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The Question of Avocado Fertilization

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It is at once obvious to one who considers the fertilization of avocado trees that this subject may be divided into a number of phases. Each of these raises certain questions. The answers can at this time be considered only as approximations and are suggested with varying degrees of confidence. This is due in part to a lack of sufficient information concerning the nature and reaction to fertilizers of the types of soils upon which avocados are grown, and also concerning the interrelations of soils and avocado trees. It has been apparent, however, that the responses of many kinds of fruit trees to fertilizer are remarkably similar in the same environment, and that certain principles of soil behavior remain more or less constant, with little regard to the nature of the fruit crop produced. The differences found are usually those of degree rather than of kind. Since insufficient information is available regarding the effects of fertilizer practices on avocado trees, it is necessary to utilize the information we have concerning soils and the responses of other fruit trees to fertilizers applied to them. This procedure leaves a great deal to be desired in the answer to many specific questions regarding the fertilization of avocados which we hope can in time be answered by the results of research and observation. However, it is probable that the orchardist can be set in the right direction in the effort to arrive at a program which suits his particular conditions.

NITROGEN DEFICIENT IN OUR SOILS

The element which is almost always deficient in the soils of southern California for the proper nutrition of fruit trees is nitrogen. The "Cost of Production Studies" carried out by the Agricultural Extension Service in the various avocado-producing counties show that this deficiency is generally recognized by growers as affecting avocado trees. The deficiency is also evident in the experiment carried out by Marsh.[1]

The greater part of the nitrogen in the soil is stored in the organic residues of plant tissues and in the living and dead bodies of soil organisms. By the oxidation of these materials available nitrogen compounds, chiefly nitrates, are produced. Thus the nitrogen supply is intimately related to the organic matter of the soil. In a virgin soil, this decomposition in turn permits the growth of additional plant material. Consequently, an approximate balance exists between the organic matter and the total nitrogen. When virgin soils are placed under orchard cultivation, these processes are disturbed. The natural additions of plant material are interfered with, and the stirring of the soil hastens the oxidation processes. Much of the nitrogen which is made available by decomposition of organic matter in cultivated soils is lost by leaching and possibly by

volatilization. Only a part of the nitrogen is utilized by the crop which is grown.

NITROGEN MAINTENANCE IMPORTANT FERTILIZATION BASIS

Intensive cultivation of soils which were originally high in organic matter and nitrogen may support the growth of trees for a relatively long period without fertilization, whereas soils which were low in these materials may respond to additions of nitrogenous fertilizers at an earlier date. In both types of soils the rate of supply of available nitrogen is not often sufficiently rapid over a term of years to encourage the most profitable yield of trees. The maintenance of an adequate nitrogen supply appears to be the backbone of a program of fertilization for avocados.

Inasmuch as the conservation of nitrogen and regulation of its availability in the soil is associated with the conservation of organic matter, it is logical to consider first the means by which serious depletion of organic matter in orchard soils may be avoided. The growing of cover-crops and of weeds is an aid in this respect. Such growth actually contributes organic matter, and by shading the soil may lower its temperature and thereby decrease the rate of organic matter decay. These crops absorb nitrates from the soil and decrease losses caused by leaching. Although valuable from the point of view of preventing nitrogen losses, this absorption may be so intense that the availability of nitrates for tree use may be temporarily reduced, during the period of covercrop growth, to such an extent that the trees are deprived of necessary supplies of available nitrogen. Marked reduction of nitrates in the soil also takes place during the initial decomposition of covercrop residues, owing to the activity of microorganisms at that time.

APPLY NITROGEN WHEN TURNING UNDER COVER CROPS

Since practical considerations favor the growth of winter covercrops which are turned under in the early spring when the nitrogen requirements of the trees may be high, as will be discussed later, it would seem prudent to insure against a temporary depletion of available nitrogen at that time by fertilization.

The type of plant used as a covercrop appears to be of little consequence. The growing of legumes might be thought to be of value because of their ability to fix atmospheric nitrogen by symbiosis with root-nodule bacteria. This is found to be of little importance in fertilized soils, however, and nonlegumes appear to be as valuable as legumes on this score. The more important consideration seems to be the production of a good tonnage of organic matter.

