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COLLEGE OF AGRICULTURE AND MECHANIC ARTS.

AGRICULTURAL EXPERIMENT STATION,

COLUMBIA, MO.

# FEEDING THE ORCHARD

BY

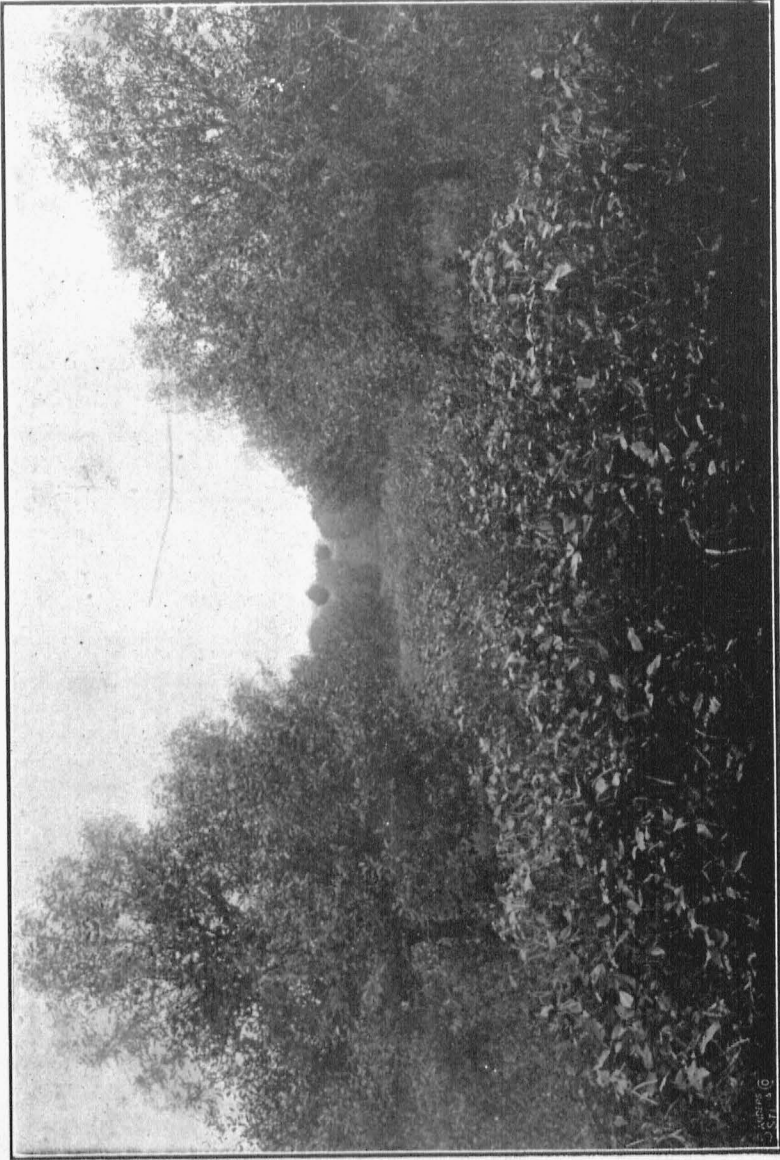
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A Well Cultivated and Well Managed Orchard. Cowpeas Furnish the Humus and Nitrogen and Keep the Surface from Washing.

## FEEDING THE ORCHARD.

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By H. J. Waters, Dean of the College of Agriculture and Director of the Experiment Station.

Information on orchard fertilization gained from accurate experimental work or based upon long conducted observations is almost entirely lacking. Moreover this phase of plant feeding presents many very intricate and difficult problems. An orchard means a large outlay of money, labor and time. If by improper or incorrect fertilization a late or soft growth be induced, the dangers of winter-killing are largely increased, the probabilities of serious attacks of fungous diseases are greater, and if this process be continued long enough, and these dangers even be eliminated, the time of coming into fruit is very much deferred and the tree is made so large as to increase materially the expense of spraying and harvesting.

In these respects mistakes in orchard management and especially in orchard feeding are particularly costly and disastrous, and have no parallel in the management and fertilization of other agricultural plants. A mistake, for example, in the fertilization of a corn crop is limited in its unfavorable results to the season in which the mistake is made, and under ordinary circumstances involves only a loss of the money paid for the fertilizer—the fertilizer at the most failing to produce any gain. It is possible, however, for a mistake in the fertilization of a pear orchard for example to result in the total destruction of that orchard by blight, or the limiting of the usefulness of the trees for many years to come.

On the other hand, there are somewhere and at some time forces at work which determine whether a bud shall result in the growth of leaf, stalk and stem or shall produce fruit. Without doubt, the kind and amount of available plant food in a soil during the previous season, together with the physical condition of the soil, taken in connection with the treatment of the land from the opening of spring until the latter part of June, exert a large influence upon the question as to whether a tree will set fruit buds for the following year or produce only growth buds. So far as we know, at some time between the starting

of growth in the early spring and the practical limit of length of growth in the latter part of June or early July, for the latitude of Central Missouri, this differentiation between fruit buds and growth buds occurs. Part of the influences affecting this differentiation are unquestionably climatic, and are, therefore, practically beyond our control. Apparently, however, the chief factors affecting this result are within our control, if we knew just what combination of conditions to make.

Theoretically, it would seem to be possible to take a soil very deficient in plant food but having a proper physical condition, and by supplying the plant food artificially, and therefore in the proper proportions, so as to hasten or retard growth as it might be found necessary, and, barring seasons when the fruit is killed by the weather, insure full fruiting every year.

The farmer in the arid region finds it more convenient and profitable in irrigating to supply all the water that the crops require so as to be able to control conditions rather than to have his plans entirely upset by an unexpected rain. For this reason, irrigation in this humid climate is fraught with many difficulties and uncertainties, just as is the feeding of fruit trees on a soil that itself supplies a goodly amount of plant food, but an amount that varies from season to season. Moreover the trees vary greatly in the amount of plant food required in different seasons. For example, in a very unfavorable season for growth on account of dry weather, if the orchard be barren of fruit, the amount of plant food taken would be very small in comparison with the amount used in full fruiting and when a good growth is made.

It should be remembered, however, that the principal amount of plant food used by the tree is for the production of fruit and leaves, the amount stored up in the tree in the form of wood being comparatively small.

#### THE EFFECT OF FERTILITY UPON THE LIFE OF THE TREE.

Two conditions affect the life of a tree, and especially the productive life. One is the physical condition of the soil upon which it grows, and the other is the amount of plant food supplied, either naturally by the soil or artificially by the orchardist.

It is a matter of common observation that fruit trees on thin soils come into bearing early, exhibit a strong tendency toward fruitfulness for a comparatively short time, and die, and that trees on good strong land come into bearing as a rule somewhat later, grow to much greater size, and live for a very much greater number of years. It is safe to say that well fed trees may have more than double the number of productive years than those which are underfed usually have. This is

strikingly shown by the results of an experiment conducted by the New Jersey Experiment Station\* with peaches, in which it was observed that on the unmanured land the crops secured at end of eight years were so small as to very materially reduce the average for the whole productive period, while in the case of the manured land the average for the entire period was not only not reduced, but very materially increased. Thus, the crops secured from the manured trees, after those receiving no manure had practically ceased to bear, were greater proportionately than those secured previous to that time. That is to say, that the properly fed trees were at their very height of productiveness at the time when the unmanured trees had practically ceased to bear.

In the case of an orchard that ceases to be productive at the expiration of a twenty-year period, almost half of this period was practically unproductive and was little else than a dead expense, namely, the first ten years and before the trees had come into bearing; whereas, if by more judicious handling and better feeding the productiveness of this orchard may be extended to thirty years, less than one-third of the total expense is for getting the tree up to the point of bearing, and two-thirds of the life of the tree is productive.

Above all is it important to have a uniform supply of available food for the orchard. Fat years alternating with lean years are very much more to be avoided than either poverty or riches as a steady diet. All radical changes in the soil condition, either with respect to the supply of plant food or the physical characteristics, should be carefully avoided. Practically all of the bad effects of overfeeding have come from the sudden change from extreme poverty to a surplus of food. It is a matter of common observation that trees in a poultry yard, when the land is manured heavily every year or lies near a dry earth closet, or adjoining a barnyard, when the supply of available plant food is excessive but regular, produce enormous crops and live to good ages.

#### THE SOIL.

So much has been said about the type of soil best suited to fruit that little need here be added. Naturally, the soil upon which the orchard is being grown will have much to do with the methods of fertilization and general cropping and cultivation. So also will the previous treatment of this land have an important bearing upon these matters.

