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PRINCIPLES OF
PROFITABLE FARMING

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NOTICE

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PREFACE.

THE following pages are intended to make clear to practical farmers the broad principles of scientific manuring, and their use in every-day farm work. Farmers need have no fear that scientific farming goes beyond their powers of understanding. It is plain and simple, and does not call for extra outlay in time or money ; but it must be studied carefully. The scientific farmer knows *why* he does things, hence he is always able to make the best of a good season, and also of a bad season. When a certain plan of working fails after many seasons' successful use, there must be a cause for the failure. The science of farming aids the farmer in studying out such causes, so their presence may be known in time and the danger of failure checked, that a whole season's work may not be lost.

INTRODUCTION.

THE contents (with illustrations) of this pamphlet are grouped into five parts, as follows :

Part I is a free translation of Prof. Paul Wagner's celebrated report on "The Rational Fertilization of Agricultural Plants" ("Die Rationelle Duengung"). As this valuable report is in a foreign language and not accessible to most readers, it is believed that a synopsis will prove to be of much interest to the masses of American farmers. Prof. Wagner is director of the Experiment Station at Darmstadt, Germany, and his official experiments in plant nutrition and in the use of artificial fertilizers, have given him a world-wide reputation as an agricultural authority. His experiments, which show that leguminous plants, such as clover, peas and beans, have the power of assimilating large amounts of nitrogen from the air, *when sufficient potash and phosphoric acid are present in the soil*, and that this element of plant food can be used to fertilize succeeding crops, are of exceedingly great value and make possible a saving of millions of dollars to farmers.

Part II gives the simplest way of testing the manure or fertilizer needs of any soil. It explains the nature of what are commonly known as plot experiments.

Manures, fertilizers, crops for green manuring, or whatever is successfully used as plant food for the purpose

of increasing the growth of plants, *always contain one or all of these three substances, potash, phosphoric acid and nitrogen.* A luxuriant plant growth is not caused merely by the manure or fertilizer as such, but by the potash, phosphoric acid and nitrogen contained in it. It must be kept clearly in mind that plants need *all three* of these plant foods; no one of them can do the work of the other two, nor any two the work of the other one. However rich a soil may be in any one of them, or in any two, if one is totally lacking, no plant can grow; if one of these substances is present, say only in sufficient quantity for a quarter crop, only a quarter crop will be grown, even if the other two substances be present in great excess of the needs of a full crop.

Once the nature of plant food is well understood, plot experiments become simple. The idea is to determine which of the three elements of plant food the soil needs. This the experimenter learns by "putting the question" to the soil itself. He applies different fertilizing materials on different plots, and he gets his answer in the quantity and quality of crop the plots produce.

Part III includes a description of the Experiment Farm at Southern Pines, North Carolina. The State Horticultural Society of North Carolina is conducting there an elaborate and extensive series of experiments with fertilizers to determine the needs of different horticultural crops in the field. This enterprise is managed with great thoroughness and the experiments are directed by trained

observers; the results are of great practical benefit to farmers, not only in the Southern States, but also throughout the country.

Part IV is devoted to the results of potash fertilization at various experiment stations. The results obtained by these field tests with different crops show the need of potash in a variety of soils and upon widely scattered farms. Many photographs of results of different experiments were taken, and some of them are faithfully reproduced in these pages. The illustrations presented may be relied upon as strictly accurate views of actual experiments.

Part V comprises a series of tables, which farmers will find useful. The figures are in every case authentic.

PART I.

PROFITABLE MANURING.

MANURING or fertilizing in this book means the use of the manurial substances, — potash, phosphoric acid and nitrogen,—for the purpose of increasing the growth of plants. In practical farming the object is to get the greatest growth for the least amount of these manurial principles, or in other words, to avoid using manures or fertilizers wastefully. A crop needs certain quantities of

FIG. 1. EFFECT OF NITROGEN FERTILIZER ON GRAIN.

potash, phosphoric acid and nitrogen, and must have them all to make the crop; but there is a way to make certain crops fertilizer producers as well as crop-makers, as shown by the following experiments.

The first experiment shows the effect of attempting to grow certain crops without nitrogen.

Figure 1 shows wheat and barley, grown in pots. Of the four pots of each experiment, two (marked O) were

fertilized with potash and phosphoric acid, the remaining two (marked N) also received potash and phosphoric acid and in addition nitrogen in the form of nitrate of soda. The increase of growth in the pots where nitrate of soda was used, shows the effect of nitrogen. Stated in figures, the gain was three to one. This experiment was made with soil known to be deficient in nitrogen, and serves to show

FIG. 2. LEGUMES NEED LITTLE NITROGEN FERTILIZER.

beyond doubt that these two crops cannot be grown to advantage unless there is enough nitrogen supplied to balance properly the potash and phosphoric acid.

Figure 2 shows the same treatment, the plants in this case being *Vetches*. The results show that some plants, at

least, do not require any considerable amount of nitrogen manuring; and that it would be wasteful to use much nitrogen fertilizer on such.

We have gone to some trouble to illustrate this point, as it is the basis of profitable manuring, and must be fully understood as a fact. For the purpose of profitable manuring, plants may be divided into two classes: First, those which *need* nitrogen manuring; and second, those which *do not need* nitrogen manuring. Among the plants of the first class are wheat, corn, oats, rye, barley, potatoes, beets, turnips, cabbage, etc. Among those of the second class are peas, beans, vetches, serradella, cow peas, alfalfa and all the clovers. Plants of the second class are called legumes. They have the power of drawing the nitrogen from the air and changing it into forms suitable for plant food. This power is due to the action of certain bacteria which infest the roots of plants of this class, and whose presence is recognized by the growth of little knots on the roots, the so-called root "nodules," as shown in the illustration Fig. 3 on the next page.

We have spoken of potash and phosphoric acid to *balance* the nitrogen; this means that if a plant is supplied with a certain amount of nitrogen in plant food, a certain amount of potash and phosphoric acid must also be supplied. If the amount of nitrogen is reduced by one-half, the potash and phosphoric acid also may be reduced by one-half; if this is not done, the extra half of the potash and phosphoric acid would not be of any use, there being no nitrogen to

FIG. 3. COW PEA PLANT, SHOWING ROOT NODULES.

associate with the two ingredients to make a complete plant food. A complete plant food, whether farmyard manure, commercial fertilizer, or a home-made mixture of fertil-

izer chemicals, should contain such quantities of potash, phosphoric acid and nitrogen, that, as nearly as may be, all of each is taken up by the crop. A manure or fertilizer thus proportioned is said to be well balanced.

In the figures referred to in the earlier part of this chapter, an illustration is given of an attempt to grow plants without nitrogen, and, through the use of pictures taken from actual photographs, it was shown that, except in the case of the class of plants called legumes, plants cannot make any useful growth without nitrogen. Had Prof. Wagner withheld either potash or phosphoric acid, no considerable growth would have been made in the case of either the barley or the legumes. The illustration was made, however, not to show that any crop or crops can do without one or another of the elements of plant food, but to show that a certain class of plants can supply their own nitrogen. Legumes must have nitrogen as well as other plants, but do not need much nitrogen manuring. This one point is the basis of the most important detail of profitable manuring.

