PRODUCTION PROTOCOLS

EFFECT OF SUBSTRATE PH ON THE GROWTH OF GOLDEN BARREL *(Echinocactus grusonii*), *Crassula* 'SPRING TIME' AND *Chamaelobivia* 'ROSE QUARTZ'

Objective:

- Determine the effect of pH on the growth rate and the optimum pH for maximum growth of the selected species

Materials and Methods

Plant Material:
Plants of Golden Barrel (*Echinocactus grusonii*), *Crassula* 'Spring Time' and *Chamaelobivia* 'Rose Quartz' in 2.5 inches pots were brought to the center on 2/27/09 and placed in a greenhouse at 78/68ºF day/night temperature. There were a total of 48 plants, 12 plants per treatment.

Treatments:
Each group of plants received a different treatment with the purpose of altering the pH of the medium. The treatments were:

- Control (CW, received city water)
- Slightly acidic (SA, watered with water containing 0.3ml/lt of sulfuric acid)
- Highly acidic (HA, received water with 0.8ml/lt sulfuric acid)
- Alkaline (Al, received water containing 75gr/lt of flowable lime)

Plants were watered as needed, receiving the different solutions 2-3 times a week, the control group received city water. Each plant received approximately 25 ml of solution, enough to provide adequate moisture and to wash salts in excess of the medium. Once every 3 weeks, 200ppm N of 15-5-15 were applied to all treatments. Twelve weeks after the trial started, the plants were transplanted into 4inches containers; after transplanting; they received about 60ml of solution/water per irrigation. The experiment lasted for 16 week.

Variables Measured:
Electric conductivity (EC, pour through method) and pH were measured once every two weeks. EC is expressed in milli Siemens (mS). The height and diameter of each plant was measured at the beginning of the experiment and at the end, the volume of the plants was determined by using the appropriate formula. The shape of golden barrels was assumed to be a sphere ($V=D^2*H$). *Chamaelobivia* and *Crassula* 'Spring Time' were assumed to be a rectangle ($V=L*W*H$). The volume of Chamaelobivia at the end of the experiment was determined based on the amount of liquid the plant displaced from a container when submerged. This was done because the growth of lateral buds did not allow determining the volume by measuring height and diameter. The water displaced by each plant was collected and measured in a graduated cylinder. The growth of the plant was determined by subtracting the final volume of the plant from the initial volume.

Statistical Analysis:
Data were analyzed using analysis of variance, and Student's t-test ($p=0.05$) was used to separate means. Regression analysis was performed to correlate growth with pH.

Results

The mean pH of the medium was between 4.16 and 7.32. The pH increased or decreased, depending on the treatment (Figure 1). The pH of the medium affected growth rate measured as the difference between the initial volume of the plant and the final one and this effect varied within the species. Figure 2 shows the growth rate of the plants by treatment while figure 3 shows the correlation between pH of the medium and volume difference. In all cases, the response was polynomial (quadratic) (Figure 3). Golden Barrels grow better at low pH and were hardly affected even by the highly acidic treatment. In contrast, growth was highly reduced by high pH values. The results indicate that golden barrels grew best when pH was around

5.5, growth was slightly less but not statistically different at pH 6.3. *Chamaelovibia* 'Rose Quartz' and *Crassula* 'Spring Time' were tolerant of acidic conditions but not of basic pH. *Chamaelobivia* grew best at pH values of 5.5 to 6.5, while 'Spring Time' did better when grown at a pH of 6.4. Regarding EC, the mean EC among treatments varied between 2.3 and 5.1mS. All plants in the study were fertilized equally and the amount of nutrients in the medium was the same, although the availability could not be the same since pH affects the availability of nutrients. The mean EC values grouped by treatment and the appearance of the plants in the different treatments by species can be seen in figures 4 and 5, respectively.

