Literature Cited

1. Basiouny, F. M. 1984. The use of municipal treated effluent for peach tree irrigation. Proc. Fla. State Hort. Soc. 97:345-347.
2. Bielorai, H., I. Vaisman, and A. Feigin. 1984. Drip irrigation of cotton with treated municipal effluents. I. Yield response. J. Environ. Qual. 13:231-234.
3. Bole, J. B. and R. G. Bell. 1978. Land application of municipal sewage wastewater: Yield and chemical composition of forage crops. J. Environ. Qual. 7:222-226.
4. Burton, T. M. and J. E. Hook. 1979. A mass balance study of application of municipal wastewater to forest in Michigan. J. Environ. Qual. 8:589-596.
5. Campbell, W. F., R. W. Miller, J. H. Reynolds, and T. M. Schreeg. 1983. Alfalfa, sweetcorn, and wheat responses to long-term application of municipal wastewater to cropland. J. Environ. Qual. 12:243-249.
6. Embleton, T. W., W. W. Jones, C. K. Labanauskas, and W. Reuther. 1973. Leaf analysis as a diagnostic tool and guide to fertilization. p. 183-210. In: W. Reuther (ed.). The citrus industry, Vol. 3, Univ. of Calif. Press, Berkeley, CA.
7. Feigin, A., I. Vaisman, and H. Bielorai. 1984. Drip irrigation of cotton with treated municipal effluents. II. Nutrient availability in soil. J. Environ. Qual. 13:234-238.
8. Koo, R. C. J. 1969. Evapotranspiration and soil moisture determination as guides to citrus irrigation. Proc. 1st Int. Citrus Symp. 3:1725-1730.
9. Koo, R. C. J. 1976. Horticultural considerations of irrigation with citrus processing wastewater. Trans. 1976 Citrus Eng. Conf., Amer. Soc. Mech. Eng. 22:1-15.
10. Koo, R. C. J. and J. W. Sites. 1955. Results of research and response of citrus to supplemental irrigation. Proc. Fla. Soil Sci. Soc. 15:180-190.
11. Koo, R. C. J. and M. Zekri. 1989. Citrus irrigation with reclaimed municipal wastewater. Proc. Fla. State Hort. Soc. 102:52-56.
12. Neilsen, G. H., D. S. Stevenson, and J. J. Fitzpatrick. 1989a. The effect of municipal wastewater irrigation and rate on N fertilization on petiole composition, yield and quality of Okanagan Riesling grapes. Can. J. Plant Sci. 69:1285-1294.
13. Neilsen, G. H., D. S. Stevenson, J. J. Fitzpatrick, and C. H. Brownlee. 1989b. Yield and plant nutrient content of vegetables trickle-irrigated with municipal wastewater. HortScience 24:249-252.
14. Neilsen, G. H., D. S. Stevenson, J. J. Fitzpatrick, and C. H. Brownlee. 1989c. Nutrition and yield of young apple trees irrigated with municipal wastewater. J. Amer. Soc. Hort. Sci. 114:377-383.
15. Neilsen, G. H., D. S. Stevenson, J. J. Fitzpatrick, and C. H. Brownlee. 1991. Soil and sweet cherry responses to irrigation with wastewater. Can. J. Sci. Soil Soc. 71:31-41.
16. Sopper, W. E. and L. T. Kardos. 1973. Recycling treated municipal wastewater and sludge through forest and cropland. 1st ed. The Penn. State Univ. Press, University Park, PA.
17. Westcot, D. W. and R. S. Ayers. 1988. Irrigation water quality criteria. p. 3.1-3.37. In: G. S. Pettygrove and T. Asano (eds.). Irrigation with reclaimed municipal wastewater—A guidance manual. Lewis Publishers, Inc., Chelsea, MI.
18. Zekri, M. and R. C. J. Koo. 1990. Effects of reclaimed wastewater on leaf and soil mineral composition and fruit quality of citrus. Proc. Fla. State Hort. Soc. 103:38-41.

Proc. Fla. State Hort. Soc. 106:35-37. 1993.