In the older avocado orchards, where a large part of the ground is shaded, it is impossible to produce much covercrop or weed growth. In such orchards, however, an increased amount of plant material is added to the soil in the form of fallen leaves, twigs and blossoms. The amounts of these plant parts are large, probably being greater than the amounts falling from citrus trees. It is logical to expect them to be of pronounced value in the maintenance of soil organic matter but whether they are sufficient for this purpose is not yet established. A heavy leaf-fall in a short period of time may have the same depressing effect on soil nitrates as does the addition of covercrop residues or of

low grade organic fertilizers, as will be discussed later, and fertilization may be desirable to counteract this effect.

RELATIONSHIP OF ORGANICS TO SOIL FERTILITY

A direct means of maintaining the nitrogen and organic matter of the soil is the addition of bulky organic fertilizers such as manures, hays, and straw. This is a common practice which has advantages other than those associated solely with organic matter. It may at this time, however, be discussed in regard to this relationship, along with the sources of organic matter previously mentioned.

The oxidation of organic materials results ultimately in the release of nitrogenous compounds in inorganic form and the loss of a large amount of carbonaceous material. The decomposition process proceeds whether the bulky materials are cultivated in or used as a surface mulch. It should be noted, however, that complete oxidation of nitrogenous compounds resulting in the production of nitrates does not occur until the ratio of organic matter to nitrogen in affected soil approaches the value for the ratio which is found in the virgin soil, that is, about 18 to 1. For this reason the application of organic materials should be considered with regard to the amount of soluble nitrogen in the soil and the analysis of the material applied.

If analysis of the organic material shows a ratio of organic matter to nitrogen much above about 20:1, one may expect a temporary depression of nitrates in the soil as a result of its use. A slight decrease in nitrates in a soil which is high in effective nitrogen is of little consequence, and hence large amounts of bulky organics may be applied to such soils with no harmful effect. In the case of infertile soils, similar applications may be distinctly harmful to the immediate crop unless they are supplemented by the use of sufficient inorganic nitrogenous fertilizers to bring the ratio of organic matter to nitrogen from all sources to about 18 or 20 to 1. The fact has been mentioned that covercrops and weeds may decrease the supply of available nitrogen during their growth period, and also when they are turned in. Decaying leaves and twigs which have fallen from the trees have a similar effect. Adequate nitrogen fertilization is therefore of importance when covercrops and weeds are grown, as well as when leaves and other tree parts or bulky organic fertilizers are applied. Nitrogen which is applied to counteract these denitrifying effects can most logically be obtained from concentrated materials.

TIME TO APPLY NITROGEN

The question arises as to the most desirable time for the application of these concentrates. Although the answer to this question depends in part on the kind of material employed, and also upon the relation of covercrops and applications of bulky organic matter to nitrogen availability, as discussed previously, the seasonal requirements of the avocado tree for nitrogen absorption are of primary importance. There is insufficient information on this point. It is possible that certain varieties may differ in some degree in their seasonal requirements. This is suggested by their varying blooming habits and also by differences in the manner in which their leaf-fall and leaf-growth occurs. Cameron and Bialoglowski[2] have shown that avocado leaves lose a

large part of their nitrogen before their abscission, and also that blossoming causes a depletion of nitrogen in the leaves. These observations suggest that the requirements for available soil nitrogen might be highest at these two times. Until this is substantiated by orchard experiments, however, the grower probably should maintain a supply of available nitrogen throughout the year, but especially just prior to and at the blooming period. A continuous supply of available nitrogen ordinarily exists in heavily fertilized orchards, except possibly on light soils, when the concentrated fertilizers are applied in a single application in later winter. On light soils where leaching takes place readily, more than one application a year may be desirable. This may also be the case when large amounts of bulky organic fertilizers or covercrop residues are used, or where heavy mulches are employed. It also seems possible that a fairly uniform concentration of soil nitrates may be more effective and result in less leaching loss than alternate periods of very high and very low nitrates.

