the virus, *Aphis, spiraecola* Patch and *gossypii* Glov. The low percentages of successful experimental transmissions indicate that they are less efficient vectors than *citricidus* (Kirk.), the vector of the tristeza virus studied in Brazil.

Tristeza-virus infected Temple orange appeared to be a more satisfactory source of virus than did the infected Valencia orange or the Key lime plants used.

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Vegetable Section

A PRELIMINARY REPORT ON THE USE OF NUTRITIONAL SPRAYS CONTAINING N, P AND K IN TOMATO PRODUCTION

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Introduction.—The use of foliar nutrient sprays as a means of supplying the major elements to vegetable crops has attracted considerable attention during the past few years. In some instances only nitrogen has been included, but more recently all three major elements have been applied as foliar sprays. Vegetable producers may purchase commercial formulations containing soluble nitrogen, phosphorus and potash along with other elements which may be deficient in some soils. Producers of tomatoes have shown a great deal of interest in these nutrient sprays, and have made many inquiries pertaining to their use. The value of sprays containing minor elements such as manganese, zinc, iron, boron and copper has been well established where these elements are lacking or are unavailable in the soil. The effectiveness of the major elements as foliar sprays has not been established, however. Some investigators have concluded that tomato plants can utilize one or more of the major elements when applied as sprays, but that this method is no better than soil applications. Since soil applications are generally more economical than the spray formulations, these investigators have not recommended the use of foliar sprays.

In working with tomatoes at the Indian River Field Laboratory it soon became evident that a shortage of nitrogen was responsible for many poor yields and premature deterioration of the plants, especially during periods of heavy rainfall. The problem seemed to be that of insuring a constant supply of nitrogen proportionate to the requirements of the plants. With this problem in mind, and due to the interest in the use of the major elements in foliar sprays, investigations were begun to evaluate the use of these nutrient sprays on tomatoes.

Figure 1 is a diagrammatic sketch which is included to illustrate the cultural methods used by producers of unstaked tomatoes in the

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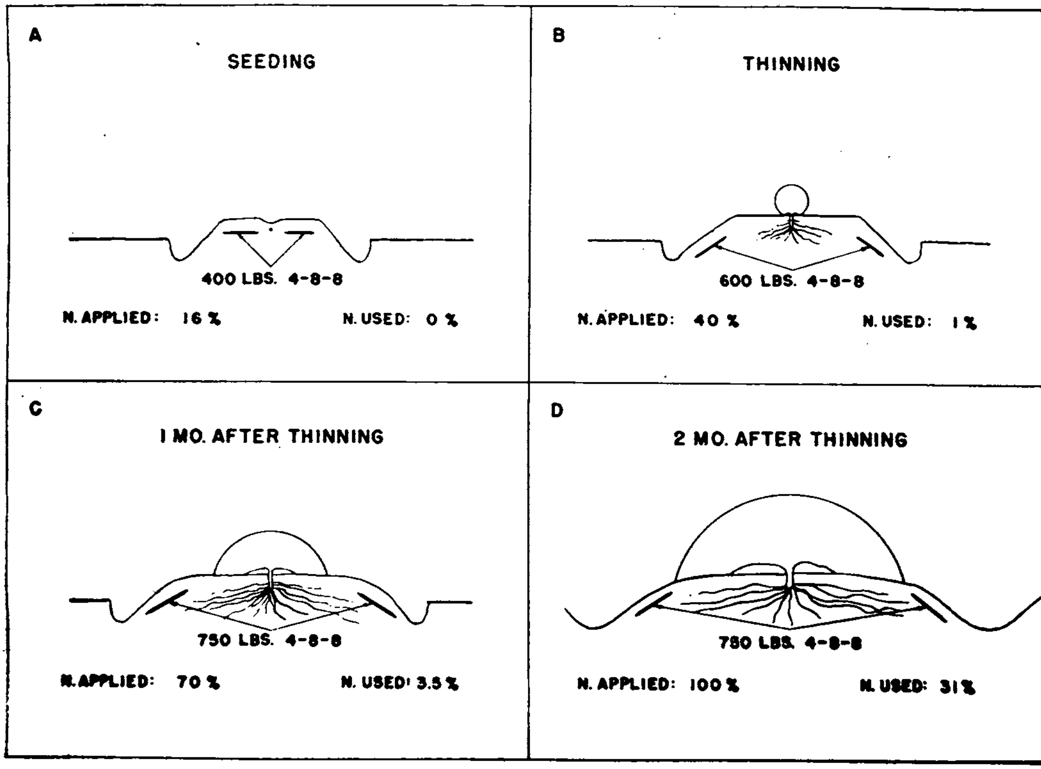
Figure 1.—Diagrammatic sketch showing tomato bed construction and fertilizer placement, rate and utilization. "N. Applied" is expressed in per cent of total to be applied. "N. Used" is expressed in per cent of total required to produce a 10-ton tomato crop as reported by Hester (Footnote [1]).



