beginning in October and getting it through not later than November 20th. We then apply the fall application of fertilizer and harrow it in with Acme harrow. It then depends on the bloom and weather conditions as to the amount of cultivation we do in the spring. If it is inclined to be dry, I find that to harrow often helps to set and size the fruit. It is desirable to get size on your early varieties, and if you fail to do this before July 1st, you will have trouble sizing it up later. We do considerable more cultivation on early oranges, early grapefruit and tangerines than we do on Seedless grapefruit and Valencia oranges, as these are the two varieties we try to carry through on as small sizes as possible to the end of the shipping season.

In conclusion, will state that we keep the matter of cost in mind at all times and believe that we are producing fruit just about as economically as can be done to produce the best quality possible.

And I will say I personally supervise the production on the 4000 acres which we own, and in addition I check over three-quarters of a million boxes annually as it passes through the packing plant, as to size, grade and quality. These remarks on this paper are based on that experience.

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**ZINC SULPHATE AS A SOIL AMENDMENT IN CITRUS GROVES**

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**INTRODUCTION**

Interest in the use of zinc sulphate on citrus trees has been steadily increasing in Florida, due primarily to the continued publications in California citrus magazines of reports on this subject by various California officials; notably, Dr. W. H. Chandler and Messrs. J. C. Johnston, L. D. Bachelor, Warren Schoonover, H. L. Thomason and others. Interest in the matter has been further increased by the fact that the Horticultural Department of the Florida Experiment Station has been experimenting with zinc sulphate for several years, and in the last two years has developed the use of this chemical on a wide commercial scale in the treatment of bronzing of tung trees. Without going into detailed discussion of the various papers published in California, they may all be summarized as follows:

In attempts to find a cure for mottle-leaf of citrus, which is commonly called “frenching” in Florida, it was found that iron sulphate gave favorable response, but later it was found that pure samples of iron sulphate failed to give satisfactory results. In studying the impure samples which were originally used, it was found that a considerable amount of zinc was present in the chemical as an impurity and subsequent experiments showed that it was the zinc rather than the iron which was having the corrective effect. As a result of this finding, extensive experiments were carried on on citrus mottle-leaf in 1932 and 1933, and the latest report would indicate that the results are about as follows:

In a large number of experiments on the use of zinc sulphate on the soil it has been found that many cases of mottle-leaf showed a startling recovery, but that in other cases no results or unsatisfactory results were obtained. The zinc sulphate was applied to the soil either broadcast under the tree or in a ring at the base of the tree. In some cases almost immediate response was obtained in the form of new and normal growth, and in other cases damage to the tree or failure to obtain any results at all occurred. The amounts used varied all the way from one-fourth pound to forty or fifty pounds per tree. The use of zinc sulphate in sprays has apparently given more consistent results than soil applications. Sprays consisting merely of zinc sulphate and water with an added spreader gave favorable results in many instances, but were likely to cause damage, and at the present time are not recom-
mended by the California Experiment Station, which recommends for experimental work a spray made up of five pounds zinc sulphate, two and one-half pounds hydrated lime to neutralize the zinc sulphate and water to make fifty gallons. Johnson reports that the results from this zinc lime spray are somewhat more inconsistent than the results obtained from the straight zinc sulphate spray, at the same time admitting the occurrence of damage to the fruit when zinc sulphate alone was used. Zinc sulphate has also been used with lime sulphur and, while very excellent results are reported so far as the correction of mottle-leaf is concerned, they also report a very considerable reduction in the toxicity of lime sulphur to insects.

