Physical Properties of Propagation Media

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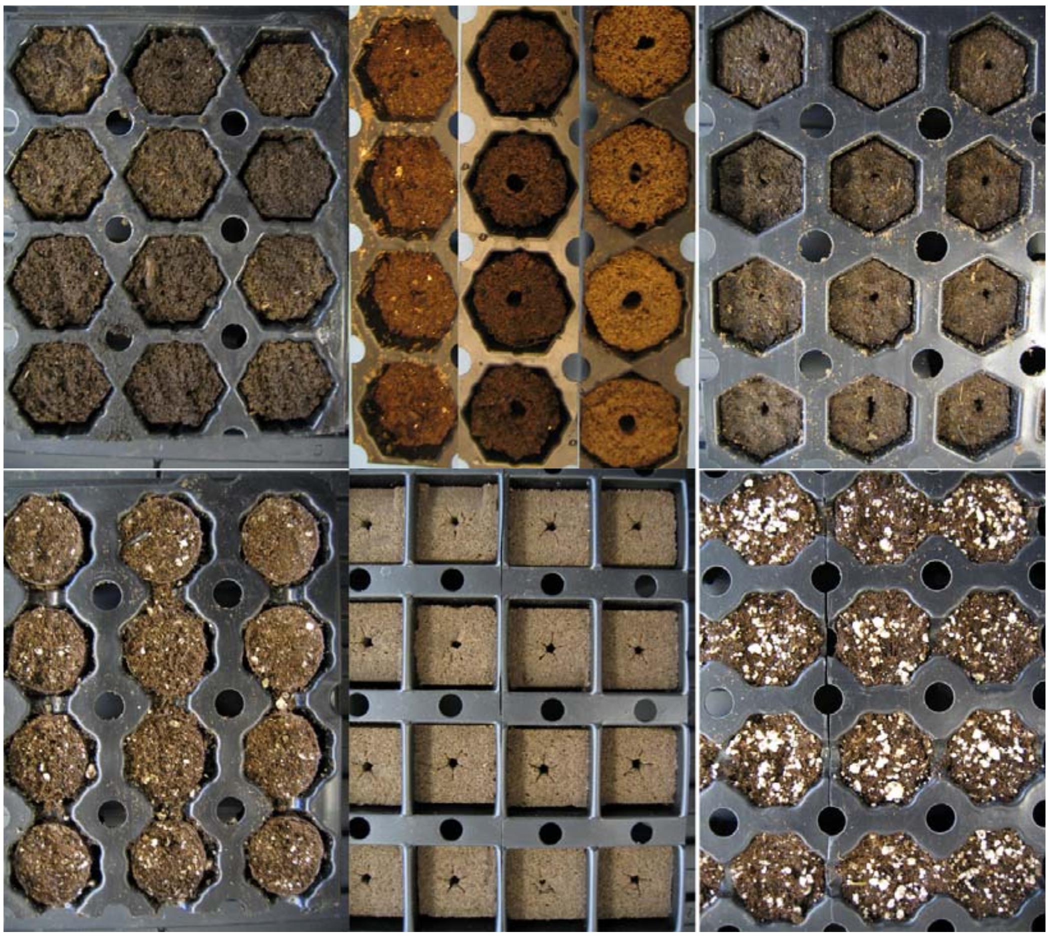

