

been widely discussed and their benefits demonstrated.

The subject of soil acidity and its relationship to citrus fruit production is a very interesting one. The importance of calcium for proper metabolism has been demonstrated by Reed and Haas. If deficient, leaf abnormalities develop, but on the other hand, excessive quantities are detrimental.

A number of years ago liming groves in Florida was a rather common practice. It took several years to realize that this practice was proving harmful on the light sandy soils of the ridge section. Objections to liming were pointed out by Floyd* while working at the Florida Station. The work of Burgess and Pohlman† in Arizona may shed some light on the problem. They have shown that excessive amounts of calcium carbonate caused injury and chlorosis but this condition was alleviated to a large extent by the incorporation of vegetative matter. The higher the organic matter of the sand the less sensitive was the plant to excessive lime application.

The physical characteristics of soils, drainage, and organic matter content are possible factors determining the influence of lime on citrus. Sections on the East Coast and the lower-lying heavy soil types of the citrus belt generally, may have a pH approaching neutrality or even alkalinity

*B. F. Floyd. Some Cases of Injury to Citrus Trees Apparently Induced by Ground Limestone. Florida Agricultural Experiment Station, Bul. 137 (1917).

†P. S. Burgess and G. G. Pohlman. Citrus Chlorosis as Affected by Irrigation and Fertilizer Treatment. Arizona Agricultural Experiment Station, Bul. 124 (1928).

and yet maintain excellent groves while a similar soil reaction on the sandy Ridge belt may be unfavorable for tree growth.

The soils of the Ridge are variable in reaction as shown in the recent work of B. R. Fudge* of the State Citrus Experiment Station, whose researches contribute to the knowledge of the lime question.

Where it is deemed advisable to apply lime to citrus soils to control the reaction, small amounts used periodically to maintain a pH of 6.0 to 6.5 would seem preferable to a single application to accomplish this soil reaction. The question of whether added lime is beneficial as a result of correcting soil acidity or because it supplies available calcium to the trees should be given thought, and the possible deficiency of calcium in Florida soils should be considered when compounding concentrated chemical fertilizers.

These problems, including a study of the effects of such fertilizers, when reinforced with essential elements, are ones which we hope to study in experiments on soils of varying reactions and types.

Among the encouraging developments in the manufacture and use of chemical fertilizers may be noted the growing appreciation on the part of both the manufacturers and the growers of technical information pertaining to the use of chemicals for different crops, on different soils and under different climatic conditions.

*B. R. Fudge—Soil Acidity and Its Relation to Growth of Citrus. The Citrus Industry, Vol. 11, No. 9 (Sept., 1930).

THE IMPORTANCE OF CALCIUM IN CITRUS CULTURE

By Gray Singleton, Consulting Chemist, Ft. Meade, Fla.

For many years it has been noted by Florida citrus growers that the citrus fruit and citrus fruit trees grown in different parts of the State exhibit different characteristics. For instance, the fruit grown along the Indian River, in Dade County, certain sections of Manatee County and parts of Pinellas County is supposed to have a thinner skin and more juice per size than the

fruit grown on the Norfolk sands of the Ridge section. It is also claimed by growers in the coastal sections that their fruit has a better color and higher aroma, or flavor, than fruit grown elsewhere.

There seems to be some basis of fact in the contentions of these growers as well as in the claims of the tangerine growers of the Brooks-

ville section and the pineapple growers of Marion County and parts of Lake County that their fruit takes on a deeper red color on maturity than fruit from other localities.

On investigating these claims we find that the rule does not hold good for any particular section but that it does hold on certain types of soil. In Marion, Lake and Pinellas we find that the fruit grown on Norfolk soil is no different from that grown on the same type of soil in any other part of the State, but the fruit grown on heavy 'hammock' soil, overlying limestone, seems to be quite different.

It is important to note that all of these soils which yield a thin skinned, highly colored and highly flavored fruit are on a calcareous base rather than a sand base.

It has also been noted that fruit grown on soils with a limestone or shell base seems to mature earlier than the same varieties grown on sandy soils. In fact, before the advent of the arsenic spray, fruit from the calcareous soils matured several weeks ahead of fruit from the sandy sections.