All workers admit that, while they sometimes obtain very outstanding results, their results are nevertheless inconsistent and that many cases of failure result. The Experiment Station of California recommends great caution in the use of zinc sulphate except on those groves which are so severely affected with mottle-leaf as to make them non-productive. No evidence has been produced in California to show the value of zinc sulphate on otherwise normal trees. This is stressed in view of some of the results which have been obtained in Florida during the last several years. The first outstanding results in this work were those obtained in the studies on the "bronzing" of tung trees. Work on this was started by Mr. Mowry of the Horticultural Department in 1931 and continued by the writer since Mr. Mowry's transfer from the department. Mention of this work will be made somewhat in detail owing to the fact that it has a very considerable bearing upon the possible use of zinc on other crops in this state. "Bronzing" of tung trees, which is in all probability a trouble very closely allied to certain types of "frenching" of citrus, has been very wide-spread during the last four or five years. It was observed first in connection with trees planted on phosphatic soils in the Gainesville region, but since that time has been found widespread on many soil types, and in particularly severe form upon soils which had been farmed to cotton for many years before being planted to tung trees. Some of these same soils when used as virgin soils have not shown this trouble so far, but when these same soils have been cultivated over a number of years their characteristics apparently changed to such an extent that extremely severe cases of "bronzing" have taken place. The extensive spread of this trouble throughout the tung-oil industry has resulted in the work of zinc sulphate being largely devoted to this crop. As a result of these experiments, it has been found that bronzing of tung-oil on trees under five years old can ordinarily be corrected with as small an amount as one-half pound per tree of zinc sulphate broadcasted on the soil, and in the case of most young plantings where bronzing is not severe as little as one-fourth pound per tree has proven highly satisfactory. All of the large commercial plantings of tung-oil in the Gainesville district are now being treated with this chemical. For larger trees, somewhat larger applications have to be made and the work is still far from being complete enough to determine the size and frequency of applications that will have to be made, and other questions will inevitably arise. There will be treated in this state this year approximately six to seven thousand acres of tung trees. This is the first wide-spread application on a commercial basis of the findings on zinc sulphate.

Similar results have been achieved by the use of sprays consisting of zinc sulphate and lime, but inasmuch as it is not the present practice to spray tung trees and inasmuch as relatively small quantities applied to the soil will produce results, the utilization of the spray has not been attempted on a commercial basis. It is interesting to point out that in several cases of tung tree bronzing under observation adjacent blocks of satsuma trees on the same type of soil have been very severely affected with "frenching," and that pecan rosette which is now known to be corrected by applications of zinc sulphate has also occurred under similar conditions. Last year workers in agronomy and chemistry also found that white-bud of corn, which occurs extensively on these same soil types, can be corrected by applications of zinc sulphate to the soil, amounts as low as 12 pounds per acre being used with success.
Knowing that zinc was a necessary element for the growth of citrus it has been frequently tried during the last six or seven years in an attempt to correct various troubles occurring in the field but without results, probably because the trees used were not deficient in zinc. The first outstanding results were obtained on a seven-year-old Satsuma orange grove at the Experiment Station at Gainesville. This grove had been planted originally as a rootstock test and is adjacent to a block of badly bronzed tung trees upon which extensive successful tests have been carried out with zinc sulphate. The land is old cotton land, but of a rather mixed soil type not readily classified, and there are limestone outcrops in one or two places. The tung trees had bronzed badly and the satsuma trees had been a failure from the start, being affected with a very severe case of frechining with the accompanying small leaves, bunchy growth and severe cold damage during the winter. It should be pointed out in this connection that while the soil was unfit for citrus that it nevertheless grew a magnificent crop of crotalaria year after year. Every care had been given the grove both as to culture and fertilization without result. In the spring of 1933 two rows of trees were treated with one-fourth pound each of 89% zinc sulphate and two rows with one-half pound each. This was broadcast under the spread of the tree. These applications were made in March and by the end of May the trees showed a marked recovery with the first willowy growth typical of Satsumas that had appeared since the planting was made and bearing unfrenched leaves. At the end of June one of each treatment was given an additional treatment. At the same time a row was treated with one pound per tree and one with two pounds per tree.

The four rows first treated grew exceedingly well throughout the summer and the difference between the treated and untreated trees was very pronounced and readily visible to the eye. The new growth was practically free from frechining and normal in shape and size and the trees filled in so as to lose the typical skeleton-like appearance which they had previously presented. By fall the difference was so striking as to be visible from a considerable distance owing to the deeper green and the increased density of the treated trees. During the winter the check trees were almost completely defoliated by cold as had been the case during previous winters while the treated trees were untouched by cold. Measurements of height and spread made during the winter showed a slight margin in favor of the treated trees, but the chief difference lay in the increased amount of foliage and the filling in of the tree as shown. The treated trees bloomed heavily and set a heavy crop in the spring of 1934, whereas the check trees bloomed very lightly.

The additional two rows which were taken into the experiment in the end of June were slow in responding. This was probably due to the fact that the application was made after the new flush and results did not show up until the fall flush. By late fall, however, the trees were markedly better than the check rows on either side and stood the winter splendidly.