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Executive Summary

- To survey physical qualities of a range of commercial propagation media, eight stabilized media plus eight loose media (16 types in total) were tested for physical characteristics. The measurements included water holding capacity, air volume, porosity, total volume, and solid density per plug.
- All loose media were placed in the same size 105 tray for testing. For the eight loose types media tested, similar physical characteristics were observed. The overall average absolute values per cell for loose media were 15 mL/cell (0.75 mL/cm^3) for water holding capacity, 1.43 mL/cell (0.07 mL/cm^3) for air volume, 17.4 g/cell (0.86 g/cm^3) bulk density at container capacity and 2.4 g/cell (0.12 g/cm^3) for dry solid bulk density. The average percentage of water porosity, air porosity and solid for the loose media were 75%, 7% and 18%, respectively.
- Stabilized media were also from 105-size trays, except one 102-size product. There was more variability between stabilized media types than between loose media. Physical properties of stabilized media were affected by varying cell dimensions and media components. The average water holding capacity, air volume, and solid dry bulk density for stabilized media ranged from 0.42 to 0.86 (average 0.67) mL/cm^3 water, 0.04 to 0.10 (average 0.08) mL/cm^3 air, and 0.02 to 0.17 (average 0.12) g/cm^3 density. Water porosity and air porosity for the stabilized media types averaged 67% and 8.7%, respectively.
- Future reports will evaluate other chemical and physical qualities of these media.

Introduction

Propagation media blend components that provide water, air, nutrients and support to cuttings. Cuttings require the optimum proportions of water and air for successful rooting. Media nutrient charge and pH are also important for fast, even root development once the cutting has developed root initials.

In plug cells, the volume of medium available per plant is very limited and an appropriate mix of air, water, and solid is essential for a rapid product cycle. Physical properties can not be easily changed after ingredients have been placed in a container. However, irrigation and climate management affect growing success with a particular product. For example, growers that tend to irrigate more frequently than average or have an environment that maintains high humidity may have more success with media that has high air porosity. In the propagation environment, high humidity and frequent misting also require high air porosity in the medium to avoid waterlogging and anaerobic conditions. For shipping and holding cuttings, however, adequate water holding capacity is important to avoid wilting.

The distribution of water, air, and solid in a small container medium depends on several factors including pore space, bulk density, particle size distribution, and container height. The amount of **total pore space** in a propagation medium is inversely proportional to the **bulk density**. As the bulk density decreases, total pore space increases. Pore space is occupied by either air or water. For a container medium, container capacity is the total amount of water present in the container after the medium has been saturated and allowed to drain. The percent of container volume composed of pore space is referred to as **total porosity**. The fraction filled with air is called **air porosity** and the fraction filled with water is called **water holding capacity**.
Media particle size influences the size of pore spaces and total porosity. Large particle size (such as coarse bark and perlite) will have larger pores between particles than small particle size (such as fine peat and bark), and will also have more total porosity. Pore size affects available water content, drainage, and the distribution of water in containers. Under gravity condition, small pores (<0.01 mm) hold water so tightly that it is unavailable for plant uptake; pores between 0.01 and 0.4 mm in diameter contain water that is readily available for plant uptake; and pores > 0.4 mm are so large that they do not hold water and are mostly filled with air (Drzal, M.S., Fonteno, W.C., and Cassel, D.K., 1999).

Another factor relating media to air/water relations in the root zone is the size of the growing container. With media in a container, the amount of air and water held in a given medium is a function of the height of the column of media. The taller the column, the smaller the ratio of water to air spaces. This relationship occurs because gravity pulls water down to form a saturated zone in a “perched water table”, and the height of the saturated zone is constant for a given growing medium. Therefore, as we increase container height above the saturated zone, we add more volume of media that contains air. Waterlogging is especially problematic in plug cell production where the small cells drain very poorly or not at all, resulting in poor root zone aeration.

Currently there are guidelines regarding the ratio of water to air spaces for general pot media, but not for liner propagation media. This report is the first step in that process – **Our objective was not to define the “best” medium, which will vary depending on growing practices, but rather to survey physical qualities of a range of commercial propagation media.**

Other physical qualities that we did not measure in this trial, but would like to compare between propagation media, are moisture release curves, rewetting of dry cells, time required to achieve a pullable, cohesive plug, media release from the cell, and pore size.

