IRON CHLOROSIS ON *Dracaena sanderiana*

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INTRODUCTION

The *Dracaena sanderiana* is a tall-stemmed, erect, unbranched ornamental plant with long lanceolate leaves 5 to 9 inches long and ¾ to 1¼ inches broad, gradually tapering to a sharp point with broad longitudinal bands of white at the margin and often other stripes further in the leaf. It is grown by the ornamental plant growers of Puerto Rico for export to the United States for the greenhouse and florist trade. In 1952, it was estimated that over 1,000,000 plants were shipped to the United States with a value of $100,000. As the demand for *sanderianas* is increasing, the present export market demand is well over 2 or 3 times the shipments of 1952.

A chlorosis of *sanderiana* was noted by some of the growers. At first not much attention was given to this chlorosis because of its limited appearance. However, with increased production of *sanderianas* for the export market and the more frequent cutting of stock plants, the extent of the chlorosis became greater. By 1952, many leading growers were threatened with limited or no production because of the chlorosis. The Agricultural Experiment Station of the University of Puerto Rico, in cooperation with the Agricultural Extension Service, as requested by the ornamental plant growers of Puerto Rico, began work on this problem in the summer of 1952.

SYMPTOMS AND NATURE OF THE CHLOROSIS

The chlorosis of *sanderiana* consists of a yellowing of the green portion of the leaf. In severe cases, the chlorosis occurs to such an extent that no chlorophyll is seen, and the entire leaf becomes ivory-white. In the earlier stages the chlorosis is evident on the youngest leaves of the plant. With age and increasing severity it moves down to the older leaves until the entire plant is chlorotic. Growth becomes limited, few new suckers appear, but no severe stunting occurs at first. There are no mottled areas or necrotic spots on the leaves, and no wrinkling occurs.

Examination of the roots reveals no evidence of insect or nematode damage. The roots of the chlorotic plants generally are smaller in volume

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and have fewer fine-branching rootlets than healthy plants of corresponding age and size.

The symptoms displayed are indicative of iron chlorosis. The occurrence of the chlorosis first in the younger leaves then in the older is strongly characteristic of iron chlorosis where the relatively immobile iron in the plant does not move to the newer leaves where it is needed. Ferrous sulfate solutions painted on the leaf relieved the chlorosis, and verified the suspicion that it was caused by a deficiency of iron.

In the summer of 1952, a survey was made by the senior author with the aid of Miguel A. Díaz of the Agricultural Extension Service to determine what environmental conditions were responsible for the chlorosis of *sanderiana* in Puerto Rico. Field trips were made to collect plant and soil samples from *sanderiana* growers where chlorosis was present and from growers who had none. The survey revealed the following:

1. The chlorosis was present in *sanderianas* growing in soils with pH's ranging from 4.2 to 7.5. The majority of the soils were below a pH of 6.0.
2. The soil textures ranged from loamy sands to heavy clays with the majority on sandy soils.
3. Poor drainage was present in many chlorotic beds. This usually was caused by a heavy clay subsoil extending 6 to 10 inches below the sandy surface soil.
4. In some cases there were healthy *sanderianas* growing next to chlorotic ones.
5. The use of commercial fertilizers containing nitrogen, phosphorus, or potassium did not seem to influence the chlorosis significantly.
6. Tip cuttings taken from chlorotic *sanderianas* and rooted in a well-drained, fertile soil recover and new growth showed no evidence of chlorosis.
7. If old plantings were uprooted after 5 to 6 years and the roots were trimmed and replanted in new soil, the new growth was free of chlorosis.
8. The older *sanderiana* stock cut for many years had many large roots with an orange-brown coating. In general, these roots did not seem to possess much power of absorbing water and nutrients. It appeared as if the small rootlets branching from these main roots did the work. It was observed that old chlorotic plants did not have sufficient new root area to support the number of above-ground stems that were growing.

It appeared from the survey that poor drainage and limited root systems were preventing enough available iron from entering into the *sanderiana* plant. There were no indications of a lime-induced chlorosis from high pH (above 7.5) nor of salt accumulations. With these facts in mind a greenhouse experiment was started to determine how the iron deficiency in *sanderiana* might best be corrected.