EFFECTS OF THREE WATER SOURCES ON THE INCIDENCE OF RIO GRANDE GUMMOSIS IN GRAPEFRUIT GROVES

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Abstract. **Four plots in an east coast grapefruit grove were monitored for the incidence of Rio Grande Gummosis for 2 years. The trial compared irrigation with 2 levels of water quality; deep well water (approximately 1400 ppm total dissolved solids [TDS]) and shallow well water (approximately 800 ppm TDS), applied by drip and microsprinkler. Individual trees within each plot were rated twice per year. Only actively gumming trees within each plot were rated for Rio Grande Gummosis. These plots were compared with a grapefruit grove in another location, irrigated with lake water (approximately 125 ppm TDS), where symptoms of Rio Grande Gummosis had never been observed.**

Rio Grande Gummosis (RGG) was first reported as "Gummosis" in California in 1875 and Florida in 1876 (Childs, 1978a). In 1945 Godfrey described what he considered a new disease in Texas as "Rio Grande Gummosis," and this name has since become widely accepted (Godfrey, 1945). Although it has been reported to occur on oranges, it occurs most frequently on lemons and grapefruit (Knorr, 1973). Grapefruit trees affected with RGG are at least 10 to 15 years of age and show profuse gumming from pockets or vertical cracks on the trunk and large limbs. Other visual symptoms often include dull green foliage and lack of flush which may occur on a quadrant or the entire tree. In severe cases, limb dieback can be observed. Internal gum pockets in the roots have been described (Childs, 1978b).

Various fungi, psorosis, and chlorides have all been proposed as possible causal agents (Childs, 1950; Godfrey, 1946). A high incidence of RGG on poorly drained land was reported from the lower Rio Grande valley where poor drainage is synonymous with salinity (Apple et al., 1947), and association of RGG with chlorides was mentioned by Calvert (1973) and Childs (1978a).

[1]Retired.

Materials and Methods

A 20-year-old grove of 'Marsh' seedless grapefruit trees on sour orange rootstock with a high incidence of RGG, located on the east coast near Ft. Pierce, Florida, was monitored for RGG symptoms for 2 years (Table 1). Irrigation with 2 levels of water quality was compared; deep well water (1280 to 2400 ppm total dissolved solids [TDS]) and shallow well water (659 to 1536 ppm TDS), applied by drip and microsprinkler (Table 2). Four independently operated plots which consisted of microsprinkler/deep well water, microsprinkler/shallow well water, drip/well water, and drip/shallow well water were set up in March 1991. Each plot was comprised of 11 rows of 28 trees spaced 20' × 30', set on double row beds. The number of actively gumming trees were recorded twice a year in each of the 4 plots (Table 1). This grove was compared with a 45-year-old grove of Thompson pink grapefruit on rough lemon rootstock, located in a flatwoods area near St. Cloud, Florida, irrigated by overhead gun with lake water, 125 ppm TDS. This block consisted of 14 rows of trees, 30 trees per row planted 22' × 22' on unbedded land, which had always been fertilized with K_2SO_4 instead of KCl and has never shown symptoms of RGG.

Wood and bark cores were taken from tree trunks above the budunion with an electric drill. Leaf samples were taken along with roots and soil which were dug from inside the drip line of each tree. Samples were collected from both healthy appearing and actively gumming trees in each plot and analyzed for 14 elements.

Results and Discussion

Table 2 shows water quality of the 2 wells used to irrigate the east coast grove at 7 dates between October 1992 and July 1993. Both wells were clearly saline, although the salt content varied in the shallow well and it had acceptable TDS levels most of the time. The difference in salinity was not great enough, however, to induce clear differences between plots (Table 1). The greatest incidence of RGG was found in the plots irrigated with shallow well water by drip irrigation (Table 1). The number of gumming trees varied from rating date to rating date, with some trees recovering. The highest incidence of RGG was at the beginning of the experiment, following periods of normal rainfall (Fig. 1).

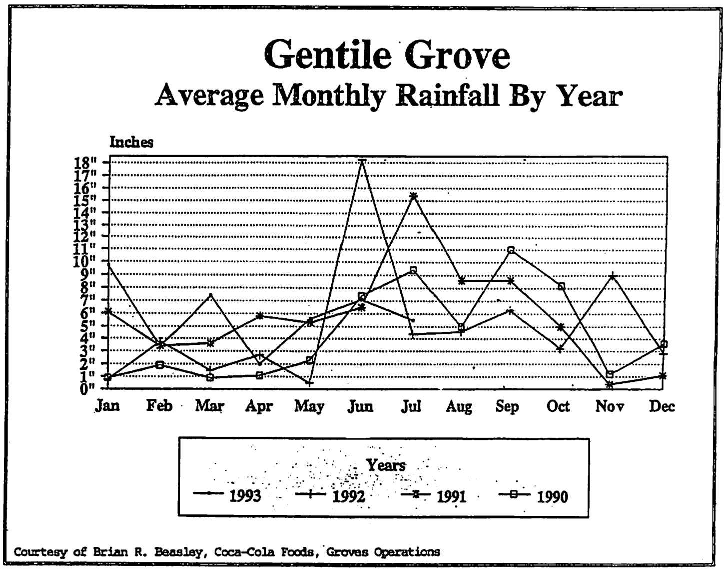

Figure 1. Gentile Grove average monthly rainfall by year. Courtesy of Brian R. Beasley, Coca-Cola Foods, Groves Operations.