If we could determine accurately the amount of available plant food

in a soil and the amount that would be rendered available each year, and then know the amount required by the crops grown on the land, it would be an easy matter to strike a balance and determine exactly what amounts and kinds of food it would be necessary to supply artificially to produce a normal crop. While we are able to say with a fair degree of accuracy what amounts are required by the growing and bearing trees per year, we do not yet know and cannot, unfortunately, yet determine how much of this the soil may be relied upon to supply. It is comparatively easy to determine the aggregate amount of plant food in a given soil, but to say how much of this an apple tree or a crop of corn or wheat will be able to take out or utilize this year or next year, is a totally different matter, and, unfortunately, the agricultural chemist has not yet been able even to approximate the solution of this important matter.

#### AMOUNT OF PLANT FOOD IN A SOIL.

To illustrate this point, the following tables show the total amount of the more important elements of plant food contained in an acre of three types of Missouri soils, one a good corn and wheat land, capable in favorable seasons of producing 60 to 70 bushels of corn and 30 to 35 bushels of wheat, another a red limestone clay, which has been considered a fine fruit soil, and a third a pine ridge clay that is considered to be practically unproductive.

#### PLANT FOOD PER ACRE IN THE SURFACE SOIL TO A DEPTH OF 7 INCHES.

Kind of soil.	Nitrogen lbs.	Potash lbs.	Phos. acid lbs.	Lime lbs.	Magnesia lbs.
Clay limestone, College Farm.....	4,840	60,621	2,541	21,054	13,794
Red limestone clay, Wayne county....	2,575	8,325	700	11,925	11,450
Pine ridge, Shannon county .....	2,050	5,350	325	4,325	7,900

#### SUBSOIL, TO A DEPTH OF 30 INCHES.

Kind of soil.	Nitrogen lbs.	Potash lbs.	Phos. acid lbs.	Lime lbs.	Magnesia lbs.
Corn land, College Farm, Boone Co. ..	8,150	208,785	9,317	66,066	44,467
Red soil, Patterson Basin, Wayne Co..	8,225	53,375	3,062	50,137	87,892
Pine ridge, Shannon Co .....	3,412	33,162	1,137	Trace	44,662

There is a striking difference in the quantities of these elements of plant food contained in these soils, and particularly between the so-called corn land and the pine ridge. At the same time, there is sufficient

plant food within the first seven inches of this pine ridge to produce 15 crops of apples of 500 bushels per acre, besides furnishing the material necessary to grow the trees. In other words, while there is sufficient plant food in even the poorest of these soils to make a man rich in the orchard business if he could only get it out, the difficulty is that it is so locked up and is rendered available so very slowly that the orchardist would be unable to wait for his trees to grow or bear.

Clearly the clay soil of the College Farm, judged by its content of plant food, is far superior to any of the others. We might safely conclude from this table that the soil would be the best of the three for general agricultural purposes, but experience has abundantly demonstrated that this is a poor orchard land on account of its very close texture and because it is not well aerated beyond the first few inches of the surface.

The practical orchardist would choose the red soil, because it has been found that soils of this color, generally speaking, have proven to be good orchard lands, i. e., trees on such soils make a good growth, reach an old age, and are uniformly fruitful. So far as we know, this is not due, as was formerly supposed, to the presence of this red oxide of iron, this iron simply indicating that the soil is open and porous, and furthermore that it is not a leached soil.

Sufficient red oxide of iron to make the soil highly colored, then, shows conclusively that the soil is well aerated and that the plant food is likely to be in a readily available form.

A red subsoil is of special importance to the orchardist, because it indicates that the soil has been aerated to a good depth, enabling the roots of the trees to reach a normal development at a good depth, so as to be protected against the excessive heat of summer, the variations in moisture content and the fluctuations of the seasons.

The red oxide of iron furthermore indicates that the soil has not been leached. A gray or a light brown soil may have quite as good a physical texture as the best of the red soils and yet be in general unsuited to orchard purposes, for the reason that the plant food originally contained in this soil has been leached out and lost. The red color, therefore, indicates a soil of good physical condition to a good depth, with plant food still present in reasonable quantities and in a fairly available form. These constitute the essential characteristics of a good fruit soil.

It is believed that a soil of moderate fertility, but of such structure as to insure the presence at all times of a moderate supply of available plant food, will prove to be, all things considered, the best fruit soil.

Here the trees will make a regular, uniform, healthy growth, will be fruitful and will ripen their wood properly to withstand the rigors of winter.

If this be true, then we have an important suggestion in the handling of soils that for one reason or another do not furnish precisely these conditions. In one case the soil may be naturally somewhat poor, but have the proper physical condition, wherefore we can supply the food in a slowly available form, and in this form the plant food is relatively cheap, so that we may be able to make liberal applications.

In another case the land may be rich enough but of such close texture that disintegration goes on slowly and the trees cannot root. Here the correction of the physical condition will furnish the remedy cheaper than an application of available plant food. If the land be a clay, a copious dressing of lime, say 2000 pounds per acre, will do much to remedy the defect.

If perchance the soil be too open and porous, as in the case of a sandy soil, so that the organic matter burns out readily, and the soil dries to a great depth in midsummer, to the detriment of the trees, an application of lime will correct this evil, and make the soil more compact and more drouth-resistant.

#### RED SOILS OXIDIZE ORGANIC MATTER READILY.

While red soils are known to be good fruit soils, it should be remembered that they oxidize or burn out their supply of humus or organic matter very rapidly:

Because this organic matter is exposed to the air, just as it is in the sandy soil, and is therefore quickly oxidized, therefore manure applied to a red soil or a sandy soil will show greater results in the first year or two than on a tight, close clay, but the benefits will not be nearly so lasting. The same is true of a crop of green manure. Such types of soils as these therefore become deficient in humus much quicker than what we commonly term slower and tighter clay lands.

It is, furthermore, true in the case of the red soils that in the change from a moist to a dry condition of the soil there are important chemical changes in the iron itself which greatly facilitate the burning out of the organic matter. This is due to the fact that the red oxide of iron in contact with organic matter and in the presence of moisture is reduced to a sub-oxide, giving off by this process a portion of its oxygen to burn the organic matter present in the soil. In the drying of the soil, the sub-oxide of iron is quickly raised to the higher form of the red oxide, ready to give up again in the presence of moisture its oxygen

to burn out the vegetable matter. This process of oxidizing organic matter continues as the land alternates between wet and dry conditions. It is of the utmost importance, therefore, that the owners of red land should be especially careful to maintain a liberal supply of humus under all circumstances, and to calculate upon this extra loss due to the presence of the iron.

#### FOOD REQUIREMENTS OF DIFFERENT CLASSES OF FRUIT TREES IN BEARING.

While the different kinds of fruit trees present important differences in their habits of growth and productiveness, yet in the proportions of the different elements of food required for their normal growth and fruitfulness, they exhibit a striking similarity, as is shown by some recent investigations conducted at the New York Experiment Station.\*

#### RELATIVE PROPORTIONS OF PLANT FOOD CONSTITUENTS USED BY BEARING TREES.

Variety.	Nitrogen lbs.	Phos. acid (P <sub>2</sub> O <sub>5</sub> ) lbs.	Potash (K <sub>2</sub> O) lbs.	Lime (CaO) lbs.	Magnesia (MgO) lbs.
Apple.....	1	0.27	1.07	1.10	0.45
Peach.....	1	0.25	0.97	1.53	0.47
Pear.....	1	0.24	1.10	1.30	0.37
Plum.....	1	0.29	1.29	1.40	0.52
Quince.....	1	0.33	1.25	1.44	0.42
Average of all ....	1	0.27	1.14	1.35	0.45

It will be noted that these proportions apply to the food requirements for trees in full bearing, and represent the food necessary not only for the development of the fruit, but of the leaf and twig growth. It will be observed that there is very little difference between the different kinds, all requiring plant food in quite similar amounts.

This means, of course, that as far as the chemical composition of a fertilizer is concerned, it would be quite as well adapted to one fruit as to another.

#### AMOUNTS OF PLANT FOOD REMOVED PER ACRE BY BEARING TREES.

It is impossible to supply data on this point applicable to all classes of trees and to all seasons. In other words, it would be exceedingly difficult to find a number that would apply to the average season and soil. When it is realized that of the total plant food required to nourish a tree during the season, including the wood growth, the crop of leaves,

\*Bulletin 285. Plant Food Constituents for Bearing Fruit Orchards.

and the crop of fruit when the tree is in full bearing, some 79 per cent of the dry matter formed by the tree is in the fruit pulp, in the case of the apple, about 19 per cent in the leaves, and 2 per cent in the new growth, and that in general the fruit requires about half of all the plant food used by the tree during the growing season, it is obvious that the size of the fruit crop will affect very materially the amount of plant food used.

On the other hand, during a season when a tree is bearing a heavy fruit crop, there is, as is well known, a comparatively small amount of new wood formed, and the requirements of plant food for this purpose are in such a season very small indeed. Yet in seasons of crop failure or when very little fruit is borne, there is a relatively large wood growth, except when it is too dry, so that the tree draws more heavily upon the soil for this particular purpose in such a year than when it is carrying a full load of fruit.