EXPERIMENTAL PROCEDURE

Rooted tip cuttings of *Dracaena sanderiana* were placed in 2-gallon glazed pots filled with cleaned white quartz sand. The plants were grown for 1 month with only distilled water added, then 1 month with a complete nutrient solution, minus iron. After this 2-month period of exhausting the iron reserve of the plant, a moderate iron chlorosis developed in all plants

TABLE 1.—*The influence of various iron salts on the control of iron chlorosis in* Dracaena sanderiana

Treatment letter	Treatment[1]	Rate of application	Degree of chlorosis	Appearance of the leaf
A	No iron	0	High	Light yellowish-green
B	$FeSO_4$ spray on leaves	2 lb. $FeSO_4$ per 100 gal. of water plus 1 lb. lime	Moderate	Dark-green spots with rest of leaf yellowish-green and covered with reddish-brown spray residue
C	Fe EDTA in nutrient solution to roots	5 p.p.m. of Fe EDTA (12 percent as metallic iron)	Slight	Green with slight yellow green in areas
D	Fe EDTA spray on leaves	1 lb. of Fe EDTA (12 percent as metallic iron) per 100 gal. of water	None	Dark-green
E	$FeSO_4$ in nutrient solution to roots	5 p.p.m. as Fe	None	Do.

[1] All received a complete nutrient solution including N, P, K, Ca, Mg, S, Zn, Mn, Cu, B, and the Fe was added as indicated.

typical of the *sanderiana* chlorosis noted under shade-house conditions in the field.

Differential treatments were then applied as shown in table 1. All plants received a complete nutrient solution containing N, P, K, and the minor elements Ca, Mg, Zn, Cu, B, and S. Iron in various forms was given in all treatments except A. Ferrous sulfate was used as a spray in treatment B, and in solution in treatment E. A new source of iron, the ferric salt of ethylenediamine tetraacetic acid, Fe-EDTA,[2] was utilized in two treatments to see whether it was more efficient than the normally used ferrous

[2] The commercial form of the salt used was Sequestrene NaFe (12.0 percent Fe as metallic) available from the Alrose Chemical Co., New York, N. Y.

sulfate. In treatment C the Fe-EDTA was supplied in solution, and in treatment D it was used as a spray.

RESULTS

The results of the various treatments are given in table 1 and figure 1. The no-iron-treatment *sanderianas* were chlorotic (see fig. 1, A). The

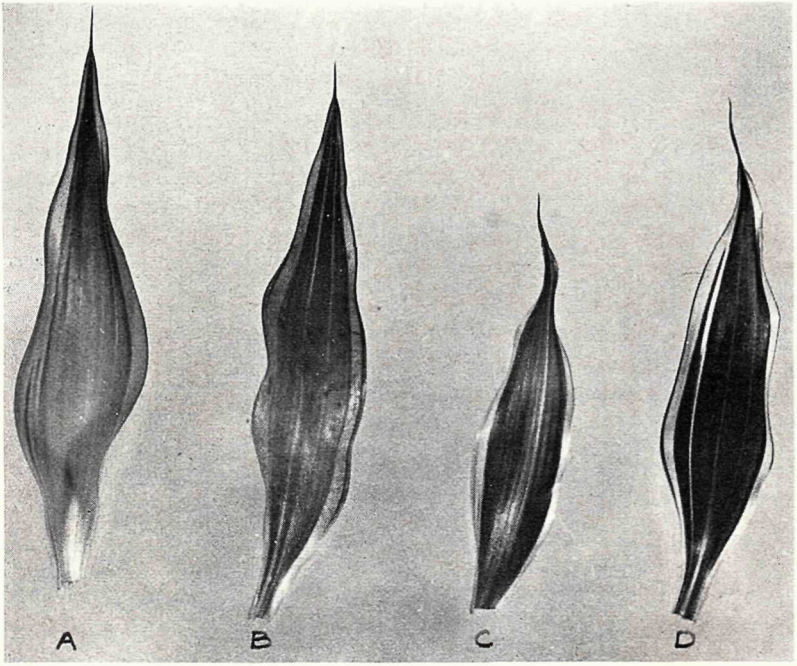

FIG. 1.—The influence of various sources of iron on *Dracaena sanderiana* grown in the greenhouse: A, Chlorotic *sanderiana* leaf which received no iron in its nutrient solution; B, *sanderiana* leaf sprayed with solution of ferrous sulfate, showing spotting and iron-stain residue; C, *sanderiana* leaf which received Fe-EDTA (chelated iron) in solution, showing improved coloring but not complete recovery; D, *sanderiana* leaf sprayed with Fe-EDTA showing healthy green leaf with no visible evidence of chlorosis.

chlorosis was evident in the new leaves at the top of the plant. Here almost the entire leaf was yellowish-green. The older leaves, although not chlorotic, were lighter green in color, and the plants did not have a healthy appearance suitable for export.

