Literature Cited


Physical Properties of Container Media Composed of a Gasifier Residue in Combination with Sphagnum Peat, Bark, or Sand

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Additional index words. water-holding capacity, bulk density, particle size, waste product.

Abstract. The physical and water-release characteristics of a gasifier residue in combination with bark, Canadian sphagnum peat, and sand were determined. Both gasifier residue and peat had characteristics more favorable for plant growth than bark or sand alone. The combination of gasifier residue and peat produced characteristics superior to gasifier residue or peat alone. Gasifier residue and combinations of gasifier residue and peat had almost twice the available water of a standard nursery medium. The addition of sand or bark decreased the performance of gasifier residue in a number of physical parameters. Unsieved gasifier residue had a particle size distribution suitable for container plant production.

Container production is an important aspect of the woody ornamental industry. Large quantities of inorganic and organic materials are used in the formulation of media (4). The most common media components currently used are soft or hardwood barks, sphagnum peats, gravels or sands, and various industrial or agricultural by-products (4, 7, 11). Some of these materials, notably the peats and barks, have in the past been in good supply, but in the future they will become more scarce or be diverted to more economically profitable uses.

A wide variety of materials can be used as media components for the growth of quality plants (6). The suitability of a material as a media component depends on both its chemical and physical properties (4, 6, 11, 17). Physical properties of a number of commonly used component materials and media combinations have been determined. Optimum range guidelines have been proposed for measurable physical characteristics of a medium which are favorable for plant growth (1, 3, 6, 8, 14, 17).

Container media may be characterized by measurements of the phase-distribution of the solid, air, and water volumes at different moisture tensions. These tensions are low compared to field soil moisture stress criteria (3, 8, 9, 14). In containerized plants, growth can be reduced at water tensions greater than 100 cm (3). A system and terminology postulated by DeBoodt and Van de Wuerffel (3) to describe water-release characteristics at 0- to 100-cm tension has subsequently been used with a number of growth media by other workers (2, 5, 6, 8). The advantages and limitations of this descriptive system as applied to porous media are discussed by Bilderback et al. (2).

A gasifier residue was recently tested as a potential container media component with several woody plant species (13). The residue is a waste product from the controlled combustion of wood biomass, namely wood chips and bark. The objectives of the present study were to determine the physical and water-release characteristics of the gasifier residue and to determine the effects of various amendments on the gasifier residue.

Materials and Methods

Char residue from a moving bed, down-draft gasifier (19) was used as a media component in combination with Canadian sphagnum peat (P), pine bark (B), and coarse sand (S). This gasifier residue (GR) is produced from burned wood chips and bark (13). All media combinations were mixed in a .09-m³ rotating cement mixer and stored dry. Mix combinations consisted of GR:B, GR:P, or GR:S in 100%-0%, 75%-25%, 50%-50%, 25%-75%, or 0%-100% ratios (vol/vol) with a 2-B:1-P:1-S combination as a standard nursery medium.

Three-liter containers were filled with the respective media to a height of 17.0 cm. A PVC ring 6 cm height × 6.6 cm i.d. was placed into each cylinder with the bottom edge of the ring 6 cm from the container bottom. The bottom of the rings were screened with 1-mm nylon mesh and the top left open. The containers were watered daily by hand for 10 days to facilitate settling of the media. The rings were removed from the containers and the medium leveled with the top of the ring. These undisturbed cores were placed on the porous ceramic plate of a
Pyrex 350-ml 90F Buchner filter funnel in a hanging water-column apparatus (16). The cores were saturated overnight and the volume of water released was measured from 0- to 100-cm water tension at 10-cm intervals. Rings were drained for 24 hours at each interval. These data were used to calculate air space, easily available water, and water-buffering capacity (3, 8). After reaching 100-cm tension, cores were removed from the funnels, weighed, dried at 105°C for 24 hr, and reweighed for determination of bulk density and total pore space. Water tensions at which volume percentage of water/volume percentage of air space = 1 were calculated using values for total pore space and interpolating on a straight line between the 10-cm release intervals. DeBoodt has proposed a system of terms to describe the air-water phases of a container medium (3). In this proposed system, total pore space (TPS) is defined as the volume percentage of water content at zero water tension. Air space (AS) is the volume percentage water released between 0- and 10-cm water tension. Easily available water (EAW) is the volume percentage water released between 10- and 50-cm water tension. Water buffering capacity (WBC) is the volume percentage of water released between 50- and 100-cm water tension. Water tension at volume percentage of water/volume percentage of air = 1 is a measure of the water/air ratio occurring in the root zone at a given tension.