Manuring, as already stated, means the use of potash, phosphoric acid and nitrogen in growing a crop. Profitable manuring includes the selling of the crop for an increase over the cost of the manure, cost of seeding, tillage, and other necessary expenses. Thus plant food may be regarded as something which is bought to grow crops and sold as crops to repay for the investment. Therefore, the potash, phosphoric acid and nitrogen converted into crops **should always be sold at a much higher price than they cost**

in the form of plant food. Nitrogen is the most expensive of the three elements of plant food and costs from two to three times as much per pound as either potash or phosphoric acid; the latter two cost about the same per pound. A rough example will illustrate the broad general principles of profitable manuring at its best. Assuming that potash and phosphoric acid cost each 5 cents per pound, and nitrogen 15 cents per pound, and that to grow a fair crop of clover requires per acre 90 pounds of potash and 20 pounds of phosphoric acid, there would be a total cost for plant food of \$5.50 per acre. The crop will contain 82 pounds of nitrogen, 90 pounds of potash and 20 pounds of phosphoric acid with a value as follows:

Nitrogen	82 lbs. at 15 cts.....	\$12.30
Potash	90 " " 5 ".....	4.50
Phosphoric acid	20 " " 5 ".....	1.00
		<hr/>
	Total.....	\$17.80
	Cost.....	5.50
		<hr/>
	Gain.....	\$12.30

While these results are theoretical, pure and simple, still they represent the problem of using legumes profitably. In many crops the margin of profit is narrow, and it is only by making use of legume nitrogen that the results may show a balance on the right side. It is not enough that a farmer in these days must know the nature of manures generally, but he must also know how to make the most of each and all of them.

GREEN MANURING.

By green manuring is meant the growing of crops for the purpose of plowing them into the soil to increase its fertility. One of the objects of green manuring is to enrich the soil in organic matter, which is valuable, especially with soils that are either too loose or too stiff. The improvement consists in bettering the mechanical texture, making soils more retentive of moisture, and consequently less subject to the effects of drouth. The most important feature, however, in connection with green manuring lies in the use of legumes, because these plants are valuable not only for the organic matter they produce, but also for the nitrogen they absorb from the atmosphere, which is useful as plant food for succeeding crops. Plants which are not legumes do not have this property of taking nitrogen from the air. Whatever plant food they contain has been taken from the soil.

Prof. Wagner has made some interesting experiments showing the value of legumes for green manuring.

Figure 4 is from a photograph illustrating one of these experiments. The four pots to the left were planted with oats and all of them received sufficient potash and phosphoric acid, but the first two were not supplied with nitrogen, while the other two received an ample supply.

The difference in growth shows the effect of the nitrogen added to the potash and phosphoric acid. The four pots to the right (also planted to oats) received potash and phosphoric acid in the same manner, and all four were green-manured, the first two by a crop of mustard, the second two by a crop of vetches. These green-manure crops were grown in the pots the previous season and worked into the soil.

FIG. 4. DIFFERENT RESULTS FROM LEGUME AND NON-LEGUME GREEN MANURE.

As will be seen from the picture, the effect of mustard and vetches, when used as green-manure crops, is strikingly different. Green manuring with mustard (a non-legume) failed to supply the nitrogen needed, and a very poor crop of oats resulted—practically no better than where neither nitrogen nor green manuring was used; while vetches (legumes), being nitrogen gatherers, supplied the nitrogen needed to make a good crop of oats, and proved equal to the nitrate of soda in the first case.

Figure 5 refers to another of Prof. Wagner's important experiments bearing on green manuring. All eight pots received potash and phosphoric acid alike. The first two pots received no nitrogen, second two were green manured with lupines, the third two with buckwheat and the fourth two with peas. The results show the usefulness of green manuring with legumes and the failure with non-legumes

FIG. 5. DIFFERENT RESULTS FROM LEGUME AND NON-LEGUME GREEN MANURE.

that is, plants that do not have the power of drawing nitrogen from the atmosphere.

As has been shown by the illustrations, crops like buckwheat and mustard are not adapted for green manuring, but farmers sometimes raise these crops in the fall, manuring them with nitrogen fertilizers, so as to get a good growth, and plow them under in the spring. Many experiments and practical experience show that this method

of green manuring is not advisable or economical. The reason is that the nitrogen in its usually soluble form, as applied in nitrate of soda, changes into less soluble organic compounds, which are not so readily available as plant food for the succeeding crop.

Figure 6 illustrates an experiment by Prof. Wagner on this subject. The ten pots were all manured alike as to

FIG. 6. DIFFERENT RESULTS FROM NITROGEN APPLICATION IN THE FALL AND IN THE SPRING.

potash and phosphoric acid, and were divided into two series of five pots each. The five pots in the first series (to the left in the illustration) were planted to mustard, with nitrogen applied in the fall. The following spring the mustard was worked into the soil as a (non-legume) green manure, and oats were planted. The second series received the same amount of nitrogen as the first series, but it was applied in the spring directly to the oats. The oats in the pots on the right made a stronger growth and

the results show that a direct application of nitrate of soda to the crop to be grown is more effective than an indirect application, using it in the form of a non-legume green-manure.

This point, it must be remembered, is true when the effectiveness of green-manure as a fertilizer is under study; if the green crop is intended merely to prevent soil washing, as a soil cover, or as a means of preventing loss by leaching of available plant food, non-legumes may, of course, be used. As a matter of practical farm economy, however, legumes should always be grown if possible, so that the supply of fertilizer nitrogen may be increased.

POTASH—PHOSPHATE MANURING.

In the illustrations so far presented, the reader will notice that in each case the pots have been supplied with potash and phosphoric acid, because no plant can make its growth without these two substances. Furthermore, in order that leguminous plants may accumulate their fertilizer nitrogen, it is necessary that potash and phosphoric acid be applied first, or at any rate be present in the soil in available forms and in ample quantities. Many soils contain considerable quantities of potash and phosphoric acid, but as they are in such an insoluble state, they cannot be absorbed by the growing crop and are, therefore, of little value.

FIG 7. SHOWING EFFECT OF POTASH-PHOSPHATE MANURING ON LEGUMES AND NON-LEGUMES.

The need of potash and phosphoric acid is well illustrated in another of Prof. Wagner's experiments. The pots shown in the upper half of illustration Figure 7 were planted to peas, and are divided into three sets of two pots each. They were treated as follows: First two, no fertilizers; second two, potash and phosphoric acid; third two, potash, phosphoric acid and nitrogen. The three sets are marked by "O"—no fertilizer, "KP"—potash and phosphoric acid, and "KPN"—potash, phosphoric acid and nitrogen. The growth shows that potash-phosphate manuring was practically as effective as when nitrogen was added, and that the use of nitrogen fertilizers in this case was a needless expense.

The lower half of this illustration shows pots treated exactly the same way, but planted to oats, a non-legume. As the picture shows, the potash-phosphate pots are scarcely better than those not manured; but the pots treated with nitrogen, in addition to potash and phosphoric acid, made an excellent growth. In other words, the peas secured practically all the nitrogen they needed, but the oats have not this power, and unless they are given the fertilizer nitrogen, they will fail to make profitable growth. It is scarcely necessary to remark that the results would have been similar had the legumes, instead of peas, been any of the clovers, vetches, lupines, soja beans, etc.

From the data already given, Prof. Wagner established two important conclusions:

1. Sufficient potash and phosphoric acid must be sup-

plied in order that leguminous plants may be able to draw a full supply of free nitrogen from the air and thus reach their full growth.

2. In order that grain and all other farm crops may utilize the nitrogen present in the soil, it is necessary that a sufficient quantity of potash and phosphoric acid be also present in the soil.

