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).

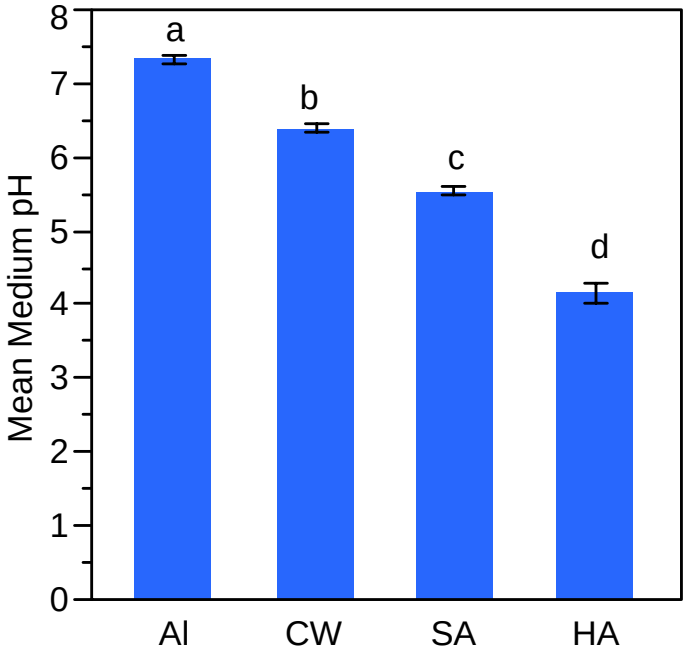


Figure 2. Mean growth (±SE) in cubic centimeters of *Chamaelobivia* 'Rose Quartz' (A), *Echinocactus grusonii* (B) and *Crassula* 'Spring Time' (C). Bars followed by different letters are significantly different, t-test (p=0.05). Treatments (x-axis) were control (CW), mean pH 6.39), highly acidic (HA,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