Weight at container capacity was determined using screened PVC cylinders 17.0 cm height × 10.5 cm i.d., following the method of White and Mastalerz (18). For saturated hydraulic conductivity measurements, screened PVC cylinders 25 cm height × 10.5 cm i.d. were filled with media and settled by the method described above. Conductivity was measured on saturated media using a 5-cm constant head after a stable flow rate was achieved (10). Particle size distribution of media components was determined using 1000-cc samples of air-dried materials placed in a series of U.S. Standard sieves (Table 1) on a mechanical shaker for 3 minutes at 160 rotations/min. All physical and water release determinations were replicated 3 times and data were analyzed using HSD for mean separation at the 5% level.

## Results and Discussion

### Particle size distribution

The majority (85%) of the gasifier residue particles were within the size range 4.00–0.42 mm (Table 1). This size range also contained the majority of particles of P, S, and B. In comparison to GR, both P and B had a greater proportion of particles larger than 4.00 mm. P and B were comparable to GR in percentage of particles smaller than 0.42 mm which make up about 35% of the total particle distribution. B, in comparison to GR, seems to have greater amount of its particles in sizes larger than 2.0 mm (log = 3.0) (Fig. 1). However, B and P have larger percentages of their particles larger than 2.0 mm, 30% and 22%, respectively. Both GR and P have similar percentages of particles smaller than 0.42 mm which make up about 35% of the total particle distribution. The S, being a sieved grade size, has relatively little of these particle sizes. B, in comparison to GR, seems to have greater amount of its particles in sizes larger than 2.0 mm or smaller than 0.42 mm.

#### Total pore space

TPS in GR was comparable to that in P and B (Table 2). Addition of P to GR caused an increase in TPS, with all the GR:P mixes having a TPS greater than the ideal substrate and the standard. There was no difference between TPS in the GR:B mixtures and in GR; however, only 1GR:3B had a larger TPS than the standard. S had a smaller TPS than GR, and additions of S caused a decrease in TPS. The ideal value for TPS is 85% vol.; however, this does not necessarily indicate satisfactory aeration in a container medium. Air and water space must be determined directly (2, 8).

#### Air space

AS of GR was similar to that of both P and S (Table 2). Addition of either P or S to GR did not change the AS. B had a greater AS than GR, and B was the only amendment tested which significantly increased AS, specifically 1GR:3B. None of the media were significantly different from the standard. None of the media fell within the ideal range of 20 to 30% for AS, but AS in GR was closest to these values.

#### Easily available water

EAW was equal in P and GR (Table 2). The addition of P to GR did not increase EAW significantly until the 1GR:3P combination, which was the only medium within the ideal range of 20 to 30% EAW. The 1GR:3P medium actually contained a greater amount of EAW than P. Both B and S were lower in EAW than GR. EAW was decreased significantly, even at the lowest levels of B and S addition. However, all GR:B and GR:S combinations were equal in EAW to the standard. GR and GR:P combinations were superior to the standard, having almost twice the EAW of the standard.

