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Fertilization of Subtropical Fruits

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Mr. Marshburn: Of the next speaker I should like to say a few words. We all know that paintings have become famous after the artist has passed on; fine music has become great after the composer passed on. Today we have with us a man, still young, who has done a great work for agriculture. His writings will be read in years to come. He is outstanding as a soil chemist and in his practical field work. I refer to Mr. W. R. Schoonover, Specialist in Agricultural Extension Service, University of California, who will talk to us on "Fertilization of Subtropical Fruits." It gives me great pleasure to introduce Mr. Schoonover.

W. R. Schoonover: Thank you very much for that introduction. Coming down on the train, a man who grows avocados sat next to me, and looking over one of your programs said: "I don't see why they have that subject on the program at all. Nobody knows anything about that." Perhaps he is right. Nobody knows anything about it. We are gradually accumulating some knowledge about soils and about fertilization of various crops that grow on these soils. Perhaps we can work out a few suggestions here that may guide you in the fertilization of your avocados and other sub-tropical fruits.

It is true that different crops have different requirements and that we do fertilize to a certain extent in relation to the crop that we are growing. Because that is true, we have gotten the idea that the function of fertilization is to feed the crop. That idea has been fostered by the fertilizer industry for many years and they put out different formulas, such as "x" for avocados and "y" for oranges, and another letter for lettuce, etc. These formulas are usually based on an analysis of the crop, and are developed on the theory that you should return to the soil everything that the crop takes out. That, I am sure, is a fallacious theory. It may not be so in raising some quick growing vegetables but it certainly is for trees which have a large and extensive root system, exploring a large portion of the soil, and also a long growing season which means they can take up nutrients from very dilute solutions. It is not the duty of a fertilizer to feed the crop directly but rather to make up for deficiencies that exist in your particular soil, under your system of management. Some soils have no deficiency. They are exceedingly fertile. They meet the full requirement. Those soils would not require fertilizer and no benefits would be secured by the application of any. No soil is so poor but that it would meet some of the requirements. All soils will go part way in supplying nutrients, so we have varying degrees of deficiencies that exist, and the problem of working out a fertilizer practice for a given crop is one of examining whatever evidence may exist and on the

basis of that evidence trying to predict what the soil fails to supply, either throughout the entire reason or throughout a temporary period. We may have permanent shortages or temporary shortages. Now it is obvious that we can't give any complete program that will apply to all orchards.

If determining a program for a given piece of land becomes one of predicting deficiencies in that piece of land, you might think that the fertilization program wouldn't be the same on any two pieces of soil. That, however, is not the case, because there are certain general deficiencies, and when you have taken care of the general deficiencies you have gone a long way toward meeting the specific deficiencies that might occur on your particular ranches. It is a basic fact, which is recognized by everybody with experience in the growth of fruits and other crops in arid regions, that all of the soils of the arid regions are deficient in organic matter. The best soils have some reserves of organic matter. Some poor, thin soils have practically none but even in the best soils we eventually reach a time of deficiency of organic matter. We started with a low percentage of organic matter in our soils because in arid regions we never did have accumulations. The best soils of the humid regions have two or three times as much as our best soils but organic matter is a vital problem even in humid regions. There is a more rapid disappearance from our soils, and that rate is greatly speeded up when we start cultivation and irrigation. If you have a dry farmed orchard such as almonds, apples, apricots, etc., the rate of disappearance is not so rapid because the soil is not kept moist during the time of year when it is warm. Organic matter serves as food for bacteria. The rate at which these organisms work depends on the temperature. When the temperature is high, the rate is greatly speeded up and when we make soil moist enough for organisms to work throughout the entire year we have an even more rapid disappearance.

We have calculated roughly that in our irrigated orchards, whether citrus or avocados, the average rate of disappearance of organic matter is somewhere in the neighborhood of 6,000 pounds per acre per year. The amount may be variable. Some orchards may have less than that disappearance; some may have more. But we have calculated that somewhere in the neighborhood of that amount should disappear in order to maintain decay processes at the proper level.

I don't expect to go into why organic matter makes soils fertile, but it does nevertheless. Very few soils maintain their fertility when decay processes get to a low level. There are very few soils in which commercial fertilizers can be used with any degree of success unless decay processes are at a sufficiently high level. In one or two deep, sandy, soils which I know near here organic matter apparently is not yet necessary to make commercial fertilizer effective, but in all other soils commercial fertilizers are 'ineffective in the absence of decaying organic matter. That means that we have a general problem throughout orchard districts of Southern California, whether growing citrus, avocados, or other sub-tropical fruits. I don't mean the same thing would apply to walnuts but when we are dealing with the ever-green, sub-tropicals as a whole, it seems necessary to keep up the decay process to rsomewhat the same level. Therefore, the foundation of a fertilizer program, regardless of soil type, would be providing for the replenishment of this organic matter which is going to disappear. You won't always have to start at the same tree age on different soil types. If you have exceedingly good soil, recently

developed, the original supply ought to last a long time. If you have a soil which had been farmed for years before avocados were planted, it is probably depleted and you may have to start this organic matter program practically from the time you plant your orchard. Sooner or later even on the best soil that is going to become your problem.

