Incidence of Rio Grande Gummosis of Grapefruit Is Not Associated with Concentrations of Anions in Soil Water

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Abstract. The objective of this study was to evaluate the role of chloride (Cl^-) and other anions in soil water on the incidence and severity of Rio Grande Gummosis (RGG) in grapefruit (*Citrus paradisi* MacFadyen) trees. White 'Marsh' grapefruit trees on sour orange (*C. aurantium* Lush.) rootstock were grown on two-row raised beds. Due to differential rates of K application (as KCl), the trees received various rates of Cl^- ranging from 0 to 156 $\text{kg}\cdot\text{ha}^{-1}$ per year. Soil water was sampled using suction lysimeters at 120- and 180-cm depths. The severity of RGG was evaluated 18 months following the application of various rates of KCl. The concentration of Cl^- in soil water samples varied from 16.2 to 617 $\text{mg}\cdot\text{L}^{-1}$, with mean concentrations across all treatments of 160.7 and 188.4 $\text{mg}\cdot\text{L}^{-1}$ for 120- and 180-cm depth water samples, respectively. The concentrations of Cl^- and other anions (NO_3^- , PO_4^{3-} , SO_4^{2-}) in soil water at either 120- or 180-cm depth were poorly related to the incidence or severity of RGG ($R = -0.10$ to -0.28). Chloride concentrations in the soil water ranged from 20 to 617 $\text{mg}\cdot\text{L}^{-1}$ near the RGG-free trees, and from 16.7 to 310 $\text{mg}\cdot\text{L}^{-1}$ near the trees that were affected by RGG. This suggests that under the conditions of this study, neither the incidence nor the severity of RGG was influenced by high concentrations of Cl^- in the soil water.

Rio Grande Gummosis (RGG) of grapefruit (*Citrus paradisi* MacFadyen) trees is a widespread problem in the East Coast region of Florida. The disease generally affects trees over 20 years of age. A survey of 18 grapefruit groves showed that 3% to 74% of the trees (white and red varieties) were affected by RGG (Hebb and Sonoda, 1992). The trees with severe symptoms become progressively less productive and eventually die. The cause of RGG is not clear; however, several hypotheses have been proposed. Davis (1980) provided evidence that infection with *Diplodia natalensis* (Pole-Evans) could induce gummosis symptoms. However, the relationship between RGG and *D. natalensis* is yet to be clearly established (Childs, 1953,

1978a; Olsen, 1952; Sonoda and Pelosi, 1992). Lee et al. (1994) compared healthy trees and RGG-affected trees and found that psoros-like agents were present in the RGG-affected trees. However, they were unable to prove conclusively that RGG was caused by psorosis. Calvert (1973) and Childs (1978a) provided some evidence for greater incidence of RGG in trees fertilized with KCl than in those fertilized with K_2SO_4 . Childs (1978b) surveyed 10 grapefruit groves and suggested that the incidence of RGG tended to be greater in trees with levels of leaf chloride in the range of 154

to 498 $\text{mg}\cdot\text{kg}^{-1}$. In contrast, a study using 20-year-old 'Marsh' grapefruit trees with four treatments and only one replication (Russo et al., 1993) revealed no significant differences in leaf Cl concentration between RGG-affected trees fertilized with KCl (278–373 $\text{mg}\cdot\text{kg}^{-1}$) and RGG-free trees fertilized with K_2SO_4 (362 $\text{mg}\cdot\text{kg}^{-1}$). Therefore, the role of Cl in the incidence and severity of RGG remains unclear. The objective of this study was to determine the effects of the short-term elevation of Cl⁻ and other anions in soil water on the incidence and severity of RGG in grapefruit trees.