Some years ago the growers noticed that fruit grown on sandy soil, but sprayed heavily with lime-sulphur, exhibited many of the characteristics of fruit grown on the limestone soils. Color and texture were better, the rind was thinner and the fruit matured earlier. This effect was generally attributed to the polysulphides of sulphur, but the fact was also noted that dusting with sulphur did not give the same results as spraying although the insecticidal effect seemed to be fully as good. It was unquestionably true that fruit heavily sprayed with lime-sulphur matured earlier, had better color and texture, a thinner peel and therefore more juice per size than fruit dusted. Some years ago the writer was employed by a group of large owners in the State to carry on systematic research work to explain, if possible, the differences noted and possibly to develop legitimate methods of producing a normal earlier maturity, thus lengthening the shipping season and getting away from the use of arsenic.

The first step was to vary the amounts of lime and sulphur in the spray. It was found that in-

creasing or decreasing the sulphur made no difference, so far as could be determined, in the physical condition of either tree or fruit. On the other hand, increasing the lime content of the spray had a very marked effect, both on the tree and on the fruit. As soon as it was definitely ascertained that it was lime that was causing the desired effects a long series of experiments was started which have been running for six years. The work is far from being completed but the data secured warrants a preliminary report from which you can arrive at your own conclusions.

The first experiment was to take a number of trees and spray them with solutions containing varying amounts of lime and sulphur. This established the fact, as stated above, that it was lime that caused the difference. The next step was to take a number of trees and spray half of each tree with solutions of lime varying from none to fifty pounds of hydrated lime in two hundred gallons of water. This was done about May first and in every case where more than two pounds of lime was used to two hundred gallons of water there was a marked improvement in the condition of both tree and fruit on the sprayed side as compared to the unsprayed part. The most striking difference was the dark green foliage and deeper colored fruit on the sprayed side while the foliage and fruit on the unsprayed side remained pale. On a number of trees it was noted that the sprayed side put on a flush of new growth and a few of them bloomed while the unsprayed side remained more dormant. This experiment was conducted in a grove that was not responding well to fertilization. It had been fertilized but the owner said that it was not "feeding well."

Another difference, which was entirely unexpected, was noted in this grove. The fruit and foliage on the unsprayed side of these trees showed much melanose. The sprayed side, where ten pounds or more of lime was used to two hundred gallons of water, showed practically no melanose on fruit or new growth. Careful examinations showed no damage to friendly fungi and no scale infestation followed. To check this observation three test plots were laid out. Plot No.

1, was sprayed with Bordeaux Mixture made from four pounds of bluestone and twelve pounds of lime to fifty gallons of water. Plot No. 2, had a Bordeaux made from four pounds of bluestone exactly neutralized with lime. Plot No. 3, was sprayed with twelve pounds of lime to fifty gallons of water. The remaining part of the grove was used as a check. The four plots, including the check, contained five acres each. The test was made on early grapefruit.

Plot No. 1, was severely damaged by scale in spite of three sprayings with oil and the copper persisted on the foliage for fifteen months.

Plot No. 2, was lightly infested with scale but this was controlled with one oil spray. Copper seemed to be gone in about three months.

Plot No. 3, showed no more scale than the unsprayed check, which was negligible.

Fruit and foliage on the three sprayed plots were practically free from melanose, while the check plot was damaged considerably, both as to fruit and foliage.

The physical condition of Plots 2 and 3, were about the same. Both showed a darker green than the check.

The next step was to take ten groves in one or more of which were planted practically all of the standard varieties of orange and grapefruit. These groves were sprayed twice, the first time in May and the second time in September. Each time ten pounds of lime was used in two hundred gallons of water. Seven of these ten groves showed markedly earlier maturity than normal. Seedling oranges gave practically the same analysis November 15th as unsprayed seedlings showed January 15th. There was no inhibition of acid formation as is the case with arsenic and the flavor, if anything, was actually better than normal fruit. Ten pounds was selected as the amount of lime to use because in some cases, where larger amounts were applied, the rind was so thin that serious splitting and creasing occurred and the fruit did not ship well. In no case was tree damage noted, even where fifty pounds of lime was used to two hundred gallons of water. Several of these groves had trees with typical cases of dieback. In all cases they seemed

to be benefited and subsequent growth was well rounded and normal.