Conclusions

- The optimum pH range for maximum growth of golden barrel was 5.5 but the plants grew well in pH as low as 4.2 and as high as 6.3.
- The optimum pH range for maximum growth of *Chamaelovibia* 'Rose Quartz' was 5.5 to 6.4. This plant can tolerate slightly acidic conditions but did not well at higher pH.
- The optimum pH range for maximum growth of *Crassula* 'Spring Time' was 6.4. This plant tolerated slightly acidic conditions.
- As we hypothesized at the beginning of this trial, it seems that cactus and succulent species are sensitive to slight changes of pH and that there is an optimum pH range for maximum growth for each species. *Echinocactus grusonii* in its native habitat grows in soils have pH that can range between 4 to 5, *Crassula* 'Spring Time' and *Chamaelovia* 'Rose Quartz' are hybrids of plants from areas of South Africa and South America. They grow in soils with neutral pH, which is the reason why these species grow better at a pH 6 to 6.5.
- Based on the results of these trials, it will be good management to consider the origin of a species when adjusting for pH and possibly grouping species by general area of origin.

Figure 1. Mean pH of medium. Bars represent standard errors. Bars followed by different letters are significantly different, t-test (p=0.05). Treatments (x-axis) were control (CW), highly acidic (HA) acidic (A) and alkaline (Al).

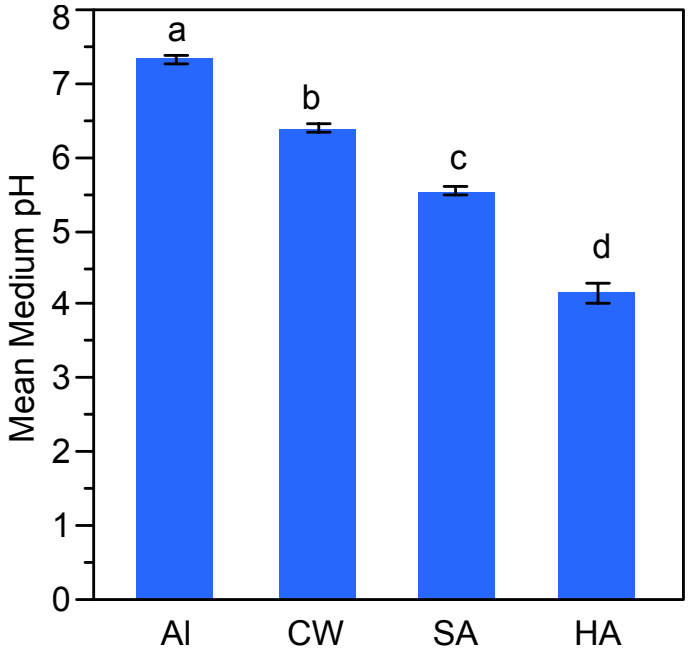


Figure 2. Mean growth (±SE) in cubic centimeters of *Chamaelobivia* 'Rose Quartz' (A), *Echinocactus grusonii* (B) and *Crassula* 'Spring Time' (C). Bars followed by different letters are significantly different, t-test (p=0.05). Treatments (x-axis) were control (CW), mean pH 6.39), highly acidic (HA, pH 4.1) acidic (A, pH 5.53) and alkaline (Al, pH 7.32).

