take as well as to the supply and uptake of calcium. Evans and Troxler (4) working with blossom-end rot, a physiological disorder of the tomato fruit, have indicated that organic acids may have an influence on calcium assimilation. Blossom-end rot seems to be similar to blackheart of celery in that calcium appears to be a limiting factor as associated with conditions similar to those associated with blackheart of celery.

In considering the nature of the suggested cause and the success of the foliar calcium treatment as well as the pertinent material in the literature, it appears that calcium must be supplied at the proper time and to the proper place for successful control of blackheart.

SUMMARY

Blackheart, a physiological disorder of celery can be completely controlled by applications of a calcium solution directly to the heart of the plant. Temperature and light as well as unbalanced moisture, high soluble salts and over fertilization seem to be factors associated with the prevalence and severity of blackheart. These factors may directly or indirectly affect the uptake, translocation or assimilation of calcium by the plant. It appears that when two or more of the many possible influencing factors are involved, the incidence of blackheart increases accordingly. Rapid growth makes the plant more sensitive to the effects of contributing factors because per unit of time, the requirement for calcium is further extended. It may be concluded that, regardless of the cause or causes, blackheart can be controlled by supplying sufficient calcium at the proper time and to the proper part of the plant.

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SOME MANGANESE-IRON RELATIONSHIPS IN TOMATO FRUITS GROWN ON MARL, PEAT AND SAND SOILS

JOHN G. A. FISKEL, W. T. FORSEE, JR. AND J. L. MALCOLM

Agricultural Experiment Station
Gainesville

Everglades Experiment Station
Belle Glade

Subtropical Experiment Station
Homestead

Manganese and iron are known to be active agents in the formation of chlorophyll in plants. Many workers have noted an inverse relationship between the availability of manganese and of iron in the soil with respect to the health and yield of crops. A comprehensive review of manganese-iron relationships in soils and plants is given by Mulder and Gerretson (5), from which the concensus is that iron and manganese have a close inverse relationship within the cells of the plant, in addition to soil relationships.

The present study was undertaken for two reasons, first to determine the relative availability of manganous sulfate, manganous oxide, manganese dioxide and the manganous salt of ethylene diamine tetra-acetic acid (Mn EDTA). The second reason was to find out

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to what extent these manganese treatments affected the iron content of tomato fruits. Three soils somewhat representative of areas growing large acreages of tomatoes in Florida were chosen for these experiments, Perrine marl, Everglades peaty muck, and Scranton fine sand.

Forsee (1) pointed out, in a review of minor element deficiencies and corrections in Florida, that manganese deficiency on the marl and peat soils has been recognized for many years and was usually corrected by the application of 50 to 150 pounds of manganous sulfate per acre. He also reported that applications of sulfur to the soil or foliar sprays containing the manganous sulfate or less soluble *oxysulfate* of manganese were effective in correcting manganese deficiency on peat which has been burnt or admixed with marl. Skinner and Ruprecht (10) in 1930 reported that low yields or crop failure of tomatoes on the marl soils could be attributed in many cases to a lack of manganese in the mineral fertilizer and that 50 pounds of manganous sulfate per acre at time of application was as beneficial as the large amounts of manure being used at that time. They stated that manganese dioxide was not a promising source of manganese for the marl soil and obtained only partial correction of the deficiency by using a manganese-iron waste material.

In Australia, Jones and Leeper (2, 3) found that certain manganese oxides are available to plants. At high rates per acre (230 pounds calculated as MnO) in greenhouse tests on manganese-deficient soils, manganite, pyrolusite, and manganous manganite were available to oats and peas and hausmannite was not, fine particle size and method of preparation of the oxides being important factors. Schropp (8) reported that several manganous phosphates are suitable sources of manganese and of phosphate to oats, beans, potatoes, clover and turnips. The above studies dealt in terms of deficiency symptoms and crop yields with respect to the manganese applied in the fertilizer, with very little or no evidence of the actual manganese content of the crop.

Experimental Methods and Observations

Since the greenhouse and outdoor pot studies differ in fertilizer rates and method of fertilizer placement the Perrine marl, Everglades peaty muck and Scranton fine sand are dealt with separately in the discussion of methods and results.

