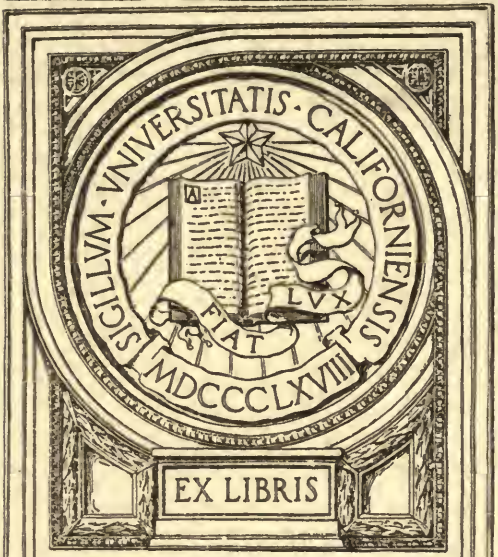

United States Department of Agriculture.

BUREAU OF SOILS—CIRCULAR No. 15.

MILTON WHITNEY, *Chief of Bureau.*

MANURIAL REQUIREMENTS OF THE LEONARDTOWN LOAM SOIL OF ST. MARY COUNTY, MD.

The Leonardtown loam is the most extensive soil type in St. Mary County, Md., and is locally known as the "white oak" or "kettle bottom" soil of the upland. Excepting the Norfolk loam, it lies at a higher altitude than any of the soils of the county. The surface is usually gently rolling. Extensive forests of white oak and pitch pine are found largely on this type of soil.

The crops to which it is best adapted are wheat, corn, and grass, although tobacco is frequently grown in rotation with these. Its crop-producing power varies greatly, this variation being due chiefly to the different treatment to which the soil has been subjected in different places. When well managed it produces good yields of the crops above mentioned.

The soil is a light-colored silt loam, containing from 8 to 20 per cent of clay and from 50 to 60 per cent of silt. It is usually free from gravel and contains very little coarse or medium sand, with a considerable percentage of very fine sand. It is rather low in organic content. If worked when too wet, the soil has a tendency to puddle, and upon drying bakes into a hard mass. This tendency can be largely overcome by the application of lime or of organic matter. The subsoil consists of a mass of clay lenses, lumps, and fragments, separated from each other by seams or pockets of sand. This peculiar structure causes it to behave much like a dense clay as regards the circulation of water.

The geographical position of St. Mary County as regards the great markets of the East and its favorable climate for agricultural operations are natural conditions justifying the best of agricultural practices. The rotation usually followed in St. Mary County is tobacco, corn, wheat, and grass, or sometimes a season of fallowing.

As the Leonardtown loam is not well adapted to the growing of a quality of tobacco which buyers expect from that county, and as tobacco is the great money crop of the locality, this has led to the abandonment of considerable areas of the type to forest occupation.

SAMPLES COLLECTED.

During the summer of 1904 a party was sent to Leonardtown to carry on investigations on different phases of the Leonardtown loam and to ascertain if the wire-basket method which had recently been devised for a study of the fertility of soils was sufficiently perfected to make it of practical use. The results obtained during the summer demonstrated that the method was capable of showing the same order in the crop-producing power of the soils as was observed in the field, and that it was also useful in determining what fertilizing materials would give the best returns. The facts gathered during the summer were thoroughly in accord with what had been previously observed in making a soil survey of this county and also with the experience of the more progressive farmers.

In 1905 samples were taken from two phases of the Leonardtown loam. The sample designated "good" was taken from a field in a high state of cultivation located within the borders of Leonardtown. For quite a number of years this field had received annually liberal applications of stable manure. It was then put down to grass and remained for five or six years, when the grass ran out. In the spring of 1903 the field was plowed and planted to corn without the application of manure or any kind of fertilizer. The result was a fine crop of corn, estimated at about 80 bushels per acre. The following year, 1904, it was again plowed and planted to corn without fertilizer, but there was a marked falling off in the crop, which may have been caused by one or all of three conditions, namely, poor cultivation, shortage in rainfall, or the fact that the same crop had been grown the preceding year.