Indian River area. The approximate rates, placement and time of fertilizer applications are shown in this illustration. The utilization of nitrogen by the tomato plant as reported by Hester[1] is also shown.

The soils used for tomato production in the Indian River area are variable, but most are sandy soils which are extremely low in organic matter. These soils are well adapted to good moisture control, but it is necessary to plant on high beds in order to protect the root systems from excessive moisture.

Most growers use 2400 to 3200 pounds per acre of 4-8-8 commercial fertilizer which is applied in from three to five separate applications, as illustrated in Figure 1. These split applications of fertilizer are designed to furnish a constant supply of nutrients as the crop matures, and at the same time to place the fertilizer ahead of the root systems as they reach out toward the shoulders of the beds. In Figure 1 it is noted that the rates of fertilizer used in early applications far exceed the requirements of the young tomato plants. At the time the final fertilizer application is made, the plant has utilized less than one third of its total requirement of nitrogen based on an expected 10-ton yield of tomatoes.

While leaching rains are more frequent during the fall tomato crop season, they may occur at any time during the year. If the grower is able to keep the surface water pumped out as fast as it falls, the amount of root damage is greatly reduced. Roots flooded for a period of 24 hours or more are seriously injured.

The thin sandy soils, high beds and heavy rains combine to promote severe leaching of soluble fertilizers. Since the tomato plant utilizes only a small fraction of its total nutrient requirements during the first two months from time of seeding, a large amount of unused nutrients is in danger of being lost if heavy rains occur. If these soluble fertilizer elements are not replaced the plants will not produce

[1]/Hester, Jackson B.—Good, fair or poor tomatoes from your soil. Campbell Soup Company, Bulletin 2, January, 1940.

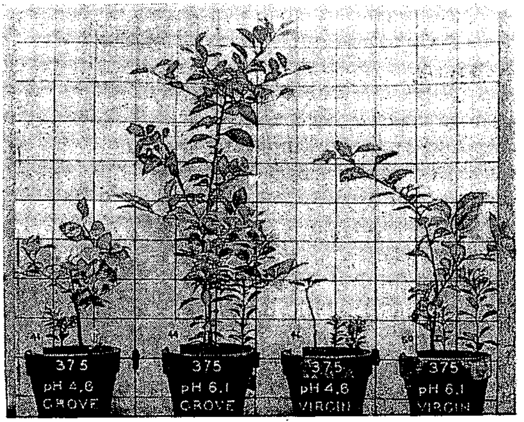


Figure 5. Relative growth of citrus seedlings in Orlando topsoil obtained in a 30-year-old Valencia orange grove and in similar virgin Orlando topsoil obtained near this grove. The total copper level in both soils was adjusted to approximately 375 lbs. of total copper (expressed as CuO per acre-six-inches) at each of two pH treatments.

in the topsoil zone, but not necessarily for measuring the behavior of citrus trees in high-copper soils under grove conditions.

Studies by Ford (1) show that the major portion (more than two-thirds) of the fibrous roots of citrus trees normally occur in the subsoil in most mature groves located on the deep, sandy soils of central Florida. Some fibrous roots are commonly found at a depth of 10 feet or more.

In view of these considerations, it seems logical to assume that damage to vigor and productivity of trees from toxic amounts of copper in the topsoil would be much greater on shallow, poorly drained soils providing unfavorable conditions for development of an extensive subsoil root system that would be the case in deep, well drained soils providing more favorable conditions for the development of an extensive, vigorous subsoil root system.