Moreover, in seasons of extensive wood growth, the leaf growth is also larger than when a tree is carrying fruit, and for the development of the leaf crop there is required about the same amount of plant food as for the normal fruit crop. In fact, to produce the leaves requires nearly double the amount of nitrogen that is used by the fruit, and ten times as much lime, although only about half as much potash and phosphoric acid.

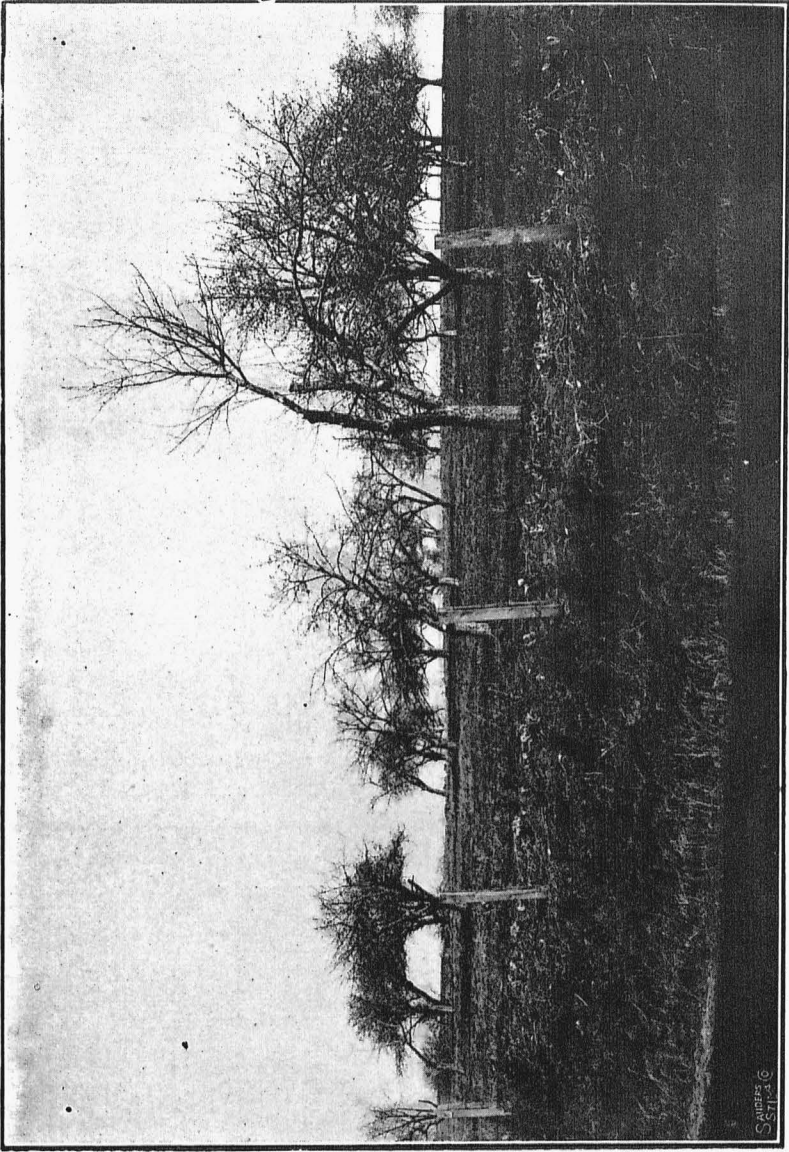
The New York Experiment Station\* has in a recent bulletin given us some very interesting and valuable data on this point that will serve as a general guide, and are fully set forth in the following table:

AMOUNTS OF PLANT FOOD USED PER ACRE.

Variety.	Number of trees per acre.	Nitrogen lbs.	Phos. acid (P <sub>2</sub> O <sub>5</sub> ) lbs.	Potash (K <sub>2</sub> O) lbs.	Lime (CaO) lbs.	Magnesia (MgO) lbs.
Apple.....	35	51.5	14.0	55.0	57.0	23.0
Peach.....	120	74.5	18.0	72.0	114.0	35.0
Pear.....	120	29.5	7.0	33.0	33.0	11.0
Plum.....	120	29.5	8.5	38.0	41.0	13.0

The plant food in the above table represents that required for the building of all the new wood growth, for what was deemed to be a normal fruit crop, and for the leaves, from representative trees in the full vigor of bearing.

"The fruit, leaves, and the new wood, as represented by the tips of the branches, were carefully gathered, weighed, dried and analyzed. Precautions were taken when necessary to avoid the loss of foliage by



An Old Orchard Showing the Effect of Sod and General Neglect.

SCOTT'S  
©

enclosing the entire tree in mosquito netting. A record was kept of the fruit that fell before the final picking. The fruit was picked at the stage of ripeness usual in common practice. The foliage was left until it showed a tendency to drop. The twigs of new wood were removed soon afterwards.”\*

It will be noted that in the above estimate only 35 apple trees are computed per acre, while it is customary in Missouri to set 70. The amounts of plant food used per acre should not, however, be doubled to make the data apply to our conditions, for the reason that these were larger trees than we grow and perhaps as fully occupied the ground as our 70 trees would under normal conditions. This being true, it is likely that as much plant food was required as would be needed for an acre of trees planted in our way, and in my judgment, the figures as given are high enough for our conditions. The number of trees grown per acre of the other sorts is essentially the same as grown by us.

It will be observed that the peach requires a larger amount of plant food per acre than any of the other classes of fruit, with the apple second, and then a large decline occurs to the pear and the plum, which did not differ materially.

It is of further interest to note that the amounts of nitrogen and potash used by a given kind of fruit tree are essentially the same, i. e., the tree requires these two elements of plant food in about the same amounts. The trees require only about one-fourth as many pounds of phosphoric acid as of nitrogen or of potash. “In most commercial fertilizers recommended for fruit trees, phosphoric acid is present in proportions about four times the nitrogen. This is doubtless on the assumption that the soil contains more nitrogen relatively than phosphoric acid, which may or may not be true in individual cases. The question may be raised as to whether quantities of phosphoric acid are not frequently applied much in excess of the actual need of a season’s crop.”\*

#### AMOUNTS OF PLANT FOOD USED PER ACRE BY DIFFERENT PARTS OF THE TREE.

Referring again to the use to which the tree puts the plant food, as shown in the previous table, it will be of interest to observe the following data:\*

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\*New York Experiment Station, Bulletin No. 265.

AMOUNTS OF PLANT FOOD USED PER ACRE BY THE DIFFERENT PRODUCTS OF THE TREE.

Part of tree.	Kind of fruit tree.	Nitrogen lbs.	Phos. acid (P <sub>2</sub> O <sub>5</sub> ) lbs.	Potash (K <sub>2</sub> O) lbs.	Lime (CaO) lbs.	Magnesia (MgO) lbs.
Fruit .....	Apple.....	20.0	8.5	45.0	3.9	6.4
" .....	Peach.....	17.5	8.6	36.0	2.2	4.1
" .....	Pear.....	9.0	3.2	20.2	2.2	2.6
" .....	Plum.....	13.3	4.7	18.5	4.4	3.0
Leaves.....	Apple.....	30.3	4.8	9.5	49.7	16.3
" .....	Peach.....	50.4	8.0	32.9	94.6	28.5
" .....	Pear.....	18.5	3.0	10.7	30.7	7.2
" .....	Plum.....	13.2	2.9	17.6	26.8	8.5
New wood.....	Apple.....	1.1	0.4	0.6	3.0	0.6
" .....	Peach.....	6.6	1.6	3.4	17.4	2.6
" .....	Pear.....	2.2	0.8	2.0	5.4	1.1
" .....	Plum.....	3.0	1.0	1.8	10.0	1.5

In respect to the amounts of plant food used per acre by the fruit of the different varieties of trees, the amounts of nitrogen, phosphoric acid and potash in the different fruits are in about the following order:

Apples, peaches, plums and pears.

Potash is present in the fruit in larger quantities than is any other plant food constituent; nitrogen coming second and being present to the extent approximately, of one-half the amount of potash. Then follow, in order, phosphoric acid, magnesia and lime, all of these being present in much smaller amounts.

In the leaves, the plant food constituents used per acre are greatest in the case of the peach, the apple coming second, then the pear and plum.

Lime is present in the leaves and also in the new wood in much larger quantities than any other plant food constituents; nitrogen coming second, followed in their order by potash, magnesia and phosphoric acid.

In the new wood, the plant food constituents used per acre are greatest in the case of the peach trees, after which comes in their order plum, pear and apple.

THE AMOUNTS OF PLANT FOOD REQUIRED BY AN ACRE OF BEARING APPLE TREES COMPARED WITH OTHER FARM CROPS.