In 1932 a number of experiments were started in central Florida on oranges and grapefruit utilizing zinc sulphate together with a number of other compounds. These were applied to trees that were mildly frechined or slightly yellow, and some cases so-called "decline" trees which were in bad shape. No results were obtained from any of these experiments, however. In 1933 these experiments were extended materially and following the obtaining of results on the Satsumas as above mentioned a very extensive series of experiments was laid out on slightly frechined trees in Polk County and on similar trees in Marion County. In no case have any results been visible from those experiments. In the case of the majority of Polk County applications, the work was done about September 1 and on September 4 a very severe storm occurred, together with heavy rains, which probably leached the zinc sulphate from the soil. Most of these experiments had to do with soil applications, but at each place some trees were sprayed and in one instance a part of a tree was sprayed and some results seemed to be visible on this tree in the spring of 1934. Part of the failure to obtain results may have been due
also to the fact that the groves in the neighborhood of Lake Wales, where the more extensive experiments were carried on, have put on a vigorous normal growth this spring, and this may have covered up any evidence of the results from the treatments. It is quite possible that results may show up when the June flush occurs.

Additional treatments were made in March of this year, using both spray and soil applications and in the case of one property very remarkable results have been obtained. This grove which was in the neighborhood of Lake Hamilton had been fenching for about five years and the Pineapple trees are in very bad condition, with practically all of the growth of previous years lost and the small remaining amount of foliage very severely frenched. Early in March Pineapple orange trees in this grove were treated with applications to the soil varying from two to fifteen pounds per tree, and two trees were sprayed with a zinc-lime spray made up of five pounds zinc sulphate and five pounds of lime to fifty gallons of water. The spray was applied by means of a bucket sprayer and it was impossible to reach the tops of the trees, but the lower two-thirds of the tree was covered very well. An examination five weeks later showed an amazing response from the sprayed trees which had produced a very heavy growth of new foliage in the spring flush, which had entirely filled in the central part of the tree, whereas neighboring check trees were still skeleton-like and the new growth badly frenched. The new growth on the sprayed trees was all normal and unfrenched and of a very desirable type, except in the top of the tree which was not reached by the spray. This shows the necessity for obtaining a full coverage when spray is used since the zinc thus absorbed apparently does not spread widely through the system of the tree. Of the trees receiving soil treatment, only those receiving application of ten and fifteen pounds per tree showed any response with the fifteen-pound application giving the best response. In this case there was considerable new growth and most of it unfrenched and the tree was beginning to fill in rather rapidly. In consideration of the fact that very little rain had occurred between the time of application and the time of observation, even this rather small response is rather remarkable as some of the zinc sulphate was still lying on the surface of the soil. Similar results have been observed on Pineapple oranges in other groves in which either spray or soil treatment was used. These groves are typical of a number of groves occurring throughout the state in which fenching, for some reason or other, has become so severe as to result in a dying back of the trees and a complete loss of fruit-bearing power. All of these groves show typical symptoms with the most severe fenching at the tips of the limbs and with more normal leaves toward the center of the tree. The trees die back from the tips of the twigs and are greatly reduced in size over a period of years. The fruit becomes smaller as the trouble increases in severity, and the trees finally stop bearing. Such groves are invariably found to have very poor root systems, sometimes reduced to almost none at all, and recently some of these groves have been found infested with a scale insect, a paper on which will be delivered at this meeting by Professor Watson of the Experiment Station. These groves represent the very worst type of fenching occurring in the Florida area, and as might be expected the most startling results have been obtained from them.

Similarly striking results have not been observed on other varieties of citrus than Satsumas and Pineapples. This is probably due, as much as anything, to the fact that trees of other varieties worked with were not in the same severely damaged condition. Pineapples suffer most severely from such troubles and striking results are thus easier to obtain. Some less noticeable but definite results have been observed on Valencia oranges which were only slightly affected with fenching, being observable as a slightly deeper green of the foliage. Other experiments are in progress on other varieties which it is believed will show results.

**DISCUSSION**

Zinc sulphate is apparently a corrective for certain types of severe fenching and probably an aid in cases of less severe fenching as represented by
the earlier stages of the same trouble. It is quite probable, however, that not all types of frenching will respond to treatment with zinc sulphate, since frenching may presumably occur as a result of a variety of causes. In other words, if the cause is a deficiency of zinc or a trouble which can be corrected with an application of zinc, response will be obtained, but in cases of frenching caused by other troubles the zinc sulphate will not be effective. It is only in this way that the very erratic results which have been obtained in both California and Florida can be interpreted. We are making every effort to classify the various types of frenching in order to see if we can distinguish between those that will respond to zinc applications and those that will not.