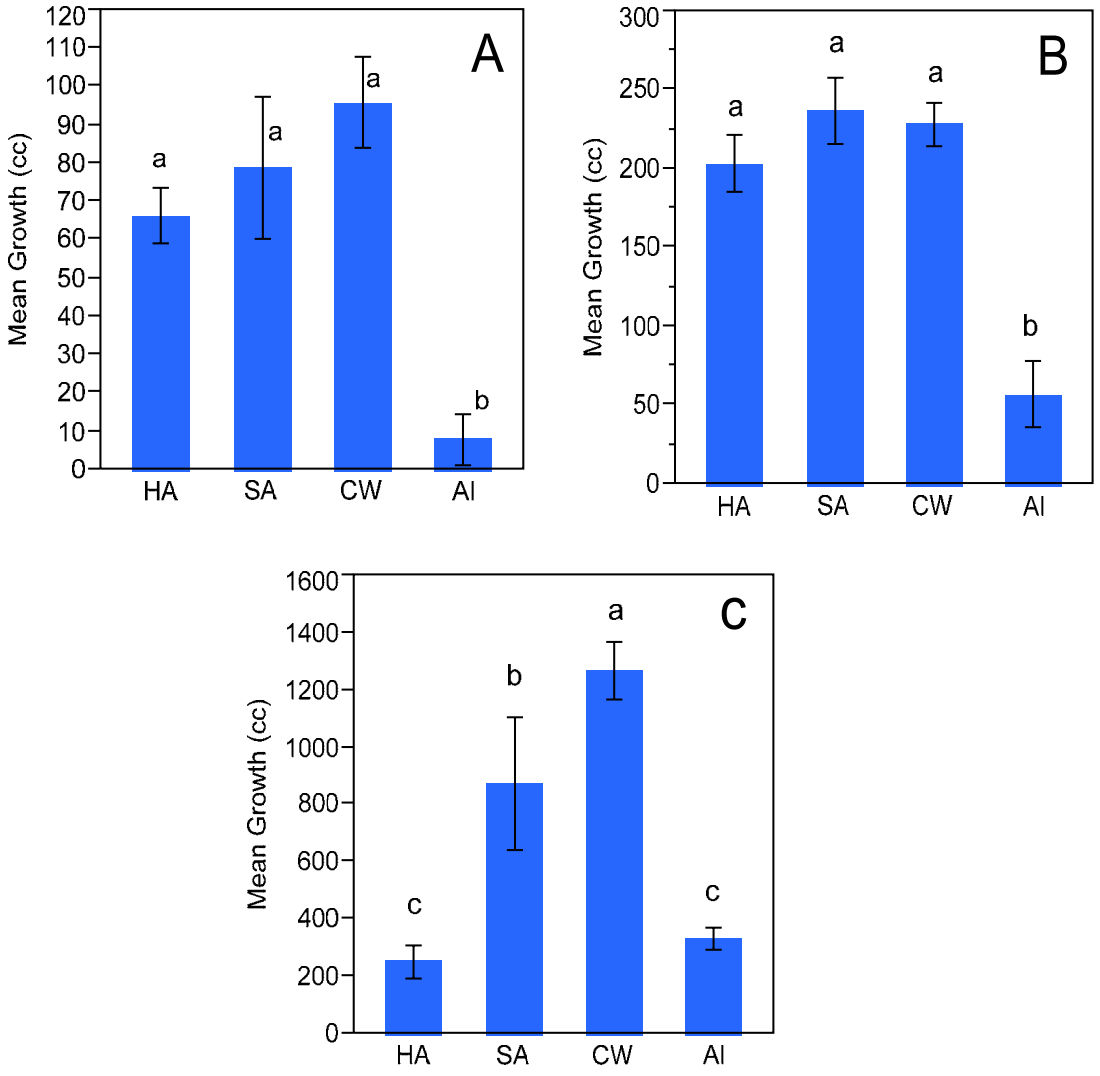
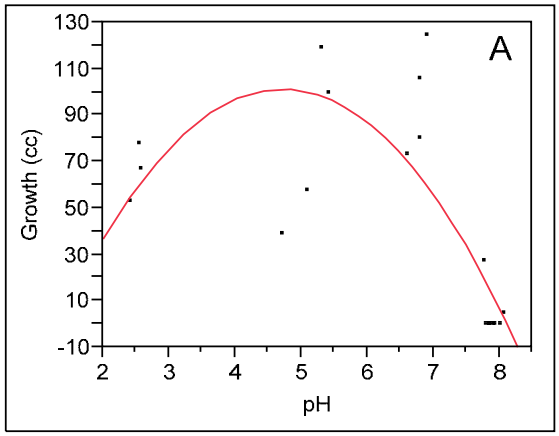
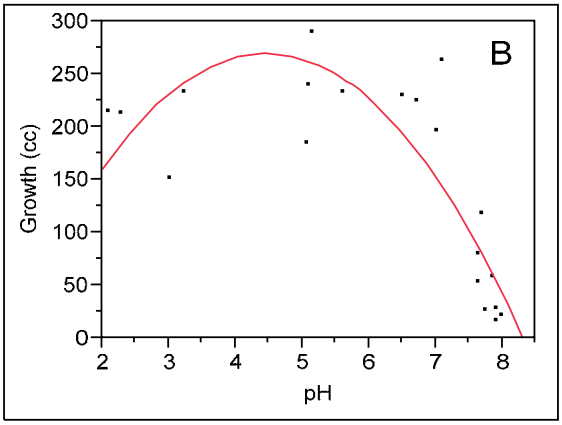


