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Substitutes for Nitrogen Fertilizers in Orcharding

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No fertilizer has been found as effective for maintenance of growth and production of fruit trees as one supplying nitrogen. Consequently, there has been a widespread and continuous use in Missouri orchards and elsewhere of nitrate of soda, sulphate of ammonia, and calcium cyanamid. Because of the war, these commercial products are becoming less available and increasingly higher in price. In fact, it is said, and on good authority, that the U. S. Priority Board may permit next year for agricultural purposes only 50% of last year's supply of nitrate of soda and that some of the other nitrogenous fertilizers may become equally scarce in the near future. In view of this situation it may be worthwhile, if not necessary, to consider certain measures and practices that the fruit grower could put into operation in lieu of the purchase and use of commercial fertilizers that furnish nitrogen.

In considering this problem, the following conditions and possibilities suggest themselves as worth taking into account and as practical solutions of the problem: (1) Amount of nitrogen required by fruit trees; (2) means of reducing this requirement; (3) making nitrogen now held in sod available through cultivation; (4) obtaining nitrogen from the air by means of leguminous cover crops; (5) supplying nitrogen from manures; and (6) utilization of waste materials as possible sources of nitrogen. These items are briefly discussed here in the light of our present war emergency, though many of the suggestions made also have a more permanent value. Moreover, it will be accepted that the fruit grower will use his own good judgment in solving his particular problem of supplying nitrogen to his orchard under the existing conditions.

Nitrogen Requirements by Fruit Trees

Based on numerous observations and much experimental work it has been estimated that a bearing apple tree, say 20 years old, requires each year about 5 lbs. of a fertilizer containing 20 to 21% nitrogen. This would be ¼ lb. per year of age of the tree, which is the present general recommendation for all trees in an average state of vigor. When a fertilizer containing 16% nitrogen, like nitrate of soda, is used then the amount to be applied for an apple tree of this size would be 6 lbs. Peaches seem to require considerably more nitrogen, or about ½ lb. for each year of the tree's age up to the time of bearing, since they grow faster than apple trees. Other stone fruits, such as cherries and plums, should be fertilized the same as apples. If a fertilizer, containing 20-21% nitrogen, is broadcast over the whole soil area, then the quantity should be 300 lbs. per acre or more, depending on the soil.

One should not hold too rigidly to the above rules, however. The "demand" for nitrogen is indicated by the trees themselves. If they are devitalized, as shown by reduced shoot growth, which in the case of apples would be less than 6 inches each year, or by pale green leaves, then nitrogenous fertilizers may be of great benefit. Mature trees that are making vigorous growth of 12 inches or more require little nitrogen and sometimes none at all.

Reduction in Demand for Nitrogen

Under present war conditions, and undoubtedly at other times also, the grower may well consider the elimination of all unprofitable and many submarginal trees, thus reducing the per acre requirement for nitrogen. The undesirable trees should be removed either in winter or early spring, during which period about ⅓ to ½ of the tree's nitrogen is held in the roots. These will rot in 2-3 years and release their nitrogen content to the benefit of adjoining trees.

Pruning is another means of reducing the demand for soil nutrients, including nitrogen. A large tree in a poor state of growth would require the use of a great deal of nitrogen to increase its vigor. Such a tree often is also in need of pruning. By cutting out a portion of the top the remaining parts will be invigorated and less nitrogen will be required. Too much pruning of course will reduce temporarily the fruit bearing capacity of the tree. It is desirable to attempt to balance the size and yielding capacity of a tree in relation to pruning and soil fertility.

Obtaining Nitrogen From Sod

Most orchards in Missouri have been maintained in heavy blue grass or other sod for a number of years. The plants making up this

sod contain relatively large amounts of nitrogen. According to some unpublished records,* blue grass sod built up about 10,000 lbs. of organic matter per acre during a period of 17 years, which would contain roughly 500 lbs. of nitrogen. In a mature orchard, with trees planted fairly closely, probably ½ or ⅓ as much sod would be present, which would amount to 250 or 150 lbs. of nitrogen. When plowed under and cut up by discing this nitrogen, using the lowest figure, would be released in a period of 2 years, furnishing approximately 100 lbs. the first year, which is equivalent to 500 lbs. of a 20% fertilizer, and 50 lbs. the following year which is equivalent to about 250 lbs. of the same kind of fertilizer.