Evaluation Methods

There were 16 propagation media types in total tested for physical characteristics measurements. Among the tested media, eight media were stabilized forms, meaning that the cell shape was stable outside the plastic tray through addition of polymers, foam, or paper wrapping, and the cell integrity outside the tray did not require binding by plant roots (Fig.1). The plugs trays hold the tested media were size 105, except the Oasis (102 size trays) (Fig.2). The Ellepot paper-wrapped media contained Blackmore Greenway media.

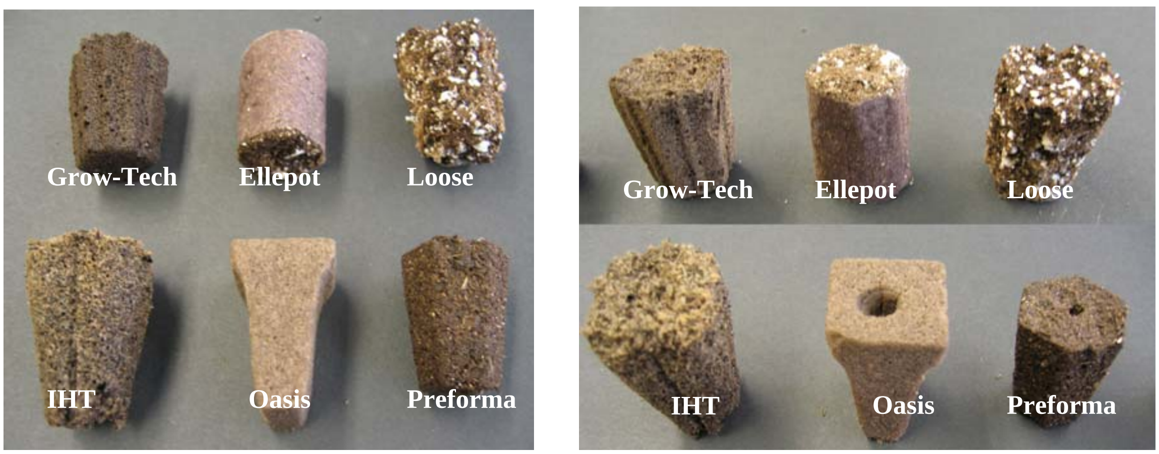

Figure 1. Types of propagation media tested.

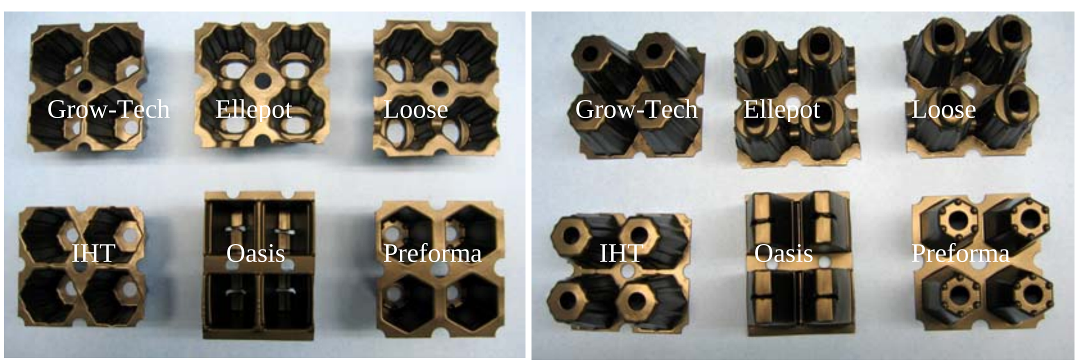

Figure 2. The corresponding plug trays for each media types as shown in Figure 1. The tray sizes are shown in Table 1.