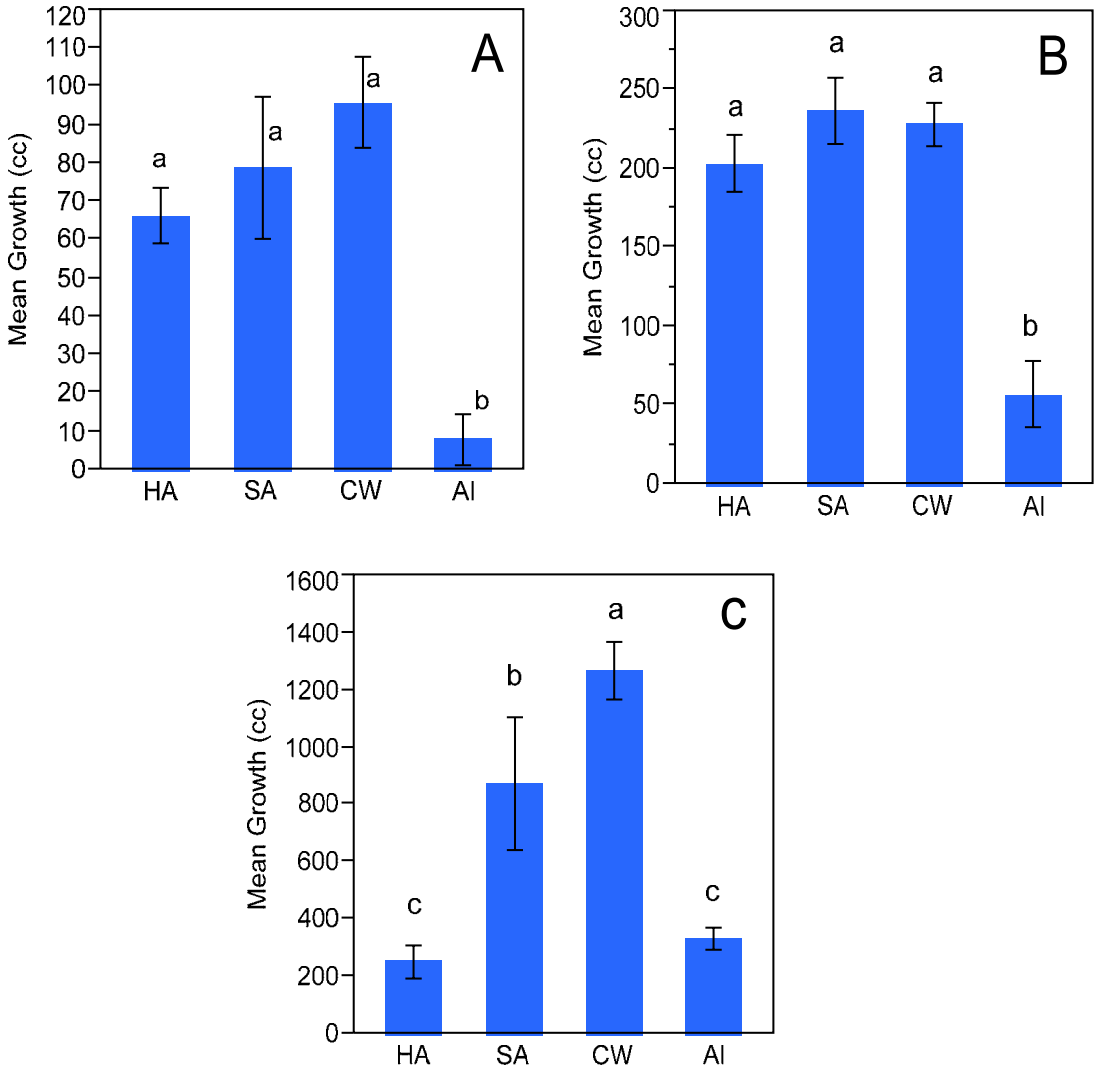
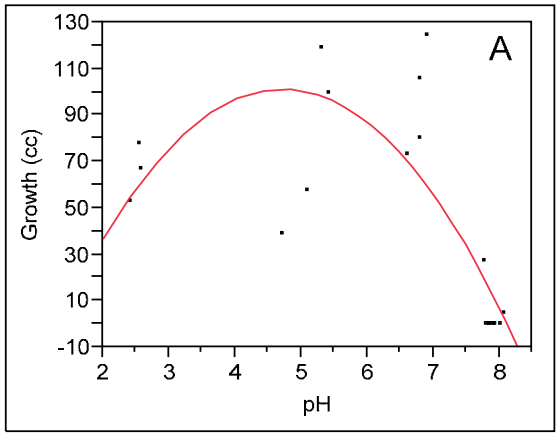
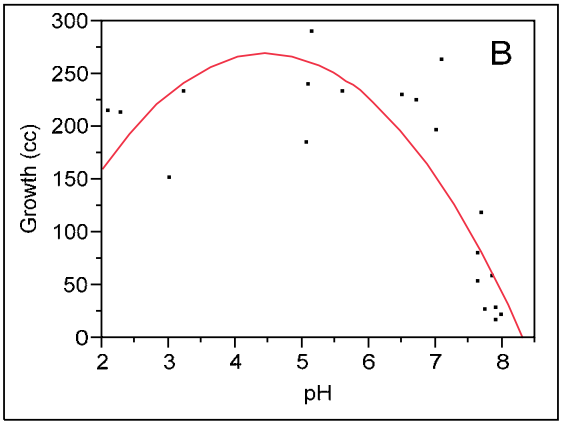


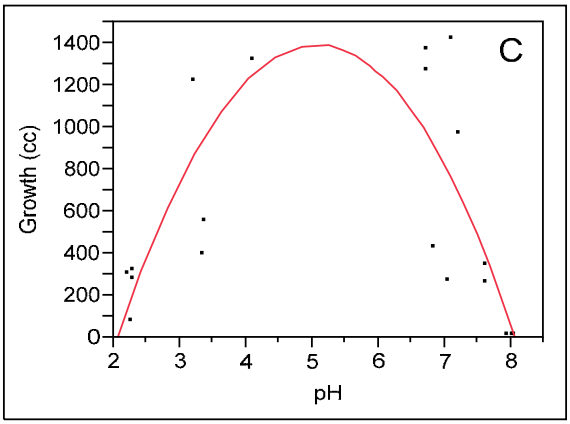
Figure 3. Correlation between pH and growth of *Chamaelobivia* 'Rose Quartz' (A), *Echinocactus grusonii* (B) and *Crassula* 'Spring Time' (C).