The other large sample of soil, designated as Leonardtown loam "poor," was taken from a field several miles distant from Leonardtown, and although it had been owned by the same man for more than twenty years he had always rented the place and knew very little as regards its past treatment. The tenants were not permanent, and very little information could be gained from that source. The land was considered in the neighborhood as very unproductive, and this statement is further emphasized by the fact that the entire tract of something over 100 acres brought the owner an annual rental of only $50. In 1902 it was occupied by a colored tenant. The following year it was unoccupied and uncultivated. In 1904 it was again cultivated, and in the field where the sample was taken corn averaged about 2 feet in height and produced practically no grain.

The chief differences in the appearance of these two soils in the field is that the poor one is somewhat lighter in color, contains less organic matter, and is much more compact and difficult to cultivate. In texture it may contain slightly more silt than the good sample.

but this difference is very slight and not sufficient to account for the great difference in yield; in fact, certain beneficial treatments given the poor soil by the wire-basket method have caused it to outrank the good soil by any treatment yet tried.

It must be understood that the results of the following investigations are held to apply only to the two fields under consideration, although it seems probable from a study of the conditions throughout the county that they might be applicable to considerable areas of this type of soil. It must be understood, also, that the conditions encountered in field practice are so different from those which obtain in these experiments that the treatments, if put to a practical field test, might prove more or less efficient, or, owing to uncontrollable conditions, such as excessive rainfall or drought, might fail entirely. Furthermore, the wheat plant has been used exclusively as the test of fertility in these experiments, and whether this plant is a safe indicator of the manurial requirements of other crops is a matter which has not yet been determined. It is, however, generally conceded that if a soil can be made productive for wheat, it will be productive, as a rule, for general farm crops. The object herein aimed at is to secure a larger crop, regardless of difference in quality or texture; that is, to change the soil conditions in such a way as to enable it to produce more vegetable matter.

WIRE-BASKET METHOD OF DETERMINING MANURIAL REQUIREMENTS.

The two large samples of soil collected were each subjected to various treatments, and the effect of the treatments ascertained by growing an equal number of wheat plants on each for a period of about twenty-five days, or as long as favorable growth could be maintained on the limited amount of soil used for the number of plants that were grown. The method of growing the plants is as follows:

Five small wire baskets 3 inches in diameter by 3½ inches in depth are used for each treatment. After the soil has been treated with its respective fertilizer and brought up to the optimum water content with distilled water, the equivalent of about 325 grams of dry soil is placed in each basket. The soil is firmly packed, and six germinated kernels of wheat are planted in each basket. During the process of packing a small portion of the soil presses out through the wire mesh, but this is brushed off and returned to the interior of the basket, after which the basket is at once dipped into melted paraffin, which not only forms an intimate contact with the soil, but also produces a water-tight covering. An eighth to a quarter of an inch of washed quartz sand is now placed over the soil of each basket and its contents at once weighed and the weight recorded. In from three to five days the wheat plants will have emerged from the soil and

have a height of approximately 1 inch, at which time the surface of the basket is sealed—that is, it is covered with a piece of paper having a small opening in the center sufficiently large to permit the plants to pass through. The paper is dipped in melted paraffin just before placing it over the soil, and then a small amount of paraffin is run around the outer edge of the paper, thus forming contact with the side of the basket. In this way all evaporation from the soil is prevented, excepting the minute amount which may pass through the small opening immediately around the plants. The loss from this source is so slight in comparison to that which is transpired by the plants that no account is taken of it, but even if the loss were considerable it should be practically the same from all baskets. The weight of the basket is taken immediately before sealing and immediately afterwards in order to ascertain the weight which has been added to it in the process of sealing. This increase is now added to the original weight of the basket, and the result is what is known as the "optimum weight," or that weight at which the contents of the basket contain the most favorable amount of moisture for the growth of plants.

