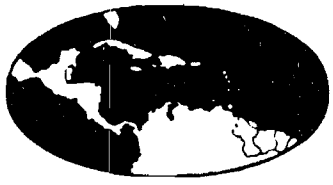
PROCEEDINGS

OF THE

CARIBBEAN FOOD CROPS SOCIETY



FOURTH ANNUAL MEETING

KINGSTON , JAMAICA

JULY 25 -- AUGUST, 1 1966

VOLUME IV

Table 5 - Air and soil temperature recorded during the tomato growing season, February 15 - May 11, 1959.

	Air temperature in °F	Soil temperature in °F at 2-4" depth	
		Under mulching	No mulching
Ave. minimum	67.3	79.5	79.0
Ave. maximum	87.0	93.6	92.2
Mean	77.2	86.6	85.6
Range	62-92	74-100	74-96

* * *

RESULTS OF MAGNESIUM FERTILIZER RESEARCH IN PUERTO RICO

E. Hernández-Medina[1/]

ABSTRACT

The results obtained in studies undertaken to determine the influence of magnesium on the yield of various crops of economic importance in Puerto Rico are briefly summarized as follows:

1. Magnesium increased significantly yields of sweet potatoes when this nutrient was applied to a Lares clay and Sabana Seca sandy clay soils.

2. The application of magnesium sulfate as spray and in the soil relieved grapefruit trees from visual symptoms of deficiency of magnesium. Heavy shedding of the leaves was corrected by using this nutrient.

3. On a highly alkaline soil magnesium applications to the soil were not effective in correcting magnesium deficiency in citrus trees. However, magnesium sprays were quite effective in controlling visual symptoms of magnesium deficiency.

4. There was a significant yield increase of marketable coffee in favour of magnesium-treated trees. The difference in

[1/]Agronomist, Agricultural Experiment Station, University of Puerto Rico, Río Piedras, Puerto Rico.

yield in favour of magnesium-treated trees was equivalent to a 43 percent over the check or untreated trees.

5. Magnesium was responsible for increasing significantly pineapple yields. Highest fruit yields were associated with the highest leaf magnesium content. A significant correlation was found between relative yields and leaf magnesium content.

6. Yields of plantains were increased by 90.9 percent by the application of magnesium. Plantains receiving no magnesium exhibited deficiency symptoms, including yellowing of the older leaves and reduced growth.

Foliar composition of the plantains at 7 months predicted their yield response to magnesium. Lowest plantain yields were associated with a leaf magnesium content of 0.15 while highest plantain yields were associated with a leaf magnesium content of 0.31 percent.

INTRODUCTION

In addition to the major elements, secondary nutrients play very important roles in plant metabolism. Magnesium is essential for growth and reproduction of all plants. The most important function of this nutrient element in green plants is in chlorophyll formation and photosynthesis.

During the past years, research work with magnesium at the Agricultural Experiment Station of the University of Puerto Rico has shown in most cases the beneficial effect of this nutrient on growth and yields of crops of economic importance.

The purpose of this paper is to summarize the results so far obtained with magnesium from those field experiments which have been already terminated and which comprise the period between 1950-1962. Part of the experimental data that will be presented here appears in several specific numbers of THE JOURNAL OF AGRICULTURE OF THE UNIVERSITY OF PUERTO RICO and in other publications, while others have not yet been published. It is hoped that by combining all the magnesium data so far obtained in a single publication will facilitate the review and evaluation of all the available information.

PROCEDURES

The experiments were established in the field following well known experimental designs with sufficient replications to warrant reliable statistical analysis. The experimental designs were either triple lattices, paired plots or randomized blocks. In most of the experiments the effect of magnesium on crops was studied in conjunction with major, secondary or minor elements. All crops were adequately fertilized with N-P-K except when the

general design and objectives of the experiment called for different quantities of the major elements. Test plants used in the magnesium studies were sweetpotatoes, citrus, acerolas, pineapples, coffee and plantains.

