Fruit Tree Fertilization with Nitrogen

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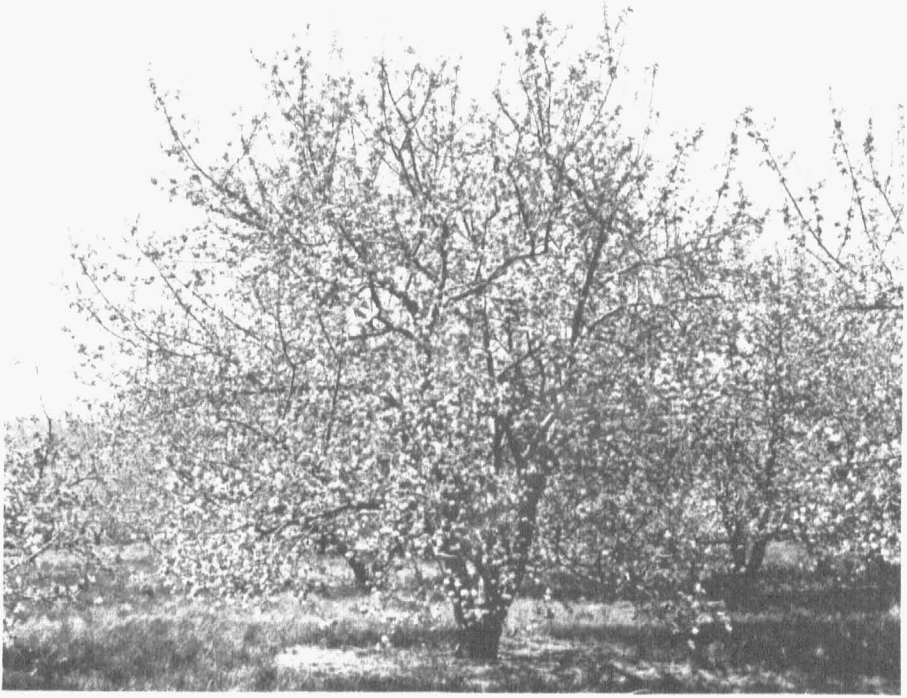

Fig. 1.—The greatest need for nitrogen by fruit trees is at the time of flowering and leaf development.

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INTRODUCTION

In orchard management practices soil fertilization with nitrogen is fully established as being of major importance. If omitted over a prolonged period, fruit growing will not be successful no matter how well the trees are pruned, sprayed or otherwise taken care of. There is no substitute for good soil fertility. In well managed orchards, nitrogen fertilizers are applied quite regularly to almost all fruit trees.

While fruit trees may be grown without the use of fertilizers, in the long run the crops will not be satisfactory under such practice. The only exception to this rule is where the trees are young and vigorous and the soil is unusually fertile and deep. Such soils are not common in our fruit growing regions. Most orchards in Missouri and elsewhere can be fertilized profitably.

No other fertilizer is likely to be as effective for the maintenance of desirable growth and yield of fruit as one containing nitrogen, particularly in readily available form. This belief is supported by the experience of numerous fruit growers and the prolonged investigations by Missouri and other agricultural experiment stations.

Complete fertilizers, carrying in addition to nitrogen, also phosphorus and potash, are sometimes recommended. They have been found of value, and sometimes necessary, for peaches on the lighter soils in the southeastern part and for sour cherries in the southwestern section of Missouri. It is probable that apple trees on such soils may also be benefited by fertilizers containing, in addition to nitrogen, phosphorus and potash.

The claim is made that nitrogen promotes growth, phosphorus increases fruit set, and potash improves color. There does not seem to be any evidence that either phosphorus or potash benefit fruit crops in such a specific and direct way, though there is some indication that, with increasing nitrogen supply, trees should get more potash. Occasionally boron, magnesium or some other so-called "minor element" has been found deficient in orchard soils. This, however, has occurred rarely in our state.

On many soils, fertilizers containing phosphorus may be of value for the growth of cover crops. Such crops, when turned under for green manure, improve the soil and eventually increase the vigor and productivity of fruit trees. Some very light soils may require, in addition to phosphate fertilizers, also potash for the proper development of a cover crop.

The use of nitrogen fertilizers in Missouri is restricted largely to four principal orchard crops; namely, apples, peaches, cherries, and plums. If proper attention to other orchard practices fails to maintain the vigor of trees and do not result in satisfactory yields of fruit, it is more than probable that fertilization with nitrogen will give profitable results. Neglected orchards often respond in a most striking manner to timely application of nitrogen in readily available form.

While an attempt is made to present here our current knowledge on the use and effects of nitrogen fertilizers for fruit trees, the recommendations given are only by way of suggestions to serve as a guide in solving particular problems. They should not be used without the exercise of judgment. Nitrogen fertilizers are not a cure-all. It is impossible to give general rules that will be applicable to all cases. Each orchard is a special problem that the owner must work out himself, keeping always in mind the soil, the condition of his trees and the relation of fertilization to his other orchard practices.

KINDS OF FERTILIZERS TO USE

There are many kinds of fertilizers that contain nitrogen. Of these only six are of importance for fruit trees in Missouri and adjoining states. They are stable manure, green manure, nitrate of soda, sulphate of ammonia, calcium cyanamid, ammonium nitrate and possibly urea.

Manures and Cover Crops

Manure.—All things considered probably no nitrogen-carrying fertilizer is as valuable as stable manure. It supplies not only nitrogen in fairly good form but also much organic matter which turns into humus and helps to improve the aeration, tilth, and water-holding capacity of the soil. It is possible that stable manure has still other, as yet undiscovered, properties that are beneficial to fruit trees.

At present manure is scarce and expensive. Its use, therefore, is restricted to relatively small orchards and to those near a local supply. There are few commercial orchards close enough to stockyards to secure manure at low or moderate cost. The making of artificial manure from straw has not gained much recognition as yet, but it seems to offer a possibility on a diversified form.