<table>
<thead>
<tr>
<th>Particle size (mm)</th>
<th>Gasifier residue</th>
<th>Peat</th>
<th>Sand</th>
<th>Bark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean SD</td>
<td>Mean SD</td>
<td>Mean SD</td>
<td>Mean SD</td>
<td>Mean SD</td>
</tr>
<tr>
<td>&gt;7.93</td>
<td>0.7* 0.62</td>
<td>6.4 1.57</td>
<td>0.0 0.00</td>
<td>7.3 1.32</td>
</tr>
<tr>
<td>7.93–5.60</td>
<td>2.4 0.96</td>
<td>8.2 2.52</td>
<td>1.0 0.45</td>
<td>10.4 1.66</td>
</tr>
<tr>
<td>5.60–4.00</td>
<td>3.3 0.92</td>
<td>6.2 0.81</td>
<td>6.6 0.64</td>
<td>11.5 1.53</td>
</tr>
<tr>
<td>4.00–2.00</td>
<td>19.6 3.56</td>
<td>18.6 0.21</td>
<td>29.5 1.51</td>
<td>26.0 0.83</td>
</tr>
<tr>
<td>2.00–1.00</td>
<td>35.9 2.10</td>
<td>25.8 1.76</td>
<td>35.5 0.76</td>
<td>20.6 1.20</td>
</tr>
<tr>
<td>1.00–0.42</td>
<td>29.7 4.46</td>
<td>20.9 3.65</td>
<td>23.4 1.77</td>
<td>14.2 1.57</td>
</tr>
<tr>
<td>0.42–0.25</td>
<td>6.7 2.25</td>
<td>7.7 0.78</td>
<td>3.2 0.72</td>
<td>5.7 0.95</td>
</tr>
<tr>
<td>&lt;0.25</td>
<td>5.6 2.60</td>
<td>6.1 0.47</td>
<td>0.6 0.23</td>
<td>5.2 0.36</td>
</tr>
</tbody>
</table>

*Data are means of 3 replications.

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Fig. 1. Summation curve of particle size distribution of gasifier residue, peat, pine bark, and sand. ▲ Gasifier residue; ○ Peat; • Pine bark; □ Sand.
Table 2. Physical and water release characteristics of gasifier residue (GR) and GR amended with sphagnum peat moss (P), pine bark (B), or sand (S).

<table>
<thead>
<tr>
<th>Medium</th>
<th>Total pore space (% vol)</th>
<th>Air space (% vol)</th>
<th>Easily available water (% vol)</th>
<th>Water buffering capacity (% vol)</th>
<th>Water tension (cm) at vol % water/ vol % air = 1</th>
<th>Bulk density at container capacity (g/cm)</th>
<th>Bulk density at container capacity (g/cm)</th>
<th>Saturated hydraulic conductivity (cm/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gasifier residue</td>
<td>79.0 bcd</td>
<td>32.3 b</td>
<td>15.5 b</td>
<td>2.6 cde</td>
<td>18.9 ab</td>
<td>.21 ef</td>
<td>.76 ef</td>
<td>1103 b</td>
</tr>
<tr>
<td>GR-P, 3:1 (v/v)</td>
<td>88.8 abc</td>
<td>41.2 ab</td>
<td>15.7 b</td>
<td>3.4 bc</td>
<td>13.2 cd</td>
<td>.20 efg</td>
<td>.79 def</td>
<td>528 de</td>
</tr>
<tr>
<td>GR-P, 1:1</td>
<td>97.6 a</td>
<td>44.3 ab</td>
<td>16.6 b</td>
<td>3.3 bc</td>
<td>11.2 cd</td>
<td>.14 efg</td>
<td>.77 ef</td>
<td>702 cde</td>
</tr>
<tr>
<td>GR-P, 1:3</td>
<td>97.6 a</td>
<td>43.3 ab</td>
<td>21.5 a</td>
<td>4.4 a</td>
<td>14.5 bc</td>
<td>.12 fg</td>
<td>.78 ef</td>
<td>677 cde</td>
</tr>
<tr>
<td>Peat</td>
<td>91.0 ab</td>
<td>38.8 ab</td>
<td>15.0 b</td>
<td>3.7 ab</td>
<td>21.7 a</td>
<td>.12 fg</td>
<td>.81 def</td>
<td>207 f</td>
</tr>
<tr>
<td>GR-B, 3:1</td>
<td>86.0 abcd</td>
<td>44.6 ab</td>
<td>10.9 c</td>
<td>2.4 de</td>
<td>9.6 edef</td>
<td>.22 e</td>
<td>.76 ef</td>
<td>444 ef</td>
</tr>
<tr>
<td>GR-B, 1:1</td>
<td>82.3 abcd</td>
<td>43.0 ab</td>
<td>10.5 c</td>
<td>2.3 ef</td>
<td>9.6 edef</td>
<td>.21 ef</td>
<td>.71 ef</td>
<td>644 cde</td>
</tr>
<tr>
<td>GR-B, 1:3</td>
<td>88.5 abc</td>
<td>49.3 a</td>
<td>10.8 c</td>
<td>1.3 fg</td>
<td>8.6 def</td>
<td>.21 ef</td>
<td>.67 ef</td>
<td>1400 a</td>
</tr>
<tr>
<td>Bark</td>
<td>88.4 abc</td>
<td>48.2 a</td>
<td>7.8 cd</td>
<td>1.4 cd</td>
<td>10.1 edef</td>
<td>.18 efg</td>
<td>.59 f</td>
<td>539 de</td>
</tr>
<tr>
<td>GR-S, 3:1</td>
<td>74.0 cde</td>
<td>45.2 ab</td>
<td>8.6 cd</td>
<td>1.2 g</td>
<td>7.6 ef</td>
<td>.64 d</td>
<td>1.08 cd</td>
<td>674 cde</td>
</tr>
<tr>
<td>GR-S, 1:1</td>
<td>64.9 e</td>
<td>42.1 ab</td>
<td>7.0 cd</td>
<td>1.1 g</td>
<td>6.8 ef</td>
<td>.96 c</td>
<td>1.31 bc</td>
<td>639 cde</td>
</tr>
<tr>
<td>GR-S, 1:3</td>
<td>46.3 f</td>
<td>32.6 b</td>
<td>5.0 d</td>
<td>.2 h</td>
<td>6.5 ef</td>
<td>1.29 b</td>
<td>1.57 ab</td>
<td>543 de</td>
</tr>
<tr>
<td>Sand</td>
<td>41.2 f</td>
<td>33.1 b</td>
<td>5.7 d</td>
<td>.1 h</td>
<td>5.1 f</td>
<td>.51 a</td>
<td>1.78 a</td>
<td>755 cd</td>
</tr>
<tr>
<td>B-P-S, 2:1:1 (standard)</td>
<td>68.8 de</td>
<td>36.4 ab</td>
<td>9.4 cd</td>
<td>1.8 efg</td>
<td>9.4 edef</td>
<td>.60 d</td>
<td>.95 de</td>
<td>846 bc</td>
</tr>
<tr>
<td>Ideal substrate</td>
<td>85.0</td>
<td>20–30</td>
<td>20–30</td>
<td>4–10</td>
<td>15–25</td>
<td>.15–50</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Mean separation within columns by HSD, 5% level.