Perrine Marl. The Perrine Marl, pH 8.3, used in the outdoor pot studies was obtained near Homestead from a virgin area being brought into cultivation. The soil was put through a one-quarter-inch-mesh screen and 8 kilograms weighed into each of 36 four-gallon pots and 6 kilograms into each of 12 lysimeter-type 3 gallon-jars. In Table I are shown the fertilizer rates of the various materials. Only the superphosphate and manganese sources were applied as solids, these materials being carefully weighed and mixed prior to the application. The remaining fertilizer was dissolved in de-ionized water and a fixed volume applied per pot.

The method of placement of the fertilizer was to remove all but two inches of the marl from the pot, apply one-quarter of the solid and of the required amount of fertilizer solution, add two more inches of marl and apply about the same proportion of the fertilizer as before. The remaining fertilizer addition was mixed with the rest of the marl and added to the pot. Additional nitrogen and potash were added every ten days at the same rate as in Table I.

Commercial tomato plants, Rutgers variety, were planted 3-10-53. On 4-11-53 manganese deficiency as exhibited by characteristic chlorosis and small necrotic lesions was observed on the check pots, those receiving the two lowest rates of manganese dioxide, and those receiving manganous EDTA, some marginal leaf burn also being observed in the last case for about one month.

The manganese deficiency in the above instances persisted during the remainder of the growth with plants and fruit being harvested 5-22-53. Fresh weight of fruit and leaves with stem and stalk were taken after the plants had been heavily watered several hours before cutting. During the course of the growing season de-ionized water was applied when the rainfall was insufficient to prevent wilting of the leaves. The yield of fruit included tomatoes at various stages of growth and ripening. Manganese-deficient plants gave about 50 per cent less yield than those with normal leaves. Chemical analyses of the fruit and of the leaves and stems were made and these results are discussed with respect to the fruit only.

Everglades Peaty Muck. The Everglades muck, pH 7.0, was taken adjacent to a drainage canal near Belle Glade from an area known to be manganese deficient that had not been recently cultivated or fertilized. The screened soil was weighed into 2-, 3-, and 4-gallon pots, the weights of soil used being 4.2, 6.3 and 8.4 kilograms, respectively. The fertilizer materials and rates applied are shown in Table I. The manganese sources were applied with the superphosphate. Two rates, 400 and 2000 pounds per acre, of superphosphate (20 per cent P_2O_5) were used to test the interaction of phosphate levels on the manganese and iron availability. Both the solids and the solution portion of the fertilizer were mixed with the top half of the muck in the pot. The additional amounts of nitrogen and potash were first added one month after planting and every ten days until the plants were harvested. Rutgers variety of tomato plants was used and the planting was made 3-23-53. The pots were left outdoors.

On 4-11-53 the check pots exhibited necrotic lesions and some chlorosis, both with the characteristics of manganese deficiency, and on 4-15-53 those plants receiving the manganese dioxide were observed to be deficient also. Those plants receiving the Mn EDTA showed the marginal leaf burn from this material for about 6 weeks and manganese deficiency symptoms appeared 4-15-53. During the course of their growth the upper leaves showed less necrotic lesions. Other deficiency symptoms were absent, with exception of some evidence that the nitrogen supply was not adequate up to the time of the first supplemental fertilization.

Blossom-end rot developed on those plants which had exhibited the severest nitrogen deficiency. No differences in the plants with the two phosphate levels were observed. Those plants receiving the manganous oxide or manganous sulfate were devoid of the manganese deficiency symptoms. Difficulty was encountered in maintaining an adequate supply of the de-ionized water for these plants even with daily watering. Harvesting was done 5-25-53 and the fresh weight of fruit and stem with the leaves were measured several hours after watering. Although the fruit were in various stages of ripening and development, the whole yield was composited for the analysis of the manganese and iron content.