When manure is used for orchard fertilization, many growers supplement it with a commercial nitrogen fertilizer. This is especially desirable when the manure contains a lot of straw or other bedding material. At best, manure is slow acting and its nitrogen content usually is low. On the average, a ton of farm manure holds about 10 lbs. of nitrogen, which is equivalent to 50 lbs. of ammonium sulphate, but stockyard manure contains less nitrogen and more straw. Spring or fall application of a readily available nitrogen fertilizer will be more effective in increasing growth and fruit setting than manure applied at the same time. This difference in response to the two types of fertilizers is of the greatest importance when for one reason or another fruit trees have become devitalized and need to be invigorated quickly. Moreover it has a bearing on coloring of apples and peaches, which is discussed further on.

Since manure contains usually much straw, it has, to some extent, a mulching effect on fruit trees when applied in some quantity. It should be distributed evenly just under the spread of the branches. To be of real value as a mulch, a tree 15-20 years old should receive no less than 300 lbs. of manure of the ordinary stockyard kind.

Green Manure.—A fairly good substitute for stable manure is so-called "green manure". It is made by growing a leguminous "cover crop" or one

Fig. 2.—Hairy vetch is a good cover crop for many parts of Missouri.

composed of legume and non-legume plants. It has been estimated that about two-thirds of the nitrogen content of legumes is obtained from the air and about one-third from the soil. All is returned to the soil when the cover crop is plowed in. A legume, therefore, offers little competition to the tree for available nitrogen. It is of great benefit to the orchard when it is incorporated into the soil in sufficient bulk.

Cover crops for green manuring are usually sown in the spring or in the fall, and turned under when still succulent and green. When thus handled, such legumes as hairy vetch, cowpeas, soybeans, velvet beans, red clover, sweet clover, and lespedeza are good green manure crops. Legumes gather nitrogen (if inoculated) from the air which is added to the soil. It has been estimated that with heavy growth of hairy vetch the amount of nitrogen added to the soil is equivalent to about 15 to 20 tons of average stable manure per acre. In addition to nitrogen, there is incorporated into the soil also 2 to 3 tons of organic matter.

A plentiful supply of plant nutrients is necessary for the highest efficiency in nitrogen fixation by the plant. Most legumes need large amounts of phosphate and lime fertilizer. There are many legumes which will grow on acid soils but all of them show a favorable response to lime. Since most Missouri soils are deficient in phosphorus, an application of 150 to 300 lbs. of superphosphate per acre will generally increase the total growth. Ex-

periments have shown that the nitrogen fixing bacteria go to work sooner and gather a greater amount of nitrogen when the soil has been well supplied with phosphorus and lime.

The winter legumes under orchard conditions will usually gather a larger amount of nitrogen in a season than those which grow only a short period during the summer. The legumes which live over winter are well adapted to use in the orchard since they make most of their growth when the trees are inactive, and therefore compete less with the tree for moisture and nutrients. Moreover, there is less interference with orchard operations. The summer legumes can be expected to add only about half as much nitrogen as the long season crops.

In the young orchard green manure crops are very desirable. With a reasonably fertile soil and proper management of the cover crop, not only the fruit trees may be maintained in good vigor, but the soil may be actually improved and its nitrogen content increased. It is much more difficult and frequently impossible to grow satisfactory crops for green manuring in a bearing orchard. There is usually too much shading by the tops of trees and competition by the roots to obtain a satisfactory cover crop. In many other cases danger from excessive erosion prevents the growing and proper management of green manure crops in orchards. The land must be seeded to and kept in permanent sod from the very beginning. In sod orchards the use of commercial fertilizers becomes necessary.

Nitrogen from Sod

Most orchards in Missouri have been maintained in heavy bluegrass or other sod. Plants making up this sod contain relatively large amounts of nitrogen. It has been estimated that bluegrass sod builds up about 10,000 lbs. of organic matter per acre during a period of 20 years, which would contain roughly 500 lbs. of nitrogen. In a mature orchard, with trees planted closely, probably one-third to one-half as much sod would be present, which would amount to 150 to 250 lbs. of nitrogen.

While these figures naturally are not applicable to all orchard conditions, they do indicate that sod plants contain large amounts of nitrogen and, of course, other soil nutrients. Where the ground is level, and therefore cultivation possible, this "fertility capital" may be utilized to advantage in releasing nitrogen and other nutrients for fruit trees.

Because many roots are close to the surface, disking or so-called "trashy cultivation" is probably the best way to break up and destroy some of the sod. Fall is the best time to do this work, since it will permit some decomposition during the winter and spring and make a part of the nitrogen available when trees start to grow. Addition of a little commercial nitrogen fertilizer will hasten the decomposition process.

Commercial Fertilizers

The most important commercial nitrogen fertilizers for fruit trees are nitrate of soda, sulphate of ammonia, calcium cyanamid, ammonium nitrate and possibly urea. They are named in the order in which they were first used on a large scale for fruit crops in this country. Choice between them

is still determined largely by their cost in terms of percentage of actual nitrogen present. Prolonged field tests have shown that these fertilizers are by no means alike in their effects on the soil and the plants, although these differences may not be easily observed by the fruit grower.

Nitrate of Soda.—This is the oldest nitrogen fertilizer used for fruit trees. It is obtained from nitrate beds in Chile and also made synthetically. Nitrate of soda contains 16% nitrogen in the nitrate form, which is very soluble, moves through the soil rapidly and reaches the root zone quickly. This speed of movement, like much other quick action, has its drawbacks. A large proportion of this fertilizer may be lost as a result of heavy rainfall through run-off and leaching. It is not readily fixed or held by the soil and therefore easily drains away. Nitrate of soda leaves a neutral or slightly alkaline reaction in the soil.

Most fruit trees probably absorb nitrogen mainly in the nitrate form over a range of acidity that exists in most orchard soils. Nitrogen in other fertilizers such as manure, calcium cyanamid, sulphate of ammonia and decaying plant matter (humus) for the most part must be changed to nitrates before it is absorbed by plants. This transformation is accomplished by microorganisms of the soil, primarily bacteria. When soils are very acid, cold, or waterlogged, bacterial action is impeded.