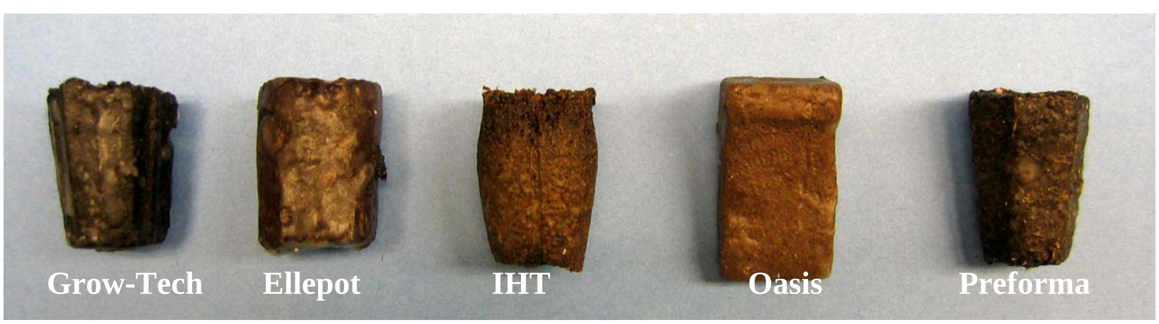

Figure 3. To calculate the volume of the simple stabilized media, media were first moistened then coated with paraffin. The volume of each type media was then estimated by water displacement.

The other media were loose materials based on peat, bark, perlite, and vermiculite, and included a research 70% peat/30% perlite medium, and media from Blackmore Greenway, Fafard, two media from Sun Gro Horticulture, and three media blended in house by commercial greenhouses. Table 1 summarizes the types of media, media volume, height of media columns and the bulk volume of plug cells used.

Table 1. Tested media height and volume and the relevant size and volume of plug trays used.

Media Types	Media Height (cm)	Media Volume (ml/cell)*	Plug Tray Size	Plug Cell Volume (ml/cell)**
Loose media	3.77	20.16	105	20.16
Ellepot	3.50	15.85	105	20.16
Grow-Tech	3.64	14.57	105	21.80
Preforma	3.80	12.52	105	20.35
IHT Q-Plugs	3.90	20.71	105	21.88
IHT Excel Plugs formulation 1 (105 Hex)	3.32	16.94	105	21.88
IHT Excel Plugs formulation 2 (105 Hex)	3.83	17.28	105	21.88
Oasis	4.35	18.33	102	23.44

**Media volume was measured with paraffin coating then water displacement method (Fig. 3).*
***Plug cell volume was measured by sealing the drainage hole then filling the cell with distilled water to the same level as the medium within. All loose media were placed in size-105 Blackmore trays.*

The physical characteristics measured were water holding capacity, air volume, porosity and volume and weight of solid per plug. For all characteristics evaluated, three repetitions of 12 cells were measured, taking the averages of these for results.

All calculations depend on the overall volume of the cell, and great care was taken to measure **total cell volume**. For the stabilized media, the volume of media column was measured by water replacement of wax coated media. Four media cubes of each type were first moistened with water then coated with wax (Figure 3), the coated media cube was transferred into a water filled beaker. The volume of medium cube was accomplished gravimetrically, by weighing the replaced (overflowed) water. The density of water is 1 gram (g) per milliliter (mL), and 1 mL = 1 cubic centimeter (cm^3).

The average of the four measurements was treated as result as shown in Table 1. For the loose media, the bottom of the plug cell was sealed of with tape and the cell was filled with distilled water until it filled with the same volume that the media had filled within the cell. The volume was then calculated by weighing the filled cell and subtracting the weight of the plastic from the total weight to give grams of distilled water, which weighs one gram per milliliter.

Figure 4. The loose media were first filled in plug trays (top), then irrigate thoroughly, letting it drain and settle to a constant level (bottom).