Juice measurements were made through the season on these ten groves and, on medium sized fruit, the increase, on both oranges and grapefruit, was from seven to nine per cent over fruit of the same size from unsprayed groves. Due to variations of seed content and thickness of rind no definite trend could be established on very small or very large sizes. In the early stages of maturity, both in orange and grapefruit, the increase in juice content was often twenty per cent over that of unsprayed fruit. Pineapple oranges did not react as well as seedling oranges except as to color of fruit.

It was noted in these experiments that Valencia oranges sprayed with lime do not turn green in spring and that they seem to remain on the tree much longer without drying. Tangerines and Temple oranges seemed to show the same tendency to hold juice later and tangerines showed a definite tendency to size up earlier in the fall. The color and texture in all oranges, tangerines and Temples was improved, but in some cases earlier maturity was not up to expectations. Later experimental work seems to show that deficiency in magnesium, or iron, or both, may affect maturity. Work along this line has not gone far enough to justify a definite statement.

It was known from previous experience that the application of lime directly to the soil would improve the appearance of the fruit, giving it a deep red color, but it was also known that this practice is dangerous to the trees.

Various combinations of lime were tried as fertilizers. Hardwood ashes and bone meal gave the characteristic dark green color to foliage if applied in considerable amounts. Calurea gave the same color and good results were gotten from a mixture of three hundred pounds of calcium cyanamid with one ton of pulp made from culled citrus fruit. This material is now being manufactured by a number of canneries from refuse. All of these materials seemed to improve the physical condition of the tree without the subsequent damage characteristic of direct applications of lime and all seemed to show a trend toward earlier maturity. The best results were gotten from

a combination of a lime-bearing fertilizer and a direct lime spray.

In order to cut down expense of spraying, experiments were made using a combination of the usual lime sulphur solution with added amounts of hydrated lime. The insecticidal value of the lime-sulphur solution seemed to be in no way diminished and the control of melanose was markedly improved. A number of experiments were tried on lemon scab but in all cases there was just as much scab on the sprayed as on the check plots.

Where calcium cyanide is used as a spray to kill Spanish Moss or prevent greasy melanose, lime may be added, but it is not recommended that it be used with oil emulsions or Bordeaux mixture. In some cases where lime, lime-sulphur solution and calcium cyanide have been used there seemed to be a definite killing of scale insects. This spray will burn young foliage and its use has not been sufficiently tested to warrant a definite statement as to what it will do. Cyanide, without lime, seems to have no effect on maturity. Lime alone seems to be definitely toxic to the Florida wax scale, even more deadly than oil emulsion but two applications are necessary, as the young under the old scale are not killed by the first application.

In summing up I would say that from what experimental work has been done it seems that lime can legitimately be used to lengthen the shipping season, both in fall and spring. It is markedly effective in causing early maturity in only about seventy per cent of the groves where it has been tried, and on lemon root and sandy soil it is not always effective in holding juice in tangerines and Temples. Its use is now standard practice on several thousand acres of groves and in all cases it has improved the color, texture and eating qualities of the fruit as well as giving a markedly beneficial reaction in the physical condition of the tree. The effect of lime is in no way similar to arsenic. It benefits both the tree and the fruit while a heavy spray of arsenic damages both and prevents the formation of acid and flavor. Lime is not nearly so effective as arsenic in getting fruit to pass the maturity test but the superiority of the fruit, especially oranges,

and the benefit to the tree more than make up the difference.

This work was financed in part by Gentile Brothers of Orlando, but principally by Mr. L. Maxcy, of Frostproof, and Mr. Barnard Kilgore, of Clearwater, and is made public at the request of Honorable Nathan Mayo, Commissioner of Agriculture for Florida.

Dr. David Fairchild: I would like Mr. Singleton to state if he ever sprays with any other substance besides calcium or lime and sulphur in the Spring?