Sulphate of Ammonia.—This is manufactured synthetically, and as a by-product from gas of coke ovens, and contains about 20% nitrogen in the ammonia form. Hence only three-fourths as much sulphate as nitrate is needed for the same amount of nitrogen.

Sulphate of ammonia is very soluble, too, but it moves through the soil much more slowly than nitrate of soda. Apples and other fruit trees may be able to absorb nitrogen in the ammonia form if the soil is neutral or slightly acid, but most of it probably changes to the nitrates before the roots take it up. For this reason it is desirable that this fertilizer be applied somewhat earlier than the nitrate.

Sulphate of ammonia leaves a distinct acid reaction, which, considering the amount used, may not be of any great importance in an average orchard. It has been found to be detrimental, however, where this fertilizer has been continuously applied 20 years or longer for field crops. Consequently, when sulphate of ammonia has been used in the orchard for more than a 10-year period, it may be desirable to switch over to a strongly non-acid fertilizer, such as cyanamid. Of course, the increased soil acidity may be corrected likewise by the application of limestone at the rate of one ton per acre, which is the approximate quantity necessary to neutralize the acid effect resulting from 10 years' use of sulphate.

Growth and development of bluegrass is stimulated greatly by ammonium sulphate. Hence, under sod culture, a larger proportion of this fertilizer than desirable may be absorbed by the plants making up the sod and the trees will get proportionately less nitrogen.

Calcium Cyanamid.—This fertilizer contains 21% nitrogen and approximately 70% lime. It is the least soluble of the three commercial fertilizers mentioned so far, and slowest in action. Because of the high lime content,

a continuous use of cyanamid will tend to make the soil less acid. Therefore, where the sod or cover crop is made up largely or entirely of legume plants, one should expect a response from the lime residue of calcium cyanamid.

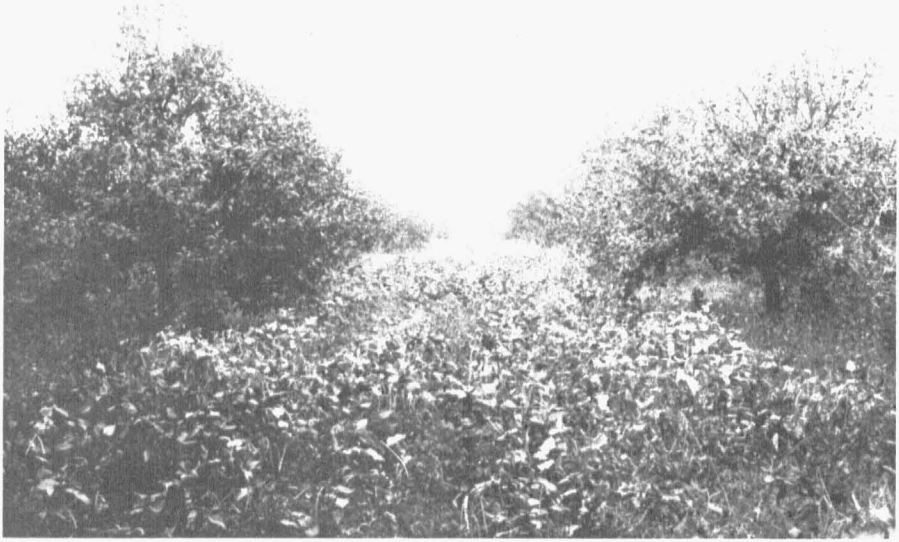

Fig. 3.—A mixed cover of legumes and non-legume plants in a young apple orchard.

Calcium cyanamid has to undergo several transformations in the soil before the nitrogen becomes available to the fruit trees. First it changes to urea, then to ammonia, and finally to the nitrate form.

When not distributed evenly, cyanamid may have a temporary toxic effect on plants making up the sod. This slight burning of the tops of grass and other plants is not harmful but may be of considerable value. It will permit more of the nitrogen to reach the feeding roots of the trees, for which the fertilizer is intended. Since the roots of sod plants are not injured, there is almost always a prompt recovery later in the season.

Better results may be expected from cyanamid on the heavier than on the lighter soils and on those containing more humus than soils poorly supplied with it. With an abundance of clay and humus in the soil, cyanamid will be broken down more rapidly to ammonia and it will not be leached out so readily. Under normal weather conditions some harmful effects have

been reported when cyanamid has been used late in the spring in large quantities for stone fruits growing on very light sandy soil, such as exists in some fruit growing regions in Michigan.

Ammonium Nitrate.—This nitrogen fertilizer has become popular as a result of increased activity in production of munitions. With processing to make it convenient to handle, ammonium nitrate has become one of the chief nitrogen fertilizers in agriculture, especially orcharding.

Ammonium nitrate contains 32-34% nitrogen. It is, therefore, about twice as concentrated as nitrate of soda. Half of the nitrogen is in the ammonia form, as in sulphate of ammonia, the other half in nitrate form, as in nitrate of soda. It is an excellent fertilizer, easily soluble, quickly available to plants and leaves no residue.

Ammonium nitrate can be used either for spring or fall application to fruit trees. It should be put on at the same time and in the same way as sulphate of ammonia is applied but only about two-thirds as much by weight. We have found, over a period of several years, that ammonium nitrate is very satisfactory as an orchard fertilizer.

Urea.—This fertilizer, sold as Uramon and by other trade names, with a 43-44% nitrogen content, has created considerable interest recently. It has been demonstrated experimentally and by many fairly large scale orchard tests, in New York, Missouri, and several other states that nitrogen can be supplied to apple trees and some other crop plants by spraying the foliage with urea. The advantages of using this rather unusual method of feeding plants with nitrogen are that it eliminates ground fertilization and that it seems to give a better control of nitrogen absorption and utilization.

It is desirable for fruit trees to have a relatively high nitrogen content in early spring for proper vegetative growth and fruit set and a comparatively low nitrogen content in late summer and fall for best development of color and quality of the fruit crop.

