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# Evaluating rootzone stresses and the role of the root system on rose crop productivity and fertilizer-water use efficiency:

## Setting-up the experiment

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**Raúl I. Cabrera**

Texas A&M University

Research and Extension Center

17360 Coit Road, Dallas, Texas 75252

Now at Rutgers University

[Cabrera@aesop.rutgers.edu](mailto:Cabrera@aesop.rutgers.edu)

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ICFG-HILL, P.O. Box 99, Haslett, MI 48840

[ICFG.HILL@yahoo.com](mailto:ICFG.HILL@yahoo.com)

The proposed studies intend to characterize the productivity, quality and physiological performance of rose plants growing on their own roots versus grafted on a rootstock ('Natal Briar') when growing under challenging and/or heterogeneous rootzone stresses, namely alkalinity (varying pH conditions), salinity, high boron and high ammonium-N ratios. The ultimate objective of the proposed studies is to suggest management practices that might minimize the deleterious effects of these stresses, maintaining their productivity-quality and perhaps even enhancing their water and fertilizer use efficiency.

## **Background**

The production of cut (greenhouse) roses is likely the most intensive agricultural cropping system, receiving some of the highest water, fertilizer and chemical inputs, coupled to high energy and labor requirements and costs. One of the prominent features of the cultural practices is the use of grafted or budded roses in soil, soilless substrates and hydroponic production systems. The rose industry in North and South America, while originally employing *R. 'Manetti'* and *R. odorata* for many decades (Hannan and Gruber, 1987), switched their rootstock selection almost completely to the South African 'Natal Briar' clone in the 1990's (Applied Plant Research, 2001; De Vries, 2003). While the benefits imparted by this rootstock are highly desirable (ease of mini-plant propagation, enhanced vigor transmitted to scion, higher flower shoot productivities under bent canopy system, etc.) recent research results and reports by growers in some areas suggest that its performance under stressful rootzone conditions, like soil/substrate compaction and poor aeration, salinity and alkalinity (high pH) conditions can be fairly poor and undesirable. Conversely, 'Manetti' proven tolerance to these rootzone stresses, particularly under soil-productions systems (Hannan and Gruber, 1987), but also under salt stress in modern soilless media cultivation (Cabrera and Perdomo, 2003) proved its long-lived use and reputation for most of the 20<sup>th</sup> century.

Among the soil/rootzone stresses and conditions that are known (based on research results) and/or reported (anecdotally by growers and rose breeding industry) to negatively impact the performance of 'Natal Briar'-grafted plants are a reduced tolerance to increasing salinity conditions, high accumulations of boron in leaf tissues and a more recent and widespread observation of partial and complete leaf chlorosis both on the cultivars (scions) on top of this rootstock and the mother plants used to produce 'Natal Briar' cuttings. This last disorder has been extensively shown in new plantings of 'Natal Briar'-grafted plants in both soil and soilless (toasted rice hulls) media, and often in partial sections of both the scion and rootstock suckers, as well as distinct sections (or halves) within a flowering shoot and even within a compound leaf and a leaflet!

Despite the intensive nature of fertigation in rose production and an apparent homogeneity of the growing medium used (Applied Plant Research, 2001), the literature and research results indicate that the physical and chemical conditions of a soil/substrate can be very heterogeneous (differential "patchiness") within the confines of the rhizosphere surrounding a root system, particularly as you get closer to the surface of the roots (Marschner, 1995). This means that the physicochemical variables we usually monitor in roses, electrical conductivity (EC) and pH and select mineral nutrients, mostly reflect or provide an average of the growing medium and bulk soil solution and not necessarily the zones of more influence, i.e. closer, to the root surfaces. Therefore, it is likely that significant portions of the root system are experiencing stressful conditions (both in time and space) but these are not being detected by our monitoring practices.

The extensive and often confusing pattern of chlorosis in several cultivars grafted in 'Natal Briar' observed in soil and soilless systems observed recently in Colombia (Cabrera, personal observations), even under the use of corrective practices (adjustment of solution pH, supplemental Fe-chelate applications) and intense monitoring of fertigation and drainage, suggest the involvement of a plant (cultivar and/or rootstock) factor. In the case of iron (Fe) nutrition, element