RESULTS AND DISCUSSION

Sweetpotatoes

Landrau, Jr. and Samuels (8) conducted four lime and minor-element fertilizer field experiments covering a range of soil textures from loamy sand to heavy clay. Two of the experiments were initiated on Cataño loamy sand. The third and fourth experiments were conducted on Sabana Seca sandy clay loam and on Lares clay, respectively. The U.P.R. No. 3 variety was used as test plant. Magnesium oxide was applied ranging from 50 to 300 pounds per acre. Yield responses to magnesium as high as 19 hundredweights per acre were obtained, especially with the highest rate of magnesium oxide per acre (300 lbs.) However, yield differences were not quite significant upon statistical treatment. Magnesium had no significant influence on the carotene and starch content of sweetpotatoes.

Citrus

Two citrus tests with magnesium were conducted by Hernández-Medina (5) at the Isabela Substation citrus orchards in a Coto clay for correcting apparent visual nutrient deficiency symptoms of magnesium. The p^H determinations of random soil samples indicated that the p^H where trees were growing were above the neutral point, in two cases close to p^H 8.0. The exchangeable calcium of the soil was relatively high as comprared to a relatively low exchangeable soil magnesium.

Leaf samples taken from several citrus trees before starting treatments were analyzed for magnesium content. Leaves which were still green had a magnesium content which ranged between 0.28 and 0.89 percent while those which showed apparent magnesium deficiency in various intensities as judged by sumptoms had a magnesium content which ranged between 0.07 and .14 percent (Table 1). It has been found that citrus leaves from trees grown in the field having a magnesium content below 0.20 percent were deficient in this element (3).

Correction of magnesium deficiency symptoms was achieved when trees received either two or three magnesium foliar sprays at the rate of 12 pounds of Epsom sald ($MgSO_4.7H_2O$) per 100 gals of water (Table 2). Sprays were given in early spring, summer and autumn. Magnesium as soil application, at the rate of 5 lbs. $MgSO_4.7H_2O$ per tree was ineffcetive in correcting the magnesium deficiency symptoms. This ineffectiveness could be attributed to the fact that the amount of magnesium sulfate per tree was not

enough to correct the deficiency, nor to counteract the effect that an excess of exchangeable calcium possibly have had in limiting magnesium absorption by the trees.

TABLE 1. Leaf magnesium content of citrus trees before receiving magnesium treatments in a Coto clay, Isabela Substation, Isabela, Puerto Rico.

Variety	Leaf Condition		
	Green	Medium Chlorotic	Chlorotic
	Percent	Percent	Percent
Valencia	0.30	0.14	0.07
Rico No. 2	.50	--	.10
China Verde	.28	--	.08
Marsh grapefruit	.89	.12	.07

TABLE 2. Leaf magnesium content of citrus trees 10 months after receiving magnesium treatments in a Coto clay, Isabela Substation, Isabela, Puerto Rico

Variety	Magnesium Treatment		
	Foliar	Soil	Check
	Percent	Percent	Percent
Valencia	0.25	0.07	0.09
Rico No. 2	.32	.06	.07
China Verde	.75	.14	.14

Landrau, Jr. and Samuels (9) also corrected a magnesium deficiency on grapefruit planted on Sabana Seca sandy clay near Arecibo by using magnesium sulphate either as soil application or as a foliage spray. Heavy shedding of the leaves was corrected by using this nutrient.

Acerolas

An experiment with acerolas (West Indian cherry), clone B-17, was established in an acid Mabí clay soil at the Gurabo Substation farm to determine the response of the acerola to lime and to foliar sprays of magnesium, among other nutrients.[2/] The use of magnesium in the spray mix significantly increased acerola production on soil limed to p^H 6.5. Increase in fruit production ranged between 0.75 to 1 ton of fruits per acre. Disregarding lime effect magnesium sprays did not significantly influence fruit yields.

Coffee

Hernández-Medina conducted an experiment in a Los Guineos clay to control a magnesium deficiency on coffee trees and to ascertain the effectiveness of this nutrient on coffee yields. Three year-old Arabica coffee of the Bourbon variety was used in the experiment. Fertilizer treatments consisted of 4 levels of magnesium at the following rates: 0, 30, 60 and 90 pounds of magnesium per acre.