There seems to be considerable experience to indicate that this figure of 6,000 pounds of decomposable organic matter per acre per year is a minimum figure for avocados rather than the maximum. We need more data to say definitely whether this is true or not. I don't think anybody knows at present. It would be safe at any rate to consider that as the minimum, at least in trial plots to see whether or not trees would respond. So, considering that eventually there is going to be this problem on every piece of land, quite a little time should be given to considering the best means of meeting that requirement.

We have several sources of organic matter which may be utilized for ¡soil improvement. One source is the leaves from the trees themselves. I don't know what tonnage is produced annually—dropped on the soil from avocado trees—but it amounts to quite a lot. Avocado leaves are a satisfactory source of organic matter. I have seen places where they have been turned under in considerable quantity and the material dug out later when still only partially decomposed these leaves would be grown through with avocado rootlets. So, apparently, they are a satisfactory source of organic matter for avocado fertilization and we should take pains to conserve the leaves. The leaves don't necessarily have to be raked out and put under in trenches or anything of the sort. They will eventually work into the soil and contribute if merely left under the trees. They contribute more toward meeting the organic requirement if mixed with Surface soil, but whether or not that should be done becomes a matter of economics. If it costs more to rake them out and disc them into the soil than it would to purchase an equivalent amount of organic matter, we should just let them alone under the trees. One would get a valuable source of organic matter by using that material.

Second, the most obvious source is manure. There are various sources of manure. Dairies, poultry yards, rabbitries, and other places. Ordinary dairy manure contains about 30% organic matter or 600 pounds per ton. If you are going to supply 6,000 pounds from that source, it would take ten tons per acre per year. You may not have to apply that much. You may get some of that from leaves. The highest grade manures—some of the steer manures from feeding lots where concentrated feeds are used—run as high as 50% organic matter, and poultry may run as high as 60%. You can secure from your Farm Advisor, I am sure, a table giving you the various classes of manure and you can make some calculations regarding material that you contemplate applying.

The third source is crop residues, or crops from other lands such as bean-straw, from the bean growers, alfalfa straw coming from places where alfalfa is grown for seed or alfalfa hay. A bale of hay is as good food for the field as it is to feed to a cow, and perhaps more so. A lot of hay, particularly of lower grades, is used for soil improvement purposes in Southern California.

The fourth source is cover-crop. This Supplies a good type of organic matter but the tonnage which can be produced from cover crops in bearing orchards is very limited. On the other hand, when trees get to that stage there are more leaves so perhaps the organic matter from the trees themselves offsets the lack of production of cover crop.

All of these sources may be utilized. When I talk about 6,000 pounds of organic matter per acre per year I should put in another word—"suitable." It is, therefore, necessary to define what we mean by suitable. The organic matter is not used directly by the tree. It is used for soil improvement. It improves the soil—not by its accumulation but by its disappearance. As it disappears, the products of bacterial activities release the fertility In the organic matter and in some instances liberate other nutrients from the soil itself. We are not interested in accumulating big reserves of organic matter from a fertility standpoint although we may be from the standpoint of physical condition of the soil. We are interested in replenishing the supply so we can have the disappearance of organic matter continue at fairly uniform rate year after year. Now if it is going to disappear and serve its full purpose of improving fertility, it must be of the right sort. It must be suitable food for microorganisms to make it disappear, to decompose it.

Balanced rations for the bacteria that live in the soil are as important as balanced rations for humans. These bacteria which live in the soil contain about ten parts of carbon to one part of nitrogen. The soil organic matter, sometimes called "humus," also contains about ten parts of carbon and one part nitrogen. It consists of the bodies, either living or dead, of these microorganisms. If you are going to supply food for these organisms that would be suitable for growth of new cells that food should contain about ten parts of carbon to one part of nitrogen. They do not use this food merely for growth purposes but for both growth and energy. Most of the organisms get energy from oxidation of carbon. That would mean that balanced rations are somewhat richer in carbon than this ratio of ten to one, perhaps, we will say 17 or even 20 parts of carbon to one part of nitrogen, would be a suitable food for both energy and growth. In other words if you apply material which has this ration of carbon and nitrogen, decay process goes on in the soil at a fairly good rate. The bacteria will be getting enough carbon for energy, enough nitrogen for growth, without digging into the supply of nutrients available in the soil.