Scranton Fine Sand. The Scranton fine sand—one of the better flatwood soils in the

TABLE I
FERTILIZER MATERIALS AND RATES APPLIED TO THE SOILS (EXPRESSED AS POUNDS PER ACRE)

Fertilizer Material	Perrine Marl	Everglades Muck	Scranton Fine Sand
Superphosphate (20% P_2O_5)	1000	400; 2000	300; 1500
Ammonium Nitrate	150	15	150
Potassium Sulfate	150	150	150
Magnesium Sulfate	200	150	200
Ferrous Ammonium Sulfate	15	15	15
Copper Sulfate	20	50	10
Zinc Sulfate	20	20	10
Borax	1	1	1
Ammonium Molybdate	0.1	—	0.1
Manganous Sulfate (as MnO)	0, 10, 40, 80	0, 20, 40, 80	0, 10, 40, 80, 120
or Manganous Oxide	0, 10, 40, 80, 120	0, 20, 40, 80, 160	0, 10, 40, 80, 120
or Manganese Dioxide (as MnO)	0, 10, 40, 80, 120	0, 40, 80, 160	0, 10, 40, 80, 120
or Manganous EDTA (as MnO)	0, 10, 20, 80, 120	0, 10, 20, 40, 80	0, 40
Supplementary Solution			
Magnesium Nitrate	200	200	200;
Ammonium Nitrate	300	150	150
Potassium Sulfate	200	200	200
Insecticides	None	None	None
Fungicides	None	None	None

state—was obtained from a field near Hague. The history of this field did not show previous fertilization with manganese, although vegetable and tobacco crops had been grown on it for many years. One-half of this soil was limed at the rate of six tons of calcium carbonate per acre, using hydrated lime to hasten the reaction. The other half was left unlimed. Thirty two-gallon pots and five of the three-gallon lysimeter jars were filled with the limed soil and the same number filled with the unlimed soil, similarly. After one month the upper half of each pot was mixed with superphosphate containing the manganese treatments and then with a solution containing the remaining fertilizer ingredients as *shown in Table* I.

The pots were planted to Rutgers variety of tomatoes on 3-1-53. Supplementary nitrogen and potash additions were made after thirty days. At this time the leaves on all the unlimed pots showed nitrogen deficiency, as contrasted to healthy leaves of the plants on the limed soil. Supplementary additions of nitrogen and potash were made every ten days. De-ionized water was used to maintain an adequate moisture level in the soil. On 4-25-53 a slight chlorotic condition developed on many plants both on limed and unlimed soil. Diagnosis as magnesium deficiency was confirmed when magnesium nitrate in the fertilizer addition made 4-29-53 decreased the chlorotic condition. After the leaves were painted with a solution of magnesium sulfate, the plants produced leaves normal in appearance.

Blossom-end rot occurred on one or more of the fruit of the first hand of plants on the unlimed soil and in a few cases on the upper fruit. No cases of blossom-end rot or other deficiency symptoms, except the slight magnesium deficiency, were observed on the plants growing on the limed Scranton. Final pH range of the unlimed soil was 4.4 to 5.0 and on the limed Scranton 7.3 to 7.9. In no case was there evidence of either manganese deficiency or manganese toxicity in these plants. Harvest of fruit, stems and leaves was made 5-7-53. Although both fruit and plants were heavier on the limed soil, differences were not significantly associated with either rates of manganese applied or sources, nor with rates of superphosphate.

Analytical Methods. The tomato fruits were washed with de-ionized water and stored in paper bags. The whole fruit yield per pot was put in a large beaker or Erlenmeyer and digested with 100 ml. of concentrated HNO_3, adding and recording increments of nitric acid as required. The wet digestion was continued by adding 10 ml. of 70 per cent perchloric acid and evaporating to white fumes of perchloric acid. Further additions of 25 ml. of concentrated nitric acid followed by 10 ml. of 30 per cent H_2O_2 were made to ensure completion of the wet digestion. The wet ash was then transferred to a 100 ml. volumetric flask and made up to volume with re-distilled water. A 20 ml. portion was taken for iron analysis and the remainder for the manganese determination.

For purposes of obtaining the dry matter of these fruit, several random samples were homogenized first in a Waring blendor prior to wet-ashing and one-fifth of the slurry taken to dryness at 70° C. The manganese content was obtained using the periodate method, with precautions for chloride and acid concentrations as recommended by Sandell (6), and using a 60 ml. cuvette with a Cenco Photelometer at 525 mu. The iron content was obtained after evaporation of perchlorate, 1 ml. of concentrated H_2SO_4 being added for this purpose, following the procedure by Sandell (6), using O-phenanthrolene and citrate buffer titration to pH 3.8. Corrections for iron content of acids added during wet digestion and for the other reagents were applied. The color was read at 510 mu. using a Beckman B spectrophometer. Similar procedure was used in the development of color for the standard curve. Precision of determinations was found to be five per cent for manganese and two per cent for iron in tomato fruit.