To measure **air porosity (air volume)**, the plugs were filled with medium (for loose media) and irrigate thoroughly, letting it drain and settle to a constant height or level (Figure 4). (The media were not moistened before tray filling). The drainage holes of plug cells filled with either the wet media or the stabilized media were then sealed of with tape (Figure 5). The media were then slowly irrigated to the point of saturation. Saturation occurred when all the pore space in the medium was occupied by water, without free water on the surface. The cells were weighed when the drainage hole was covered (plugged), then plugs were removed, and the cells were drained and weighed again. The difference in weight between these two measurements as water drained from air spaces gave the air volume in the media at saturation. The air porosity (%) was calculated as (air volume/ total cell volume) x 100. The moisture level after the media finished draining was called **container capacity**, which was used as the standard reference point at which all physical properties are measured, allowing for comparisons among different growing media.

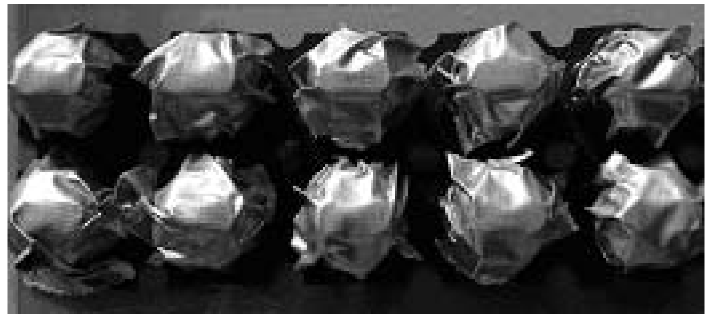

Figure 5. To measure media air porosity, the drainage holes of plug cells were covered with tapes and slowly adding water to the medium until reaching saturation point. The cells were weighed when the drainage hole was covered (plugged), then unplugged, drained and weighed again.

To measure the **water holding capacity**, the **fresh weight** was first obtained when the medium stopped draining (at container capacity point), and the medium was then put in an oven to dry overnight at 110 ^{o}C. The **dry weight** of the medium was then obtained. The difference between the fresh weight and the dry weight gave the amount of water retained in the media, thus measuring water holding capacity.

The **total porosity**, or pore space in the media available for air or water, was calculated by adding the total water holding capacity and air porosity in the media. The amount of solid within the cell was determined by subtracting the total porosity from the volume of the media column or cell to give the volume of solid contained within each plug.

Results

Physical characteristics can be expressed in several ways, including:

- Absolute values per cell represent how the medium and its container combine to affect total water, air and solid weights and volumes in the “package” of the cell.
- Percentage of cell volume show the proportion of cell space taken up by air, water and solid.

Absolute values per cell are shown in Table 2. The absolute values of water holding capacity, air volume and solid content were influenced by both the plug cell dimensions and the media composition. For the loose media types, 105 size plug trays were used with an average cell volume of 20 mL, whereas cell size differed between stabilized media. For the stabilized type media, in part because plug size differed, the water holding capacity values ranged from 7.9 to 15.7 mL, with an average of 11.6 mL per cell. Stabilized medium 1 held the most water per cell (highest water holding capacity) and had the lowest weight (dry bulk density). Polymer/peat media 4, 7, and 8 held the least water per cell. Loose media had similar water-holding capacity, with an average of 15 ml per cell (Table 2). Stabilized medium 4 (formulated with large air pores) and Loose medium 8 (with 50% perlite) had the greatest air volume per cell. Loose medium 6 had coarse peat and also had a high air volume per cell. Dry bulk density was similar between loose media, and Loose medium 3 was the heaviest medium and the only medium that contained field soil.

The porosity of the media as a percentage is shown in Table 3. As noted for Table 2, there was more variability between stabilized media than between loose media types. Percent water for stabilized media ranged from 44.8 to 85.7% between stabilized media. Percent water was fairly consistent between loose media, averaging 74.6%. Air porosity varied more than water porosity. The % air ranged from 4.5% to 11.3% across all media types. Total porosity ranged from 76.2% to 85.1% for the loose media, and from 55.3% to 91.6% for the stabilized media. The % solid ranged from 8.4% to 44.7%, with the highest values in Stabilized medium #4, and the lowest value for the Stabilized medium #1.

