Citrus Section

RESPONSE OF CITRUS GROWING ON CALCAREOUS SOIL TO SOIL AND FOLIAR APPLICATIONS OF MAGNESIUM

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ABSTRACT

Three magnesium rates were compared in one experiment over a 16-year period on mature 'Marsh' grapefruit trees planted on calcareous Parkwood loamy fine sand in the Indian River Field Laboratory grove. Treatments consisted of 3 rates of magnesium sulfate applied to the soil. In a second experiment, 4 rates of magnesium nitrate have been applied by foliage sprays annually since 1964 to mildly magnesium-deficient 'Valencia' orange trees.

Fruit yields were significantly affected by the high magnesium treatment applied to the soil over the 16-year period, while tree condition and internal fruit quality factors were not significantly changed. Leaf Mg was slightly increased by Mg treatments.

Spraying with magnesium nitrate diminished considerably the amount of visual Mg deficiency symptoms. Leaf Mg content increased with increasing concentration of magnesium nitrate in the spray. Foliar application of magnesium nitrate shows promise as an effective method of controlling Mg deficiency of citrus growing on calcareous soil.

INTRODUCTION

Low levels of Mg in citrus leaves are not uncommon in groves planted on calcareous soils in the Indian River area, although Mg fertilizers are used. Peech and Young (7) reported that visible leaf Mg deficiency symptoms are sometimes severe on these calcareous soils, in spite of their usually relatively high exchangeable Mg content. They attributed this to the large excess of Ca, and an unfavorably wide Ca:Mg ratio. These workers contended that a Ca:Mg ratio between 8 and 10 to 1 was desirable and necessary to prevent Mg deficiency.

Embleton and Jones (2) reported foliar sprays of magnesium nitrate were effective in alleviating Mg deficiency of citrus on California soils where uptake of Mg was a problem.

One experiment to be described here was a 16-year study begun in 1949 to determine the effect of soil applications of magnesium sulfate (Emjeo) on tree condition, yield, and quality of 'Marsh' grapefruit growing on calcareous Parkwood soil. The second experiment reported here was undertaken in 1964 to test the effectiveness of magnesium nitrate as a foliar spray on mature 'Valencia' orange trees also planted on Parkwood soil.

EXPERIMENTAL METHODS

A Mg rate experiment was initiated in the Indian River Field Laboratory grove near Fort Pierce during the spring of 1949. The trees, 'Marsh' grapefruit on sour orange rootstock, were planted in 1930 on single row beds placed 30 feet apart with trees 25 feet apart in the rows. The soil type was Parkwood loamy fine sand with pH ranging from 6.8 to 8.3 in the surface and above 6.8 in all depths to 42 inches. Reitz and Hunziker (9) found the soil contained about 14 per cent calcium carbonate and 3 per cent organic matter. Also, the soil contained 12 to 30 per cent clay plus silt (particles less than 0.05 mm. in diameter), thus being much finer in texture than soils used for citrus in Central Florida.

Three differential treatments were applied, consisting only of 3 rates of magnesium from

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Table 1. Mineral elements applied in the 16-year experiment with 'Marsh' grapefruit.

	Pounds of elements per tree per year					
				MgO treatments		
Years	N	P_2O_5	K_2O	Mg1	Mg2	Mg3
1949-1953	3.00	4.50	6.00	0	2.25	3.75
1954-1955	3.75	3.75	7.50	0	2.25	4.50
1956-1961	2.40	2.00	4.00	0	1.20	2.40
1962-1966	2.40	2.00	4.00	0	0	0

magnesium sulfate (Emjeo). The experimental design used was a randomized block, with 3 treatments and 5 replications. Plot size was 6 trees. Applications were made in mixed fertilizers The treatments are summarized in Table 1. In the early years of the experiment, the trees were fertilized frequently (3 times per year) and very liberally. This was a period in which the trees were recovering from the nearly-complete defoliation caused by the August, 1949 hurricane. In the later years, the trees were fertilized less frequently and at moderate rates, since recovery from the hurricane was apparently complete, and since information from a nitrogen rate experiment was becoming available for guidance (9). Differential magnesium treatments were discontinued in 1962 after it had become obvious that differences due to treatment would be small at the established magnesium levels.