Comparison of the data in tables 2 and 3 shows that although the ranges of pH studied were not exactly comparable, the over-all growth of citrus seedlings in Orlando soil with 250 lbs. of added CuO was about equal to that in Lakeland soil with no added copper. A growth reduction of about one-third resulted from 125 lbs. CuO in the Lakeland soil, but 500 lbs. of CuO was required for a reduction of similar magnitude in the Orlando soils. This suggests that the ratio of copper to the exchange capacity of the soil or the degree of copper saturation of the exchange complex is an important factor in determining its toxicity or availability. At 125 lbs. of CuO per acre, the Lakeland soil has about 10 percent of its total exchange capacity occupied by copper. At 500 lbs. of CuO per acre, the Orlando soils are also about 10 percent saturated with copper.

It was not the objective of these pot studies to determine exact limits of "deficient," "optimum" and "excess" levels of copper for all grove soil types and conditions—this problem is far too complex. However, it was hoped that they would shed some light on the factors influencing the toxicity of copper to citrus roots and establish approximate limits of the range of copper content in which toxicity to roots is likely to occur in some common soils. The limited evidence available suggests that acid, sandy soils containing as much as 40 p.p.m. of CuO (equivalent to 80 lbs. per acre-six-inches) or more per milli-equivalent of exchange capacity are likely to be distinctly unfavorable for the normal growth of citrus roots. Further, it seems probable that one-half this amount, or about 20 p.p.m. (or 40 lbs. per acre-six-inches) per milli-equivalent of exchange capacity would be in the range that causes no to slight toxicity to roots under average conditions in mature groves in Florida. Thus 120 to 240 lbs. of CuO per acre-six-inches of topsoil is likely to be distinctly toxic to roots in an average acid Lakeland soil having from 1.5 to 3 milli-equivalents of exchange capacity per 100 grams. With a better type of soil such as that of the Eustis or Orlando series, an equivalent toxicity level would be from 320 to 480 lbs. of CuO in topsoil ranging from 4 to 6 milli-equivalents of exchange capacity per 100 grams. At a given toxic copper level, damage to roots may be less severe in old groves than in younger groves on comparable soil, possibly because of the higher phosphate content of the former.

The data presented in table 3 and figure 4 show clearly that the higher copper treatments depressed the growth of citrus seedlings more in virgin Orlando soil than in similar soil obtained from a 30-year-old Valencia orange grove. Previous studies showed that one of the most striking changes brought about by continued fertilization of soil in citrus groves over the years is in the total phosphate content. Phosphorus, like copper, zinc and manganese, has a strong tendency to accumulate in the topsoil (4,5). The data in table 1 show that the old grove topsoil had approximately 3 times as a normal yield. When the tomato plants begin to mature a large number of fruit, their nutrient requirements are at the peak. A heavy rain at this time will cause a rapid deterioration in the vines unless nitrogen and possibly other fertilizer elements are supplied at once and placed where the plant can utilize them.

Experiments with nutrient sprays and soil applications of nitrogen and potash.—Two experiments are reported. One was conducted during the Spring of 1952 when weather conditions were more or less ideal for the production of tomatoes. The second trial was conducted in the Fall of 1952 on tomatoes which had received about 20 inches of rain during the month of October.

Spring trial, 1952.—The tomato variety Manasota was transplanted on February 22 to plots arranged in a 5 x 5 Latin square design on Immokalee fine sand which had been limed to adjust the pH to approximately 6.0. All plots received identical initial and side dressed applications of a 4-8-8 fertilizer amounting to a total of 2500 pounds per acre. On May 15, about the time of the second tomato harvest, and four days following a 3.2 inch rain, one half of each spray plot and of the unsprayed check received a side dressed application of 300 pounds per acre of nitrate of soda-potash (15-0-14).

The five treatments consisted of the following formulations applied in sprays at weekly intervals by means of a power sprayer equipped with a hand carried boom.