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).

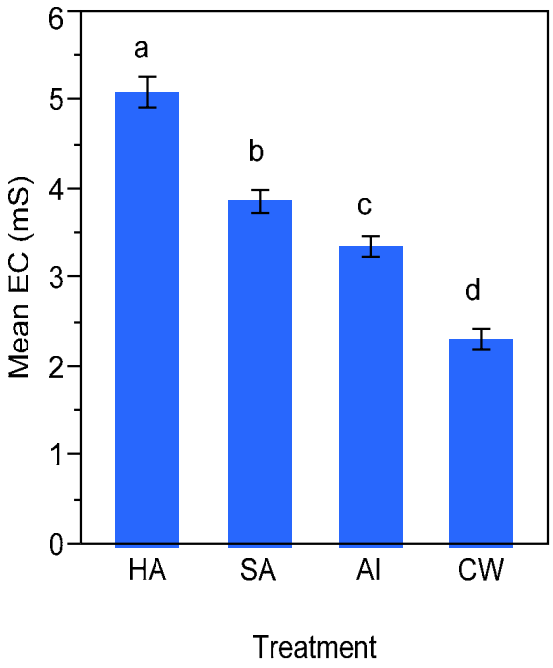


Figure 5. Appearance of *Chamaelobivia* 'Rose Quartz' (A), *Echinocactus grusonii* (B) and *Crassula* 'Spring Time' (C) grown at different medium pH. From left to right the treatments were highly acidic (HA) acidic (A), control (CW) and alkaline.

EFFECT OF BIOCONTAINER TYPE ON SHOOT AND ROOT GROWTH OF TOMATOES AND COIR POT EFFECT ON FIELD ESTABLISHMENT OF TOMATO PLANTS

Abstract

The use of biocontainers in the nursery industry is on the rise. Biocontainers, are pots that are made with renewable resources, can be composted or recycled and are biodegradable. These materials are innovative; their main purpose is to reduce the impact of the nursery industry on the environment while appealing to sustainability-minded consumers. Since biocontainers are relatively new, there is not a lot of information available on their efficiency and use. Vegetables are an ideal crop to grow in biocontainers, since they can be planted directly in the garden with minimum disturbance to the roots. This should result in plants that grow faster and in reduced waste, since the containers are manufactured to degrade in the soil. There has recently been increased interest in home grown vegetable gardens, and nursery growers are responding to this by increasing the number of vegetable crops they grow. We designed a trial to test the effect of biocontainers on shoot and root growth, and for the degradability of the pot in the soil. We tested four types of biocontainers, DOT pot, CowPots, paper pulp pots and coconut coir pots and compared them to black plastic pots. In general, plants were taller when grown in plastic containers but more tender. Roots grew out of the biocontainers but some of them were more restrictive than others. The rate at which biocontainers degraded in the soil varied. DOT pot and CowPots degraded faster than paper pulp and coir pots. Biocontainers are a viable alternative to conventional plastic containers.

Objective:

- Determine the effect of several types of biocontainers on plant growth of greenhouse grown tomato plants and the effect of coir pots on height of field-grown tomato plants.

Materials and Methods

First Trial:

Plugs of tomato 'Cherry Red' were obtained from a local grower. Plugs were planted in several types of biocontainers:

- Paper pulp pots (Western Pulp Products Co.), made of 98% recycled paper.
- DOT Pots (Fertil SAS), made of 80% spruce fibers and 20% peat moss.
- Coir pots (ITML Horticultural Products), made of coconut coir fibers.
- CowPots (The Liquid Fence Company), made with 100% composted cow manure.
- Black plastic pot (Poppelmann Plastic USA, Inc.)

