Testing the Use of Glass as a Hydroponic Rooting Medium

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FINAL REPORT

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1.0 INTRODUCTION AND BACKGROUND

This experiment tested the use of recycled glass as a hydroponic rooting medium. The hypothesis of this study was that glass is a viable rooting medium and will produce no greater or lesser growth yields than an expanded clay aggregate. Results supported the hypothesis -- there was no statistical difference between the glass-grown basil and the control-grown basil. This report describes the experiment conducted, presents results, and discusses the significance of the findings.

2.0 MATERIALS AND METHODS

THE EXPERIMENTAL SYSTEM

To test the use of recycled mixed colored glass as a hydroponic rooting medium, 20 basil plants were grown in glass and 20 basil plants were grown in an expanded clay aggregate over a period of ten weeks and two days (May 7 - July 16). An expanded clay aggregate was selected as a control because it is a commonly used hydroponic medium. It is popular among hydroponic hobbyists because it is light, clean, and sterile. The following sections provide a description of the experimental system (Figures 1 arid 2).

Lighting

A reflector and 1000 watt halide bulb hung over the four foot by eight foot growing area. An electrically powered chain mover slowly shifted the light from left to right over 20 minute intervals throughout the day. The lighting system was operated by a timer that turned the lights on at 6:30 a.m. and off at 8:30 p.m., providing 14 hours of light each day. The growing area was surrounded by three walls, each lined with reflective paper. A fourth piece of reflective paper hung across the open side to reflect as much light as possible onto the plants (Figure 2).

Glass and Clay Aggregates

Table 1 provides details of the glass and clay analyses. The glass used ranged in size between Sieve Number 200 and Sieve Number 4 with most of the particles falling in a range of between Sieve Number 8 and Sieve Number 4. The clay used ranged in size between Sieve No. 100 with most of the particles falling in the range of between Sieve Number 4 and 3/8 inch.

Table 1
Glass and Clay Sieve Results

Nominal Opening	Sieve	Glass Percent Passing	Clay Percent Passing
9.5mm	3/8 inch	100%	70.4%
4.74mm	No. 4	82.6%	5.9%
2.36mm	No. 8	3.5%	2.2%
1.18mm	No. 16	1.36%	2.1%
0.6mm	No. 30	1.23%	2.1%
0.3mm	No. 50	.6%	2.0%
0.15mm	No. 100	.21%	1.8%
0.075mm	No. 200	.07%	-

To ensure that the glass was sterile and contained no organic matter, it was heated in a kiln at 1,000 degrees Fahrenheit for four hours. The clay was also sterilized by being manufactured in a kiln where temperatures exceeded 1000 degrees Fahrenheight.

The Plants

Three day old basil seedlings started in one-inch rockwool cubes were set into four inch pots containing growing medium, 20 with only glass, 20 with only clay. (The young plants were started in rockwool because the small seeds would have fallen through the spaces between the glass and clay media particles and because the glass and clay would not have held enough water for the seedlings.) The young plants were set on two tables, each measuring four feet by four feet. One table housed the glass and the other, the clay. Each table held four trays and each tray contained five potted basil plants. Under each of the tables were nutrient solution tanks. The set up prevented the clay-system nutrient solution from mixing with glass-system nutrient solution.

The Nutrient Solution Feeding System

The plants received nutrients through an ebb and flow system. Both nutrient solution tanks contained a small pump that flooded the trays for a period of four minutes, four times a day (at 6:30 am, 10:00 am, 1:30 pm, and 5:00 pm).

Each reservoir contained 20 gallons of water. On an as needed basis, nutrients and water were added. On a weekly basis, pH, conductivity and temperature were monitored. Appendix A, Log Notes, provides a day by day and weekly summary of observations and system care.

3.0 RESULTS

Three basil plants were damaged during the course of the experiment and were therefore excluded from results. At harvest, plants were cut from their roots and dried to eliminate transient differences in moisture content. Dry weights were obtained by weighing the plants on a Sartoris balance and are presented in Table 2.

All statistics were calculated using the Minitab Release 8.2 statistical computing program. Mean dry weight of the glass-grown plants was 21.5 grams, with a standard deviation of 5.1 grams. Mean dry weight of clay-grown plants was 21.9 grams, with a standard deviation 6.8 grams. To test the significance of the difference between the two sample means, the Fisher statistic was calculated'. No significant (p= 0.05) difference in dry weight was found between plants grown in glass and plants grown in expanded clay aggregate.