A very striking practical illustration of successful green manuring is in meadows of mixed grasses. Among the grasses in meadows will be found more or less of clovers and other legumes, and if a meadow be fertilized with potash and phosphoric acid, these leguminous plants will show a more vigorous growth and condition.

The grasses of such meadows will also show the beneficial effect of this treatment. The first year or two they may not seem to do much better than before. That is because they were not supplied with sufficient nitrogen. But in the third and fourth years, the grasses begin to thrive and run rank, because they feed upon the nitrogen supplied to the soil by the decaying leaves, stalks and roots of the legumes, the growth of which was promoted by the use of potash and phosphoric acid.

Every farmer should practice potash-phosphate fertilization on poor meadow fields. It is thus possible to transform an unprofitable "grass meadow" into a valuable "clover meadow." By repeated and heavy applications of potash and phosphoric acid, the very appearance of a neglected meadow, which has produced only sour grasses, can

WITHOUT FERTILIZER.

FERTILIZED WITH PHOSPHORIC ACID.

FERTILIZED WITH PHOSPHORIC ACID AND POTASH.

Showing effect of Potash-Phosphate Fertilization on Meadows.
Experiments by Prof. Hellstroem (Sweden).

be entirely changed, owing to the predominance and rank development of clovers and other legumes.

This is well illustrated in the pictures on page 23, which have reference to the experiments by Prof. Hellstroem of Sweden.

To sum up: It is necessary to supply liberal amounts of potash and phosphoric acid to the soil in order that the costly nitrogen present, or applied in the form of fertilizers, or in the form of green manuring, may exert its full effect upon the growing plants and thus produce a maximum crop.

PLANT FOOD MUST BE AVAILABLE TO BE USEFUL.

All farmers should know, by this time, that what is commonly called "plant food," comprises three ingredients: Potash, phosphoric acid and nitrogen. Large quantities of these plant food elements are usually present in agricultural soils, most of which, however, is in an insoluble (unavailable) condition, and, therefore, useless to growing plants. Thus soils may contain, as shown by chemical analysis, large supplies of plant food and still fail for the lack of it. Prof. Wagner shows this by an experiment, illustrated in Fig. 9.

The four pots to the left contain clay soil, the four pots to the right sandy soil. The crop planted was peas. The first two pots in each soil received no potash fertilizer,

while the second two pots of each soil were given the regular potash application. While the clayey soil without potash fertilizer produced a heavier growth than the sandy soil under the same conditions, the application of potash in both cases showed a material gain from its use, notwithstanding the fact that, in all the pots, the soil contained enormous quantities of potash naturally. Of the two soils

FIG. 9. THE POTASH IN SOILS IS OF NO VALUE, UNLESS AVAILABLE used, the amount of potash in the top twelve inches of one acre, was as follows:

Clayey soil.....8249 lbs.

Sandy soil.....2110 "

The amount of potash applied to the soil was about 100 pounds per acre, whereas the crop removed only about 70 pounds. This small fertilizer application of *available* potash made all the difference between success and failure

on these two soils, although the sandy soil contained enough potash for 30 successive crops, and the clayey soil for 117 and more.

The principle, that potash, phosphoric acid and nitrogen, to be useful to plants, must be in an available form, refers with equal force to plant food contained in artificial fertilizers, their agricultural value is dependent on and measured solely by the *available* potash, *available* phosphoric acid and *available* nitrogen, which they contain. Thus crude phosphate rock, while very rich in phosphoric acid, is nearly valueless as plant food, and the phosphoric acid it contains must be made soluble (*available*) by treatment with sulphuric acid (acidulated) and converted into "acid phosphate," so that it may become useful. The same refers to crude bones, which contain their phosphoric acid, for the most part, in an unavailable condition, and must be converted into acidulated or "dissolved bone" to become fully effective. The potash in potash salts from the Stassfurt mines is all soluble in water, and, therefore, readily available to the crop. The potash contained in feldspar and other natural products is insoluble and practically useless, while that contained in organic matter is slowly available. Nitrogen is also irregular in availability; in the form of nitrate of soda and sulphate of ammonia, it is readily soluble and available; in dried blood, fish scrap and tankage, it is more slowly available; while in leather and wool wastes, the nitrogen is so slowly available, that they are well nigh worthless as plant food.

SOIL IMPROVEMENT.

The experiments by Prof. Wagner show, first, that plants of a certain class have the power of absorbing nitrogen from the air, and converting it into such a form that it serves as plant food. They show, further, how this nitrogen may be afterwards employed to the best advantage in practical planting or farming. The reader, however, should thoroughly understand that, though these legumes have the power of absorbing nitrogen from the atmosphere, still they in turn must be fed with potash and phosphoric acid to promote full growth. While it is not known exactly how much potash and phosphoric acid is necessary to enable a legume to gather or produce or "make" one pound of fertilizer nitrogen, it may be estimated, by taking the composition of a number of staple legume crops. The following table shows the pounds of plant food contained in an average acre of several legume crops:

	POTASH.	PHOSPHORIC ACID.	NITROGEN.
Red Clover	184 lbs.	52 lbs.	212 lbs.
Crimson Clover.....	196 "	42 "	172 "
Alfalfa.....	224 "	52 "	288 "
Cow Peas.....	124 "	40 "	108 "
Common Vetch.	280 "	60 "	236 "
Total.....	1008 lbs.	246 lbs.	1016 lbs.
Average.....	202 lbs.	49 lbs.	203 lbs.

For 203 pounds of nitrogen, as an average, are required 202 pounds of potash and 49 pounds of phosphoric acid. That means for every pound of nitrogen "made" by the use of legumes, the crop must have used *one pound of potash* and about *one-quarter of a pound of phosphoric acid*.

Much has been said about clovers "leaving the soil better than they find it," and it is the common belief that they improve the soil. This is true in one sense, but not in another. To illustrate, a clover crop, cut for hay, removed from the soil per acre about 184 pounds of potash, 152 pounds of phosphoric acid and 212 pounds of nitrogen. Of this most of the nitrogen may come from the air, but the potash and phosphoric acid come from the soil, and when the crop is removed, the soil is poorer by just that much potash and phosphoric acid. The rowen, or after-crop, contains nitrogen which may be turned into the soil; also, the roots and stubble count for something. At the same time, all must keep in mind, that the gain is in *nitrogen only*, and there is not even this gain if potash and phosphoric acid are lacking. Clover failure is very common, indeed, but a farmer rarely stops to think that exhaustion of the soil in potash and phosphoric acid may be the cause of it.

To sum up: To use legumes profitably, they must be well supplied with potash and phosphoric acid, and the crop either turned under as green-manure, or used as forage and returned to the soil as farmyard manure. In

either case, a sale crop, such as wheat, corn, oats, barley, potatoes, or other non-legume, should be grown, to be followed by a legume again, either the following season, or the second season after. In this way less nitrogen fertilizer need be bought, and this comprises practically the whole value of legumes as a fertilizer.

PART II.

HOW TO EXPERIMENT.

In Part I is given in detail the general nature of legumes or nitrogen gatherers, and the best use to be made of them. At best, however, legumes are only an aid, and on many farms and plantations legumes cannot be grown regularly in such manner as to supply most of the nitrogen fertilizer needed. There also remains to be determined on all farms the natural richness of the soil, that is, its contents in available potash, phosphoric acid and nitrogen. Chemical analysis informs us how much plant food a soil contains, but unfortunately it does not indicate what portion of this plant food is in an available or useful form. A soil, as we have shown in the preceding chapter, may contain potash enough for a hundred crops, and still fail for lack of available potash plant food.