Black plastic pots, coir, and CowPots were 4 inches in diameter while Fertilpots and paper pulp pots were 4.5 inches in diameter. The plugs were transplanted on March 8th 2009. Plugs were planted in a peat-perlite mix (Sunshine #1 mix, Sun Gro Horticulture). The plants were placed in a climate controlled greenhouse at 75º/65ºF day/night temperature. All plants were fertilized once a week, for 4 weeks while in the pot stage, with 200ppm N of 15-0-15. The plants received two applications of 200ppm N of 24-7-15 at 5 and 6 weeks after transplant. The height of 8 plants per treatment was measured once a week. Six weeks after transplant, a fresh and dry weight of roots and shoots was taken. Nine plants per treatment were selected and planted in 5-gallon containers filled with a peat-perlite mix (Sunshine #1 mix with 5lbs. slow release fertilizer, Sun Gro Horticulture). Three plants were planted in each 5-gallon pot; there were 3 pots per treatment. The control group consisted of plants that had been grown in plastic pots and were transplanted bare root in the 5 gallon containers. Plants were fertilized with 200ppm N of 24-7-15 immediately after transplant. Starting one week after transplant and for four consecutive weeks, one plant per treatment was carefully dug out and the development of the roots was inspected with the objective to determine how long it took for each plant to develop roots through the container walls.

Second Trial:

Twelve six week old 'Cherry Red' tomato plants grown in coir pots and twelve grown in plastic pots were transplanted in a commercial vegetable patch. Six additional plants per treatment were used to determine the fresh and dry weight of roots and shoots before transplant. The plants in the field were watered and fertilized at the discretion of the patch grower. Plant height was measured once a week for five, two plants per treatment were dug out of the ground at 28 and 38 days after transplant to determine if the roots had grown out of the coir pot.

Analysis:
All plants were placed in a complete randomized design. Data were analyzed using analysis of variance, and Student's t-test (p=0.05) was used to separate means.

Results

First Trial:
Plants grown in plastic pots were taller than the plants grown in biocontainers (Figures 1 and 2) the rest of the plants were similar in size (Figure 1). Plants grown in plastic pots had heavier shoots than all other plants (Figures 3 and 4). Plants in coconut coir pots, DOT pots and CowPots had similar fresh shoot weights and they were lower than that of the shoots of plants in paper pulp pots (Figure 2).
Shoot dry weight was highest in plants grown in plastic pots and significantly higher than that of plants grown in coir, Cow and DOT pots, but similar to that of plants grown in paper pulp pots. Shoot dry weights of plants grown in coir and Cow pots were similar to those of plants in paper pulp and DOT pots. However, plants in paper pulp pots had heavier dry shoots than those of plants in DOT pots (Figure 4).
The fresh and dried roots of plants in plastic pots were heavier than the roots of the rest of the plants (Figures 3 and 4). Root fresh weights were lowest in plants grown in Cow and coir pots and progressively increased in plants in DOT and paper pulp pots (Figure 3). Root dry weights of plants in coir, Cow and DOT pots were similar and lower than those of plants in paper pulp pots (Figure 4). Figures 5 and 6 show the general aspect of the roots six weeks after transplant.
After plants in biocontainers were transplanted in 5 gallon pots, one plant per treatment was dug out starting one week after transplant. Roots started growing out of the biocontainers approximately one week after planting (Figure 7). By week 4 after transplant a mass of roots had formed out of the biocontainers (Figures 8, 9 and 10). All pots allowed roots to grow into the medium. DOT Pots allowed easy escape of the roots and degraded faster than the rest of the pots. All biocontainers remained in the soil for a period longer than 4 weeks.

Second trial:
Six weeks after transplant, the plants grown in the plastic containers were taller and heavier than the plants in the coir containers, when planted in the field, the control group continued to grow taller than the plants in coir pots (Figures 11 and 12). Five weeks after transplant, both groups had similar height, which shows that coir pots could restrict plant growth until the roots are able to break free from the container, once this occurs, the plants recover.

