, it responds well to liming and phosphating, as was demonstrated at the West Tennessee Station. Under some conditions it may even be worth while to sow the seed. This may be done the latter part of March. About 25 pounds per acre is required for a full stand the first year. Ten pounds, however, will be sufficient to give it a good start.

MELILOTUS

Melilotus, or sweet clover, like Lespedeza, is a legume but not a true clover. This plant requires, like alfalfa, a soil well supplied with lime; also soil inoculation with the same kind of bacteria required by alfalfa, which do not appear to be naturally present in these soils. It is probable that with attention to liming, phosphating, and inoculation, sweet clover could be grown to advantage as a green-manure crop. Sweet clover may be sown either in the spring, with oats, or in late summer.

COWPEAS AND SOYBEANS

Both cowpeas and soybeans are adapted to the Plateau and should be grown extensively. Very poor land which has been limed and phosphated should be planted at first in peas or beans, to be pastured off or turned under for green manure, and not in some non-legume, like millet or sorghum. The Whippoorwill is the standard, all-round variety of peas, but the Clay is suggested for soil-improvement purposes, because of its more vigorous growth. Mammoth Yellow soybeans make an excellent growth, but are rather late for this section.

The capacity for hay production of the late-maturing varieties of soybeans is much greater than that of any variety of cowpea, but the soybean requires more attention both in cultivation and in harvesting than the cowpea. Soil inoculation, which never seems necessary for the cowpea, is required for varieties other than Mammoth Yellow the first year grown. However, since the nodules do not seem to be entirely lacking the first year, their thorough inoculation would be expected the following season if grown on the same land.

Both cowpeas and soybeans, the latter in particular, give largest yields when planted in rows and cultivated. For broadcast seeding, 1½ bushels of seed per acre is required; but for planting in rows only ½ bushel. Two and one-half foot rows are advised.

Only acid phosphate or a mixture of acid phosphate and muriate of potash is advised as a fertilizer.

CANADIAN FIELD PEAS AND SPRING OATS

Canadian field peas and spring oats can be grown successfully on soils of good productivity. The peas add materially to the feeding value of the hay, as do cowpeas in the common mixture of cowpeas and millet. The Canadian peas are closely related to the common smooth varieties of garden peas, and, like them, should be sown as early in the spring as possible. Both the altitude of the Plateau and the sandy nature of the soil are favorable to Canadian peas, and the mixture with oats is recommended for trial. A fair seeding per acre is 2 bushels of oats and 1 bushel of peas. In the cooperative trials there has been much evidence that soil inoculation is necessary in order to get the best results. Three hundred pounds of a garden soil where garden peas show nodules on the roots is sufficient for an acre, and may be either drilled in or sown broadcast and harrowed into the soil.

PEANUTS

The season is rather short for peanuts to reach full maturity, so that they can hardly be advocated except for the home garden, for which use the Spanish variety is recommended.

THE SMALL GRAINS

Wheat, as well as rye and oats, may be grown on the Plateau, but the soils are not naturally well adapted to it. They are too poor in plant food and too light in texture. For the latter reason they heave greatly in freezing and thawing, so that fall-sown crops of all kinds must be planted extra early or the soil be above the average in fertility; otherwise they stand a good chance of being frozen out. However, if the fertility of the soil is increased there is nothing to prevent the getting of excellent crops of all the small grains, including winter barley, which requires a richer soil than any of the others. Winter barley should be sown early in September. Wheat and rye should be sown the latter half of September. On account of the uncertainty of winter oats, only spring oats are advised. They should be sown as early in the spring as the season will allow.

In regard to fertilizers, the same suggestions as made for corn may be followed.

GRASSES

The newly cleared lands of the Plateau are rather easily set in grass, and advantage should be taken of this opportunity before the continued growing of corn, millet, etc., seriously impoverishes the soil. Lime and phosphate are very important from the outset. Grass seed is frequently wasted by being sown on land that is too poor for any of the cultivated grasses, and emphasis is placed on the necessity of first improving such land by the use of manure or by the growing of rye, cowpeas, etc., for pasture or green-manure purposes, in addition to liming and the judicious use of phosphate. The physical make-up of these soils, the abundant rainfall, and the long growing season are all favorable, and the culture of grass is urged in connection with that of clover as an important means of maintaining fertility.

Red-top is probably the best all-round grass for both hay and pasture. With the aid of manure, lime, etc., timothy, orchard grass, and tall oat can be grown to advantage, and under such a condition either red or alsike clover should be sown with the grass. As heavy a seeding of the clover is recommended as though no grass seed were sown—say 10 pounds of red or 7 pounds of alsike per acre.