Materials and Methods

This experiment was conducted in a commercial grove with 26-year-old white 'Marsh' grapefruit trees on sour orange (*C. aurantium* Lush.) rootstock in Martin County, Fla. An area of ≈ 8 ha was surveyed in 1993 for tree health and uniformity. All of the trees chosen for the experiment had no symptoms of RGG. Five healthy and uniform trees were selected for each plot. The experiment involved two irrigation treatments as main plots: 1) irrigation at low moisture depletion, i.e., tensionmeter set point at 10–15 kpa, and 2) irrigation at high moisture depletion, i.e., tensionmeter set point at 20–25 kpa. Fertilizer treatments were subplots. The fertilizer applied was 6N–1P–6.1K at rates of 0, 466, 933, 1866, and 2800 $\text{kg}\cdot\text{ha}^{-1}$, with K supplied as KCl to provide annual rates of Cl application at 0, 26, 52, 104, or 156 $\text{kg}\cdot\text{ha}^{-1}$. All treatments were replicated four times. Suction lysimeters were installed at two depths (120 and 180 cm) at 120 cm from the tree trunk along the tree line. Soil water samples were collected from suction lysimeters at 2-week intervals. The concentrations of chloride (Cl^-), nitrate (NO_3^-), sulfate (SO_4^{2-}), and phosphate (PO_4^{3-}) were determined using a Dionex 500 Ion Chromatography (Dionex Corp., Sunnyvale, Calif.). The application of treatments began in Apr. 1994, and water sampling and anion analysis began in Aug. 1994.

Results and Discussion

Soil water was sampled 26 times between Aug. 1994 and Sept. 1995. The concentration of Cl^- varied from 16.2 to 617 $\text{mg}\cdot\text{L}^{-1}$ depending on treatment, with mean concentrations across all treatments of 160.7 and 188.4 $\text{mg}\cdot\text{L}^{-1}$ for 120- and 180-cm depth water samples,

Table 1. Correlation coefficients between concentration or ratio of anions in soil water at 120-cm depth, and 1) Rio Grande Gummosis (RGG) of grapefruit trees, 2) irrigation rate, and 3) rates of application of Cl, N, P, and S, and between severity of RGG and 1) irrigation rate and 2) rate of application of Cl, N, P, and S (n = 104).

	Severity of RGG	Irrigation rate	Rate of application of:			
			Cl	N	P	S
Concentration of anions						
Cl^-	-0.20	-0.07	0.33			
NO_3^-	-0.10	-0.01		0.22		
PO_4^{3-}	-0.11	0.22			0.21	
SO_4^{2-}	-0.28	0.05				0.11
Ratio of Cl^- to all anions ^a	0.20	-0.18	-0.07	0.01	0.29	0.20
Severity of RGG	---	0.14	-0.12	-0.12	-0.23	-0.02

^aRatio = $[\text{Cl}^-]/[\text{Cl}^- + \text{NO}_3^- + \text{PO}_4^{3-} + \text{SO}_4^{2-}]$.

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respectively. Irrigation did not influence the concentration of any of the ions monitored in the soil water at the 120 (Table 1) or 180-cm depth (data not shown). As expected, application of Cl increased Cl^- concentrations at 120-cm depth ($R = 0.33$, $P = 0.01$) but had no effect at the 180-cm depth (data not shown).

On 12 Sept. 1995, the trees were examined for symptoms of RGG. The severity of the symptoms was ranked on a scale of 0 to 5 (0 = no RGG symptoms and 5 = severe symptoms). A total of 26% of the trees showed symptoms of RGG and the severity of RGG for affected trees ranged from 0.5 to 4.0 with the mean of 1.5. Regression analysis of the data indicated that the concentrations of Cl^- and other anions (NO_3^- , PO_4^{3-} , SO_4^{2-}) in soil water at either 120 or 180 cm (data not shown) depth were poorly related to the incidence or severity of RGG ($R = -0.10$ to -0.28) (Table 1). Chloride concentrations in the soil water ranged from 20 to 600 $\text{mg}\cdot\text{L}^{-1}$ near the RGG-free trees, and from 16.7 to 310 $\text{mg}\cdot\text{L}^{-1}$ near the trees that were affected by RGG. There was some improve-

ment in the relationship between the severity of RGG and soil water Cl^- when Cl^- was expressed as a ratio of Cl^- to other anions. However, the correlation coefficient was still very low ($R = 0.20$). Irrigation rates and rates of ion application were also poorly related to the incidence or severity of RGG ($R = -0.23$ to 0.14) (Table 1). Therefore, under the conditions of this study, neither the incidence nor the severity of RGG was influenced by high concentrations of Cl^- in the soil water.

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