Literature cited:

Drzal, M.S., Fonteno, W.C., and Cassel, D.K. 1999. Pore fraction analysis: A new tool for substrate testing. Acta Hort. 481: 43-54

Table 2. Physical characteristics as **absolute levels per cell** of the tested propagation media.

Media sources	Water Holding Capacity (ml/cell)	Air volume (ml/cell)	Dry Solid (ml/cell)	Moist Bulk Density (g/cell)	Dry Bulk Density (g/cell)
Stabilized					
1. Stabilized foam	15.70	1.08	1.54	16.53	0.35
2. Stabilized peat/ perlite/ vermiculite	10.86	1.03	3.96	16.10	2.64
3. Polymer/peat	10.82	0.89	2.87	12.76	1.95
4. Polymer/peat	9.29	2.17	9.26	11.11	1.83
5. Polymer/peat	13.86	0.76	2.33	15.88	2.02
6. Polymer/peat	11.25	1.77	2.25	13.86	2.61
7. Polymer/peat	8.88	1.06	2.58	10.54	1.66
8. Polymer/peat	7.92	1.42	3.18	9.32	1.39
Overall stabilized	***11.61***	***1.60***	***4.43***	***13.71***	***2.06***
Loose					
1. 70% peat + 30% perlite	15.98	1.17	3.01	18.50	2.52
2. 60% peat + 15% perlite + 25% vermiculite	13.91	1.44	4.80	16.10	2.19
3. 74% peat + 19% perlite + 7% soil	15.20	1.06	3.90	18.82	3.62
4. 70% peat + 30% perlite	15.19	1.14	3.83	17.33	2.15
5. 70% peat + 30% perlite	15.05	1.47	3.63	17.50	2.45
6. 80% peat + 20% perlite	15.02	1.94	3.19	17.10	2.08
7. 55-65% peat moss + 45-35% perlite	15.36	1.17	3.63	17.63	2.27
8. 50% peat moss + 50% perlite	14.56	2.08	3.52	16.48	1.92
Overall loose	***15.03***	***1.43***	***3.69***	***17.43***	***2.40***

Table 3. Loose media composition and physical characteristics as **percentages of cell volume**.

Media Sources	Water Porosity (%)	Air Porosity (%)	Total Porosity (%)	Solid (%)
Stabilized				
1. Stabilized foam	85.7%	5.9%	91.6%	8.4%
2. Stabilized peat/ perlite/ vermiculite	68.5%	6.5%	75.0%	25.0%
3. Polymer/peat	74.2%	6.1%	80.3%	19.7%
4. Polymer/peat	44.8%	10.5%	55.3%	44.7%
5. Polymer/peat	81.8%	4.5%	86.3%	13.7%
6. Polymer/peat	65.1%	10.2%	75.4%	24.6%
7. Polymer/peat	70.9%	8.4%	79.4%	20.6%
8. Polymer/peat	63.3%	11.3%	74.6%	25.4%
Overall	***67.0%***	***8.7%***	***75.7%***	***24.3%***
Loose				
1. 70% peat + 30% perlite	79.3%	5.8%	85.1%	14.9%
2. 60% peat + 15% perlite + 25% vermiculite	69.0%	7.2%	76.2%	23.8%
3. 74% peat + 19% perlite + 7% soil	75.4%	5.2%	80.7%	19.3%
4. 70% peat + 30% perlite	75.4%	5.7%	81.0%	19.0%
5. 70% peat + 30% perlite	74.7%	7.3%	82.0%	18.0%
6. 80% peat + 20% perlite	74.5%	9.6%	84.2%	15.8%
7. 55-65% peat moss + 45-35% perlite	76.2%	5.8%	82.0%	18.0%
8. 50% peat moss + 50% perlite	72.2%	10.3%	82.6%	17.4%
Overall	***74.6%***	***7.1%***	***81.7%***	***18.3%***