Dolomite applications were inadvertently applied to one of the check plots during 1961. Although data from this plot do not appear to be different from that obtained from other check plots, they have been discarded.

Soil samples collected during the spring of 1965 from the long term experiment were analyzed by the University of Florida Soil Testing Laboratory. The testing procedure included extraction of the soil for exchangeable Ca. Mg and K with ammonium acetate buffered at pH 4.8. Exchangeable Ca and K were determined on a Beckman Model B flame spectrophotometer, while Mg was determined on a Beckman Model DU flame spectrophotometer. Further details concerning site, sampling and analytical techniques are described elsewhere (1, 5, 8).

In the foliage spray experiment initiated in 1964, 4 rates of magnesium nitrate were applied in 1964 and 1966 during June and May, respectively, to mature 'Valencia' orange trees in the Indian River Field Laboratory grove. The soil was very similar to that in the long-term experiment described above. Spring cycle leaves were three-fourths to fully expanded at time of spray applications. Because of extremely dry weather, applications were delayed until late August during 1965. These trees exhibited slight to moderate Mg deficinency symptoms in certain years prior to the experiment, although they had received at least 0.70 pounds of MgO equivalent as magnesium sulfate per year in the regular grove fertilization program. Separate additional applications of 5 to 10 pounds magnesium sulfate per tree had not appreciably raised the prevailing low magnesium content of the leaves.

Treatments were arranged in a randomized block with 6 replications of each treatment, each plot consisting of 4 uniform trees with adequate buffer trees. Spray treatments included concentrations equal to 0, 5, 10 and 15 pounds of magnesium nitrate per 100 gallons of water. Magnesium nitrate was obtained by reacting equal quantities of magnesium sulfate (Epsom salts) and calcium nitrate. For example, 10 pounds each of magnesium sulfate and calcium nitrate when mixed in 100 gallons of water react to produce approximately 10 pounds of magnesium nitrate. A small amount of Dreft was added to each spray tank as a wetting agent.

The ground under each tree was covered with a plastic sheet during the 1964 spray application to prevent infiltration into the soil.

Table 2. Effect of magnesium treatments on yield of 'Marsh' grapefruit over a 16-year period.

Mg rate	Average yield in boxes per tree																16 year avg.[1]
	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	
Mg_1	10.3	7.1	10.3	7.4	14.5	5.0	15.0	5.6	7.9	7.0	9.1	9.3	11.9	5.9	5.8	8.2	8.8[a]
Mg_2	11.1	6.6	9.5	7.9	15.1	5.3	14.1	6.5	7.4	8.9	8.9	9.0	10.2	7.3	5.7	8.7	8.9[a]
Mg_3	12.5	7.1	9.3	8.4	15.8	5.3	14.9	6.4	7.0	7.9	9.6	10.3	12.0	7.2	6.4	8.9	9.3[b]
Stat. sign.[2]	*	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	*

1/ Sixteen-year averages followed by the same letter do not differ at P = 0.05.

2/ * = significant at 5% level.

n.s. = not significant at 5% level.

This precaution was not taken in subsequent applications. It usually required 17 to 20 gallons of spray for complete coverage of each tree. Spring flush leaves from non-bearing twigs were sampled in July or early August in 1964 and 1966, but were not sampled in 1965 because of the lateness of the spray application. Leaf magnesium was analyzed with a modified EDTA titration method (6).

Results and Discussion

Yield and fruit quality.—Table 2 shows grapefruit yields were significantly affected over the 16-year period by the Mg treatments applied to the soil, but in only one individual year out of 16 years were the differences statistically significant. Yields resulting from low rate plots (Mg_1) were actually higher than yields from high rate plots (Mg_3) in 4 out of 16 years. An analysis of variance using years as replications and treatment means as main effects disclosed a significant difference among treatment means over the 16-year period. Overall difference between Mg_1 and Mg_3 rates amounted to 8.1 boxes or approximately one-half box per tree per year over the 16-year period.

Soil Mg applications had no effects on soluble solids, juice acidity, soluble solids to acid ratio, juice content, or fruit size.