The only reliable way to determine the crop-making value or power of a soil is by making what are called plot experiments. Small portions of land, usually one-tenth or one-twentieth of an acre each, are laid out on an even, level field. These plots are all broken, seeded and tilled precisely in the same manner, but are treated differently as to applications of plant food. Some of the plots receive no fertilizer, others one or two or all three of the plant food ingredients and in varying proportions. The crops are harvested separately from each plot, carefully weighed, and their quality noted. Thus, the results obtained from the various plots show the effectiveness of the different fertilizer combinations in producing yield and quality. Plot experiments have been made extensively for years and a great deal of valuable information has been obtained from them, but it is necessary to continue them more or less all the time, as soils change quickly when not systematically fertilized.

The agricultural experiment stations, as a rule, make fertilizer experiments, some of them extensively, but the stations have many problems in agriculture to work out, and cannot give all their attention to one line of work. In Europe there are a number of special experiment farms, confined largely to the study of plant food and soils. In this country thus far we have but one, the Experiment Farm of the North Carolina State Horticultural Society, at Southern Pines, North Carolina, of which a more detailed account will be given later in this book.

The careful work that is done at experiment stations and experiment farms is useful mainly for the study and definition of scientific principles, and is thus of great value and importance, the practical application, however, in individual cases should depend on home experiments. Not only do the various agricultural crops differ widely in their requirements of plant food elements, especially when grown under different conditions, but also the various soils of the farm show different needs, and the same kind of soil may vary under different treatment, even from one season to another. Hence every progressive farmer, who wishes to economize his resources and to use fertilizers to his best advantage and with the largest profit, must continuously study the condition of his soils and crops, and must himself become an experimenter. Decisive results are rarely obtained in one season, and frequently the experiments are spoiled by unfavorable weather, insects, plant diseases and other causes, therefore, the experimenter is advised to continue his trials with fertilizers from year to year. Every farmer will be fully repaid for his time and trouble, after he definitely learns what his soils and crops require, and the knowledge gained will be worth many dollars to him in buying and using fertilizers.

The following simple plan for experimenting can be carried out by any farmer without difficulty, and enables him to find out if an increased yield can be produced by the use of fertilizers.

One acre of land can be divided into three plots of

one-third of an acre each (a convenient size would be $155\frac{1}{2}$ ft. x $93\frac{1}{3}$ ft.), and fertilizer applied as follows:

No Fertilizer.	1.
Phosphoric Acid. Nitrogen.	2.
Potash, Phosphoric Acid, Nitrogen.	3.

From this simple plan can be learned the following lessons:

Plot No. 1 shows what the land without any fertilizer will produce.

Plot No. 2 shows the effect of nitrogen and phosphoric acid, without potash.

Plot No. 3 indicates what effect an average complete fertilizer will have.

A MORE ELABORATE PLAN FOR EXPERIMENTING.

For those who wish to make a more detailed experiment, so as to study the effects of different combinations of potash, phosphoric acid and nitrogen, a more elaborate plan is given on page 34.

The plan comprises seven plots of equal size and separated by paths four feet wide. The size of the plots must depend somewhat on local conditions and the kind of crop to be grown. A very convenient size is one-tenth of an acre. A strip $93\frac{1}{3}$ feet long by $46\frac{2}{3}$ feet wide, would represent one-tenth of an acre in convenient shape. However, it may be best to arrange differently if the size is not convenient. Each plot should be numbered separately.

PLAN FOR EXPERIMENT.

Seven plots, each $\frac{1}{10}$ acre in size ($93\frac{1}{3}$ by $46\frac{2}{3}$ feet).

No Fertilizer.	1.
Potash and Phosphoric Acid.	2.
Potash and Nitrogen.	3.
Phosphoric Acid and Nitrogen.	4.
Potash, Phosphoric Acid and Nitrogen.	5.
Potash, Phosphoric Acid, Nitrogen and Lime.	6.
No Fertilizer.	7.

**THE RESULTS FROM THESE EXPERIMENTAL PLOTS
WILL SHOW:**

Plot No. 1. What the land will produce without any fertilizer.

Plot No. 2. The effect of Potash and Phosphoric Acid.

Plot No. 3. The effect of Potash and Nitrogen.

Plot No. 4. The effect of Phosphoric Acid and Nitrogen.

Plot No. 5. The effect of a "complete fertilizer," that is, one containing potash, phosphoric acid and nitrogen.

Plot No. 6. The effect of lime in connection with a "complete fertilizer."

Plot No. 7. Shows what the soil will produce without any fertilizer; it is also a check on Plot No. 1, and will indicate if the land is uniform in composition.

It will be noticed, that one plot in each series received an application of lime. This will point out if the soil needs liming. Some soils, through the decay of vegetable matter in them, or other causes, have become acid or "sour," and are unsuited for the growth of many crops, unless lime is added. In cases where land is known to be sour and notoriously deficient in lime, it is best to modify the above described plan by applying lime to all of the plots with the exception of plot No. 6, which is to be left unlimed for comparison. Lime corrects the acid condition of the sour soils. The best manner of applying the lime would be to slack it first and then broadcast during fall or winter, or at any rate, early in the spring, so as to allow plenty of time for the material to leach well into the soil.

PRECAUTIONS NECESSARY IN MAKING EXPERIMENTS WITH FERTILIZERS.

In the preceding pages it was shown how to make experiments with fertilizers on a simple and also on a more elaborate scale. The proposition is to judge the effect of fertilizers from the actual increase produced by their use. This is simple, indeed, yet accurate manipulation and many precautions are necessary to make such experiments really truthful and reliable, and as a guide to the practical experimenter, the following rules are given :

1. The greatest care should be taken to select a portion of the field which is as even in fertility as possible. Lack of uniformity of soil will give misleading results, and often render the experiments of little value.

2. It is best to select level land for experimenting. If such cannot be had, make the experimental plots run up and down the slope, so that the washings by rain will not carry the fertilizers from one plot to another.

3. Land that has been freshly cleared, that has been fertilized in preceding years, or that has been in sod, is not well adapted for experiments, because such locations are often uneven in fertility, and, therefore, would not give reliable results.

4. The experimental field can be measured by a chain or pole, marked with feet and inches. Each plot should be indicated by stakes or stones at the boundaries, so that the divisions will be well defined. It is best to

have a stake at each corner of the different plots, which should be marked with the number of the plot.

5. It is best to have the experimental plots long and narrow, because thus they will average up for unevenness of soil.

6. It is best to separate plots by paths, in order to prevent roots of plants of one plot from feeding on the fertilizer supplied to the adjoining plots.

7. Avoid windy days in spreading the fertilizers, so that they may not be blown and scattered unevenly over the plots.

8. All the plots must be treated alike in every respect, except as to the amount and kind of fertilizer applied. The same kind and quality of seed must be used over the whole area. The planting or sowing on all the plots must be done the same day. (If a part be planted before and a part after a rain, the experiment may become valueless.) Use every precaution necessary to secure a full stand of plants, and if a uniform stand has not been secured at the first planting, plow up the whole field and plant over again. Arrange the same number of rows on each plot, and the same number of hills and plants (as nearly as possible) in each row. The plots should be plowed and cultivated alike, and whatever operation is needed in the experimental field, should be carried out uniformly all over the plots.