Table 2
Growth Yields of Clay and Basin-Grown Plants

Plant Number	Glass in Grams	Clay in Grams
1	25.07	17.86
2	10.66	15.84
3	26.00	18.85
4	26.96	19.07
5	28.62	20.06
6	27.77	20.80
7	18.02	9.58
8	18.35	23.47
9	24.16	29.84
10	15.50	21.53
11	18.20	24.70
12	21.61	19.65
13	25.64	16.30
14	17.12	26.35
15	19.32	27.27
16	28.04	41.64
17	21.70	20.80
18	14.97	19.76
19	19.95	-

Table 3
Descriptive Statistics for Glass-Grown and Clay-Grown Basil Plants

	Sample Size	Mean	Median
Glass	19	21.5	21.6
Clay	18	21.9	20.4

Conductivity and pH

During the course of the experiment conductivity and pH were measured each week. Conductivity provides a measurement of the total nutrients within the growing liquid solution. It was measured in order to determine whether glass-grown basil used nutrients at the same rate as clay-grown basil. pH was measured to monitor acidity and compare nutrient uptake - differences in acidity indicate differences in the way nutrients are absorbed by plants. Table 4 provides weekly pH readings and Table 5 provides weekly conductivity readings.

Table 4
Weekly pH Levels

Date	Week Number	Glass Solution pH	Clay Solution pH
5-8	1	6.2	6.2
5-17	2	6.3->6.2	6.3->6.2
5-21	3	6.2	6.0
5-28	4	6.2	6.2
6-4	5	6.2	6.2
6-2	6	6.2	6.2
6-9	7	6->6.2	6->6.2
6-26	8	6->6.2	6->6.2
7-2	9	5.6->6.0	5.7->5.9
7-9	10	5.8->6.1	6->6.2

While there were no significant difference in the pH between the clay and glass solution tanks, conductivity appeared slightly lower in the glass tank during weeks four through eight. This corresponds with differences in growth during those same weeks. As the clay-grown basil grew faster during weeks four through eight, it also used more nutrients, reducing the conductivity of its solution.

Table 5
Weekly pH Levels

Date	Week Number	Glass Solution Conductivity	Clay Solution Conductivity
5-8	1	1200	1200
5-17	2	1200	1200
5-21	3	1500	1500
5-28	4	1230	1170
6-4	5	1100	1080
6-2	6	1080->980	1080->980
6-9	7	880->1000	700->1020
6-26	8	930->960	640->1040
7-2	9	970->900	1030->900
7-9	10	790->960	700->940

Where two values are listed in Tables 4 and 5, the first is the pH or conductivity before changes were made to the system (i.e., adding water or nutrients) and the second is the pH or conductivity after changes were made.

4.0 DISCUSSION

The results of this experiment confirmed the hypothesis -- glass serves as a viable rooting medium and produces no greater or lesser growth yields than expanded clay aggregate. The results are somewhat surprising given the noticeable difference in plant growth apparent in weeks four through eight. The difference in growth may have been due to one of three factors.

1. The glass grown basil may not have been receiving enough oxygen due to the smaller air spaces between the glass particles than between the clay particles. (Glass air spaces were smaller due to the smaller size of the glass particles. Also the relatively flat surfaces of the glass particles allowed for better packing than the rounded surfaces of the clay.)

2. Light may have permeated the glass and reached the roots.

3. The darker color of the clay may have absorbed more heat and may have provided the clay grown roots with additional warmth. (The temperature of water was measured in the reservoir tank. not individual pots.)

These three factors would have been mitigated during week five when aerators were added to the tanks and reflective paper was placed at the bases of the plants. These changes would have allowed the glass-grown basil to "catch up."

While our experiment indicates that glass can serve as a hydroponic rooting medium, the experience also brought to light some problems with the glass.

1. It was much heavier than the expanded clay aggregate. Glass weighs fifteen ounces per cup while expanded clay aggregate weighs seven ounces per cup.

2. The glass stuck to the fingers of the experimenters and they perceived this as inconvenient. This problem might be mitigated by wearing rubber gloves.