Grey Singleton: Experiments have been carried on with a wide variety of substances and combinations, but the best results that have been gotten come from the use of lime.

Dr. David Fairchild: What were some of those substances?

Grey Singleton: Iron, manganese, magnesium, and a combination of those elements.

Dr. David Fairchild: I would like to tell a story, Mr. President, in regard to this very interesting paper of Mr. Singleton's. I was in the Mediterranean district and stopped in to see the citrus collection at a famous garden. The manager told me the experience he had had in the spraying of citrus trees, and it was rather striking. I think you would be interested in it. When he took charge of this wonderful garden, which is the most famous garden on the Mediterranean, the authorities and pathologists had condemned the citrus collection of about seventy varieties of fruit, on account of the scale insects and citrus diseases, which were eating them up. The new owner of the garden inquired of his manager whom he had to take charge of the estate, what he had better do. The authorities had recommended that the citrus grove be destroyed. He said to the owner of the estate "If you will give me the money that it would cost to dig those citrus trees out I think I can cure them." I said "What did you do." He said "I laid out a pipe from the house sewer and put some spigots in the grove, and dressed up in slickers, and sprayed those trees with the sewerage water from the house." He said he immediately created a new

garden. All I can say is that I seldom have seen a more perfect grove than that which he had in this garden, and he had continued this process of

spraying with sewerage water from the house. It was evident some of the applications were made, but it was rather an odorous process.

THE IMPORTANCE OF CERTAIN SPECIAL ELEMENTS IN THE AGRICULTURE OF SOUTH FLORIDA

By R. V. Allison, Everglades Experiment Station, Belle Glade

An inspection of the literature will indicate that during the past few years the question of the role of certain of the rarer elements in plant nutrition has come to occupy a place of increasing importance in many of the seminars and congresses of our own and other countries in which the more fundamental problems of plant development and reproduction are brought forward for serious thought and discussion. The workers of your Experiment Station here in Florida have contributed to this field in a number of ways and it is particularly on account of the almost paramount importance of some of these studies to the agriculture of South Florida that the present subject was suggested. Through the courtesy of your Secretary, provision has been made for the use of slides and a considerable number will be presented as this is by far the most satisfactory way of comprehensively displaying results of this kind.

The composition of the plant is of first importance from the standpoint of its usefulness in animal nutrition. Naturally, therefore, the unusual results that have been obtained in these investigations of the role of the rarer elements in the growth of higher plants have greatly stimulated, in turn, the investigation of the possible importance of these elements in the normal development and functioning of the many organs and parts of the animal body. Witness the unusually important work of McHargue in Kentucky who started out upon the investigations, in pure culture, and has continued on into animal nutrition with the use of plant material developed under such rigidly controlled conditions.

Likewise the current work of McGhee of Emory University, among many others, who is

contributing importantly to the considerable amount of work that already has been done upon the role of certain metals in the maintenance of the hemoglobin content of the blood. His studies are largely based upon the use of milk that has been very carefully drawn and preserved from contact with metals in any form. He obtains remarkable results in the control of anemia by simply soaking alloys of certain of these metals in the milk to be used in feeding tests in comparison with untreated milk and finds that sufficient of the necessary ions go into solution to give very satisfactory regeneration of the hemoglobin and maintain normal health in the bodies of the animals involved. On the other hand, animals receiving a continuous diet of untreated milk rather rapidly became comatose and showed very little appetite. With the use of animals showing this latter condition for further study, however, it is found that after but four days upon a diet of the so-called "Metallized" milk they become quite normally active, play about freely and eat ravenously. In the course of eight weeks such animals have been observed to rise from below thirty-nine per cent hemoglobin to ninety-two per cent.

You will be interested in learning that the Experiment Station hopes to be able, in the near future, to announce the results of rather extensive studies upon what has been referred to as "Salt Sickness" that is found to be especially common among cattle upon the open range in certain sections of the State. The results of these studies to date have shown striking correlations between the use of certain of these metals referred and the correction of the disorder. In fact, it is this work in particular that has