It will be interesting to note the following comparison between the amount of plant food used per acre for trees in full bearing as already reported, and the amount of material ordinarily used by the different farm crops, as shown in the following table:

AMOUNTS OF PLANT FOOD USED PER ACRE BY BEARING APPLE TREES AND OTHER FARM CROPS COMPARED.

	Nitrogen lbs.	Phos. acid lbs.	Potash lbs.
<b>Apple:</b>			
Fruit.....	20	8.5	45.
Leaves.....	30	5.0	9.5
New wood.....	1	.5	.6
Total.....	51	14.0	55.1
<b>Corn, 30 bu. per acre:</b>			
Grain.....	27.6	12.	10.
Stover.....	14.3	0.6	22.
Total.....	41.9	12.6	32.
<b>Wheat, 15 bu. per acre.</b>			
Grain.....	16.6	8.5	5.
Straw.....	16.8	7.6	19.
Total.....	33.4	16.1	24.
Timothy hay, 1½ tons per acre:	35.4	22.8	38.

The notion that a bearing orchard requires an insignificant quantity of plant food as compared with the ordinary farm crops is shown by this table to be entirely wrong. In fact, apple trees bearing a normal crop require for fruit leaves and new wood more pounds of each of the three commercial elements of plant food, viz.: nitrogen, potash and phosphoric acid, than a 30-bushel crop of corn for the grain and stalks, and very much more than a 15-bushel crop of wheat and its accompanying straw.

MAKING THE PLANT FOOD IN THE SOIL AVAILABLE.

As is well known, only a small portion of the plant food contained in any good soil is at any one time available to growing crops. The processes which render this plant food available are going on more or less actively, practically all the time. The rate, however, at which this

food is made available to the growing tree will vary according to the season and to the method of treating the soil.

For example, during an excessive wet season, when the soil is either water-logged or being leached much of the time, there is unlocked in the soil a relatively small amount of plant food, and much of that which was already made available is lost either temporarily or permanently through the processes of leaching. This means that the soil should be watched carefully the year following an excessively wet season. This is particularly true if the trees following such a season happen to set a large crop of fruit.

Then, during a very wet season, the soil solutions are so diluted that the trees will actually find less plant food and have greater difficulty in getting that which they do find.

Likewise, in a very dry season the chemical and biological changes are very much retarded, owing to the absence of moisture. Nevertheless, it should be remembered that in such a season the movement of soil moisture is upward from great depths, and large quantities of moisture are brought to the surface and vaporized. The plant food that had in wet seasons been carried beyond the depths of the ordinary growing crop is brought by this upward movement of the water to the surface and by the vaporization of the water deposited there in a readily soluble form. This does not mean, however, that the plants derive benefit from these salts during the drouth, for there is not sufficient moisture in the soil to make this possible. Therefore, while a dry season does not favor the breaking down of the plant food compounds in the surface soil, it does in fact favor the accumulation of this soluble plant food in the surface soil, by bringing it from great depths, and also by the limited amounts used by the trees on account of the small fruit crop and the very sparse growth they make in such an unfavorable season.

Thus should we expect following a very dry season an extraordinary season of growth, and if by any treatment in that dry season we can without permanent injury to the trees induce them to set a good fruit crop the following year, it is very likely to prove exceedingly favorable for the development of this fruit. Not only are the conditions likely to be favorable for the development of a fine crop of fruit following a dry year, from the standpoint of an abundance of plant food to mature a maximum crop, but from the standpoint of a diminution of insect pests and a reduction of the prevalence of fungous diseases.

In the ordinary season it is necessary for orchardists to put forth some effort in order to unlock the plant food contained in this soil. The conditions most favorable for the unlocking of this food and render-

ing it available are the presence of air, carrying as it does free oxygen, and carrying also carbonic acid gas, which is indirectly a very powerful solvent. Thus the systematic aeration of the soil favors its breaking down and increases the ratio of available plant food. This aeration may be accomplished in two important ways: One, by systematic tillage, another by keeping up the supply of vegetable matter. Humus or vegetable matters keeps the soil open and porous, so that the air may circulate freely, and in addition, through the decaying of organic matter, liberates a large quantity of carbonic acid gas, which we have just learned is effective in unlocking plant food. Humus also assists in maintaining a more uniform water content in the soil, preventing it from becoming water-logged for long periods after a rain and preventing it from drying out to that point where very little or no chemical changes occur.

In soils deficient in humus this dry condition occurs as a rule in midsummer, when the temperature and other conditions are naturally most favorable to the breaking down of the soil, and at the same time when the trees are carrying the maximum of fruit and when they stand in greatest need of a copious supply of moisture and plant food. And even if the trees are not carrying fruit, they need food at this time of the year to mature the growth they have started in the spring and to fill out and perfect the fruit buds they have formed, in order that both wood and buds may be in good condition for the succeeding winter.

#### HUMUS AN IMPORTANT FACTOR.

Thus does humus play a very important part:

- (1) In keeping the soil from washing.
- (2) In keeping it from becoming too dry in midsummer.
- (3) In keeping it cool in the heat of the summer.
- (4) In draining it in a manner.
- (5) In assisting in unlocking mineral plant food.
- (6) In holding in an available form and in preventing loss by leaching of the mineral constituents.
- (7) In adding nitrogen.
- (8) In making the soil warmer in spring.
- (9) In making the soil more friable and loamy, and therefore cheaper and easier to handle.

As to the best methods of getting this humus in orchard soil, circumstances must govern in all cases.

On land of fair fertility and not so rolling as to prohibit cultivation on account of washing, it has been found most profitable to employ both

cultivation and humus for aerating the soil and unlocking this plant food. That is to say, cultivation is carried on from the very earliest spring until the buds for next year are fully formed and until after the differentiation between fruit and growth buds occurs, say the latter part of June or early July, when this treatment in the ordinary season and under average conditions ceases, and the land is seeded to some crop that will cover the surface during the middle of the summer, autumn, and if possible during the winter, to prevent washing, and to prevent as far as possible the alternate freezing and thawing that favors the eroding of the surface. This growth should not be so rank as to be difficult to incorporate with the soil the following spring. At the same time, it should be of rank enough growth to produce a goodly supply of vegetable matter. For this reason, the orchardists of the east, particularly of New Jersey, Delaware and Maryland, employ the crimson clover. This crop may, in my judgment, be successfully employed on the southern slopes of the Ozarks in seasons when there is sufficient rainfall in early September to insure germination and a good start, but is not reliable north of that point.

A second crop, and a much more important one for this purpose, is the cowpea. There is less risk of crop failure from its use, and it stands the drouth better than any other legume known to us and has greater ability to get along on a variety of soils and produce a large growth and to accumulate a large quantity of nitrogen. Unfortunately, the plants die with the first frost, and the land is not, therefore, so well protected in winter against washing as is the case when crimson clover is grown.

In favorable seasons the ordinary red clover may be sown in July and a good winter cover and a liberal quantity of humus secured, to be disced or plowed in the soil the following spring.

It too often happens that the orchardist limits his effort to the supplying of humus and nitrogen through leguminous crops, and trusts to the soil entirely for the mineral ingredients necessary to the proper nourishment of his orchard. He should remember, however, that on many soils the introduction of the humus and the cultivation necessary to incorporate it with the soil, while effective in unlocking the mineral constituents, do not operate rapidly enough to supply the trees in full bearing with the necessary potash, and in some cases the phosphoric acid required. To make the nitrogen that he is adding to the soil really effective, it is necessary to introduce, in a commercial fertilizer, a quantity of potash and phosphoric acid. As is pointed out elsewhere, the application of these minerals in amounts somewhat in excess of the immediate requirements of the trees is not such a serious waste, in view of

the fact that, unlike nitrogen applied in available form, comparatively little of these elements of plant food is lost when not used by the growing plants the first season. Under good handling, practically all of the potash and phosphoric acid may be recovered in succeeding crops, in case more than is needed is applied at one time.

#### IMPORTANCE OF TILLAGE.

As has already been pointed out, tillage will greatly facilitate the liberation of the mineral food of the soil, and it should not be forgotten that a relatively large quantity of these minerals is required. For example, a considerable part of the ash of wood growth is potash; considerably more than half of the ash in fruit consists of this material, while, as we know, this element forms the basis of the common fruit acids.

The western orchardist has, I believe, led in the extent and thoroughness of orchard cultivation, and the eastern man, particularly the New England, New York and Pennsylvania fruit man, has been disposed, in the past, to look with disapproval upon this western practice. It appears, however, from recent reports issued by the Cornell University,\* that the sod treatment of bearing orchards, even on the best apple land of New York, is proving less profitable than the culture treatment. It is true that only about 11 per cent of the orchards there have been in cultivation during the past five years, while 33 per cent have been in sod in this leading apple export county of New York, where some 8 per cent of the entire tillable area of the county is in apple orchards, and where are about 1-25 as many apple trees as in the entire State of Missouri. Of the young orchards, however, it may be of interest to note that only 36 per cent of the area is sown to grass, 9 per cent sown to small crops, while the remaining 55 per cent is given clean culture.