The recommended concentration is 5 lbs. of Uramon to 100 gallons of water. Satisfactory results with apples have been obtained from three applications given at petal fall and with the first two cover sprays. To save the cost of labor, urea can be added to regular pest control spray mixtures.

Aboue one-fourth to one-half of the nitrogen sprayed on the leaves and branches usually drips down or is washed off the trees, if rain follows soon after application. This portion of the sprayed fertilizer enters the soil and eventually becomes available later on through root absorption. Urea deposited on leaves and new shoots appears to be utilized in a few days. A considerable part of it seems to get into the leaves during the first 2 hours and most of it in the first 24 hours after application. Quite frequently the immediately visible effect from a urea spray is an increased green color of the leaves, especially when the nitrogen content of the tree is rather low.

Experimental tests with apples during the past 2 years at the Missouri Station with urea sprays, compared with an equivalent amount of soil fertilization, have shown considerable promise. Of the 10 groups of trees used for this purpose, in 8 the fruit set was increased when nitrogen was applied in the form of urea. The spring weather in both years was rainy and cold—

just the kind when urea sprays are supposed to be particularly effective. The green color of the leaves, however, was not affected to an extent where it could be easily noticed by observation. Trees in these orchards, therefore, were not suffering from marked nitrogen shortage.

It should be emphasized here that fertilizing fruit trees with urea sprays is not yet (1951) an established orchard practice. It is still "on trial" for the following reasons:

(a) The results in fruit set and size and vegetative development vary considerably, depending evidently on many other factors affecting the tree.

(b) Apples, some varieties probably more than other, seem to respond to urea sprays quite well, while most stone fruits apparently do not.

(c) Contrary to expectations, spraying with urea does not always lead to improved color of the fruit in the fall.

TIME TO FERTILIZE

The kind of fertilizer used determines the time of its application. Manure is commonly applied in winter or early in the spring when the grower is not occupied with urgent orchard work. Since its effect is slow is does not matter so much when it is put on the soil. Not so with the highly soluble chemical products. By applying them at the right time the action of these fertilizers can be controlled to a considerable extent.

There is a prevailing opinion that the greatest need for nitrogen by fruit trees is at the time of flowering and leaf development. Hence the fertilizer should reach the roots and be absorbed either in the fall or early in the spring to make it certain that nitrogen will move to the growing points in time and in sufficient amounts. Not only fruit setting is affected by nitrogen, but also shoot growth and development of leaves. It is desirable that both the tree and the crop be benefited by nitrogen application.

While nitrogen is required in large amounts by fruit trees early in the growing season, it seems desirable to have a relatively low nitrogen level in the tree in the fall when the fruit is maturing. This will help the development of color and quality of most fruits, certainly apples and peaches. Such a seasonal adjustment from comparatively high to low nitrogen status of the tree would occur most readily when the soil is light and a quickly available nitrogen fertilizer is used either in the fall or early spring and in not too large a quantity, unless, because of general weakness, it is required. As stated before, urea sprays are supposed to be particularly effective in controlling the seasonal nitrogen level.

Apples

Formerly nitrate of soda was the only soluble nitrogen fertilizer used for apple trees. The general recommendation was that it be applied 2 weeks before the expected time of flowering and in the main the results were satisfactory, expcepting in fruit growing regions of uncertain spring rainfall. The present rule for Missouri at least is that it be on the ground not later than 3 weeks before the flowers open. This will give a better assurance that the fertilizer will reach in time the root zone and will be absorbed and utilized when needed most.

As nitrate of soda was replaced in many orchards by the slower acting, but otherwise just as satisfactory sulphate of ammonia, the time of application was moved back. The present recommendation is that the sulphate be put on the soil about 4 weeks before full bloom.

Since ammonium nitrate contains nitrogen both in the ammonia and nitrate forms, it should be applied about 3-4 weeks before the expected time of flowering of trees.

Fig. 4.—An extremely heavy set of apples is shown here, on a biennially bearing variety fertilized with nitrogen in the spring of the "on" year.

Calcium cyanamid is now a fairly popular nitrogen fertilizer for apple trees. For spring fertilization it should be used early in March or about 6 weeks before the flowers open. It is not so effective for fruit setting when given later in the spring. Then, too, there is a slight danger that late fertilization with cyanamid on very light soils, containing little organic matter, may occasionally injure the roots. Of the hundreds of cases where cal-

cium cyanamid has been used in Missouri apple orchards, no harmful effects have been reported, though in numerous instances this fertilizer has been applied regularly for several years.

Fall vs. Spring Fertilization.—There has occurred a distinct change in the practice as to the time of application of commercial nitrogen fertilizers to apple trees. As a result of experiments performed over a period of 15 years at the Missouri Agricultural Experiment Station, it has been found that fall is just as satisfactory as spring to fertilize apples. In fact, the Missouri Station was one of the first to point out the value and to recommend the use of nitrogen fertilizers in the fall.

In Missouri fall application may be made any time between late September and early November, or about one month before a killing frost (one severe enough to kill apple leaves) is expected. Roots of apple trees remain active throughout this time of the year and early winter. Nitrogen is absorbed by the trees in autumn and winter and stored in the larger roots for use in the spring. It is probable, however, that more of the fertilizer will be taken up at the time when the leaves are still present and functioning, and it should be expected that the nitrogen reserves of the tree resulting from early application will be greater in the following spring.

In most cases it has been found that fall fertilization of fruit trees is equal to or better than spring fertilization. There seems to be greater economy and more convenience in applying fertilizers in the fall than in the spring. Work is less pressing at this time and the ground is usually in a better condition to get about. Moreover, there is greater certainty that nitrogen will be available to the trees early in the spring when it is needed most.