Leaf analysis.—Leaf Mg increased slightly with increasing Mg rates. The differences were statistically significant in 9 out of 13 years (Table 3). The application of water soluble magnesium sulfate to the soil in quantities substantially higher than the applications of nitrogen (Table 1) was an extremely ineffective method for raising the magnesium nutritional level of these trees growing on calcareous soils. This is in decided contrast to the results of soil applications on acid soils (4).

Soil analysis.—High exchangeable Mg existed even in the Mg_1 plots of the Parkwood soil (Table 4). Magnesium sulfate applications substantially increased the level of soil Mg. Whether Mg was native to the soil or resulted from fertilizations prior to this investigation is not known. However, Peech and Young (7) found marl soils on the Florida East Coast contained the highest exchangeable Mg among those analyzed.

Relationships among deficiency symptoms, leaf and soil analyses.—The Mg deficiency symptoms observed were relatively minor and occurred primarily in the early years of the experiment. Even in check plots these symptoms were found in only 4 out of 16 years. The records generally show that during years when mean leaf Mg in check plots fell below 0.20, leaf deficiency symptoms were observed. Infrequently, Mg deficiency symptoms were noted in Mg_2 rate plots and recorded only once for Mg_3 plots. Working with 'Pineapple' oranges on Lakeland fine sand, Spencer and Wander (12) found a leaf level of 0.33 per cent Mg in July would result in no Mg deficiency symptoms during that crop year. Even at the Mg_3 rate, leaf Mg levels this high were never attained. Thus, it would appear for the calcareous Parkwood soil a value of 0.20 per cent leaf Mg would represent a level

Table 3. Effect of magnesium rates on mineral composition of mature 'Marsh' grapefruit leaves expressed as per cent of oven-dry weight.

Mg rate	Mineral elements				
	% N	% P	% K	% Mg	% Ca
	(13-year averages)				
Mg_1	2.18	.118	1.37	.216	5.85
Mg_2	2.23	.117	1.40	.242	5.74
Mg_3	2.23	.120	1.49	.244	5.67
Years of statistical significance[a]	1	1	1	9	2

[a]Number of years in which treatment effects were significant at 0.05 level of probability.

above which leaf deficiency symptoms are rarely found in 'Marsh' grapefruit.

Failure to obtain significant yield and tree responses during most years is in agreement with the work of Reuther and Smith (11) who reported slight Mg deficiency symptoms did not influence, appreciably, tree growth and fruiting. They concluded there was no advantage in supplying Mg in excess of that needed to prevent visible deficiency symptoms. It is probable that low leaf Mg content is at least partly due to the trees being on sour orange rootstock. Koo and Calvert (4) found 'Pineapple' orange on 'Cleopatra' mandarin rootstock showed consistently higher leaf Mg content than 'Pineapple' on sour orange rootstock planted on the same soil type.

High exchangeable Mg in this soil (1, 7) is misleading when considered without examining the Ca:Mg ratio and soil pH. Lack of tree response to Mg rates undoubtedly is related to soil reaction. Koo and Calvert (4) found leaf and soil Mg contents from several Mg sources decreased with increasing soil pH. Work of Peech and Young (7) and Fudge (3) indicated that leaf Mg level is related to the Ca:Mg ratio of the soil. Peach and Young (7) pointed out a Ca:Mg ratio of 10 to 1 was desirable and a ratio over this would in most cases lead to Mg deficiencies. It is interesting to note that the ratio for the surface soil in the Mg_1 plots was approximately 13:1.

Magnesium nitrate spray experiment.—Only yield and leaf Mg contents and other data directly influenced by the treatments are included. The Mg spray treatments did not influence fruit quality or leaf constituents other than Mg.

Leaf Mg content, Mg deficiency ratings and yield from trees sprayed with magnesium nitrate are presented in Table 5. The very slightly higher yield measured in plots sprayed with magnesium nitrate could not be demonstrated to be statistically significant. Increases in leaf Mg were obtained by spraying magnesium nitrate especially in the third year, in 1966. Leaf Mg level increased with increasing rate of magnesium nitrate application. The 10 and 15 pound rates resulted in significant increases in leaf Mg in both years.