During the growing of the plants, which usually continues from eighteen to twenty-one days from the date of sealing, the baskets are weighed at intervals of two or three days and watered with distilled water in order to retain a favorable moisture content for plant growth. By this method the loss of water or the amount transpired by the plants is ascertained periodically, and at the end of the experiment the total amount of water given off through the plants of each basket is obtained for comparison with the growth and green weight of the plants, which is ascertained by cutting and weighing the plants at the time the experiment is concluded. All conditions of the experiment are so carefully controlled that the average result of five baskets rarely differs more than 5 per cent from the average result of any other five baskets that have been treated throughout in precisely the same manner. Differences which occur beyond this amount may therefore safely be attributed to the different manurial treatments which have been given. This method has several advantages over the growing of plants in open and porous pots. The method of coating the baskets with paraffin prevents any accumulation of roots between the soil and receptacle, a trouble which is so common in pot experiments. The complete sealing up of the soil also enables the experimenter to determine the amount of water which the plant has actually used and transpired in its process of growth, and this, together with the small size of the baskets, enables the moisture content and its fluctuations to be carefully controlled. When the plants have attained considerable size, the draft made upon the soil moisture is very great, and on warm days with bright

sunshine the plants may use half of the moisture which the soil contains. The draft upon the soil that occurs during this period of growth, both as to moisture and mineral-food constituents, is probably as great as that under field conditions by the removal of a large mature crop, providing we assume that the removal takes place to no greater depth than 1 foot, which, in the case of wheat and other similar crops, would be approximately correct. For example, the amount of green matter in the plants of the untreated poor Leonardtown loam soil was at the rate of 12,000 pounds to the acre-foot, and the water removed was equal to 20 per cent of the weight of the soil, or the equivalent of 3.1 inches of rainfall.

A large number of moisture determinations show that the wheat plants at the time of cutting from the baskets contain about 85 per cent of water. On this basis the air-dry matter produced in the tops of the plants would be equal to 2,000 pounds per acre. In case of a mature crop of wheat we know that the straw and the thrashed grain are about equal in weight, and on this basis the above amount of material removed from the soil is equivalent to a crop of about 16 bushels of wheat per acre, or far more than would probably be obtained in practice on the field from which this sample was taken, especially when untreated.

Another portion of the same sample of soil when given a liberal application of barnyard manure, nitrate of soda, sulphate of potash, and acid phosphate produced a yield of green matter equal to 32,300 pounds per acre-foot of soil, and the plants used an amount of water equal to 44 per cent of the weight of the soil, or the equivalent of about 7 inches of rainfall. By computation as above this would be equal to 45 bushels of wheat per acre, or a crop which on Leonardtown loam soil would be considered unusually large, although perhaps not beyond what has occasionally been obtained under most favorable conditions in field practice.

In the case of the sample of good soil the yield from the untreated was 50 per cent greater than that from the poor, or the equivalent of 24 bushels of wheat per acre. The difference is not so great as might be expected, judging from the crop-yielding power of the two soils as observed in the field. In case of the poor soil, however, the above-estimated yield of 16 bushels per acre for the untreated portion is probably far greater than would have been obtained under field conditions, and has probably arisen from the fact that the mechanical condition of the soil has been very greatly improved as used in the basket experiments, and nearly the optimum amount of water has at all times been maintained. From the above data it will be seen, therefore, that by this method of cropping the draft made upon the soil within the short period of twenty-five days is fully as great, if not greater, than that made in field practice during the whole season.

This is further substantiated by the fact that when the soil in these baskets is immediately replanted with wheat there is a decline in the growth of the second crop of 50 per cent, especially where the soil is untreated. With certain beneficial treatments, however, or by re-treating the soil just before planting the yield may be maintained.

RESULTS OF DIFFERENT MANURIAL TREATMENTS OF LEONARDTOWN LOAM.

In view of the fact that this soil is apparently deficient in organic matter, it was believed that treatments with barnyard manure would be especially beneficial. All practical farmers are of course aware of the fact that there is considerable variation in the composition of barnyard manure, and that its efficiency also depends upon its state of decomposition. In order to get some results bearing upon these points samples of manure were obtained from eight different sources, and the above two samples of soil, as well as others, were treated with these manures at the rate of 20 tons per acre.