The average quantity of nitrogen which should be applied to full-bearing avocado trees has not as yet been determined. Common practice is to apply each year the amount most commonly used in citrus orchards, that is, about two hundred pounds per acre of actual nitrogen. This quantity permits some leaching in citrus soils, but appears to be necessary to maintain desirable concentrations of nitrate for citrus. It may be somewhat higher or lower than the amount needed for the most profitable production of avocados. Since avocado leaves appear to show nitrogen starvation symptoms less readily than citrus leaves, it may be that the nitrogen requirements of avocados are not so high. However, leaf condition may not be a reliable criterion of the requirements of avocado trees as measured by yield response. It is also possible that the requirements of avocados at certain seasons may be higher than those of citrus. Our present knowledge, therefore, would suggest that about two hundred pounds per acre of nitrogen from all sources should be applied during the year. The amount is, of course, reduced for young trees which are not in full production.

SOURCES, COMPARATIVE VALUES AND COSTS OF NITROGEN

The next question is concerned with the sources of nitrogen. Considerable information exists on this point from the results of fertilizer experiments with citrus and deciduous trees[3] in California. It is reasonable to believe that the results would apply to avocado fertilization. Briefly they indicate that many materials are of equal value when considered on the basis of their nitrogen content. This applies to bulky organic materials, provided they are not applied in excessive quantities to impoverished soil, and provided that when used they are supplemented with inorganic sources of nitrogen. It also applies to the following concentrates: ammonium sul-fate, nitrate of soda, nitrate of lime, urea, mixed fertilizer, tankage, blood, and cottonseed meal. Probably Ammo-phos and Cal-nitro would give equal satisfaction as sources of nitrogen, but experimental evidence on their value is lacking. Various interesting problems concerning the use of anhydrous ammonia are being studied.

Since the evidence indicates that a pound of nitrogen is of equal value if derived from each of the materials listed, it follows that in general the choice of materials should be based upon the cost per unit of nitrogen. If this is done, a variety of materials would

probably be used over a period of years. There are, however, certain other factors which may influence the choice in particular instances. It may be desirable to avoid fertilizers which leave a residual material already too abundant in the soil or irrigation water. The presence of such materials can be determined by analysis. There is no information indicating that the slightly acid or alkaline reaction of certain of the inorganic fertilizers can be used to good advantage in avocado orchard soils. The effect of such fertilizers on soil reaction (pH) is slight in relation to the forces which tend to maintain the existing reaction. It should be pointed out that information is not available to indicate the advisability of changes in the reaction of most soils.

In many instances the choice of concentrated fertilizer is influenced by the season and method of application. When penetration of immediately available nitrogen into the root-zone with the first rain or irrigation is desired, the nitrate sources are preferable. These will also leach most readily. If more gradual penetration or availability is judged to be satisfactory, or if reduced chance of rapid leaching is wanted, the ammonium or high grade organics may be chosen. Likewise, if the material is to be distributed in the irrigation water, a fertilizer should be used which will not cause deterioration of the pipe lines, and which will be distributed satisfactorily. In the majority of cases the method and time of application can be varied to suit the fertilizer which is chosen on the basis of lowest cost per unit.

OTHER EFFECTS OF ORGANIC MATERIALS

Mention has been made of the relation of organic matter to the conservation of nitrogen and also to the gradual supply of nitrogen made available by the oxidation of this material. A few additional remarks should be made about other effects of organic matter. This material has a marked relation to the physical condition of soils. A lack of sufficient quantities of it is shown in many of our soils by a compact structure with reduced pore space. This unfavorable condition restricts both vertical and lateral movement of water and reduces the effectiveness of the irrigation practice. It may also effectively decrease the aeration of the soil, a factor which appears to be essential to satisfactory health of avocado trees. Organic matter also enters into the complex chemical reactions of the soil, increasing the solubility of certain elements and serving as a substratum to hold various plant nutrients in an available form. The conservation of organic matter in soil is therefore highly important. The effect of reduced cultivation, covercrops, and also of mulches of bulky organics and leaves may be helpful in this respect.

Additions of organic matter (produced on other land) to the orchard soil also contribute large quantities of plant nutrients in addition to nitrogen. This is particularly true of phosphoric acid and potash. Although these compounds have not been demonstrated to be deficient for the satisfactory performance of fruit trees in southern California, the use of bulky organics in the fertilizer program appears to be ample insurance against their future depletion. With one known exception which will be mentioned, it appears from our present understanding that this insurance can be obtained if no more than half the nitrogen is derived from bulky organic fertilizers, such as dairy manure or its equivalent in nitrogen and organic matter. This may be more than may be needed in

avocado orchards to maintain good physical condition of the soil, provided the greatest possible use is made of cover-crops, weeds, and tree residues such as leaves and other tree parts which fall to the ground.