Conclusions

- Based on our results, biocontainers are a viable alternative for use in the nursery industry, in particular for tomatoes.
- Plants grown in biocontainers were smaller and lighter than plants grown in plastic pots.
- DOT Pots were the fastest to degrade when planted and the least restrictive to the roots, however, they also tend to break easily when handled.
- CowPots degraded easily in the soil and allowed good root growth; they conserved their integrity better than DOT pots during the growth period.
- Coir pots allowed adequate growth of the roots but after 4 weeks in the soil they had not significantly degraded.
- Paper pulp pots degrade in the soil but at a slower pace than Cow and DOT Pots.
- Plants grown in coir pots were smaller than plants in plastic pots, however, they progressively recovered once planted in the ground.

Figure 1. Mean (±SE) height of tomato plants grown in biocontainers and plastic pots. Bars followed by different letters are significantly different, t-test (p=0.05). Treatments (x-axis) were control (C, plastic pots), coconut coir pots (CCP), CowPots (CP), DOT Pots (DP) and paper pulp pots (PPP).

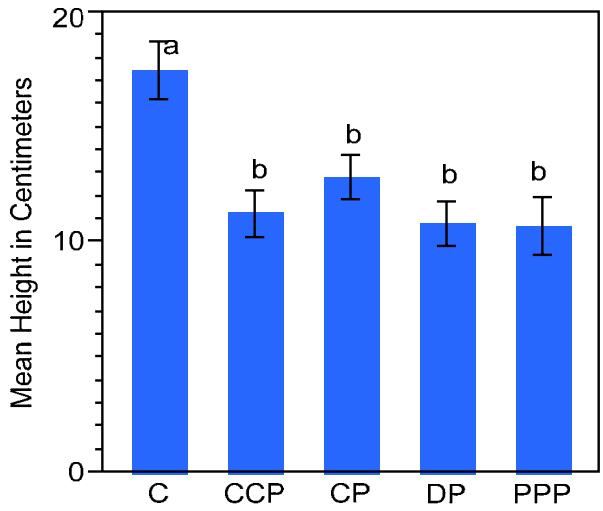


Figure 2. Tomato plants six weeks after transplant. Treatments were, from left to right, control, DOT Pot, paper pulp, CowPot and coconut coir pot.

Figure 3. Mean (±SE) shoots (SFW) and roots (RFW) fresh weight of tomato plants grown in biocontainers and plastic pots six weeks after transplant. Bars followed by different letters are significantly different, t-test (p=0.05). Treatments (x-axis) were control (C, plastic pots), coconut coir pots (CCP), CowPots (CP), DOT Pots (DP) and paper pulp pots (PPP).

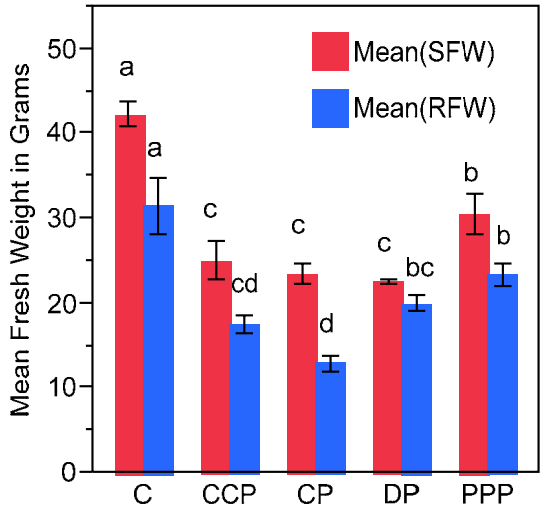


Figure 4. Mean (±SE) shoots (SDW) and roots (RDW) dry weight of tomato plants grown in biocontainers and plastic pots six weeks after transplant. Bars followed by different letters are significantly different, t-test (p=0.05). Treatments (x-axis) were control (C, plastic pots), coconut coir pots (CCP), CowPots (CP), DOT pots (DP) and paper pulp pots (PPP).