9. The harvesting of the crop and weighing of yields must be accurate. Experiments are usually made on plots of one-tenth or one-twentieth of an acre, and a mistake will

show ten or twenty fold when calculating the yields per acre.

10. All this experimental work, requiring as it does, care and intelligence, should be performed by intelligent men and not left to ignorant workmen.

TIME OF APPLYING FERTILIZERS.

Fertilizers are either broadcasted evenly all over the field or drilled in ; and which of these methods is preferable depends on conditions. As a general rule, where fertilizers are used in small quantities only, they are often more effective when applied with a drill, because they come closer to the rows of planted crops. It must be remembered, however, that fertilizers may produce injury when coming in direct contact with the seed or the young roots of plants, and this danger, of course, is greater when fertilizers are applied with the drill and at planting time, than when applied broadcast and previous to planting. To reduce the danger from injury when fertilizers are drilled in, it is well to dilute them by mixing them with several times their bulk of mellow earth.

A useful method is to apply the mineral fertilizers, that is, potash and phosphoric acid, some time before sowing or planting, so that they may mix thoroughly with the soil. On some soils it would even be best if the potash and phosphoric acid be applied in the fall preceding the planting.

Nitrogen, however, especially when in the form of nitrate of soda, or other very soluble compounds, will always give best returns if used at planting time, or even after the planting as a topdressing. Nitrogen fertilizers generally are readily soluble, and if not taken up by the plants shortly after applying are apt to be washed away by rains and lost. At times it is advantageous to apply nitrogen fertilizers in two or three doses during the growing season, at intervals of several weeks.

PART III.

EXPERIMENT FARM AT SOUTHERN PINES, N.C.

This farm was established through the enterprise of the State Horticultural Society of North Carolina, near the town of Southern Pines in that State, for the express purpose of making the most thorough experiments with different fertilizers on different crops. The plans and operations are so outlined, that the plant food requirements of a great variety of crops can be studied in such a manner as to make the results useful, not alone to the special section in which these experiments are located, but to every farmer, vegetable and fruit grower in the United States. It was essential in this connection to select a locality in a climate suited to a variety of crops, and a soil of uniform

and low natural fertility, so that it may represent an average condition of generally worn-out soils. No place could have been better suited for the purpose sought than that selected for these experiments.

The farm is situated in what is known as the long-leaf pine belt, covering an enormous area of this country and reaching through the Atlantic States from Virginia to Texas. Thus it is located in a section which is typical for a considerable portion of this country and represented in nearly every southern state. Moreover, the soil, being of a thin, sandy, uniform texture, is very favorable for these experiments. It was virgin at the time that the farm was established, and therefore, uninfluenced by the effect of previous manuring and other operations tending to make the soil less uniform. The town of Southern Pines, near which the farm is located, is easily accessible, and many farmers avail themselves of the opportunity to visit the Experiment Farm and to study the operations there as an object lesson.

The Experiment Farm is divided into two departments, one of them especially intended for the study of annual farm crops and the other for perennial fruit crops. It comprises in all about 80 acres. The principle employed is that of plot experimenting, as described in a previous chapter. Thus the farm comprises certain series, each series representing a particular crop to be experimented upon, and each of these series is subdivided into a certain number of plots treated with different elements of plant

food in various combinations. Thus one plot receives no fertilizer at all; another plot is fertilized with only potash and nitrogen; a third plot has potash and phosphoric acid, while a fourth has all three elements of plant food, namely, potash, phosphoric acid and nitrogen. Further variations are made by increasing and decreasing the amounts of potash or the other two ingredients. On some plots lime is added, while green-manuring is given to other plots in order to study its effects. These experimental plots usually are $1/20$ or $1/10$ of an acre in size and are separated by paths and roadways. Each series is cultivated, harrowed and treated in the same manner, except as to the amounts of fertilizer used.

The progress of these experiments is being carefully noted during the growing season under the guidance of trained observers, and a careful record is kept of all observations made, to ascertain not only the rate of growth, but also the general vigor and health of the plants upon the different plots, also the effects of wet weather, drouth, disease, attacks of insects, etc. At the end of each season the product from each plot is compared in quality with the yield from other plots, while the quantity grown in each plot is accurately measured.

The experiments with each particular crop are continued through a series of many years, so as to obtain an average and a true knowledge of the various conditions and effects, from which the irregularities of certain seasons have become eliminated. It is only after a number of suc-

cessive years that correct and authoritative conclusions can finally be reached.

Through the courtesy of the North Carolina State Horticultural Society and the managers of the Experiment Farm, some illustrations have been obtained, showing the progress of the work, which are reproduced here.

REMOVING STUMPS.

The appearance of the experimental field after the clearing of the land and the manner of clearing are shown in the above illustration. It should be noted that the clearing and breaking of the land was done with special regard to the experiments to be carried on there; all stumps were dug out and not burned, because the burning would pro-

duce ashes, which would furnish fertilizing material for some spots, while others would be left without it.

The following illustration shows the field after the land has been prepared, and is ready for the planting of crops.

READY FOR PLANTING.

The fertilizers are compounded with more than ordinary care and accuracy. They are applied uniformly over the area of each plot under the supervision of competent men. The amounts of different fertilizing ingredients are carefully weighed and applied separately to each plot, and in some cases to each plant. The work of applying the fertilizers is shown in the illustration on the next page.

APPLYING FERTILIZERS.

Three series of combinations of the principal plant foods are now under way at this Experiment Farm. One series is devoted to the study of the effect of potash; the second to the effect of nitrogen; the third to the effect of phosphoric acid. In each series the quantities range from a small amount of fertilizer to what may be considered an excess. In the four illustrations on the pages following the effect of fertilizers on sweet potatoes in some of the experimental plots is illustrated. In the first illustration is shown the actual yield obtained from one plot which received no fertilizer (the plots in this series contain $\frac{1}{20}$ of an acre each). The yield calculated to an acre was 30

SWEET POTATOES,—UNFERTILIZED. EXPERIMENT FARM, SOUTHERN PINES, N. C.

SWEET POTATOS, FERTILIZED PER ACRE WITH 400 LBS. ACID PHOSPHATE AND 250 LBS. NITRATE OF SODA.
EXPERIMENT FARM, SOUTHERN PINES, N. C.

SWEET POTATOES, FERTILIZED PER ACRE WITH 160 LBS. MURIATE OF POTASH, 400 LBS. ACID PHOSPHATE AND 250 LBS. NITRATE OF SODA. EXPERIMENT FARM, SOUTHERN PINES, N. C.

SWEET POTATOES, FERTILIZED PER ACRE WITH 480 LBS. MURIATE OF POTASH, 1200 LBS. ACID PHOSPHATE
AND 750 LBS. NITRATE OF SODA. EXPERIMENT FARM, SOUTHERN PINES, N. C.

bushels. The next illustration shows results from a plot to which phosphoric acid and nitrogen were applied.

The yield amounted to 43 bushels per acre. As will be seen from the picture, the amount of first-class potatoes is considerably larger than obtained from the unmanured plot. The next illustration shows the actual yield obtained from a plot treated as the preceding one, but with the addition of potash.

The yield from this plot was 176 bushels per acre.