The following table shows the results of the experiment, the relative growth of plants being expressed on the basis of 100 for the untreated soil in each case:

Effect of manure from different sources on Leonardtown loam.

Kind and source of manure.	Relative growth on—	
	Poor soil.	Good soil.
Untreated soil	[a]100	[a]100
Rotten manure from propagating gardens	175	139
Manure from Takoma Park	173	125
Cow manure fresh from pasture	158	131
Decayed organic matter from city dump	155	120
Horse manure from city dump	154	142
Rotten manure from Department greenhouse	131	123
Partly decomposed horse manure	110	115
Horse manure, fresh	81	88

[a] In this and subsequent tables the actual relative growth on the untreated samples of these two soils is 100 for the poor and 148 for the good, but the results of each treatment are stated on the basis of 100 for the untreated soil to simplify the comparison of the different treatments.

The above results show that the efficiency of barnyard manure on these soils is widely variable and that under certain conditions of the soil or of the decomposition of the manure it may actually be harmful. The depressing effect of the sample of fresh horse manure can not be attributed to its lack of plant food constituents, for it was probably one of the most concentrated in the series. It seems likely that some product in the manure or the decomposition which took place in the soil gave rise to products that were somewhat injurious to the plants. It is noticeable throughout the experiment with barnyard

manure that the poor soil responds to a much greater degree than the good one, the maximum increase attributable to manure being about 75 per cent. As a result of many experiments with these two samples of soil where manure has entered into the treatment in amounts ranging from 2½ to 20 tons per acre it has been found that the small amounts give relatively larger increases than the larger amounts, and it suggests the probability that applications of barnyard manure in field practice will be most economical if applied at the rate of about 10 tons per acre.

EFFECT OF LIME.

Lime having proven decidedly beneficial, especially on the poor soil, it was applied in different amounts ranging from 1,000 to 8,000 pounds per acre, the rate of application being based on the calculated weight of an acre of soil to a depth of 7 inches, which is approximately 2,000,000 pounds. The following table shows the relative increase in growth attributable to the different applications of lime as compared with the untreated soil, which is taken as 100 in each case:

Effect of lime on Leonardtown loam.

Lime per acre.	Relative growth on—	
	Poor soil.	Good soil.
Untreated soil	100	100
1,000 pounds	138	111
2,000 pounds	140	112
4,000 pounds	136	110
6,000 pounds	137	108
8,000 pounds	135	119

The lime above used was air slaked. It will be noticed that its effect is relatively much greater on the poor soil than it is on the good one, and that there seems to be no appreciable increase for applications greater than 1,000 pounds per acre. In other words, the lime requirements of the soil seem to be fully met by applications of 1,000 pounds, but there is apparently no harmful effect even where the amount is 8,000 pounds per acre. It is possible that in subsequent crops the larger amounts may have a residual effect greater than the smaller application, but it would seem wiser to give small applications at frequent intervals rather than large applications with the expectation to have the results extend over a long period of time. In another experiment where lime was applied at the rate of 6,000 pounds per acre and three successive crops grown without re-treatment, the yield for lime was 136, 213, and 112 for the first, second, and third crops, respectively, as compared with 100 for each of the three successive crops grown on the untreated soil, or a mean gain