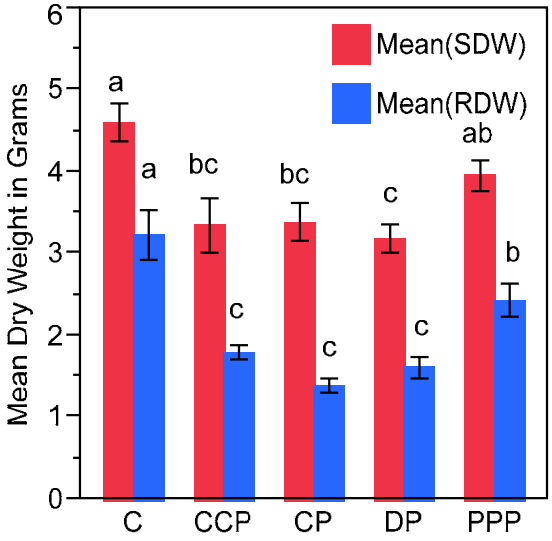


Figure 5. Roots of tomato plants grown in plastic pots and biocontainers six weeks after transplant. Treatments were, from left to right, control, DOT Pot, paper pulp pot, CowPot and coconut coir pot.

Figure 6. Washed roots of tomato plants grown in plastic pots and biocontainers six weeks after Treatments were, from left to right, control, DOT Pot, CowPot, paper pulp pot and coconut coir pot.

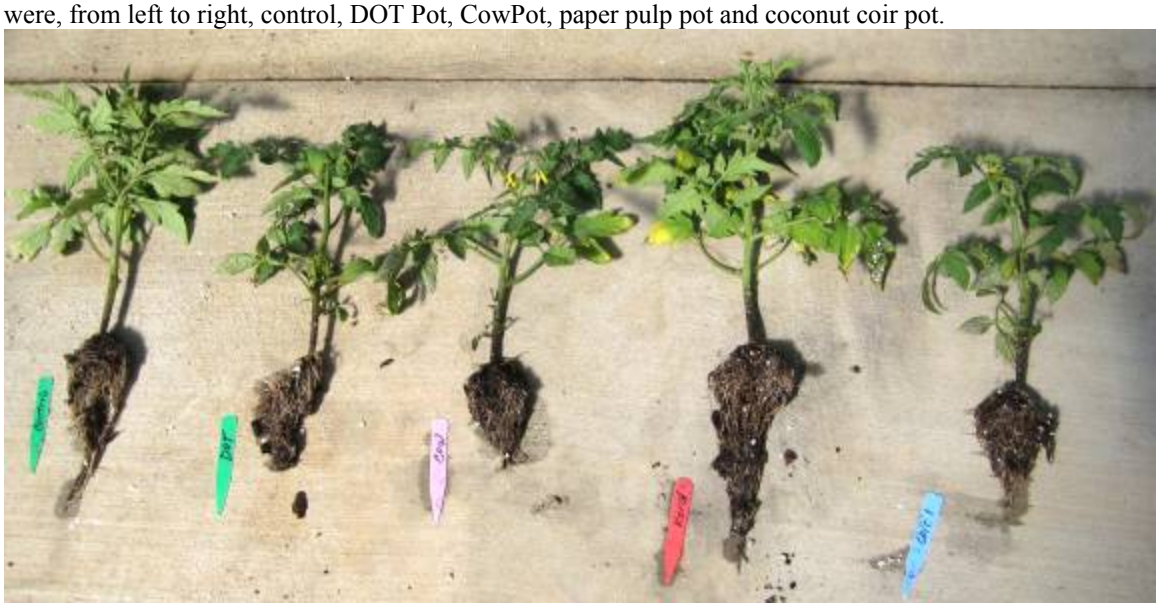


Figure 7. Overview and detail of roots of tomato plants grown in plastic pots and biocontainers one week after transplant into 5-gallon pots. Treatments were, from left to right, control, DOT Pot, CowPot, paper pulp and coconut coir pot.

Figure 8. Roots of tomato plants grown in plastic pots and biocontainers two weeks after transplant into 5-gallon pots. Treatments were, from left to right, control, DOT Pot, CowPot, paper pulp and coconut coir pot.

Figure 9. Roots of tomato plants grown in plastic pots and biocontainers three weeks after transplant into 5-gallon pots. Treatments were, from left to right, control, DOT Pot, CowPot, paper pulp and coconut coir pot.