(1) Check, no nutritional spray.
(2) 18-13-16 with Cu, Mn, Zn, B, Fe, Mg and Mo applied at the rate of 8 pounds per 100 gallons of water.
(3) 16-16-16 with Cu, Mn, Zn, B, Fe, Mg, Mo and Ca ("Nutri-Leaf") applied at the rate of 6 pounds per 100 gallons.
(4) 13-26-13 with Cu, Mn, Zn, B, Fe, and Mg ("Hy-Gro") applied at the rate of 5 pounds per 100 gallons.
(5) 44-0-0 with N as soluble urea ("Nu-Green") applied at the rate of 6 pounds per 100 gallons.

While no record of gallonage per acre was kept, a thorough plant coverage was obtained and it is estimated that 75 to 200 gallons per acre were applied, depending upon the size of the plants. Treatments were made on March 4, 11, 18, 25; April 2, 10, 17, 24; May 1, 12, 15 and 23.

The tomatoes were harvested three times; on May 7-8, May 15-17, and May 31-June 2. Ripes, pinks and mature greens were taken at each harvest. The third harvest was made on the split-plot basis to conform to the soil applications of 15-0-14 to one half of each plot.

The plots were under careful observation during the entire period of the experiment and at no time were there any recognizable differences between spray treatments. However, a distinct darker green color of the foliage was noted on the half of each plot receiving a side dressed application of the 15-0-14 fertilizer after the heavy rain.

The total yield of ungraded fruit, and the amount of fruit harvested during the third picking, are listed in Table 1. There were yield trends in favor of the nutritional sprays. The average yields for all spray treatments were slightly higher than the unsprayed check, but these yield trends were not statistically significant. The third harvest yields for the sub-plots receiving a side dress treatment of 15-0-14 were only slightly higher than for those receiving no side dress. This difference in yields was not significant in spite of the fact that the side dressed plots were greener in appearance. All nutrient spray formulas applied to plots not receiving post-rain fertilizer gave a higher yield than similar unsprayed plots, although this difference was not statistically significant.

Fall trial, 1952.—Nineteen days with rain in October delivered a total of 19.72 inches of

Table 1.—Third harvest sub-plot yields, and total yields of ungraded tomatoes taken from the Spring, 1952 foliar nutrient spray trial.

Spray Treatment	No. of 60 pound crates per acre		
	Third Harvest		Total from three harvests
	300 lbs./A. 15-0-14	No 15-0-14	
Check, not sprayed	373	298	704
18-13-16	368	361	751
Nutri-Leaf	319	327	717
Hy-Gro	314	330	732
Nu-Green	330	330	716
	N.S.D.	N.S.D.	N.S.D.

rainfall for that month. The severe leaching and root damage resulting from these rains presented an opportunity to test the use of major elements in sprays as a method of reviving badly damaged tomato plants. Two rows, each planted to an experimental tomato line of "131" stock, were used for this trial. These tomatoes had been "laid by" with the final application of complete fertilizer shortly before the October rains began. They had received 2500 pounds per acre of a 4-8-8 commercial fertilizer containing 2.0, 0.40, 0.30, 0.20, 0.15 and 0.30 per cent of MgO, MnO, CuO, ZnO, B_2O_3 and Fe_2O_3, respectively.

Each row of tomatoes was divided into four 40-foot plots, each plot containing 10 tomato plants spaced 4 feet apart. Two of these plots received an application of nitrate of soda-potash (15-0-14) along each shoulder of the bed at the rate of 600 pounds per acre. The other two plots did not receive a post-rain soil application of fertilizer. The 40-foot plots were then subdivided into 20-foot plots, each containing 5 plants; one sprayed with Nu-Green (45-0-0) or Nutri-Leaf (16-16-16) and the other unsprayed. Both Nu-Green and Nutri-Leaf were mixed at the rate of 6 pounds per 100 gallons of water and applied at the rate of about 200 gallons per acre.

The soil application of nitrate of soda-potash was made on October 27 immediately following the long rainfall. Nutrient spray treatments were made on October 27 and 30; November 4, 7, 11, 15, 22 and 28; and December 5, 13 and 19; or twice each week for three weeks followed by 5 treatments once each week. The total sprayed on the plants was about 132 pounds per acre of each mate-

Table 2.--Yield data from a foliar spray trial of Nu-Green and Nutri-Leaf on tomatoes, with and without soil applications of nitrate of soda-potash.