*From DeBoodt and Verdonck (3); Poole and Waters (12).

Water-buffering capacity. GR had a lower WBC than P, but all the GR:P combinations were comparable to P and the 1GR:3P medium was the only medium within the ideal range of 4 to 10% (Table 2). Both B and S were lower in WBC than GR, and additions of either one tended to decrease WBC. However, this decrease was not significant until the 1GR:3P level with bark. All GR:B and GR:S combinations except 1GR:3S were equal to the standard medium in WBC, and all GR:P combinations were superior to the standard.

Water tension (cm) at volume percentage of water/volume percentage of air = 1. The condition of 50% air/50% water in the total pore space is the optimum air-water ratio for plant growth and ideally should occur at 15- to 25-cm water tension (3, 8). A higher tension would indicate that too much water and not enough air was present for optimum plant growth. Of the media tested, only GR and P individually fell within the ideal range (Table 2). These materials became more aerated when combined but the 3GR:1P mixtures were close to the ideal range. Both B and S were significantly drier than GR, as were all combinations with B and S. Only GR and P had tensions higher than the standard; all other media were equal to the standard.

Saturated hydraulic conductivity. GR had a saturated hydraulic conductivity greater than that of P, B, or S (Table 2). Addition of P, B, or S reduced the conductivity of GR at lower amendment rates, but conductivity was increased in 1GR:3B. This effect might be due to particle fitting and critical concentration of amendment as described by Spomer (15). Three combinations—3GR:1P, 3GR:1B, and 1GR:3S—had values less than the standard.