most often associated with chlorosis, it is known that some plant species, cultivars and selections are “iron-efficient”, which means that they can absorb Fe from the soil solution even if the pH is high and the Fe is mostly insoluble (Reed, 1996). Some of these plants actually secrete their own-chelating agents or release acidifying compounds into their surrounding environment to make Fe available. Other plants, like the acid-loving group that includes azaleas and many members of the rose family (*Rosaceae*), are “iron-inefficient”, which can only absorb Fe when it is found in adequate levels and the soil/media pH is in “check” (5 to 6.2). In the case of roses, it was reported that when scions (cultivars) susceptible to Fe-chlorosis are grafted on chlorosis-tolerant rootstocks, the scions exhibited a higher degree of tolerance, but when tolerant cultivars were grafted on susceptible rootstocks, they exhibited increased chlorosis and decreased growth (Reed et al., 1992). The iron use efficiency of ‘Natal Briar’, to our knowledge, has never been evaluated, and there is the strong suspicion that it may not rate as favorable as ‘Manetti’. On the other hand, the propensity of ‘Natal Briar’-grafted plants to accumulate high levels of boron (B) in their leaves under “normal” solution B concentrations has been confirmed (Cabrera, 2002), but it is unknown the degree of its effect on flower productivity and quality under increasing B concentrations in the irrigation water. Scarcity of good quality water in large amounts, and current environmental pressures forcing the greenhouse industry to recycle/recirculate drainage effluents are certainly increase the potential for salt stress and B-toxicity problems in relatively B-intolerant species like roses.

### **The experiment**

#### ***Split-root system:***

A set of ‘Revival’ (on ‘Natal Briar’ rootstock) mini-plants were acquired on the spring of 2009, and transplanted to 5-gallon containers filled with a peat:pine bark:sand medium (3:1:1 by volume), and fertigated with a base ½ strength Hoagland formulation that provided (in mM): 9.5 N, 0.5 P, 4.0 K, 2.0 Ca, 1.0 Mg and 1.0 S (corresponding in ppm to 133 N, 16 P, 156 K, 80 Ca, 24 Mg and 32 S). Micronutrient concentrations are applied at the normal strength Hoagland formulation (i.e. non-deficient, normal concentration range). The plants were grown in those containers until they reached a commercial production size, and on September 2009 they were transplanted to square Dutch rose pots that were paired, effectively dividing the root system in two (each half effectively growing on one of the adjacent square pots; see Figure 1). The growing medium used in the split-root system was the same as before. The plants were allowed to acclimate to this split root system, using the same nutrient solution for irrigation in both root halves. In January 2010 the plants will be ready to be exposed to differential nutrient solutions on each one of their split root sections (containers). Considering the nutritional issues that are reported for ‘Natal Briar’ (mentioned above), the differential nutritional treatments will primarily focus on pH/alkalinity (for effect on minor elements), high boron, a high ammonium (NH<sub>4</sub><sup>+</sup>) ratio on the nitrogen fertilizer formulation (provided as urea) and salt stress (provided as high NaCl), as shown in Table 1.

**Table 1.** Treatments to be used the rose split-root system studies.

<b>Treatments</b>	<b>Container 1</b>	<b>Container 2</b>
Control	Base solution	Base solution
pH	5.8 to 6.2	7.8 to 8.2 (w/ KH <sub>2</sub> CO <sub>3</sub> )
Boron	≤ 0.6 ppm	1.2 to 1.5 ppm (w/ H <sub>3</sub> BO <sub>3</sub> )
Urea (NH <sub>4</sub> <sup>+</sup> )	133 ppm N	231 ppm N (98 ppm as Urea-N)
Salinity	1.6 dS/m	4.6 dS/m (3 dS/m as NaCl)

Each “split”-container is being individually irrigated via Roberts spitters (one per pot) connected thru spaghetti tubing to ½” polyethylene pipes hooked to submersible pumps inside 160-L tanks containing one of the five nutrient solutions needed to produce the treatments shown in the above table. Irrigation volume applied per day is being based on gravimetrically-determined evapotranspiration (ET) on control plants growing in single containers. Leachate solutions will be collected from the “split” containers from each treatment and analyzed for EC, pH and concentrations of N, B, Na and Cl.



**Figure 1.** View of the experimental set-up (top) and close-up of the split-root system (bottom) in ‘Revival’ (on ‘Natal Briar rootstock) rose plants.

Plant biomass and flower productivity/quality will be measured over a reasonable period (6-12 months- at least 4 flushes of growth and flowering to assess the long-term response of the split root systems to the treatments). In addition, physiological parameters like stem/leaf water potential, leaf osmotic potential, relative water content (turgor) and chlorophyll concentration will also be systematically monitored. The onset of visible physiological and/or nutritional disorders will be recorded and the affected tissues will be subjected to both anatomical observations and nutritional analyses. If time and labor/resources allow it, anatomical observations of the vascular architecture of developing (flowering) and old stems, flower peduncles, leaf petioles and main leaf veins will also be anatomically studied in own-rooted and grafted plants.

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