Where iron was supplied as ferrous sulfate in solution (treatment E), the plants gave no evidence of chlorosis, and were healthy in appearance with dark-green leaves. This confirmed that control of the chlorosis could

be obtained if iron were made available to the plant. However, the use of ferrous sulfate as a soil treatment is limited, as the very soil conditions which limit the intake of available iron to the *sanderiana* also fix the iron added to the soil in an unavailable form. For this reason, ferrous sulfate was then tried as a spray (treatment B).

The application of the iron as a ferrous sulfate spray gave unsatisfactory results from a commercial standpoint. As can be seen in figure 1, B, the leaf had a residue which made the plant unsuitable for sale as an ornamental. The residue consisted of a reddish-brown coating on the leaf left by the spray. The residue could be removed by washing only with difficulty, which meant extra labor costs for the grower if the spray were used. Even more objectionable was the uneven coloring obtained with use of the ferrous sulfate spray. The leaves developed dark-green spots while other areas still remained chlorotic. This spotting gave the plant an unsatisfactory appearance for commercial sales purposes. The spotting appeared to be caused by an uneven absorption of the spray from the glossy surface of the *sanderiana* leaf. The dark-green spots occurred near stomatal openings where the intake of the iron was more rapid.

Commercial plantings of chlorotic *sanderianas* exhibited this spotting effect when sprayed with ferrous sulfate. However, new growth from these plants was very healthy and showed no chlorosis. The older chlorotic plants never recovered their appearance sufficiently for sales purposes and could be used only as stock plants. Evidence of spray injury with ferrous sulfate sprays was encountered in trials on *sanderianas* and other ornamentals near the sprayed beds when rates above 5 pounds of ferrous sulfate per 100 gallons of water were used.

The use of Fe-EDTA, the chelated iron source, gave very promising control of iron chlorosis. When used as a spray once weekly, 1 pound of the Fe-EDTA (12 percent as metallic iron) per 100 gallons of water for 2 weeks gave complete control as can be seen in figure 1, D. The leaves were dark green, and the entire plant was healthy in appearance. Growers who saw the plants stated that they were of very high quality and satisfactory for export sales.

There was no evidence of any spotting effect or residue as when ferrous sulfate was used. Preliminary trials on commercial plantings showed that if the spray application was not uniform for highly chlorotic *sanderianas* a certain amount of spotting occurred. The greener areas of the leaf were much larger than when ferrous sulfate sprays were used, and after continued spraying the areas merged to produce a normal leaf. The fieldwork indicated that higher rates of Fe-EDTA are usually needed for control of the chlorosis than were required in the greenhouse experiment, and that thorough sprayings must be made. The use of a sticker is recommended.

A detergent (Dreft) was utilized as the sticker in greenhouse work with satisfactory results.

Although complete studies in the field have not been finished, preliminary trials by growers indicate that 2 to 4 pounds of Fe-EDTA (12 percent as metallic iron) per 100 gallons of water give satisfactory control when sprayed thoroughly on chlorotic *sanderianas*. Trials have shown that rates up to 15 pounds of Fe-EDTA per 100 gallons of water neither produced leaf injury nor left insoluble residues on the leaf. More frequent applications were needed for highly chlorotic *sanderianas* than for those tested under greenhouse conditions.

FE-EDTA gave satisfactory control over a long period of time when applied to the roots of the plant in solution; however, recovery was not as fast as when the plants were sprayed. At 4 weeks control was achieved with the spray, while the solution had still not given an entirely satisfactory green color (see fig. 1, C). One month later no visual differences could be detected between the two Fe-EDTA treatments. It appears that for rapid control of the chlorosis, Fe-EDTA in spray form is best. Preliminary field trials showed that Fe-EDTA applied to the soil, and worked into it near the plant, controlled chlorosis in the new growth, but the old chlorotic leaves did not show a full recovery for quite a long while. Chlorotic tip cuttings rooted in Fe-EDTA-treated soils recovered rapidly.