Treatment[1]	Ungraded Fruit No. 60 lb. crates/A.[2]	Average fruit size (lb.) 1st Harv.	Average fruit size (lb.) 2nd Harv.	Average per cent cracked mature greens 1st Harv.	Average per cent cracked mature greens 2nd Harv.	Average per cent puffy mature greens 1st Harv.	Average per cent puffy mature greens 2nd Harv.
1- Check	170	.273	.206	30.0	16.6	35.0	43.7
2- Nutri-Leaf spray	225	.279	.205	25.5	18.2	32.5	42.5
3- Nu-Green spray	292	.284	.204	34.0	12.0	5.0	40.0
4- Nitrate of soda-potash	280	.277	.234	9.2	3.9	23.7	37.7
5- Nitrate of soda-potash plus Nutri-Leaf	409	.284	.263	8.5	3.4	20.0	32.5
6- Nitrate of soda-potash plus Nu-Green	468	.296	.253	10.0	4.1	30.0	52.5

[1] Treatments 1 and 4 were replicated four times. Balance of treatments were duplicated.
[2] Total yield of tomatoes taken on January 7 and 28.

rial, or about 60 pounds of N where Nu-Green was applied, and about 21 pounds of N where Nutri-Leaf was used.

The plots were scored for leaf color and growth one day following the third spray treatment, or nine days after the first treatment was applied. In every case the plots sprayed with Nutri-Leaf or Nu-Green were rated above the unsprayed plots.. Scores were also obtained on November 17, or three weeks following the first spray treatments. Those plots sprayed with Nutri-Leaf or Nu-Green were rated above the unsprayed plots on this date also.

The tomatoes were harvested on January 7 and 28. The fruit were weighed and counted for yield and fruit size data. They were *also* checked for puffiness and fruit cracks. This information is included in Table 2.

Since this was an exploratory type of experiment without the advantages of randomized and replicated plots, the findings can be accepted only as indicative. However, since the differences in yield and amount of cracked fruit were so great, there are some strong implications which are of considerable interest.

The combination of a soil application of 600 pounds per acre of 15-0-14 and foliar sprays with Nu-Green gave almost three times the yield of the plots receiving no fertilizer following the series of heavy rains. The 15-0-14 with sprays of Nutri-Leaf gave over two times the yield of the unfertilized plots. Distinct yield increases were obtained where Nu-Green and Nutri-Leaf sprays were applied without a post-rain soil application of 15-0-14. Where 15-0-14 was applied to the soil without any foliar sprays a definite yield increase also resulted. The maximum yield was obtained where 15-0-14 was applied to the soil and the plants sprayed with Nu-Green.

The average size of the fruit was similar for all plots during the first harvest; however, size differences appeared during the second harvest. The largest fruit were obtained from the combined soil application of 15-0-14 and foliar sprays with Nu-Green or Nutri-Leaf. The fruit taken from plots which had received the soil application of 15-0-14 were larger than those taken from the check plots and from the plots receiving only foliar sprays of Nu-Green or Nutri-Leaf. The size of the fruit taken from plots receiving foliar sprays of Nu-Green or Nutri-Leaf only were no larger than the fruit from the check plots. The check plots and the plots receiving foliar sprays of Nu-Green and Nutri-Leaf only contained a large percentage of cracked fruit, while the plots receiving 15-0-14 alone and with foliar sprays contained a greatly reduced number of cracked fruit. There was a large amount of puffy fruit harvested; however, there was no correlation between puffy fruit and any of the treatments. The untreated check plots contained as many puffy fruit as any of the treatments.

Discussion.—The two trials reported seem to indicate that nutrient sprays of the major elements would be of no benefit on tomatoes grown during good weather conditions. However, there may be times when these same nutrient sprays may be used to definite advantage. One of these times would be immediately following heavy rains which may have leached the fertilizer and damaged the root systems of the plants. It is believed to be best to apply enough liquid to obtain some run-off onto the ground around the base of the plants. It may be necessary to spray twice a week for one to three weeks following a damaging rain for maximum response.

In a recent trial Nu-Green used at the rate of 5 pounds per 100 gallons of water caused slight marginal leaf burn. A commercial 20-20-20 formulation caused injury to large tomato plants when used above 3 pounds per 100 gallons of water. These experiences would seem to indicate a need for caution in the use of foliar nutrient sprays.