Periodic observations on tree growth revealed that magnesium applications were quite effective in controlling leaf magnesium deficiency symptoms. There was a significant yield increase of marketable coffee in favor of magnesium-treated trees at the 3 levels of magnesium tested (Table 3).[3/] This was equivalent to a 35, 45 and 50 percent increase, respectively. However, no significant yield differences were attained between trees differentially treated with magnesium.

Abruña et al (1) conducted an experiment also in Los Guineos clay at Jayuya to determine the fertility requirements of intensively managed sun-grown coffee. In addition to the major elements (N-P-K) magnesium was also tested. They reported, contrary to the findings mentioned above, that the coffee trees did not respond to magnesium applications. The lack of response

---

[2/] Hernández-Medina, E., Annual Progress Report, 1956.

[3/] Hernández-Medina, E., Annual Progress Report, 1962.

to magnesium was attributed by the author[4/] to the fact that the lime applied to all experimental plots at the rate of 4 tons of limestone per acre in a 3-year period contained 1 percent magnesium as such. This implies that the soil treated with this material was supplied with 80 pounds magnesium per acre, sufficient enough to take care of any soil magnesium deficiency.

Previous experimental work with magnesium failed to produce any significant yield increases in coffee grown on an Alonso clay at the Adjuntas Substation.[5/]

TABLE 3. Effect of magnesium application on yields of intensively managed sungrown coffee on Los Guineos clay, Jayuya, P.R.

Treatment No.	Magnesium Lb./A	Yield of market coffee per acre*	Increase in yield over check trees
		Cwt.	Cwt.
1	0	17.1	--
2	30	23.3*	6.2
3	60	24.9*	7.8
4	90	25.8*	8.7

*Significant at 5 percent level over treatment

Pineapples

Extensive field work has been conducted by Hernández-Medina with pineapples to determine whether this crop responded favorably to the application of secondary and/or minor elements when these were applied via the soil or as foliar sprays. Magnesium was one of the secondary nutrients studied. The fertilizer trials were established in soils typical of the pineapple growing region near Arecibo and Manatí and in other soils with great potentialities for pineapple growing.

[4/] Abruña, F., Personal communication, Feb. 1966.

[5/] Hernández-Medina, E., Annual Progress Report, 1961.

The first of the pineapple experiments was initiated near the vicinity of Arecibo in a Río Lajas sandy soil, a potential soil for pineapple growing. Observations as to plant growth revealed that magnesium-treated plants made more vegetative growth, were more vigorous and greener in color than plants not supplied with this nutrient (6). This 1st group of plants showed magnesium deficiency symptoms which were similar to those reported previously (2). The yield data for the plant crop indicated that magnesium was the only nutrient which influenced significantly yields of pineapple whether it was applied to the soil or as foliar sprays (Table 4).

TABLE 4. Effect of fertilizer treatments on pineapple yields - Plant Crop - Río Lajas Sandy soil, Arecibo, P. R.

Fertilizer application	Treatment	Mean yield fruit per acre (Tons)1/
Soil	Mg + M.E. except Ca	17.03**
Soil	Mg + M.E. except Zn	16.20**
Soil	Mg + Ca + M.E. except Fe	15.18**
Foliar	Mg + Ca + M.E. except Mo	15.14**
Foliar	Ca + M.E. except Mg	11.77
Foliar	Ca + M.E. except Mg	12.34
Check - NPK only	Check - NPK only	11.45

1/** Significant at 1-percent level over the last three treatments.

Magnesium-treated plants produced on the average 4 tons more fruit per acre than plants lacking this nutrient. This was equivalent to a 34 percent increase in yield. For the ratoon crop, magnesium-treated plants were also the heaviest yielders (Table 5). They produced on the average 6 tons more fruit per acre than plants receiving other nutrients, including the check plants. For the average of two crops, the percent increase in yield in favor of plants supplied with magnesium amounted to 54 percent. Magnesium-treated plants were also far superior in green and dry weights than plants treated otherwise (Table 5).