The exception mentioned above referred to zinc deficiency. This has occasionally been observed in avocado orchards. The symptoms of this deficiency are easily recognized as mottle-leaf, little-leaf, rosette, or "frizzles"; such conditions are readily controlled as they appear by applications of suitable zinc sprays to the foliage. Although avocados are produced in some areas where citrus is affected by exanthema, a condition which is remedied by the use of bordeaux sprays, no avocado trees have to my knowledge shown symptoms which suggested this disorder.

Brief mention might be made regarding soil analysis and the use of soil amendments.

SOIL, ANALYSES AND SOIL AMENDMENTS

The intelligent study by several methods of orchard soils for moisture content can obviously be a very good guide to irrigation practice or to indicate poor drainage. Chemical examination of soils and irrigation waters for the presence of harmful concentrations of various salts is of course desirable if their presence is suspected. Analysis of soils for soluble nitrates also provides an indication of the level of available nitrogen in the soil. This can be helpful in timing the application of concentrated nitrogenous fertilizers. However, it must be recognized that variations in sampling methods and orchard conditions, as well as the lack of knowledge concerning the forms of nitrogen which can be utilized by avocado trees and the desirable minimum concentration of nitrates at any season, necessitate the use of a great deal of personal judgment in the interpretation of the analyses for nitrates. On the other hand, analyses for phosphoric acid and potash by present methods fail to show the amounts of these materials which are available to plants and are therefore of no practical value as indicators of their need. Proper analyses may, however, indicate that abundant supplies of available phosphoric acid and potash exist in the soil, but low results do not necessarily indicate that applications would be beneficial. Observation of the growth of covercrops and weeds which have higher requirements for phosphoric acid than fruit trees is probably of value as an indicator of the need for this fertilizer.

Analyses of soil reaction, or pH, indicate the intensity of alkalinity or acidity of the soil but not the reserve of materials present which cause this reaction. The pH therefore tells only a part of the story. Nevertheless it sometimes serves as an indicator of unsatisfactory soil conditions if the values are about 4 or 5 on the acid side or 9 on the alkali side. The latter may suggest black alkali. This condition is generally recognizable by observation of the soil as well as by detailed chemical analysis. Black alkali is often benefited by the application of gypsum or sulfur.

SOIL AMENDMENTS DO NOT APPEAR JUSTIFIED

In the case of soils which have a very high soil reaction, about pH 9, caused by the presence of large amounts of lime, the solubility of certain nutrients may be depressed to a very low point. Under these conditions lime-induced iron chlorosis may appear on

avocado trees. The reduction of the pH of such soils by the application of soil sulfur is very difficult, owing to their high buffering capacity. Furthermore, the net effect of such a reduction cannot now be estimated. Where it is desirable to experiment with the use of sulfur on such soils, it would be advisable to treat only small areas and to observe the treated trees in comparison with trees growing on untreated soils. The cost of effective treatment may also be prohibitive.

Most California soils, however, range in pH values between 6.5 and 8.5, and there is no information which indicates that avocado trees will not grow satisfactorily within these limits. Although variations within that range affect the solubility of many soil constituents, the effect of any changes which might be caused by the application of soil amendments to a particular soil are not known. It is not clear that all the effects would be beneficial. The use of soil amendments for the purpose of changing the reaction of the more normal avocado soils does not therefore now appear justified.

1. Marsh, R. H. Fertilizer trials on the Fuerte avocado. California Avocado Assoc. Yearbook 1935: 118-119.
2. Cameron, S. H., and J. Bialoglowski. Effect at fertilization, ringing, blossoming, and fruiting on the nitrogen content of avocado leaves. California Avocado Assoc. Yearbook 1937: 142-148.
3. Proebsting, E. L. Fertilizing deciduous fruit trees in California. California Agr. Exp. Sta. Bul. 610:1-29. 1937.