Results and Discussion

The literature gives only a few values on the manganese and iron content of tomato fruit. Schreiner and Dawson (7) in 1927 found that fruit from manganese-deficient plants on the marl contained about 0.2 parts per million (ppm) Mn and about four times this value from healthy plants. Their description of manganese deficiency symptoms is similar to the more recent observation of Wallace (11) and to that observed in these studies. Using solution culture Lyon, Beeson and Ellis (4) found that manganese-deficient plants yielded fruit with 0.2 ppm Mn compared to a value of 1.7 from these plants not deficient. These authors further found that fruit from Fe-deficient plants contained 1.0 to 1.7 ppm Fe as compared to a range 2.9 to 3.7 for plants not deficient. Sims and Volk (9) reported that the iron content of the dry matter of tomato fruit grown on a wide range of Florida soils varied from 32 to 59 ppm Fe or about 1.5 to 3 ppm Fe on a fresh weight basis; but the manganese content was not stated.

On Perrine marl by the present studies, tomato fruit from plants showing severe manganese deficiency contained 0.09 to 0.16 ppm Mn. This compares with 0.30 to 0.39 ppm Mn in fruit where slight deficiency of leaves was found and 0.40 to 0.75 ppm Mn in fruit from plants supplied with available manganese in the soil sufficient to prevent foliar symptoms of deficiency of this element. The manganese contents relative to rates and sources of manganese are shown in Figure 1.

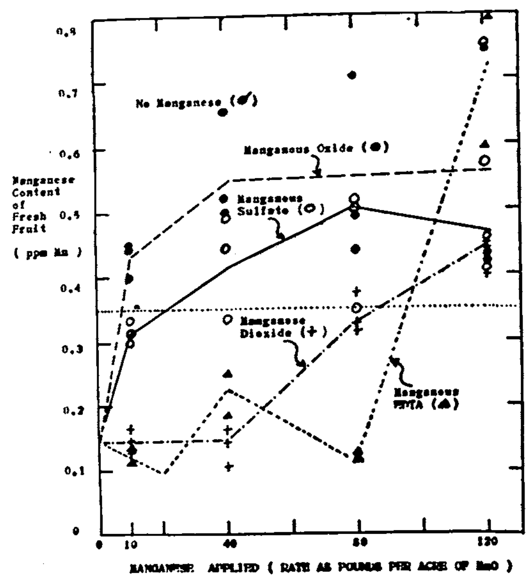

Figure 1. Effect of rate and source of manganese on the manganese content of tomato fruit from plants grown on the Perrine marl. The plants below the dotted horizontal line showed visual symptoms of manganese deficiency and those above the line did not.

Under the conditions of this experiment, the manganous oxide source furnished a sufficient supply of manganese for the plant at 10, 40, 80 and 120 pounds per acre and was more efficient than manganese sulfate. The effect on the manganese content of the fruit is shown. The manganese applied as the dioxide or EDTA was less available from the criteria of deficiency symptoms and manganese content of the fruit. The Fe/Mn ratios in the fruit are shown in Figure 2. Note that when