TABLE 5. Relationship between fruit yields, plant weight and leaf magnesium content - Ratoon crop - Río Lajas sandy soil, Arecibo, Puerto Rico.

Treatment application	Treatment	Mean yield fruits per acre 1/	Mean Weight of plants		Leaf Mg Content
			Fresh	Dry	
		Tons	Pounds	Pounds	
Soil	Mg + Ca + M.E.	14.11**	--	--	--
Soil	Mg + M.E. except Ca	14.83**	10.9	2.7	0.17
Soil	Ca + M.E. except Mg	8.44	6.0	1.9	.09
Foliar	Ca + M.E. except Mg	8.44	5.4	1.8	.08
Check-NPK	Check-NPK only	8.38	5.3	1.8	.11

1/** Significant at 1-percent level over the last three treatments

They produced 59 percent more dry matter than plants receiving no magnesium or those receiving N-P-K only, or the check plants. There was a highly significant correlation between yield and leaf magnesium content (r = .823). Highest fruit yield was associated with the highest nutrient content of magnesium in leaves.

Two more experiments with magnesium were conducted by Hernández-Medina[6/] in the Arecibo area on Bayamón sandy clay, typical soil of the pineapple growing area. Rates of magnesium applied to the soil varied from 75 pounds to 1200 pounds of magnesium sulfate per acre. Magnesium sulfate used as foliar spray and magnesium chelate applied to the soil were also tested. Once more plants supplied with magnesium either as soil or foliar sprays produced significantly higher fruit yields than the check plants or plants not supplied with magnesium. They produced on the average 2.5 tons more fruit per acre than untreated plants.

Further work with magnesium was carried out at the Pineapple Farm, Manatí, of the Agricultural Experiment Station. At this site two experiments were established also on the acid lateritic

6/ Hernández-Medina, E., Annual Progress Report, 1960.

soil Bayamón sandy clay. In the first trial magnesium was studied in conjunction with trace elements while in the second trial three sources of magnesium were tested as soil application. The influence of magnesium sprays on yields of pineapples was also evaluated in both trials.

Table 6 summarizes the results of the first experiment on the influence of magnesium on pineapple yields(7). Magnesium was the only nutrient which had a significant influence in yields of pineapples, whether it was applied via the roots or foliage of plants. Plants supplied with magnesium produced on the average 2.7 tons more fruit per acre than plants lacking this nutrient. Highest fruit yields were associated with the highest leaf-magnesium contents. The correlation between these two criteria was highly significant (r = .553).

TABLE 6. Relationship between pineapple fruit yields and leaf magnesium content with and without magnesium supplement, Manatí Experiment.

Type of fertilizer application	Treatment	Mean yield of fruit per acre	Leaf Mg Content
		Tons	Percent
Soil	Mg + T.E.	17.19**	0.27
Foliar	Mg + T.E.	16.09*	.23
Soil	T.E. except Mg	14.55	.13
Foliar	T.E. except Mg	14.37	.19
Soil	Check, NPK only	14.28	.19

1/** Significant at 1-percent level over the last three treatments.

* Significant at 5-percent level over the last three treatments.

The tree magnesium sources used as soil treatment in the second experiment were equally effective in outyielding significantly plants not supplied with magnesium (check plants).7/

7/ Unpublished data of author.

The same results were obtained when magnesium was used as a foliar spray (Table 7). On the average, magnesium-treated plants produced over 3 tons more fruit per acre than the check plants, this being equivalent to a 22 percent increase in yield. Lowest pineapple yield was associated with a leaf magnesium content of 0.14 percent while highest pineapple yields were associated with leaf magnesium contents above 0.14 percent.

Plantains

Caro-Costa, et. al. (4) conducted an experiment in a Cialitos clay, the most extensive latosol of the humid mountain region of Puerto Rico. Corms of the Maricongo variety were used. The experiment was aimed at determining the response of plantains to the major elements (N-P-K) and magnesium on yield and foliar composition. Magnesium was applied at the rate of 100 pounds per acre.