In Missouri, weather and soil moisture conditions often interfere with the effectiveness of spring application of even the most soluble forms of fertilizers. Hence a large part of the nitrogen required by the tree must come from its reserves or else must be provided promptly by a quickly acting soil fertilizer or perchance urea sprays. Then, too, if applied late in the spring, grass and other plants making up the sod will get a larger share of it than is desirable. It has been estimated that even with heavy applications of nitrogen, a good stand of blue- or crabgrass may absorb about half of it. As a result of these difficulties the present tendency is to use nitrogen fertilizers much earlier in the spring than formerly with emphasis on fall applications. Many apple growers prefer to supply the total yearly quantity of nitrogen in the fall, especially when the slower acting cyanamid is used. There are others who, at least in some years, practice the so-called "split applications", where half of the total yearly amount is given in the spring and the other half in the autumn. Some growers, perhaps those of a pioneering nature, may desire to experiment with half application of nitrogen on the soil in autumn and the other half in the form of urea sprays in the spring. This would seem to be a desirable combination.

Relation to Biennial Bearing.—Apple trees that produce crops in alternate years only, should be fertilized with nitrogen somewhat differently

Fig. 5.—Though growing on light soil, this vigorous peach tree produced a light crop in its third year. Nitrogen fertilizer and a legume cover crop were largely responsible for this good growth.

than trees bearing fruit annually. If a variety that gives excessive crops in one year and nothing at all the next is fertilized every year, then in the bearing year when a large yield is expected anyway, the tendency to overbear will be fostered. It will be pushed to the limit if such trees are fertilized heavily only in the spring of the year when a crop is borne. Such a practice will favor the natural tendency of the variety to bear crops in alternate years.

In order to counteract as much as possible the biennial bearing habit in such varieties like York and Wealthy, it is advisable to apply nitrogen only in the spring of the off-year, when little or no fruit is expected. Naturally, the amount given each tree should be larger than that supplied annually to trees of the same age. If spring fertilization in the off-year is insufficient then another application should be made in the fall of the same vear.

It is necessary to emphasize in this connection that there is no assurance that giving nitrogen in the non-bearing year will transform alternate bearing trees into annual bearers. But when combined with regular thinning of fruit and proper winter pruning after the cropping year, it will have a marked tendency to counteract the biennial bearing habit. Exceptions are some old and devitalized trees, which, like old people, may not respond to any treatment aimed to change their well established habits.

Peaches

In the central states peach trees suffer frequently from winter killing of flower buds. A common practice is not to fertilize the trees when no crop is expected. It is a year when they are pruned heavily. Trees that have become devitalized, from whatever cause, should receive nitrogen whether they are yielding fruit or not. If they are worth saving, they are worth preserving in good vigor. Any of the four fertilizers mentioned may be used for peaches either in the spring or in the fall. Caution should be exercised, however, in giving large amounts of cyanamid late in the spring, when the soil is light and sandy.

If peach trees are expected to set fruit, then one should wait till danger from spring frosts is over and apply a fertilizer in accordance with the amount of fruit anticipated, as judged by the bloom. Fertilizing at the time of blooming or a little before is a common practice in commercial peach culture. The larger the expected crop, the more nitrogen should the tree receive. Fertilization, even at the time of full bloom or soon thereafter, will stimulate growth and leaf development. And the larger and more numerous the leaves, the better will the fruit develop, but there may be a delay of a few days in their maturity and a slight reduction in color as a result of too late fertilization.

In the peach-growing section of Southeastern Missouri complete fertilizers have been found beneficial not merely to cover crops but directly to the trees.

Cherries and Plums

Sour cherries are benefited by nitrogen fertilizers. The usual practice is to fertilize in the spring about the time the buds begin to swell. It is preferable to apply the more slowly acting fertilizers, like cyanamid, in the fall. Vigorous trees should receive less, and weak trees more nitrogen. Fertilizers will help cherry trees to overcome more successfully the ill effects produced by attacks of certain diseases, especially leaf spot.

Plums are fertilized with nitrogen the same as cherries. Varieties that bear heavily require more fertilizer. Moreover, one should determine the amount given by the vigor of the trees and the color of foliage.

AMOUNT OF FERTILIZER TO USE

The quantity of nitrogen fertilizer to use for fruit trees depends upon the kind of fertilizer, the age and vigor of the trees, the fertility of the soil and the cultural practices. Trees in sod, as a rule, have to be fertilized more heavily than when grown under clean cultivation.

If stable manure or green manure is used, it may be necessary to supplement it with a commercial nitrogen fertilizer. A moderate application of stable manure for large apple trees would be 400 lbs. to a tree. It is not always possible to supply every year that much manure, hence additional nitrogen should be provided in some other way. Likewise, if the

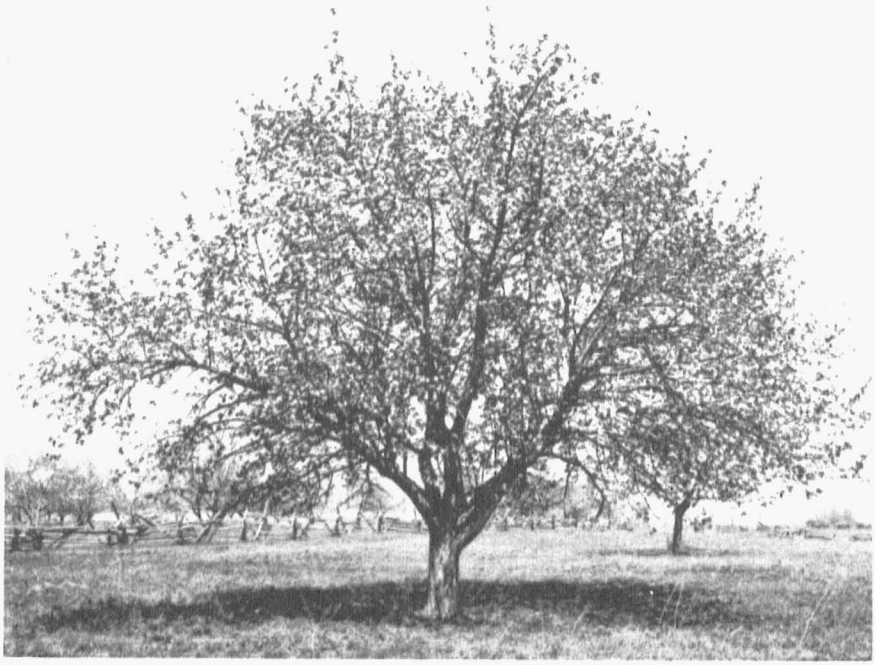

Fig. 6.—Trees growing on poor soil, like this one and the orchard in the background, respond very profitably to nitrogen fertilizers.

green manure or cover crop is scanty, which is frequently the case in mature orchards, it should be supplemented with chemical fertilizers. The amount of additional nitrogen to be used in each case must be left to the judgment of the grower.