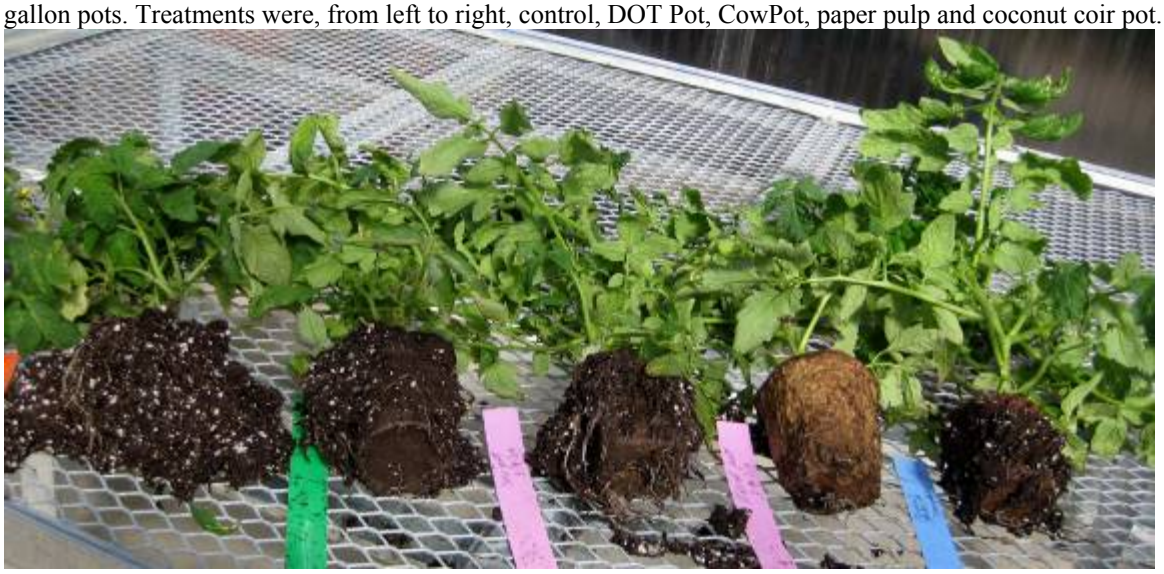


Figure 10. Overview and detail of roots of tomato plants grown in plastic pots and biocontainers four weeks after transplant into 5-gallon pots. Treatments were, from left to right, control, DOT Pot, CowPot, paper pulp and coconut coir pot.

Figure 11. Mean (±SE) height of tomato plants grown in the field. Bars followed by different letters are significantly different, t-test (p=0.05). Treatments (x-axis) were bare-root plants (control) and in coir pots (coir) within weeks after transplant.

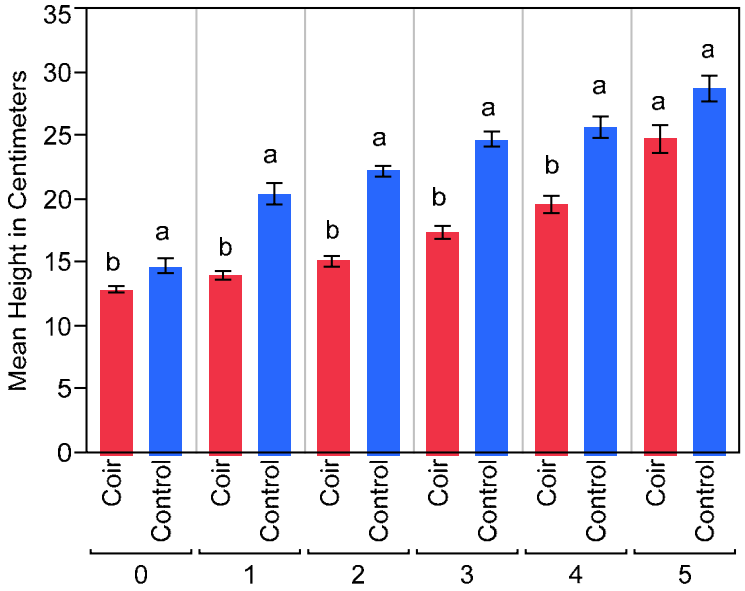


Figure 12. Aspect of tomato plants in the field three weeks after transplant