It must be noted that the plots represented in the two preceding illustrations were treated with what may be considered a moderate application of potash, phosphoric acid and nitrogen. On other plots this application of the three plant foods was doubled and trebled, and the illustration represented on page 48 shows the actual yield obtained on the plot which received the highest application of a complete fertilizer. The yield was 628 bushels per acre

As it may be of interest, it is stated here that the actual fertilizer per acre used on this plot consisted of

480 lbs. Muriate of Potash,
1200 lbs. Acid Phosphate,
750 lbs. Nitrate of Soda.
<hr/> Total, 2430 lbs.

This quantity of fertilizer used per acre is much more than ordinarily would be applied upon the farm ; it is what is considered excessive, nevertheless, in this particular instance the excessive application was both useful and remunerative. An adjoining plot, to which only $\frac{3}{4}$ of this amount (1620 lbs. in all) was applied, produced 506 bushels

per acre, that is 122 bushels less. On the plot receiving more than 2400 lbs. of fertilizer per acre the actual cost per bushel of potatoes to the grower, including seeding, cultivation and fertilizers used, was only 8 cents per bushel. Making the same calculation on the yield obtained on the unfertilized plot, the cost per bushel of potatoes was 50 cents.

These results were obtained in a season which was favorable to the growth of sweet potatoes. In ordinary seasons excessive applications of fertilizers often do not produce such paying results, and medium amounts are most profitable; nevertheless, the example shows what can be done in a favorable season, and this also is a valuable lesson to the grower.

This brief outline of the operations at the Experimental Farm at Southern Pines will give the practical farmer some idea of the value and importance of the tests being made to study the question of how to fertilize different crops in the best and most economical manner.

The results thus far obtained have thrown much light on the problems of plant feeding, and the conclusions drawn promise to be of great value and usefulness to every farmer, fruit and vegetable grower in the United States. The farm management issues publications for the benefit of agriculture, which may be obtained free by the applicant, and there will thus be spread, as widely as possible, practical information of great value to the farmers of the North and South, East and West.

PART IV.

RESULTS OF OFFICIAL FERTILIZER EXPERIMENTS.

Our experiment stations are now at work finding out what forms and quantities of fertilizers will best supply the soils and crops at the lowest cost. Although each station works upon the soils and crops of its own region, the results of such work are often of great value to the farmers of other states. Thus, the results with fertilizers for cotton and remedies for cotton blight are useful to the planters of all cotton growing states. The results obtained at the West Virginia and Connecticut stations with fertilizers upon potatoes may apply also in New York and Ohio. What is found as the result of a certain kind of fertilizer upon corn at the Kentucky and Tennessee stations may be useful to farmers in Virginia and Illinois.

The results of experiments with fertilizers are published in many of the experiment station "bulletins." It is important that the practical information gained in the experimental fields of the stations should be known to the farmers, not only of the states in which the tests were made, but to the farmers of other states. For this purpose we have selected from experiment station bulletins some results obtained with fertilizers upon the most common and staple crops. The facts and illustrations here given are all taken from the official bulletins and records.

COTTON.

The following illustration is reproduced from the picture in the Alabama Experiment Station Bulletin No. 36:

Here we see rows of fine, healthy cotton plants,

WITHOUT KAINIT.

WITH KAINIT.

growing side by side with rows of cotton, thin and unhealthy looking.

A few years ago Prof. Atkinson, who was biologist at the Station, began a series of experiments with fertilizers for cotton.

Twenty experimental plots were arranged. The plots were treated differently; some of them received no manure while most of the plots had applications of the various fertilizer ingredients, such as acid phosphate, cottonseed meal and kainit. The most striking results were obtained from the use of kainit. Prof. Atkinson says: "The yield on the kainit plots is increased from 70 to 100 per cent. above that where no fertilizer was used, and an average of 40 per cent. increase over that of any other single fertilizer or combination, without the kainit, used."

COTTON BLIGHT.

(Rust.)

The next illustration is taken from the same bulletin.

This shows the difference between a strong, vigorous cotton plant and one that is suffering from blight or red rust. No cotton planter needs to be told of the great loss occasioned by this mysterious and much-dreaded disease. It is more destructive in some places than in others, but the damage done all through the South amounts to thousands of dollars every season.

Cotton blight can be largely, if not entirely, prevented by the use of kainit. Prof. Atkinson states as the results of his experiments, that "in all of these plots it was easy to see by comparison with the others that the entire or partial prevention of the disease was due to the kainit * * *

NO FERTILIZER.

POTASH AND NITROGEN.

There can be no doubt as to the effect of kainit, as my former experience is the same as that of this year, but I think to thoroughly prevent the disease would require not less than 500 or 600 pounds of kainit per acre."

POTATOES.

The following illustration is taken from the West Virginia Experiment Station Bulletin No. 20 :

Here we see two hills of potatoes, the difference in development of the plants, and also in the product of the yield of tubers. A number of experimental plots were laid out. Three rows, each one rod long and three and three-

WITHOUT POTASH.

WITH POTASH.

tenths feet apart, were planted with potatoes of the White Star variety. Plot No. 5 received no fertilizer of any kind. Plot No. 3 had an application of kainit and acid phosphate.

Now for the results. The potatoes produced by the three rows of Plot No. 5 weighed 21 pounds, and the plants and the potatoes are represented on the left side of

the picture. The potatoes produced by the three rows of Plot No. 3 weighed 55.8 pounds, and the plants and the potatoes are shown on the right-hand side. The increased yield due to the use of kainit and acid phosphate was reckoned to be at the rate of $161\frac{1}{3}$ bushels per acre.

Referring to Bulletin No. 61 of the Kentucky Experiment Station, dated March 1896, we find some very interesting experiments conducted upon potatoes, which the following illustration sets forth :

NO FERTILIZER.

PHOSPHORIC ACID AND NITROGEN

POTASH.

POTASH, PHOSPHORIC ACID AND NITROGEN

The season was an unfavorable one for potatoes, but all the results obtained plainly reveal the importance of potash for this crop. The two plots on the left side of the illustration, Plots Nos. 5 and 6, received no potash, Plot No. 5 being unfertilized and Plot No. 6 receiving nitrogen and phosphoric acid without potash. The two plots appearing on the right side of the picture were fertilized with potash, Plot No. 4 receiving muriate of

potash alone and Plot No. 9 receiving the same application as Plot No. 6, but with potash added. The results are very striking. The average yield from the unfertilized plots was 42.9 bushels. Potash alone produced 87 bushels, which is an increase of more than 100 per cent. Plot No. 9 produced nearly 127 bushels against 59 bushels from Plot No. 6, where phosphoric acid and nitrogen were used without potash, being an increase of 115 per cent. produced by the use of muriate of potash.

One more result may be given, showing the favorable influence on potatoes, of a fertilizer containing potash. Recent experiments (by Mr. T. J. Stroud) at Shaker Station, Connecticut, confirm the conclusions reached independently at the West Virginia and Kentucky Experiment Stations. For the purpose of comparison, the yield of potatoes from plots numbered 1, 2 and 4, all of the same size, are shown on the preceding page.

No. 1 shows the yield of potatoes from a plot which received no fertilizer. The product was at the rate of 73 bushels per acre. About one-half of the potatoes, as you will see, are small in size.

No. 2 shows the yield of potatoes from a plot which was fertilized with acid phosphate and nitrate of soda. Here, the yield was at the rate of 140 bushels per acre. About one-fourth of the potatoes from this plot were undersized.

No. 4 shows the yield of potatoes from a plot which received the same fertilizer as No. 2, but with 240 pounds

EXPERIMENT WITH POTATOES. SHAKER STATION, CONN.

per acre of muriate of potash added. The only difference in treatment between this plot and the preceding one was the addition of muriate of potash. What was the result? Here, the yield was at the rate of 230 bushels per acre. Notwithstanding this large yield, only about one-fifth of the potatoes were small in size.