Early spring seeding, with a nurse crop of either spring oats or fall-sown rye, is the usually successful procedure, but summer seeding of both clover and grass without a nurse crop has done well. Sometimes, however, under favorable conditions they may be sown with buckwheat, or even with cowpeas and sorghum.

Bermuda grass is not advised for this section. Kentucky blue grass may be grown if conditions are specially favorable, but otherwise it is not recommended.

Some successful hay raisers have depended almost entirely on rather heavy applications of manure—20 to 25 tons per acre—and the suggestion is offered that by making soil conditions favorable to the getting of clover along with the grass, 400 pounds of acid phosphate and 50 pounds of muriate of potash per acre would probably take the place of one-half of the manure.

Nitrate of soda may be profitable on grass, especially if a fertilizer be desired to forward a late seeding or to thicken a stand. Eighty to one hundred and twenty pounds per acre, to be applied early in the season, is a moderate application.

BUCKWHEAT

Buckwheat may be raised to some advantage, especially on newly cleared lands, for which only acid phosphate, at the rate of 200 to 300 pounds per acre, is advised as a fertilizer. In the case of an old and rather poor soil 225 pounds per acre of Formula 2, as advised for corn, may be used.

MILLET FOR HAY

German millet, which is sown either alone, or better, with cowpeas, for hay, responds well to rather heavy fertilization. Table 8 gives the average results obtained from five complete series of experiments, two conducted in different seasons on one farm, and each of the other three on different farms. The soils were poor and of similar needs to those of the Plateau, except that they were more deficient in potash.

According to these and other trials on old land, 300 pounds of acid phosphate and from 80 to 160 pounds of nitrate of soda per acre may be used with fair assurance of profit. Also a small amount of muriate of potash may be used along with the acid phosphate, the two being mixed and well worked into the ground before seeding. The nitrate is advised to be applied broadcast as a top-dressing soon after the plants come up. In the case of recently cleared land only acid phosphate is advised. Also it should be noted that in a mixture of millet and peas the phosphate and potash will encourage the growth of cowpeas in particular, but that the nitrate increases the growth of the millet much more markedly than that of the peas.

SORGHUM

The saccharine, or sweet, sorghums, are well adapted to Plateau conditions, and may be used either for forage or for syrup. The Red Top variety is advised for forage purposes, but the juice is too dark to make the best syrup. Tennessee-grown seed has proved to be superior to western-grown seed. For syrup making the Amber variety is about as good as any. Late varieties, such as Gooseneck and Honey, which have done extra well at the Knoxville Station, are too late for the Plateau and have not proved desirable when tried there.

Sorghum may be planted in rows, and cultivated like corn, or sown broadcast like millet. In either case cowpeas may be planted to advantage. For planting in rows, 6 to 8 pounds of seed are used for forage and about 4 pounds for syrup. A good mixture for broadcast seeding is 1¼ bushels of peas and ¾ bushel of sorghum. If sown in rows, ½ bushel of peas is ample.

The same kind of fertilizers recommended for corn may be used for sorghum.

The most serious trouble with sorghum sown broadcast is the difficulty of curing; and for this reason millet is often preferred, especially on fertile land. When planted in rows sorghum may be put into the silo with the best of results; otherwise it is cut and shocked and will make excellent feed up to about New Year's. The planting in rows is advised for soil of good fertility, while broadcast seeding is adapted to the poor land where the sorghum does not grow too rank.

TABLE 8—*Fertilizer experiments with millet—average of five complete sets conducted on four different farms*

Series	Phosphate and potash per acre	Application of nitrate of soda and yield of hay per acre						
		No nitrate	40 lbs nitrate	80 lbs. nitrate	160 lbs. nitrate	240 lbs. nitrate	320 lbs. nitrate	Series average
		Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
1	None	1622	2367	2622	3164	3429	3281	2748
2	300 lbs. acid phosphate	2454	2782	3216	3820	4587	4357	3536
3	300 lbs. acid phosphate 100 lbs. muriate of potash	2942	3240	3839	3655	4428	4671	3796
4	150 lbs. acid phosphate 100 lbs. muriate of potash	2450	2754	3354	3566	4111	4365	3433
5	600 lbs. acid phosphate 100 lbs. muriate of potash	1923	2980	3548	4263	4268	5159	3690
	Average of series 2, 3, 4 & 5	2278	2825	3489	3826	4349	4638	----

CROP ROTATIONS

LIST OF ROTATIONS

1. General Farming—Five-Year Rotation

1st year—Corn, followed by winter cover crop of rye for pasture and green manure.

2d year—Cowpeas or soybeans.

3d year—Rye or other small grain.

4th year—Clover and grass.

5th year—Clover and grass.

Note—Potatoes could be introduced the 5th year after clover instead of clover and grass, or could take the place of part or all of the corn the first year.

2. General Farming—Four-Year Rotation

1st year—Corn—rye cover crop.