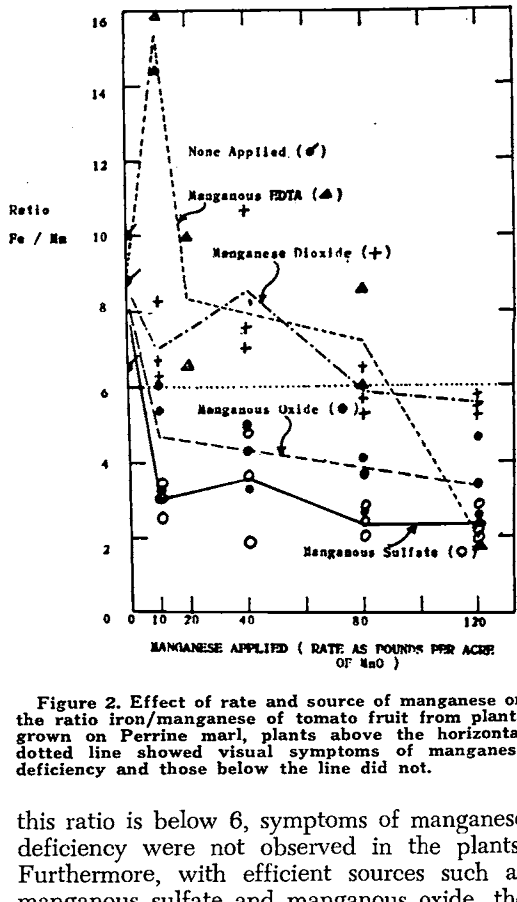

Figure 2. Effect of rate and source of manganese on the ratio iron/manganese of tomato fruit from plants grown on Perrine marl, plants above the horizontal dotted line showed visual symptoms of manganese deficiency and those below the line did not.

this ratio is below 6, symptoms of manganese deficiency were not observed in the plants. Furthermore, with efficient sources such as manganous sulfate and manganous oxide, the ratio lies between 2 and 4. The Mn EDTA at the highest rate produced a Fe/Mn ratio in the fruit in this range and this suggests that the chelation of iron by the EDTA was not such as to greatly increase the iron content of the fruit. From these data the efficiency of manganese sources on this marl would appear to be manganous oxide > manganese sulfate > manganese dioxide > manganous EDTA.

On the Everglades peaty muck, tomato fruit from plants showing manganese deficiency contained 0.10 to 0.16 ppm Mn, those with the deficiency on the older leaves 0.15 to 0.26 ppm. Fruit from plants not showing deficiency symptoms contained 0.27 to 0.65 ppm Mn and from 0.70 to 2.6 ppm Fe. Rate of superphosphate addition was not found to be a statistically significant factor in the availability of the manganese sources in this test as indicated by deficiency symptoms and by the iron and manganese contents of the fruit. The manganese content of the fruit is illustrated in Figure 3. In this experiment

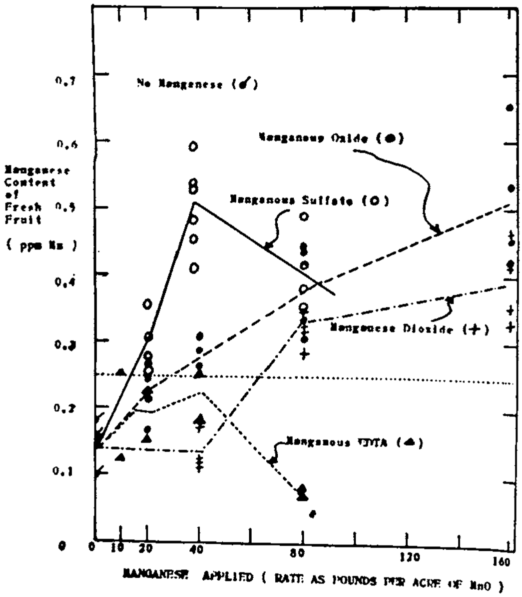

Figure 3. Effect of rate and source of manganese on the manganese content of tomato fruit from plants grown on Everglades peaty muck. The plants below the dotted line (horizontal) showed visual symptoms of manganese deficiency and those above the line did not.

manganous sulfate at the rates tried was the most effective source although manganous oxide was effectively available. Manganese dioxide at the higher rates was also effective but manganous EDTA was not an efficient source of manganese. In Figure 4 the Fe/Mn ratios in the tomato fruit are shown and in general where this ratio is below 6 there was no evidence of manganese deficiency exhibited by the plant. Again the ratio lies between 2 and 4 where an efficient source of manganese was applied.

In the light of the above observations on manganese deficient soils, the data from Scranton which was not made manganese deficient by the heavy liming are worthy of some study. These data are shown in Figure 5a. It can be seen that the manganese content of the fruit on soil without manganese addition ranges from 0.47 to 0.88 ppm and with manganese addition from 0.45 to 1.20 ppm. In addition, the manganese content was not altered significantly in the fruit either by rates or sources of the manganese application. In Figure 5b the Fe/Mn ratio varies from 0.41 to 3.87, which is well below the critical ratio of 6 found for the other two soils.