There appears to be considerable irregularity in the response obtained from soil applications of zinc sulphate and the reaction to sprays seems to be somewhat more certain. While our knowledge is too meager at the present time to determine the meaning of this it is quite probable that some soils are in such a condition as to nullify the effect of the soil application. There is also another factor in favor of spray applications arising from the fact that while we have used applications of ten to twenty pounds per tree on the soil without immediate injury to the tree, we nevertheless know nothing concerning the future effect of such applications upon the soil itself.

So far results would indicate very strongly the undesirability of the promiscuous use of zinc sulphate. There are several reasons for stressing this point at the present time. In the first place, we do not have as yet a thorough knowledge of what happens to the zinc sulphate when it is applied to the soil. If it is leached out the problem will probably be quite simple, but if it is "fixed" through interaction with other compounds in the soil the problem may become much more complicated.

In order to aid any purchasers of zinc sulphate we wish to call attention to the following:

Zinc sulphate may be encountered in the market in at least three different forms carrying varying percentages of water and zinc sulphate. The water is technically called water of crystallization and is bound up in the crystals along with the zinc sulphate. It is nevertheless water and for the purposes of treating trees should be considered as such and prices estimated accordingly. Pure zinc sulphate without water of crystallization is not likely to be found on the market and careful inquiry should be made to determine the analysis of the material offered for sale. For the sake of clarity the following table is made up to show the relative value of the three commercial products as compared with pure, 100% zinc sulphate (which will probably not be found on the market). Since some companies indicate the percentage in terms of zinc metal and some in terms of actual zinc sulphate both percentages are given and for the additional clarity the approximate percentage of water and impurities is also shown. In order to show clearly and to give some basis for figuring the last column was added to show the relative value per pound and for the sake of convenience 5c per pound for the 89% zinc sulphate was taken as a basis. It is obvious that quotations must be taken in relation to the percentage of active zinc or zinc sulphate in the compound and all figuring should be done accordingly since if one pound of the zinc sulphate containing 36 per cent. of zinc metal is recommended approximately 1.4 pounds of the 25 per cent. material and 1.6 pounds of the 22 per cent. material will be required. Quotations should also be figured to a delivered price since f. o. b. factory figures may be misleading due to the large amount of water to be transported in the low analysis material. It will be noted that in the material containing 22 per cent. metallic zinc that 44 pounds

<table>
<thead>
<tr>
<th>Formula</th>
<th>% Zinc Sulphate</th>
<th>% Zinc</th>
<th>% Water</th>
<th>Relative Value by Weight</th>
<th>Relative Value in Price per Lb.</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZnSO₄</td>
<td>100</td>
<td>40</td>
<td>00</td>
<td>1</td>
<td>5.0c</td>
</tr>
<tr>
<td>ZnSO₄·H₂O</td>
<td>89</td>
<td>36</td>
<td>11</td>
<td>1.4</td>
<td>3.5c</td>
</tr>
<tr>
<td>ZnSO₄·5H₂O</td>
<td>63</td>
<td>25</td>
<td>37</td>
<td>1.6</td>
<td>3.1c</td>
</tr>
<tr>
<td>ZnSO₄·7H₂O</td>
<td>56</td>
<td>22</td>
<td>44</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

¹The above figures are approximate and used to conform to commercial values.
in every hundred will be water and freight will have to be paid on it along with the actual zinc sulphate. For making up sprays the tank may be nearly filled with water and the lime required, or with lime sulphur solution and the sticker added. Dissolve the zinc sulphate separately in a bucket of water. This is most easily accomplished by first putting the water in the bucket and adding the zinc sulphate slowly with constant stirring, since the 89% per cent. material will cake badly if water is poured onto the dry salt. Start the agitator in the spray tank and add the zinc sulphate solution slowly and spray out of the tank without stopping the agitator.

The Experiment Station recommends no particular brand of zinc sulphate and has used all three types listed with success. Owing to the fact that the bulk of the work has been done with 89% zinc sulphate (36% zinc) recommendations are made in terms of this and should be increased as outlined in the table for the lower percentage materials. Materials should be purchased and used, however, upon the basis of zinc or zinc sulphate content and not upon gross weight.

Member: Which grade did you use in your experiments?

Dr. Camp: We have used all the grades mentioned. As far as we can see there is no particular difference between them in value. We have used more of the 89 per cent. than any other. In making the sprays if you use the 89 per cent don't put it in a bucket and pour water on it. Put the water in the bucket and pour the zinc sulphate very slowly on it. The lower grades with a higher percentage of water of crystallization dissolve easier.

Member: How much calcium did you put in that?

Dr. Camp: The regular amount.