This remarkable increase leads to the conclusion that potash is the element which exerts the most marked effect upon the yield of potatoes.

CORN.

The experiments illustrated on the following page are described in Bulletin No. 45, published in 1893, of the Kentucky Experiment Station.

Here the results of the use of different fertilizers upon corn and fodder are plainly illustrated. Plot No. 10 in the above received an application of nitrogen only, but shows no increase over the unfertilized plot. Plot No. 5, which received nitrogen and phosphoric acid, shows but a slight increase over the nitrogen plot. On plot No. 6, where potash was added to the nitrogen, the yield was increased from 27 bushels to 61.7 bushels per acre, or 129 per cent. On plot No. 3, which received potash, phosphoric acid and nitrogen, the yield was almost identical with Plot No. 6; this shows plainly that potash is the regulating ingredient in a fertilizer for corn upon soil such as that where the experiments were made, and

wherever it is applied, there is a considerable increase in the yield.

The illustrations on page 62 show the results of a series of experiments with corn, conducted by Prof. W. P. Brooks of the Massachusetts Experiment Station. For the purpose of comparison the yields of two plots of exactly the same size are given side by side.

The first illustration shows the yield of corn from two plots, each $\frac{1}{20}$ of an acre :

The one marked "no fertilizer" produced 117 pounds of stover and 123 pounds of ear corn. The other plots received acid phosphate and muriate of potash and yielded 101 pounds of stover and 198 pounds of ear corn, that is, an increase of 61 per cent. over the plot not fertilized.

The lower illustration is interesting, as giving a comparison between the effects of chemical fertilizers and barnyard manure on corn.

The plot receiving barnyard manure produced 188 pounds of stover and 219 pounds of ear corn. The plot, which received chemical fertilizers (consisting of nitrate of soda, acid phosphate and muriate of potash) produced 204 pounds of ear corn, or about the same results as with the stable manure.

The illustration on page 63 is even more valuable as showing the marked effects of the potash on corn.

Here we have two plots of same size, one unfertilized and another fertilized with muriate of potash. Note the wonderful difference in the yield of corn. The yield from

ACID PHOSPHATE AND MURIATE OF POTASH.

NO FERTILIZER.

BARNYARD MANURE.

COMPLETE FERTILIZER.

EXPERIMENTS WITH CORN.

MASSACHUSETTS EXPERIMENT STATION.

the unfertilized plot amounted to 89 pounds of stover and 52 pounds of ear corn, while from the plot receiving muriate of potash were gathered 180 pounds of stover and 167 pounds of ear corn. Here the increase of stover is 100 per cent. and that of ear corn 300 per cent., due to the use of potash.

MURIATE OF POTASH.

NO FERTILIZER.

Thus, the experiments with corn at the Massachusetts Experiment Station show, as they did at the Kentucky Station, that the yield of stover and ear corn follows the amount of potash in the fertilizer.

HEMP.

The following illustration is reproduced from the Kentucky Station Bulletin No. 18:

This shows the results of the use of fertilizer on the quantity of hemp produced. The quality of hemp, which is a very important item, was likewise improved by applications containing potash. The yield on the plot receiving no potash is, as you will see, very small in comparison with the size of the yield of hemp on the plot which had an application of potash, phosphoric acid and nitrogen.

HEMP EXPERIMENTS AT KENTUCKY EXPERIMENT STATION.

The experiments were made on blue grass land, much worn, and considered by most farmers unfit for hemp. Further results are given in Bulletin No. 27 of the same station. The results show that a fertilizer containing about 6 per cent. phosphoric acid, 4 per cent. nitrogen and 10 per cent. potash will produce good results on hemp.

PART V.

USEFUL TABLES.

Farmers and planters must do a little thinking on their own account, to apply any useful information to their own surroundings. At best, scientific experimenters can only give general directions — all farms cannot be studied in detail, and there are no two farms exactly alike. We have given in this book such information that a thoughtful farmer should be able to figure out his local needs. As a general aid, the following tables are given, taken from reliable sources.

COMPOSITION OF POTASH SALTS.

NAME OF SALTS	GUARANTEED PER CENT OF ACTUAL POTASH
A. Salts containing Chlorides:	
Muriate of Potash.....	50
Manure Salt.....	20
Kainit (crude potash salt).....	12
B. Salts free of chlorides:	
Sulphate of Potash.....	48
Sulphate of Potash-Magnesia...	25

COMPOSITION OF FERTILIZER MATERIALS USED AS SOURCES OF PHOSPHORIC ACID.

	Nitrogen %	Equivalent in Ammonia. %	Potash, (K ₂ O) %	Available Phosphoric Acid. %
So. Carolina Acid Phosphate.....	.....	.....	.....	13 to 14½
Florida Acid Phosphate.....	.....	.....	.....	13 to 16
Tennessee Acid Phosphate.....	.....	.....	.....	14 to 18
Bone Black, dissolved.....	.....	.....	.....	16 to 19
Basic Slag.....	.....	.....	.....	14 to 15
Bone Meal.....	2½ to 4½	3 to 5½	.....	6 to 9
Bone, dissolved.....	2 to 3	2½ to 3½	.....	13 to 15
Peruvian Guano.....	6 to 10	7¼ to 12	1½ to 4	7 to 8

COMPOSITION OF FERTILIZER MATERIALS USED AS SOURCES OF NITROGEN.

	Nitrogen. %	Equivalent in Ammonia. %	Potash (K ₂ O.) %	Phosphoric Acid (P ₂ O ₅) %
Nitrate of Soda.....	15½ to 16¾	19 to 19¼	—	—
Sulphate of Ammonia.....	19¾ to 20¾	24 to 25¼	—	—
Cyanamid	15 to 17	18 to 20	—	—
Dried Blood (high grade)	13 to 14¾	16 to 18	—	2 to 3
Dried Blood (low grade).....	10¼ to 11	12½ to 15	—	1½ to 2
Concentrated Tankage.....	12¼ to 13	15 to 16	—	1 to 2
Tankage	7½ to 9	9 to 11	—	7 to 9
Bone Tankage.....	5 to 6	6 to 7½	—	9½ to 15
Dried Fish Scrap.....	9 to 10	11 to 12	—	5½ to 7
Cotton Seed Meal.....	6½ to 7½	7½ to 9	1½ to 2	2 to 3
Castor Pomace	5 to 6	6 to 7	1 to 1½	1½ to 2
Tobacco Stems.....	2½ to 3	3 to 3½	2 to 10	½ to 1

AVERAGE COMPOSITION OF THE MOST IMPORTANT FARM MANURES.

(Table prepared from figures published by the United States Department of Agriculture.)

	Nitrogen	Equivalent in Ammonia.	Potash (K ₂ O)	Phosphoric Acid (P ₂ O ₅)
Cow-Manure (fresh)	0.29%	0.35%	0.10%	0.17%
Horse-Manure (fresh)	0.44%	0.53%	0.35%	0.17%
Sheep-Manure (fresh)	0.55%	0.67%	0.15%	0.31%
Hog-Manure (fresh)	0.60%	0.73%	0.13%	0.41%
Hen-Dung (fresh)	1.10%	1.34%	0.56%	0.85%
Mixed Stable-Manure	0.49%	0.59%	0.43%	0.32%

TABLE GIVING THE AMOUNTS OF FERTILIZER INGREDIENTS (Potash, Phosphoric Acid and Nitrogen) CONTAINED IN THE CROP FROM ONE ACRE.