Bulk density. GR had a dry bulk density (BD) similar to B and slightly greater than P, so media containing only these materials show very little change in BD (Table 2). Addition of S increased BD of GR; the 3GR:1S was comparable to the standard medium. The GR, P, and B media were about 1/3 the weight of the standard medium on a dry weight basis; this is considered light for a container medium, but is acceptable for greenhouse crops (8). A more realistic measurement of media weight would be to determine the BD at container capacity. This would include the weight of the water held by the media at container capacity. When BD was determined at container capacity, the GR, GR:P, and GR:B media compared more favorably to the optimum media weight ranges (12) and were comparable to the standard medium. This reflects the proportionally greater amounts of water weight in GR and GR:P in comparison to the GR:S or standard medium. Correspondingly, additions of B in excess of 3GR:1B rapidly reduced wet media weight because less water was held at container capacity.

The data indicate that a number of trends occur when amending GR with various materials. The addition of peat can increase the EAW of GR, but only at the 75% rate. However, the WBC of GR can be significantly increased with the addition of only 25% P. Addition of B to GR increases AS but this is at the expense of both EAW and WBC. The addition of S not only reduces AS but also EAW and WBC significantly. The addition of B or S to GR produces a drier medium than the GR or the GR:P media. These factors could be utilized in management practices according to the specific needs of the production system. For example, a drier GR:B medium might be chosen for propagation or growth of rot-prone species. A medium with a large EAW and WBC would be desirable to reduce irrigation frequency, resulting in a reduced incidence of foliar disease and leaching loss of fertilizers. The GR and GR:P media are lighter than the standard medium but they contain twice the amount of EAW. This would reduce shipping weight and also reduce plant water stress in transit.

The upper cost limit of a medium should be comparable to the cost of the standard nursery medium unless the performance qualities of the new medium can justify the added costs. GR and GR:P media provide physical and water-release characteristics superior to those of B, GR:B, S, GR:S, and the standard medium for growth of plants. GR has characteristics very similar to those of P but is much less expensive. The addition of P to GR in excess of 3GR:1P only slightly increases one parameter (WBC); however, medium cost increases greatly. A medium
Movement of Photosynthates in Muskmelon Plants*

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Additional index words: transport, leaf position, starch, Cucumis melo, cantaloupe

Abstract. Individual leaves of Cucumis melo L. acropetal to a developing fruit were treated with a pulse of $^{14}$CO$_2$. The level of $^{14}$C in the leaves, internodes, and fruits was determined after various periods of time when the leaf at the 3rd node acropetal to the fruit was treated. Leaves at the same node as the fruit, the 2nd, the 3rd, the 6th, and the 18th node acropetal to the fruit were treated and the level of $^{14}$C in the leaf, internodes, and fruit was determined after 2 hours. The percent of the incorporated $^{14}$C which was exported from the leaf was strongly affected both by time and leaf position relative to the fruit. Leaves which were 3 nodes acropetal to the fruit exported 65% of the label of $^{14}$C label is limited to a few internode lengths along the branch.

Fruit quality of muskmelon (cantaloupe) has been the subject of numerous investigations, beginning in 1928 when Rosa published his work on the sugar content of Cucumis melo (9). This plant, grown exclusively for its sweet, succulent fruit, will produce from one to many fruits, which usually set and ripen in sequence throughout the summer. The time of setting and ripening of the fruit varies according to the weather, cultivar, and condition of the plant (7). Fruit quality is based on many factors but the most important variable is sweetness (11). Since Rosa's time, melon quality has been measured by soluble solid content (SSC), which usually ranges from 8–13%. The quality is estimated by randomly sampling melons from a field, measuring their SSC and assigning a quality rating to the entire field (1). Not only is there great variation from field to field (3) but from fruit to fruit on the same plant (11). MacGillivray (6) found variation in SSC even in different regions of the same fruit.

Few studies have been conducted to determine the role of an individual leaf in the economy of the fruit plants. Hale and Weaver (5) found that the movement of $^{14}$C from $^{14}$CO$_2$-treated grape leaves was strongly influenced by clusters of developing fruit. Wardlaw (10) cited several workers who found that, in cereals, the supply of carbohydrates to the developing fruit was from the uppermost leaves, the "flag" leaf being the most important.

Muskmelon plants normally form a single large fruit sink which persists for a significantly large portion of the life of the plant. During this time, as much as 100 g of sucrose is deposited.

Literature Cited


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