#### YIELD OF CULTIVATED AND UNCULTIVATED ORCHARDS CONTRASTED.

Five-year average per acre, 1900-1905. Orchards all well cared for.†

	Bushels.	Income.
Tilled ten years or more.....	337	\$189 00
Tilled five years or more .....	296	148 00
Tilled over half of preceding five years.....	234	121 00
Sod over half of preceding five years.....	242	118 00
Sod five years or more.....	253	134 00
Sod ten years or more.....	232	117 00

\*A Bearing Orchard Survey of Orleans County. Bulletin 229, May, 1905.

†An Apple Orchard Survey of Orleans County, N. Y. Bulletin 229, Cornell University.

It should be noted that these orchards were all well cared for, all receiving some fertilizer, and were sprayed, yet cultivation shows an increase in the average return during the last five years of \$72.00 per acre, or 61 per cent, as compared with similar orchards grown in sod.

In another report from the same institution,\* on Wayne county, New York, a county producing apples chiefly for evaporating purposes, some very interesting and valuable data still further emphasizing the advantages of tillage are presented, of which the following is a brief summary:

WAYNE COUNTY, N. Y., YIELD IN BUSHELS OF TILLED AND UNTILLED ORCHARDS.

	Number orchards.	Acres.	Average yield.
1900.			
Tilled five years or more.....	35	222¾	341
Tilled most years.....	36	298¾	309
Sod most years, tilled occasionally.....	43	241	301
Sod five years or more.....	51	620½	156
1901.			
Tilled five years or more.....	32	232¾	82
Tilled most years.....	88	319	73
Sod most years, tilled occasionally.....	54	292½	56
Sod five years or more.....	69	609	31
1902.			
Tilled five years or more.....	53	483¼	317
Tilled most years.....	67	428½	279
Sod most years, tilled occasionally.....	85	491½	214
Sod many years.....	122	1,100¾	176
1903.			
Tilled five years or more.....	31	379	325
Tilled most years.....	24	125	255
Sod most years, tilled occasionally.....	31	225¾	238
Sod five years or more.....	43	368½	230
			Bushels.
<b>Four-year averages per acre:</b>			
Tilled five years or more.....			266
Tilled most years.....			229
Sod most years, tilled occasionally.....			202
Sod five years or more.....			148

\*Cornell University Bulletin 226. An Apple Orchard Survey of Wayne County, N. Y.

Thus it is seen that orchards tilled five years or more produced 266 bushels per acre, while those that had been in sod for five years or more produced only 148 bushels per acre, as an average for the four years from 1900 to 1903.

When it is realized that this represents a large number of orchards and involves thousands of acres, the figures are entitled to the greatest weight.

In one sense the foregoing figures are misleading, in that they include all of the orchards examined, whether well cared for or neglected.

It goes without saying that the man who does not cultivate is likely at the same time to fail to spray, prune, fertilize, etc., and that the benefits of tillage in these figures are magnified.

Eliminating all of the orchards that were in any sense neglected, and taking those where the only difference in management was tillage, we have the following results:

\*WAYNE COUNTY, N. Y., YIELD OF APPLES FROM TILLED AND UNTILLED ORCHARDS AVERAGE OF THE COUNTY FOR TREES SET BEFORE 1880.  
ALL ORCHARDS WELL CARED FOR.

Treatment.	Number.	Acres.	Average yield.	Four-year average yield.
1900.				
Tilled five years or more.....	25	175%	348	.....
Tilled most years.....	22	181	353	.....
Sod most years.....	24	209	260	.....
Sod five years or more.....	25	206	224	.....
1903.				
Tilled five years or more.....	23	345	326	271
Tilled most years.....	16	99½	249	245
Sod most years.....	15	122	257	206
Sod five years or more.....	22	157%	263	200

"The real difference, therefore, due to sod or due to the lack of tillage, is between 80 per cent, shown in the table including all of the orchards, and 35 per cent, shown in the table relating only to the orchards well cared for."

It does not follow that under any and all circumstances an orchard should be tilled. In many cases the land is too rough or stony, and in other cases, if the orchards are giving good yields and the trees are making sufficient growth to keep up their vitality, it is possible that it

will be safe to allow them to remain in sod. By the liberal use of barnyard manure, it is possible to keep an orchard in good condition without tillage.

It should be remembered, however, that the results of good and bad treatment are not always apparent the first year. The great difficulty in determining what kind of treatment pays best in any particular orchard is the fact that it may be several years before the results are apparent in the difference in crops. Very frequently a grower has followed a few years of good care by a period of neglect, and has received an increased yield as a result. The trees may be making almost no new wood, and may be easy victims to insects, drouth and disease. Yet the increased crop may have persuaded the grower that this is the most profitable treatment.

"No care can be good that does not take heed of the future of the orchard.

"In some cases the orchard may need such treatment as will actually decrease the yield for several years, in order that new wood may be formed and new vitality given the trees. On the other hand, it frequently occurs that the orchard is growing too fast, producing too much wood, and is not as fruitful as it should be, and will need such treatment as will retard growth and increase fruitfulness."

It is claimed by some that apples from uncultivated orchards are more highly colored, have a higher flavor, are firmer and keep better.

On the other hand, these apples are usually smaller, and statistics recently compiled by the Cornell University\* show that the apples from cultivated orchards sold for a slightly higher price per bushel during the past five years than did those from the orchards that were not cultivated. That is to say, the extra size of the apples from the cultivated orchards more than compensated for whatever difference in color, flavor or firmness there may have been.

It may be said, in passing, that the apples of the Ozark region and of the river bluffs of Missouri are likely to be sufficiently well colored for all practical purposes, without adopting the apparently unprofitable practice of growing the trees in sod.

#### BENEFICIAL RESULTS FROM CULTIVATION IN MISSOURI.

Unfortunately, the commercial orchard industry in Missouri is too young to permit the gathering of such data from our own experiences as have been presented for the two leading apple counties of New York.

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\*An Apple Orchard Survey of Orleans County. Bulletin 229.

Professor Whitten of the Missouri Experiment Station gathered a number of years ago\*\* some very important data on the difference in the rate of growth of trees cultivated and uncultivated, of which the following table is a summary:

TABLE SHOWING INFLUENCE OF CULTIVATION AND CARE UPON THE GROWTH OF APPLE TREES.

No.	Variety.	AGE IN YEARS.	Growth in inches.				Kind of cultivation.
			1895	1896	1897	1898	
1	Ben Davis.....	7	17.6	21.7	23.2	24.5	Clean cultivation throughout each growing season.
2	Ben Davis.....	11	12.1	12.4	16.6	14.5	Clean cultivation until 1895; since then clean cultivation until June, when cover crop of cow peas or clover was sown.
3	Ben Davis.....	14	17.0	9.5	16.2	10.8	Clean cultivation until 1895; then seeded to clover, clover giving away to bluegrass in 1898.
4	Jonathan.....	9	17.2	9.3	13.6	11.0	Cultivated with corn between trees until 1895. In clover since 1895; space cultivated under each tree throughout each summer.
5	Jonathan.....	10	7.3	6.6	11.4	9.6	Clean cultivation until 1895. Since then clean cultivation until June, when crop of cow peas or clover was sown.
6	Genet.....	30	4.2	6.1	10.4	6.6	In bluegrass and clover; some cultivation around each tree.
7	Genet.....	30	3.6	5.5	8.0	4.4	In bluegrass pasture.
8	Genet.....	14	13.0	9.3	11.2	7.4	In clover; no cultivation since 1895.
9	Miscellaneous varieties.....	15	11.0	11.8	19.8	12.0	Plowed each spring, cultivated, seeded in summer to cow peas, rye or wheat.

It will be noted that in every instance the growth was materially larger wherever the orchards received good cultivation. Of more importance, it is shown that the trees under cultivation made a more uniform growth than did those that were in sod.

#### EFFECT OF FERTILIZERS IN OVERCOMING UNFAVORABLE CONDITIONS.

In the case of such disastrous drouths as in 1901, it is always the neglected and underfed orchard that suffers most. It is likewise true that underfed trees fall a victim to the attacks of borers, aphids, root rot, etc., much more readily than those that are well nourished. As in the animal kingdom, it is the starved animal that carries all the parasites known to the kingdom, whereas, sleek, fat, well fed animals escape their ravages.

When an unfavorable season finds an orchard well set with fruit the fact as to whether it has been well cultivated and is well nourished or not, in other words, as to whether there is present a reasonable supply of available plant food in the soil, exerts a profound influence upon the effect of this unfavorable season upon the crop and upon the life and vitality of the trees. This is well shown in an experiment recently reported from the New Jersey Experiment Station with peaches.\*

\*\*Bulletin 49 Missouri Experiment Station, "The Apple Orchard."