While these figures naturally are not applicable to all orchard conditions, they do indicate that sod plants contain very large amounts of nitrogen and other soil nutrients. In case of necessity and where cultivation is possible because of relatively level ground, this "fertility capital" may be utilized to advantage in supplying nitrogen to fruit trees. It is said that in England much grass land is being broken up at present and the accumulated soil fertility in grass is being utilized during the war emergency for the growing of crops that supply human food. Likewise this practice may be put into operation here to furnish raw food materials for fruit trees in a somewhat similar but not as great an emergency.

The best time to break up sod is in the fall. This will permit some decomposition during the winter and spring and make some of the nitrogen available when the trees start to grow. If a commercial nitrogen fertilizer of some form is available, it may be used very satisfactorily in the spring following the fall plowing. This will help the decomposition process and at the same time stimulate to some extent the trees, pending the release of more nitrogen from the sod.

Nitrogen From the Air

Most of the air over an orchard is nitrogen, but only inoculated leguminous plants, as the clovers, beans, and peas, have the ability to utilize this supply in their growth. This has led to their extensive use as soil building crops, since approximately two-thirds of the nitrogen in a mature plant comes from the air.

Even the legumes have to use soil nitrogen until the nodule forming bacteria become established. Legumes cannot gather nitrogen from the air unless they are inoculated at planting time or sown on land that has grown a well inoculated crop belonging to the same nodule

*Obtained by Dean M. F. Miller of the Missouri Agricultural Experiment Station.

bacteria group. It is always good insurance to inoculate legume seed with the correct bacteria before sowing. After an orchard has been planted several years to the same crop the nodule bacteria will live over from year to year so that no further inoculation is necessary. The pure culture type of inoculation is the easiest and most satisfactory to use.

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 fertilizers. 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. Recent experiments 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. Such crops as Hairy Vetch and Crimson Clover may be benefited on very poor soils by the use of a complete fertilizer containing nitrogen and potash in addition to the phosphorus.

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 trees 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.

Hairy Vetch can probably accumulate as much nitrogen as any other crop in a single season. The nitrogen gathering efficiency of the other winter legumes is probably in the following order: Sweet Clover, Crimson Clover, Red Clover, and Bur Clover. Crotalaria is one of the best nitrogen fixing crops among the summer legumes. Ranking next are Cowpeas, Soybeans, and Korean Lespedeza. Crimson Clover, Bur Clover, and Crotalaria are adapted only to the extreme southern part of the state. Most Missouri soils have to be limed before satisfactory stands of Sweet and Red Clover can be secured. All of the legumes respond favorably and will fix more nitrogen on a soil well supplied with lime.

The selection of a green manure crop will depend upon the conditions existing in each individual orchard. Such factors as kind of fruit, age of trees, kind of soil, slope of orchard and tendency to erode, location, and prevalence of insects and diseases must be taken into

consideration. Those crops which compete seriously with the trees for moisture or cause excessive erosion should be avoided.

A green manure crop should be managed so that the nitrogen is made available to the trees when it is most needed. The nitrogen in a succulent immature crop will become available in a few weeks when turned under during warm weather. A mature crop that has become woody will take much longer to liberate its nitrogen. The nitrogen fixed by a legume plant will not become available to the fruit tree until after the plant has almost completely decayed. A growing legume may even cause a nitrogen deficiency in the orchard soil.

The nitrogen in a legume can be stored temporarily by leaving the plant material on the surface and not working it into the soil until needed. A summer legume may be left standing until early the following spring. A winter legume may be left as a surface mulch during the summer and not worked into the soil until early fall. Any nitrogen leached into the soil will be absorbed by the roots. Tree roots are capable of taking up nitrogen at any time during the season when the ground is not frozen.

A good crop of Sweet Clover or Hairy Vetch may take as much as 100 lbs. of nitrogen from the air. Not all of the amount added to the soil will be utilized by the trees. If it is assumed that not more than one-half will be available, a crop of Hairy Vetch is equivalent to only 50 lbs. of nitrogen applied as a commercial fertilizer. Even this is equal to 300 lbs. of nitrate of soda per acre. Bearing age trees occupy the land to such an extent that the area available for growing a legume will often be less than one-half of that in an open field.

In orchards with very large or closely planted trees it may be impossible to obtain a satisfactory growth of a legume crop. It is generally not advisable to attempt to supply the entire nitrogen requirement of a bearing fruit tree by the use of a leguminous green manure crop.

A non-legume cover, like rye, may be useful in checking erosion but it will not add nitrogen to the soil. The orchardist should use every precaution to prevent losses by erosion. A single heavy rain can remove more nitrogen and undecomposed organic matter than the entire amount added to the soil by a good cover crop grown during the whole season.