2d year—Sorghum and peas sown broadcast.

3d year—Clover and grass.

4th year—Clover and grass.

3. Potato Grower's Four-Year Rotation

1st year—Potatoes, followed by cowpeas and millet for hay.

Note—The hay crop is sown at last working of the potatoes and is harvested before the potatoes are dug.

2d year—Spring oats and Canadian field peas, followed by buckwheat, with which clover and grass are seeded.

3d year—Clover and grass.

4th year—Clover and grass.

This is a rotation practiced by Mr. O. H. Overdell on recently cleared land near Crossville.

4. Potato Grower's Three-Year Rotation

1st year—Cowpeas, hogged off and followed by rye cover crop for pasture.

2d year—Potatoes, followed by cowpeas sown at last cultivation.

3d year—Corn, with cowpeas and rye sown at last cultivation.

GUIDE IN THE ESTABLISHMENT OF A ROTATION

The writer has prepared Table 9 with a view to furnishing a practical guide during the establishment of the five-year general farming rotation. The spring of the year 1914 is taken as the commencement of the project and it is assumed that the land is in an ordinary state of fertility. According to this plan the rotation will not be in full operation until 1916; at least two years being required to accomplish this result.

TABLE 9—*Five-year crop rotation (No. 1), showing crops, amount per acre of fertilizers, etc., suggested for each field during the establishment of the rotation—based on experiments conducted on Cumberland Plateau soils—all operations assumed to begin in spring of 1914*

FIELD 1	FIELD 2	FIELD 3	FIELD 4	FIELD 5
1914 — Corn—followed by a winter cover crop of rye. Acid phosphate 200 lbs., muriate of potash 10 lbs., and cottonseed meal 100 lbs.	1914 — Cowpeas. Acid phosphate 300 lbs., muriate of potash 20 lbs.	1914 — Soybeans. Acid phosphate 300 lbs., muriate of potash 20 lbs.	1914 — Spring oats. Acid phosphate 200 lbs., muriate of potash 10 lbs., nitrate of soda 80 lbs.	1914—Spring oats. Acid phosphate 200 lbs., muriate of potash 10 lbs., nitrate of soda 80 lbs.
1915 — Soybeans. Acid phosphate 300 lbs., muriate of potash 20 lbs.	1915 — Rye. Ground limestone 2 tons, acid phosphate 200 lbs., manure 6-10 tons.	1915 — Corn—followed by a winter cover crop of rye. Acid phosphate 200 lbs., muriate of potash 10 lbs., cottonseed meal 100 lbs.	1915 — Red clover — sown in Aug., 1914. Ground limestone 2 tons, acid phosphate 300 lbs., muriate of potash 25 lbs.	1915—Clover and grass (sown Aug., 1914—hay).
1916 — Rye. Ground limestone 2 tons, acid phosphate 200 lbs., manure 6-10 tons.	1916—Clover and grass (hay).	1916 — Soybeans. Acid phosphate 300 lbs., muriate of potash 20 lbs.	1916 — Corn—followed by winter cover crop of rye. Acid phosphate 200 lbs.	1916—Clover and grass (chiefly for pasture).
1917—Clover and grass (hay).	1917—Clover and grass (chiefly for pasture).	1917 — Rye. Ground limestone 2 tons, acid phosphate 200 lbs., manure 6-10 tons.	1917 — Soybeans. Acid phosphate 300 lbs., muriate of potash 20 lbs.	1917 — Corn—followed by winter cover crop of rye. Acid phosphate 200 lbs.
1918—Clover and grass (chiefly for pasture).	1918— Corn — followed by a winter cover crop of rye. Acid phosphate 200 lbs.	1918—Clover and grass (hay).	1918—Rye. Acid phosphate 200 lbs., manure 6-10 tons.	1918 — Soybeans. Acid phosphate 300 lbs., muriate of potash 20 lbs.

It may be noted that after the establishment of the rotation—1916 and later—a change is made in the commercial fertilizers, both for corn and for the small-grain crop. This change consists in the omission of both the cottonseed meal and the muriate of potash. In the case of the rye, the manure would much more than replace these two ingredients and the residues from the clover and grass would be expected to furnish an appreciable supply of nitrogen for the corn which follows. Also in case of freshly cleared land neither meal or potash is advised from the outset.

NOTES ON TABLE 9

1. The liming may be done sooner than directed in the table. In fact, although especially beneficial to clover, liming is apt to increase the yield of any of the crops to an appreciable extent. According to our experimental evidence, two tons of ground limestone will be ample for at least five years, and possibly for twice that length of time.

2. The acid phosphate and muriate of potash should always be applied before planting the crop for which they are especially intended, and give best results when applied in the row for crops planted in rows. For broadcast-sown crops these materials may be applied broadcast before the land is turned, or may either be drilled in afterward or scattered broadcast and well harrowed into the soil.