\*Voorhees' "Fertilizers." Page 235.

## YIELD OF PEACHES IN UNFAVORABLE YEAR.

		Baskets per acre.
1889	Unmanured.....	10.9
1889	Fertilized.....	152.5
1889	Manured.....	162.5

It will be observed that the unmanured plot yielded in all about eleven baskets per acre, while the manured plots produced more than 150 baskets. "The manure strengthened and stimulated the trees, and enabled them to successfully resist such conditions as were fatal to the crop on the unmanured land."\*\*

## NITROGEN SUPPLY.

On practically any soil in Missouri that is likely to be planted to orchard, it is possible to keep up the supply of nitrogen as well as the supply of humus by growing such crops as have been indicated, and at the same time pursue what is commonly known as "clean cultivation" for the orchard.

While the temptation is very strong to make the land earn something during the early life of the orchard when the trees are small and occupy but a small portion of the area, and when, without some such crop, the orchard is a dead expense, the utmost care should be exercised on the lighter and thinner soils, lest the supply of humus and of available plant food be to a large extent exhausted by the growing of such crops as corn, thus leaving the land in no condition to produce a thrifty and healthy growth of trees.

One can readily determine whether the nitrogen supply is inadequate for the trees by observing closely the color of the leaves and the length of the growth in the average season. When these leaves are somewhat sparse, that is, thin on the tree, pale or yellowish in color, it is certain that the soil is deficient in available nitrogen. Likewise, if the length growth in an average season, particularly when there is no fruit crop to nourish, is deficient, the limbs knotty, the bark rough, instead of the new growth being long, straight and having a smooth bark, we may conclude that there should be more nitrogen present in the soil to normally develop the tree.

If, on the other hand, the opposite of all these conditions are to be observed, that is, an abundant growth of foliage of a dark, rich

\*\*Voorhees' "Fertilizers." Page 297.

green color, and the new growth is ample, we may say that the soil is supplying plenty of nitrogen, and that it is not necessary to add more. When these latter conditions are emphasized, that is, when there is an unusual and even an unnecessary leaf and wood growth, when the vegetative processes are particularly active at the expense of fruitfulness, we may conclude that there is more available nitrogen than is necessary, and it will be profitable to grow some crop in the orchard that will remove a portion of this nitrogen, such as a corn crop, if the trees are small enough to make this feasible, or of timothy in an older orchard, the timothy being mown and removed from the land. It is never advisable, however, to allow orchards to remain long in timothy, even though it be necessary to plow the land in the spring, cultivate during the summer and resow in September, for while in sod there is a tendency for the tree roots to develop very near the surface, and if this process be permitted to go on for several years there will be a serious disturbance of the root system when the land is again put in cultivation.

#### SUPPLYING MINERALS.

The mineral element of plant food required in the largest quantity by the fruit, as has already been pointed out, is potash. Only about one-fourth as much phosphoric acid as of potash is required. A relatively large amount of lime is required for the development of the leaf. By reference to the table of the composition of soils, already presented, it will be observed that the content of potash is relatively large in most of our Missouri soils, particularly if we consider the subsoil to a depth of three feet, which is certainly not beyond the reach of a growing tree on any soil on which a sane man would plant an orchard. In other words, there would seem to be sufficient potash to supply all the needs of trees for many years to come, and that this would be one of the last elements to be supplied artificially. Considering, however, the special need of bearing trees for potash, it is believed that this element can be profitably applied over most of the Ozark region at any rate.

The amount of phosphoric acid in the soil is not nearly so large, and perhaps is rendered available more slowly, and is one of the first elements to be exhausted under the ordinary system of grain farming.

Land, therefore, that has been grown in the ordinary farm crops for many years before it was planted to orchard, is quite likely soon to need a limited supply of phosphoric acid in some reasonably readily available form. Virgin soils planted to orchards would naturally seem to be less in need of this element, and at the same time, when it is considered that these soils are in all probability thinner and contained orig-

inally a much smaller amount of phosphoric acid than the lands that were brought into cultivation earlier, as will be seen by observing the composition of the red limestone land, or of the pine ridge land, shown in the table of plant food in soil. It is likely, therefore, that if two or three corn crops have been taken off of this land while the trees are young, that it will stand in very sore need of a limited amount of phosphorous in some artificial form.

In view of the great abundance of limestone in Missouri and of the fact that most of the soils of South Missouri are the result of a limestone decayed in place, it has been assumed that our soils are very rich in this element and that it would be a waste of time and money to apply lime.

All of the analyses thus far made in our Soil Survey work indicate, however, much to our surprise, that many of our soils are really deficient in this element, and have possibly an overplus of magnesia. It is, therefore, a serious question whether lime may not be very profitably applied on a great variety of our soils. This is especially true of those soils which have been in cultivation long enough to develop an acid condition so that the legumes do not thrive well.

#### FORMULAE FOR SPECIFIC CROPS.

In earlier times the chemist, in recognition of the fact that different time is required for the normal development of different classes of plants, and they require plant food in different amounts and in somewhat different proportions, suggested various formulæ adapted to the requirements of different crops, as, for example, a formula for a cotton fertilizer, another for wheat, and a somewhat different one for corn etc. It has often occurred in practice, however, that the so-called corn grower would produce on some soils better wheat than the fertilizer especially designed for this crop, and vice versa. This is not to say that much cannot be learned concerning the fertilizing of different fruits by studying the amounts and proportions of plant food required for their normal development, but to rely upon these data alone would lead us into costly errors.

#### DIFFERENCE IN AVAILABILITY FOR DIFFERENT KINDS OF FRUIT.

This does not mean, however, that one fertilizer would be as well adapted to one fruit as to another. That is to say, there are qualities in a commercial fertilizer outside of the chemical composition which affect very materially its value and adaptability to particular uses. Chief

among these qualities is the ease with which the elements of plant food contained therein are available. Under some conditions a very readily available plant food is required; under others, one that acts more slowly is much to be preferred.

For example, it would perhaps be dangerous to use very much of a very quick acting fertilizer, especially if it contained very much nitrogen, on pears, for it is quite likely to leave the tissue in such a condition as to fall easy prey to blight. Likewise, it is as a rule not advisable to apply large quantities of a readily available plant food to apples.

On the other hand, a peach orchard, located on comparatively thin land, and loaded with fruit, would be greatly benefited by a liberal quantity of a very readily available food. The same would be true of all the small fruits.

A safe rule in all cases would be in making up a commercial fertilizer to supply a small quantity of immediately available material and furnish the remainder in a slow acting form, so that a uniform supply of food may be provided and a steady and uniform growth promoted. This is more particularly true of nitrogen than of the mineral elements. To secure this condition with nitrogen the readily available material may be supplied in the form of nitrate of soda, or preferably dried blood, or cottonseed meal, and for the slow acting material, barnyard manure, tankage or a pure raw bone meal, or cheaper than any of these, cow-peas or clover.

In the case of the phosphorous, a small quantity of acidulated rock would furnish the material required for immediate use, and the remainder could be more advantageously supplied in steamed bone, or much cheaper and probably quite as well in the long run, in finely ground raw phosphate rock. In this case it will always be necessary to plow under vegetable matter frequently to facilitate the unlocking of this phosphorus.

#### DANGERS THAT MAY FOLLOW THE USE OF FERTILIZERS.

If care and judgment be exercised in the amount of nitrogen applied and the season of the year in which the application is made, whether it be commercial fertilizer, barnyard manure, or a leguminous crop turned under, there will be no unfortunate results to follow. The only disadvantage in applying too much potash and phosphoric acid comes from the expense of buying an unnecessarily large amount of these ingredients. They will not cause too much wood growth, as will an excessive amount of nitrogen, and will not, so far as we know, di-

minish the tendency toward fruitfulness, or cause a late growth, or prevent a proper ripening of the wood for winter, or produce a soft and immature tissue that is especially subject to the attacks of fungous diseases. In truth, they and lime have just the opposite tendency.

Special care, then, need only be exercised in the application of nitrogen. The wood and leaf growth, as has already been pointed out, will show whether sufficient nitrogen is being supplied or not, and any excessive growth of leaf or twig will be conclusive evidence that too large a quantity has been used.

Such a mistake in a young orchard may be readily remedied by planting to corn and removing both the corn and fodder, and in the case of large trees that seem to have been overfed with nitrogen, seed to timothy, removing as hay the crops, and by one or the other of these means the danger is quickly removed.

The utmost care, however, should be taken not to carry this depleting process too far. It is like bleeding a patient for some malady—a most excellent thing to do when the patient really requires to be bled, but not a good thing if the bleeding process is carried too far.