While RGG in the deep well/microsprinkler plots increased 14% between August 1991 and December 1992, the incidence in the other plots remained static or decreased somewhat. There was a sharp decrease in RGG in all plots after December 1992, coinciding with unusually heavy rainfall, especially in the summer of 1992 (Fig. 1). It can be assumed that chlorides were leached not only from the soil but also from the leaves, and very little irrigation water was applied.

Chlorides in the saturation extract of the soil in the east coast grove were significantly higher, twice as high as in the RGG-free grove (Table 3). Analysis of the leaves, bark, wood, and feeder roots of the trees at the 2 locations showed the same normal chloride levels in the leaves (Table 4), but chloride in the bark and the wood was about 10 times higher and in the roots almost 4 times as high in the east coast, well-irrigated grove than in the RGG-free grove in the flatwoods, irrigated with lake water. The high tissue chloride levels on the east coast may also have been due in part by the KCl fertilizer applied there, while the K_2SO_4 used in the flatwoods is reflected in the higher sulfur levels in the

Table 1. Percent gumming per plot—East Coast.

Observation Date	8/07/91	4/23/92	12/16/92	4/29/93	7/21/93	Cummulative avg. per plot
Shallow well						
Microsprinkler	26	31	13	8	16	19
Drip	47	37	46	30	25	37
Deep well						
Microsprinkler	26	46	40	9	23	29
Drip	40	32	38	13	17	28
Average by date	35	37	34	15	20	

Table 2. Total dissolved solids (ppm)—East Coast water.

Sample date	10-02-92	10-18-92	2-06-92	12-16-92	1-26-93	4-30-93	7-21-93	Average
Deep well	1376	1280	1408	1344	1568	1344	2400	1531
Shallow well	1536	1408	832	704	659	832	1160	1019

Table 3. Soil analysis (saturation extract).

Grove	Water source	Total dissolved solids	Cl (ppm)
St. Cloud	Lake water	332.0a	14.0c
East Coast	Shallow well water		
	Microsprinkler	204.0b	33.0b
	Drip	303.0a	33.0b
	Deep well water		
	Microsprinkler	255.0ab	39.0b
	Drip	304.0a	58.0a

Means not sharing the same letter within columns are significantly different. Mean separation by t-test, p = 0.05.

leaves and the roots of these trees. Why there was no difference in leaf chlorides between the 2 sites is uncertain, but accumulations of elements in tissues other than the leaves are common, but often overlooked. This may explain the sometimes uncertain results when an attempt was made to link KCl fertilization with RGG (Childs, 1978b; Calvert, 1973).

Significant tissue level differences of elements other than chloride between plots and locations can be attributed to fertilization regimes, environmental factors, and interaction between elements (Table 4). Nitrogen, K, Mg, B, and S were clearly higher in the flatwoods grove than on the east coast, while P, Ca, Na, Fe, Mn, Zn, and Cu were lower, the last 3 elements clearly because of fewer leaf spray applications. In the bark, P, Zn, and Cu were lower in St. Cloud, in the wood only P was consistently lower. The roots of the RGG-free trees had higher N, P, K, Na, and Mn levels.

Table 4. Plant tissue analysis.