Nitrogen from Manure

Since a bearing orchard will require more nitrogen than can be added by growing a leguminous green manure crop, nitrogen containing materials will have to be brought into the orchard. One of the best is barnyard manure. The average farm manure contains about 10 lbs.

of nitrogen per ton. This is equivalent to 60 lbs. of nitrate of soda or 50 lbs. of ammonium sulphate. Farm manures vary considerably in quality depending upon the care with which they have been handled. The amount and nature of bedding materials used as well as the kinds of feed being fed the animals also influence the quality. There is a considerable variation from different kinds of animals. Chicken and sheep manures may contain as much as 1% nitrogen when unleached. Cow and pig manures usually contain less than one-half of one per cent. Horse manure is somewhat better. If considerable quantities of coarse fiberous materials have been used for bedding the quality will be lowered.

Manure should be applied around the tree just under the spread of the branches. Since the nitrogen becomes available more slowly than that from commercial fertilizers, the manure should be applied well in advance of bloom. It may be hauled to the orchard and spread as soon as obtained. This is especially desirable when there is no suitable place for storage on the farm, since one-half of the nitrogen may be lost if left in loose exposed piles. It is not necessary to incorporate the manure into the soil, unless it is desirable to have most of the nitrogen become available in a short period. It should be spread evenly under the trees and not left in piles or bunches.

Other Sources of Nitrogen

There are a number of waste materials which contain considerable amounts of nitrogen and which may be secured locally for little expense other than the cost of hauling. One of the best of these is activated sewer sludge. This material can be secured in any town having a modern sewage disposal plant. A ton of the dry sludge will contain from 50 to 100 lbs. of nitrogen. Stockyards manure is also a valuable source of nitrogen but contains less than farm manure because of the large amount of bedding used. This manure can be obtained in car lot quantities from the terminal stockyards. The charges for freight and hauling to the orchard will largely determine the extent to which it can be used. Packing house refuse as well as waste from hatchery and poultry plants may contain considerable quantities of nitrogen. Cannery waste from legumes is valuable. Tomato cannery waste and apple pomace are sometimes used but do not carry large quantities of nitrogen.

There are some organic materials which are of little value as sources of nitrogen. Straw, cane pomace, cotton hulls, sawdust, and similar fiberous materials may have a detrimental effect when applied as mulches around fruit trees. The mocro-organisms which decay these materials may take up most of the nitrogen so that it is unavailable to

the trees. This nitrogen is not released until the processes of decay are almost completed. When the nitrogen supply is limited it is not advisable to apply any dry material containing less than one per cent nitrogen. An application of 60 lbs. of a 20% nitrogen carrier to each ton of straw will hasten release of the nitrogen. Straw which has decayed until it has become manure-like in character may be used safely.

The value of any material used in an orchard is determined by its nitrogen content. It is possible to supply the entire nitrogen requirement of a bearing orchard through the use of legumes and barnyard manure. The problem for most orchardists is to secure a *good growth* of the legume and *enough* manure. Every precaution should be taken to prevent losses by erosion and leaching. It may not be practicable to entirely eliminate the application of commercial nitrogen to Missouri orchards through the use of legumes and manures. Their fullest use, however, will aid materially in conserving nitrate of soda, ammonium sulphate, and calcium cyanamid, which are vital war materials.

LEGUMES FREQUENTLY GROWN AS GREEN MANURE CROPS IN MISSOURI ORCHARDS.

Legume	Time to Plant	Seed per Acre—lbs.	Nodule Bacteria Group	Notes on Management
Hairy Vetch	Aug. 15-Sept. 1 (may reseed)	20-30	IV	Inoculate carefully, may be planted with grain.
Crimson Clover	Aug. 15-Sept. 10	15-20	II	Sow on firm seed bed, or in lespedeza.
Bur Clover	Aug. 1-Sept. 1 (often reseeds)	30-60 in hull	I	Not necessary to inoculate, sow with top dressing of manure.
Sweet Clover	Feb. or March	15-25	I	Requires lime on most soils. Do not allow to bloom.
Red Clover	Feb. or March	10-15	II	Requires lime and a high level of fertility.
Cow Peas	June 1-10	60-90	III	Use resistant varieties on wilt infested soils.
Soybeans	June 1-10	60-90	V	Late maturing, forage varieties are most satisfactory.
Korean Lespedeza	Early spring (reseeds)	15-20	III	Mow during August if competing with trees for moisture.
Crotalaria—Early Strain	June 1 (may reseed)	15-30	III	Same as lespedeza.