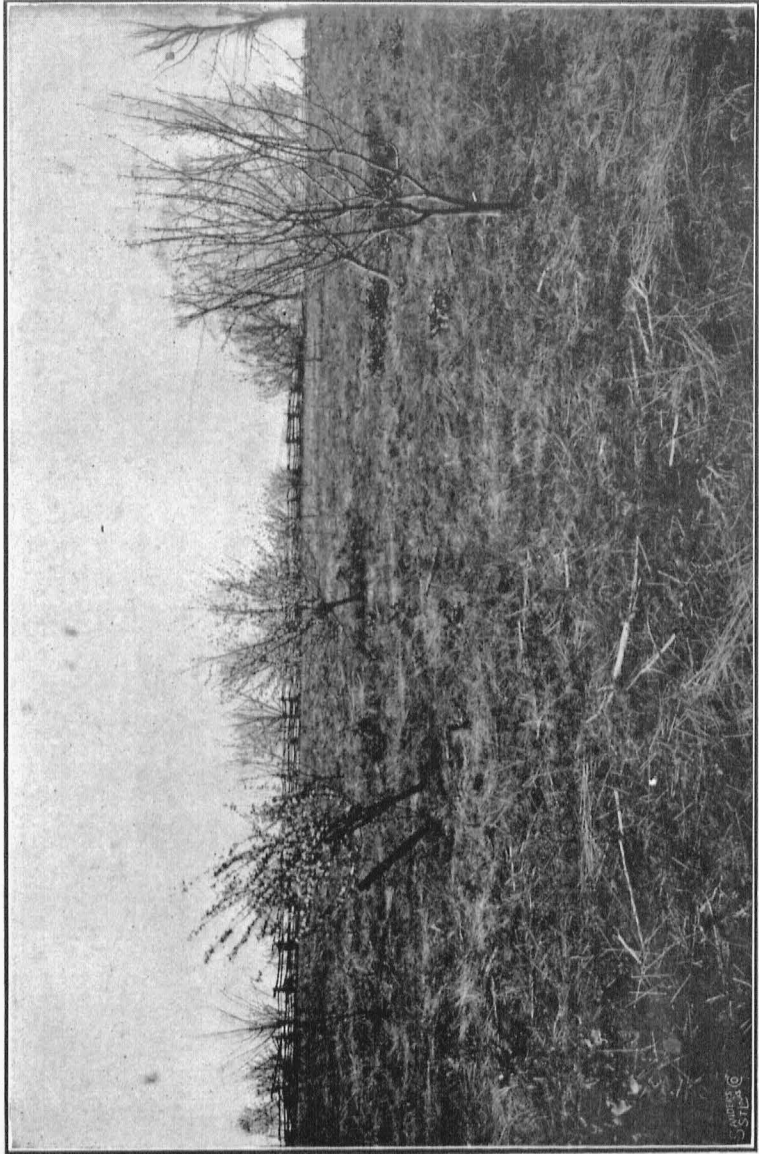
This cropping under all circumstances is a great temptation, as it is reducing the expenses of handling and giving an additional return from the land, but if carried to the extent of depleting the soil and no effort be made to restore the fertility thus removed, the small return obtained from the farm crop will be much more than lost in the reduced vigor of the orchard and the diminishing crops of fruit.

As has already been pointed out, it is especially bad policy to have the land alternately rich and poor. Better trees and better fruit will be obtained by a consistent policy of one side of the proposition or the other, and rather a somewhat underfed tree, existing under uniform conditions, than one that is this year underfed and next year overfed, or that is alternately rich and poor.

#### PHOSPHORIC ACID.

The commercial forms of phosphoric acid vary in availability more than do those of any other element. We have every grade, from the immediately available forms of dissolved bone black and dissolved rock, through the medium acting forms of raw and steamed bone, to the very slow acting, finely ground, untreated, phosphate rock.

It depends very much upon how one is situated as to which of these forms it will be most profitable to employ. Unless one has an orchard of bearing age that is very badly run down and needs immediate stimu-



A Young Orchard Struggling With Grass, Weeds and Borers.

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L. S. S. Co.

lation, there is no need for the employment of a very quick acting, readily available and high-priced dissolved bone black; besides, the cheaper form of acidulated rock will furnish quite as readily available phosphoric acid.

Under many circumstances the choice would lie between the two forms of bone meal, namely, pure raw bone meal, and steamed bone meal. The essential differences are, the raw bone meal is more readily available, contains a higher content of nitrogen, from 3 to 4 per cent, and a smaller content of phosphoric acid, from 18 to 22 per cent, and these ingredients cost somewhat more per pound than in the steamed bone. Steamed bone is the residue after the extraction of the glue from the bone, and leaves it poorer in nitrogen, containing only from  $1\frac{1}{2}$  to  $2\frac{1}{2}$  per cent, but richer in phosphoric acid, containing from 23 to 26 per cent, but neither of these ingredients is so readily available, the fertilizer being what would be termed slow acting, and is the cheapest form of finely ground bone.

At the present time the cheapest source of phosphoric acid is the finely ground raw rock, which contains from 28 to 32 per cent of phosphoric acid, and will cost, laid down at an average point in Missouri, about \$7.50 or \$8.00 a ton, in car lots. This means that a ton of rock contains from 560 to 650 pounds of phosphoric acid, making this material cost, laid down at the farmer's station, 1.2 to 1.3 cents a pound.

If the orchardist buys this material after it has been treated with sulphuric acid, the best that he can hope for is for a ton to contain 300 pounds of phosphoric acid, for which he will be obliged to pay, laid down at his station, from \$15.00 to \$18.00, which means that the available phosphoric acid in this form will cost from  $5\frac{1}{2}$  to 6 cents per pound. In other words, for the same money that 300 pounds of available phosphoric acid can be purchased, about 1270 pounds of unavailable material can be secured, or about half the quantity usually found in the first ten inches of an acre of our good land.

Experiments conducted at the Pennsylvania Experiment Station and a number of other places, extending over a long series of years, clearly indicate that this material can be rendered available rapidly enough for all crop requirements by good tillage and by keeping a goodly supply of humus in the soil, both of which are necessary for other reasons in orchard management.

In the matter of the amount of phosphoric acid to apply, it will depend necessarily upon the extent to which the soil has been depleted and the age and condition of the orchard, and what other crops are in the near future to be removed. If the trees are just coming into bearing

and the land has not been hard cropped with corn or other grain crops, from 100 to 150 pounds of bone meal per acre, or 400 pounds of rock phosphate will be sufficient to apply once every third or fourth year for ten or twelve years, when there would be sufficient phosphoric acid to satisfy all of the demands of the orchard perhaps until its usefulness had ended. As has already been shown, the amount of phosphoric acid used by bearing orchards is not large, but most Missouri soils are depleted of this material earlier than any other, with the possible exception of nitrogen.

#### RELATIVE VALUE OF DIFFERENT FORMS OF POTASH SALTS.

Generally speaking, the supply of wood ashes has been exhausted. This leaves two important forms of potash in commercial fertilizers, commonly known as the muriate of potash and the sulphate of potash. One is quite as readily available as the other, since the potash in both of the salts is readily soluble in water.

For general agricultural crops, such as corn, wheat, timothy, etc., and perhaps for potatoes that are sold on the open market in a mature condition, the muriate serves every purpose and is considerably cheaper than the sulphate. It has long been known, however, that the presence of the muriate exercised a deleterious effect upon the quality of certain delicate and very sensitive crops. For example, a high grade cigar tobacco cannot under any circumstances be grown with this salt. Grapes do not produce a high class wine when fed upon a muriate. Early potatoes are edible and palatable much younger and come on earlier when fed upon a sulphate than a muriate.

It has been assumed by practically all of the agricultural chemists of the country that for the ordinary fruits, such as the apple, peach, pear and plum, the muriate is quite as effective. Therefore, in all of the fruit formulae the potash is suggested to be in the form of a muriate on account of its relative cheapness.

Some experiments now in progress, however, at the Massachusetts Agricultural Experiment Station, indicate that a sulphate is superior to a muriate. The results have not been published, and it is through the courtesy of Professor of Agriculture, Dr. Wm. P. Brooks, Professor of Agriculture and Acting President, that I am permitted to make the foregoing statement.

In a recent letter to the writer, Dr. Brooks says: "One of the most striking points brought out by our experiments, which began with the setting of the orchard in 1894 and have continued since, is the great su-

periority of the sulphate over the muriate as a source of potash. The tree girth is considerably greater in the case of those trees receiving a combination of sulphate of potash and bone meal than in the case of those trees receiving a muriate of potash and a similar amount of bone meal. It is also important to note that the trees receiving the sulphate of potash have borne the largest quantity of fruit of any in the experiment. The fruit on the plot receiving 20,000 pounds of barnyard manure per acre each year is in general rather coarse and slightly inferior both in quality and in appearance, while the fruit on the plot receiving wood ashes is superior in appearance and quality to all other methods of treatment. The fruit on the plot receiving the sulphate of potash and bone meal is considerably superior in appearance to that on the plot receiving the muriate, and ranks next in this respect to the fruit grown from wood ashes."