There is a wide range of carbon to nitrogen ratio in materials we might use. We might apply sawdust. Hardly anyone would do that, yet they do sometimes buy manure that is pretty largely shavings. The wood in there would have a ration of about 400 parts carbon to one of nitrogen. Now suppose that were going to decay in the soil; were the only source of food for bacteria working in the soil. In order to decay the sawdust we would need a lot of microorganisms and they would have to have a lot of nitrogen. They would have to chew up a lot of sawdust to get nitrogen. Sawdust in poor soil would stay there for many many years. Sawdust in good soil would rot fairly rapidly but would deplete the soil fertility while in process of rotting. The reason it would rot rapidly is that the soil itself would supply the available nitrogen, use up your available nutrients instead of fertilizing your crop. We don't ordinarily apply sawdust but we might apply grain straw which would have a ratio of 100 to 1, and that wouldn't be very suitable food for bacteria. It is one that would remain in the ground for a long time. One grower at San Luis Obispo told me he had applied straw eleven years ago and said it was still there, undecomposed.

Lots of folks like to see the organic matter and don't want to plow under a cover crop while green and succulent because it decays too fast. That is nice if you get your pleasure out of looking at the little pieces of cover crop sticking up through the ground

but if you are talking about soil improvement, it has to disappear. We get the benefit out of its decay and not out of its staying there. So we try as far as possible to apply materials which have a ratio somewhere in the neighborhood of 20 to 1, or varying between 15 and 25 to one. That gives us a pretty good class of material, or if we have material that is of wider ratio than that, we supplement with commercial nitrogen—fertilize the bacteria, so to speak, and give them a balanced ration.

As the other extremes from straw is dried blood, which would have a ratio of four to one. That wouldn't supply enough carbon for energy. So we say material like dried blood is concentrated nitrogenous fertilizer and straw at the other end is very different because it has a deficiency of nitrogen and a big excess of carbon. Then it must follow almost as an axiom that if you are going to get the proper type of organic matter in the soil, you have to have a certain amount of nitrogen along with it. Many lots of ordinary manure will have a ratio of 30 parts carbon to one of nitrogen or 35, instead of being down near 20. Therefore, if you are going to get best results out of that manure, you should use a little nitrogen along with it. You may have applied bean straw which has 40 parts of carbon to one of nitrogen, but unless supplemented it will be pretty slow as fertilizer. Alfalfa hay gets to work right at once. That doesn't mean in the long run that alfalfa hay is necessarily better for a soil improvement standpoint than bean-straw but it does mean that if you get just as good results you have to use supplementary nitrogen along with it. Because the organic matter you eventually leave in the soil will have approximately 10, 11 or 12 parts of carbon to one of nitrogen. You cannot build up fertility without supplying enough nitrogen so that ratio may be maintained.

So you can see that regardless of the fact that different soils vary, and deficiencies differ in various soils, we can make some approach to a general recommendation. This is because all of our soils are in the first place deficient in organic matter, or eventually will be. And, in the second place, as we supply that organic matter we inevitably supply other nutrients which keep the soil fertile.

Some of my friends in the fertilizer industry have accused me of saying that trees utilize only nitrogen and organic matter. I have never made any such statement. Trees utilize all of the plant nutrients just like any other plant. They have heavy requirements for phosphoric acid, potarsh, calcium, magnesium, and minor requirements of sulphur, iron, copper, manganese, zinc, etc. A tree has to have all of these. I have said, and still say, that the most likely deficiency in the arid regions, whether the Salt River Valley of Arizona or California, is deficiency of organic matter. Along with that goes deficiency of nitrogen but not necessarily of minerals. You cannot build up organic matter unless nitrogen is built up as well. To that extent we have the existence of a general problem which applies to almost all soils—eventually will apply to all soils on which we grow sub-tropical fruits in California.

How about the requirements for other materials? There are soils in Orange County in which you grow avocados and lots of soil in San Diego County of low phosphate supplying power. Does that mean that phosphates should constitute a necessary part of your fertilization program? I think not, with a few possible exceptions. It seems impossible to meet the organic matter requirements of a piece of soil without bringing in material from the outside. I don't believe that taking just leaves from an avocado tree and such cover crops as you may grow, you can maintain the requirements.

It is inevitable that our industry be a parasite on the rest of agriculture to the extent that fertility cannot be maintained on soil itself. You have to bring in plant nutrients from some other fellow's land—alfalfa hay, bean-straw or nutrients used for animals when you bring in the manure. We wish we might maintain permanent fertility without being parasitic on some other lands, but the other fellow doesn't mind it. He has hay, bean-straw and manure to sell and considers us good customers. When we bring in other fertility, we bring in supplies of phosphate, available lime, potash and other nutrients. We cannot help but meet the need and while I never said an avocado tree or citrus tree does not use phosphate, I have said that when you meet the organic matter requirements, you will meet the phosphate and other mineral requirements on practically all soil.