Young fruit trees, even when planted on moderately fertile soil, may be maintained in good vigor without nitrogen fertilizers by proper cultivation of the soil and the application of stable manure or the growing of a leguminous green manure crop. If the land is kept in sod with ring or strip cultivation, then the trees should be fertilized at the rate of ¼ lb. of

a 20-21% fertilizer and ½ lb. of one containing 16% nitrogen per year of age for apple trees, and slightly less for stone fruits till they are 4 or 5 years old, excepting peaches which seem to require considerably more or about ½ lb. for each year they are old. At this age cherry and peach trees will be producing crops, and apple trees should enter the bearing age. If vigorous apple trees are over-stimulated at this period, the bearing age may be delayed.

For mature apple trees growing in sod the general practice is to use about ¼ lb. of 20-21% fertilizer for each year of age of the trees, and proportionally less of one containing 32-34% nitrogen but more of a 16% fertilizer. Thus one twenty years old would be given 5 lbs. of ammonium sulphate or cyanamid or 6 lbs. of nitrate of soda or about 3⅓ lbs. of ammonium nitrate. One should not, however, hold too rigidly to such a rule. The exact quantity to be used in each case must be determined by the grower himself on the basis of his experience. If the trees are devitalized, as indicated by lack of shoot growth and pale green color of leaves, they ought to receive a larger application. On the other hand, apple trees in very vigorous state, with yearly shoot growth of 12 inches or more and dark green leaves, should get less nitrogen. In fact, trees in overvigorous condition, which is not common among those bearing good crops, should not be fertilized at all.

Tests made at the Missouri Agricultural Experiment Station and elsewhere indicate strongly that apple trees growing in sod may be benefited greatly by larger applications of nitrogen than heretofore recommended. This is certainly true in the case of some of our older orchards where the trees, because of soil exhaustion and crowding, are not producing satisfactory crops regularly. Twice the usual amount, or ½ lb. of 20% nitrogen each year of the tree's age, has been found highly desirable for such trees.

In order to give an idea of the approximate amount of nitrogen lost yearly in various ways by o 20-year-old bearing apple tree and its nitrogen requirement, the following estimated figures may be of interest.

Nitrogen Loss and Needs of a 20-Year Bearing Apple Tree

(Figures expressed in pounds of fertilizer containing 20-21% nitrogen)

Removed with fruit crop	2.0 lbs.
Removed by pruning	.5 lbs.
Loss from autumnal dropping of leaves	2.0 lbs.
Loss from dropping of flowers and young fruit	.3 lbs.
Required for maintenance (growth)	1.0 lbs.
	5.8 lbs.
Returned to tree from decaying flowers, fruit and leaves	1.2 lbs.
Net requirement	4.6 lbs.

It will be noted that the net requirement of 4.6 lbs. of fertilizer is nearly the recommended amount; namely, 5 lbs. for a 20-year-old apple tree growing in sod. Some of the nitrogen supplied through a fertilizer, of course, is lost due to run-off or leaching, or both. Much of it may be absorbed by plants making up the sod.

The amount of fertilizer recommended for bearing plums and cherries 4 years old or older is ¼ lb. per year of age of trees up to 3 lbs. per tree. Peaches, especially on the lighter soils, require up to 4 lbs. of fertilizer when of large size. Young stone fruit trees should receive at least ¼ lb., but preferably ½ lb., per year of age. If the fertilizer is broadcast throughout the soil area, then the total quantity should be about 300 lbs. per acre or more, depending on the fertility of the soil. These amounts are for fertilizers containing 20-21% nitrogen.

METHOD OF APPLICATION

Little need be said about the simple procedure of applying fertilizers to fruit trees. Manure is spread in the usual way. Chemical fertilizers as a rule are broadcast by hand though they may be drilled between the rows of trees. Most of the feeding roots of fruit trees are under the spread of the branches but many roots extend much farther out from the trunk than the branches. The fertilizer should be scattered evenly not only under the branches as far as they reach but somewhat farther. Care must be taken that it does not come in contact with the trunk of the tree, as there is danger of injury to the bark.

Application of urea, in the form of a spray, is discussed elsewhere in this bulletin.

A common practice is to move the fertilizer through the orchard on a trailer, carry it to the trees to be fertilized in buckets and measure out the necessary amount by means of a tin can or a deep pan. The quantity, in weight, that the container holds when either level or heaping full is determined beforehand. One should use judgment not only in applying the right quantity but also in distributing the fertilizer evenly around the trees. This will make it more certain that it will spread uniformly through the soil and come in contact with the largest number of feeding roots.

EFFECTS OF NITROGEN FERTILIZERS

There is quite general agreement among fruit growers that nitrogen fertilizers are of unquestionable value to fruit trees, hence their general use by orchardists. A survey of orchard practices and costs in Jackson County, Missouri, for example, shows that the application of nitrogen has been "extremely profitable" even in this district of comparatively high soil fertility. Undoubtedly, the results from careful use of commercial nitrogen fertilizers have been profitable in most other fruit growing regions and in many, indispensable.

The most conspicuous effects obtained from nitrogen fertilizers are increased growth, larger leaves, higher set of fruit, and their better development. Vigorous and productive trees are usually more hardy and are better able to resist or overcome the effects of attack of diseases and insect pests.