Member: What is the advisability of getting a very much lower grade, I mean a grade of zinc with all the impurities, at a very much less price?

Dr. Camp: We have some samples already in from one of the companies working on that point. This sample that came in I think contains about 80% zinc sulphate. I might point out that the cost in making zinc sulphate lies largely in the last purification, largely removal of iron. What we are trying to do is to get from these companies a grade that they can handle commercially, which will be cheaper on the market. They have started sending samples and we are trying them out. We may be able to materially reduce the price.

Member: I would like to ask if you found that the soil reaction has any bearing on whether you get results with zinc sulphate in attempting to cure frenching. Can a tree growing in acid muck, and badly frenched be improved with zinc sulphate?

Dr. Camp: I wouldn't attempt to answer that. The problems in relation to muck are so different from those in relation to the sandy soils. I think frenching in some instances is caused by something else besides zinc deficiency.

Member: I would like to ask a question about frenching. Last year and the year before there was a lot of it, and this year there is less. Why is it—on account of more rain or what?

Dr. Camp: I know both bronzing and frenching is considerably reduced this year, and many trees slightly frenched last year have come back with a beautiful growth this spring. I think it is largely a moisture condition.

Member: Last year I tried ashes on frenching and I must say I didn't get any results. I tried some different things. This year, so far, both of them have disappeared, and I think one reason why there was so much frenching last year was because of lack of moisture.

Dr. Camp: I think that's true of both frenching and bronzing.

Member: I have spent fifty years with an orange grove, and I never saw so much frenching as last year, and particularly bronzing. Can you tell me the cause?

Dr. Camp: No. I know of some cases where it has been corrected largely by mulching and improving moisture supply.

Member: Is it not a fact that calcium is absolutely essential for fruit, and is there any calcium in Florida soil, and if there isn't what is the
necessary amount to use to have the Florida soil in proper condition so there will be no frenching and permit conversion of organics to take place properly?

Dr. Camp: That varies in different soils. In the northern belt some soils have a very large amount of calcium; the same is true of the East Coast. That would have to be determined on the individual groves. Discussion on lime could run into the rest of the day.

MACHINE PLACEMENT OF FERTILIZERS APPLIED TO SNAP BEANS IN FLORIDA

George H. Serviss, Soil Fertility Division, Soil Investigations Bureau of Chemistry and Soils, U. S. Department of Agriculture

Since 1931, experiments have been conducted in the Winter Garden area of Orange County, Florida, to determine the best placement of fertilizer for snap beans. The fertilizer was applied and the seed planted with a machine especially designed for the work by the Bureau of Agricultural Engineering. This machine could be adjusted to place the fertilizer in any desired position in respect to the seed. One of the experiments was on St. John's fine sand and the others were on Leon fine sand. Three fertilizers were used in the experiments, which were placed in 9 positions in relation to the seed. Two were fertilizers analyzing 5-7-5, one having its nitrogen derived wholly from mineral or inorganic sources and the second containing nitrogen one-half from inorganic and one-half from organic sources. The third fertilizer analyzed 10-14-10, containing ammonium phosphate, urea, nitrate of soda, ammonium sulphate, and sulphate of potash.

Stand counts were made on the fifth and seventh days after planting and again after all the plants were up, which was usually on the twelfth or fourteenth day. Stand counts and yield records were taken from 100-foot sections of row replicated 6 times throughout the field for each placement.

The photographs reproduced in Plates 8 and 9 show the results of fertilizer placement in different positions to the seed on germination, "come-up" and early growth of snap beans.

Snap beans failed to come up when 700 pounds per acre of a 5-7-5 fertilizer or 350 pounds per acre of a 10-14-10 fertilizer was applied at planting in contact with the seed. When these fertilizers were applied 1 inch below the seed in bands 1.75 inches wide (Plate 9-A), or 3.5 inches wide (Plate 8-c), germination of seed, as evidenced by appearance of plants above ground, was delayed or stands were poor. Fertilizer mixed in the soil under the seed (Plate 9-c) delayed the appearance of the plants above ground and caused poor stands. Where fertilizers were applied 2 inches (Plate 8-b), or 4 inches (Plate 8-a) to the sides of and 1.5 inches below the level of the seed, and where fertilizers were applied 3 inches directly below the seed in wide (Plates 8-d and 9-d) and narrow (Plate 9-b) bands, plants appeared above ground as rapidly and in as large numbers as on unfertilized rows. Mixing the fertilizer with the soil under the seed and placing it in a band 3 inches below the seed were satisfactory placements in so far as stand