It is doubtful that spraying alone is advisable; highest yields were obtained where a soil application of 15-0-14 was made in addition to the sprays.

While a soil application of 600 pounds per acre of 15-0-14 was applied in the fall, 1952 trial, the amount used would vary greatly depending upon the amount of rainfall, the size of the plants, the amount of complete fertilizer applied before the leaching rains, and the source of the nitrogen used in the complete fertilizer.

Investigations at the Indian River Field Laboratory have failed to establish that the application of nitrogen in either spray or ground treatments has caused a reduction of fruit quality. Tomatoes have been examined for softness, puffiness and cracking. A considerable amount of puffy fruit and cracked fruit has followed the heavy leaching rains, however, these defects have been no more prevalent in nitrogen treated plots than in plots not receiving post-rain applications of nitrogen. In one trial a heavy application of nitrate of soda-potash resulted in a reduction in fruit cracking.

In relation to the expense of applying the major elements as foliar sprays, it should be stated that it is necessary to spray tomatoes immediately following heavy rains with fungicides and insecticides in order to replace those washed off by the rains. In that sense, the application of the nutrients can be considered without cost.

Acknowledgments.—The authors wish to express their appreciation to E. I. du Pont Company, Miller Chemical and Fertilizer Corporation and Kilgore Seed Company for donation of some of the materials used in these experiments.

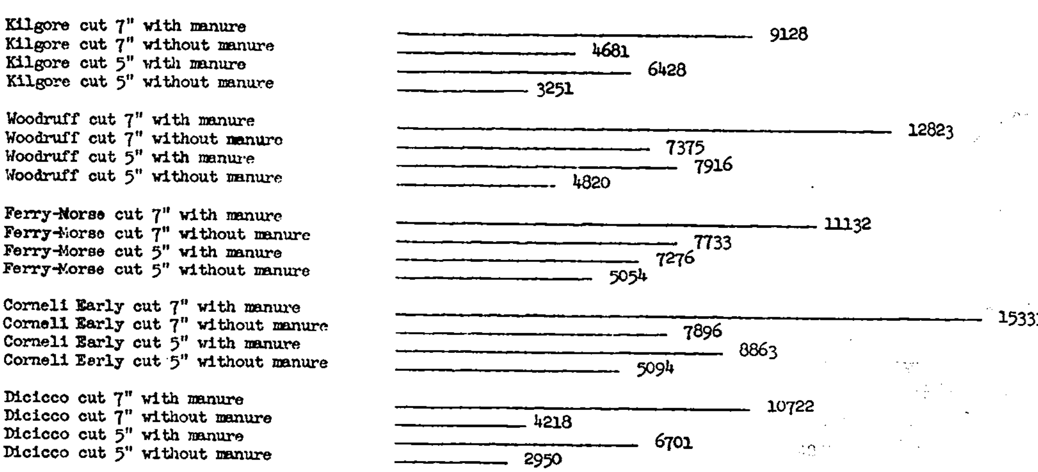
SOME FACTORS AFFECTING THE YIELD OF BROCCOLI ON SCRANTON FINE SAND IN FLORIDA

Gray Singleton
J. William Horsey Corp.
Plant City

Broccoli is becoming increasingly important as a cash crop in Florida, both for fresh market and processing. Only a few years ago broccoli was almost unknown to our farmers. Today it is shipped in increasing volume to Northern markets and is grown on contract for the freezing plants. Some farmers ship their large center heads to fresh market and sell the side shoots to the processors of frozen foods. The fresh market wants the center heads and the side shoots fit the cartons in which frozen food is packed. A center head which weighs two or three pounds must be cut into small pieces to fit into a ten-ounce package. The processor likes side shoots weighing about one ounce each.

As late as 1947 it was customary for the farmers to grow broccoli only as a winter fill-in crop. They would grow a fall crop of tender vegetables. At the same time they would have a broccoli seed bed coming on.

SOUTHLAND EXPERIMENTAL FARM. SEASON OF 1951-52
BROCCOLI YIELDS, IN POUNDS PER ACRE, WITH, AND WITHOUT, MANURE. SANDY SOIL.



Scale: 1" equals 3000 pounds per acre.