CROP.	YIELD.	STRAW, ETC.	POTASH.	PHOSPHORIC ACID.	NITROGEN.
Apples	15 tons	.....	60 lbs.	30 lbs.	39 lbs.
Barley	30 bu.	2,000 lbs.	51 "	17 "	57 "
Beans	30 "	2,700 "	53 "	30 "	75 "
Buckwheat	34 "	2,800 "	40 "	14 "	56 "
Cabbage	30 tons	.....	270 "	70 "	200 "
Clover, green*	.....	15 tons	140 "	40 "	130 "
Clover, dry .....	.....	2 "	88 "	18 "	82 "
Corn	70 bu.	6,000 lbs.	55 "	48 "	83 "
Grapes	2 tons	7,000 "	39 "	11 "	32 "
Hops	600 lbs.	2,700 "	53 "	23 "	84 "
Mixed Hay	...	5,000 "	77 "	18 "	70 "
Oats	60 bu.	3,200 "	62 "	22 "	55 "
Onions	45,000 lbs.	.....	72 "	37 "	72 "
Pears	16 tons	.....	26 "	19 "	32 "
Peas	30 bu.	3,000 lbs.	52 "	33 "	108 "
Plums	8 tons	.....	40 "	4 "	30 "
Potatoes	200 bu.	1,500 lbs.	74 "	21 "	46 "
Rye	30 "	4,250 "	45 "	26 "	51 "
Sugar Beets	15 tons	6,000 "	143 "	32 "	69 "
Timothy Hay .....	.....	4,000 "	94 "	23 "	89 "
Tobacco	1,600 lbs.	1,400 "	20 "	16 "	76 "
Tomatoes	10 tons	.....	54 "	20 "	32 "
Turnips	70 bu.	5 tons	180 "	52 "	80 "
Wheat	35 "	3,000 lbs.	31 "	24 "	59 "

* Crimson Clover.

USUAL DISTANCES FOR PLANTING VEGETABLES—(Bailey).

Asparagus, rows 3 to 4 feet apart, 1 to 2 feet apart in rows.

Beans, bush, 2 to 3 feet apart, 1 foot apart in rows.

Beans, pole, 3 to 4 feet each way.

Beets, early, in drills 12 to 18 inches apart.

Beets, late, in drills 2 to 3 feet apart.

Cabbage, early, 16x28 inches to 18x30 inches.

Cabbage, late, 2x3 feet to $2\frac{1}{2}$ x3 $\frac{1}{2}$ feet.

Carrots, in drills 1 to 2 feet apart.

Cauliflower, 2x2 feet to 2x3 feet.

Celery, rows 3 to 4 feet apart, 6 to 9 inches in row.

Corn, sweet, rows 3 to 3 $\frac{1}{2}$ feet apart, 9 inches to 2 feet in rows.

Cucumber, 4 to 5 feet each way.

Egg-plant, 3x3 feet.

Lettuce, 1x1 $\frac{1}{2}$ feet or 2 feet.

Melon, Musk, 5 to 6 feet each way.

Melon, Water, 7 to 8 feet each way.

Onions, in drills from 14 to 20 inches apart.

Parsnip, in drills 18 inches to 3 feet apart.

Peas, in drills early kinds, usually in double rows from 6 to 9 inches apart; late, in single rows 2 to 3 feet apart.

Pepper, 15 to 18 inches x 2 to 2 $\frac{1}{2}$ feet.

Potatoes, 10 to 18 inches x 2 $\frac{1}{2}$ to 3 feet.

Pumpkin, 8 to 10 feet each way.

Radish, in drills 10 to 18 inches apart.

Rhubarb, 2 to 4 feet x 4 feet.

Salsify, in drills 1 $\frac{1}{2}$ to 2 feet apart.

Spinach, in drills 12 to 18 inches apart.

Squash, 3 to 4 feet x 4 feet.

Sweet Potatoes, 2 feet x 3 to 4 feet.

Tomato, 4 feet x 4 to 5 feet.

Turnip, in drills 1 $\frac{1}{2}$ to 2 $\frac{1}{2}$ feet apart.

DISTANCES FOR PLANTING TREES.

(In planting trees the greater distance should be given on
the richer soils.)

Apples	20 to 30 feet each way.
Pears (Standard)	20 " 25 " " "
Pears (Dwarf)	12 " 15 " " "
Quinces	15 " " "
Peaches	18 " 24 " " "
Plums	15 " 20 " " "
Cherries	15 " 20 " " "
Figs	12 " 15 " " "
Japan Persimmons	15 " 20 " " "
Mulberries	20 " 25 " " "
Oranges (Sweet)	20 " 25 " " "
Oranges (Japanese)	12 " 15 " " "
Blackberries	6 by 4
Raspberries	6 " 3
Currants	5 " 3
Gooseberries	5 " 3
Strawberries (Hills)	36x18 inches.
Strawberries (Matted rows)	48x12 "
Grapes	8x8 to 10x12 feet.

NUMBER OF PLANTS PER ACRE AT VARIOUS DISTANCES.

DISTANCE, INCHES.	PLANTS.	DISTANCE, INCHES.	PLANTS.	DISTANCE, FEET.	PLANTS.	DISTANCE, FEET.	PLANTS.
1 X 1	6,272,640	10 X 48	13068	4 X 5	2178	9 X 10	484
1 X 3	2,090,880	15 X 15	27878	4 X 6	1815	9 X 11	440
1 X 4	1,568,160	15 X 30	13939	4 X 7	1556	9 X 12	403
1 X 5	1,254,528	15 X 36	11616	5 X 5	1742	10 X 10	435
2 X 2	1,568,160	18 X 36	9680	5 X 6	1452	10 X 12	363
2 X 3	1,045,440	18 X 48	7260	5 X 7	1244	10 X 15	290
2 X 4	784,080	FEET.		5 X 8	1089	10 X 18	242
2 X 5	627,264			5 X 9	968	10 X 20	217
3 X 3	696,960			6 X 6	1210	12 X 12	302
3 X 4	522,720	1 X 1	43560	6 X 7	1037	12 X 15	242
3 X 5	418,176	1 X 2	21780	6 X 8	907	12 X 20	181
4 X 4	392,040	1 X 3	14520	6 X 9	806	15 X 15	193
4 X 5	313,632	1 X 4	10890	6 X 10	726	15 X 18	161
5 X 5	250,905	1 X 5	8712	7 X 7	888	15 X 20	145
6 X 6	174,240	2 X 2	10890	7 X 8	777	18 X 18	134
7 X 7	128,013	2 X 3	7260	7 X 9	691	18 X 20	121
8 X 8	98,010	2 X 4	5445	7 X 10	622	18 X 24	100
9 X 9	77,440	2 X 5	4356	8 X 8	680	20 X 20	108
10 X 10	62,726	3 X 3	4840	8 X 9	605	20 X 24	90
10 X 20	31,363	3 X 4	3630	8 X 10	544	20 X 30	72
10 X 24	26,136	3 X 5	2904	8 X 11	495	30 X 24	60
10 X 30	20,908	3 X 6	2420	8 X 12	453	30 X 30	48
10 X 36	16,124	3 X 7	2074	9 X 9	537	30 X 36	40
		4 X 4	2722

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