for the three crops of 46 per cent. Lime always gives an increase in growth on Leonardtown loam, poor, no matter whether used alone or in combination with barnyard manure, chemical fertilizers, or green manure. Its most pronounced effect, however, was where it has been used in connection with barnyard manure. In this instance manure was used with and without lime, the former at the rate of 10 tons per acre and the latter at the rate of 2,000 pounds per acre. Four successive crops of seedling wheat were grown without re-treatment of the soil. In the first crop manure gave an increase of 14 per cent, and manure and lime together gave an increase of 93 per cent, or an increase attributed to the lime of 79 per cent. The succeeding crops showed a marked diminution in growth for both the treated and untreated soil, the diminution being equally as great in the manure-treated soil as in that which was untreated, but much less marked in the case where lime was applied with the manure. The results of the four crops showed an aggregate increase attributable to the lime equivalent to 26½ bushels of wheat. If results approximating these can be obtained in field practice, it is plain that the application of lime at the rate of a ton per acre as above used would be an exceedingly profitable treatment, especially in view of the fact that where lime is obtainable near by its cost should not exceed $3 per ton. It is not at all improbable, however, in this case that the application of the lime in conjunction with the manure has rendered the manure more effective. This seems most likely because the lime in this instance has been about twice as effective as when used alone, and, furthermore, the manure used without lime has had very little permanent effect, the application of 10 tons producing an aggregate increase in yield for the four crops equivalent to a little less than 5 bushels of wheat, the main effect showing in the first crop.

EFFECT OF CHEMICAL FERTILIZERS.

Nitrate of soda, sulphate of potash, and tricalcium phosphate have been used in numerous instances alone, in combination with each other, and in various combinations with manure, lime, and both manure and lime. Nitrate of soda and sulphate of potash have been used in amounts approximately 250 and 500 pounds per acre each, while tricalcium phosphate has been used at the rate of 150 and 300 pounds per acre. Nitrate of soda, whether used alone or in combination with other constituents, has usually given an increase in growth except where lime enters into the combination. In the presence of lime, nitrate of soda invariably either gives no increase or produces a slight decrease in the effect of the lime alone. Its beneficial effects are most pronounced where used in combination with barnyard manure. In the experiment above referred to under the heading of lime, where four successive crops were grown without re-treating the soil,

nitrate of soda was used at the rate of 500 pounds per acre in connection with an application of 10 tons of manure. In the first crop it produced an increase in growth amounting to 49 per cent over the manure alone, but had practically no residual effect, for the baskets treated with barnyard manure alone in the two following periods gave equally as large returns as did those which had been treated also with nitrate of soda.

Sulphate of potash is also beneficial on this soil, especially where used in combination with manure, and in the above-mentioned experiment, where used at the rate of 500 pounds per acre in connection with manure and nitrate of soda, the increase attributable to the potash amounts to 31 per cent. It is quite noticeable, also, that this effect has been felt in the subsequent crop, and, in fact, the aggregate increase attributable to the potash salts, when used in combination with manure, for the four crops is equal to 28 per cent. Tricalcium phosphate, on the other hand, has rarely given any increase in growth. There is some question, however, as to whether this constituent could be expected to show its effect in the early growth of the wheat plant. It is quite possible that its effect might become beneficial to the final growth of the plants.

The following figures show the comparatively small increase from applications of nitrate of soda, potassium sulphate, tricalcium phosphate, or a combination of two or all of these substances when used without manure or lime. The plant-food constituents added to the soil by this treatment supply certainly an adequate amount for the needs of the crops, and the small relative increase due to their use indicates very clearly that the cause of the infertility of the Leonardtown loam, poor, is not due to a lack of plant food, but is due to some other unfavorable condition in the soil.

Effect of different mineral fertilizers on Leonardtown loam, poor.

Treatments, pounds per acre.	Relative growth.
Untreated soil	100
Sodium nitrate, 250 pounds + tricalcium phosphate, 150 pounds + potassium sulphate, 250 pounds	121
Potassium sulphate, 250 pounds	115
Sodium nitrate, 250 pounds + potassium sulphate, 250 pounds	111
Sodium nitrate, 250 pounds	107
Sodium nitrate, 250 pounds + tricalcium phosphate, 150 pounds	100
Tricalcium phosphate, 150 pounds	92

EFFECT OF GREEN MANURE.

The green manure applied in this case was cowpeas cut in the early stages of growth. The peas were run through a mill and intimately mixed with the soil at the rate of 9,000 pounds of the water-free substance per million of soil, or an equivalent of 9 tons per acre.