Visual leaf Mg deficiency symptom ratings appear to be closely related to leaf Mg contents (Table 5). Leaf Mg deficiency symptoms decreased markedly with increasing Mg rate in the spray, but did not entirely disappear, presumably due to retention on the tree of some deficient leaves developed during the course of the corrective series of treatments. The series

Table 4. Effect of magnesium rates on soil pH and extractable phosphorus and exchangeable potassium, calcium and magnesium.

Mg rate	Soil pH *	Pounds per acre			
		Ca*	Mg**	P**	K**
0-6 inch soil layer					
Mg_1	7.6	5500+	406[a]	113[a]	379[a]
Mg_2	7.7	5500+	1178[b]	84[a]	577[a]
Mg_3	7.5	5500+	1063[b]	88[a]	569[a]
6-12 inch soil layer					
Mg_1	7.7	5500+	685[a]	64[a]	489[a]
Mg_2	7.7	5500+	865[a]	53[a]	451[a]
Mg_3	7.7	5500+	1249[b]	37[a]	502[a]

*Data not statistically analyzed.

**Within any column for each soil depth, means followed by same letter do not differ at $P = 0.05$.

of plots were not continued sufficiently long to justify a statement of minimum leaf Mg content giving freedom from symptoms. The visual ratings also show the 10 and 15 pound rates were about equal in effectiveness, while the 5 pound spray rate gave only slight increases over the check treatment.

Since after the first spray application, the soil was neither protected from the drip of spray material nor from subsequent washing of the material onto the soil by rain, definite statements about the mode of entry of the magnesium into the tree cannot be made. However, the spray treatments were strikingly more effective in increasing leaf magnesium than were the even heavier soil applications over a much longer period, and were very effective in alleviating magnesium deficiency symptoms. A substantial proportion of the magnesium is suspected to have entered the tree through the aerial parts.

The results of the long-term experiment suggest that soil applications of water soluble Mg sources, although highly inefficient, often may be effective in preventing Mg deficiency symptoms of citrus growing on calcareous soils in the Indian River area. Growers with deficiency levels of leaf Mg should first try increased rates of water soluble magnesium in the fertilizer as recommended in Florida Agricultural Experiment Station Bulletin 536B (10). In stubborn areas of groves which fail to respond to repeated higher applications of water soluble Mg, spray applications of magnesium nitrate may be found effective in preventing Mg deficiency.

Table 5. Effect of magnesium nitrate spray applied to 'Valencia' orange trees on leaf magnesium content, magnesium deficiency ratings[⸸] and yield.

Magnesium nitrate spray rate (#/100 gal.)	Leaf magnesium, %		Magnesium deficiency ratings*				Yield, boxes/tree	
	1964	1966	8/14/64	11/10/64	11/19/65	3/24/66	1965	1966
0	.159[a]**	.247[a]	1.83	2.12	1.10	1.70	1.93[a]	4.12[a]
5	.225[b]	.324[ab]	0.58	1.88	0.42	1.10	2.58[a]	5.39[a]
10	.237[bc]	.360[b]	0.66	0.92	0.05	0.25	2.38[a]	4.13[a]
15	.258[c]	.391[b]	0.50	0.75	0.06	0.25	2.61[a]	4.52[a]

⸸ Key for magnesium deficiency ratings:

0. No magnesium deficient leaves.
1. Mild deficiency on a few scattered twigs.
2. Moderate, but general deficiency symptoms.
3. Severe and general deficiency symptoms.

* Data not statistically analyzed.

** Within any column, means followed by the same letter do not differ at P = 0.05.

Conclusions

Grapefruit yields were very slightly increased over a 16-year period by heavy soil applications of magnesium sulfate. With the exception of minor Mg deficiency symptoms in check plots, tree condition and fruit quality were not affected by soil Mg treatments. Leaf Mg was slightly, but significantly, higher due to the treatments in 9 years out of 13.

Magnesium nitrate sprayed at rates of 10 and 15 pounds per 100 gallons of water gave consistent significant increases in leaf Mg levels of 'Valencia' orange trees on Parkwood soil and reduced magnesium deficiency symptoms. It is suggested that foliar application of magnesium nitrate is a quick and effective method of controlling Mg deficiency for citrus growing on calcareous soil.

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