On Growth

Poor growth is one of the first signs of shortage of nitrogen. Consequently the usual response to nitrogen fertilizers is a markedly increased growth. But there will be no greater growth if there is already an adequate

supply of nitrogen in the soil or as reserves in the tree. Good growth means not only an increase in elongation of twigs but, what is even more important, a greater vigor of the whole tree.

Leaf Size and Color

A very conspicuous symptom of possible nitrogen starvation of a fruit tree is a sparse, pale green foliage. To be sure, the leaves may be small in size, yellowish green in color, and drop prematurely as a result of drought, the attack of borers, or for some other reason; but nine times out of ten, it is a sign of lack of nitrogen in the soil.

Many alert fruit growers are quite skilled in determining the nitrogen shortage or requirement of their trees by the shade of green color of the foliage in June or July, when the leaves have attained full development and have absorbed the available nitrogen. Another sign of nitrogen shortage is the premature dropping of leaves in the fall. The paler green the foliage is in midsummer, the more promptly and heavily the trees should be fertilized with nitrogen that fall or next spring.

There is usually a noticeable recovery soon after a nitrogen fertilizer is applied. The leaves will become larger and of healthy green color and, as a result of increased growth and vigor of the tree, they will be more numerous. A heavy and healthy foliage is conducive to the formation of fruit buds and the proper growth and development of fruit. An abundant leaf area is necessary for the manufacture of food which goes into the making of the flesh of the fruit. In order to attain a full size, an apple, for example, requires 35-50 leaves to support it. Therefore, without good foliage there cannot be a satisfactory crop. Then, too, healthy leaves suffer less from certain fungus diseases and are injured least by spray materials.

Fruit Set

Because of lack of nitrogen, fruit trees may bloom profusely every spring but set very little fruit. In such cases the response to chemical nitrogen fertilizers may be very rapid and striking indeed. Manure, of course, cannot act so quickly for the nitrogen from it is released slowly. Because of this marked effect at flowering time, many fruit growers apply nitrogen solely with the object of increasing the fruit set. Under most circumstances nitrogen containing fertilizers will not only increase the crop but benefit all parts of the tree due to increased vigor and growth. Only vigorous trees can bear satisfactory crops regularly.

One should always remember that nitrogen is necessary for the growth of shoots, spurs, and leaves just as much as for the development of flowers and the setting of fruit. The tendency of apple trees to acquire an alternate or irregular bearing habit can be traced back largely to shortage of nitrogen. Tree growing in sod in particular will sooner or later develop this habit unless the fertility of the soil is maintained at a high level and the trees are not permitted to overbear.

Size and Color of Fruit

It has been mentioned already that with increasing number and size of leaves, as a result of nitrogen fertilization, there may be expected a corresponding increase in the size of fruit. While some of the food that goes

into the making of the flesh of the fruit comes from reserves in the tree, most of it is made in the leaves during the time the fruit is developing. The largest and best specimens of apples and peaches are produced on vigorous branches carrying good foliage.

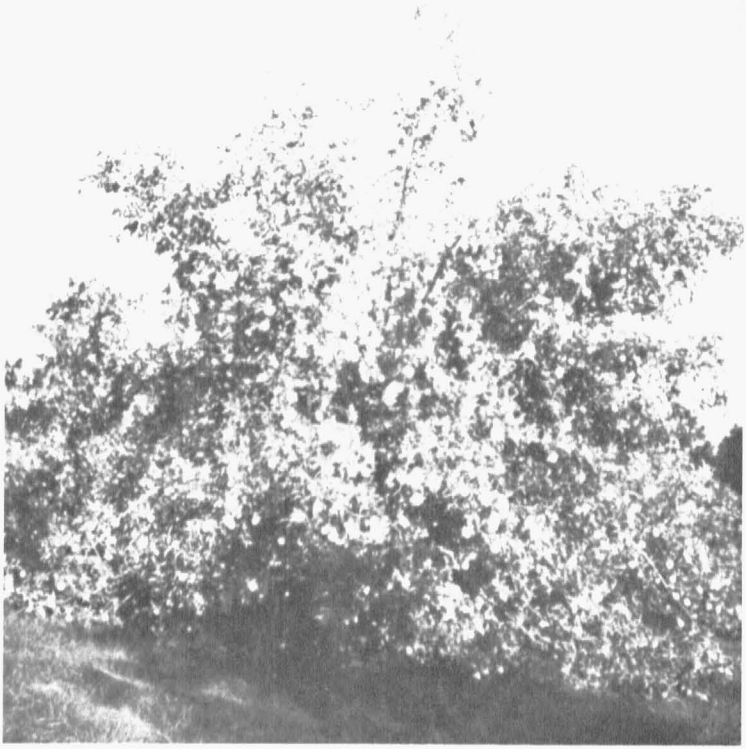

Fig. 7.—A fruit tree maintained in good vigor and productivity by proper application of nitrogen.

While the size of the fruit may be increased by nitrogen fertilizers, there is frequently a decrease in color due to greater shading by the leaves. Reduction in red or blush color seems to be in proportion to the amount of nitrogen supplied or, more directly, with the vigor of the tree. This disadvantage may be of considerable importance in growing red apples and certain varieties of peaches, especially if it is the object of the grower to produce fancy fruit.

It is possible to counteract this difficulty of reduction in color by proper pruning and thinning of the fruit, one of the main objects of which is to permit sunlight to reach the interior of the tree.

Every grower knows that sunlight has a lot to do with development of red color on fruit. Then, too, one should remember that there are many

red "bud sports" now available, the fruit of which will naturally develop better color, independently of nitrogen effects. Moreover, the present widespread use of preharvest hormone sprays permits growers to hold apples longer on trees which usually results in better development of color.

The possibly unfavorable effects of nitrogen fertilizers on the red color of apples and peaches may be overcome to some extent by resorting to fall applications. This procedure should have the least detrimental effect on fruit color.

The color of cherries is not influenced by fertilizers; neither are the yellow and green varieties of most fruits.