The green cowpeas contained at the time of cutting 90 per cent of water. For a few days after the plants came up the treatment seemed to be slightly harmful. In a short time, however, the plants recovered and began a renewed growth, making an increase of 89 per cent over the untreated soil. Both the untreated and treated soils were replanted three times, thus producing four successive crops. In the second crop the comparative yield of the untreated and treated soils was 100 and 650, respectively, or a gain of 550 per cent for the treated soil. It is also worthy of note that while the untreated soil produced only one-third as much as it did the first time, the treated soil produced more than it did the first time, whereas a crop grown on a fresh sample of the same soil yielded approximately the same amount as the first crop of the above untreated sample. In the third crop the relation of the untreated and treated soil was 100 and 293, respectively, and for the fourth crop 100 and 288. The fourth crop on the treated soil was slightly greater than the first crop on the untreated soil, which shows that the treatment had lasted through four successive crops of wheat without permitting the yield to go below what it originally was on the untreated soil and without re-treatment with the green manure. The aggregate increase produced by this treatment was equivalent to 55,000 pounds of green matter per acre, or 76 bushels of wheat for the four crops.

Both the treated and untreated soils were now re-treated with cowpeas at the rate of 5,000 parts per million of dry matter, or the equivalent of 5 tons per acre, and replanted to wheat for the fifth time. The yield from each of the soils was greater than any of the yields from the previous treatment and was the largest for the sample which had grown poor crops without any treatment, the yield being at the rate of 45 bushels per acre.

The following table gives the relative growth for various treatments which have proven decidedly beneficial on the Leonardtown loam, poor:

Relative growth for various treatments on Leonardtown loam, poor.

Treatments, pounds per acre.	Relative growth.
Untreated	100
Manure, 20 tons + lime, 6,000 pounds + sodium nitrate, 500 pounds + potassium sulphate, 500 pounds	230
Manure, 10 tons + sodium nitrate, 500 pounds + potassium sulphate, 500 pounds	195
Manure, 10 tons + lime, 2,000 pounds	193
Cowpeas, 9 tons	189
Manure, good quality, 20 tons	176
Cowpeas, 2½ tons + lime, 1,000 pounds	174
Manure, poor quality, 10 tons + sodium nitrate, 500 pounds	163
Lime, 1,000 pounds + potassium sulphate, 200 pounds	148
Cowpeas, 5 tons	145
Lime, 2,000 pounds	140
Cowpeas, 2½ tons	136

From the foregoing data it is obvious that both barnyard manure and green manure are beneficial to this soil when in a run-down condition, but that the effects from applications of green manure are decidedly more beneficial in that they are more lasting than for equal amounts of barnyard manure. The benefits from liming are so obvious that they need no comment, while potash and nitrogen in combination with manure are sufficiently beneficial to justify their application, at least in amounts not to exceed 250 pounds per acre, but the results do not seem to indicate that when applied alone they are of enough effect to warrant their use.

That the results obtained in the above experiments are attributable to the applications given to the soil there can be no doubt, but the applications have been made to small samples under ideal conditions in regard to the manipulation of the soil and the growth of the plants. For instance, as has been explained; the moisture content of the soil in these experiments has been maintained at or near the optimum or most favorable condition at all times. Again, the fertilizers have been intimately mixed with the soil—far more intimately than would be practicable in the field—and therefore the same degree of success may not follow under field conditions. In the case of barnyard manure, green manure, and lime, however, there is undoubtedly a physical effect in the field which does not enter into these experiments, and which, in the case of a soil like the Leonardtown loam—poor—would very likely more than overbalance the loss which would occur in field practice from the less intimate mixture of the fertilizer and the less thorough control of the conditions. The results above obtained are sufficiently marked to justify the suggestion that the treatments be tried on a small scale, particularly where this type of soil is in a run-down condition.

The Bureau realizes the importance in this connection of a practicable field test, but this would involve much more time than has been required in making the above experiments, and should preferably be made by the farmers themselves under the usual farm conditions. Furthermore, it must be insisted that good results can be anticipated only under the best possible conditions of tilth and intelligent handling of the mechanical factors involved in cropping.

EXPERIMENTAL RESULTS AGREE WITH PRACTICE.