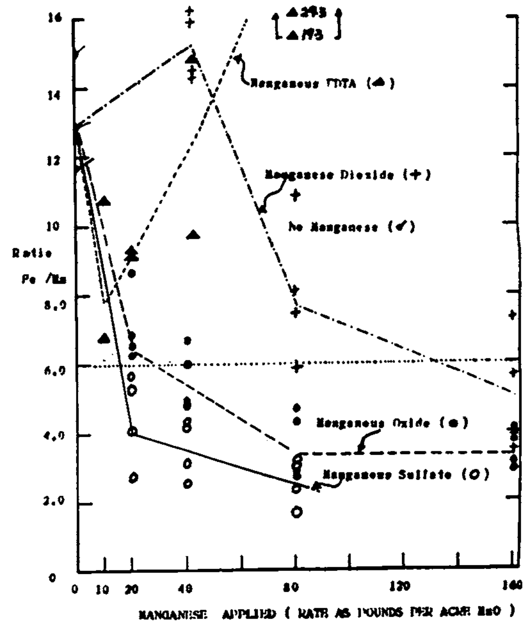

Figure 4. Effect of rate of manganese and source of manganese on the iron/manganese ratio in tomato fruit grown on Everglades peaty muck. The plants above the horizontal dotted line showed visual symptoms of manganese deficiency and those below the line did not.

The conclusion drawn from these data is that both manganese and iron were satisfactorily available in the soil for these plants and that the rates of manganese applied do not greatly affect either the manganese content or Fe/Mn ratio of the tomato fruit grown on this limed Scranton soil. The data are shown in Figure 6a and 6b for the unlimed soil with pH 5.0 approximately. The range of values for the manganese content of the fruit without manganese addition is from 0.27 to 1.06, and the range with a manganese fertilizer from 0.70 to 3.78.

The Fe/Mn ratios of the fruit show a wide spread from 0.71 to 2.98 from pots without manganese addition and a range from 0.21 to

1.50, with few exceptions, with the different rates and sources of manganese applied. The differences were not significant with respect to the two levels of superphosphate. There did not appear to be any correlation between frequency of fruit with blossom-end rot and either manganese content or Fe/Mn ratio. Although the availability of native manganese is apparently higher on the unlimed Scranton fine sand, the addition of manganese under these greenhouse conditions did not result in either a very great increase in the manganese content of the fruit nor a decrease in the ability of the roots to absorb sufficient iron.

Field data will be necessary to evaluate fully the significance of manganous oxide as a source of manganese, and the rate required under the particular circumstances encountered by the grower.

Summary

Rates and sources of manganese fertilizer materials were used in pot studies with Perrine marl, Everglades muck and Scranton fine sand. On both the marl and the muck, tomato fruit from plants showing manganese deficiency contained less than 0.4 parts per million of manganese and the Fe/Mn ratios were greater than 6. On the limed or unlimed Scranton soil, neither deficiency nor toxicity of manganese was encountered. Manganous oxide in these soils and under these conditions was at least as satisfactory a source as manganous sulfate. Manganese dioxide and manganous EDTA were less efficient sources. The iron content of the fruit was not greatly altered beyond the normal variability encountered when the rate of manganese from the different sources was increased under the conditions of this experiment.

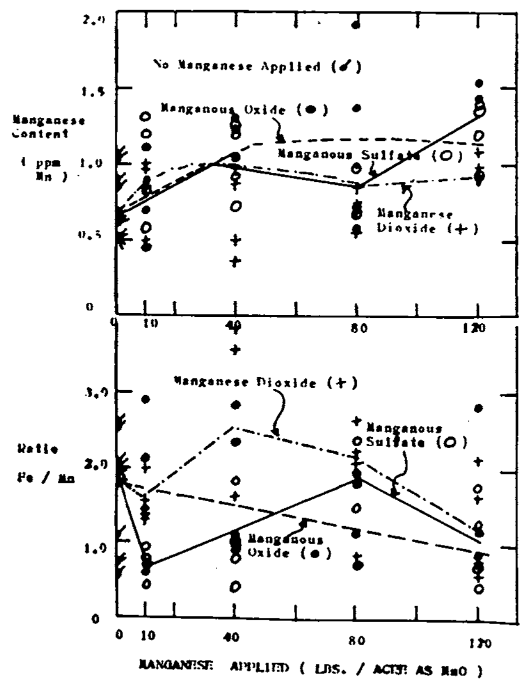

Figure 5a (upper graph). Effect of rate and source of manganese on tomato fruit grown on limed Scranton f. s., is shown with respect to manganese content and Figure 5b (lower graph) shows the effect on the iron/manganese ratio.