DISCUSSION

The use of Fe-EDTA to control iron chlorosis is not new. It was used by Jacobson (2)[3] in nutrient-solution work in the greenhouse and by Stewart and Leonard (3) for control of iron chlorosis in citrus. EDTA is an organic complex (ethylenediamine tetraacetic acid) which is known to organic chemist as a chelating agent, a name derived from the Greek word meaning "claw". The organic molecule of EDTA acts like two jaws and removes metal ions from solutions, and the reaction is reversible (1). Thus, when chelated with EDTA to give Fe-EDTA, iron can be released to the plant without being fixed by the soil as are ordinary iron salts added to the soil.

RECOMMENDATIONS

The results of the greenhouse experiments reported here and of preliminary field trials suggest the following measures for the control of iron chlorosis of *Dracaena sanderiana* in Puerto Rico:

1. Plant *sanderianas* in well-drained soils.
2. If heavy cutting of stock plants is practiced, high rates of fertilizers

[3] Numbers in parentheses refer to Literature Cited, p. 272.

(major and minor elements) are needed to offset the heavy drain of nutrients on the stock plant.

3. Forking the soil, or spading so as to prune old inactive roots and force new roots, is recommended for old-stock plantings.
4. Two to four pounds of Fe-EDTA (12 percent as metallic iron) per 100 gallons of water should be used as a spray for chlorotic plants.
5. Highly chlorotic plants should be sprayed once a week for 1 month, followed by spraying once a month until chlorosis is under control.
6. For preventive control of chlorosis in soils in which *sanderianas* have shown chlorosis, spray the plants once every 3 months, or apply Fe-EDTA to the soil mixed in the fertilizer at the rate of 25 pounds per acre.

SUMMARY

A study of a chlorosis on *Dracaena sanderiana* in Puerto Rico disclosed the following facts:

1. The chlorosis which consists of a yellowing of the younger rather than the older leaves of the *sanderiana* is caused by a lack of available iron.
2. The chlorosis was found in soils with pH's ranging from 4.2 to 7.5 and with textures from loamy sands to heavy clays. It was more prevalent on poorly drained soils.
3. The use of ferrous sulfate sprays gave unsatisfactory results because of a spotting or uneven greening of the leaf and an unsightly residue which could be removed only with difficulty by washing.
4. The use of Fe-EDTA (12 percent as metallic iron), an organic iron complex as a spray (1 pound per 100 gallons) gave satisfactory control without leaving any spray residues or causing spotting.
5. Fe-EDTA gave satisfactory results when applied to the roots in solution, but took longer to work than did the Fe-EDTA spray.
6. General recommendations are given for the control of iron chlorosis in *sanderianas*.

RESUMEN

El estudio de la clorosis que afecta a la *Dracaena sanderiana* en Puerto Rico ha revelado lo siguiente:

1. La clorosis, que es un amarillamiento de las hojas jóvenes de la *sanderiana*, la causa una falta de hierro asimilable en la planta.

2. La clorosis fué hallada en suelos con pHes que variaron desde 4.2 hasta 7.5 y en texturas desde las arenas margosas hasta las arcillas pesadas. Estas últimas fueron las más predominantes en los suelos con desagüe pobre.

3. El uso del sulfato de hierro en aspersiones dió resultados poco satisfactorios debido a que produjo una especie de moteado o reverdecimiento irregular de las hojas y a que deja, además, un residuo de fea apariencia, el cual se hace difícil remover aunque se lave la hoja.

4. El uso de hierro en la forma orgánica EDTA (12 por ciento hierro metálico) en aspersiones (1 libra por cada 100 galones) dió resultados satisfactorios en el control de la clorosis sin dejar residuos o producir moteo.

5. Cuando el hierro EDTA se aplicó en solución a las raíces de las plantas, dió resultados satisfactorios, pero tomó más tiempo en actuar que cuando se usó en aspersiones.

6. Se hacen recomendaciones generales para el control de la clorosis producida por la falta de hierro en la *sanderiana.*

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