As above stated, the results obtained with the wire-basket method appear to be in harmony with the actual field experience of successful farmers in the locality. In 1900 Dr. Jay A. Bonsteel surveyed and mapped all the soils of St. Mary County, Md., and in his report of that year, entitled "A Soil Survey of St. Mary County, Md.," he says:

The Leonardtown loam would benefit materially from liming, except, of course, when tobacco is to be raised. The plowing under of green crops, especially the

leguminous plants of the clover and cowpea varieties, furnish another method of enrichment highly desirable on almost all the soil types of St. Mary County. and does not present the difficulties of liming, since this kind of fertilizer is of great benefit to the tobacco crop. These leguminous crops furnish a fair forage for cattle during a period of their growth, and if allowed to continue growing they produce a mass of organic matter for incorporation with the soil; and all the time, beneath the surface of the ground, certain minute bacteria, living on the roots, are taking nitrogen from the air and storing it in the soil, thus helping in the enrichment of the soil. * * *

For certain crops special fertilizers will always be necessary, and commercial fertilizers are to be commended highly, but in St. Mary County on all soils the use of stable manure and the plowing under of green crops are to be preferred, while on the soils least suited to tobacco the abandonment of that crop and the free use of lime in conjunction with organic matter have already become necessary, as is shown by the forest areas given over to nature's cultivation.

During the same year Bonsteel also surveyed and mapped the soils of Calvert County, Md., and in his report, "A Soil Survey of Calvert County, Md.," in discussing the Leonardtown loam, he makes the following statement:

The uniformly yellow appearance of the surface soil indicates a lack of organic matter, which should be supplied in the form of stable manures and by plowing under green crops, like crimson clover and cowpeas. Such a treatment would not only increase the actual supply of plant food, but would also improve the texture of the soil. Unless it is absolutely necessary that tobacco should be raised upon areas of this type, the application of lime should be tried in connection with stable manures and green fertilizers. The fact that tobacco is not largely raised on this soil should make this line of improvement much easier than on other types of soil to which tobacco is one of the crops best adapted.

The following year, 1901, this same type of soil was encountered in making a survey of Prince George County, Md., and in his report upon that area Bonsteel states:

This soil is only producing to its full capacity in the northern part of Prince George County, where, through the use of green manures and lime, from 15 to 18 bushels of wheat per acre are frequently raised upon it. Elsewhere this soil type is generally lacking in organic matter. The Leonardtown loam should furnish an excellent soil upon which to introduce stock raising and dairying at points where market gardening can not be undertaken.

While Bonsteel has repeatedly recommended the use of green manure and lime, it would seem from this last statement that he had not previously found the farmers actually putting its use into practice. In the same report, under the heading of "Agricultural conditions," he makes the following statement:

Upon those farms where tobacco is raised lime is little used, since its application injures the burning quality of the leaf. Commercial fertilizers, however, have been used in large quantities for many years to increase the production of tobacco and the grain crops. They have been considered a complete fertilizer in many cases, and too little attention has been paid to the restoration of organic matter to the soil. Recently leguminous crops in the form of cowpeas and crimson clover have been introduced and the system of agriculture improved through this means. The production of good forage crops can only be resumed by a more generous use of lime and the leguminous green manures. The cowpea seems better adapted to this end than any other leguminous crop.

In 1903 Taylor and others were sent to St. Mary County and elsewhere to investigate the relation between the chemical constituents

of the soil and its crop-producing power. Taylor, in writing from Leonardtown, Md., under date of May 4, 1903, makes the following statement:

> There are two or three farmers in this vicinity who have gradually brought their farms up to a very fair state of cultivation by deeper plowing, more thorough cultivation, and by the use of cowpeas and clover as green manure.

The above statements show that a few of the more successful farmers have already realized the benefits to be derived by the use of lime and green manure, and, in fact, have begun the practice of it with results which are unmistakably beneficial.

FRANK D. GARDNER,
In charge of Soil Management.

Approved:
JAMES WILSON,
Secretary of Agriculture.

JUNE 2, 1905.

O