3. It's edges caused skin irritation from handling. In contrast, the expanded clay did not. This problem might also be mitigated by wearing rubber gloves.

Based on the findings from this experiment, mixed-color recycled glass will not be the hot new hydroponic rooting medium of the '90s. It may, however, find itself a niche market among the environmentally minded hydroponic hobbyists.

5.0 ACKNOWLEDGMENTS

ReTAP is a joint venture of the Clean Washington Center, Washington State's lead agency for market development of recycled materials, and the National Recycling Coalition, a 3,500 member nonprofit organization committed to maximizing the benefits of recycling. ReTAP is an affiliate of the national Manufacturing Extension Partnership (MEP), a program of the U. S . Commerce Department's National Institute of Standards and Technology. The MEP is a growing nationwide network of extension services to help smaller U. S . Manufacturers improve their performance and become more competitive. ReTAP is also sponsored by the U. S. Environmental Protection Agency and the American Plastics Council.

6.0 REFERENCES

1) Reference: Applied General Statistics. 1967. F.E. Croxton, J.J. Cowden, and the S.K. Klein. Prentice-Hall, Englewood Cliffs, N.J. 754 pp.

APPENDIX A

A WEEK BY WEEK SUMMARY

Week One, begins May 7

The cotyledons shed their seed shells and the first sets of true leaves appeared. Seedlings were sprayed with carbonated water on a daily basis. Some leaks in houses occurred and were repaired (Figures 1 and 3).

Week Two, begins May 14

Some seedlings developed a mild fungus (their leaves were brownish). These were replaced with healthy seedlings that were started at the same time. Some seedlings were very small and these were also replaced. In all, six seedlings grown in glass and two grown in clay were replaced. Daily spraying of plants with carbonated water continued. The true leaves grew to the size of the cotyledons (Figures 4 and 5).

Week Three, begins May 21

The roots grew beyond the rockwool and into the growing medium. Second sets of true leaves appeared. Daily spraying of plants with carbonated water continued (Figure 6).

Week Four, begins May 28

At the beginning of the week water was added to the solution tanks. The plants in the glass appeared smaller than those in the clay. Plants continued to develop new leaves. Spraying with carbonated water on a regular basis was stopped (Figure 7 and 8).

Week Five, begins June 4

The solution tanks were cleaned and fresh water and nutrients were added at the beginning of the week. The plants were vigorous. Reflective paper was added to the bases of all the plants to prevent light from penetrating into the root systems and to reflect the light back up to the leaves (Figures 9 and 10). Aerators were added to the nutrient solution tanks to oxygenate the water.

Week Six, begins June 11

More water was used by the clay-grown basil. (Figures 11 and 12).

Week Seven, begins June 18

Nutrients and water were added to both systems. The plants were vigorous (Figure 13).

Week Eight, begins June 25

The tanks were cleaned, water was changed, and new nutrients were added. The clay-grown basil was so large that they begin to tip over. The light was raised to prevent leaves from burning. Flower buds appeared and were removed (Figures 14 and 1S).

Week Nine, begins July 2

Nutrients and water were added. Plants in both media were tipping over on a daily basis. A glass-grown basil plant was accidentally broken at the base. Buds appeared and were regularly picked off. Ron Kleinman of Hygro Technolgies videotaped the system for his video, The Inside Scoop on Inside Gardening (Figure 16).

Week Ten, begins July 9

The frequent tipping over of plants became a significant problem. Duct tape was used to secure the plants to the table. The reflectors and bulb were also changed so that the light could be moved farther from the leaves. A fan fell on a clay-grown plant and was removed from the experiment. (Figurel7).

Week Eleven, Day Two, begins July 16

The basil was harvested by cutting it at its base and hanging it on a twine line (Figures 18)

Week Thirteen, begins July 30

The basil was almost dry, but not quite, so it was put in paper bags and into the oven. The plants dried quickly. One ignited.

The following pages contain photos 1, 9, 17, and 18. When converted to file, the number of photos needed for this report were reduced and only the beginning, middle and end photos are presented; there were 18 photos in all.

FIGURE 1- FULL SYSTEM VIEW, WEEK 1

FIGURE 9 - FULL SYSTEM VIEW, WEEK 5

FIGURE 17 - FULL SYSTEM VIEW, WEEK 10

FIGURE 18 - HANGING TO DRY