Time of Ripening and Storage Quality of Fruit

Though the season determines in a large measure the time of ripening of particular varieties of fruits, nitrogen fertilizers have a tendency to delay it. This is particularly true of peaches and to some extent apples also, but cherries do not seem to be affected. The difference in time of maturity may be as much as 2 to 3 weeks. Whether this is desirable or not depends to a great extent on the marketing practices of the grower.

Claims are sometimes made that, as a result of fertilization with nitrogen, winter varieties of apples will not keep well, especially when placed in cold storage. Careful studies conducted by several experiment stations have failed to find such effects. Fruit from trees normally fertilized will store and ripen in the same way as from trees not fertilized. It is possible, however, that excessive applications of nitrogen, combined with abnormal weather conditions, especially a heavy moisture supply, may shorten the storage properties of apples and other fruits.

Resistance to Drought

Trees that have a relatively large leaf area transpire more water and their soil moisture requirements are greater. In fruit growing sections where drought may be anticipated frequently, and on soils that have a low water holding capacity, one should consider carefully before large amounts of nitrogen are used. Under such circumstances the benefits that will be gained from fertilization may be neutralized by drought injury. The trees will produce longer shoots and a heavier foliage in the spring and early summer but the leaves may be scorched from lack of moisture and may drop prematurely. This, however, should be expected to happen only when the soil is light and shallow and rarely when it is quite heavy and deep.

Disease Resistance

Vigorous fruit trees are able to resist various diseases much better than weak trees. What is even more important, they will recover more quickly and completely from disease injury, which may have caused the dropping of large numbers of leaves or the dying of twigs and branches.

One possible danger from nitrogen application and an increased growth is the greater susceptibility of trees to fire blight. This is especially true of the pear and the quince, which should not be stimulated too much with nitrogen, else injury from blight may be serious in some years. The Jonathan variety is often subject to excessive blighting of twigs and therefore should be fertilized with moderation.

Hardiness

Another advantage of augmented vigor resulting from nitrogen application is an increased resistance of twigs and buds to low temperatures. Vigorous trees are usually more hardy than weak ones. But injudicious use of nitrogen, as when too much is applied or at the wrong time of year, may result in late growth and make fruit trees less hardy. After growth has ceased, the twigs and buds go through a hardening process, which should be completed before the severe winter weather sets in. If, as a result of late activity of the tissue, hardening is not completed then the trees will be highly susceptible to cold injury. Tho more immature the twigs are during the dormant period, the less hardy they will be. Thus it will be seen that the proper use of nitrogen will tend to increase hardiness of fruit trees and improper use of it will decrease hardiness.

Size and Age of Trees

It is of common knowledge that the more vigorous a tree is, the larger, as a rule, will be its size for the same age. Mere size, of course, is of no particular value to the grower, excepting in its relation to fruit yield. Though of equal age, productive large trees are apt to yield bigger crops than small trees, and since the size of a tree depends mainly on soil fertility, it is but another way in which nitrogen fertilizers may be expected to give profitable results. In closely planted orchards, however, beyond a certain size the trees may become so crowded that with increased growth there will be no further gain in yield of quality fruit.

With an optimum supply of nitrogen, not only size but the life of many fruit trees may be extended. Though some trees in most old orchards are destroyed by serious attacks of various insect pests and diseases, and many break down from trunk splitting and other physical causes, probably the most important reason for their gradual dying is a serious reduction in vitality. Old trees as a rule are weak trees. It is really surprising how much a systematic and ample use of nitrogen fertilizers can do to prolong the life of fruit trees and maintain the old orchard in a productive state. Apparently nitrogen is the most serious limiting factor in the soil nutrient supply of an old orchard, particularly when under sod culture.

FERTILIZATION IN RELATION TO OTHER ORCHARD PRACTICES

Neither soil fertilization nor any other orchard operation can be taken by itself but only in relation to other orchard practices.

No matter what system of maintenance of soil fertility is adopted, the main object is to keep the trees in good growth while they are young and in moderate vigor and continuous productivity when they bear crops. It is the tree that one must go by, with the rate of growth of twigs and size and color of leaves the best guides. If the soil is above average, it is possible to overfertilize fruit trees, especially when they are young. Fruitfulness will then be delayed due to excessive vegetative growth. The best remedy for such a situation is to withhold fertilization and cultivation, which will decrease soil fertility. Once the trees are induced to set fruit, the crop will tend to reduce its excessive nitrogen content and vitaliy. In young or-

chards, if the soil is quite fertile, all the nitrogen the trees require may be made available by cultivation around each tree or on either side of the rows. If the trees do not produce the desired amount of growth as a result of clean cultivation, then a nitrogen fertilizer must be applied on the cultivated area or the fertility increased by growing of a legume cover crop.

Fig. 8.—The results of heavy pruning and over-stimulation with nitrogen fertilizer.

When a young orchard is intercropped there is always the danger of robbing the trees of their nitrogen requirement. Every effort should be made to incorporate into the soil either stable manure or complete fertilizers in sufficient amounts to maintain its fertility, and the intercrop should be kept at a reasonable distance from the trees.

Another orchard practice closely related to fertilization with nitrogen is pruning. Both operations have a tendency to move the tree in the same direction—toward increased vigor. In fact, pruning in a measure will compensate for lack of nitrogen by reducing the number of growing points and thereby decreasing by that much the demand for this soil nutrient. While valuable for other reasons, pruning cannot be relied upon to maintain growth and vigor of bearing trees. Most certainly it is not a real substitute for nitrogen fertilizers.

All things considered, the less a tree grows, the more it should be pruned, but the more nitrogen it should also receive. The ideal would be to invigorate the trees to some extent by pruning and to a greater extent by he use of nitrogen. Very little nitrogen should be given in the fall preceding or in the spring following a winter when the fruit trees are cut back or pruned heavily, else one will have trouble with too many water sprouts.

Nitrogen fertilization should be considered likewise in relation to other orchard operations, such as fruit thinning, spraying, irrigation, and the marketing practices. In orcharding probably more than in most other farming enterprises the grower must be alert, and continuously use his best judgment to correlate the various orchard operations to obtain the most profitable results.