Plantains responded strongly in yield to application of magnesium (Table 8). This nutrient was responsible for the production of larger bunches of fruit and for an increase in the number of bearing plants. Weight of the individual fruit was not significantly affected by magnesium. Yields of plantains were increased by 90.0 percent, from 9,680 to 18,480 pounds of fruit per acre by the application of magnesium. Plantains lacking magnesium showed typical deficiency symptoms, including yellowing of the older leaves and reduced growth. Lowest plantain yields were associated with a leaf magnesium content of 0.15 percent while highest plantain yields were associated with a leaf magnesium content of 0.31 percent.

TABLE 7. Pinapple yields and leaf magnesium content as affected by magnesium application on Bayamón sandy clay, Manatí, P. R.

Treatment No.	Description of treatment	Leaf Mg	Mean weight of fruit	Mean yield of fruits per acre	Outyielded at .01
		Percent	Pounds	Tons	
1	$MgSO_4$, 300 lbs. per acre	0.18	4.14	18.25	5
2	MgO, 300 lbs. per acre	.22	4.24	18.69	5
3	Mg chelate, 100 lbs. per acre	.18	3.85	16.97	5
4	$MgSO_4$ spray, 15 lbs. per 100 gals.1/	.18	4.33	19.09	5
5	Check, NPK only	.14	3.38	14.90	-

1/ Plants received 3 magnesium sprays at the rate of 15 lbs. $MgSO_4.7H_2O$/100 gallons of water.

TABLE 8. Effect of magnesium on yields and leaf magnesium content of intensively managed plantains growing on a typical latosol (Cialitos clay) in the Humid Mountain Region of Puerto Rico.

Treatment No.	Mg Lb./A	Fruits per acre		Average weight of bunch	Average weight per bunch	Average weight per fruit	Plants bearing a crop	Leaf Mg content
		Lb.	Number	Lb.	Number	Lb.	Percent	Percent
1	100	18,400	29,830	24.4	40	0.61	94	0.31
2	0	9,680	15,440	20.9	34	.61	55	.15
L. S. D.	0.05	5,500	9,340	3.2	5.7	N.S.	28	0.08
	.01	7,400	12,515	4.3	7.7	N.S.	38	.11

LITERATURE CITED

1. Abruña, F., et al, Effects of liming and fertilization on yields and foliar composition of high-yielding sun-grown coffee in Puerto Rico, J. Agr. Univ. P.R. 49(4) 413-28, 1965.

2. Cibes-Viadé, H. R. and Samuels, G., Mineral deficiency symptoms displayed by Red Spanish pineapple plants under controlled conditions, Tech. Paper 25, Agr. Exp. Sta., Univ. P. R., Río Piedras, 1958.

3. Childers, N. F., Fruit Nutrition (Temperate to Tropical), Somerset Press, Inc., Somerville, N. J., 2nd ed., 1966.

4. Costa-Caro, R., Abruña, F. and Vicente-Chandler, J., Response to fertilization of strip-cultivated plantains growing on a steep latosol in the humid mountain region of Puerto Rico, J. Agr. Univ. P. R. 48(4) 312-17, 1964.

5. Hernández, E., Efectos del uso de cal y de elementos secundarios y menores en el cultivo de frutales en Puerto Rico, Rev. de Agr. de Puerto Rico 52(1):18-23, 1965.

6. Hernández-Medina, E., Pineapple response to magnesium in Puerto Rico, Proc. Amer. Soc. Hort. Sci. (Caribbean Region) 5:70-5, 1961.

7. Hernández-Medina, E., Magnesium an important nutrient in pineapple production in a Bayamón sandy clay, J. Agr. Univ. P.R. 48(1): 17-24, 1964.

8. Landrau, Jr. P. and Samuels, G., The effect of fertilizers on the yield and quality of sweetpotatoes, J. Agr. Univ. P. R. 35(2): 71-87, 1951.

9. Landrau, Jr. P. and Samuels, G., Results of lime and minor-element fertilizer research in Puerto Rico, 1949-50; J. Agr. Univ. P. R. 40(4) 224-34, 1956.