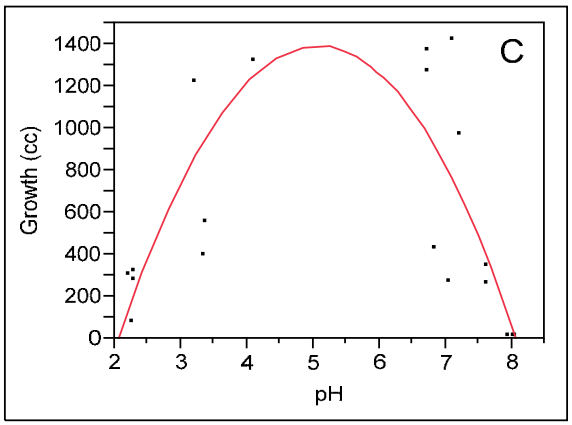
Figure 3. Correlation between pH and growth of *Chamaelobivia* 'Rose Quartz' (A), *Echinocactus grusonii* (B) and *Crassula* 'Spring Time' (C).



Growth = 246.00784 - 26.44282*pH - 8.7692358*(pH-6.22579)^2
R-square= 0.61



Growth = 574.14754 - 57.828261*pH - 18.097968*(pH-6.0575)^2
R-square= 0.73



Growth = 2244.9048 - 160.04062*pH - 153.1007*(pH-5.585)^2
R-square= 0.61

Figure 4. Mean (±SE) medium EC. Bars followed by different letters are significantly different, t-test (p=0.05). Treatments (x-axis) were control (CW), highly acidic (HA) acidic (A) and alkaline (Al).

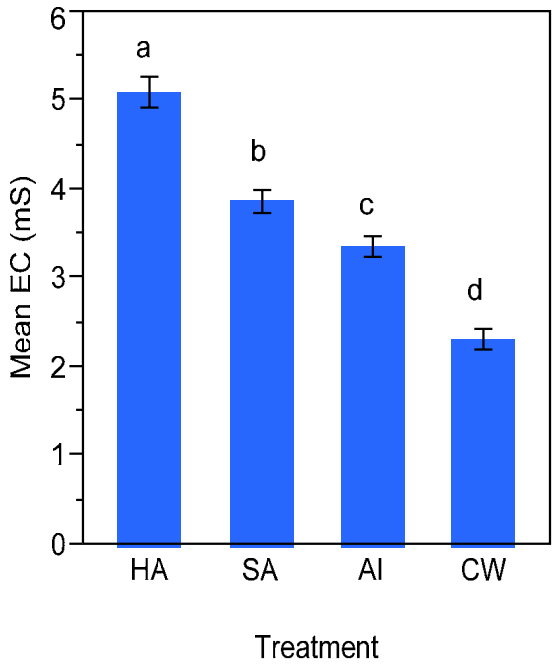


Figure 5. Appearance of *Chamaelobivia* 'Rose Quartz' (A), *Echinocactus grusonii* (B) and *Crassula* 'Spring Time' (C) grown at different medium pH. From left to right the treatments were highly acidic (HA) acidic (A), control (CW) and alkaline.