You will all be interested in a bulletin which will soon be printed by the University—by Dr. H. D. Chapman, in which he reports his phosphate studies in Southern California orchards. He found that even the moderate amounts of manure used have increased the phosphate supply. This even occurs in those soils in San Diego County which have low phosphate supplying power. The soils in Orange County which have low phosphate supplying power for field crops do not have a low total phosphate content. The water soluble supply is low because of the presence of excess amounts of lime. I suppose somebody may try to get you to put lime on your soil and I would do that with considerable caution. Many of our soils in this part of the state have too much lime now.

We haven't a whole lot of data on the effect of lime on phosphate supplying power of soils. We do have some. Some virgin soils from this district fail to supply enough for the best growth of grain or tomatoes in pot culture. We know that citrus seedlings in that same soil do not make the response because of the fact that citrus has a longer growing season and has smaller requirements. The same would apply to avocados which have a bigger root system, more contact between root particles and greater absorbing power. We have some plots which Mr. Wahlberg has conducted in this county on citrus which have run ten years. Both sets of these plots happen to be, because of lime content, of rather poor phosphate supplying power. Yet the application of phosphates on those plots has had no effect on trees or on the fruit. If the tree gets enough, giving it more than enough has no effect.

Let's consider two other soils of known lower phosphate-supplying power than any soil we have in Southern California. One of these soils is on the Yuma Mesa, where citrus is grown. It has been found by actual experiment that citrus trees make no response to phosphate materials even though the virgin soil is very low in phosphate supplying power, provided somewhere in the neighborhood of five tons of good manure is applied per acre per year. That is not a very heavy application, but it does supply enough phosphate to produce twenty to twenty-five boxes of grape-fruit per tree. Additional supplies have no visible effect on yield or quality. The same experience was obtained in Northern California on soils of the Aiken series which are very low in phosphate supplying power. Some avocados are grown there as well as citrus and there is no evidence of shortage of phosphate even for sensitive crops, where a program includes five tons of manure per acre per year. I think we can say with absolute certainty that when you are bringing enough organic matter you will meet the mineral requirements for soil on which you are growing avocados.

However, there is one circumstance under which I would recommend that you make small trials with phosphate. This is where local experience shows that you get a response on the cover crop. If you are greatly increasing the cover crop with phosphate it will pay you to buy the phosphate for the sake of soil improvement you get from the greater green manure crop. Probably there are sections in San Diego where you will get some response in cover crop. You can try this in a small way in plots of a few yards square.

Now we may summarize in the time we have left and say that the chief problem in fertilization is maintaining a supply of organic matter plus some supplemental nitrogen. I don't know what amounts to suggest except that I have indicated about the rate organic matter will disappear—how much it will take to maintain a supply. The amount of supplemental nitrogen we should supply, you will have to determine more or less by local experience. I believe some people are inclined to apply too much. They hope to do with fertilizer what cannot be done with fertilizer. Avocado trees are many times shy-bearers under our conditions. I don't know why avocado trees are shy bearers. I do know that the difficulty can't always be overcome by fertilization and perhaps in some cases it can't be overcome at all. The most we can hope to do with fertilization is overcome the deficiencies in the soil and make it possible for a tree to bear what the climate and other limiting factors which affect it will permit it to bear. Lots of times shy-bearing is not from lack of fertility at all. I don't think it is possible to make an avocado tree bear by fertilization any more than a similar tree of the same variety would naturally bear in some of our best soils in this county without any fertilization at all. We certainly have some fine old avocado trees in deep fertile soils. I believe the amount those trees bear represents about the maximum yield possible as limited by factors other than fertility. Let's not get our hopes too high and spend money unnecessarily for fertilization. We can try to improve the yield but a tree can take up only so much. Shy bearing may be a matter of climate or something else. While it is said that avocados are heavy feeders, that hasn't been demonstrated. I don't think the requirements for avocado trees are necessarily very much greater than for orange trees, which do have requirements far in excess of most deciduous fruit trees. I don't believe we are forced into a very expensive program.

In meeting this program I would suggest that we use a variety of sources of organic matter. Buy whatever materials are most suitable and least expensive on the market at a given time and supplement the organic matter with nitrogen. Finally in some regions in this county and San Diego County experiment in a small way with phosphates, paying not so much attention to trees but rather to the effect on cover crops.

I realize that this talk has not given you a definite program to follow—I have not said that you should apply a given amount per acre per year. It has, I hope, given you some suggestions which may enable you to think about your particular property and may guide you in developing your own program. The industry as a whole is at the stage where citrus was 30 years ago. Information developed by growers themselves and exchanged in just such meetings as this has been of immeasurable value to the industry. I hope the avocado growers will make a study of fertilization and exchange ideas just as citrus growers have done. After all, aside from a few generalities, the details of fertilization must be based on local experience.