3. As a cover crop after corn, rye is especially advised for the poorer soils. Under favorable conditions, either crimson clover or hairy vetch may be used. Crimson clover is an ideal crop for this purpose in some respects, but requires a rather fertile soil in order to thrive. Even then, when sown in corn at the last working, it is apt to be killed before winter by dry, hot weather. Rye would help to hold the crimson clover from freezing out during the winter, and the mixture may be sown considerably later than crimson clover alone, any time from the middle of August to the middle of September being favorable, provided the soil moisture supply is good. Vetch sown the latter part of September is apt to go through the winter. Like crimson clover it may be sown with rye.

The cover crop should be turned under at a rather early stage of growth—in the case of rye not later than when in boot, but for crimson clover and vetch when in early bloom. Attention is called to the fact that vetch makes only a small growth during the fall, winter, and early spring, and is a vigorous grower only after warm weather comes in the spring; so that to get the most good out of this crop for green-manure purposes it must remain on the land later by several weeks than either of the others, or until about the first of June. This would not, however, be a serious objection, as either cowpeas or soybeans can be planted to advantage after this date.

4. The manure is well applied for the oat crop after the land has been turned, and is then disked into the soil. Applied in this

way it is very favorable to the getting of a stand of clover and grass. If the land is new a stand of clover and grass is easily obtained. Then the manure may well be applied for the corn, which offers the greatest possible increase in yield of grain.

In the absence of manure, an extra application of both phosphate and potash is advised in the preparation for clover and grass.

5. Red clover is preferred, but alsike may be used, and a mixture of the two is sometimes advisable.

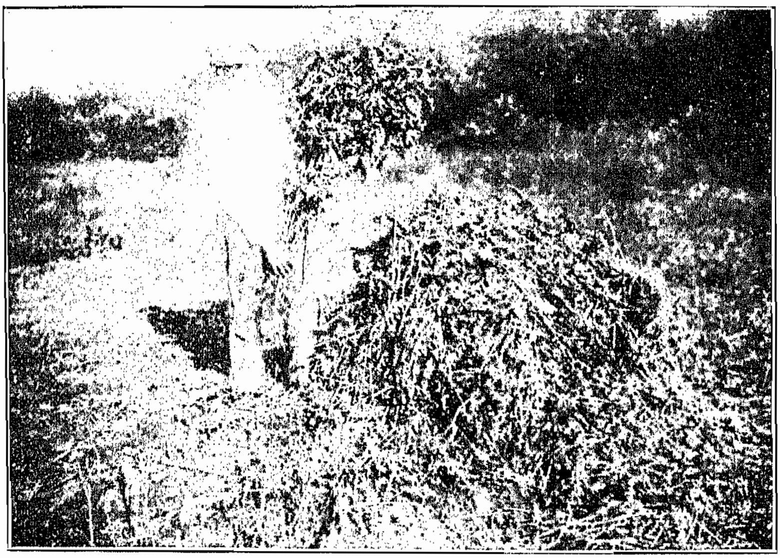
In case of a failure of clover, in the spring following the seeding an application of 100 pounds per acre of nitrate of soda may be made to advantage for the grass, and should be applied as soon as the spring growth begins, or about the middle of March.

6. The Plateau has a great advantage over most parts of the State in that there is a large amount of free range. The cattle carried over during the winter should be handled so as to save all the manure possible. Cottonseed meal has been recommended as a fertilizer ingredient, but the best way to use it is as a feed for cattle. No other feed is equal to it either in richness or in returns for the money invested. At least one pound per head per day should be fed, and this small quantity, without corn or other grain, but with only the common rough feed of the farm, will winter stock nicely, and the cost of the meal should be gotten back in the increased value of the manure.

NATURAL MEADOWS

Small areas of poorly drained land, known as "natural meadows," are occasionally found on the Plateau. As far as the writer's observation goes, the soils of these meadows are dark colored and very rich in nitrogen and humus. Field experiments conducted on a soil of this character near Crossville showed it to be very much in need of both lime and phosphoric acid, and somewhat in need of potash. With proper drainage and the application of the minerals needed, little difficulty was found in getting excellent yields of the common farm crops, such as corn, sorghum, timothy, and other grasses. Without liming, soybeans did better than anything else. With proper handling, garden crops could probably be grown to advantage.

Burnt lime at not less than two tons per acre is recommended. In order to get the lime well mixed throughout the soil, one-half may be applied before plowing and one-half after. At least 300 pounds of acid phosphate and 50 pounds of muriate of potash per acre is recommended.



SOYBEAN HAY GROWN ON "NATURAL MEADOW"

A rich-looking but sour soil, on which most crops fail