All things considered, wood ashes, unleached, applied at the rate of from 600 to 1000 per acre, will be as good a form of potash as can be found, provided the cost per pound of actual potash in this form is not more than that of the sulphate. Recently some of the large packers have used large quantities of wood in curing their meats, leaving a high grade wood ash available for a fertilizer at a reasonable price. When this is available and the cost is not too great it is to be recommended.

When a supply of wood ashes is not available, I should recommend a sulphate at the rate of about 2 pounds per bearing tree or 150 lbs per acre.

For the growing trees, before they come into bearing, I am inclined to the opinion that the muriate would be good enough, and should be applied in the vicinity of the tree at a rate which would supply about 100 pounds of actual potash per acre, which means 200 pounds of the muriate salt.

It is claimed by many fruit growers that the use of potash as a fertilizer in bearing orchards will favor the development of high color in the fruit and cause the trees to hold their fruit better. In this connection, Professor Taft, personally known to most every Missouri Horticulturist, writes: "The Michigan orchardists have found that the use of mineral fertilizers tends to the production of fruit buds, and that the flavor and color of the fruit is enhanced. In numerous instances that have come to my knowledge, the difference in the amount of fruit blown from the trees that have been fertilized with phosphoric acid and potash in severe wind storms as compared with the amount lost from un-

fertilized trees was more than sufficient to pay the entire cost of the fertilizer."

In some instances liberal applications of lime have accomplished the same results, which may be due either to a deficiency of lime in the soil or to the fact that the added lime liberates a portion of the potash already contained in the soil, so that the indirect effect is the same as the application of potash. Certainly, on many of our soils, if lime is applied, it is not necessary to apply a potash the same season, as the lime is quite likely to liberate sufficient potash for all of the requirements of the trees for that year.

#### FEEDING THE PEACH.

As is well known, the habits of the growth of the peach are quite different from those of the apple or the pear. The former grows more rapidly, comes into fruitfulness earlier, produces a relatively larger quantity of fruit, which has a much shorter season of growth than either the apple or the pear. It is, therefore, as might be supposed, a somewhat more exhaustive crop, and requires the plant food in a more readily available form than either the apple or the pear. In practice it has been found, as would necessarily follow from these facts, that no fruit is more sensitive to thorough cultivation and good treatment than the peach. It is necessary to aerate the soil more thoroughly than with any other fruit.

Fortunately, we have from the New Jersey Experiment Station the results of some very excellent fertilizer experiments which extended over a rather long period of years, that will be very helpful in this connection. The soil upon which these experiments were conducted was of moderate fertility, of good mechanical condition, and considered to be fairly representative of the peach lands of the Atlantic Coast. The fertilized plots received annually:

	Pounds per acre.
Nitrate of soda.....	150
Bone black superphosphate.....	350
Muriate of potash.....	150

This particular fertilizer would cost at present prices about \$6.50 per acre, although it would be possible to buy an equally good fertilizer here in the west for less money.

Those plots having barnyard manure received twenty tons per acre per year. The following shows the results:

	Baskets per acre.
<i>I. The yield without manure.</i>	
1884-1891, inclusive, 8 years, average per year.....	65.7
1884-1893, inclusive, 10 years, average per year.....	60.3
1887-1891, inclusive, 5 crop years, average per year.....	105.0
1887-1893, inclusive, 7 crop years, average per year.....	86.2
<i>II. Yield with complete chemical manure.</i>	
1884-1891, inclusive, 8 years, average per year.....	164.2
1884-1893, inclusive, 10 years, average per year.....	183.4
1887-1891, inclusive, 5 crop years, average per year.....	262.8
1887-1893, inclusive, 7 crop years, average per year.....	262.0
<i>III. Yield with barnyard manure.</i>	
1884-1891, inclusive, 8 years, average per year.....	169.5
1884-1893, inclusive, 10 years, average per year.....	194.7
1887-1891, inclusive, 5 crop years, average per year.....	271.3
1887-1893, inclusive, 7 crop years, average per year.....	276.8

It will be observed that the yield was very materially increased by feeding the trees either with commercial fertilizer or with barnyard manure. The difference between commercial fertilizer and barnyard manure was in this case not material.

It should be remarked in this connection that the amount of plant food supplied was much larger in the barnyard manure in this particular case than in the commercial fertilizer, indicating that a smaller amount than was given in the form of barnyard manure was sufficient to produce maximum crops. For example, in ten years the fertilized plots received—

	Pounds.
Nitrogen.....	250
Phosphoric acid.....	580
Potash.....	750

whereas, the trees receiving barnyard manure were fed a total in ten years of

	Lbs.
Nitrogen.....	2,000
Phosphoric acid.....	2,000
Potash.....	1,600

As in the case of the other fruits, one must exercise the greatest care not to overfeed with nitrogen, which over-stimulates the vegetative tendencies of the tree, belating and minimizing the fruitfulness, besides such fruit as is produced is lacking in color and flavor and is much more liable to the attacks of fungus diseases.

#### FEEDING THE PEAR.

The dwarf varieties require better cultivation, more uniform and heavy fertilization than do the standard sorts, for the reason that the quince roots upon which they are grown feed from a much more restricted root area and near the surface, in proportion to the wood growth they make and the fruit they bear. It is self-evident also that the fertilizer should be applied nearer the tree than in the standard sorts.

In fertilizing the pear, however, it should be remembered that the permitting of a rank growth through the supply of a liberal quantity of available nitrogen makes the tree much more subject to blight and leaves the wood in such a condition that this disease is particularly fatal.

This has led to the very common practice of planting pears on relatively close, thin land, giving very limited cultivation, oftentimes none at all, and keeping the tree in what is commonly considered a half starved condition, so as to develop a wood that is resistant to the attacks of this disease. It is for the practical grower to determine in either case which of these policies he shall pursue.

#### HOW TO TELL WHAT SORT OF FERTILIZER THE ORCHARD NEEDS.

After all that is said and done, the only way to determine accurately what a bearing orchard on a given soil needs is to try it, and under ordinary circumstances it will be necessary to continue this experiment over a considerable length of time. Certainly it would not be sufficient to apply the fertilizers in the spring and expect a full and profitable return in the crop that same season. It is possible that the influence of this application may not manifest itself for two or three years, and it may continue to exert an influence for five or six years.

The best plan, therefore, would be to repeat the application at the end of about the third year, taking special pains to note the difference in the growth and vigor of the trees under each treatment, the color of the leaves and the amount, size, color and soundness of the fruit.

It will not be sufficient, however, to trust to one's eye to determine the difference in the yield of fruit. A difference of 25 per cent may be

easily undiscovered, whereas this difference might show a very large profit on the use of a commercial fertilizer.

Men engaged in the orchard business at all extensively can afford to make these experiments, accurately weighing the crop of fruit from each plot carefully, and keeping a record from year to year until the experiment is closed.

In passing, I may say that the Experiment Station will be very glad to enter into co-operation with any of our orchardists who have land growing in orchards which in their judgment need some artificial feeding. We may be in position to supply the fertilizer in the necessary amounts, and to send a man to the orchards to gather the data at time of harvest.

The following scheme will serve as a general guide and be sufficient for a preliminary test. It is not to be assumed that the particular kinds of fertilizers proposed in this plan are the ones that would be necessarily recommended for use in actual practice, but these are selected for the preliminary test in the main because of the convenience with which they may be procured and the uniformity of their quality on the market. Later, if it should be shown by results, for example, that nitrogen is required, it would be very easy to get it in a cheaper form than nitrate of soda.

#### PLAN OF PRELIMINARY TEST OF FERTILIZERS.

Plot.	Treatment.
1.	Nothing.
2.	Muriate of potash, 150 pounds per acre. Pure raw bone meal, 250 pounds per acre.
3.	Dried blood, 200 pounds per acre. Pure raw bone meal, 200 pounds per acre.
4.	Muriate of potash, 150 pounds per acre. Dried blood, 200 pounds per acre.
5.	Muriate of potash, 150 pounds per acre. Dried blood, 200 pounds per acre. Pure raw bone meal, 200 pounds per acre.
6.	Nothing.
7.	Barnyard manure, 10 tons per acre.
8.	Lime, 2000 pounds per acre.

## APPLICATION OF COMMERCIAL FERTILIZERS.

On mature bearing orchards that are occupying the entire ground, it is quite as well to make the application broadcast and in the spring, immediately before the first cultivation, letting the tillage given mix the fertilizer with the soil.

In the case of barnyard manure, it is possible and advisable to make the application in the autumn, after the ground is firm, say, from the first of November on, unless the land be very steep so that there will be serious loss from surface washing. The material would then be incorporated with the soil by the early cultivation, just as in the case of the commercial fertilizer.