Grove	Source	Subject	N %	P %	K %	Ca %	Mg %	S (ppm)	Na (ppm)	Fe (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)	Cl (ppm)	B (ppm)
St. Cloud	Lake water	Leaves	2.64a	0.150b	1.89a	2.09c	0.424a	0.287a	173.0c	40.0c	14.0c	19.0b	16.0c	362.0a	124.0a
East Coast	Shallow well microsprinkler	Leaves	2.44b	0.128a	0.97b	3.85ab	0.360bc	0.234b	465.0a	53.0a	32.0b	63.0a	341.0a	278.0a	65.0b
East Coast	Shallow well—Drip	Leaves	2.40bc	0.130a	0.88b	4.01a	0.336c	0.239b	386.0b	48.0b	34.0ab	60.0a	266.0b	291.0a	61.0b
East Coast	Deep well microsprinkler	Leaves	2.30c	0.129a	0.98b	3.65b	0.395ab	0.239b	394.0ab	47.0b	39.0a	61.0a	314.0a	363.0a	66.0b
East Coast	Deep well—Drip	Leaves	2.27c	0.125a	0.91b	3.96ab	0.365bc	0.227b	400.0ab	45.0b	35.0ab	62.0a	270.0b	373.0a	66.0b
St. Cloud	Lake water	Bark	0.78b	0.028b	0.44b	4.56a	0.136a	0.078ab	167.0a	21.0b	7.0b	11.0b	11.0b	24.0c	49.0a
East Coast	Shallow well microsprinkler	Bark	0.81ab	0.037a	0.51a	4.49a	0.084b	0.071b	153.0a	28.0ab	10.0ab	21.0a	55.0a	164.0b	47.0b
East Coast	Shallow well—Drip	Bark	0.90a	0.036a	0.50ab	4.39a	0.080b	0.083a	140.0a	29.0a	9.0b	21.0a	47.0a	219.0a	49.0a
East Coast	Deep well microsprinkler	Bark	0.84ab	0.036a	0.53a	4.54a	0.114a	0.075ab	161.0a	33.0a	13.0a	27.0a	67.0a	267.9a	47.0ab
East Coast	Deep well—Drip	Bark	0.83ab	0.035a	0.54a	4.58a	0.089b	0.073ab	147.0a	26.0ab	11.0ab	22.0a	53.0a	218.0a	46.0ab
St. Cloud	Lake water	Wood	0.39c	0.018c	0.13d	0.82b	0.041c	0.020c	56.0c	16.0b	2.2ab	3.4a	3.0c	18.0c	11.0b
East Coast	Shallow well microsprinkler	Wood	0.45bc	0.031ab	0.19bc	0.83b	0.046abc	0.024bc	80.0bc	30.0ab	1.5b	2.0b	4.0bc	161.0ab	12.0b
East Coast	Shallow well—Drip	Wood	0.56a	0.034ab	0.23ab	1.10a	0.058ab	0.039a	91.0ab	22.0b	2.3ab	3.3ab	7.0abc	222.0ab	13.0ab
East Coast	Deep well microsprinkler	Wood	0.52ba	0.036a	0.24a	1.01ab	0.059a	0.028b	119.0a	50.0a	2.7ab	3.3ab	9.0ab	236.0a	15.0a
East Coast	Deep well—Drip	Wood	0.46bc	0.030b	0.17cd	0.90ab	0.045bc	0.021bc	106.0ab	26.0b	3.0a	3.3ab	12.0a	155.0b	13.0ab
St. Cloud	Lake water	Roots	1.98a	0.112a	0.65a	1.03b	0.371a	0.436a	690.0a	248.0b	604.0a	816.0a	166.0c	2432.0b	31.0b
East Coast	Shallow well microsprinkler	Roots	1.49bc	0.069b	0.45b	1.35a	0.329a	0.317b	344.0b	290.0ab	113.0c	522.0a	280.0ab	8879.0a	31.0b
East Coast	Shallow well—Drip	Roots	1.56b	0.077b	0.49b	1.38a	0.411a	0.274b	234.0b	207.0b	114.0c	817.0a	214.0bc	8665.0a	31.0b
East Coast	Deep well microsprinkler	Roots	1.34c	0.074b	0.44b	1.27a	0.316a	0.295b	346.0b	275.0ab	362.0b	720.0a	243.0b	7609.0a	31.0b
East Coast	Deep well—Drip	Roots	1.47bc	0.083b	0.42b	1.26ab	0.406a	0.284b	195.0b	365.0a	218.0bc	633.0a	317.0a	8125.0a	35.0a

Means not followed by the same letter within the columns of each tissue group are significantly different.
Mean separation by t-test, p = 0.05.

The data from this experiment make a strong case for involvement of chlorides in RGG, particularly the chloride levels in the bark and the wood where the RGG gumming lesions occur (Childs, 1978a). In further work to prove that chloride is the cause of RGG, analysis of other tree tissues in addition to the leaves should be a key element.

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Literature Cited

Apple, S. B., C. Edwards, G. Otey, and G. Williams. 1947. Results of a citrus disease survey. Proc. Second Ann. Lower Rio Grande Valley Citrus and Vegetable Institute, pp. 118-120.

Calvert, D. V. 1973. Response of 'Marsh' grapefruit trees in the Indian River area to potassium application - Yield and fruit quality. Proc. Fla. State Hort. Soc. 86:13-19.

Childs, J. F. L. 1950. Rio Grande Gummosis - Its occurrence in Florida citrus. Proc. Fla. State Hort. Soc. 63:32-36.

Childs, J. F. L. 1978a. Rio Grande Gummosis disease of citrus trees. Part I. A brief review of the history and occurrence of Rio Grande Gummosis. Plant Disease Reporter 62:390-394.

Childs, J. F. L. 1978b. Rio Grande Gummosis disease of citrus trees. Part II. The causal relations of Rio Grande Gummosis. Plant Disease Reporter 62:395-399.

Godfrey, G. H. 1945. A gummosis of citrus associated with wood necrosis. Science 102(2640):130.

Godfrey, G. H. 1946. Infectious wood necrosis and gummosis of citrus. Proc. First Annual Lower Rio Grande Citrus Institute, pp. 66-70.

Knorr, L. C. 1973. Citrus Diseases and Disorders. The University Presses of Florida, pp. 70-72.