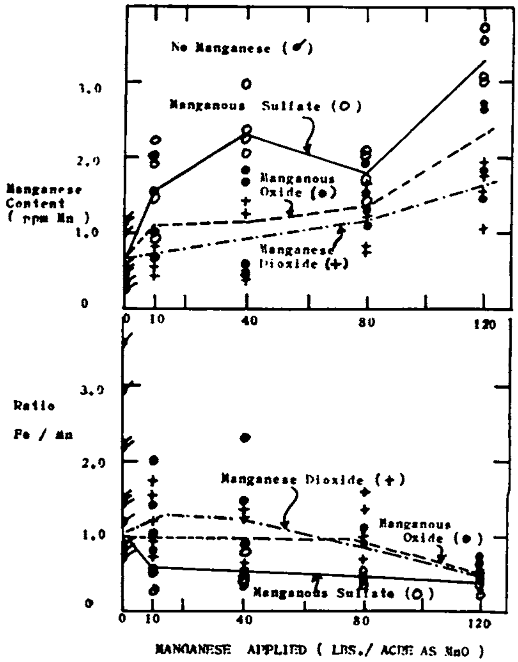

Figure 6a (upper graph). Effect of rate and source of manganese application on the manganese content of tomato fruit grown on the unlimed Scranton f. s. is shown and Figure 6b (lower graph) shows the effect on the iron/manganese ratio.

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RETARDING EFFECT OF SOME INSECTICIDES ON CABBAGE SEEDLINGS

T. M. Dobrovsky
Florida Agricultural Experiment Station
Potato Investigations Laboratory
Hastings

Numerous observations have been published during the past few years concerning the toxic effects of organic insecticides on various plants. Since soil insecticides are increasingly coming into use, such observations deal not only with injuries resulting from the contact of insecticides with the above-ground parts of plants, but also with the adverse chemical behavior of insecticides in the soil.

The most common concern is in regard to burning, defoliating, or killing of plants. To less extent, the more subtle effects of poisons upon plants are observed and reported. DDT is known for stunting some varieties of bush lima beans (9) and for dwarfing some varieties of tomatoes and cucurbits (1, 4, 10); parathion is reported to have delayed "foliation" of some ornamental plants (7).

As to soil behavior of insecticides, it has been noted that DDT may suppress the growth of strawberry plants (2, 3), that BHC and parathion in the soil can retard sprouting and reduce growth of Irish potatoes (8), and that BHC may delay germination of seed and growth of cantaloupe plants (6). In experiments with cotton, octamethyl pyrophosphoramid has caused stunting of plants growing both in nutrient solution and in soil (5). It appears that stunting or similar defects may be inflicted upon certain plants by some organic insecticides.

Florida Agricultural Experiment Station Journal Series, No. 208.

Information of this nature regarding cabbage seedlings is lacking. In this paper, therefore, are presented a few observations made in a preliminary inquiry into the effect of insecticides upon the growth of cabbage seedlings. The fall season of 1952 was favorable for investigating this problem because the insect populations remained low, and it was possible to obtain accurate figures on both the weights and the numbers of seedlings grown not only in treated plots but also in those which were not treated with insecticides.

The cabbage seedbed plots for this experiment were planted on October 31, 1952. Each plot consisted of two 20-foot sections in 2-drill-row seedbeds. The cabbage variety was Medium Copenhagen Resistant. The treatments were randomized, and four replications of each were made. The following insecticides were used: DDT alone, DDT with parathion, chlordane alone, chlordane with parathion, and parathion alone. All were emulsions. They were applied with a three-gallon hand sprayer, at the following rates of actual insecticide per acre: DDT alone–9.6 ozs.; chlordane alone–19.2 ozs.; and parathion alone –9.6 ozs. In the mixed applications of DDT or chlordane with parathion, each material was used at half the above rates. Three applications were made at the following intervals: 17 days after planting, two weeks later, and one week after the second. The plants were pulled two days after the third application.

Number and weight of large plants drawn from three feet of seedbed in each plot were used to determine the effect of the insecticides on plant growth. The pulled plants were